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72nd ANNUAL MEETING
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Editor's Notice

The Proceedings of the North Dakota Academy of Science was first published in 1948, with Volume I reporting the business and scientific papers presented to the fortieth annual meeting, May 2 and 3, 1947. Through Volume XXI, the single yearly issue of the Proceedings included both Abstracts and Full Papers. Commencing with Volume XXII the Proceedings were published in two Parts. Part I, published before the annual meeting, contained an Abstract of each paper to be presented at the annual meeting. Part II, published later, contained full papers by some of the authors.

Commencing with Volume XXXIII of the Proceedings of the North Dakota Academy of Science, a new and functional format appeared. The Proceedings changed to an 8½ x 11 format, it is produced from camera-ready copy, and it is issued in a single part prior to the annual meeting (*i.e.* in mid-April).

Each presentation at the annual meeting is represented by a full page "Communication" which is more than an abstract, but less than a full paper. The communications contain results and conclusions, and permit data presentation. The communication conveys much more to the reader than did an abstract, but still provides the advantage of timeliness and ease of production.

The first section of this volume of the Proceedings contains communications presented in the Professional section of the 1980 annual meeting of the Academy. All professional communications were reviewed by the Editorial Committee prior to their acceptance for presentation and publication herein. The professional communications have been grouped together in this volume, and are numbered in the sequence in which they appear in the meeting program. Professional communications are numbered 1-27 and 34-45.

The second section of this volume contains collegiate communications representing those papers presented in the A. Rodger Denison Student Research Paper Competition. Undergraduate and graduate students reported on the results of their own research activities, usually carried on under the guidance of a faculty advisor. While the student competitors were required to prepare a communication similar to those prepared by their professional counterparts, these communications were not subject to editorial review prior to publication herein. The students also were required to prepare a full manuscript for submission to the Denison Awards Committee which judged the oral presentation, the communication, and the manuscript in arriving at their decision for the first and second place awards in both the graduate and undergraduate competition. The collegiate communications are numbered in the sequence in which they appear in the meeting program, but are grouped together in this volume. Collegiate communications are numbered 28-33 and 46-54.

Readers may locate papers by presentation number or by referring to the author index in this volume.

A. William Johnson
Editor

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NORTH DAKOTA ACADEMY OF SCIENCE

I. Rules for Preparation of Proceedings Communication

1. Each paper presented at the annual meeting of the Academy must be represented by a communication in the Proceedings, including A. Rodger Denison student research competition papers.
2. Only communications intended for presentation at the annual meeting will be considered for publication. They must present original research in as concise a form as possble. Quantitative data should be presented with statistical analysis (i.e., means with standard errors). Papers which merely summarize conclusions or ideas without supporting data are discouraged and will not normally be accepted. The communication should include the purpose of the research, the methodology, results, and conclusions.
3. Authors are encouraged to utilize the full space available in order to provide sufficient information to fully describe the research reported.
4. Communications must be prepared on the special blue-line form and sent, with two legible xerox copies, by first class mail to the Secretary, North Dakota Academy of Science, University Station, Grand Forks, ND 58202. The form must not be folded; a cardboard backing should be used to avoid damage. The Proceedings will be published by direct photo-offset of the submitted communication. No proofs will be prepared.
5. All typing, drawing and secured art or photographic materials must be within the boundaries of the blue-line form. Consult the example on the reverse side of the special form for proper style (i.e., titles, authors, address, tables, figures, references, indentations, headings, and punctuation). *Indicate the author to present the communication by an asterisk (*) after that person's name.*
6. Tables, diagrams, and photographs are acceptable provided they are secured to the special form and do not occupy a total area of more than 100 square centimeters.
7. Only essential references should be cited, and should be indicated in the text by numerals and quoted at the end of the communication. Up to three authors' names may be cited in full; with four or more authors only the first should be cited. The following form of citation should be used:

   Journals: Neary, D., Thurston, H. and Pohl, J.E.F. (1973) *Brit. Med. J.* 3., 474-475. (Abbreviate titles.)

   Books: Batsone, G.F., Blair, A.W. and Slater, J.M. (1971) *A Handbook of Pre-natal Paediatrics*, pp. 83-90. Medical and Technical Publishing, Lancaster

   Individual chapters in books: Farah, A.E. and Moe, G.K. (1970) in *The Pharmacological Basis of Therapeutics*, 4th edition (Goodman, L.S. and Gilman, A., eds.), pp. 677-708. Macmillan, New York

   Conferences and symposia: Rajewsky, M.F. (1973) Abstr. 2nd Meeting European Association for Cancer Research, Heidelberg, Oct. 2-5, pp. 164-5

8. Use a typewriter with elite type and with a carbon or good quality black silk ribbon. Single space and begin paragraphs with a 3 space indentation. Special symbols, not on the typewriter, must be hand lettered in black ink.
9. Abbreviations: Only standard abbreviations should be used, and should be written out the first time used with the abbreviation following in parentheses.
10. Titles: It is sugested that authors select a sufficient number of keywords to describe the full content of their paper, and then construct a title using as many of these as practicable. Title normally should not exceed 140 characters in length. In particular, they should be free from unneccessary phrases such as "a preliminary investigation of" or "some notes on" which add little or nothing to their meaning.
11. Session Assignment: In order to assist the program committee in organizing the presentations, please indicate on the reverse side of the blue-line form your 1st, 2nd, and 3rd preferences for the topical classification of your paper.
12. The authors' permission for the North Dakota Academy of Science to publish is implied by a submission. The Academy does not restrict the right of authors to include data presented in a communication in full papers submitted at a later date to other publishers.

II. Rules for Oral Presentation of Paper

1. All papers are limited to 15 minutes total time, for presentation and discussion. It is suggested that the presentation be limited to 10 minutes with an allowance of 5 minutes for discussion. It is also suggested that major emphasis be placed on the significance of the results and the general principles involved rather than on the details of methods and procedures.
2. Academy members represent a variety of scientific disciplines; therefore, speakers should avoid "jargon" and briefly explain or define such specialized terminology as may be judged to be indispensable to the presentation.
3. Projectors for 2" x 2" slides only will be available in all session rooms. Opaque projectors will NOT be provided. Only slides which can be read easily on projection should be used. Authors who desire suggestions for preparation of slides are referred to Smith, Henry W. 1957. "Presenting information with 2 x 2 slides." Argron. J. 49, pp. 109-113.
4. Timed rehearsals with slides are highly recommended. There is usually time for a *maximum* of 6 or 7 slides for a presentation of this kind.

THE USE OF CROWN VOLUME MEASUREMENTS FOR PREDICTING NET ANNUAL PRODUCTIVITY IN *ATRIPLEX CANESCENS*

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Phenological measurements have been shown to expeditiously provide reliable indicators of shrub productivity. Total aboveground weight and leaf weight have been adequately predicted using basal diameter, height, and circumference of several Rocky Mountain shrub species (1, 2). Even though site-specific relationships such as these are in no way new (3), the validity of recent reports to estimate biomass of a species over a large geographical range has remained untested. In this report, standing biomass and net annual productivity of *Atriplex canescens* from four sites in the Great Basin area in the western United States are predicted from species-specific equations.

Atriplex canescens (Pursh) Nutt., (fourwing saltbush), is a facultatively-evergreen, cold season, dioecious, browse shrub inhabiting semiarid and arid regions of the western United States. Total crown volume and plant density were measured in 10 (15 x 15 m) plots at one site in Wyoming (S_1), two sites in Utah (S_2 and S_3), and one site in Nevada (S_4). Based on a phenological classification, biomass of harvested plants was separated into current year's growth (B_c), middle aged growth (B_m), and old wood (B_o). Net annual biomass was subsequently divided into leaves, stems, fruits.

Table 1. Mean volume, density, and biomass of *Atriplex* at sample sites.

	S_1	S_2	S_3	♀	S_4	♂
# Plants ha^{-1}	1022	400	752	304		400
Mean Crown Volume (m^3)	0.6	1.77	7.05	7.71		1.37
height (cm)	64	92	135	121		51
d_1 (cm)	99	135	255	236		82
d_2 (cm)	70	135	255	236		82
B_c (kg)	0.68	0.79	5.11		4.99	
% leaves	31	32	22		10	
% twigs and stems	38	47	37		23	
% fruits	31	21	41		67	
B_m (kg)	1.64	2.68	6.3		5.40	
B_o (kg)	0.90	3.15	4.97		5.60	
B_{total} (kg)	3.22	6.62	16.39		15.99	

Highest plant densities (1022 plants ha^{-1}) and lowest (400 plants ha^{-1}) were recorded at Sites 1 and 2 respectively (Table 1). The range of percent cover was 38.4% of the ground space at Site 3 and 5.7% at Site 2. Although plant densities at Sites 3 and 4 were similar, the percent cover at Site 4 (15.4%) was fairly low due to the wide range of plant sizes. Pistillate plants were the larger than staminate plants at all sites; however, significant differences ($P < .01$) between height, diameter and volume of pistillate and staminate plants were found only at Site 4. The largest crown volume of any plant was 26.04 m^3 at Site 4. The five plants harvested each at Site 1 and Site 2 showed wide variation in B_c, B_m, and B_o. Unlike Sites 1 and 2, pistillate plants from Sites 3 and 4 allocated considerably more energy to fruit than leaf production. The percent fruits for Site 4 represents 3.34 kg $plant^{-1}$, or approximately 2.14×10^5 seeds.

Using biomass data and volumes of harvested plants, site-specific linear prediction equations were calculated for Sites 1 and 2. Mean crown volumes for both sites were used in the respective equations to obtain more representative estimates of mean plant biomass components. Actual and predicted biomass values for Sites 1 through 4 were used to describe an overall species-specific relationship between biomass (B) and crown volume (X_v). Net annual productivity of *Atriplex canescens* ranged from a low of 0.222 kg ha^{-1} yr^{-1} at Site 1 to a high of 2.482×10^3 kg ha^{-1} yr^{-1} at Site 3.

Table 2. Species-specific relationships between crown volume and biomass for *Atriplex canescens*.

$B_T = 1.29 + 1.43X_v + e$	$r^2 = 0.96$	$S_{y.x} = 1.51$
$B_o = 0.60 + 0.47X_v + e$	$r^2 = 0.92$	$X_{y.x} = 0.71$
$B_m = 0.77 + 0.49X_v + e$	$r^2 = 0.90$	$X_{y.x} = 0.80$
$B_c = -0.08 + 0.48X_v + e$	$r^2 = 0.96$	$S_{y.x} = 0.51$

(1) Brown, J.K. (1976) *Can. J. For. Res.* 6, 153-158.
(2) Harniss, R.O. and Murray, R.B. (1976) *J. Range Manage.* 29, 430-432.
(3) Pechanec, J.F. and Pickford, G.D. (1937) *J. Am. Soc. Agron.* 29, 894-904.

TAXONOMY AND DISTRIBUTION OF THE GENUS RORIPPA (BRASSICACEAE) IN THE GREAT PLAINS

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The Great Plains Flora Association was organized in 1973 for the purpose of compiling a floristic treatment of the Great Plains. Several taxonomists are involved, and the herbaria with which they are affiliated, are providing most of the resources for the proposed Flora of the Great Plains (1). For this particular study, the results of which will be published in the Flora, specimens from the following herbaria were examined: the University of Kansas (KANU), North Dakota State University (NDA), the University of Nebraska--Lincoln (NEB), and the University of South Dakota (SDU).

Rorippa, which was first described by Scopoli in 1760, consists of those yellow-petaled, numerous-seeded, dehiscent-fruited marsh and shore plants in the Brassicaceae, commonly known as the marsh cresses or yellow cresses. Synonyms for the genus include Brachiolobus, Radicula, and Nasturtium, and member species have also been variously placed in Cardamine, Sisymbrium, and Erysimum (2).

Key characters for delimiting the taxa of Rorippa in the Great Plains are: fruit size and shape; style length, shape, and mode of attachment to the silique; pedicel position and length in fruit; petal length, and length in relation to the sepals; manner of raceme development; trichome types and location; leaf shape and lobing; seed size, surface markings, and number per silique; and replum shape.

Nine species occur in the Great Plains. Rorippa sinuata and R. sessiliflora are two of the most widespread and abundant taxa, and, along with R. curvipes, R. tenerrima, and R. truncata, are native to North America. R. austriaca and R. sylvestris are introduced from Europe and have been collected only rarely. These seven species are delimited with relative ease.

The two remaining species, both native, are problematical. Rorippa palustris, which for years was known as R. islandica, is a highly complex species. According to current nomenclature (2), both subspecies and varietal ranks are used, so as to portray levels of morphological complexity and geographical segregation. Two subspecies are found in this area, the key characters being the location and abundance of hairs on leaves and stems. The combinations of characters which have been used to separate the varieties are not consistent in material from the Great Plains. Therefore, we have decided to retain only the rank of subspecies.

Rorippa calycina has been reported from one locality each in the states of Montana, North Dakota, and Nebraska (3). We have also communicated with a taxonomist who has collected specimens of this taxon in Wyoming. Several specimens which were labeled R. calycina, have upon close scrutiny proven to be R. sinuata. The confusion has come about through equating the vesicular trichomes on the siliques of the latter with the very short, pointed, thick-based simple hairs on fruits of the former.

1. Barkley, T. M. (ed.) (1974) The Great Plains Flora Project. Research proposal submitted to the National Science Foundation. Kansas State University, Manhattan. 139 pp.

2. Stuckey, R. L. (1972) Sida 4, 279-430.

3. Barkley, T. M. (ed.) (1977) Atlas of the Flora of the Great Plains. Iowa State University Press, Ames. 600 pp.

3 FORAGE QUALITY OF BARLEY STRAWS AS INFLUENCED BY GENOTYPE

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Crop residues are the largest, basically untapped carbohydrate source for ruminant livestock feed. Straws have been used effectively in dry, nonlactating beef cow rations to reduce wintering feed cost or replace up to two-thirds of the conventional hays used to overwinter beef cows (1). Meyer, Davila, and Erickson (2) found genotypic differences in forage quality of oat straws, but similar information on barley straws is lacking. Therefore, our objective was to determine if the forage quality of barley straws was affected by the genotype.

Straws from 37 genotypes of the Mississippi Valley Barley Nursery located at Langdon, ND in 1977 and 31 genotypes from a combined variety-regional nursery trial located at Fargo, ND in 1978 were sampled. Fifteen entries were common in both trials. Quality parameters measured included straw protein percentage, fiber, total cell walls, lignin, hemicellulose, *in vitro* dry matter disappearance (IVDMD), ash, and phosphorus.

Genotypic differences were found among straws of the 15 genotypes for protein percentage, fiber, total cell walls, hemicellulose, ash, and phosphorus (Table 1). Six-row barleys had a higher fiber and ash content but lower hemicellulose content than 2-row barleys. 'Hector' barley had the highest straw protein and phosphorus content of the 15 genotypes. 'Karl' barley included in 1977 only had a straw protein percentage 2.4 units higher than Hector. 'Glenn' barley was lowest in total cell walls indicating the highest potential intake. 'ND2674' was lowest in fiber. The 15 genotypes were not different in lignin and IVDMD.

Significant environment effects were detected for ash, phosphorus, total cell walls, and hemicellulose probably due to the markedly better yield environment in 1977. Genotype x environment interactions were detected for phosphorus, total cell walls, and hemicellulose characters.

Table 1. Forage quality of 15 barley genotypes in 1977-78.

	Quality component					
Entry	Protein	Fiber	Cell wall	Hemi.*	Ash	P
	----------% of dry weight----------					
6-row barley						
Larker	5.1cd**	52.3ab	73.4ab	21.2abc	11.6abcd	0.12ab
Beacon	4.5d	53.4a	73.5ab	20.1bcd	11.8abc	0.11ab
Bonanza	5.1cd	52.4ab	74.5ab	22.1abc	10.7de	0.12ab
Nordic	5.1cd	52.2ab	72.6abc	20.4abc	11.6abcd	0.10b
Manker	6.2ab	50.4bcd	69.3cd	18.9cd	11.8abc	0.13ab
Park	5.5bcd	51.9ab	72.1abc	20.2abcd	12.4a	0.12ab
Glenn	5.6abc	51.5abc	68.4d	16.9d	12.6a	0.12ab
Morex	5.4bcd	51.9ab	73.1ab	21.2abc	12.0ab	0.12ab
ND1156	5.7abc	51.5abc	75.2a	23.7a	11.8abc	0.12ab
Mean	5.4	51.9	72.5	20.5	11.8	0.12
2-row barley						
Hector	6.6a	49.6cd	72.9ab	23.3ab	10.3e	0.15a
Klages	5.3bcd	49.6cd	72.8abc	23.2ab	10.0cde	0.12ab
Shabet	5.0cd	51.5abc	74.6ab	23.1ab	10.9cde	0.14ab
Summit	5.8abc	49.4cd	71.1bcd	21.7abc	11.3bcde	0.14ab
ND2654	5.5bcd	49.3cd	68.5d	19.1cd	11.0bcde	0.11ab
ND2674	5.4bcd	49.2cd	72.4abc	23.2ab	11.0bcde	0.14ab
Mean	5.6	49.8	72.1	22.3	10.9	0.13

*Hemicellulose **Means followed by different letters are significantly different at the 5% probability level.

1. Conlon, T.J. 1975. Using straw in cow wintering rations. 26th Annual Livestock Research Roundup. Dickinson Exp. Stn.

2. Meyer, D.W., R.S. Davila, and D.O. Erickson. 1978. Nutritive value of straws from several oat genotypes. Agron. Abstr. p. 123.

4

Techniques of Establishing Wetland Vegetation on Strip Mine Ponds

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Fargo, North Dakota 58105

In the summer of 1979 a study was begun in cooperation with the U.S. Forest Service and the Consolidation Coal Company to investigate techniques of wetland plant revegetation. This paper covers the initial techniques used and the growth of plants during the year of planting.

Twelve species (Table 1) were selected for planting at the Glenharold Mine, Stanton, North Dakota. All species were found in natural wetlands on mine property, with Alisma plantago-aquatica, Eleocharis palustris, Scirpus validus, Typha angustifolia, Scirpus acutus, Scirpus fluviatilis Typha latifolia, and Scirpus maritimus being observed in mine impoundments. Two adjacent ponds having shorelines of similar slope and aspect were selected as planting sites. Measurements of specific conductance taken at both sites (1500 u mhos and 1100 u mhos) indicated a salinity in the "slightly brackish" range. All the species chosen were at least tolerant of this salinity (1).

Three planting techniques were designated as fiber pot (FP), no support (NS), and mesh net (MN). Plants were obtained by digging from nearby wetlands. For the fiber pot technique a ball of soil or a plug of soil with several shoots was used for the no support technique. The mesh net technique required trimming the roots, rhizomes, and shoots to make small pieces which were held in place by the net. Disturbance and injury to the plants was evaluated as high with the mesh net technique, moderate with the no support technique, and low with the fiber pot technique.

Plantings consisted of three replications (two on the first pond and one on the adjacent pond). Three techniques for each of twelve species, plus three control plots, resulted in 39 plots in each replication. Three to five rows (each row one meter wide) were planted from shallow water to deep water. Pots, plugs, or rhizomes were spaced a half meter apart in each row. Pots were placed in holes, keeping the rim below the soil surface. Plugs were planted in slits made with a tile spade. Rhizome sections were worked into the soil and held in place by the mesh net. Plantings were completed by the third week in July.

Plant survival was monitored during the summer with shoot counts being made at the end of August. During the month following planting the pond water levels declined gradually. On August 21 a brief but intense rain storm raised the water levels of both sites 24 cm and 30 cm respectively.

August shoot counts showed an overall loss in the fiber pot technique (-12%) and nearly equal gains in the no support (+18%) and mesh net (+17%) techniques (Table 1). The first seasons growth appeared to be related to species differences rather than technique differences. The taller species fared better than the shorter species, with two exceptions: Scolochloa festucacea, a tall slender species, suffered the greatest losses, while Scirpus maritimus, a short species, displayed the best growth. Scirpus americanus, Carex atherodes and Eleocharis palustris had more losses in deep water, while Alisma plantago-aquatica lost more in shallow water. Typha angustifolia, Scirpus acutus and Scirpus fluviatilis had greater gains in shallow water, while Scirpus validus and Sparganium eurycarpum had greater gains in deep water. Typha latifolia gained well in all depths. Frequent damage to the slender shoots of Scolochloa during handling probably added to its decline. Consistent losses on all mesh net replications for Scirpus fluviatilis indicate that this technique may be too injurious for this species. The reasons for gains or losses in all these species are not clear at this time. Soil analysis (in progress) and observations during 1980 may lend additional insights.

Table 1. Number of pots, plugs, rhizomes, and shoots planted, number of shoots present in August, and percent change in shoot number for each species and technique.

	Initial Planting						Shoots Present in August			Percent Change		
	Fiber Pots		No Support		Mesh Net							
Species	Pots	Shoots	Plugs	Shoots	Rhizomes	Shoots	F.P.	N.S.	M.N.	F.P.	N.S.	M.N.
Scolochloa festucacea	36	401	45	123	45	90	103	32	35	-74	-74	-61
Scirpus americanus	34	385	45	125	48	95	151	70	80	-61	-44	-16
Carex atherodes	36	206	46	154	46	82	186	97	68	-10	-37	-17
Alisma plantago-aquatica	39	46	54	54	53	53	39	46	40	-15	-15	-25
Eleocharis palustris	34	695	45	635	45	320	401	635	279	-42	0	-13
Scirpus validus	27	246	46	152	45	63	260	258	61	+6	+70	-3
Typha angustifolia	27	49	46	49	45	45	81	68	46	+65	+39	+2
Scirpus acutus	27	231	45	131	45	56	325	200	69	+41	+53	+23
Scirpus fluviatilis	27	47	45	58	45	45	124	80	21	+164	+38	-53
Sparganium eurycarpum	36	51	45	45	50	50	93	107	130	+82	+138	+160
Typha latifolia	27	33	39	39	42	42	85	127	95	+158	+226	+126
Scirpus maritimus	36	154	52	67	45	57	383	206	242	+149	+207	+325
TOTALS	386	2544	553	1632	554	998	2231	1926	1166	-12	+18	+17

1. Stewart, R.E. and H.A. Kantrud. 1972. U.S. Geol. Surv. Prof. Paper 585-D.

5

Facile Preparation of Azidodeoxynucleosides

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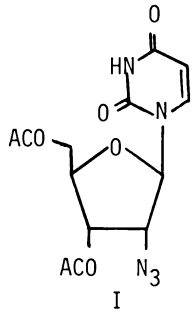
Among the nucleoside antibiotics produced by microorganisms only three are known to possess aminodeoxyribofuranose structures, puromycin (1), 3'-amino-3'-deoxyadenosine (1), and 2'-amino-2'-deoxyguanosine (2). The last is the only known occurrence of 2'-amino-2'-deoxyribose in nature. The occurrence and biological activities of these aminodeoxynucleosides has prompted considerable interest in the synthesis of other aminodeoxynucleosides. The least studied of the aminodeoxynucleosides have been the pyrimidine 2'-amino-2'-deoxyribonucleosides.

We wish to describe a facile synthesis of 3',5'-di-O-acetyl-2'-azido-2'-deoxyuridine(I) in good yield from 2',3'-O-(methoxyethylidene)uridine(II) by a one-flask procedure. Azide II serves as a ready high-yield precursor for the production of 2'-amino'2'-deoxyuridine via catalytic reduction over palladium.



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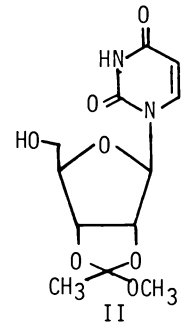

II

Azide I has previously been synthesized (3); however, the overall yield is low (32%) and the procedure requires the use of hexamethylphosphoramide (HMPA), a cancer suspect solvent.

Treatment of II with excess sodium azide and Me_3SiCl in dimethylformamide (DMF) for 14 h at 95° followed by 7.5 h at 150° produced I in 40% yield after acetylation with acetic anhydride. The yield would not be improved by changing the reaction times at these temperatures. Since the sodium azide is mostly undissolved under the reaction conditions, we decided to repeat the reaction in the presence of an equimolar (to N_3^-) amount of tetramethylammonium chloride (TMAC). Under these conditions azide I was isolated in 79% yield.

We have ruled out the intermediacy of Me_3SiN_3 in this reaction since all attempts to convert II to I with Me_3SiN_3 were unsuccessful.

In summary the present methodology offers greatly improved yields and simplified procedures for the synthesis of pyrimidine 2'-azido-2'-deoxynucleosides.

1. Suhadolnik, R.J. (1970) Nucleoside Antibiotics, Wiley-Interscience, New York.

2. Nakanishi, T. et. al. (1976) Chem. Pharm. Bull. 24, 2955-2960.

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C-NUCLEOSIDE SYNTHESIS VIA GLYCOSYL ALKYNYL KETONES

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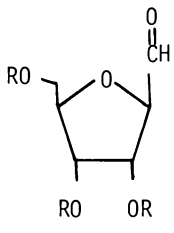
The discovery of C-nucleosides and their antibacterial and antitumor properties (1) has prompted considerable attention to the development of synthetic routes to this fascinating class of compounds (2). Although a number of synthetic routes to C-nucleosides have been developed, only a few are versatile enough for general heterocyclic synthesis.

Our approach to the development of synthetic routes for C-nucleosides has been in the preparation of highly functionalized C-glycosides such that they will be generally suited as intermediates for elaboration to a variety of heterocyclic systems. The facility with which acetylenic esters and ketones undergo nucleophilic additions and cyclizations (3) has prompted us to investigate the feasibility of synthesizing glycosyl alkynyl ketones and their suitability as versatile intermediates for C-nucleoside synthesis.

The desired glycosyl alkynyl ketone(III) was successfully synthesized by the addition of lithium phenylacetylide to 2,5-anhydro-3,4,6-tri-O-benzyl-D-allose(I) followed by oxidation of the resultant acetylenic alcohol. The addition of lithium phenylacetylide proceeds in 86% yield. Oxidation of II was performed in 78% and 68% yields with either the Pfitzner-Moffatt reagent (4) or the modified Ratcliffe-Rodehorst reagent (5), respectively. Treatment of the alkynylketone(III) with hydrazine hydrate in ethanol produce the C-nucleoside 5(3)-phenyl-3(5)-(β-D-ribofuranosyl) pyrazole(IV) 36% yield.



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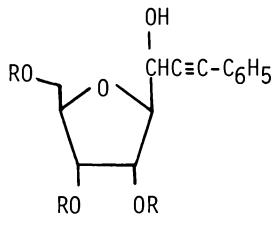

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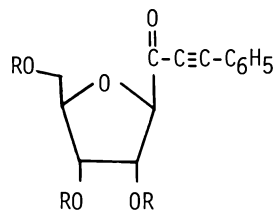

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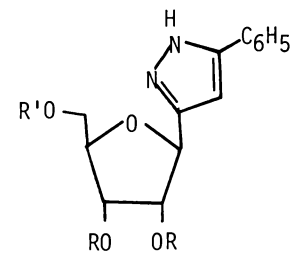

IV

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7

INTERMEDIATES IN THE PREPARATION OF ARYLALDOXIMES: COLOR AND SOLUBILITY CHANGES DURING THE SYNTHESIS OF ANTHRACENE-9,10-DICARBOXALDOXIME.

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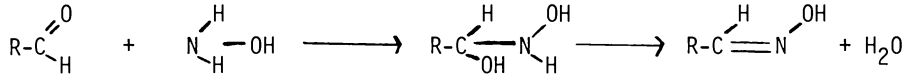
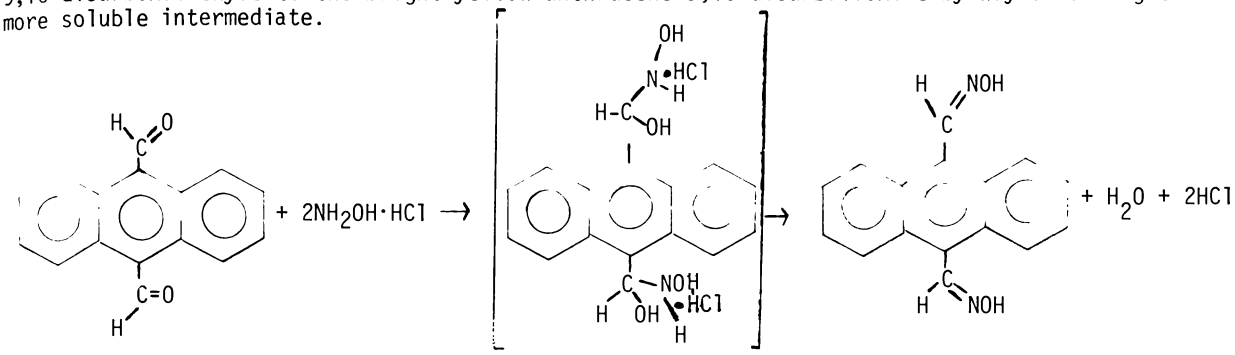
INTRODUCTION

The formation of an oxime by the action of hydroxylamine or hydroxylamine hydrochloride on an aldehyde proceeds by way of an intermediate addition compound, presumably:



Ordinarily this reaction is not observed. When however the aldehyde and the oxime are colored, especially of markedly different colors, or if the aldehyde is only slightly soluble, the transient formation of the more soluble intermediate can be observed. This phenomenon is especially spectacular in the case of the conversion of the bright orange and only very slightly soluble anthracene-9,10-dicarboxaldehyde to the bright yellow anthracene-9,10-dicarbaldoxime by way of a bright orange more soluble intermediate.



EXPERIMENTAL PART

2.34 g (0.010 moles) of anthracene-9,10-dicarboxaldehyde (Eastman 9381)[1], previously very finely ground in a mortar and pestle, was suspended in 100 ml of absolute alcohol, and heated to boiling to give a bright orange suspension (to dissolve completely requires about 500 ml of ethanol). On addition of 10 ml of 4.0 molar aqueous hydroxylamine hydrochloride, the suspended di-aldehyde dissolves to a clear, bright orange solution. After five to ten minutes a very fine bright yellow cloud, and then a precipitate, forms. After cooling for 24 hours, this was filtered off, allowed to air-dry; weight 2.38 g., or 90% of theory for $C_{16}H_{12}O_2N_2$=264.

Instead of grinding in a mortar and pestle the finely divided di-aldehyde may also be prepared by recrystallization from 500-600 ml ethanol with vigorous stirring of the solution while cooling.

The dioxime melts with decomposition around 280-285°C. The dioxime is only slightly soluble in all common solvents. It dissolves on heating and reprecipitates on cooling, both very slowly. In all cases the product is a powder or a semi-microcrystalline, yellow to orange, substance. The solubility in grams per liter in hot and cold solvent is on the order of: Methanol, 1.0, 0.25; ethanol, 1.3, 0.4; propanol-1, 2.0, 0.5; propanol-2, 1.0, 0.25; sec. butyl alcohol, 3.3, 1.0; $CHCl_3$, 0.1,-; CCl_4, 0.2-; glacial acetic acid, 10, 2; 25% acetic-,0.2; H_2O, 0.05,-; ethyl acetate, 1.1, 0.4; benzene, 0.5, .1, toluene, 0.2, 0.05; xylene, 1.0, 0.1, cyclohexanol, 25, 2. The dry powder becomes highly electrostatic, and then clings strongly to paper, glass, and the skin.

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8

SECONDARY TREATMENT OF EFFLUENT STREAMS FROM POTATO PROCESSING PLANT

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In recent years potato processing plants in this country have given attention to the reuse of treated wastewaters in order to reduce water cost. Primary treatment is only effective in removing solids and free floating oils by gravity separation. Secondary treatment becomes necessary to prepare wastewater for in-plant reuse as suspended and dissolved contaminants are not effectively removed by primary treatment. In this investigation the objectives were to determine the feasibility in using activated sludge treatment for potato processing wastes and to determine factors affecting treatment performance.

Bench-scale completely mixed continuous activated sludge reactors were used in the treatability study of potato processing wastewaters. Two sets of reactors were used in the test runs. The operating conditions for first set of reactors, A, B, and C, resembled those used in second set of reactors, D, E, and F. Reactors A, B, and C had higher feed strengths than reactors D, E, and F. The aeration tank hydraulic detention time ranged from 1.80 to 5.05 days. Reactors A, B, and C had volumes of 4.88, 2.93, and 1.83 l, respectively. Reactors D through F had volumes between 2.13 and 4.73 l. Diffused aeration provided a means of completely mixing the aeration tank contents. A nutrient buffer solution which contained 297 gm/l NH_4Cl, 40 gm/l Na_2PO_4, and 24.2 gm/l $NaH_2PO_4 \cdot H_2O$ was used to provide nitrogen and phosphorous requirements for microorganisms.

Table 1 presents performance data of activated sludge reactors. As the hydraulic detention time increased, effluent quality improved. Under these conditions raising the wastewater feed strength, on a COD basis, also produced effluents with superior properties. For the first set of reactors, A, B, and C, feed COD was 2540 mg/l. When the hydraulic detention time was increased to 5.05 days effluent COD was reduced to 207 mg/l. An increase in MLVSS levels were observed to follow decreasing hydraulic detention times. Shorter hydraulic detention times were the result of smaller aeration tank volumes which would have higher food concentrations available to microorganisms. This was reflected in higher oxygen uptake rates. A higher rate of biological activity along with decreases in detention time would explain increasing effluent concentrations of TSS. Similar results were observed for the second set of reactors, D, E, and F. At a maximum hydraulic detention time of 4.99 days influent COD was reduced from 1950 to 346 mg/l. MLVSS levels increased with decreasing feed dilution in the aeration tank. Ammonia removal efficiencies were higher in reactors A, B, and C than D, E, and F. As hydraulic detention time increased, better ammonia removal was obtained. Reactors A, B, and C had higher COD removal efficiencies than reactors D, E, and F. It was observed that for a COD removal of 90 percent or better a hydraulic detention time of 5 days will be required. Secondary effluents still contain significant amount of COD and TSS. Additional treatment will be needed to produce effluents suitable for in-plant reuse.

Table 1

Performance Data of Activated Sludge Reactors

Reactor	Hydraulic Detention Time (day)	MLSS	MLVSS	Eff. TSS	COD			NH_3-N		O_2 Uptake Rate (mg/l/day)	Reactor pH
					Inf.	Eff.	% Removal	Inf.	Eff.		
A	5.05	2510	2070	184	2540	207	92	28.7	0.4	8030	8.3
B	3.20	2510	2100	204	2540	255	90	28.7	1.1	8500	8.3
C	1.82	2590	2080	258	2540	349	86	28.7	1.5	9660	8.4
D	4.99	2910	2250	185	1950	346	82	31.0	0.7	7300	8.3
E	3.63	3090	2400	296	1950	378	81	31.0	4.3	7500	8.5
F	2.00	2800	2600	319	1950	484	75	31.0	5.5	8400	8.5

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Sand Column Treatment of Potato Processing Wastewaters for In-Plant Reuse

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In recent years potato processing plants in this country have shown increasing interests in the reuse of treated wastewater effluents to minimize water pollution as well as to reduce water cost. In this study sand columns were used in the tertiary treatment of potato processing wastewaters to improve the quality of treated effluent for meeting water reuse needs. The objectives of this investigation were to determine effects of hydraulic detention time and feed strength on the performance of sand columns and also to determine optimum operating conditions.

Three biological sand columns with lengths of 2 feet and diameters varying from 0.25 inches to 1 inch were used in two separate time periods of study. Each period lasted for one month. The sand sizes varied from U. S. sieve number 12 to 10. The maximum particle diameter in the column packing was equal to 0.066 in.

Two different types of feed were used. In period 1 secondary effluents from bench-scale activated sludge reactors were fed to the sand columns, while in period 2 secondary effluents from potato processing plants were used. Hydraulic detention time ranged from 0.29 to 3.34 hours in period 1, while in period 2 it varied from 0.44 to 1.42 hours. Operating conditions were similar in both periods except for detention time and feed strength.

Performance data of biological sand columns for both periods are shown in Table 1. It was observed that increasing hydraulic detention time improved COD (chemical oxygen demand) removal efficiency. Increasing column volumes were followed by increasing hydraulic detention times. In period 2 hydraulic detention times were slightly higher than those used in period 1, which resulted in lower filtration rates and longer contact times between the microorganisms and the wastewaters. Also, in period 2 the sand columns had operated for a longer period of time compared to period 1, which resulted in better acclimated microorganisms. These conditions contributed to higher COD removal efficiency in period 2 in spite of higher feed COD concentrations. The feed water in period 2 contained 230 mg/l COD, which was 30% higher than that in period 1, but effluent COD in period 2 was about 50 mg/l compared to 90 mg/l in period 1. The COD removal efficiency for period 1 was less than 50% while in period 2 COD removal efficiency of approximately 80% was obtained. It appears that for the feeds used in this project, wastewater strength did not have significant effect on the COD removal using biological sand columns. Hydraulic detention time had significant effects on the sand column performance. Sand column effluents still contained appreciable quantity of COD, which would require additional treatment such as activated carbon adsorption and ozonation to render effluent suitable for in-plant use.

Table 1

Biological Sand Column Treatment Performance

Period	Column	Diameter (inch)	Flow Rate (l/day)	Actual Detention Time (hr.)	Filtration Rate (gpm/ft^2)	COD Inf.	COD Eff.	% Removal
1	1	0.25	0.71	0.29	0.38	174	94	46
1	2	0.5	0.56	1.21	0.08	174	88	49
1	3	1.0	0.58	3.34	0.02	174	88	49
2	1	0.25	0.47	0.44	0.25	230	53	77
2	2	0.5	0.48	1.39	0.07	230	48	79
2	3	1.0	0.47	4.12	0.02	230	44	81

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ANALYSIS OF LOW-RANK COALS BY X-RAY FLUORESCENCE

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In the conventional method for determining the inorganic composition of a coal, the sample is ashed at a temperature of 750°C in a muffle furnace according to the American Society for Testing and Materials (ASTM) procedure in order to remove all combustible organic material. A problem with this procedure is the possibility that some of the volatile elements may be partially or completely volatilized at this temperature. The elements of particular concern are sodium and sulfur and some trace elements such as As, Pb, Se, Mo, and Sr. A possible solution to this problem is the direct X-ray fluorescent analysis of coal. A wavelength dispersion and a solid state energy dispersion X-ray spectrometer are currently being used at the Grand Forks Energy Technology Center (GFETC) to analyze coals directly.

Determination of the nine major elements (Na, Mg, Al, Si, S, K, Ca, Ti, and Fe) was accomplished using the wavelength dispersive X-ray spectrometer. A thallium acid phthalate crystal with a large 2d spacing was used for the light elements Na, Mg, and Al, and a pentaerythritol crystal was used for the remaining elements. Results of a typical analysis of a well-analyzed sample from the Illinois Geological Survey are shown in Table 1.

Minor element analysis was performed by the Solid State Energy Dispersion System (EDS). The flexibility of this instrument permits the selection of various secondary targets and filters so that optimum excitation conditions can be achieved for many of the elements in the periodic table. The lighter elements Na through S are excited directly by the rhodium X-ray tube. Higher atomic number elements are most efficiently excited by secondary excitation where the composition of the secondary target is of higher atomic number than the element of interest. The secondary targets used here were Fe, Ag, and Gd. Filters were also used to filter peaks from the target and Bremsstrahlung background radiation to an acceptable level. Table 2 lists the results obtained from an analysis of a National Bureau of Standards Standard Reference Material 1632 trace elements in coal.

These results demonstrate that X-ray techniques are adequate for analyzing raw coals. At GFETC X-ray methods are used in addition to other techniques such as atomic absorption and plasma emission spectroscopy for trace element determinations.

Table 1. Elemental Analysis of the Major Elements in Coal by Wavelength Dispersion Spectrometer (WDS)

Element	WDS	Accepted (1) Analysis
Fe	1.8	1.7
Ti	0.06	0.06
Ca	0.70	0.93
K	0.27	0.17
S	3.44	3.56
Si	2.6	2.3
Al	1.3	1.2
Mg	0.07	0.07
Na	0.15	0.15

Table 2. Trace Element Analysis of a NBS SRM 1632 by an Energy Dispersion Spectrometer (EDS) (ppm $\pm$ 2 σ)

Element	EDS	Analyzed Values[2]
Ni	15±2	15±1
Cu	15±2	18±2
Zn	30±2	37±4
Ga	5±2	6.1±.3
Se	2±1	2.9±.3
Br	16±3	17.5±.3
Sr	157±20	161±16
Mo	4±2	--
Pb	24±8	30±9
Y	7±2	7.9±.6
Zr	35±10	33±4
Ge	2±2	2.9±.2
As	6±2	5.9±.6
Rb	22±6	21±2

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11

ORGANIC SPECTRAL STUDIES OF LIGNITE LIQUEFACTION SOLVENTS

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The lignite liquefaction program at the Grand Forks Energy Technology Center utilizes a 2.3-Kg coal/hr continuous process unit in which CO and H_2, pulverized lignite and startup anthracene oil solvent are reacted at high pressure and temperature (1). The product stream is batch recycled with added coal after light components are removed. Since the choice of a good hydrogen donor startup solvent is essential for the success of the conversion process, simple analytical methods were sought for the comparison of a prospective solvent with other solvents and with the lined-out recycle product stream.

The anthracene oils used tended to be heavy black liquids that boil > 300°C at 1.3 MPa. In this study two anthracene oils, AO-1 and AO-3 were compared with each other and with the recycle slurry after reaction. The recycled product stream used for comparison was 28-14 derived from the 30th pass of a continuous experiment for which AO-1 was the startup solvent.

Elemental analyses, IR spectroscopy both of thin films and of dilute solutions, fourth derivative U.V. spectroscopy, 200 MHz ^{1}H NMR and 50 MHz ^{13}C NMR were used to characterize the solvent samples. All of these methods were useful in establishing differences and similarities between samples. Some of the results of the NMR and IR studies are shown in Table 1.

Table 1

Spectral Comparisons of Liquefaction Solvents and Recycle Stream

	^{13}C NMR		^{1}H NMR			I.R.
Sample	$f_a(C_{ar}C_{total})$	C_{ar}/C_{aliph}	% H_{ar}	% H_α	% H_o	A_{3020}/A_{2925}
AO-1 (raw oil)	0.74	2.9	30.7	32.7	36.6	0.22
AOD-1 (distilled, 296°, 1.3 MPa)	0.68	2.1	28.8	29.0	42.2	0.18
AOB-1 (bottoms)	0.80	3.9	35.3	35.5	29.2	--
AO-3 (raw oil)	0.44	0.8	13.8	20.1	66.1	0.11
AOD-3 (distilled, 296°, 1.3 MPa)	0.38	0.6	11.8	15.6	72.9	0.076
AOB-3 (bottoms)	0.86	6.3	38.3	38.5	23.2	--
28-14 (recycle stream)	0.73	2.7	43.1	28.3	28.6	--

It has been suggested (2) that a good hydrogen transfer solvent contains a large percentage of aromatic protons, % H_{ar}, and a significant percentage of hydroaromatic rings, % H_α. The aliphatic side chains and/or saturated hydrocarbons, H_o, do not contribute to the hydrogen donor ability of the solvent, and their presence may be undesirable. Seshadri, et al., have employed ^{13}C NMR in the calculation of transferable hydrogen in coal liquefaction solvents (3). The method is based on the 22 ppm to 31 ppm region of the aromatic fraction after the acenaphthene has been subtracted.

The use of ^{13}C and ^{1}H NMR appears to offer the best quick analytical method of the methods investigated for characterization of anthracene oils before use in liquefaction processes. By comparing $f_a(C_{ar}/C_{total})$ obtained from ^{13}C NMR and the % H_{ar} from ^{1}H NMR with corresponding values for the lined-out recycle stream, a solvent which closely resembles the recycle stream may be selected.

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NEW METHODS FOR ANALYSIS OF LIGNITE LIQUEFACTION PRODUCTS

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The complex mixtures of organic compounds resulting from liquefaction of lignite present a challenge to modern analytical instrumentation. To simplify the mixtures for analysis, simple separations into chemical classes by column chromatography or solvent extraction have proven useful. New computer interfaced instrumentation has proven to be useful in mixture analysis.

Differential infrared spectroscopy using computer subtraction was applied to a succession of light oils from a liquefaction reactor. The start-up solvent was "anthracene oil" (Crowley Tar Products Co.), free of phenols and redistilled under vacuum to remove high boiling components. The buildup of phenolic components as the continuous process approached steady state conditions was apparent from comparison of subtraction IR spectra, taken of 0.015 mm thick neat liquid films. The spectra are shown in Figure 1.

Quantitative carbon-13 NMR spectra at 50 MHz of complex mixtures have been obtained using gated decoupling, 5 sec. delays for relaxation, and added $Cr(AcAc)_3$ to promote relaxation and minimize NOE. The use of a high field (47 kG) superconducting magnet has definite advantages in quantitative ^{13}C over conventional electromagnet instruments in improved field stability, increased sensitivity, and faster relaxation time. Figure 2 illustrates the approach to steady state concentrations of a set of liquefaction light oil samples. The increase in f_a (fraction aromatic carbon) from 0.30 to 0.54 is apparent in these spectra (which show only the aromatic region). The appearance of phenol and cresol resonances at 113.9, 120.6, 121.5, 153.6, and 155.6 ppm as the light oil became lignite derived rather than start-up solvent derived is also apparent in the ^{13}C NMR spectra. Subtraction and fourth derivative ultraviolet spectrophotometry have also been useful in the examination of these complex mixtures. The fourth derivative UV spectrum displays maxima which correspond to the maxima in the UV spectrum, and also the intensity of the fourth derivative band obeys Beer's law. Absorptions caused by phenol, cresols, and phenanthrene are readily recognized in the fourth derivative UV, but not in the featureless underivatized spectra.

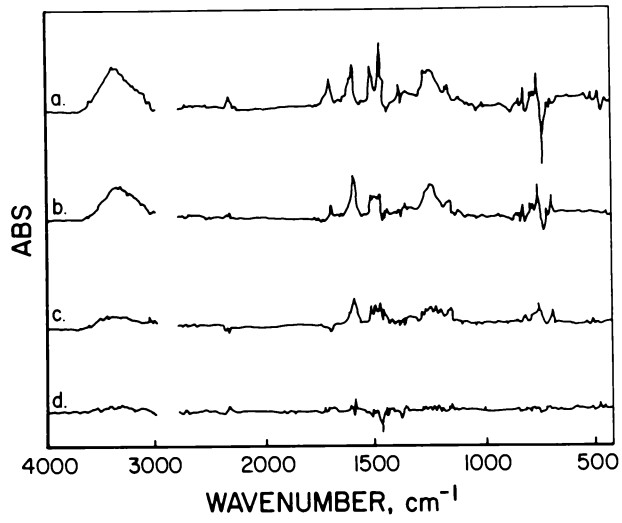

Figure 1. Differential Infrared Spectra of Light Oils from Liquefaction of Lignite
a. 40L5-40L1 b. 40L10-40L5
c. 40L15-40L10 d. 40L19-40L15

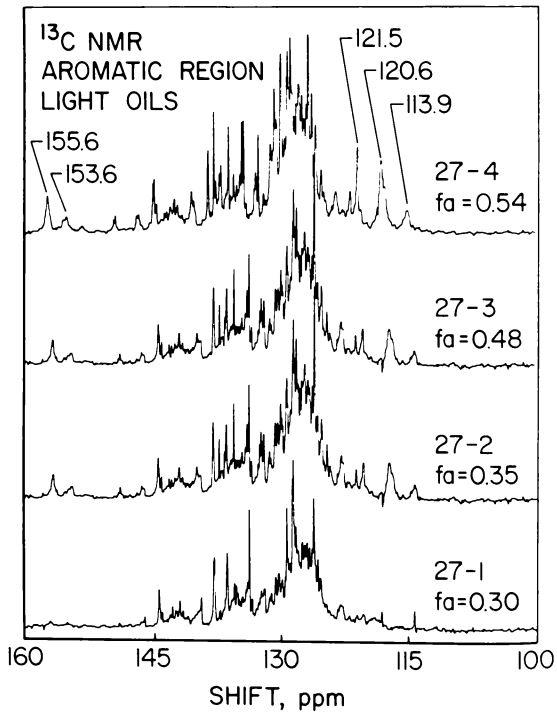

Figure 2. Carbon-13 NMR Spectra of Light Oils

13 ANALYSIS OF LIGHT OILS FROM THE CONVERSION OF LOW-RANK COALS BY CAPILLARY GAS CHROMATOGRAPHY AND MASS SPECTROMETRY

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Researchers at the Grand Forks Energy Technology Center are investigating the liquefaction behavior of low-rank coals. In a 2.3 kg/hr continuous process unit, synthesis gas, raw lignite, and anthracene oil solvent were reacted at elevated temperatures in a continuous-stirred tank reactor.[1] This study considers one portion of the process stream which is designated High Pressure Light Oil (HPLO) and is defined as that fraction with an initial boiling point of 300°C at 27.5 MPa. Detailed analysis of the products from this process is necessary to understand the behavior of low-ranked coals during liquefaction. Mass spectrometry is useful because it provides molecular weight data and aids in compound identification.

Initial capillary gas chromatographic analysis of the gross light oil, LO28-14, indicated that the sample was made up of more than 100 resolvable components. The sample was then subjected to a solvent separation scheme that separated the sample according to compound type.[2] This scheme is shown in Figure 1. Each fraction from this separation was analyzed by capillary gas chromatography. The number of components resolved in each fraction is given in Table 1.

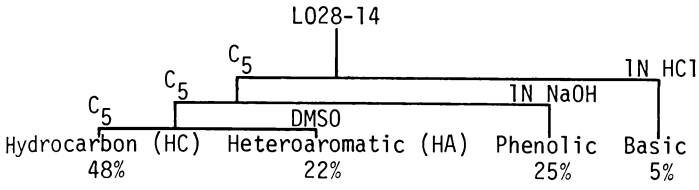

Figure 1. Solvent Separation Scheme

Fraction Area %	No. of Components 1%	0.5-1%	0.5%	Total
HC	26	14	81	121
HA	21	18	79	124
Phenolic	26	23	25	84
Basic	12	7	29	48
				377

Table 1. Summary of Components Resolved.

Mass spectral analysis was performed with a KRATOS MS-30† double focusing mass spectrometer operating in a low-voltage (10eV) mode. This technique was used to obtain quantitative results from the analysis of mixtures.[3] A DuPont 21-491B† mass spectrometer interfaced with a Varian 2740† gas chromatograph was used to confirm compound type assignment. This instrument was modified to increase the pumping at the source and to allow direct capillary column/ion source connection.

Each fraction was analyzed by low-voltage mass spectroscopy and by GC/MS. The phenolic fraction was the only fraction that produced GC/MS spectra which were of sufficient quality to identify more than six or eight compounds. The phenolic fraction consisted mainly of phenol and substituted phenols in the range of C_1 to C_6. This series of compounds accounted for 65% of the total for this fraction. Other groups present were indanols, benzenes and tetrahydroquinolines. The basic fraction contains a relatively large percent of phenolic carryover (42%) consisting of phenols, indanols, and naphthols. The basic constituents of this fraction were pyridines, tetrahydroquinolines, and quinolines with traces of indoles and phenylpyridines. The HA fraction contained benzenes, indanes/tetralins, naphthalenes, fluorenes, phenanthrenes, and pyrenes. Trace amounts of compounds corresponding to oxygen and nitrogen heterocycles were also present. The final fraction, HC, was the only fraction containing only carbon and hydrogen (88% carbon, 12% hydrogen). The aromatic portion of the hydrocarbon fraction was made up of benzenes, indanes/tetralins, indenes, naphthalenes, acenapthenes/biphenyls, fluorenes, and phenanthrenes. Aliphatic hydrocarbons were not quantified by LVMS due to extensive fragmentation at 10eV.

This study is part of a multi-instrument effort at GFETC. More data will be published in the future.

† Reference to specific brand names or models is done to facilitate understanding, and neither constitutes nor implies endorsement by the Department of Energy.

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SEPARATION AND IDENTIFICATION OF GASIFIER WASTEWATER ORGANICS BY ION-PAIR LIQUID CHROMATOGRAPHY

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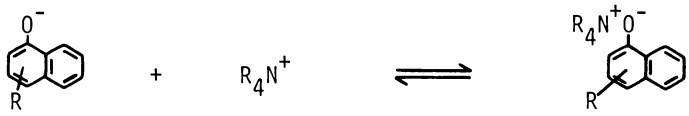
Emphasis on gasifier wastewater clean up and reuse requires the development of analytical methods to monitor contaminant levels in the effluent streams. Ion-pair liquid chromatography is effective in the separation of weak organic acids and bases -- predominant wastewater moieties.

High-pressure liquid chromatography separations were carried out on an octadecylsilane (C_{18}) analytical column using 20% methanol/buffer → 100% methanol gradient systems. Three buffer systems were investigated: 1) 0.01 M potassium monobasic phosphate (pH 3.0), 2) 0.005 M n-heptane sulfonate (pH 3.5), and 3) 0.005 M tetrabutylammonium phosphate (pH 7.5). By the addition of these buffers, separation was enhanced by ion suppression of weak acids, ion pairing of weak bases, and ion pairing of weak acids, respectively. For example, at pH 3-4,

$$R_2NH_2^+ + R'SO_3^- \rightleftharpoons R'SO_3^-H_2N^+R_2$$

solute counter-ion ion pair

at pH 7-8,



solute counter-ion ion pair

The order in which the buffers affected the capacity ratios of concentrated liquor organics is 0.005 M n-hexane sulfonate > 0.01 M potassium monobasic phosphate > 0.05 M tetrabutylammonium phosphate. Peaks attributed to phenol and cresols showed no improvement in resolution in the buffer separations as compared to reverse phase (20% methanol/H_2O > 100% methanol) separations.

The nitrogen-containing compounds in the sample were further concentrated by column chromatography using Florisil adsorbant and methanol eluant. Chromatographic results show that the capacity ratios of the nitrogen fraction components were highly influenced by change in pH and the addition of counter ion.

Compounds identified in the liquor sample were phenol, cresols, ethyl phenols, naphthol, indole, dimethyl quinoline, methyl aniline, dimethyl aniline, toluene, naphthalene, and benzoic acid.

15 Effect of Hydraulic Detention Time on the Activated Sludge Treatment of Coal Conversion Wastewaters

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To alleviate the energy shortage problem in this country, conversion of coal into synthetic natural gas or liquid fuel has been investigated extensively. This will utilize the vast quantity of coal reserves in the U. S. One of the problems associated with the coal conversion plant operation is the pollution potential of wastewaters produced from the coal conversion process. In this study the activated sludge process was investigated for its applicability in treating coal conversion wastewaters and the effect of hydraulic detention time on the treatment performance.

Coal conversion wastewaters contained high concentrations of phenol, ammonia, alkalinity and COD (chemical oxygen demand). Pretreatment of gas liquors was employed to remove excessive amounts of ammonia and phenol, which exert inhibitory effects on the microorganisms in the subsequent biological treatment step (1). During pretreatment tar and oil were separated from gas liquors by gravity settling. Lime was then added to the gas liquors to precipitate heavy metals and to raise the pH to 11 which would convert ammonium ions present in gas liquors into free ammonia. The last step of pretreatment was the use of diffused air to strip off free ammonia.

Pretreated gas liquors were diluted to 10% strength and fed to bench-scale activated sludge reactors. Two types of gas liquors were used. Coal liquefaction wastewaters were used in reactors A, B, and C; coal gasification wastewaters were used in reactors D, E, and F. Coal liquefaction wastewaters contained higher COD concentrations than the coal gasification wastewaters. Both wastewaters had approximately the same levels of phenol and ammonia. Hydraulic detention time in the aeration tanks ranged from 1 to 5 days, while sludge age was maintained at 10 days for all reactors. Table 1 shows the reactor performance data. It was observed that an increase in hydraulic detention time resulted in an increase in COD, phenol, and ammonia removal efficiencies. Contact time between microorganisms and wastewaters seems to play in important role in the biodegradation process. With a hydraulic detention time of 1 day, less than 70% of COD, and less than 50% of phenol were removed in the activated sludge reactors. When hydraulic detention time was increased to 3 days, COD, phenol, and ammonia removal efficiencies were increased to at least 85%, 95% and 83%, respectively. About 8% of the COD in the liquefaction wastewaters and 6% of the COD in the gasification wastewaters were non-biodegradable. Tertiary treatment such as activated carbon adsorption and ozonation may be required for reducing COD to an acceptable level for either reuse in coal conversion plants or release to the environment.

Table 1

Performance Summary Data for Continuous Feed Reactors

Reactor	Hydraulic Detention Time (day)	COD			Phenol			Ammonia-Nitrogen		
		Inf.*	Eff.*	% Removal	Inf.	Eff.	% Removal	Inf.	Eff.	% Removal
A	1	3468	1456	58	538	350	35	66	25	62
B	3	3468	502	86	538	5.5	99	66	1.2	98
C	5	3468	291	92	538	3.3	99	66	0.8	99
D	1	2170	684	68	611	342	44	52	24	54
E	3	2170	242	89	611	28	95	52	9	83
F	5	2170	136	94	611	4	99	52	0.5	99

*All data in mg/l

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OPTIMIZING COAGULATION FOR COAL LIQUEFACTION WASTEWATERS

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The importance of effective treatment for coal liquefaction wastewaters can not be overemphasized as the need for conservation of water resources increases and the discharge regulations become more stringent. A large portion of the impurities present in the coal liquefaction wastewaters are in the colloidal form which can not be removed by gravity settling. Chemical coagulants can be added to form larger, more readily settleable aggregates in which these impurities are enmeshed (1). This type of primary treatment employing a coagulation-sedimentation process is often used to reduce the concentration of impurities to an allowable level before the wastewaters are treated biologically. The most extensively used coagulants for wastewater treatment are the aluminum and iron salts. Aluminum salts are effective coagulants for water containing appreciable organic matter. The iron coagulants are operative over a wide pH range, and are generally more effective in removing color from water, but they are usually more expensive. The coagulants chosen for use in this study were ferric chloride, ferric nitrate, and aluminum sulfate. The objectives of this investigation were to determine the type of coagulant, dosage, and pH required for effective coagulation.

The effects of coagulation can be evaluated by analyzing the removal of COD and TOC, but in this study an increase in the percent transmittance was used as an indication of the effectiveness of the coagulation process. The procedure followed was that of the jar test method, which used a six-place laboratory stirrer manufactured by Phipps and Bird, Inc. The concentration of the coagulant ranged from 0 to 10,000 mg/l, and the pH was varied from 4 to 12. After the addition of coagulant to the wastewater, the solutions were agitated at 100 rpm for 3 minutes. After this time, the paddle speed was reduced to 20 rpm and the solutions were stirred for an additional 30 minutes. The flocculant material was allowed to settle for at least 30 minutes before a sample of the supernatant was withdrawn for analysis of percent transmittance on a Bausch and Lomb Spectronic 20.

The optimum conditions for each coagulant tested are summarized in Table 1. Ferric nitrate proved to be the coagulant which was most effective in increasing the transmittance of the coal liquefaction wastewater. The optimum results were obtained at a dosage of 4000 mg/l, and a pH of 9, where the transmittance was increased from 0 to 35 percent. Ferric chloride provided a similar increase in transmittance, but a larger dosage of 10,000 mg/l and a higher pH of 11.6 were required. Aluminum sulfate was ineffective in increasing the transmittance of the wastewaters. In all cases, it was noticed that the transmittance could be increased from 0 to over 20 percent without the addition of coagulant by lowering the pH from 12 to 4.

Table 1

Optimum Coagulant Conditions in the
Treatment of Project Lignite Wastewater

Coagulant	Concentration (mg/l)	pH	Transmittance (%)
$FeCl_3 \cdot 6H_2O$	8000	11.6	34
$Fe(NO_3)_3 \cdot 9H_2O$	4000	9	35
$Al_2(SO_4)_3 \cdot 18H_2O$	0	4	24

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CHARACTERIZATION OF VOLATILE ORGANIC CONSTITUENTS IN NAHCOLITE

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Nahcolite is a naturally occurring mineral associated with oil shale and composed primarily of sodium bicarbonate (1). The mineral has been proposed as a possible dry adsorbent of sulfur dioxide to be used for flue gas desulfurization in coal-burning power plants (2). Laboratory kinetic studies done on sulfur dioxide removal by nacholite at the Grand Forks Energy Technology Center have indicated that the mineral has promise as a dry adsorbent, as well as a conditioning agent to lower the electrical resistivity of fly ash to improve its collectibility by electrostatic precipitation (3). Consequently, interest has developed in quantification and identification of traces of organic oils in the mineral for their possible adverse environmental effects.

Samples of nahcolite were ground to -100 mesh, treated with hydrochloric acid to remove soluble bicarbonates (12% HCl-insoluble material recovered). X-ray powder diffraction and scanning electron microscope analyses indicated that the mineral composition of the HCl insoluble material was primarily silica. It was then pyrolyzed under nitrogen gas at temperatures of up to 650°C to obtain a thick, dark brown oil. The oil was condensed in a train of receivers cooled at successive temperatures of ambient air, 0°, and -195°C. The yields of each of three separate pyrolysis runs are shown in Table I along with the results of thermal gravimetric analysis (TGA).

Table I

Yields of Oil Recovered from Pyrolysis of Nahcolite

Temperature, °C	Run III	Run IV	Run V	TGA
260	--	0.06	0.12	--
400	1.19	1.05	1.19	--
650	0.09	0.17	0.14	--
Total Percent	1.28	1.28	1.45	1.17

Total carbon found in the filtrate from the acid pretreatment of nahcolite was 23 mg/100 g of nah**colite. Elemental analysis of the oil collected** in the three traps to a temperature of 650°C is shown **in Table II.**

Table II

Elemental Analysis of Oils Collected from Pyrolysis of Nahcolite

Collection Temp., °C	C	H	N	H/C	C/N
ambient air	81.24	11.08	1.71	1.63	55
0	82.58	11.87	1.31	1.71	73
-195	81.59	11.62	1.18	1.70	81

Ninety MHz proton NMR was used to obtain percent aromatic hydrogen values of 6% for the 0 to 400° pyrolysate fraction and 10% for the 400-650° fraction. The infrared spectra indicated the pyrolysates were largely aliphatic hydrocarbons. Very little ultraviolet absorbance was noted. Gel permeation HPLC using UV detection at 254 nm indicated an average molecular weight of 375 for the UV-absorbing materials. Simulated distillation by gas chromatography indicated 30% of a combined sample boiling in the 217 to 343°C range (C_{14} - C_{20} hydrocarbons), 49% boiling from 344 to 467°C (C_{24} - C_{32} hydrocarbons), and 15% boiling above 468°C (C_{36} and higher hydrocarbons).

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18 VEGETATION STUDIES IN THE PRAIRIE-FOREST TRANSITION REGION. I. UPLAND FOREST VEGETATION OF MAPLEWOOD STATE PARK

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The upland forests are a major feature of Maplewood State Park, and during the summers of 1978 and 1979 we began an analysis of such vegetation. After using aerial photographs to grid the park into 16.2 ha stands (40 acres), those with 50 percent or more tree cover were identified, and we randomly selected 30 stands for sampling. Within each stand we sampled trees with a diameter at breast height of 2.5 cm or greater by the point-centered quarter method, using 40 points located along transect lines in a restricted randomization system. The understory was sampled concurrently in two 1-m^2 quadrats placed 1 m from each point. Tree saplings and shrubs were counted, and cover estimates were made for herbaceous species.

A total of 110 vascular plant species were encountered within the stands, including 11 trees, 23 shrubs, 66 forbs, and 10 graminoids. On the basis of importance value (I.V.), an index consisting of the summation of relative values of frequency, density, and basal area, the leading tree species were Acer saccharum, Ostrya virginiana, and Tilia americana (Table 1). Leading tree saplings were Acer saccharum and Ostrya virginiana, and primary shrubs were Dirca palustris, Prunus virginiana, Rhus radicans, Symphoricarpos occidentalis, and Zanthoxylum americanus, based on relative frequency and density. Considering relative frequency and cover, leading forbs included Aralia nudicaulis, Desmodium glutinosum, Smilacina racemosa, Solidago flexicaulis, Thalictrum dioicum, and Uvularia grandiflora. Carex pensylvanica, Oryzopsis asperifolia, and Oryzopsis racemosa dominated the graminoid cover.

In 20 of the 30 stands, Acer saccharum had the highest I.V., with Ostrya virginiana second in 13 of them and Tilia americana second in the others. Ostrya virginiana, followed by A. saccharum, dominated five stands. In four other stands T. americana was the leading species, followed by either A. saccharum or O. virginiana. Populus grandidentata had the highest I.V. in one stand. Ranking second even in that stand was A. saccharum.

Table 1. Average importance values for tree species over all 30 stands.

Species	I.V.
Acer Negundo	1.7
Acer saccharum	106.8
Betula papyrifera	4.7
Fraxinus pennsylvanica	2.6
Ostrya virginiana	56.1
Populus grandidentata	16.9
Populus tremuloides	13.1
Quercus borealis	14.8
Quercus macrocarpa	10.4
Tilia americana	53.4
Ulmus americana	18.5
Total	300.1

The deciduous forest of Maplewood State Park may be included in what has been called the "Big Woods" of Minnesota, a region which Braun (1) designated as part of the Maple-Basswood association. A similar forest type has been described in southern Wisconsin (2), many of the species reported there also occurring in Maplewood. In a section of the "Big Woods" investigated in central Minnesota, it was concluded that suitable climate, soils, and protection from fire and disturbance were the features important in the establishment and perpetuation of maple-basswood forest (3). The study conducted in the park provides baseline information that may be useful in further vegetation analysis in the area as well as in establishment of interpretive programs.

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VEGETATION STUDIES IN THE PRAIRIE-FOREST TRANSITION REGION. II. SMALL HILL PRAIRIES AT MAPLEWOOD STATE PARK

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Several small prairies, each only a small fraction of a hectare, occur within the forest matrix of Maplewood State Park. Three such areas are found close together on sandy soils on a steep, south-facing slope. These are unique, but little-known, bits of vegetation within a park which was established to preserve natural features of the region, and I began a survey as part of a broader effort to characterize the park vegetation. After occasionally visiting these sites over a 3-year period to compile a species list and make phenological observations, I sampled each during August 1979. Sampling consisted of recording species presence in a continuous series of 0.1-m^2 quadrats extending through the middle of each site from bottom to top.

At least 59 vascular plant species occur among the three hill prairies, including 10 grasses and 1 sedge, 36 forbs, 1 clubmoss, 7 shrubs, and 4 trees. Of these, 27 species appear in all three sites, 14 are found in two of the three, and 18 occur in only a single site. The number of species per prairie is 44, 41, and 42.

During quadrat sampling the number of species encountered per site was 30, 23, and 26. As indicated in Table 1, about two-thirds of the quadrat occurrences were attributable to grasses and sedges. Carex pensylvanica, common in the adjacent forests, is widespread, although, because of its low stature and diffuse canopy, it is perhaps less significant than Andropogon gerardi, Bouteloua curtipendula, A. scoparius, and Stipa spartea, which contribute most to the aspect of these areas.

Table 1. Relative frequency values for grasses and sedges expressed as percentages of total plant occurrences on each hill prairie.

Species	East Prairie	Central Prairie	West Prairie
Agropyron smithii	0.2	3.9	0
Andropogon gerardi	14.0	17.4	22.1
Andropogon scoparius	9.1	6.6	4.3
Bouteloua curtipendula	13.5	8.5	13.9
Calamovilfa longifolia	0	0	4.3
Carex pensylvanica	17.4	25.9	16.5
Elymus canadensis	0	0	0.3
Panicum leibergii	0.2	0	0
Panicum oligosanthes	0.7	0	0
Stipa spartea	10.8	1.9	5.3
Total	65.9	64.2	66.7

Despite their greater diversity, forbs contributed little more than a fourth of total plant occurrences. Allium stellatum was the most common forb in all three sites. Some of the other forbs observed most frequently were Apocynum androsaemifolium, Artemisia campestris, Erigeron strigosus, Petalostemum candidum, and P. purpureum. Additional ground cover came with Selaginella rupestris, a clubmoss having relative frequency values of 6.4, 0.4, 1.0 percent. Scattered unidentified lichens also occurred on small areas of exposed soil.

Shrubs included Amelanchier alnifolia, Amorpha canescens, Prunus virginiana, Rhus radicans, and Symphoricarpos occidentalis, but none were frequent constituents. Small, scattered trees occurred within one of the three prairies. These invaders, Populus grandidentata, P. tremuloides, Quercus macrocarpa, and Tilia americana, are not thriving under the relatively harsh conditions.

Immediately before modern settlement large areas of prairie existed no more than 10 miles to the west. During dry periods, such as the earlier Hypsithermal Interval, prairie undoubtedly expanded eastward, and these perhaps represent relict areas, which have persisted because of local microclimatic and edaphic conditions. Furthermore, re-establishment of a species after local extinction was possible with migration from other prairie areas. Now those areas have been eliminated by agricultural development. The intriguing question is how long will such small plant populations persist when outside seed sources are absent? Many natural areas now remain only as small, isolated fragments, and the issue of local extinction is poorly understood. For the ecologist willing to undertake a long-term study, areas like the hill prairies offer an ideal opportunity to study the dynamics of small, isolated plant populations.

VEGETATION STUDIES IN THE PRAIRIE-FOREST TRANSITION REGION. III. FOREST VEGETATION OF BUFFALO RIVER STATE PARK AND BLUESTEM PRAIRIE

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Approaching the Lake Agassiz basin from the east, forests rapidly diminish until they become localized along river valleys. Such riparian forests along the Red River and three of its North Dakota tributaries have been studied (1, 2, 3, 4, 5). Less attention has been given to the Minnesota counterparts which serve as the direct bridge between continuous deciduous forest areas and the western riparian forests.

During the summer of 1978 we sampled the riparian forest and five upland groves at Buffalo River State Park and Bluestem Prairie. This included 82, 100-m^2 quadrats within the river valley and 10 similar quadrats in the groves. After measuring all trees with a diameter at breast height of 2.5 cm or greater in the major quadrat, 5, 1-m^2 quadrats were placed systematically within the larger quadrat. Here we counted shrubs, vines, and saplings, as well as making cover estimates for the herbaceous species.

The riparian overstory included 9 species with an overall density of 1425.8 trees/ha (Table 1) and a total basal area of 36.0 m^2/ha. Based on importance values (I.V. = sum of relative frequency, density, and basal area), *Tilia americana* far outweighed all other species. Four secondary species had nearly equal I.V.'s: *Acer Negundo, Fraxinus pennsylvanica, Quercus macrocarpa*, and *Ulmus americana*. Of lesser importance were *F. nigra, Populus deltoides, P. tremuloides* and *Salix amygdaloides*. Only three of these tree species occurred in the nearby groves, where overall density was higher, 1780 trees/ha, but total basal area was lower, 19.2 m^2/ha. Four of the five groves were dominated almost exclusively by *P. tremuloides*, while in the fifth site, a lower and wetter area, *F. pennsylvanica* was the major contributor.

Tree reproduction and mortality were also considered by censusing saplings and dead trees. Within the river valley *F. pennsylvanica* had the highest sapling density, 3800/ha, followed by *T. americana* and *A. negundo. P. tremuloides* had the highest sapling density in the upland groves, 7200/ha. Dead trees averaged 192/ha in the riparian areas, and to that could be added another 183/ha cut by beaver. Among the groves there was an average of 840 dead trees/ha. Causes of mortality, in addition to beaver-cutting, include windthrow, bank-slumping, competition, pathogens, and normal senescence. Regardless of cause, mortality was concentrated in the smallest diameter class of 2.5-7.5 cm.

Table 1. Forest overstory composition at Buffalo River State Park–Bluestem Prairie.

	Riparian Forest		Upland Groves	
Species	Density (trees/ha)	Mean Basal Area (cm^2/tree)	Density (trees/ha)	Mean Basal Area (cm^2/tree)
Acer Negundo	156.1	139.4	30	53.4
Fraxinus nigra	24.4	187.4	–	–
Fraxinus pennsylvanica	147.6	181.7	610	73.5
Populus deltoides	20.7	1109.4	–	–
Populus tremuloides	22.0	64.1	1140	127.8
Quercus macrocarpa	85.4	672.5	–	–
Salix amygdaloides	9.8	615.3	–	–
Tilia americana	497.6	337.3	–	–
Ulmus americana	62.2	882.2	–	–
Total	1425.8		1780	

Shrub and vine density totaled 8.13/m^2 in the riparian forest and 8.20/m^2 in the upland groves. In the former area there were a total of 24 such species, with *Parthenocissus vitacea, Rhus radicans,* and *Symphoricarpos occidentalis* most common. In the latter area *P. vitacea, S. occidentalis* and *Vitis riparia* dominated the 19 species.

Herbaceous cover in riverine areas was almost equally divided between graminoids (13.80%) and forbs (16.67%). Among the former group of 26 species, *Poa pratensis, Carex pensylvanica*, and *Carex Sprengelii* were major contributors. The 100 forb species were dominated by *Aralia nudicaulis, Smilacina stellata, Sanguinaria canadensis, Rudbeckia laciniata,* and *Thalictrum dasycarpum*. Graminoid cover in the groves averaged 10.85%. Although 9 species were present, *Bromus inermis* provided most of the cover. Thirty-seven forbs added 13.70% cover, and prominent members of this group were *Zizia aurea, Thalictrum dasycarpum, Galium aparine, G. boreale*, and *Lycopus americanus*.

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VEGETATION STUDIES IN THE PRAIRIE-FOREST TRANSITION REGION. IV. EFFECT OF BURNING ON NET PRODUCTION OF A WESTERN MINNESOTA TALL GRASS PRAIRIE

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An intensive two-year study, 1978-1979, was conducted to investigate selected structural and functional attributes of six herbaceous plant communities of Bluestem Prairie. The major objective of this research was to determine the trends of net primary productivity among these plant communities. In October 1978, after the first growing season of study, a wildfire swept across most of the prairie and consumed all of the vegetation on five of the six study areas. This event presented the opportunity for a comparison of pre-burn and post-burn productivity. A description of the area and sampling methodology has been presented in a previous communication (2).

The effects of fire on grasslands have been thoroughly discussed (1, 4). The characteristic response of tall grass prairie vegetation to a fall burn is a marked increase in net production in the following growing season. It has been shown that the increased production results primarily from greater soil temperatures early in the growing season due to litter removal and the darkened soil surface (3). The effect is to promote rapid spring growth.

The predicted increase in net production of the plant communities following the fall burn was not realized (Table 1). Indeed, a marked decrease in both aboveground and belowground production was noted at nearly all the study areas. Of the three upland prairie communities, Bouteloua-Stipa, Andropogon-Sorghastrum, and Andropogon-Sporobolus, only the latter exhibited a net aboveground production (462 g/m^2) comparable to the pre-burn value (461 g/m^2). The lowland or swale community Carex-Calamagrostis, however, experienced a 100 g/m^2 post-burn increase in productivity. The only site to escape burning, the Melilotus-Agropyron community, exhibited a marked decline in production due to the almost complete lack of Melilotus that had dominated this area in the first year. Melilotus is a biennial species which attains maximum growth in its second year following germination. The post-burn values of peak belowground root mass (combined living and dead roots and rhizomes to a depth of 61 cm) were significantly lower than the pre-burn values.

The growing season of 1979 began with a very protracted cool, wet spring which delayed the renewal of shoot growth at the prairie. The cool weather precluded early-season warming of the burned prairie and hence negated any early temperature advantage to which the vegetation might otherwise have responded. In addition, the photosynthetic base of many of the dominant clump-forming grasses had been reduced when the fall burn had extensively damaged the crowns of these species. This was manifested in the greatly reduced basal cover of most of the plant communities (Table 1). We conclude that the unusually cool spring combined with the reduced basal cover of the communities account for most of the observed decrease in net production in the post-burn growing season.

Table 1. Basal cover and peak standing crop values for the 1978 and 1979 growing seasons.

	Basal Cover (%)		Aboveground Biomass (g/m^2)		Belowground Root Mass (g/m^2)	
Community Type	1978	1979	1978	1979	1978	1979
Bouteloua-Stipa	23.3	10.6	462.1	305.0	4222.5	2309.4
Andropogon-Sporobolus	44.6	25.5	460.8	462.0	3383.1	2175.4
Andropogon-Sorghastrum	28.4	17.7	334.8	249.6	4233.8	2560.6
Calamagrostis-Andropogon	39.8	20.0	581.9	405.4	3905.1	2104.9
Carex-Calamagrostis	25.7	22.6	637.3	737.0	8703.2	8177.0
Melilotus-Agropyron	11.4	9.5	1136.3	473.1	3621.5	2896.4

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VIABLE SEED POPULATIONS IN SOILS OF REVEGETATED NORTH DAKOTA COAL STRIP MINES

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Seeds of many plant species tend to accumulate over time in the top layers of soil and remain dormant until the onset of conditions favorable for their germination. The diversity of these buried, viable seeds (also known as the "seed bank") reflects the past, present, and potential future vegetation of a site and provides useful insight into the floristic makeup of the seral stages as succession advances. Reproductive strategies and dispersal mechanisms of parent plants and dormancy patterns of seeds affect the quantities of seeds in the soil. Soil properties, predation by animals, decomposition by bacteria and fungi, disturbance, and weather fluctuations also influence the nature of the seedbank. Since the characteristics of the seed bank have an important influence on the patterns of revegetation, this study was designed to determine seedbank composition on some North Dakota mined sites and to examine factors affecting seed populations.

Soil samples were taken in July 1979 at seven sites near Beulah, ND. Six of the sites had been mined, contoured, and seeded; the years of seeding ranged from 1973 to 1977. The seventh site was a stockpile of topsoil which was removed from a South Beulah site in 1978 and seeded with rye (*Elymus*) for a cover crop. At the time of sampling it was covered with pioneer species such as *Salsola, Chenopodium, Helianthus,* and *Setaria*. All of the contoured spoils had been seeded with a mixture of *Agropyron, Stipa, Melilotus*, and *Vicia*; the dominant species at these sites were *Melilotus* (all sites), *Agropyron* (Beulah 1973 N only), and *Chrysothamnus* (Zap 1975 S only). Fifteen soil cores, 5 x 7.5 cm, placed at random, were taken at each site. Soils were analyzed for pH, electrical conductivity, and water saturation percentages. Seeds were extracted from the soils using a technique of soil aggregate dispersion and organic matter flotation with a solution of $MgSO_4$, $NaHCO_3$, and $(NaPO_3)_6$ (1). Viability of seeds from seived organic matter was determined using a dilute solution of 2, 3, 5-triphenyl tetrazolium chloride, a compound which is reduced by metabolic activity to the bright red, nondiffusable formazan. Staining of certain portions of the embryo is a reliable indication of seed viability (2, 3). Results of the seed counts are shown in Table 1.

Table 1. Numbers, diversity and dominant taxa in the seed banks of study sites.

Seeding date	Site	Mean number of viable seeds per m^2 to 7.5 cm depth	Seed "diversity"	Taxa comprising over 10% of seedbank
1973	Beulah, W-facing	2461	1.92	*Melilotus* sp., *Agropyron* spp. *Iva xanthifolia, Brassica* sp.
1973	Beulah, N-facing	2196	2.27	*Festuca octoflora, Chenopodium* spp., *Lactuca* sp.
1974	Beulah, S-facing	1585	1.47	*Agropyron* spp., *Melilotus* sp., *Stipa viridula*
1975	Beulah, S-facing	2517	1.45	*Agropyron* spp., *Rumex crispus*
1975	Zap, S-facing	3976	1.28	*Melilotus* sp., *Kochia scoparia*
1977	Beulah,	2631	1.59	*Kochia scoparia, Melilotus* sp.
1978	stockpile	186	1.23	*Melilotus* sp.

Higher diversity in the seed populations at the two oldest sites reflects the existing vegetation at those sites; the Beulah 1973 slope showed the most diverse floristic composition of all the sites. The variability of seed counts in soils generally is very high [Champness (4) found that variance is usually three times the mean number of seeds of a given species]. Still, the mean number of seeds per unit area at the Zap site, where pioneering species are far more prevalent than at other sites, is significantly higher than that of the Beulah 1973 N-facing ($P < 0.05$), Beulah 1974 S-facing ($P < 0.005$), and Beulah 1975 S-facing ($P < 0.05$) sites. The stockpile samples contained very low numbers of viable seeds, and thus respread topsoil is unlikely to have contributed many seeds at the six mined sites. At the sites studied, origin of seeds is probably by short-distance dispersal (only a few of the seeds found were of the wind-dispersed type); seeds with a hard coat like those of the early-stage pioneers *Chenopodium, Polygonum*, and *Rumex* must persist for several years. Seeds of *Melilotus* also seem to accumulate in the soil, probably requiring some disturbance (e.g. abrasion) for imbibition and initiation of germination. High populations of viable *Kochia scoparia* seeds were found only in the two youngest sites since *Kochia* is a first-year pioneer with a relatively soft-seed coat. With the exception of the Beulah 1973 W-facing sites (where vegetation is dominated by clover and alfalfa), the four older sites showed higher proportions of grass seeds (Beulah 1973 N-facing, 51%; Beulah 1974 S-facing, 53%; Beulah 1975 S-facing, 66%) than did the youngest site, Beulah 1977 W-facing (2%) or the Zap site (14%). Thus, in addition to the viable seeds of some pioneering species at the older sites, a reserve of seeds of grasses (as well as the perenial *Melilotus*) is also found.

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23 PRECIPITATION, EVAPOTRANSPIRATION, AND RUNOFF IN A NORTHERN PRAIRIE WATERSHED

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Studies of various phenomena in the upper Turtle River and its watershed, Grand Forks and Nelson Counties, North Dakota, have been pursued since 1967. Major effort has been devoted to surface water and organisms in the river, but sampling of groundwater, precipitation, and evapotranspiration has been conducted to the extent allowed by time and personnel limitations. Precipitation coverage permitting acceptable annual load computations has been possible only for the period 10/1/77 to 9/30/78, although numerous records were collected during preceding years. Daily weather records for the immediate vicinity were provided by the Grand Forks Air Base; stream discharge measurements followed usual U.S. Geological Survey practices. Precipitation was collected in enamel pans placed above splash and beyond tree drip and evapotranspiration as condensate in plastic bags placed over forbs and bushes and on plastic sheets over grasses. Stream and groundwater sample collection and all chemical analyses were according to standard procedures.

The studied watershed (539 km^2) lies almost entirely above the Lake Agassiz Plain, has a deep, permeable glacial drift soil, and is 90+% utilized as fertilized croplands, chiefly small grains. Over 1967-79, annual precipitation has ranged from 31-65 cm (12.34 - 25.66"); air temperatures have varied from -37 to 37C (-35 to 99F). Snow and ice cover were usually from November to March or April, with an occasional mid-winter thaw. Stream discharge maxima have been activated by snow melt when they have amounted to 33% of available precipitation and minima (1.82% of precipitation) occurred during the growing season. On an annual basis mean runoff has amounted to 9.84% of mean precipitation. In 1977-78 precipitation of 219,094 acre feet was divided as follows: runoff, 25,460 af; evapotranspiration, 19,989 af; snow vaporization, 17,916 af; evaporation from open water, 110 af; use by plants, 200 af; remaining in ground, 155,510 af. Chemical quality records for the three water categories (Table 1) suggest no particularly reliable relationships between pH and acidity and show precipitation and evapotranspiration to be carriers of nitrogen and phosphorus despite their low mineralization. Nutrient loads per mi^2 during the 1978 growing season (Table 2) indicate that evapotranspiration is a significant contributor of P and N to the atmosphere, and the absence of P in snow suggests evapotranspiration may be a major P source. Runoff loads indicate greater use of N than P in the growing season. Evapotranspiration has not been previously examined as a source of atmospheric compounds, but precipitation chemical records go back to the 1930's. Recent concerns have been with acid rain in industrialized regions and forest ecosystems, but since most accounts refer only to pH, few acidity comparisons are possible.

Table 1. Summary of Chemical Records

	Precipitation			Evapotranspiration			Runoff		
	Mean	Range	N_s	Mean	Range	N_s	Mean	Range	N_m
pH	5.97	3.1-7.2	78	4.82	4.2-5.3	24	8.09	7.42-8.50	68
Acidity-mg/l	4.0	2-10	40*	2.5	1-7	13	6.73	1-12	25**
Alkalinity-mg/l	0.89	0-20	77	2.5	1-6	8	266	115-403	68
Calcium-mg/l	4.4	0-17	47	6.0	4-8	3	258	115-363	68
Magnesium-mg/l	0.23	0-4	47	0	0	3	115	50-163	68
SRP-mg/l	0.036	0-0.43	83	0.13	0-0.21	31	0.29	0-0.79	68
Total P-mg/l	0.052	0-0.51	83	0.15	0.12-0.16	8	0.82	0.21-2.37	23
Ammonia-mg/l	0.61	0.1-2.40	81	0.77	0.55-1.25	28	0.10	0-0.37	68
Nitrite-mg/l	0.005	0-0.03	80	0.009	0.001-0.05	12	0.005	0-0.037	68
Nitrate-mg/l	0.124	0.013-0.50	80	0.055	0.008-0.21	22	0.073	0.002-0.38	68
Sulfate-mg/l	1.33	0-7	27	-	-	-	141	79-217	47
Chloride-mg/l	5.0	2-20	21	-	-	-	36	18-68	17
Conductivity-µmhos/cm	22	4-89	75	43	26-60	2	633	456-817	68
Periods Covered	1972-73, 1976, 1977-78			1975-76, 1978			1970-74, 1977-78		

N_s=number of samples N_m=number of monthly means *1977-78 **winter and early spring

Table 2.
Nutrient Loads
(lbs. per square mile)
May 15 - October 1, 1978

	Rainfall	Evapotrans.	Runoff
SRP	46	33	3.175
Total P	61	45	11.000
Ammonia	805	208	2.440
Nitrite	6	5	<0.050
Nitrate	110	18	0.110
Total N	921	231	3.620

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CHANGES IN AMMONIA-NITROGEN AND RELATED PHOTOSYNTHETIC BLOOMS IN BREWER LAKE, ERIE, N.D., BASED ON SIX YEARS OF MEASUREMENTS

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Brewer Lake (Reservoir), Erie, N.D., an impoundment of a branch of the Rush River (SE 1/2 Sec, T14N R53W; area, 51.8 ha; vol., 2.05 x 10^6 m^3; depths, max. = 8 m, mean = 4 m), was made available for general use in the spring of 1974. On 30 April 1974, a study of the lake was begun to determine the number of photosynthetic blooms, their magnitude, time of occurrence, and relationship to the seasonal cycling of nutrients. Six years of data show that there are two photosynthetic blooms each year. Bloom I begins as the ice breaks up, peaks at mid-May, and approaches zero in the first week of June. Bloom II begins in the first week of June, peaks about 1 August, and approaches zero about 1 October.

Between 9 and 16 July 1974, water temperature @ 1 m was 23.5°C and ammonia concentrations ranged from 55 @ 0 m to 91 µg at l^{-1} @ 8 m. The total amount of ammonia in the lake was 1497 kg. Winds mixed the lake and a strong fish kill occurred. About 10 days were required for recovery. Early in March 1975, a bottom drawdown was installed permitting bottom water discharge. Through 1975, bottom water was discharged as appropriate. On 15 July 1975, the 1 m temperature was 22.5°C and ammonia concentrations ranged from 15.2 @ 0 m, then increased from 16.1 @ 6 m to 63.1 @ 7 m and to 194.8 µg at l^{-1} @ 8 m. The total amount of ammonia in the lake was 946 kg. These were stress conditions for the fish fauna but a major fish kill was averted. Drawdowns occurred over the periods, 1 to 15 July and 23 July to 12 August 1975.

During 1976 the maximum temperature @ 1 m was 21°C on 13 July. Ammonia concentrations ranged from 8.2 @ 0 m to 43.1 @ 6 m to 83.1 @ 7 m and 127.1 µg at l^{-1} @ 8 m. The total amount of ammonia in the lake was 719 kg on that date. Also in 1976, turnover occurred about 1 August so that the resulting temperature was 20.8°C and ammonia was uniformly distributed at about 36 µg at l^{-1}. On that date the total amount of ammonia for the lake was 930 kg. No stress conditions were noted.

With appropriate drawdown during 1977 and on the date of maximum temperature at 1 m, 21.0°C, the ammonia concentration ranged from 12 @ 0 m to 20.9 @ 7 m and 43.3 µg at l^{-1} @ 8 m. The total amount of ammonia in the whole lake was 368 kg. The maximum surface temperature of 24.9°C was reached on 19 July. No stress was noted. During 1978, appropriate drawdowns continued and the 1 m water temperature was 20.6°C on 22 August and a dramatic decrease in ammonia was noted, ranging from 0.7 @ 0 m to 4.1 @ 7 m and 12.3 µg at l^{-1} @ 8 m. The total amount of ammonia in the whole lake was only 37 kg. The maximum surface temperature was 24°C on 18 July 1978. No stress was noted at any time. During 1979 the 1 m temperature was 20.2°C on 14 August when the ammonia concentrations ranged from 11.8 @ 0 m to 14.6 @ 6 and 7 m and 31.5 µg at l^{-1} at 8 m. The total amount of ammonia in the lake was 325 kg on that date. The maximum surface temperature was 23.0°C on 10 July 1979. No stress occurred. By the end of 1978 the total amount of ammonia in the lake was reduced to 1.6% of that measured on the fish kill date in 1974. The rise in total amount of ammonia in 1979 is not explained by comparing the precipitation for the two years for the summer period: 14.96 for 1978 and 12.57 inches for 1979.

The period of peak ammonia production occurs regularly at mid-to-late July every year as a result of maximum photosynthesis in bloom II when water temperatures are also maximal. Over the six years, photosynthesis was correlated at the 1% level with pH, temperature, chlorophyll-*a* and CO_2, and at the 5% level with NO_3-N.

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CURRENT STUDIES OF PRECAMBRIAN BASEMENT ROCKS OF THE RED RIVER VALLEY OF NORTH DAKOTA AND MINNESOTA

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Buried basement rocks of the Red River Valley record major Precambrian geologic events and a later extensive weathering period which produced a thick kaolinitic residuum in southeastern North Dakota and west central Minnesota. Our current studies are directed toward petrographic and chemical characterization of samples obtained in 26 cores from the Red River Valley Drilling Project (RRVDP) financed by the Bendix Field Engineering Corporation (1,2), preparation of an updated geologic map, and detailed studies of the kaolinitic weathering zone (3).

The Precambrian basement is below about 300 m of overlying sedimentary rocks and glacial deposits in the Red River Valley. The surface dips 5-10 m/km to the west-northwest. Seventeen of the RRVDP cores contain intermediate to felsic plutonic igneous rocks and compositionally similar gneisses, and nine contain metavolcanic and metasedimentary rocks. Seven trondjhemites and compositionally similar gneisses are characterized by 65-72% SiO_2 and low K_2O/Na_2O of 0.3-0.6. Three quartz monzonites contain 67-73% SiO_2, but have significantly higher K_2O/Na_2O of 0.9-1.4. Two metavolcanic? or sheared and silicified plutonic rocks contain about 75% SiO_2 and have low K_2O/Na_2O ratios. Other cores include altered diorite?, a high-Mg metabasalt, and five chlorite schists. Compositionally, the RRVDP rocks resemble the Archean assemblages expected from the regional Precambrian rock distributions (4,5) except for the near lack of mafic volcanic rocks.

A thick (up to 75 m) weathering residuum is developed on the upper surface of the Precambrian in the southern part of the Red River Valley, wherever it is immediately overlain by Cretaceous strata. The end product of weathering is generally a white to greenish clay containing suspended angular quartz grains, regardless of original rock type. Scanning electron microscope studies show that feldspars and micas have been progressively altered to kaolin minerals (Figure 1). Chemical trends are also generally similar regardless of original rock type. Calcium is lost in the early stages of weathering, followed by sodium, potassium and silicon. However, iron values vary as a function of original rock type, being high where aluminum and silicon are low and conversely (Figure 2).

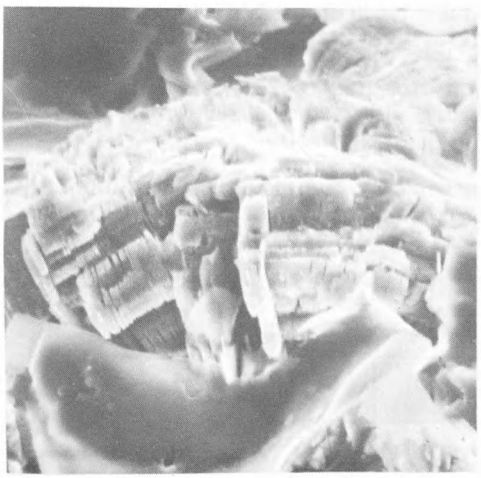

Figure 1. Kaolinite grain in RRVDP 1-3, Sargent County, N.D. SEM photo 1600X.

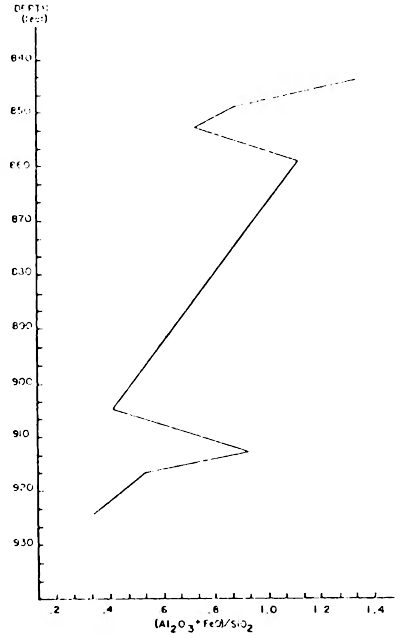

Figure 2. $(Al_2O_3 + FeO)/SiO_2$ vs. depth, RRVDP, Sargent County N.D. Original rock is a migmatite.

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ORGANIC SPECTROSCOPY OF LIGHT OILS FROM LIGNITE LIQUEFACTION I: FRACTIONATION AND OPTICAL METHODS

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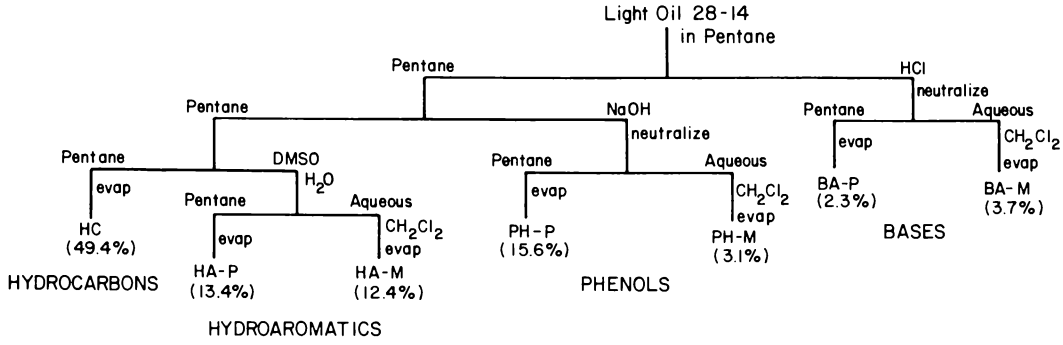
Liquefaction of Beulah lignite in the high pressure, high temperature continuous process unit at the Grand Forks Energy Technology Center yields the following process streams: C_1 to C_4 hydrocarbon gases, high pressure light oils, low pressure light oils, water effluents, vacuum distillates, THF-soluble vacuum bottoms, and THF-insoluble fractions (1). This paper summarizes a study of a typical high pressure light oil, LO 28-14, taken from the 30th recycle pass after equilibrium conditions were attained.

LO 28-14 was separated into its phenolic, basic, hydroaromatic, and hydrocarbon components, using the extraction scheme shown in Figure 1. This is a modified version of the extraction suggested by J.S. Fruchter (2). The resulting seven fractions were analyzed using U.V. and I.R. spectroscopy.

Figure 1



In the I.R. study, each fraction was scanned as a thin film on NaCl or KBr discs, in the region from 4000 to 650 or 400 cm^{-1}. The basic and phenolic fractions were also scanned as dilute CCl_4 solutions in a silica cell, in the region from 4000 to 2500 cm^{-1}. In the U.V. study, each fraction was scanned as a dilute CH_2Cl_2 solution in the wavelength region from 350 to 230 nm. Each solution was scanned again to obtain a computed fourth derivative spectrum. The average wavelength increment was set at 7 nm.

As an example of the U.V. fourth derivative, the spectrum of the hydroaromatic fraction (HA-P) is given in Figure 2. The usefulness of the fourth derivative is demonstrated by its resolution of peaks not clearly visible in the absorbance spectrum.

This data, in conjunction with other analytical data, can be utilized to determine the value and possible uses of coal liquid products.

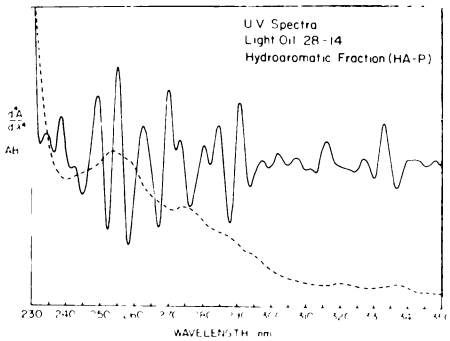


Figure 2

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ORGANIC SPECTROSCOPY OF LIGHT OILS FROM LIGNITE LIQUEFACTION II: CARBON-13 AND PROTON NUCLEAR MAGNETIC RESONANCE

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Liquefaction of Beulah lignite in the high pressure, high temperature continuous process unit at Grand Forks Energy Technology Center yields the following process streams: C_1 to C_4 hydrocarbon gases, high pressure light oils, low pressure light oils, water effluents, vacuum distillates, THF soluble vacuum bottoms and THF insoluble fractions (1). The high pressure light oil discussed here (BP 300°C @ 27.5 MPa), designated 28-14, was collected after 30 recycle passes through a continuous stirred tank reactor operated at 460°C and 27.5 MPa.

The light oil was separated into fractions by an extraction method (2). Each fraction was examined using a number of analytical techniques. Elemental analyses were carried out by combustion (C, H, N, S), Karl Fischer titration (H_2O), coulometry and neutron activation (O).

Examination of the whole oil and of each fraction by 200 MHz ^1H NMR and 50 MHz ^{13}C NMR and by gas chromatography positively identified many of the components. In Figure 1 an example is given which shows both the ^{13}C and ^1H NMR spectra of one of the fractions analyzed. Some of the major components identified were: naphthalene, 2-methylnaphthalene, tetralin, fluorene, phenanthrene, alkyl-benzenes, phenol, o-cresol, m-cresol, p-cresol and indanol. Pyrene and 1-methylnaphthalene were minor components.

A summary of the NMR results obtained by quantitative examination of the fractions is given in Table 1.

Figure 1

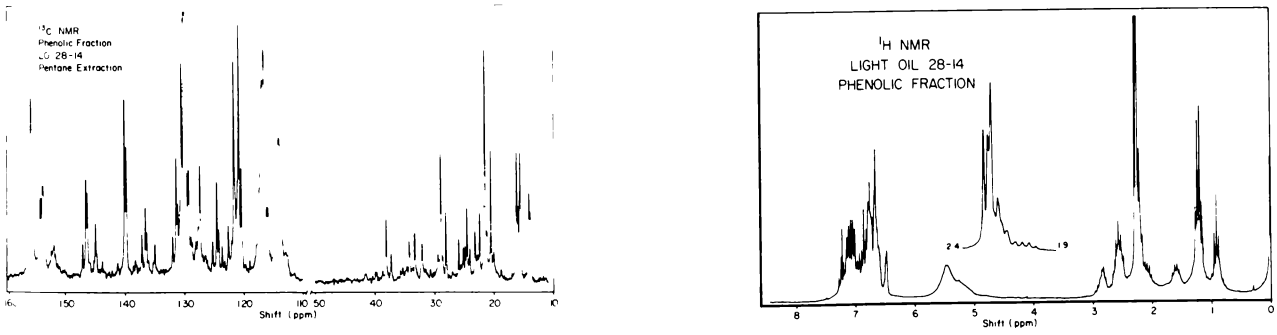

Table 1

Integrated ^1H and ^{13}C Areas for 28-LO-14 and Fractions

	^1H NMR				^{13}C NMR
	% H_{ar} (8.8-5.7 ppm)	% H_α (4-1.9 ppm)	% H_o (1.9-0.3 ppm)	% H_{phe} (varies)	f_a
28-14 Whole Oil	23.1	23.0	53.3	(part of H_{ar})	0.45
Basic Fraction	34.1	34.1	31.8	--	0.56
Phenolic Fraction 1	31.3	32.3	25.9	10.5	0.66
Phenolic Fraction 2	63.5	22.7	--	13.8	0.95
Hydroaromatic Fraction	48.1	29.0	22.5	--	0.81
Hydrocarbon Fraction	15.3	19.0	65.7	--	0.33

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34 ZINC-DEFICIENCY, APPETITE CONTROL AND PLASMA AMINO ACIDS

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Young growing rats fed a high protein zinc-deficient diet display anorexia and dramatic fluctuations in food intake within 3-4 days. Recent evidence suggests a relationship between the large neutral amino acids in plasma and food intake (1). Disturbances in amino acid metabolism occur in zinc deficiency (2,3). We therefore measured plasma amino acids in rats fed a high protein (20% sprayed egg white) zinc deficient diet (4) in particular regard to food intake. In each experiment, four groups of young weanling rats were used; zinc-deficient (ZD), pair-fed (PF), ad libitum (AL) and overnight-fasted (OF). The ZD group was fed the diet ad libitum and deionized glass distilled water, and the PF group was given 25 ppm zinc acetate in the drinking water. The AL group was given the same diet ad libitum and 25 ppm zinc acetate in the water and the OF rats were treated as the AL group but were fasted overnight. The rats were housed in plastic cages in laminar flow hoods in a humidity and temperature controlled room. Flame atomic absorption spectroscopy was used to measure zinc. Plasma amino acids were measured using a Beckman (5) 119 CL amino acid analyzer, except for tryptophan (6,7). Other biochemical paramters measured were plasma glucose (8) and free fatty acids (9).

Plasma tryptophan concentrations were correlated with food intake at 15 days of zinc deficiency in young growing rats. Similar trends were found with the plasma tryptophan concentrations at 8 and 20 days of zinc deficiency. However, these correlations were absent at 30 days and in an experiment with one-year-old rats fed a zinc-deficient diet for 84 days. Many of the differences observed in plasma amino acid concentrations at the top and bottom of the cycle in zinc deficient rats were mirrored by plasma amino acid concentrations in ad libitum rats, one group fasted the other group fed. Neither plasma glucose nor free fatty acid concentrations were correlated with food intake of zinc-deficient rats. In all experiments, there was correlation between plasma zinc and food intake in the zinc-deficient rats (Table 1). These data suggest that zinc plays a more central role in appetite control than was previously thought.

Table 1

Plasma zinc concentrations in rats fed a zinc-deficient diet for 15 or 20 days with or without zinc supplementation in the drinking water

	Plasma Zinc µg/dl					
	15 days			20 days		
Group	N	Range	Mean[a]	N	Range	Mean
Zinc-deficient B	(7)	46.0 - 113.7	82.7 ± 25.0	(8)	24.0 - 60.3	47.0 ± 12.0
Zinc-deficient T	(8)	28.3 - 57.6	42.2 ± 10.5	(7)	22.2 - 41.2	29.6 ± 6.3
Pair-fed B	(7)	166.1 - 315.0	227.8 ± 47.1	(8)	149.4 - 606.4	292.1 ± 142.4
Pair-fed T	(7)	139.9 - 234.5	187.9 ± 29.8	(7)	157.2 - 483.2	221.4 ± 119.1
Ad libitum	(10)	149.7 - 201.0	177.7 ± 18.1	(10)	135.8 - 191.1	164.3 ± 16.1
Overnight fasted				(5)	154.2 - 178	163.0 ± 9.9

B - bottom of cycle, T - top of cycle. [a]Mean ± S.D.

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35 THE USE OF CHROMIC OXIDE AND GLASS BEAD MARKERS FOR THE STUDY OF FEED PASSAGE THROUGH ADULT DOGS WITH NORMAL OR ENLARGED CECA

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Clinical and epidemiological evidence supports the postulate that dietary fiber is a protective factor against certain colonic disorders and metabolic diseases (1). In order to fully assess the possible roles played by dietary fiber in these diseases, the dynamics of food passage, particularly that of dietary fiber, must be known. Harvey et al. (2), using barium impregnated pellets as markers, observed that bran added to human diets decreased the long transit times of food through the tract but lengthened the short transit times. Allen et al. (3) reported that polyethylene glycol (PEG) passed through human digestive tracts faster than Cr_2O_3 and concluded that PEG was a valid marker for nitrogen, Mg, Fe, and Zn but was less valid for Na transit. Information regarding the rate of food passage through the alimentary canal of dogs or other monogastric animals including man is minimal. This study was conducted to determine some of these parameters for adult dogs and assess their correlation with the apparent digestibilities of various dietary components.

Sixteen adult dogs of both sexes and varying in weight from 8 to 20 kg were used for this study. The dogs were fed either Purina Dog Chow, containing 4.5% acid detergent fiber (ADF) or Purina Dog Chow supplemented to contain protein and fat equivalent to Purina Dog Chow but 15.7% ADF. The feeds were fed ad lib to a maximum of 30 g/kg of body weight per day. A group of four dogs having normal ceca were used to study both diets. Another group of six dogs with ceca twice normal length and a third group of six dogs with ceca three times normal length were each subdivided into three dogs/subgroup and fed either the lower ADF diet or the higher ADF diet. The cecal enlargements were made by surgically translocating the terminal ileum caudally along the ascending colon. Following four weeks recovery from surgery and seven days adjustment to diet, 1 g of Cr_2O_3 and 60 to 100 glass beads (3 mm diameter) in readily soluble gelatin capsules were administered to the dogs. Feces were collected at 4, 8, 12, 24, 36, 48, 60, 72, and 84 hours post-administration of the markers. Feces were assayed for Cr_2O_3 by a color elution technique (4) and for glass beads by washing and visual inspection. After 14 days of preconditioning in another experiment, the digestibilities of each diet by the various dogs were determined according to a 48 hour total collection method.

The mean passage times (time required for 80% recovery of the administered dose) of Cr_2O_3 were significantly faster ($p < .05$) for dogs consuming the higher ADF feed, 8.4 hrs, than for dogs consuming the lower ADF feed, 16 hrs. The two feeds contained equivalent amounts of dry matter (DM), 94.3%, crude protein (CP), 23.3%, fat, 8.7%, and minerals, 8.0%, but there were significantly less ($p < .05$) soluble carbohydrates, 40.5% vs. 50.2% NFE, in the higher ADF feed. All of these components were significantly less digestible ($p < .05$) by dogs consuming higher ADF feed, DM 56.8%, CP 70.6%, fat 89.3%, minerals 15.1%, and NFE 68.2%, than by dogs consuming the lower ADF feed, DM 74.6%, CP 77.5%, fat 94.2%, minerals 19.1%, and NFE 84.3%. The lower digestibility of the NFE in the higher ADF feed might be due to the inclusion of hemicellulose in this fraction. These data suggest that Cr_2O_3 passes at a similar rate to CP, fat, minerals, and NFE and might be used as a suitable marker for these components. It appears that ADF or a degradation product of ADF is responsible for the accelerated passage of Cr_2O_3 and the decreased digestibilities of DM, CP, fat, minerals, and NFE in the higher ADF feed.

Variations in cecal lengths did not significantly alter the mean passage times of Cr_2O_3 through dogs with normal, 18 hrs, doubled, 23 hrs, or tripled, 23 hrs, cecal lengths and consuming the lower ADF feed, nor of 8 hrs through dogs having normal, doubled, or tripled cecal lengths and consuming the higher ADF feed. Similarly, the apparent digestibilities of DM, CP, fat, and minerals of both diets were not significantly changed when fed to dogs with increased cecal length.

Although the differences were not significant, the mean rate of passage, of glass beads appeared to be faster, 24 hrs, through dogs consuming the lower ADF feed than through dogs consuming the higher ADF feed, 28 hrs. Similarly the apparent digestibility of ADF, although not significant, appeared to be lower, -1.0%, by dogs consuming the lower ADF feed than 4.9% by dogs consuming the higher ADF feed. This suggests that glass beads might be an appropriate marked for studies involving ADF. As cecal length was increased, the mean passage times for glass beads were shorter for dogs consuming either feed. However as cecal length increased, the apparent digestibility of ADF increased by dogs consuming either feed, particularly the higher ADF feed, 1.8% by dogs with normal cecal lengths and 12.6% by dogs with tripled cecal lengths. Thus it appears that neither glass beads nor Cr_2O_3 are appropriate markers for mean passage time of ADF. It does, however, seem very likely that increased cecal lengths in the dog do allow for increased digestion of ADF.

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36 STIMULATION OF CYTOPATHIC EFFECT ON A VERTEBRATE CELL LINE WITH A MOTH EXTRACT[1/]

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Viral infections are widespread throughout the Class Insecta. Pathologic viral effects range from paralysis in bees to sterility in Drosophila (1). Recent electron micrographs have revealed microbial infestations in the tobacco budworm (2). This study was undertaken to isolate and characterize the virus-like particles associated with the tobacco budworm.

Fifth instar larval insects were homogenized in double distilled water and carbon tetrachloride (1:4) to remove lipids. Suspensions were centrifuged on a linear sucrose gradient (50-80%). Dialyzed fractions were analyzed at 280 nm and absorbance readings indicated a band at 55% sucrose. Concentrated bands were inoculated onto an African Green Monkey Kidney (AGMK) cell line. The third passage on the AGMK cell line developed cytopathic effect (CPE) as evidenced by plaque formation (Fig. 1). Samples were prepared for electron microscopy by negative staining with 1.5% phophostungstic acid (w/v) in 0.4% sucrose, pH 6.9. Grids were examined within a Philips EM 300 electron microscope at an accelerating voltage of 60 kV. Electron micrographs (Fig. 2) revealed a spherical particle with a diameter of 30 nm.

Particle associated proteins were analyzed by SDS-polyacrylamide gel electrophoresis (SDS-PAG) (3) and isoelectric focusing (4). SDS-PAG electrophoresis resolved a single polypeptide with a molecular weight of 67,500 daltons (Fig. 3). Isoelectric focusing gels also resolved one polypeptide with an isoelectric point of 4.75.

Bioassays are being performed to determine the possible sterility effects of the particles on mid-instar budworm larvae.

Morphology and characteristic CPE on AGMK indicate the presence of a small isometric virus-like particle resembling the parvovirus group.

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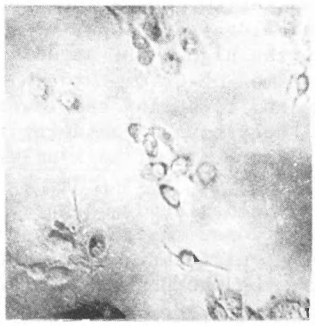

Fig. 1. Observed CPE on AGMK cell line after 3rd passage.

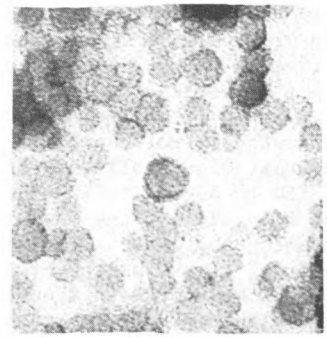

Fig. 2. TEM of particles isolated from AGMK cell line after observed CPE, 140,000X.

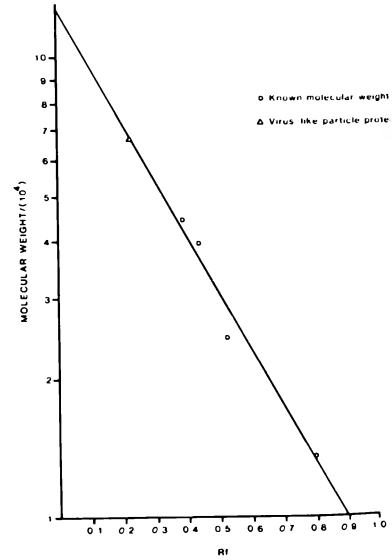

Fig. 3. Molecular weight determination by SDS-PAGE, 67,500 daltons.

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37 EFFECT OF FORM OF IRON ON THE INTERACTION BETWEEN NICKEL AND IRON IN RATS: IRON ABSORPTION

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Recent findings showed that nickel and iron interacted in rats when dietary iron was supplemented as ferric sulfate only (1). When the dietary ferric sulfate level was low (25 µg/g), hemoglobin levels were lower in nickel-deprived than in -supplemented rats. Dietary nickel apparently did not affect hemoglobin when the diet contained 100 µg of iron/g. When iron was supplemented to the diet as a 60% ferric -40% ferrous sulfate mixture, nickel and iron apparently did not interact. The apparent dependence of the nickel-iron interaction upon the presence of only the relative insoluble ferric sulfate suggests that nickel has a role in the absorption of the ferric ion but not of the ferrous ion. The following study was done to further substantiate that suggestion.

Female weanling Sprague-Dawley rats were assigned to groups of six in a fully-crossed, three way, two by two by two design. Iron was supplemented to the diet (containing about 10 ng of nickel and 2.3 µg of iron/g) at levels of 15 and 50 µg/g as either a mixture of 40% $FeSO_4 \cdot nH_2O$ and 60% $Fe_2(SO_4)_3 \cdot nH_2O$, or as $Fe_2(SO_4)_3 \cdot nH_2O$ only. Nickel was supplemented to the diet at levels of 0 and 5 µg/g as $NiCl_2 \cdot 3H_2O$. The diet and environmental conditions have been described (1). After the rats were fed their respective diets for 9 weeks, they were given an oral dose of ^{59}Fe by mixing 1 µCi of isotopic ferric sulfate in 10 g of diet. The rats were counted in a gamma-ray scintillation whole body counter 1/2, 4, 6 and 11 days after consumption of the isotope-supplemented diet. Immediately after the 11-day-count, the rats were decapitated subsequent to ether anesthesia and cardiac exsanguination with a heparin coated syringe. Microhematocrits were determined on the heart blood. The amount of ^{59}Fe in heart blood, kidney and red blood cells (RBC) was determined by using a well-type gamma-ray scintillation counter. The results are summarized below.

Effects of Nickel, Iron Level, Iron Form and Their Interactions on Hematocrits, and Body and Tissue ^{59}Fe Uptake in Rats

Treatment				^{59}Fe at 12 hours			
Ni	Fe level	Fe form	Hematocrit	Whole body	Kidney	Blood	RBC
µg/g	µg/g		%	% of initial dose			
0	15	+2,+3	38.2	56.6	0.51	5.5	14.5
5	15	+2,+3	40.6	55.4	0.58	5.0	12.4
0	50	+2,+3	41.4	25.5	0.32	1.7	4.1
5	50	+2,+3	40.5	27.4	0.31	1.8	4.5
0	15	+3	31.7	61.7	0.57	5.9	18.7
5	15	+3	36.3	72.2	0.67	7.0	19.4
0	50	+3	40.2	49.6	0.50	3.8	9.4
5	50	+3	40.0	51.9	0.46	3.7	9.5
Analysis of Variance - P Values							
Ni			0.04	NS	NS	NS	NS
Fe			0.0001	0.0001	0.0001	0.0001	0.0001
Fe x Ni			0.005	NS	0.04	NS	NS
Fe form			0.0001	0.0001	0.0001	0.0001	0.0001
Ni x Fe form			NS	NS	NS	0.07	NS
Fe x Fe form			0.002	0.002	NS	0.04	NS
Fe x Ni x Fe form			NS	NS	NS	0.03	NS

The hematocrit data confirmed previous findings (1). When dietary ferric sulfate level was low, hematocrits were lower in nickel-deprived than in -supplemented rats. There was an apparent inverse correlation between the hematocrit and whole body ^{59}Fe data. As the hematocrit increased, the whole body uptake of ^{59}Fe decreased. The only exception was when the diet contained 15 µg of iron/g of diet as ferric sulfate. In that group, the whole body uptake was less in nickel-deprived, even though they had lower hematocrits, than in -supplemented rats. Nickel deprivation apparently inhibited iron absorption in rats fed 15 µg of iron/g of diet as ferric sulfate.

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EFFECTS OF COLD ON EXPERIMENTAL HEART DISEASE

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The protective effects of hypothermia against the deleterious effects of hypoxia have been demonstrated in the laboratory and observed clinically. Isolated kidneys and limbs withstand hours of isolation from the circulation if cooled, for example (1). The experiments to be reported were done to find if the heart likewise could be protected from ischemia by cold.

METHODS: Adult dogs under pentobarbital anesthesia were prepared by opening the chest and exposing the heart during positive pressure respiration. Two cannulae were inserted into the pericardial sac. Thermistors measured heart and rectal temperatures. In the experimental groups the anterior descending coronary artery was ligated at its point of origin from the circumflex artery. Following coronary occlusion, in one group the heart was kept at body temperature by suffusing the pericardial sac with saline at about 38° C. In a second group preparation was as above, except suffusion was with saline at about 5° C. Blood pressures, heart rates, and electrocardiograms were monitored before coronary occlusion, and at intervals during the period of occlusion. Unless ventricular fibrillation (VF) occurred beforehand, experiments were terminated two hours after occlusion.

RESULTS: Warm saline and coronary occlusion. Blood pressure and heart rates changed only slightly, except in one animal that developed VF after 40 minutes. In a few minutes after coronary occlusion all had electrocardiographic changes indicative of myocardial ischemia, such as T-wave and S-T segment deviations, which persisted throughout the experiment. Nine out of ten animals survived the two-hour occlusion period.

Suffusion with cold saline. In animals without coronary occlusion, application of cold saline induced severe cardiovascular changes from normal. Heart rate decreased by 53%, systolic blood pressure fell 48%, and diastolic 50%. Heart temperature lowered 62%, and rectal temperature 24%. Electrocardiographic changes induced by cold alone in intact normal hearts resembled those seen after coronary occlusion in several ways, as follows: 1) slowing of beats. 2) irregular beats. 3) prolongation of the P-R and QRS intervals. 4) deviation of the S-T segment. 5) T-wave distortion. Cooling the intact heart brought on VF in three of six dogs within two hours.

Coronary occlusion superimposed on cooled hearts. The effects on heart rate and rhythm were more rapid in onset, and of greater magnitude than those found in occluded but warmed hearts. Likewise distortions of the electrocardiographic patterns appeared sooner, and were more marked than in coronary occluded hearts that were kept warm. VF onset time average was 54 minutes. All 12 animals expired within 120 minutes.

Causes for the deterious effects of cold on the heart are not clear, but possibly are related to the depression of metabolic processes in heart muscle (2). Cold has been found to delay enzyme activity which in turn controls oxygen transport from the blood to the myocardium. Oxygen deficiency would interupt conversion of foodstuffs to energy used for myocardial contraction. This is of great importance in myocardial tissue since anaerobic metabolism is strictly limited. Cooling blood vessels results in vasconstriction, further reducing blood supply. Low temperatures also delay the conduction rate of bioelectric currents, and the blockage of normal impulses may allow the establishment of ectopic pacemakers in the heart that set off the local contractions seen in VF.

Numerous theories to explain the cause of VF have been proposed, but only two are presently accepted. One holds that local pacemakers become active, and trigger rapid contractions ($\pm$ 500/min) in small areas of the myocardium. The other proposes that a single ectopic pacemaker emits impulses that travel rapidly around the heart in a circle (circus movement) and set off local contractions that make the heart refractory to impulses from the normal pacemaker (3). Regardless of cause, fibrillation produces weak uncoordinated beats that result in little or no blood movement. Oxygen lack to the brain is then responsible for death in a few minutes.

In human subjects exposed to cold air the heart is subjected to cooling by physical contact with the lungs. Also in deep rapid respiration cold air may lower blood temperature in the pulmonary vessels. This cooled blood is then pumped directly into the left heart chambers where contact with the myocardium occurs. In normal persons electrocardiographic wave distortions have been reported, but no ill effects result. Cardiac patients, however, suffer pain and other distress on cold exposure. In some heart patients severe cardiac arrhythmias, or even fatal VF may ensue. American Heart Association data indicate that heart fatalities in the US are doubled during winter months.

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THE TURNING POINT IN THE DEVELOPMENT OF THE SCIENCE OF GEOLOGY

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The late 18th and early 19th centuries were a time of vigorous contention between strongly divergent schools of geologic thought. The "Neptunists" perceived a simple development pattern in which nearly all the earth's crustal rocks were deposited layer by layer by chemical and mechanical precipitation from a globe-enveloping ocean. The "Catastrophists" saw the earth as only a few thousand years old with its surface features formed by a series of violent catastrophes. Proponents of these concepts included such leading geologists as Abraham Werner of the Freiburg (Saxony) Mining Academy, Robert Jameson of the University of Edinburgh, and Richard Kirwan, President of the Royal Irish Academy at Dublin. The concepts of the Neptunist/Catastrophist schools were based largely on philosophical speculations with field observations playing only a minor role.

Opposed to these views were the concepts of "Uniformitarianism" and "Plutonism" both of which originated with James Hutton of Edinburgh and were advanced by John Playfair of Edinburgh and later by the great British geologist, Sir Charles Lyell. Uniformitarianists perceived the earth as very old and its geologic development as due to processes still operating today. The concept of Plutonism was that a great deal of the earth's crustal rock, including the very abundant granites and basalts, originated through igneous activity. These views, in contrast to those of the Neptunist/Catastrophist schools, were based on extensive field observations and deductive reasoning from those observations. Because their arguments were based on field sites, it was obviously important that these sites be carefully chosen to show the geological relationships clearly and unequivocally.

In 1977 I studied and photographed many of these field sites, concentrating on those described by John Playfair (1) in his Illustrations of the Huttonian Theory of the Earth, a book acknowledged to have been most influential in the controversy. The main thrust of Playfair's book was to present a set of field examples perceived as supporting Uniformitarian/Plutonist concepts in the hope of persuading observers of the validity of those concepts. To be successful, such an approach would require clear field examples which could be logically interpreted solely (or at least best) by use of Uniformitarian/Plutonist concepts. My study sought to test the quality of Playfair's field examples in meeting these criteria.

In all, 35 sites were sought using Playfair's original descriptions of their locations, and 29 were successfully located and studied (18 in Britain, 4 in Italy, 4 in Switzerland and 3 in France). Of the 29 sites, 26 (90%) displayed relationships with reasonable clarity and 22 (76%) were deemed solely or most logically interpreted by Uniformitarian/Plutonist concepts.

Among the most convincing sites for demonstrating Plutonist concepts of igneous origin of granite were 5 sites in Britain showing veins of granite cutting older rock. These are easily explained as intrusions of molten granite, whereas the Neptunists had no conceptual framework to account for such phenomena. Other very significant examples included 4 sites in Britain showing angular unconformities. These arrangements of near-horizontal strata overlying eroded surfaces on steeply inclined strata can be logically explained by Uniformitarian concepts of a very old earth on which mountains were formed, destroyed by long erosion, and their roots covered over by younger sediments. Again the opposing school had no concepts to explain these features.

Playfair's examples were not infallible. For example, lacking the concept of Ice Ages (not developed until the middle 19th century), he overextended Uniformitarianism in attempting to account for blocks of Alpine granite found far from source areas, explaining them as due to gravity transport on no-longer-existing slopes.

Taken as a group, however, Playfair's sites were found to be well-chosen and very convincing in supporting the Uniformitarian/Plutonist concepts which have become the paradigm of modern geology. No less importantly, they helped to establish the science on a firm basis of field observations.

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BENCH-FORMING SANDSTONE AS A CORRELATION TOOL: CANNONBALL FORMATION (PALEOCENE), NORTH DAKOTA

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Throughout much of the area of outcrop of the Cannonball Formation (Paleocene) in southwest-central North Dakota where exposures are poor, its presence is revealed by flat-topped topographic benches. Laird and Mitchell (1) first called attention to these benches in southern Morton County. Having established their traceability over a large part of the outcrop area and their general stratigraphic position, I suggest the use of these benches in physical (non-chronologic) correlation.

Using measured stratigraphic sections as control points, bench-forming sandstones were mapped on aerial photographs in four areas (Table 1), and field checked in July, 1979. Approximate elevations of the mapped benches were determined by comparing their configurations on aerial photographs with those shown on 7.5-minute topographic quadrangles.

Two topographic benches are variably present laterally and vertically within the area of Cannonball outcrop. One occurs near the middle and the other in the upper part or near the top of the formation (Table 1). Laird and Mitchell (1) recognized in the lower part of the formation in southern Morton County a third bench, which is generally indistinct and untraceable. I have traced discontinuously the middle bench for about 70 miles from northeastern Morton and southwestern Burleigh Counties to southwestern Grant County, and about 30 miles east-west across southern Morton County. Likewise, I have traced discontinuously the upper bench for about 40 miles from east-central Morton County to southern Grant County, and about 40 miles from northeastern Grant County to east-central Sioux County. In the Flasher east area, where perhaps the benches are most clearly defined, the two benches are separated vertically about 70 feet. In the Leith south area, the two benches are separated vertically by about 140 feet. In the Carson north area, and in the Porcupine Hills 8.4 air miles north-northeast of Selfridge (SE¼SE¼ sec. 14, T. 131 N., R. 82 W.), only the upper bench seems to be present. And in the Mandan west area, only the middle bench is present.

The benches are held up by one or more indurated, concretionary sandstones that are usually 2-2.5 feet thick but may be up to 6 feet thick. They are contained within brownish-yellow-weathering, poorly consolidated sandstone, about 20-45 feet thick, that overlies light gray-weathering mudstone with a gradational contact. Both types of sandstone commonly contain mollusks, crabs, and the trace fossil Ophiomorpha.

Topographic benches seem to result primarily from regressive shoreline or barrier-island sandstones that have shifted laterally with time. Subsequent to sandstone deposition, groundwater-carried carbonate salts were precipitated to produce the indurated, resistant sandstone beds that give rise to benches upon weathering and erosion. The extent to which a bench can be traced depends on the continuity of the original depositional environment and the degree of sandstone cementation.

Table 1

Elevation and stratigraphic position of two topographic benches in the Cannonball Formation, southwest-central North Dakota[a]

Area	Middle bench		Upper bench		Cannonball thickness
	Elevation above sea level	Distance above base formation	Elevation above sea level	Distance above base formation	
Leith south[b]	2220-2280	180	2380-2420	320	330
Flasher east[c]	2040-2140	180	2120-2160	250	300
Carson north[d]	---------	---	2040-2060	250	290
Mandan west[e]	1800-1900	140	---------	---	250

[a]Elevations are approximate, other values are estimates; all values are in feet.
[b]28-square mile area 4-7.5 air miles south of Leith (composite measured section in NE¼NW¼ sec. 11, T. 132 N., R. 88 W. and SE¼NW¼ sec. 19, T. 132 N., R. 87 W.).
[c]16-square mile area 3.7-7.7 air miles east of Flasher (measured section in N½SE¼ sec. 21, T. 135 N., R. 83 W.).
[d]12-square mile area 9.5-12.5 air miles north of Carson (composite measured section in E½ sec. 21 and SE¼SW¼ sec. 17, T. 136 N., R. 86 W.).
[e]48-square mile area 3.1-11.2 air miles west of Mandan (measured section in SW¼SE¼ sec. 10, T. 138 N., R. 83 W.).

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PERIGLACIAL GEOMORPHOLOGY OF DAKOTA MOUNTAIN, ALASKA

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The distribution and characteristics of cold environment landforms in the southern Kenai Mountains, Alaska, were investigated during the summer of 1979. The area selected for this study was Dakota Mountain, a 3-square-kilometre mass rising to 1300 metres, about 50 kilometres northeast of Homer. Comparison with similar surfaces throughout the southern Kenai Mountains was accomplished from a low altitude aircraft.

Dakota Mountain stood as a nunatak above the surrounding glacier ice during the last general glaciation of the region. Its surface was subject to a cold rigorous periglacial climate with widespread permafrost. Its smooth topography stands in striking contrast to the angular glacially carved adjacent landscape. Active or relic periglacial features on the mountain include gelifluction lobes, nivation hollows, cryoplanation terraces, tors, turf-banked steps, a string bog, and various other forms of patterned ground such as sorted circles, polygons, steps, and stripes, earth hummocks, and small ice-wedge polygons.

Ground temperature measurements and the freshness of many of the features indicate that permafrost must have existed in the area recently; no permafrost appears to exist now, though. The sorted polygons, cryoplanation terraces and nivation hollows are relic features which have been inactive for a considerable time. The turf-banked steps and large prominent gelifluction lobes probably were active until the very recent thawing of permafrost. Cryofraction (frost shattering) and frost sorting are still vigorous processes acting to modify the present features.

An excavation into one large gelifluction lobe exposed a thin sand layer 4 to 12 mm thick. In several other sites buried soil horizons were discovered. The soils are interpreted to have been buried beneath a slowly flowing lobe during a time when the lobes were more active than now. Samples of the soils have been collected for radiocarbon dating. It is expected that these soils reflect a period of climatic stability in this area, perhaps during the Hypsithermal. The time of increased activity, then, probably dates from about 6000 years ago until perhaps less than 100 years ago when the permafrost melted.

The sand layer, originally interpreted to be of volcanic origin, is more likely eolian; but, it may instead be a shore deposit of a small proglacial lake. Such a lake could have existed had the glacier (in the deep valley along the southeast side of Dakota Mountain) been thick enough to block the drainage from a higher valley. If the mountain had been tilted about 1° to the east, because of isostatic adjustment to regional glacial loading, the shore of the hypothetical lake would be located at the site of the sand deposits. Glacier mass estimates indicate that such tilting is realistically possible. The alignment of an unusual bifurcated set of sorted stripes tends to indicate that the mountain was in fact tilted.

There is no geomorphic evidence that Dakota Mountain was ever glaciated. Discovery of erratics and a polished faceted cobble on the mountain, however, conclusively show that the area was glaciated. The degree of development of the periglacial features suggests that the mountain has been free of ice since the Eklutna glaciation which ended about 90,000 years ago.

The finely jointed bedrock, a previously colder environment, and long exposure in the absence of glacial ice has allowed the periglacial processes to be the dominant surface agent on Dakota Mountain as well as in similar areas along the western side of the Kenai Mountains.

Similar periglacial processes were important in southwestern North Dakota during the glacial episodes of the Pleistocene. Most of the periglacial features developed there are difficult to recognize, however, because of subsequent modification. The extent of these still needs to be determined.

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Terrestial Heat Flow in Southeastern North Dakota

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During the summer of 1977, three wells drilled as part of a project in eastern North Dakota and western Minnesota (1) were cased with 2" iron pipe and grouted to bottom hole. Equilibrium temperature profiles were determined in the cased holes and the thermal conductivities of representative samples of earth materials from the wells have been measured. The terrestial heat flow was then calculated over sections throughout which the temperature gradient is constant. Pertinent results are included in Table 1.

Table 1

Approximate Location, Depth, and Heat Flow (HFU = 10^{-6} cal/cm^2/sec) Values for Three Holes in South East North Dakota

Well #	Location	Total Depth (m)	Heat Flow (HFU) Deepest Section Studied	Heat Flow (HFU) Average All Sections
2	46°5'N,97°4'W	260	1.21 ± 13%	1.38
8A	46°57'N,97°25'W	107	1.28 ± 10%	1.57
10	47°22'N,97°18'W	174	0.76 ± 10%	.73

Heat flow values reported for the deepest section studied are those least likely to be altered by local water movement, hence best represent the conductive heat flow.

It is assumed that the significant difference in heat flow between well #10, and wells #2 and #8A can be attributed to a difference in the heat produced by the decay of naturally occurring radioactive elements in the underlying crustal rocks. A linear relationship between heat flow and radioactive heat generation of plutonic rocks has been observed (2). On the basis of this relation three major heat flow provinces have been identified within the continental United States. These are designated the Basin and Range, the Sierra Nevada, and the Eastern United States heat flow provinces. The relation between heat flow and heat production found to obtain over the eastern United States (2) predicts heat production of near 1 HGU (HGU = 10^{-13} cal/cm^3/sec) for well #10 and 5 HGU for #2 and #8A. Heat production values for the rocks underlying the sites #2, #8A, and #10 are unknown. However, heat production values determined at other sites in the region (3) range from a low of 1 HGU to a high of 4.3 HGU. Thus in contrast to data which suggest that western North Dakota is Basin and Range like in its heat flow-heat production character (3), southeastern North Dakota evidently lies in the Eastern United States heat flow province.

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3

ORIGIN OF THE MISSOURI ESCARPMENT

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The Missouri Escarpment is perhaps the most distinctive topographic feature in North Dakota and represents a rise of 500 to 600 feet from the level of the Central Lowlands to the surface of the Missouri Plateau. The escarpment crosses the state diagonally entering North Dakota in Divide County continuing southeastward to Foster County and then south into South Dakota. The Missouri Escarpment has been defined as the eastern edge of the Great Plains. Similar escarpments are found on the western edge of the Red River Valley, flanking the Prairie Coteau, flanking the Turtle Mountains, and flanking numerous upland areas in Manitoba and Saskatchewan.

A variety of hypotheses have been proposed in the literature to explain the origin of these escarpments. Thornbury (1) summarizes a common view that the Missouri Escarpment marks the boundary between two topographic levels of erosion. Lemke (2) proposes a synclinal valley between the Missouri Plateau and the Turtle Mountains and suggests the Missouri Escarpment may follow a fault line. Flint (3) suggests the steep smooth character of the Missouri Escarpment and the flanks of the Prairie Coteau in South Dakota are the result of lateral erosion by glacier ice. Bluemle (4) states the preglacial Missouri Escarpment was somewhat more subdued than present and positioned slightly west of the modern feature.

The purpose of this paper is to propose a new hypothesis for the origin of these escarpments. Study of topographic maps of North Dakota, Saskatchewan, and South Dakota; study of Landsat imagery of the same region; study of slope profiles along these escarpments; and review of published literature and maps relating to glacial features of this region led to the development of the hypothesis.

This hypothesis proposes the Missouri Escarpment; the Pembina Escarpment; the escarpments flanking the Turtle Mountains, the Prairie Coteau, and various upland regions of Manitoba and Saskatchewan are in fact the walls of large glacial through valleys. Each of these glacial through valleys probably originated as a diversion channel for blocked drainage systems from nonglaciated regions and glacial meltwater. Advancing ice flowed into each diversion channel blocking it and forcing creation of new diversion channels further southwest and upslope. The advancing ice then proceeded to flow south and southeastward through these valleys greatly widening and streamlining them as soft Cretaceous and Tertiary sediments eroded at a rapid rate. At times the ice filling these valleys thickened sufficiently to spill over onto surrounding upland areas. The Missouri Coteau in effect forms a large scale lateral moraine along the west margin of the westernmost of the through valleys. Glacial deposits covering the Turtle Mountains, the Prairie Coteau, and many upland areas of Manitoba and Saskatchewan are similar in origin.

The modern Missouri River and related channels provide a good example of how the various through valleys were initiated. The Missouri River channel complex developed when ice blocked an earlier complex of diversion channels occupying the region between the present Missouri Escarpment and the Turtle Mountains. Howard (5) and Salomon (6) describe evidence suggesting that tongues of ice then flowed up valleys connecting the earlier channel complex with the then newly developed Missouri River. In the case of the valley system east of the Missouri Escarpment ice flow was of sufficient magnitude and duration to carve a major through valley. Ice flow in the channels related to the modern Missouri River was not of sufficient magnitude or duration to develop a glacial through valley.

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44 Spatial and Temporal Dynamics of Tornadoes in North Dakota, 1950-1975

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Of all weather phenomena, the most extraordinary and the most violent are tornadoes. Tornadoes are local storms of short duration formed of winds rotating in a counterclockwise fashion at high speeds. They are very infrequent in North Dakota but have been recorded to the Weather Bureau since the establishment of its service in 1891. During the twenty-five years that this study covers, 1950-1975, three hundred, thirty-one tornadoes were sighted in North Dakota. Although tornado intensity in the state is a small percentage of the national yearly average, 1.8 percent, spatial dynamics can be observed and patterns noted. Through the interpretation of these patterns generated by a computer SYMAP mapping package and from observations, probabilities can be formulated as to the optimum time and place a tornado may strike in North Dakota.

SYMAP is a computer program employing a line printer to produce digital maps that display isoline intensity of a computer-manipulated set of data (1). A SYMAP, "Tornadoes of North Dakota," depicts varying intensities of tornadoes per thousand square miles per county centroid. Area of highest incidence is the counties of Stutsman, Barnes, and Cass astride the Alberta Storm Track, one of two major storm paths across the state of North Dakota. The Alberta Storm Track is a generalized atmospheric path on which a high percentage of low pressure cells followed by intense cold fronts move in times of acute thermal-and-moisture air mass differentiation.

Most North Dakota tornadoes form within the southeastern quadrant or dry-over-moist air warm sector low pressure centers. As the air mass with the low pressure center traverses the state from the northwest to the southeast, moist and unstable south to southwest winds are induced by pressure gradient differences into the deepening warm sector by the crowding effect of a following cold front. An updraft along the upper front seems to trigger a vigorous vortex between the two thermal-and-moisture differentiated slip currents. Most tornadoes form many kilometers in advance of the surface cold front that is advecting into the warm sector of the low, beneath a strong subpolar jet stream at an intermediate level of the atmosphere.

In the 1950 to 1975 time period, North Dakota averaged 12.73 tornadoes sighted per year. There was an uneven annual distribution and a generalized upward trend in tornadoes reported. In part, the upward trend can be attributed to improvements in gathering data on tornadoes by the National Weather Service. Most noticeable on the computer graphic histograms is the variations in reporting and clustering in 1965 when forty-four tornadoes were sighted in the state. Tornadoes can occur in every month, have been recorded between April and October, but the month with the largest number of tornadoes recorded in the study period, one hundred and ten or 32.28 percent were recorded in July. Annual month of maximum frequency varies little from year to year and may be related to the increased northward penetration of warm, moist, and unstable air into contrasting cool, dry, and stable air in a shallow atmosphere. Probability of a tornado striking a predetermined point in North Dakota is infinitesimal, approximately once in 2,500,000 years if the point is outside North Dakota's tornado alley.

The state lies on the northern margin of the area in the North American continent that records high tornado incidence, thus the state has only one peak month while most states have two peak months. June and July tornado observations totaled 64.3 percent of the twenty-five year period. Nationally, April, May, and June are the months with highest tornado sightings--with a national peak in May. Tornadoes occur twenty-four hours a day, but the majority of the diurnal observations were between 1500 and 2100. Of the total North Dakota tornadoes sighted, 57.0 percent were recorded between 1500 and 1900. The most critical time for tornado activity in the state was between 1500 and 1800, and may be attributed to marked heating-moisture contrasts in the upper air this time of day.

Property damage was reported from only one hundred and ninety tornadoes or 58.3 percent, and only two hundred injuries and seventeen fatalities were reported. All North Dakota tornado averages are misleading, for the Fargo disaster of June 20, 1957 claimed ten lives and injured one hundred and three. Property damage from this one Fargo tornado exceeded $10,000,000. North Dakota tornadoes are quite small by national standards; much less than one kilometer in diameter, wind speed less than two hundred knots, and their averaged length of path less than six kilometers. The highest probability for a tornado sighting in North Dakota would be in Cass County, July 27 at 1800 hours.

1. SYMAP, Version 5.20, Laboratory for Computer Graphics and Spatial Analyses, Graduate School of Design, Harvard University, Cambridge, Massachusetts.

TOTAL ECLIPSE OF THE SUN ON FEBRUARY 16, 1980

45
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A total eclipse of the sun (1,2) occurred on February 16, 1980 on a path varying from 53 miles at the beginning and end, to 92 miles wide at the center, and extending from Longitude 15° W and Latitude 1.0° S in the Atlantic Ocean across Angola, Tanzania and Kenya in Central Africa, across the Arabian Sea, striking the Indian subcontinent near Ankola at 74°15' E, 14°37' N, some 80 miles south of Goa, across India just south of Hyderabad and through Berhampur, across the Bay of Bengal, Chittagong in Bangladesh, and ending at sunset at Long. 108.6° E, Lat. 26.6° N in the People's Republic of China, some 375 miles east of Kun-Ming, and 115 miles east of Kuei-Yang, both almost on the center line.

This eclipse was No. 7589, Series 130, in the Oppolzer Canon (4), the fiftieth in a cycle of 73 beginning August 20, 1096 near the South Pole, 21 partial, then 40 total eclipses from April 5, 1475 to July 18, 2232 in Lapland, then nine partial eclipses, ending October 25, 2394, almost at the North Pole (3).

The widest path (92 miles) and longest duration of totality on land (4'08") (1,3) occurred near Voi, in Kenya, just south of Mount Kilimanjaro, and about 200 miles southeast of Nairobi; 94 miles and 4'12".4 in the Bay of Bengal. In central India the maximum duration of totality was only about 2'40", but the weather prospects for February were much more favorable--almost no rainfall (5,6). While no large cities were included in the eclipse-path across Africa and India, the Astrophysical Observatory of Japal-Rangapur with its large instruments was in the rare position of an observatory being able to make observations during totality.

Our own observing site was some fifty miles south of Hyderabad, between the towns of Palem and Bjinapalli, on the center line at Long. 78°15'.0 E and Lat. 16°31'.5 N, where the partial phase began at 8^h 57'13".2 and ended at 11^h 25'34".2. Totality, lasting two minutes and 40 seconds, began at 10^h 14'57".7 and ended at 10^h 17'38".0 Universal Time (3:14-3:17 P.M. local time).

Observations were made with a Celestron-8 telescope fitted with a Pentax 35 mm camera, a Celestron-5 fitted with a Konica camera, and visually. The erratic behavior of animal life was also noted. The temperature drop in both open as well as in shaded areas was only a few degrees centigrade. The sun was in a very active state as shown by the numerous red flares, or prominences, and by the shape and extent of the corona. These phenomena will be illustrated by slides made from photographs taken during the eclipse. Visual observations yielded views of several planets, as well as of several first magnitude stars.

The next eclipse of the sun will be an annular eclipse on August 10, 1980, extending along the Equator from a point between Honolulu and Pago Pago, and ending in Brazil. The next total eclipse of the sun will occur on July 31, 1981, and cover a path extending from the Black Sea, across southern Siberia, and end at sunset near the Hawaiian Islands. The next total eclipse in North America will occur on July 11, 1991, with a path-width up to 159 miles, a duration of totality up to six minutes, fifty-four seconds, very near to Mexico City, just after local noon.

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EFFICIENCY OF UTILIZATION OF PhAR DURING PHOTOSYNTHESIS IN BLUE GREEN ALGAE IN THE UPPER THREE METERS OF BREWER LAKE (RESERVOIR), ERIE, N.D.

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During the ice-free period of 1979, weekly measurements of gross photosynthesis, chlorophyll-a, and available PhAR were made for the upper three meters of Brewer Lake (reservoir), Erie, N.D. The measurements of chlorophyll-a and PhAR were used to calculate the amount of light absorbed by the chlorophyll at each of the four sampling depths. These quantities and the photosynthetic rates were used to calculate quantal efficiencies for the photosynthetic utilization of absorbed light.

The results demonstrate a marked photoinhibitory effect near the surface which was correlated ($r = -0.56$, $n = 21$, $p < 0.01$) with the intensity of the incident radiation. A consequence of this effect is a significant increase in efficiency with increasing depth, the efficiencies ranging from 0.000 to 0.034 moles O_2/Einstein at 0 m ($\bar{x} = 0.011$) to 0.000 to 0.462 moles O_2/Einstein at 3 m ($\bar{x} = 0.112$). The maximum efficiency noted at 0 m was found at the peak of the spring bloom, on 29 May, which, in addition to its high phytoplankton population, had a low incident radiation level. The maximum efficiency (0.462) found at 3 m occurred on 24 July, the peak of the mid-summer bloom. It is probable that the heavy shading provided by the overlying standing crop coupled with the metabolic state of the algae combined to yield this high efficiency. During the inter-bloom period (early June), the light intensities measured at 3 m were 6X greater than those during the rest of the year and, as a result, the efficiencies were relatively low at all of the levels.

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A PRELIMINARY SKELETAL ANALYSIS OF THE HOFF BURIAL

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In September 1979, a human skeleton was discovered during construction work near the Red River in Grand Forks County, North Dakota. Local law enforcement officials sent the skeletal material to the Department of Anthropology, University of North Dakota for study. The primary goals of the subsequent analysis were the determination of the age, sex, stature, and race of the individual. Obvious pathological features were also noted.

The legal location of the burial site was in the SW¼ of the SW¼ of Section 12, Township 154 North and Range 51 West. The skeletal material was recovered from the crest of the west bank of the Red River. However, construction at the site had destroyed any information which might have been gained from the geologic context of the burial. The bowl of a ceramic pipe was recovered near the disturbed burial, but its association with the skeleton could not be conclusively demonstrated due to the disturbance of the site.

The skeletal analysis consisted of three major phases. First, the skeletal material was assigned catalog numbers and each bone was described in detail. Second, 22 cranial and 14 post-cranial measurements were taken. Twelve cranial and four post-cranial indices were then calculated. Third, analysis of the data permitted estimation of the stature, age, sex, and race of the individual.

The sex determination was based upon pelvic and cranial features. The destruction of the os pubis of the pelvis eliminated the most reliable method of sexing the individual. The pelvis exhibited both male and female traits. However, the majority of the cranial features were characteristic of a male. The use of a multi-variate discriminant function based upon cranial measurements yielded a male determination in this case.

An estimate of the age of the individual was based upon epiphysial fusion (24+ years), dentition (25-35 yrs), and endocranial suture closure (26-29 yrs). The extreme variability of molar wear and cranial suture closure in human populations introduces a source of error into these age estimates.

Racial determination from skeletal material is a difficult, and questionable, procedure. The natural variability of human populations is a major source of error in such racial determinations. The cranial index and cranial height index were average in this individual, suggesting a Mongoloid classification. However, the narrow face of the cranium is characteristic of Caucasians. A multivariate discriminant function based upon cranial measurements classified this individual as caucasian.

The stature estimation was based upon measurements of upper limb bones since no lower limb bones were recovered from the site. These measurements indicated the individual had been approximately 165-175 cm tall (5'5"-5'9"). However, stature estimations based upon upper limb bones are less reliable than estimations based upon the bones of the lower limbs.

The cause of death of the individual is unknown. An oval fracture of the frontal bone exhibiting extensive healing indicated that the individual had survived the trauma for a least a year.

In conclusion, analysis of the skeletal material suggested they were the remains of an adult caucasian male approximately 165-175 cm in height (5'5"-5'9"). Death of unknown causes was estimated to have occurred at an age of 26-29 years.

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PRAIRIE BIRD SURVEY

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Over the past twelve years from 1968 to 1979, a bird population study has been conducted in an area north of Dickinson. The survey started four miles northwest of Dickinson partially following the Dunn County line in an East-North-East direction, with the last stop north of Gladstone. Most of the survey followed little traveled roads and section lines. Green River was crossed twice in the survey.

The survey procedure involved fifty stops, one-half mile apart, along the route described previously. Three minutes were spent at each point observing birds, by auditory and visual observation, within a quarter-mile radius. The bird survey started one-half hour before sunrise. The weather conditions were noted and had to be within a certain specified range.

The area covered by the survey is located within the unglaciated Drift Prairie. Part of the survey followed a belt of anastomosing, out-wash plains which are now being utilized by two sand and gravel companies. The majority of the survey area is short-grass, upland prairie. The annual precipation in this area is fourteen to fifteen inches per year, with sixty percent of the total coming in the months of April, May, and June. The average annual precipitation for the last twelve years has been over seventeen inches.

The ten most common birds found in the survey area include (listed from most common to least common):

Lark Bunting (Calamospiza melanocorys)
Horned Lark (Eremophila alpestris)
Western Meadowlark (Sturnella neglecta)
Red-Winged Blackbird (Agelaius phoeniceus)
Brown-Headed Cowbird (Molothrus ater)
Mourning Dove (Zenaida macroura)
Chestnut-Collared Longspur (Calcarius ornatus)
Grasshopper Sparrow (Ammodramus savannarum)
Killdeer (Charadrius vociferus)
Ring-Necked Pheasant (Phasianus colchicus)

Of the ten most common birds in the survey the Lark Bunting, Chestnut-Collared Longspur, and Grasshopper Sparrow showed decreases in population. These three birds are pristine habitat dwellers, and their population decrease may be attributed to increased human activity due to energy development in the past few years. The other seven birds showed slight to moderate population increases. National population trends were very similar to the trends found in the population survey done in this area.

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A WATER CHEMISTRY STUDY TO DETERMINE THE COMPATIBILITY OF GARRISON DIVERSION WATER WITH THAT OF THE SPIRITWOOD AQUIFER

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The Spiritwood Aquifer extends from western Ramsey County in north-central North Dakota southward to Sargent County in southeastern North Dakota. The aquifer is of a glacial deposit type composed of buried sand and gravel deposits. Aquifers of this type are recharged primarily by subsurface underflow and secondarily by direct precipitation and runoff. (1) In recent years there has been a drawdown of the water level due to irrigation and industrial uses. At current levels of drawdown there is no danger of a permanent reduction, however, with increased use this possibility does exist. As part of the Garrison Diversion Project, the terminal end of the McClusky Canal in Sheridan and Wells counties is located near the New Rockford Aquifer which feeds into the Spiritwood Aquifer. This provides a route for using the Missouri River water, impounded behind Garrison Dam, to recharge and maintain the water level in the Spiritwood Aquifer should the need arise.

The data used to assess the quality of the Missouri River was obtained from the U. S. Geological Survey as reported by the International Garrison Diversion Study Board. (2) The Spiritwood Aquifer data was obtained from the analysis of test well water performed by the N.D. State Water Commission. This data is shown in table 1. The categories of comparison were the ions Ca^{++}, Mg^{++}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{--}, Cl^{-}, and hardness. The high and low categories were taken at the 90th and 10th percentile, respectfully, so as to correlate with the Missouri River data. Compared are the low, median, and high values recorded as mg/l. This method results in a more comprehensive representation than using a comparison of means which can be affected by unusually high or low extremes. In all areas there is a lower concentration of ions in the Missouri River water therefore incurring a net gain in the quality of water present in the Spiritwood Aquifer.

The findings are significant in that a reduction in the salts present in the water of the aquifer would reduce the maintenance needed for irrigation systems as well as the amount of salts introduced into the soil which would reduce the detrimental impacts of irrigation upon agricultural lands. If this concept proved feasible it could be used as an alternate to the Garrison Diversion Project. By using underground aquifers as routes of water transmission the need for open canals and above ground storage resivors could be eliminated reducing the amount of water lost to evaporation and the adverse affects aboveground construction would have on agricultural lands and wetlands.

TABLE 1.

Spiritwood Aquifer

	Ca	Mg	Na	K	HCO_3	SO_4	Cl	Hardness
Low	30	16	36	6.8	386	73	7	140
Median	67.5	24.5	150	8	481.5	200	43	270
High	110	40	300	9.3	570	260	76	410

Missouri River

	Ca	Mg	Na	K	HCO_3	SO_4	Cl	Hardness
Low	36	16	48	3.5	171	120	6	160
Median	50	20	58	4.1	182	170	9	210
High	65	23	69	8.2	201	190	11	250

*all values are in mg/l

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32

DESIGN AND CONSTRUCTION OF A COOLING TOWER

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A cooling tower is basically a heat exchanger which transfers waste heat from cooling water to the atmosphere. This device has many industrial uses but is primarily utilized in the power industry. The cooling tower aids in the conservation of water and prevents the thermal pollution of lakes and rivers. The heat transfer from the water to air is about 75 percent due to evaporization with the remaining 25 percent due to convection.

The objective of this project is to design, construct, and test a mechanical draft cooling tower to be used by the undergraduate student to demonstrate cooling tower theory and give hands-on experience in the operation of a cooling tower.

The cooling system consists mainly of a fan, pump, tower body, tower fill, piping, and a water heater. The water heater corresponds to a condenser in a power plant. This heats up the cooling water which is pumped to the top of the tower. The water is then evenly distributed and sprayed downward on to the top of the tower fill. The tower fill breaks up the water and creates thin films of water which continue to fall due to the force of gravity. The fan forces air into the bottom of the tower and up through the tower fill in the opposite direction of the falling water. The purpose of the tower fill is to maximize the air-to-water surface area to promote the greatest heat transfer. The cold water is collected at the bottom of the cooling tower to be recirculated into the system.

The reference point to which this system is designed to is a hot water temperature of 102°F and a cold water temperature of 77°F with an ambient air WBT of 60°F. The amount of water circulating through the tower is 3.5 GPM and the air velocity is 427 FPM. The cooling capacity of the system is approximately 43654 BTU/hr for these design conditions.

The tower body was constructed using half inch thick plexiglas with a steel frame. One inch polyvinyl chloride (PVC) piping was used for the plumbing on the tower and half inch polyvinyl chloride (PVC) pipe was used for the water distribution system on the top of the tower. A Labawco pump with a Dayton motor, which delivers 14 GPM at five feet of head, is used to circulate the cooling water. A Dayton air blower, which delivers 815 CFM free air, is used to force the air through the tower. A 36 KW Dayton hot water heater simulates the condenser. Johnson Control temperature and humidity sensors are used to monitor the water temperature and the air temperature and humidity. The air and water flow measurements are made with deflection manometers. The three cubic feet of 12060-Series Tower fill was donated by the Munters Corporation of Fort Myers, Florida.

A computer mathematical model was formulated to determine the tower characteristic. This model is based on Merkel's equation and data supplied by the Munters Corporation. Preliminary tests have shown a close correlation between the test data and the results generated with the computer mathematical model.

33 LIGHT-TRANSMISSION BY WELDER'S LENSES: EYE PROTECTION DURING SOLAR ECLIPSE

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The need for protection of the eyes during direct observation of the sun was known long ago. During complete totality of a solar eclipse it is safe enough to observe the eclipsed sun and the surrounding halo of the prominences and the more or less white corona with the naked eye, but observations just before or just after can result in very serious painful burns, and even a permanently distorted vision.

It has generally been assumed that the damage was due to the ultraviolet rays. Various filters were therefore used, most commonly plates of glass smoked by means of a candle, or completely exposed and developed black and white film,-but eyesight damage resulted anyway. While opthalmologists (1) were aware of such retinal damage already a decade or two ago, such knowledge did not get to the general public. Some advice on how to watch the total eclipse of the sun on February 26,1979, pointed out that one must not only reduce the intensity of the visible light, but also filter out most of the ultraviolet and the infrared.

The effects of the burns by the ultraviolet were obvious,-very painful burns on the lens and the iris; the seemingly painless burns on the retina due to infrared light were not readily obvious. A similar phenomenon occurs in observing welding-torch flame. The Encyclopedia of Welding (2) does warn of these dangers, and the welder's lenses are presumably made in accordance with standards prescribed by the U.S. Bureau of Standards, but few welders are aware of the hazard due to the infrared rays. Advice given to amateur astronomers and the general public was to use welder's lenses No.14. Since # 14 was not available in many places, combinations such as 8 + 7, or 9 + 6, or 10 + 5, (by the strange algebra; $a + b \simeq \{(a + b) - 1\}$ were used.

The welder's lenses were obtained from Acme Welding Co. of Fargo, ND. The light-source chosen was a quartz slide-projector bulb. A Keithley electrometer with current ranges from 10^{-10} to 10^{-3} amperes used. As one goes from lower to higher numbers of welder's lenses, the optical absorption increases, requiring greater amplification, from about 10^{-4} for lense #4 (3) to 10^{-8} for #13, to produce a signal strong enough to record.

The experimental data are illustrated by 31 figures and two tables. Transmittance spectra of lenses 4, 5, and 8 show almost no photo-energy below 4000 A; lens 9 three small peaks at 2200 A, 2400 A, and 3150 A. For lens 13 the two at 2181 A and 2385 A are very high.

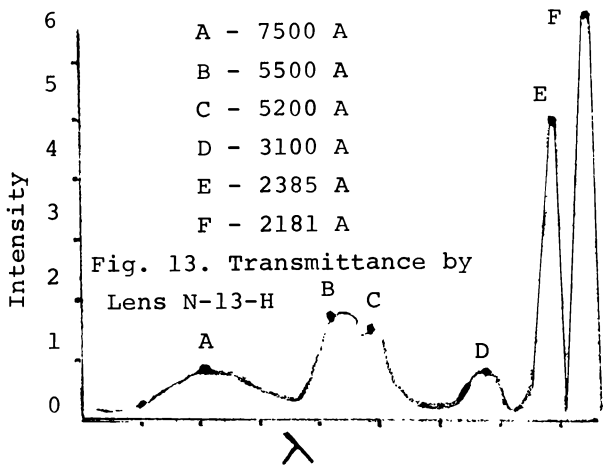

Fig. 13. Transmittance by Lens N-13-H

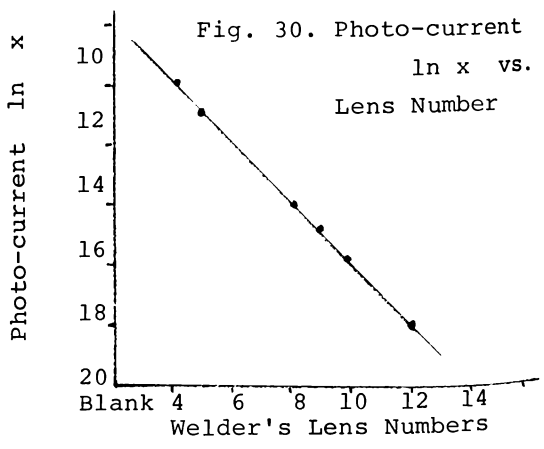

Fig. 30. Photo-current ln x vs. Lens Number

SUMMARY AND CONCLUSIONS: Welder's lenses exhibit strong absorption in the ultraviolet region of the spectrum, with two surprising narrow windows at 2181 and 2385 A. Since such radiation is very weak in sunlight coming through the ozone layer of the upper atmosphere and a thick layer of air, welder's lenses serve will to protect the outer eye, iris, lens, etc. against damage by solar radiation, except at very high altitudes.

1. Private consultation with Dr. John R. Goff, M.D., Opthalmologist, Fargo.
2. The Welder's Encyclopedia 17th Ed.,pp. E23-27,F1,H17.
3. Journal of Opthalmology,"Effects of UV Radiation",55(1):19-35,Jan 78.

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A DESCRIPTIVE ANALYSIS OF THE LEPIDOPTERA FAUNA OF EASTERN ZAIRE WITH NOTES ON THE SEASONAL VARIATIONS FOUND IN Precis oenone(L.)

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A survey of the Lepidoptera fauna in Eastern Zaire, Africa was conducted between October 1977 and April 1979. This area, specifically the province of Kivu, is a tropical montane region. The average altitude of approximately 1600 m provides a temperate climate with little temperature fluctuations unlike that of the low lying jungle basin. Observations of the influences of other environmental factors on the Lepidoptera fauna were noted. One such factor was the humidity consisting of a wet and dry season. The wet seasons lasted from February through May and from September through December. During these periods the fauna was at its numerical peak.

The overall study site was divided into four areas, each differing in vegetative cover to allow a more representative sample. The families which are representative include: Papilionidae, the swallowtails; Danaidae, the monarchs or milkweed butterflies; Satyridae, the browns; Nymphalidae, nymphalids; and Pieridae, the whites.

Within the Pieridae two species (Precis octivia and Precis oenone) illustrated a seasonal dimorphism. The seasonal variations were due to changes in the humidity rather than the temperature.

47 SEASONAL VARIATIONS IN UREA UPTAKE BY A PREDOMINATELY BLUE-GREEN ALGAL POPULATION IN BREWER LAKE, ERIE, NORTH DAKOTA

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Measurements of loss or gain of urea in light and dark bottles were made at weekly intervals from July through September in 1978 and from mid-May through September during 1979. Photosynthesis as milligrams oxygen per liter per hour (mg O_2 l^{-1} hr^{-1}) and urea loss or gain as microgram atoms urea nitrogen per liter per hour (ug at urea-N l^{-1} hr^{-1}) were determined in separate sets of light and dark bottles suspended at one meter intervals from the surface to five meters and incubated from approximately 8 am to 3 pm. Urea uptake rates were determined using sets of light and dark bottles inoculated with 10 ug at urea-N l^{-1}. Additional sets with no urea added were run simultaneously for comparison. Weekly measurements of nitrate, nitrite, ammonia, pH, phosphate, chlorophyll-a, temperature, and radiation available in the lake were also made.

In 1978, the maximal urea uptake occurred near the peak of the mid-summer bloom. This maximal rate of uptake was noted when initial (8 am) ammonia concentrations were minimal. As the summer bloom was nearing its peak, urea concentrations approached zero at the end of the incubation period in light bottles containing no added urea. The highest efficiencies of uptake (as a ratio of urea uptake to chlorophyll-a) were recorded between mid-July and mid-August when photosynthesis and chlorophyll-a both increased six fold. After the decline of the summer bloom, urea uptake was erratic.

Similar patterns of urea loss and gain were observed in 1979. The highest uptake rates occurred when initial (8 am) ammonia values were near zero. Both high urea uptake rates and low ammonia values were recorded between early July and mid-August. Concurrently, chlorophyll-a and photosynthesis gradually increased from late June to peaks on 24 July and 7 August respectively. High urea uptake rates were also noted in late May which coincided with the short but intense first bloom.

In both 1978 and 1979 urea loss in the light bottles appeared to be dependent upon initial ammonia available to the algal population. Both photoinhibition of photosynthesis and low daily incident radiation were factors in urea loss in the light bottles during the summer bloom. In both years studied, there was a significantly ($P < .01$, $n = 33$) greater loss of urea in the light bottles as opposed to the dark bottles. These data reinforce theories linking urea uptake to ATP formed by photophosphorylation.

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HARVEST SEQUENCE EFFECTS ON ROOT RESERVES OF IRRIGATED ALFALFA IN NORTH DAKOTA

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Previous forage management trials have indicated that harvesting irrigated alfalfa under the recommended 3-cut system (3 cuts by September 1 at 10% bloom growth stage) can result in a yield loss compared to a 2-cut system due to winter injury effects. However, an early 3-cut system which maximizes the protein and disgetible forage yield per acre is a must to make alfalfa competitive with other irrigated crops. These same studies indicated that delaying the second harvest 1 to 2 weeks and harvesting the third after a killing frost increased forage yields during subsequent years over the early 3-cut system. The objective of this study was to determine if previously noted yield and winter injury differences by harvest sequence could be associated with differences in root total non-structural carbohydrate (TNC) reserve levels in the fall.

Seven harvesting sequences were initiated on established, irrigated alfalfa plots at Carrington, N.D. in 1978. Vernal, winterhardy, and Thor, moderately winterhardy, alfalfa varieties were used to determine if root reserves differed with varietal winterhardiness. Root samples were taken throughout the 1978 growing season to monitor TNC cycles on each treatment. A final sampling was taken on November 21 and compared to first harvest yields in 1979.

Deferring the third harvest until after a killing frost (Treatments 4,5, and 6) resulted in TNC levels equal to or greater than the 2-cut system (Treatment 3) on October 19 (Table 1). The higher root reserve level of deferred harvested plots follows the forage yield relationship found in previous management trials (1). However, unusually warm late October and early November temperatures promoted utilization of root reserves for regrowth as evidenced by the decreased TNC levels in all treatments by November 21. This caused substantial winter injury to all 3-cut systems as evidenced by the spring 1979 vigor ratings. Thor alfalfa had less winter injury than Vernal even though Vernal is classified higher in winterhardiness. The fall TNC level was correlated positively (r=0.75) with the first harvest forage yield. These data indicate that the November TNC level in irrigated alfalfa can be used to predict relative varietal and harvest sequence effects.

Table 1. Total nonstructural carbohydrates, spring vigor, and 1979 first harvest yields of irrigated alfalfa as influenced by harvest sequence at Carrington, N.D.

Treatment	1978 harvest dates	% TNC 10-19	% TNC 11-21	Spring vigor*	1979 First harvest yield (tons DM/acre)
1	6-6, 7-13, 8-17	22.1c**	17.0b	2.6ab	2.63b
2	6-15, 7-20, 8-24	19.2d	16.2b	3.5bc	2.61bc
3	6-15, 8-3	24.6bc	21.1a	2.5a	3.04a
4	6-6, 7-27, 10-19	27.4a	17.1b	4.5d	2.46bc
5	6-15, 7-27, 10-19	27.1ab	17.4b	4.4cd	2.45bc
6	6-15, 8-3, 10-19	23.8c	16.3b	4.4cd	2.59bc
7	6-15, 7-20, 9-13	18.5d	12.5c	4.3cd	2.36c

*Vigor rating: 1 = Vigorous, 9 = dead
**Means followed by different letters are significantly different at the 5% probability level.

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THE INFLUENCE OF TEMPERATURE, DAYLENGTH AND SALINITY ON GONADAL DEVELOPMENT OF THE BANDED KILLIFISH, FUNDULUS DIAPHANUS

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Various species of killifish, Genus Fundulus, have been reported to undergo seasonal cycles of reproductive development. The effects of different environmental conditions of temperature and daylength on reproductive development have been studied in a variety of fish species (1). The purpose of the research presented in this report was to 1) describe the annual gonadal cycle of the banded killifish, Fundulus diaphanus and 2) to ascertain the effects of different conditions of temperature, daylength and salinity on reproductive development of this species.

The fish utilized throughout this research were collected from Kelly's Slough in Grand Forks County and temporarily maintained in 20 gallon aquaria under conditions of temperature, daylength and salinity appropriate for the time of year. For the determination of the annual reproductive cycle, fish were killed within a week of the time of capture, weighed and subjected to gravimetric and histological analysis of gonadal development. Criteria for staging gonadal development in histological analyses were a variation of those employed by de Vlaming (1).

In the experiments of environmental influences on reproductive development, the fish were placed under different daylength, temperature and salinity conditions within one week from the date of capture. To determine the influence of temperature, different groups of fish were held at 5, 15 and 25°C under light-dark cycles of 12L:12D. In the experiment on the influence of daylength, groups of fish were maintained on LD cycles of either 8L:16D, 12L:12D or 16L:8D at 15°C. To assess the effect of different salinities, fish were maintained in water of either 100, 200, 300 or 400 mosm. at 15°C under a 12L:12D photoregime. After 4 to 6 weeks of acclimation to experimental conditions, the fish were sacrificed, body and gonadal weights determined and the gonads were prepared for histological examinations.

The analysis of seasonal changes in gonadal development in feral fish confirmed the presence of an annual reproductive cycle and indicated a direct relationship between the changes in the gonadosomatic index (G.S.I.) and histological changes in the gonadal tissue. From May until mid June the weight of the gonads increased dramatically and the gonadal tissues were in the prespawning stage. The greatest gonadal weights were observed on June 15 (Male G.S.I. = 2.407 ± 0.452; Female G.S.I. = 28.436 ± 3.786). After the time of maximum breeding activity the gonads underwent regression until late August or September. In October the gonads were observed to have advanced to the initial phase of gametogenesis.

Table 1. Effects of different temperature on gonadal development of Fundulus diaphanus.

	Males			Females		
Temp.	N	G.S.I.[a,b]	Gonadal Stage	N	G.S.I.	Gonadal Stage
Initial controls	6	0.633±0.319	early postspawning	6	2.799±1.417	postspawning
5°C	7	0.617±0.210	postspawning	5	2.655±0.825	postspawning
15°C	9	0.359±0.113	late meiotic	5	2.823±0.766	vitellogenesis
25°C	10	0.165±0.032	quiescent	4	1.711±0.290	oogonial proliferation

[a]Gonad Weight/Body Weight X 100; mean ± S.D.
[b]Pattern of gonadal responses is statistically significant at $p < .01$.

As indicated in Table 1, acclimation of fish to 15°C water temperature resulted in an enhanced rate of progression into the normal fall reproductive condition, whereas acclimation to 25°C water resulted in a complete gonadal regression without an advancement to the fall condition. The differential effect of daylength on gonadal development was less pronounced than that of temperature. In the females it appeared that the intermediate daylength condition was most conducive to gonadal development. Preliminary analysis of the effect of acclimation to different salinities revealed no pronounced effect on gonadal development.

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50 DISTRIBUTION AND ORIGIN OF ELONGATE SANDSTONE CONCRETIONS, BULLION CREEK AND SLOPE FORMATIONS (PALEOCENE), ADAMS COUNTY, NORTH DAKOTA

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Distinct linear features in sandstone of the Bullion Creek and Slope Formations (Paleocene) in Adams County, North Dakota are apparent on aerial photographs. The features generally trend east-west across the county. The purpose of this study is to determine the distribution of the features, identify and describe them in outcrop, and suggest a mode of origin for the rectilinear pattern.

Field work has shown that the linear features are discrete, elongate concretions of calcareous sandstone, encased in unlithified sand. The presence of continuous bedding from the sand into the sandstone indicates the concretions are post-depositional in origin. Differential erosion of the enclosing sand has exposed the sandstone concretions so that they are visible as linear features on aerial photographs.

The elongate concretions are composed of calcite-cemented, very fine- to medium-grained sandstone (0.0625-0.5 mm). They do not contain a nucleus. Six samples of the concretions and the enclosing sand were analyzed petrographically. The sand averages 29% feldspar, 31% quartz, and 32% rock fragments. The concretions average 28% feldspar, 30% quartz, and 34% rock fragments, indicating compositional similarity between the sand and sandstone. The enclosing sand shows more compaction and grain deformation than the associated concretion, suggesting that the concretion formed shortly after burial.

The concretions are oriented with their two greatest dimensions (length and width) parallel to bedding. In cross section perpendicular to their length, they are oblate. An average elongate concretion is 1-2 m thick, 2-5 m wide, and at least 10 m long. The concretions are usually concentrated along discrete horizons in the enclosing sand that recur vertically and terminate laterally. Therefore, they cannot be used as stratigraphic markers.

In south-central Adams County, a series of buttes are capped by tabular, concretionary sandstone beds that may reach several square kilometers in lateral dimensions. Superimposed on the sandstone beds are aligned "pinchings" and "swellings" that form rectilinear patterns and closely resemble individual elongate concretions in size and geometry. These beds probably represent an advanced stage of concretion growth, where, with time, individual concretions have coalesced laterally to form broad sheets of sandstone. These beds cannot be correlated from one butte to the next.

An average concretion orientation was calculated for each of 50 randomly chosen square-mile sections that showed elongate concretions on aerial photographs. In nearly all cases, the vector strength (a measure of data dispersion) is above 0.90 (maximum of 1.00), indicating uniformity in concretion orientation. The grand mean of the 50 values is 84 degrees. Azimuths of cross-bed sets were recorded as paleocurrent indicators at eleven locations where elongate concretions were present. At nine of the locations, the average concretion orientation agrees with the average paleocurrent direction. This suggests the paleochannels controlled the growth of concretions, probably by serving as paths of maximum permeability so that calcium carbonate-bearing grounwater flowed along their lengths. Probably, the ancient groundwater flowed eastward rather than westward, in response to the topography of the time.

Calcium and carbonate ions, derived from the dissolution of detrital calcite, feldspar, and gypsum, precipitated as calcite in zones of maximum permeability in the sands. Precipitation probably was controlled by a rise in temperature or drop in pressure in the groundwater. Either of these changes, possibly caused by a lowering of the water table, would drive CO_2 out of the groundwater, causing a rise in pH and calcite precipitation.

The elongate form of the concretions is a result of growth in the direction of maximum permeability. Groundwater flowing through an aquifer will deliver constituent ions to the upstream side of a growing concretion, resulting in more rapid growth in this direction. Growth in other directions will be aided only by the slower process of ionic diffusion.

Using the relative age classification of Fenske (1), these elongate concretions are assigned a late diagenetic age, meaning they formed after some, but not total, compaction of the sediment had occurred. Evidence for this age assignment is their oblate shape in cross section (a result of pre-cementation compaction), and the lower porosity in the enclosing sand, indicative of post-cementation compaction. The greater porosity in the concretion suggests burial could not have been excessive before cementation, perhaps several hundred feet. Since overlying Paleocene strata in Adams County (Bullion Creek and Sentinel Butte Formations) are about 500 feet thick, concretion formation probably occurred before the end of the Paleocene Epoch.

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51 ROBERTSONIAN AND POSSIBLE TELOMERE TO TELOMERE TRANSLOCATIONS IN DOWN SYNDROME SUBJECTS

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Karyotypic analysis of chromosomal preparations from whole blood cultures of approximately 90 Down syndrome patients from a North Dakota institution for the mentally retarded resulted in identification of three subjects with the translocation type of the syndrome. These three individuals were analysed further by C and G banding as well as silver staining of the nucleolar organized regions (Ag-NOR), in order to identify the individual chromosomes involved in these translocations and to determine the approximate break points of the translocated chromosomes. The translocations were identified by G banding as 46,t (13q; 21q), 46,t (14q; 21q) and 46,t (21q; 21q). The G banding procedure was a slight modification of the Seabright (1971) method.

C banding and silver staining for Ag-NOR were performed in order to determine whether the translocations were typical Robertsonian fusions or other forms of translocation. It is known that all the human acrocentric chromosomes (13,14,15,21 and 22) have a C-positive centromeric region, C-negative secondary constriction and a C-positive satellite (Jalal et al., 1974). It has also been shown that the secondary constrictions represent the nucleolar organizer regions (NOR) in all five pairs. The presence of NORs have been elegantly demonstrated by their highly specific reaction to silver staining (Lau et al., 1978). Only active NORs are selectively stained by this method. The silver staining, along with the banding procedures provide a unique opportunity to improve considerably the cytological resolution of the proximal arms of human acrocentric chromosomes.

Silver staining of active NORs by the Lau et al., (1978) procedure, of the three translocation type and three G_1 trisomies lead to the following results. The Ag-NOR/cell for the 13/21, 14/21 and 21/21 were 9.1, 7.7 and 6.6 respecitvely, compared to the average of 8.45 in the G_1 trisomies. The maximum number of active NORs per cell was eleven in one translocation type and two G_1 trisomy subjects. These figures are comparable to those reported in the literature. The 21/21 translocated chromosome was devoid of any Ag-NOR; whereas double spots were clearly defected in the 13/21 and 14/21 translocations. It appears that the 21/21 translocation has lost NORs from both chromosomes and that both NORs have been maintained in the 13/21 and 14/21 translocations.

The C banding procedure used was a modification of Arrighi and Hsu (1971) method to determine the number of centromeres present in the translocated chromosomes. The 21/21 translocation has a single centromere. It appears to be clearly a classic case of Robertsonian fusion where breaks occur in both chromosomes (one below and the other above the centromeric region) followed by a fusion. In this process the Ag-NORs and one centromere are lost.

Translocations of 13/21 and 14/21 did not involve Robertsonian type of fusion. Both had double silver spots indicating that secondary constrictions have not been lost in any chromosome involved in translocations. C banding indicated a single large centromeric region in 13/21 and two in 14/21. We therefore consider these as possible telomere to telomere fusions where one centromere becomes latent and the other is functional.

Fusions between non-homologous chromosomes may occur in mammalian species without apparent breaks or single breaks, resulting in translocations between telomere to telomere (T-T), centromere to telomere (C-T) and centromere to centromere (C-C) as reported by Stock and Hsu (1973). Robertsonian fusions have been reported in humans though silver staining has been used in only a handful of cases. Occurance and demonstration of telomere to telomere fusions are extremely rare. We believe that these results are of significance in elucitation of fundamental details of translocations and an aid to the question of loss of Ag-NORs without deleterious effects in development.

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IMMUNOHISTOCHEMICAL STAINING OF RAT REPRODUCTIVE ORGANS AND ANTERIOR PITUITARY USING ANTISERA TO hPL AND oPRL

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Localization of specific proteins at specific tissue sites has been a problem in many histological investigations. Of the many methods that have been tried in recent times, immunohistochemical techniques have been used successfully to localize the cells of origin and receptor tissues for many hormones. These techniques were used in localizing human placental lactogen (hPL) and human chorionic gonadotrophin (hCG) in the human placental syntrophoblast (1, 2). Immunological studies have shown that antibodies are usually specific in binding reactions but exceptions have been reported, such as immunological crossreactions with similar protein antigens from different species (3, 4). Antigen-antibody crossreactions have also been reported to occur between proteins of the placenta and pituitary proteins. It was upon these characteristics that this study was based in attempting to localize rat PL in rat reproductive organs and to find evidence of immunological crossreactions in the rat anterior pituitary.

Placenta, ovaries, mammary glands and pituitaries were obtained from female Long-Evans rats 12 and 19 days pregnant. Antiserum to hPL and to ovine prolactin (oPRL) and normal rabbit serum (NRS) were used to treat sectioned tissue for immunohistochemical staining. Either the indirect-labeled antibody technique or the enzyme-bridge method was used in staining tissue for light microscopy.

Following treatment with anti-hPL, staining was observed in trophoblastic tissue and in decidual tissue of the rat conceptus. Anti-oPRL treated tissue showed staining that appeared to be limited to trophoblastic tissue. Ovarian tissue showed staining in cells of the corpus luteum following treatment with either antiserum. Mammary gland tissue showed staining in apical portions of acinar cells also following treatment with either antiserum. Following treatment with each antiserum, anterior pituitary tissue had stain in two separate cell types which were characterized by a difference in morphology and in distribution.

The appearance of stain in trophoblastic tissue indicates the presence of hPL-like and PRL-like proteins. The localization of hPL-like proteins in trophoblastic tissue was in harmony with current reports that trophoblastic tissue is the origin of placental lactogens. The apparent presence of hPL-like protein in maternal or decidual tissue was unexpected. The decidual tissue could be a site of synthesis, storage, or diffusion mechanism for an hPL-like protein. The presence of PRL reactive sites, however, suggests either a site of synthesis, a type of immunological reaction, or a storage site for PRL. None of these have yet been confirmed in the rat. The staining seen in the two receptor organs showed that luteal cells of the ovary and acinar cells of the mammary gland contained both hPL-like and PRL-like proteins. These two tissues have been shown to be sensitive to PRL and hPL by bioassay and have been used in radioreceptor assays for these two hormones. It would be expected during various stages of development and function of these organs that PL or PRL would be localized in these tissues.

The observations of separate cell types being stained in the anterior pituitary shows that anti-oPRL and anti-hPL are reacting to two distinct proteins. This observation would support the identification of two different proteins in the other tissues reported above using the two antisera. The staining seen, however, does not prove sites of synthesis but shows that hPL-like or oPRL-like are present in some form. These forms could be whole proteins, precursor subunits, or metabolic subunits which closely resemble immunologically the primary antigen for each antiserum.

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ARSENIC-ZINC INTERACTIONS IN CHICKS

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Previous studies showed that arginine supplementation (20 g/kg of diet) made arsenic deprivation signs in chicks appear earlier and more severe (1). Arginine supplementation also made some zinc deprivation signs in chicks more severe (2). This suggested to us that there may be an interrelationship between arsenic and zinc metabolism in the chick. Thus, the following study was done.

Day-old cockerel chicks were assigned to groups of 24 in a fully-crossed, two way, two by two design. Arsenic was supplemented to the diet (containing about 13 ng of arsenic and 7 µg of zinc/g) at levels of 0 and 2 µg/g as $Na_2HAsO_4 \cdot 7H_2O$. Zinc was supplemented to the diet at levels of 5 (zinc-deficient) and 40 µg/g as $Zn(C_2H_3O_2)_2 \cdot 2H_2O$. The acid-washed ground corn, high-protein casein based diet and environmental conditions have been described (3). After 32 days on experiment, the chicks were weighed and examined for leg abnormalities and shank skin dermatitis. Then the chicks were decapitated subsequent to cardiac exsanguination with a heparin coated syringe. Several tissues were removed and weighed. Microhematocrits were determined on heart blood. Plasma alkaline phosphatase and uric acid, and kidney arginase were determined by using standard procedures. Some of the results are summarized below.

Effects of Arsenic, Zinc and Their Interaction on Body and Liver Weight, Hematocrit and Plasma Alkaline Phosphatase Activity

Treatment		Body	Liver wt./Body wt.		Plasma Alkaline
As	Zn	Weight	Ratio (x 100)	Hematocrit	Phosphatase Activity
µg/g	µg/g	g		%	units*
0	5	783	2.39	31.3	1.381
0	40	904	2.03	30.9	1.632
2	5	746	2.08	32.0	2.012
2	40	979	2.07	29.8	1.464
			Analysis of Variance - P Values		
Arsenic effect		NS	0.01	NS	NS
Zinc effect		0.0001	0.0006	0.01	NS
Arsenic x zinc		0.06	0.002	0.05	0.003

*Units are µmoles p-nitrophenyl phosphate split/min./ml plasma.

Arsenic and zinc interacted to affect growth, leg development, liver wt./body wt. ratio, hematocrit, plasma alkaline phosphatase, and kidney arginase. The effect of dietary arsenic on growth and hematocrits was dependent upon the zinc status of the chick. When dietary zinc was 40 µg/g, the arsenic-deprived chicks exhibited depressed growth and elevated hematocrits. During zinc deficiency, however, growth was more markedly depressed and hematocrits more markedly elevated in the arsenic-supplemented than arsenic-deficient chicks. In contrast, effects of dietary zinc on liver wt./body wt. ratio, plasma alkaline phosphatase and kidney arginase apparently depended upon the arsenic status of the chick. Zinc deficiency did not affect the liver wt./body wt. ratio, but elevated kidney arginase activity of arsenic-supplemented chicks. When the chicks were arsenic-deprived, zinc-deficiency elevated the liver wt./body wt. ratio, but did not affect kidney arginase activity. Plasma alkaline phosphatase activity was elevated in zinc-deficient chicks that were fed supplemental arsenic. On the other hand, zinc deficiency slightly depressed plasma alkaline phosphatase activity in arsenic-deprived chicks. Regardless of zinc status, arsenic deprivation depressed gonad weight and plasma uric acid, and elevated the incidence of shank skin dermatitis. The findings suggest that arsenic is an essential element which interacts noncompetitively with zinc. Arsenic may be involved in nitrogen metabolism.

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CARBOXYL-METHYLATION OF NON-HISTONE CHROMOSOMAL PROTEINS

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Grand Forks, North Dakota

Eucaryotic chromatin is composed of DNA, histones, and non-histone chromosomal proteins (NHCP). Evidence has been presented suggesting an important role for NHCP in the regulation of gene expression and/or possible role in the higher-order structure of chromatin (1). Post-translational methylation of NHCP was first reported in 1969 (2). This observation was substantiated in our laboratory in 1976 (3). The purpose of this study was to investigate the type of methylation and the number of NHCP methylated in various organs.

The in vitro methylation of NHCP was investigated in nuclei from 6-8-day-old rats. Sucrose gradient purified nuclei (3) were incubated in the presence of S-adenosyl-[^{3}H-methyl]methionine (AdoMet). The nuclei were lysed with 10 mM potassium phosphate buffer, pH 6.8, and the chromatin separated from the nucleoplasm by centrifuation. Chromatin was solubilized in 5 M urea - 0.5 M NaCl and the NHCP separated from histones on hydroxyapatite chromatography. The NHCP were fractionated on sodium dodecyl sulfate (SDS) acrylamide gel electrophoresis. After the gels were dried, autoradiography was used to detect ^{3}H-methyl groups associated with the proteins. Six NHCP from the brain and thymus were methylated, while only five were detected in the liver. (Fig. 1). Some of these proteins appear to be organ specific, while three appear common to all three organs. Nucleoplasm contained proteins with similar molecular weights, as determined by SDS gel electrophoresis. However, all these proteins were devoid of ^{3}H-methyl groups (data not presented). Since the methyl groups of NHCP are heat labial, yielding methanol, it is apparent that they are esterified at the carboxyl position. The carboxyl-o-methyltransferase is primarily located in the nucleoplasm. It has a pH optimum of 8.0, was inhibited by adenosyl-homocysteine, and was specific for non-histone proteins.

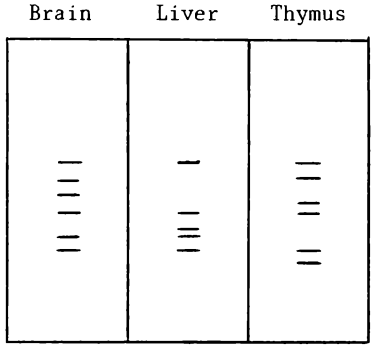

Fig. 1 Diagram of an autoradiogram of ^{3}H-methyl NHCP.

The o-methylation of NHCP was verified in vivo. Twenty-four hours after the rats were given L-[^{14}C-methyl]methionine, chromatin and nucleoplasm from the various organs were prepared as described above. The chromatin was sheared in a Virtus-homogenizer operated at maximal speed for 15 seconds and the NHCP were solubilized by hydrolysis of the DNA with Staphylococcal endonuclease (4). The nucleosomes were removed by centriguation and the supernatant fluid dialyzed against 10mM potassium phosphate buffer, pH 6.8, with 3 changes. Significant amounts of ^{14}C-methanol were detected by gas chromatography from all NHCP analysed. Nucleoplasm was found to contain free ^{14}C-methanol. This suggests that a demethylase may be present.

1. Decker, J. M., and Marchalonis, J. J. (1979) Contemp Top Mol Immunol 7:365-413.

2. Friedman, M., Schull, K. H., and Farber, E. (1969) Biochem Biophys Res Commun 34:857-864.

3. Wallwork, J. C., Quick, D. P., and Duerre, J.A. (1977) J Biol Chem 252:5977-5980.

4. Sollner-Webb, B., and Felsenfeld, G. (1975) Biochem 14:2915-2920.

OBITUARIES (1979-80)

Ernest D. Coon (1889-1980)

Dr. Ernest D. Coon died February 16, 1980 at his home in Grand Forks.

Coon was born on November 17, 1889 in Pierre, S.D. He graduated from the Model High School, University of North Dakota and received a bachelor's degree in 1920 and a master's degree in 1922, both from UND. The University of Wisconsin awarded him the Ph.D. degree in Chemistry in 1932. His entire professional life was spent at the University of North Dakota, where he rose from instructor to full professor of Chemistry. He served as Chairman of the Department from 1957 to 1960, at which time he retired.

Dr. Coon was a member of the American Chemical Society and a member of the Academy from 1923 until his death.

On June 23, 1923 he was married to Jennie Duncan at Neche, N.D. He is survived by his wife and one sister.

Theodore H. Harwood (1911-1980)

Dr. Theodore H. Harwood died May 31, 1979 at his home in Arlington, Vermont. At the time of his retirement in 1973 he was Dean of the Medical School at the University of North Dakota.

Harwood was born on April 28, 1911 in Dorset, VT. After receiving his high school diploma from Burr and Burton Seminary in Manchester, he attended Hamilton College, Clinton, N.Y. and received an A.B. degree. He was awarded the M.D. by the University of Vermont and did post-graduate work at the Lahey Clinic, Boston, the Royal Victoria Hospital, Montreal, and the Mary Fletcher Hospital, Burlington. He became Associate Professor of Medicine at the University of Vermont in 1941, and was named Assistant Dean in 1951.

Dr. Harwood was named Dean of the UND School of Medicine in 1953. He was active in virtually all aspects of medical service and education in the state, including Blue Cross-Blue Shield, Heart Association, Regional Medical Program, and the Medical Societies. Harwood was instrumental in the organization of the Medical Center Rehabilitation Hospital, and developed the outstanding reputation of the two-year medical education program at UND. He prepared the program for evolution to its present four-year status and the awarding of the M.D. degree.

Harwood resigned as Dean in 1973 for reasons of health and retired to his family home in Vermont. He was a member of the Academy from 1954 until his death. He is survived by his wife, Jean, and three children, Judith Williford, Theodore, Jr., and William.

Clifford O. Anderson (1908-1979)

Mr. Clifford O. Anderson died November 5, 1979 in Fargo.

Anderson was born on January 21, 1908 in St. Paul. He graduated from the University of Minnesota and held the B.S. and M.S. degrees in Mechanical Engineering. After teaching at Iowa State College from 1942-1948 he joined the NDSU Mechanical Engineering department where he taught until his retirement. Anderson was an Academy member from 1962 to 1972.

Anderson married Evelyn Johannsen in 1936, and she preceded him in death in 1967. He is survived by three daughters, a brother, and a sister.

Membership of North Dakota Academy of Science

ADOMAITIS VYTAUTAS A	1966301 16TH AVE NE	JAMESTOWN	ND58401
ALBRECHT, STEVEN	1979JAMESTOWN COLLEGE	JAMESTOWN	ND58401
ALESSI JOSEPH	1962N GREAT PLAINS RES CENTE	MANDAN	ND58554
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BARES, RICHARD	1977PROJECT RECLAMATION UND	GRAND FORKS	ND58202
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BLUEMLE JOHN P	1963N D GEOLOG SURVEY UND	GRAND FORKS	ND58202
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BROSCHAT, MYRON D	1976203 E CHANNING AVE	FERGUS FALLS	MN56537
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BRUMLEVE STANLEY	1958PHYSIOLOGY DEPT UND	GRAND FORKS	ND58202
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*CALLENBACH JOHN A	1954ENTOMOLOGY DEPT NDSU	FARGO ND	58102
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CASSEL J FRANK	1954ZOOLOGY DEPT NDSU	FARGO	ND58102
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+ Student member
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DUYSEN MURRAY E	1966RBOTANY DEPT NDSU	FARGO ND	58102
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FRAASE, RONALD G	1973PO BOX 223	BISMARCK	ND58501
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FRANCKOWIAK, JEROME	1979AGRONOMY DEPT NDSU	FARGO	ND58105
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+GLUCK, WILLIAM	1980352 6TH AVE. S., #4	FARGO	ND58103
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GRONHOVD, GORDON H	1957US BUREAU OF MINES	GRAND FORKS	ND58202
+GROSS, THERESA	1978ENTOMOLOGY DEPT., NDSU	FARGO	ND58105
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GUSE, PAUL A	1979SCHOOL OF PHARMACY NDSU	FARGO	ND58105
*GUSTAFSON BEN G	1939421 PRINCETON ST	GRAND FORKS ND	58201
GUTHRIE, PHYLLIS A	197810329 CARROLLWOOD LN #82	TAMPA	FL33618
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HARRELL JAMES W	1970PHYSICS DEPT UND	GRAND FORKS	ND58202
+HARRISON, STEPHEN	1979BIOLOGY DEPT., UND	GRAND FORKS	ND58202
HASSETT, DAVID J	197920 FENTON AVE	GRAND FORKS	ND58201
HAUNZ EDGAR A	19511029 LINCOLN DR	GRAND FORKS	ND58201
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+HOFFMAN, DENNIS	1979	DEPT OF BIOCHEMISTRY-UND	GRAND FORKS	ND58202
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HOLLAND FRANK D	1961	GEOLOGY DEPT UND	GRAND FORKS	ND58202
HOLLOWAY HARRY L	1973	BIOLOGY DEPT UND	GRAND FORKS ND	58202
HOWELL, FRANCIS L	1970	PHYSICS DEPT UND	GRAND FORKS	ND58202
HUNG, YUNG-TSE	1975	CIV ENG DEPT UND	GRAND FORKS	ND58202
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HUSAIN, SYED	1977	PHYS & PHARM DEPT UND	GRAND FORKS	ND58202
+IVERSON, LOUIS	1978	PROJ RECLAMATION UND	GRAND FORKS	ND58202
JACOBS FRANCIS A	1955	BIOCHEMISTRY DEPT UND	GRAND FORKS	ND58202
JALAL SYED M	1965	BIOLOGY DEPT UND	GRAND FORKS	ND58202
JENKINS, DENNIS R	1975	493 MCMULLIN DR	GRAND JUNCTION	CO81501
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JOHNSON, A WM	1961	416 TERRACE DR	GRAND FORKS	ND58201
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JOHNSON DOUGLAS H	1973	BOX 1747	JAMESTOWN ND	58401
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JOHNSON, PHYLLIS E	1978	HUMAN NUT LAB	GRAND FORKS	ND58202
JOHNSON ROBERT E	1969	624 SINCLAIR	BOTTINEAU	ND58318
+JORDE, DENNIS G	1978	BIOLOGY DEPARTMENT UND	GRAND FORKS	ND58202
JOSHI, MADHUSUDAN	1978	ANATOMY DEPT UND	GRAND FORKS	ND58202
KANNOWSKI PAUL B	1960	BIOLOGY DEPT UND	GRAND FORKS	ND58202
KANTRUD, HAROLD A.	1980	ROUTE 7	JAMESTOWN	ND58401
KARNER FRANK R	1963	GEOLOGY DEPT UND	GRAND FORKS	ND58202
KEHEW, ALAN E	1979	315 LEONARD HALL UND	GRAND FORKS	ND58202
KELLEHER JAMES J	1972	MICROBIOLOGY DEPT UND	GRAND FORKS	ND58202
KEMP, JUDY B	1978	253 COLLEGE SW #3B	VALLEY CITY	ND58072
KIESLING RICHARD	1961	PLANT PATH DEPT NDSU	FARGO	ND58102
KILLINGBECK, KEITH	1977	BOTANY DEPT U OF RI	KINGSTON	RI02881
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KLEVAY LESLIE M	1973	223 27TH AVE S	GRAND FORKS ND	58201
KNOBLICH, JEROME	1958	BOX 63	ELDRIDGE	ND58435
KNUDSON, CURTIS L	1978	DOE ENGR RSCH/BOX 20 UND	GRAND FORKS	ND58202
KOCH, FRANK	1979	315 SATURN DRIVE	BISMARCK	ND58501
*KOENKER, WM E	1958	9039 SLIGO CRK PKWY 1812	SILVER SPRING MD	20901
*KOHANOWSKI, N	1949	GEOLOGY DEPT UND	GRAND FORKS ND	58202
KOLLMAN, ALDEN L	1973	PROJECT RECLAMATION-UND	GRAND FORKS	ND58202
KOLSTOE RALPH H	1962	PSYCHOLOGY DEPT UND	GRAND FORKS	ND58202
+KOOB, MICHAEL D	1979	BIOLOGY DEPT UND	GRAND FORKS	ND58202
KOPONEN, MARK A	1975	BOX 5225 NDSU	FARGO	ND58105
+KORTE, SR CLARE	1979	BIOLOGY DEPT UND	GRAND FORKS	ND58202
KRAFT DONALD J	1970	BEMIDJI STATE COLLEGE	BEMIDJI	MN56601
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KRESS WARREN D	1958	GEOGRAPHY DEPT NDSU	FARGO	ND58102
KRUSCHWITZ EARL H	1947	431 6TH ST SW	VALLEY CITY	ND58072
KUBE WAYNE R	1949	CHEM ENG DEPT UND	GRAND FORKS	ND58202
KUCERA HENRY L	1966	AGR ENG DEPT NDSU	FARGO	ND58102
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LAMBETH, DAVID	1979	1909 20TH AVE S	GRAND FORKS	ND58201
LANA EDWARD P	1957	HORTICULTURE DEPT NDSU	FARGO	ND58102
LARSON, GARY F	1978	405 2ND AVE E	W FARGO	ND58078
+LARSON, LAURN	1980	4 N 21ST ST	GRAND FORKS	ND58201
LARSON OMER R	1964	BIOLOGY DEPT UND	GRAND FORKS	ND58202
+LEIER, PAULA	1979	202 BEK HALL, UND	GRAND FORKS	ND58202
LEOPOLD ROGER A	1970	BROOKTREE PK	HARWOOD	ND58042
LI KAM W	1968	MECHANICAL ENG DEPT NDSU	FARGO	ND58102
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LIPP WILLIAM V	197	295 28TH AVE N	FARGO ND	58102
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LOENDORF, LAWRENCE L	1973	ANTHRO DEPT UND	GRAND FORKS	ND58202
LOGUE, MARSHALL W	1979	DEPT OF CHEMISTRY NDSU	FARGO	ND58105
+LOKEN, GREGORY	1978	2918 GRINNELL CT #10	ROCKFORD	IL61109
LORENZ RUSSELL J	1962	N GREAT PLAINS RES CNTR	MANDAN	ND58554
LOW FRANK N	1964	ANATOMY DEPT UND	GRAND FORKS	ND58202
MACCARTHY, RONALD F	1968	2618 CLOVER DR	GRAND FORKS ND	58201
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MADHOK OM P	1967	MINOT STATE COLLEGE	MINOT	ND58701
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*MAGNUSSON, ADELYNN M	1951	703 S 20TH ST	GRAND FORKS	ND58201
MALAND HARTLEY B	1969	LAKE REGION JUNIOR COLLG	DEVILS LAKE	ND58301
+MANSKE, LLEWELLYN L	1978	BOTANY DEPT NDSU	FARGO	ND58102
MANZ, OSCAR	1970	CIVIL ENGR DEPT UND	GRAND FORKS	ND58202
MARKELL CLARK	1972	MINOT ST COLLEGE	MINOT	ND58701

MARTIN DEWAYNE C H	19622104 7TH AVE NW	MINOT		ND58701
MARWIN RICHARD M	1949MICROBIOLOGY DEPT UND	GRAND FORKS		ND58202
MASON, HARRY	19511602 2ND PL NE	JAMESTOWN		ND58401
+MASTEL, JEROME A.	1980BOTANY DEPT., NDSU	FARGO		ND58105
MATHSEN, DON	1970MECH ENGR DEPT UND	GRAND FORKS		ND58202
MATTHIES DONALD L	1973ANATOMY DEPT UND	GRAND FORKS	ND	58202
MCDONALD CLARENCE E	1965CEREAL TECHNOLOGY NDSU	FARGO		ND58102
+MCDONNELL, TIMOTHY	1978ANATOMY DEPT UND	GRAND FORKS		ND58202
+MCKENNA, MICHAEL	19762121 LOVETTE AVE	BISMARCK		ND58501
MCMAHON KENNETH J	1970BACTERIOLOGY DEPT NDSU	FARGO		ND58102
*MCMILLAN WILLIAM W	1947407 7TH ST W	GRAFTON		ND58237
*MELDRUM, ALAN	1957512 COLUMBIA RD	GRAND FORKS		ND58201
+MERCURY, MICHAEL G	1979615 39TH ST N #204A	GRAND FORKS		ND58201
MESSENGER, THEO	1976PHIL DEPT UND	GRAND FORKS	ND	58202
MEYER DWAIN W	1970AGRONOMY DEPT NDSU	FARGO		ND58102
MEYER, MAVIS	1978NORTHERN PRAIRIE WILDLIFE	JAMESTOWN		ND58401
MILLER, DAVID	1979ENERGY RESEARCH CTR UND	GRAND FORKS		ND58202
MILLER, JAMES E	19644901 SEARLE PARKWAY	SKOKIE		IL60076
MITCHELL E N	1960220 GLENHILL LN	CHAPEL HILL		NC27514
MOLITOR, THOMAS	19781121 2ND AVE S	FARGO		ND58102
MOLLAND, GIBBS	19791205 N 22ND ST	BISMARCK		ND58501
MONTGOMERY, GEORGE	1979BOX 76	MANVEL		ND58256
MORRISON, WILLIAM W	1972STATE HEALTH DEPT	BISMARCK		ND58501
MOWERY, GARRY B	1979334 FOREST AVE N	FARGO		ND58102
+MURPHY, KATHLEEN A	1979MICROBIOLOGY DEPT UND	GRAND FORKS		ND58202
MUTH, EDITH ANN	1980	ARDOCK		ND58213
NAISMITH DONALD P	1958MECH ENGR DEPT UND	GRAND FORKS		ND58202
NALEWAJA JOHN D	1963AGRONOMY DEPT NDSU	FARGO		ND58102
NAYES, JAMES B.	1980PLANT PATH., NDSU	FARGO		ND58105
+NEAL, DEAN	1977500 TULANE DR #201	GRAND FORKS		ND58201
NEEL JOE K	1969BIOLOGY DEPT UND	GRAND FORKS		ND58202
NEIDLINGER, TERRY R	19781912 COTTONWOOD ST	GRAND FORKS		ND58201
*NELSON C N	1972NDSU BOTTINEAU BRANCH	BOTTINEAU		ND58318
NELSON DELBERT R	1961218 E OWASSO LN	ST PAUL		MN55112
NELSON DENNIS R	1964MET & RAD RES LAB NDSU	FARGO		ND58102
NELSON, ERIC	1980BOTANY DEPT., NDSU	FARGO		ND58105
NELSON, HARVEY K	196710515 KELL AVE S	BLOOMINGTON		MN55437
+NEWMAN, JOEL P	1979SPYCHOLOGY DEPT UND	GRAND FORKS		ND58202
NIELSON, FORREST H	1974USDA HUMAN NUTR LAB UND	GRAND FORKS		ND58202
+NILL, KIMBALL	1978REED HALL #123	FARGO		ND58102
NORDLIE ROBERT C	1962BIOCHEMISTRY DEPT UND	GRAND FORKS		ND58202
NYSTUEN PEDER A	1964EXPERIMENT STA NDSU	FARGO		ND58102
O'CONNELL JAMES W	1973535 8TH AVE SW	VALLEY CITY	ND	58072
OGAARD, LOUIS	1976AGRIC ECON DEPT NDSU	FARGO		ND58105
OLESON, ARLAND E	1973BIOCHEM DEPT NDSU	FARGO		ND58102
OLSON, JACQUELYN K	1978DOE ENGR RSCH CTR BOX 20	GRAND FORKS		ND58202
+OLSON, NORMAN	1979162 D COURT UNIV VILL	FARGO		ND58102
ORING LEWIS W	1971BIOLOGY DEPT UND	GRAND FORKS		ND58202
ORTH, JAMES	1970CP 1076 SCHEFFERVILLE	QUEBEC CANADA		
+O'TOOLE, FREDERICK	19791324 UNIVERSITY AVE.	GRAND FORKS		ND58201
OVERVOLD, CAROL	1979920 3RD AVE S	FARGO		ND58102
OWEN ALICE K	1966BIOLOGY DEPT UND	GRAND FORKS		ND58202
OWEN, JOHN B	1966BIOLOGY DEPT UND	GRAND FORKS		ND58202
*OWEN, SHUBEL D	19588000 PANORAMA RD	PANORA IA		59216
OWENS THOMAS C	1970CHEM ENGR DEPT UND	GRAND FORKS		ND58202
+PAKOLA, HARLEY A	1978PHYSIOLOGY DEPT UND	GRAND FORKS		ND58202
PARK, CHUNG S	1979DEPT OF ANIMAL SCI NDSU	FARGO		ND58105
PARMAR, SURENDRA	1977PHYS & PHARM UND	GRAND FORKS	ND	58202
PARRILL, CLARK	1977BOX 18	NEWBURG		ND58782
+PARSONS, MICHAEL	1980217 HANCOCK HALL, UND	GRAND FORKS		ND58202
PEARSON, MARGARET A	19771105 N 11TH ST #3	FARGO		ND58102
PEDERSON A ROBERT	1972414 20TH AVE N	FARGO		ND58102
PEDERSON VERNYL D	1968PLANT PATHOLOGY NDSU	FARGO		ND58102
PEKAS JEROME C	1968MET & RAD RES LAB NDSU	FARGO		ND58102
PEMBLE RICHARD H	1971MOORHEAD STATE COLLEGE	MOORHEAD		MN56560
+PERSKY, BRUCE	1972ANATOMY DEPT UND	GRAND FORKS		ND58202
PERSON, DONALD A	19613022 WINSLOW	HOUSTON		TX77025
PETERKA JOHN J	1968ZOOLOGY DEPT NDSU	FARGO		ND58102
PFISTER, PHILIP C	196830 MEADOWLARK LANE	FARGO		ND58102
PORTER, ROBERT B	1976DOE ENERGY TECH CNTR UND	GRAND FORKS		ND58202
PRATT GEORGE L	1961AGRICULTURAL ENGR NDSU	FARGO		ND58102
PRESZLER, DALE A	19781717 E INTERSTATE AVE	BISMARCK		ND58501
PUYEAR, ROBERT L	1968ZOOLOGY DEPT NDSU	FARGO		ND58102
+RAHMAN, AMRANA	1978216 SQUIRES HALL-UND	GRAND FORKS		ND58202
RAND ROGER W	1975542 5TH AVE SW	VALLEY CITY	ND	58072
*RATHMANN, FRANZ H	1955NDSU CHEM DEPT	FARGO		ND58102
+RAY, JOHN T	1979201 WALNUT ST	GRAND FORKS		ND58201
RAY PAUL D	1968BIOCHEMISTRY DEPT UND	GRAND FORKS		ND58202
REDMANN, ROBERT	1964126 MT ALLISON CRES	SASKATOON		SK
REICHMAN GEORGE A	1962306 6TH AVE NW	MANDAN		ND58554
REID JOHN R	1962GEOLOGY DEPT UND	GRAND FORKS		ND58202
REIFF, THEORDORE R	1978DEPT OF MEDICINE UND	GRAND FORKS		ND58202
+REINISCH, JERRY	19773904 UNIV AVE #220	GRAND FORKS		ND58201

+REISKIND, JEREMY	1978GEOLOGY DEPT UND	GRAND FORKS	ND58202
RICHARDSON, J L	19781245 N 9TH	FARGO	ND58102
RINDT, DIANE	1979BOX 8213 UNIV STATION	GRAND FORKS	ND58202
RIEDER WILLIAM G	1973MECH ENGR DEPT NDSU	FARGO ND	58102
RIES, RONALD E	1979908 2ND AVE NW	MANDAN	ND58554
RODEWALD RANDOLPH F	1975SCIENCE DIV MINOT ST COLL	MINOT ND	58701
*ROGLER GEORGE A	1962BOX 459	MANDAN ND	58554
+ROHDE, MONICA	19791132 16TH ST N #2A	FARGO	ND58102
ROTHENBERGER, STEVE J	MIDLAND LUTHERAN COLL	FREMONT	NE68025
RUDESILL JAMES T	1958COLL OF CHEM & PHYS NDSU	FARGO	ND58102
RUSTAN, JERRIL H	1979BOX 140 DSC	DICKINSON	ND58601
*SAIKI A K	1949PATHOLOGY DEPT UND	GRAND FORKS ND	58202
SANDAL PAUL C	1955AGRONOMY DEPT NDSU	FARGO	ND58102
*SANDS F H	1946COLL OF CHEMISTRY NDSU	FARGO ND	58102
SARGEANT ALAN B	1972N PRAIRIE WILDLIFE RES	JAMESTOWN	ND58401
SAUMUR JEAN H	1975PATHOLOGY DEPT UND	GRAND FORKS ND	58202
SCHAFER, JOHN E	1979412 8TH AVE W #4	DICKINSON	ND58601
SCHEIBE, PAUL	19603 SHIRLEY LANE	WOODSIDE	CA94062
SCHIMMELPFENNIG, D.	1978618 BOYD DR	GRAND FORKS	ND58201
SCHNEIDER FREDERICK	1973SOC & ANTHRO DEPT UND	GRAND FORKS ND	58202
SCHOBERT, HAROLD	1978DOE ENGR RSCH BOX 20 UND	GRAND FORKS	ND58202
SCHULZ JOHN T	1960ENTOMOLOGY DEPT NDSU	FARGO	ND58102
SCOBY DONALD R	1968BOTANY DEPT NDSU	FARGO	ND58102
SEABLOOM ROBERT W	1962BIOLOGY DEPT UND	GRAND FORKS	ND58202
+SEARS, SHEILA	1977MRR LAB NDSU	FARGO ND	58102
+SEILER, GERALD J	1978210 WALDRON HALL NDSU	FARGO	ND58102
+SEPE, FRANK	1978PHYSIOLOGY DEPT UND	GRAND FORKS	ND58202
SEVERSON ARTHUR L	1970U S BUREAU OF MINES UND	GRAND FORKS	ND58202
SEVERSON D E	1949CHEMICAL ENGR DEPT UND	GRAND FORKS	ND58202
SEVERSON ROLAND G	1958CHEMISTRY DEPT UND	GRAND FORKS	ND58202
SHELTON, DAVID R	1978BOX 5195 NDSU	FARGO	ND58102
SHELVER, WILLIAM	1979COLLEGE OF PHAR NDSU	FARGO	ND58105
SHUBERT L ELLIOT	1974BIOLOGY DEPT UND	GRAND FORKS ND	58202
SILVERMAN LOUIS B	19572524 OLSON DR	GRAND FORKS	ND58201
SIMS, RODGER L	1979718 25TH ST N	GRAND FORKS	ND58201
SINGH, SHINA P	1978PHYSIOLOGY DEPT UND	GRAND FORKS	ND58202
SLEEPER BAYARD P	1952BACTERIOLOGY DEPT NDSU	FARGO	ND58102
+SLIND, DARLA	19791025 DEL MAR CT #4	MINOT	ND58701
*SMITH, GLENN S	19301115 N 14TH ST	FARGO	ND58102
SMITH HARRY C	1968BOX 145	SAWYER	ND58781
*SNOOK, THEODORE	1954ANATOMY DEPT UND	GRAND FORKS	ND58202
SOMERVILLE MASON H	1974MECH ENGINEERING UND	GRAND FORKS ND	58202
SOUBY ARMAND M	1973CHEMICAL ENGR UND	GRAND FORKS ND	58202
STACK, ROBERT W.	1980PLANT PATH., NDSU	FARGO	ND58105
STANISLAO, JOSEPH	1979ENG & ARCH-NDSU	FARGO	ND58102
*STARCHER GEORGE W	19543605 JAFFA DR	SARASOTA	FL33579
STARKS, THOMAS	1978503 S ASH	CROOKSTON	MN56716
STATLER GLEN D	1970PLANT PATH DEPT NDSU	FARGO	ND58102
+STEFANOVSKY, GARY	1980923 B N 20TH	GRAND FORKS	ND58201
STENBERG VIRGIL I	1961CHEM DEPT UND	GRAND FORKS	ND58202
STEWART JAMES A	1960CHEMISTRY DEPT UND	GRAND FORKS	ND58202
STINNETT, HENRY O	1978PHYSIOLOGY DEPT UND	GRAND FORKS	ND58202
STOAKS, RALPH D	6714 NORTHWEST DR	DES MOINES	IA50322
STOY, W. MICHAEL	19801826 N. BELL ST.	BISMARCK	ND58501
+STRIEGEL, PAUL	1978ROUTE #2	BISMARCK	ND58501
SUGIHARA JAMES M	1965GRADUATE SCHOOL NDSU	FARGO ND	58102
SUMMERS LAWRENCE	1951CHEMISTRY DEPT UND	GRAND FORKS	ND58202
SWANSON GEORGE A	19671727 4TH AVE NE	JAMESTOWN	ND58401
SWANSON RICHARD J	1972507 3RD ST CT	WEST FARGO	ND58078
+TAYLOR, RAYMOND J.	19802914 7TH ST. N., #3	FARGO	ND58102
THACKER EDWARD J	196411 WOODCREST DR	FARGO	ND58102
THOMPSON CLARENCE E	19751526 COTTONWOOD ST	GRAND FORKS ND	58201
THOMPSON, JOAN	1977NDSU BOX 15 STEVENS	FARGO	ND58102
THOMPSON MICHAEL B	19702208 CRESCENT DR	MINOT	ND58701
TILTON JAMES E	1966ANIMAL SCI DEPT NDSU	FARGO	ND58102
TIMIAN ROLAND G	1954PLANT PATH DEPT NDSU	FARGO	ND58102
TIMPE, RONALD C	1973MAYVILLE STATE COLLEGE	MAYVILLE	ND58257
TODD ROBERT G	1962DICKINSON STATE COLLEGE	DICKINSON	ND58601
VANALSTINE JAMES B	1975DIV OF SCI&MATH UNIV MN	MORRIS MN	56267
VAN DEUSEN JAMES L	1975USFS SHELTERBELT LAB	BOTTINEAU ND	58318
VENETT, JAMES R	PLANT PATH-NDSU	FARGO	ND58102
VENNES JOHN W	1957MICROBIOLOGY DEPT UND	GRAND FORKS	ND58202
VINCENT MURIEL C	1957COLL OF PHARMACY NDSU	FARGO	ND58102
VOLESKY, ALLEN E	1978DOE ENGR RSCH BOX 20 UND	GRAND FORKS	ND58202
WAHTOLA, CHARLES H	1970457 PARK AVE	PEWAUKEE	WI53072
WALLER JAMES R	1971MICROBIOLOGY DEPT UND	GRAND FORKS	ND58202
WALLWORK, JAMES C	1979HUMAN NUTRITION LAB UND	GRAND FORKS	ND58202
WALSH ROBERT G	1968MINOT STATE COLLEGE	MINOT	ND58701

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 WANEK WALLACE J      1965RT 1 BOX 307              BEMIDJI          MN56601
 WARD, GREGORY T      1978ANATOMY DEPT MICH STATE UE LANSING         MI48824
*WARDNER, C ARTHUR    19583518 CHERRY ST            GRAND FORKS      ND58201
 WATREL- ALBERT A     19791071 W 5TH ST             DICKINSON        ND58601
 WEISSER WILBUR U     1957PHYSICS DEPT UND          GRAND FORKS      ND58202
 WERTH RICHARD G      1964CONCORDIA COLLEGE         MOORHEAD         MN56560
 WETSCH, JOHN R.      1977BOX 277                   KILLDEER         ND58640
*WHEELER GEORGE C     1924DESERT RES INST UNIV NV   RENO             NV89507
 WHITE GLYNDON        1972BOX 1394                  JAMESTOWN        ND58401
 WHITMAN WARREN C     1950BOTANY DEPT NDSU          FARGO            ND58102
 WICKS ZENO W         1974POLYMRS & COAT DPT NDSU   FARGO ND         58102
 WIEDERANDERS R E     1968HARMON PARK CLINIC        WILLISTON        ND58801
*WIIDAKAS WILLIAM     1946AGRONOMY DEPT NDSU        FARGO ND         58102
 WILLIAMS NORMAN D    1965AGRONOMY DEPT NDSU        FARGO            ND58102
 WILLMAN, CLYDE A     1968620 10TH ST S             FARGO            ND58102
 WILSON, RUSSELL H    19666218 WALNUT HILL LN       DALLAS TX        75230
+WINBOURN, GARY        1979GEOLOGY DEPT UND          GRAND FORKS      ND58202
 WINCZEWSKI, LARAMIE  1977ROUTE 1                   BUXTON           ND58218
 WINGER, MILTON       1973MATH DEPT UND             GRAND FORKS      ND58202
 WITZ RICHARD L       1960AGRI ENGR DEPT NDSU       FARGO            ND58102
 WOLF, EDWARD G       19771436 TIPPERARY            BOULDER          CO80303
+WOLFSON, ALAN C       1979BOX 8 ABBOTT HALL UND     GRAND FORKS      ND58202
 WORTHAM KENNETH E    1975BIOL DEPT-STATE COLLEGE   MAYVILLE ND      58257
 WOSICK, FREDERICK D  1975569 SUNSET PLACE          BISMARCK         ND58501
 WRENN WILLIAM J      1970BIOLOGY DEPT UND          GRAND FORKS      ND58202
 WYMORE, ROBERT W     1977350 1ST ST NW             MAYVILLE         ND58257
+YUTRZENKA, GERALD     19783719 UNIVERSITY AVE #310  GRAND FORKS      ND58201
 ZELAZEK, JOHN R      1979812 4TH AVE SW            VALLEY CITY      ND58072
 ZIEMAN DALE M        1961DICKINSON ST COLLEGE      DICKINSON        ND58601
 ZIMMERMAN, EMIL      1979                          RICHARDTON       ND58652
+ZOELLNER, ROBERT W    1978CHEM DEPT UND             GRAND FORKS      ND58202
 ZOGG, CARL           1979PHYSIOLOGY DEPT UND       GRAND FORKS      ND58202
 ZOLLER, MARK L       1977PO BOX 5888               DENVER           CO80217
 ZUBRISKI J C         1955SOILS DEPT NDSU           FARGO            ND58102
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