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NORTH DAKOTA ACADEMY OF SCIENCE
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Editor's Notes

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 in 1979 with Volume XXXIII of the Proceedings of the North Dakota Academy of Science, a new 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 the 44 papers presented in the six symposia at the 1986 annual meeting of the Academy. The papers are presented in the same sequence as presented at the meeting, and are numbered as they appeared in the meeting program.

The second section of this volume of the Proceedings contains the 58 communications presented in the Professional section of the 1986 annual meeting of the Academy. All professional communications were reviewed for conformity with the instructions 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.

The third section of this volume contains the 30 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 review prior to publication herein. The Denison Awards Committee judged the oral presentation and the communication 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.

Readers may locate papers by presentation number within the major sections of these Proceedings or by referring to the author index in this volume for a page reference.

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 possible. 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 three 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.)

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   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.

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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 suggested that authors select a sufficient number of keywords to describe the full content of their paper, and then construct a title using as many as these as practicable. Titles normally should not exceed 140 characters in length. In particular, they should be free from unnecessary 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." Agron. 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.

SYMPOSIUM

on

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Electrical Engineering Department, UND
Grand Forks, ND

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(1) USE OF STRAIN GAUGES IN ROBOTICS

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Advances in robotics technology and automation of industrial processes demand providing industrial robots with precise sensors and sophisticated schemes for fast action and better adaptation to the surrounding environment. Identification of objects and their location and orientation in the work-space of the robot is a basic requirement in applications like assembly and quality control. Artificial vision using cameras and image processing was found to be effective under specific lighting conditions and tolerated speed. Use of load cells as tactile sensors facilitates identifying location of objects in an efficient and precise way [1].

Here we present the experimental results for an identification method based on sensing the gravitational force that is inserted on load cells or strain gauges. A rigid plate supported at its corners by load cells was used as a platform for locating objects. Distribution of forces at the corners of the platform determines the location of center of gravity for the object and consequently the cartesian coordinates, required by the robot to reach that object, could be identified. The static equilibrium equations, for the platform, about the center of gravity for the object were used to derive the identification equations. The robot controller will then convert the cartesian coordinate values into natural joint coordinate values which are used for direct control commands. Figure 1 shows a picture of the constructed 34 x 40 cm platform where the load cells are of the Lebow, model 3168 type. These load cells have strain gauges bonded to their interior structure and they are connected in a four arm Wheatstone bridge configuration network. The bridge generates 2.2 mV per input volt at its full capacity of 10 Ibs. To interface the bridges with the computer, for data acquisition and processing, a Burr-Brown instrumentation amplifier (INA101) was used. This amplifier was operated at a gain of about 600. A four channels Analog-to-Digital (A/D) converter of a 7-bits resolution was also employed. Table 1 shows the results of identifying several arbitrarily selected locations on the platform, where X and Y are the cartesian distances from the origin corner shown in Figure 1. The errors in identifying locations were found to be well within a calculated maximum error of 0.6467 cm which is obtained from the following derived formula,

$$\text{max. error} = \frac{2L}{2^{n-4}} \quad \text{cm}$$

where L is the length of the platform and n is the number of bits of the A/D. It is apparent from the above equation that more resolution of the A/D will result in a considerable reduction in errors. A 12-bits A/D will reduce the errors of Table 1 by a factor of 32, bringing them down to a small fraction of a millimeter which is acceptable in many practical applications.

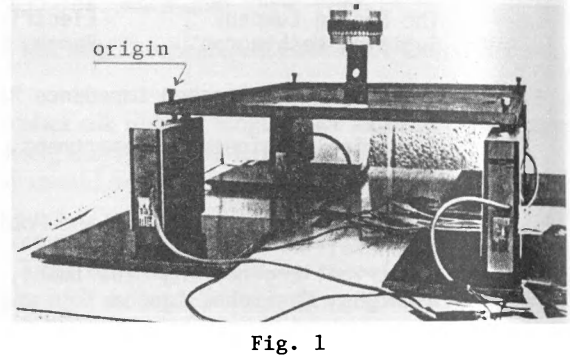

Fig. 1

[1] Sherif S. Gindy, "A New Concept For Strain Gauge Tactile Sensing", Robot 8 Conference, Detroit, Michigan, June 4-7, 1984.

Table 1
w = 105 counts

Measured		Identified location		Error		
X_{cm}	Y_{cm}	X_{cm}	Y_{cm}	$\lvert\Delta X\rvert_{cm}$	$\lvert\Delta Y\rvert_{cm}$	$\lvert\Delta\rvert_{cm}$
5.5	7.5	5.8114	7.2561	0.3114	0.2439	0.3114
28.4	6.3	28.4114	6.1104	0.0114	0.1896	0.1896
9.0	13.4	9.04	13.3666	0.04	0.0334	0.04
26.0	14.2	25.8285	14.13048	0.1715	0.0696	0.1715
8.0	27.8	8.0714	27.8790	0.0714	0.0790	0.079
21.0	26.4	21.3085	26.7333	0.3085	0.3333	0.3333
10.2	33.9	10.6542	34.3714	0.4542	0.4714	0.4714
26.4	31.8	26.7971	32.08	0.3971	0.28	0.3971
0.0	0.0	0.3228	0.3919	0.3228	0.3919	0.3919
33.9	0.0	34.2228	0.0	0.3228	0.0	0.3228
33.9	40.1	34.2228	39.7181	0.3228	0.3819	0.3819
0.0	40.1	0.3228	39.7181	0.3228	0.3819	0.3819
17.0	20.0	17.1114	19.8590	0.1114	0.141	0.141

(2) RF SPECTRUM CONSERVATION/NARROW BAND TODAY

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Technology and Regulation have determined the system operational Bandwidths utilized by Radio Products since the development of two way Radio Communications. Recently, demand for services and an intense increase in applications interest has caused renewed efforts to expand the available channels. Major efforts to employ conservational techniques like frequency reuse, channel splitting, trunking, FDMA and TDMA digital radio, and even Spread Spectrum have been proposed along with narrower channel allocations to alleviate the congestion. A clear solution is not visible.

Modulation modes and Signal Processing Techniques have also been studied including; Narrowband FM (1), compandored SSB (2), reduced carrier transparent tone-in-band (3) and tone above band suppressed carrier sideband. The wide proliferation of data into radio has dichotomized the desire to operate narrow bandwidth channels with the ever increasing throughput needs of Data systems. Optimization of parameters is vital.

Efforts are being made to investigate the low energy wide band techniques of spread spectrum, however, narrower channels and the required processing of information have been quietly evolving a variety of SSB systems. Air to Ground telephone, for example, is currently employing 6 KHz channels at 900 MHz (4) and tests have already been performed on Satellite links at 4.5 GHz (5). We will summarize the parameters of several SSB systems and discuss their features and restrictions.

System	Channel	Frequency	Modulation	Service
Airfone, Inc.	6 KHz	945 MHz	Voice, FSK, CSSB	Air/Ground Telephone
CCC [1]	5 KHz	152 MHz	Voice, PSK, FFSR	VHF Mobile Telephone
SkyLink Corp.	5 KHz	12 GHz	Voice, RSM, ACSB	Satellite Communication
Stevens [2]	5 KHz	160 MHz	Voice, CTCSS, ACSB	VHF Dispatch Radio

[1] Contemporary Communication Corp. [2] Stevens Engineering Associates

The Table shows several systems that are in or near operation utilizing some form of SSB along with their frequency, channel spacing, modulation system and the type of information sent in the channel. Regulators are being forced into comparing technologies and their relative advantages and have established several band segments for experimentation.

Signal processing techniques have made it possible to attempt data transmissions using SSB and several reduced carrier systems are discussed including: Feed Forward Signal Restoration, Transparent Tone in Band, Controlled Carrier and, Tone Above Band Single Side Band. Each has its own merits and demerits, forcing specific system applications decisions.

1. Lee, C.Y., (1985), Spectrum Efficiency: A Comparison Between FM and SSB In Cellular Mobile Systems, Two Way Radio Dealer, Vol. 220, 100-115.
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3. McGeehan, J.P. et al. (1984), Data Transmission Over Fading Mobile Radio Channels, IEE Proceedings, Vol. 131, 364-374.
4. Childs, Joseph R. (1985), Proceedings of the 35th IEEE Vehicular Technology Conference, May 21-23, 1985, 73-80.
5. SkyLink Corp., (1985), Application For Mobile Satellite Service, Application for FCC License, Vol. 2, 46-56.

(3) OPTICAL FIBER COMMUNICATION WITH COMPENSATION ON THE RECEIVING END

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The LED has been used as an optical source for optical fiber communication systems. The advantages of the LED are small size, compatible with optical fiber, ease of modulation, long lifetime, insensitive to the interference of electromagnetic fields and low cost compared with a laser diode. But there are some drawbacks in using the LED as the optical source. In analog applications the main problem is the nonlinearity of the LED's dynamic characteristic. This will cause harmonic and intermodulation distortion and result in the degradation of the ratio between signal and noise, especially in deep modulation and multichannel applications.

There are many methods of improving the LED's nonlinearity, such as negative feedback compensation, feedforward compensation, quasi-feedforward compensation, selected harmonic compensation, and nonlinear phase shift modulation techniques. All these methods were carried out on the transmitting end. We now present two other methods to reduce the harmonic and intermodulation distortion on the receiving end.

One method of reducing the second order distortion of the LED on the receiver end is the use of a two piece-wise linear compensation active network. After receiving the optical signal being demodulated on the receiver end, the output is proportional to the optical power, which has been distorted. Then letting this signal pass through another suitable nonlinear device, one can get the resulting signal, which has two second order distortion terms. Correctly choosing the parameters of the nonlinear device in order to insure that these two terms have the same magnitude and opposite sign, these two terms can be cancelled (or significantly reduced) i.e., the second harmonic and intermodulation distortion cancelled. Here, of course, higher order distortions are created. Fortunately, in practice, they are very small compared with the original second order distortion. Theoretically, an improvement of 20 to 30 dB can be reached. If one wants to reduce or cancel the second and third order distortion simultaneously, a three piece-wise linear compensation active network must be used. Experimently an average improvement of 10 dB has been achieved over the range of modulation index from 20% to 100%.

A second method of reducing the second order distortion of the LED is the use of multipliers on the receiver end. The received optical signal, which has been demodulated, is fed to the two inputs of a multiplier simultaneously. The output of the multiplier is the square of the signal. This signal then is sent to one input of the second multiplier. The other input is a constant, but can be controlled in order to get the second order distortion equal to original second order distortion in magnitude but with opposite sign. Then adding the original signal, which has not passed through the multiplier, and the signal, which has passed through the multiplier, results in the cancellation (or significant reduction) of the second order terms. Here the higher order terms which are caused by the square of signal, are neglected. The optimum constant is controlled by a microcomputer. An average of 9.8 dB reduction of the intermodulation distortion is observed in this approach. For the harmonic distortion, an average of 8.1 dB reduction can be achieved. If one wants to eliminate the higher order terms, then more multipliers must be used.

The two methods that were investigated for the reduction of second harmonic and intermodulation distortion on the receiving end in optical fiber communication systems have both shown encouraging results.

(4) RECENT ADVANCES IN DIPOLE ANTENNA DESIGN

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The main goal of this paper is to modify the current distribution along a dipole antenna for the purpose of maximizing the gain in specified directions and minimizing it in other directions. The multiple voltage excitation technique along the antenna is employed to control the current distribution. For N multiple excitations, the complex voltage value and location of each source are the optimization parameters in the routine used to maximize the gain at $\theta = 90°$ which is calculated using the numerical electromagnetics code (NEC) based on the method of moments by Burke and Poggio (1). The results are obtained for different numbers of excitations located at different antenna lengths of $\lambda/2$, λ, $3\lambda/2$ and 2λ and indicate that both the gain and beam width are improved by employing this technique at the expense of appearance of new side lobes and requirement for the design of a more complicated feed network following the approach suggested by Saoudy and Hamid (2).

The same procedure is followed using multiply lumped impedance loadings along the antenna. In the optimization routine the real value of the loading impedances is allowed to become negative to investigate the feasibility of using active elements as well as passive ones to maximize the gain for various antenna lengths. The optimization parameters not only include the complex values of the loading impedances but also the location of each load and the number and location of the feed voltages.

Another advantage of introducing active elements in the design of a monopole over a ground plane is to achieve antenna resonance at a lower frequency or to reduce the physical height of the monopole at any given frequency. This is along the procedure proposed by Saoudy and Hamid (3) involving a modification in the transistor circuitry of an active loop monopole antenna which can reduce the electrical height of loop monopoles and dipoles by a larger factor than previously reported. This is simply achieved by placing the transistor in the appropriate location along the wire and connecting the collector to the emitter or base through a resistor. The location of the transistor whose parameters are predetermined, is optimized in order to diminish the imaginary part of the input impedance. Thus a prediction is made that already existing monopole antennas can operate efficiently (transmit and/or receive) at very long wavelengths through this modification.

The authors wish to acknowledge the financial sponsorship of the Faculty of Graduate Studies of the University of Manitoba and the Natural Sciences and Engineering Research Council of Canada who made this research possible.

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2. Saoudy, S. and Hamid, M. (1985) 1985 North Amer. Radio Sci. Meet., Vancouver, June 17-21, U.R.S.I. Symposium Digest, p. 60.

3. Saoudy, S. and Hamid, M. (1985) Int. J. Electronics, Vol. 58, No. 6, pp. 933-939.

(5) OPTIMUM FIBER OPTIC RECEIVER SENSITIVITY IN THE LONG-WAVELENGTH REGION

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The reduction in dispersion and attenuation in optical fibers at long wavelengths, 1100 to 1600 nm, has led to increased research into the design of long-wavelength fiber optic receivers. Of primary concern to this design for digital systems is the determination of the sensitivity of receivers incorporating state-of-the-art long-wavelength photodetectors (avalanche photodiodes [APD's] and PIN diodes) and transistor (FET and BJT) amplifiers.

An expression for the sensitivity of a fiber optic receiver is derived from expressions for the mean-squared noise currents and voltages (referenced to the receiver input) of BJT and FET transistors and APD and PIN photodiodes (1). This expression is optimized with respect to bit rate by optimizing the base and collector bias currents (in BJT's) and the avalanche gain (in APD's) which are themselves functions of bit rate. Plots of optimized receiver sensitivity versus bit rate can easily be made for any combination of photodiode and transistor amplifier. Factors which are independent of bit rate such as data format integrals (2), wavelength, input impedance, and device characteristics can be varied to accommodate specific devices and configurations.

Figs. 1 and 2 show the optimized sensitivity versus bit rate (1 to 100 Mbits/s) for the two most popular amplifier types using a Si JFET and a Si microwave BJT, respectively. In each case the amplifier is combined with one of the following state-of-the-art photodetectors: 1) InGaAs PIN, 2) InGaAs/InP PIN, 3) InGaAsP/InP PIN, 4) Ge APD, 5) InGaAs APD, 6) GaAlAsSb APD, 7) InGaAs/InP APD, 8) GaAlAs/GaAs APD, 9) GaAlSb/GaSb APD, or 10) InGaAsP/InP APD. Both figures are plotted for return-to-zero bit pattern format, 1550-nm wavelength, and high impedance amplifier configuration. The device characteristics are typical values available from technical journals.

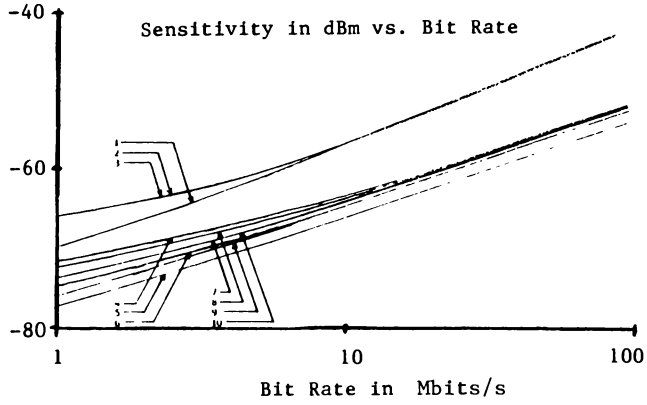

Fig. 1 Sensitivity for a Si JFET amplifier and ten different photodetectors.

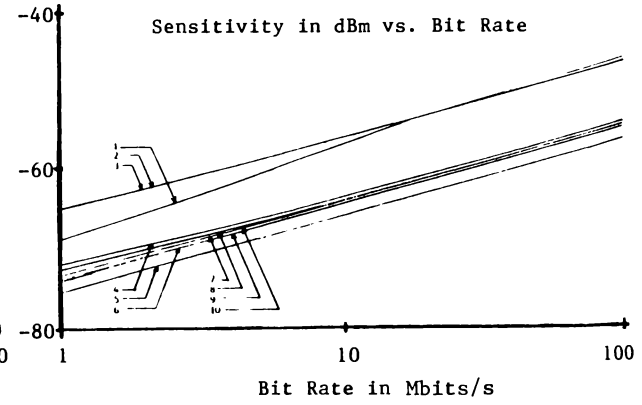

Fig. 2 Same as Fig. 1 but for a Si microwave BJT amplifier.

These figures show the better sensitivity expected by using an APD over a PIN photodiode (specifically, InGaAs). In addition, at low to moderate bit rates, the better noise characteristics of the FET make it 1 to 2 dB more sensitive than the BJT. This small gain in sensitivity is especially important in long distance communications where the number of repeaters must be minimized for cost effectiveness. At higher bit rates the FET becomes noisier than the BJT due to a bit rate cubed noise term compared to a bit rate squared noise term for the BJT. Hence the BJT is a more sensitive receiver. Additional plots of sensitivity versus bit rate for other FET type transistors (MOSFET, MESFET) and other configurations as well as different system parameters can be made to provide an essential graphical aid for a fiber optic system designer (3).

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(6) DESIGN OF STRIPLINE STEPPED IMPEDANCE RESONATOR FILTERS FOR MOBILE COMMUNICATION

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The helical resonator filters traditionally used for mobile communication exhibit deteriorating performance over temperature variation and changing weather conditions. The stripline stepped impedance resonator band-pass filters may be suitable replacement of helical resonator filters especially with the high-Q dielectric materials now available for this purpose.

This paper summarizes the simple design, fabrication and performance of a stripline stepped impedance resonator band-pass filter at 858.5 MHz. The performance of the filter over a temperature variation of -30°C to +70°C has also been investigated and suitability for mobile communication has been established.

The filter has been designed to meet the mobile communication specifications as; Pass-band 15 MHz (851-866 MHz), Center frequency f_o=858.5 MHz, Chebyshev response, Pass-band ripple 0.01 dB, Center frequency insertion loss 1.5 dB and insertion loss at $f_o \pm 22.5$ MHz as 35 dB.

Selection of impedance ratio $K(=Z_2/Z_1)$ and spurious resonance frequencies are important design considerations. It is observed that K<1 is more suitable for physical compactness or wide stop band characteristics while K>1 results in low in-band loss. For mobile communication K>1 is selected to result into low insertion losses. For present case K=1.5 with Z_1=33.3 ohm and Z_2=50 ohm, (Fig. 1).

The resonance condition is given as, $\theta_o = \tan^{-1}\sqrt{K}$

and spurious resonance frequencies are determined from,

$$\frac{f_{s1}}{f_o} = \frac{\pi}{2\tan^{-1}\sqrt{K}} \quad ; \quad \frac{f_{s2}}{f_2} = 2\left(\frac{f_{s1}}{f_o} - 1\right) ; \quad \frac{f_{s3}}{f_o} = \frac{2f_{s1}}{f_o}$$

where f_{sn}(n=1,2,3,...) are spurious resonance frequencies.

The number of resonators n and the admittance slope parameters are obtained by the usual method given by (1). The filter shown in Fig. 2 is designed from even and odd mode impedances of the coupled microstrip line. The parallel coupled sections are treated as impedance inverters.

The filter has been fabricated using the substrate PTFE-glass copper clad, K=6098-11 with ε_r=2.5 and thickness h=62.5 mil and spacing between two ground planes b=125.0 mil. The photolithographic technique has been used for fabrication with 6500 lbs. pressure at 200°C to obtain a fine bonding interface.

The filter has been tested for its performance using a spectrum analyzer, tracking generator and network analyzer. The pass-band insertion loss is 1.5 dB with 0.2 dB ripple. The 3 dB and 50 dB bandwidths are 20 MHz and 48 MHz respectively and a very sharp cutoff is observed at 56 MHz. The temperature performance of the filter shows a stability of 37.3 ppm/°C for a 100° temperature variation.

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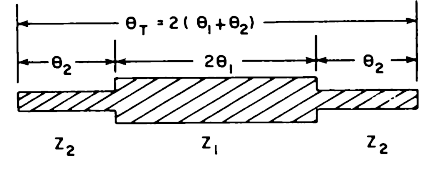

Impedance ratio, $K = Z_2/Z_1 > 1, \theta_T > \pi$

Fig. 1. Structure of Stepped Impedance Resonator (SIR)

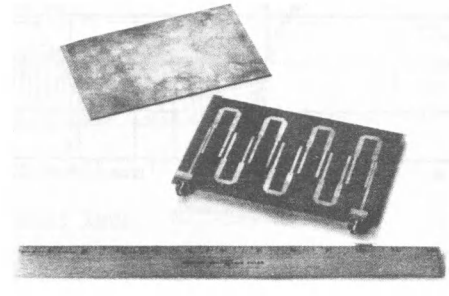

Fig. 2. Bandpass filter using SIR

(46) VEHICULAR ANTENNA CONCEPTS FOR LAND MOBILE SATELLITES

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The land mobile satellite communication is intended to provide a direct communication link for private and commercial vehicles. The transmission will be circularly polarized and will operate within the frequency band of 821 MHz - 876 MHz. With a geostationary satellite the vehicular antenna must track the satellite beacon to retain its beam stationary in the space and in a proper elevation angle, to maximize the signal reception. In the North American region, the antenna beam must cover the elevation angles between 10° to 60°. The tracking requirement can be met either by the mechanical systems or electronics phase shifters, using small phased arrays. The former can use existing technology, but may not be desirable due to the high cost and weight or large size. The electronic tracking can be more attractive, but its cost and complexity depends on the antenna configuration. The required gain of the antenna is planned to be around 12 dB_i (U.S. approach) or 9 dB_i (Canadian approach). Such gains can be met by a variety of antennas, in the form of small phased arrays. The unit cost will be mostly in the beam forming electronics and will depend on the array size. The desirable antenna configurations also depend on the application and the vehicular shape. For private vehicles, the low profiles are more desirable, but the commercial vehicle may require small sizes with medium heights.

To date, four different antenna configurations have been designed and evaluated. Here only two candidates will be described briefly. For low profile applications, microstrip antennas are prime candidates where the fabrication is simple and the beam forming network can be integrated with the array. The array elements can operate in the dominant mode which requires beam scanning in the elevation, or the higher order modes with the maximum radiation in the desired evaluation. Our designed unit consists of a 19-element circular patch array, which operates in the dominant TM_{11} mode. Its configuration was optimized to give the required 9 dB_i gain with a good ellipticity within the coverage zone [1]. Fig. 1 shows the geometry and a sample of its measured pattern, using a rotating dipole method. The measured gain, including the losses associated with the beam forming network was at 10 dB_i.

The second unit was designed using drooping and inverted V-dipoles. Here the element height above the ground plane was used to increase the gain. Consequently, the required array size is considerably smaller. Fig. 2 shows the array geometry and a sample of the element pattern, again measured using a rotating dipole method. The peak radiation is at about 25° elevation with an element gain of about 5 dB_i. Adequate gain can therefore be obtained from a small array of about 7-elements. Its small size reduces the beam forming network cost and consequently, the unit is a low cost option desirable for commercial vehicles.

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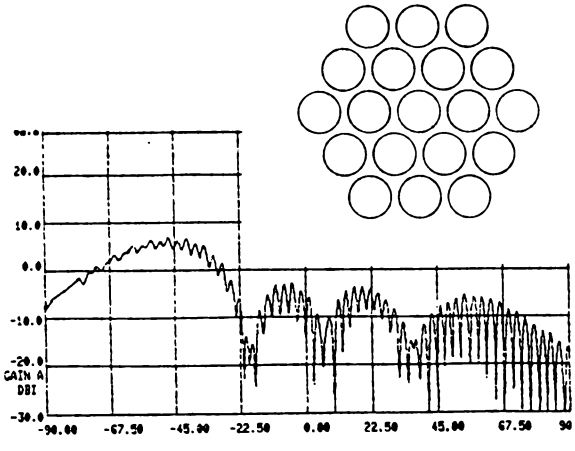

Fig. 1 Measured Elevation Pattern of Microstrip Array.

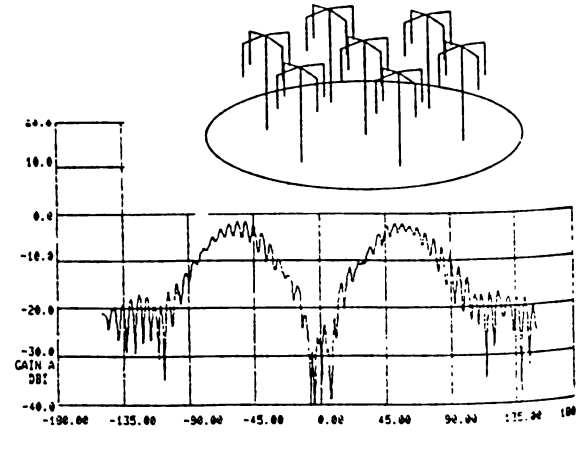

Fig. 2 Measured Elevation Pattern of Dipole Array.

(47) QUASI-STATIC CHARACTERISTICS OF INHOMOGENEOUS BROADSIDE-COUPLED STRIPLINES WITH ARBITRARY ANISOTROPIC SUBSTRATES

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In the last few years, interest in the analysis of planar striplines constructed using anisotropic dielectric materials has increased (1). Basically this has occurred because: (a) many of the dielectric materials used in microwave integrated circuits or for microstrip antennas are naturally or artificially anisotropic and (b) the anisotropic dielectric can be used in order to improve the characteristics of certain circuits.

In a previous work (2), the method of moments was used for the characterization of symmetric inhomogeneous broadside-coupled striplines. This type of structure permits the development of nonhomogeneous filters and directional couplers with certain advantages in relation to those that use homogeneous structures. In (2), the expression for the Green's function, obtained in integral form from the boundary value problem, was expressed in a series form. Anisotropic dielectric layers were considered to be oriented so that their tensors were diagonal.

In this work the analysis developed in (2) is extended in order to include symmetric inhomogeneous broadside-coupled striplines with two more layers and asymmetric inhomogeneous broadside-coupled striplines (Fig. 1). In addition, the relative permittivity tensor of each layer is nondiagonal.

The determination of the Green's functions for the even and odd propagating modes for the structures was accomplished by solving Laplace's equation in each anisotropic dielectric region and imposing the boundary conditions inherent for each structure. The boundary value problems for the structures considered are similar, permitting their rapid characterization through the method of moments (1),(2). Integral forms of the Green's functions were used.

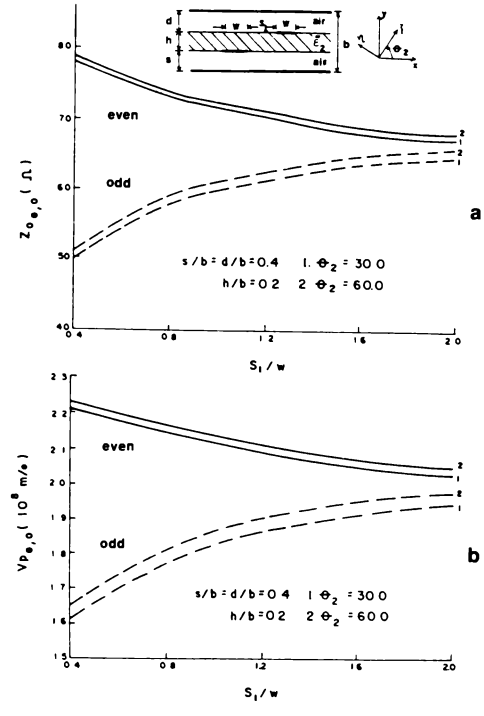

Fig. 1 (a) Characteristic impedances and (b) phase velocities, versus S_1/w, for Epsilam 10 as medium 2.

The results of this analysis agree with those of Kitazawa et al. (3), for the special case of asymmetric suspended striplines using broadside coupling. Fig. 1 demonstrates the effects of the arbitrary anisotropy of one of the layers in this structure on the even- and odd-mode characteristics. Still as a special case in this study, parallel-coupled microstrip lines on two anisotropic layers were considered. Excellent agreement with the results of Horno and Marques (4) was observed.

The method of moments showed itself to be quite adequate for the quasi-static analysis of nonhomogeneous striplines with arbitrary anisotropic layers. For simplified structures, agreement was observed with the results obtained by a variational method (3),(4).

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[1] Presently at North Dakota State University, E.E.E. Dept., supported by CAPES and UFRN, Brazil.

(48) MULTIFEED TECHNIQUE TO GENERATE ANY HIGHER ORDER MODE OF CIRCULAR MICROSTRIP ANTENNAS

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Circular microstrip antennas when operated at the fundamental mode, generate broadside radiation pattern and when operated at the higher order modes, generate a conical pattern with a null along the broadside direction [1],[2]. The direction of the maximum radiation shifts towards the endfire direction with increase in the mode order and/or with the increase in the value of the dielectric constant of the substrate [3],[4]. The lower elevation angle radiation patterns (typically 30° to 50° from the endfire direction) are required for the mobile satellite vehicular communication.

In order to operate a circular microstrip antenna at any particular higher order TM_{n1} mode, when the antenna is fed at a single point, all the lower and higher order modes are generated thereby distorting the actual radiation pattern of the desired TM_{n1} mode. Normally, the effect of lower order modes is more significant due to the shape of their radiation pattern and their tendency to be excited more efficiently. To prevent the excitation of these lower order modes, the antenna may be fed at several locations. Because the intensity of each mode is simply the Fourier coefficient of the total field, they can be cancelled by forcing appropriate degree of symmetry in the excitation source. A multifeed technique has been proposed to generate only a particular TM_{n1} mode. In this technique, to generate any particular linearly polarized TM_{n1} mode, the circular microstrip antenna must be fed at n radial points which are spaced at an angle 360/n degrees with identical inputs. The zero order modes are suppressed by shorting the center of the disk to the ground plane. This arrangement cancels all the lower order modes and most of the higher order modes except the multiples of the nth mode. To generate circularly polarized TM_{n1} mode, additional n feed-points are required, which must be placed at an angle 90/n degrees with respect to the previous n feed-points. The inputs to these additional n feed-points must be of equal magnitude but in phase quadrature to those of previous n feed-points. These circular microstrip antennas with multifeed arrangement for the various modes have been analyzed numerically using a Numerical Analysis Program and results were consistent with the theory.

Experiments have been carried out for the TM_{21} and TM_{41} modes operation using the above multifeed technique. The substrate specifications are $\varepsilon_r = 2.32$ and thickness = 0.159 cm, and the resonant frequency of the antenna is 4.0 GHz. For the TM_{21} mode operation, the disk was excited at two feed-points spaced 180° apart with identical inputs using two-way power divider. The measured peaks for both the fields (E_θ and E_ϕ) were at an angle 50° from the endfire with a null of 30 dB along broadside. For the TM_{41} mode operation, the disk was fed at four feed-points located 90° apart with a four-way equal power divider. The measured peaks for both E_θ and E_ϕ were along 35° from the endfire with 20 dB null along the broadside. The circularly polarized radiation pattern for the TM_{21} mode was obtained by feeding the disk at four points using two two-way equal power dividers and one two-way 0° - 90° power divider. The ellipticity of the radiation pattern was less than 2.5 dB for all the angles greater than 10° from the elevation and the beam peak was at 50° from the elevation. The experimental results justify the multifeed technique proprosed.

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(49) FILTER MINIATURIZATION - WAVE OF THE FUTURE

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The frequency selective filter, often called the electric wave filter, frequently uses the TEM mode of operation, as well as coupled electromechanical means. Considerable change in volume for given filter capability has occurred over the years, and the once-familiar saying of "Q comes by the gallon" has been tested and severely challenged. Since Q (quality factor) is linked to filter shape factors and insertion loss, it has been difficult to compromise filter size and Q so that newer, smaller filter designs can keep up with the pace of electronic miniaturization and its tightening specifications.

In coincidence with electronic "downsizing", it is easy to see the material world collapsing; cars, stereos, home products such as humidifiers and cameras, have shown a drastic decrease in size and increase in capability in the last 20 years, and electronics and electronic components have had to match the pace. Often times, in two way portable transceivers, the bulk of the size and weight are occupied by items such as the battery, filters, speaker/microphone, thus exhibiting Pareto's rule that 90% of the weight/size is constituted by only 10% of the parts. Consequently, the pressure to densify has become imminent.

To exemplify this situation, in particular with respect to filters, the trend toward reducing volume while maintaining their corresponding Q is tabulated below in Table I. The information shown exhibits the relationship between Q volume, frequency, and time (era) used.

TABLE I. Data illustrating trends of size reduction and accompanying Q.

Unit	Q**	Volume/Resonator, in^3	Frequency, Mhz	Type/Er	Year
1	570	1.24	160	Helical	1975
2	1200	1.21	880	Helical	1978
3	950	.26	880	Helical	1983
4	850	4.96	454	Coaxial	1980
5	1800	3.80	835	Coaxial	1980
6	230	.012	880	Ceramic/9.6	1982
7	205	.005	897	Ceramic/37	1988***
8	700	.115	880	Ceramic/37	1986
9	200,000	.029	5-100	Quartz	1960
10	5,000	4.0×10^{-6}	200-6000	Ga As/AlN	1990***

** $Q = \text{Quality Factor} = 2\pi \times \frac{\text{Maximum Energy Stored/Cycle}}{\text{Energy Lost/Cycle}}$; Resonators are $\lambda/4$ long.
*** Estimated Time of Use

The information in Table I shows the effect of dielectric constant on resonator length, or $L = \frac{K}{f\sqrt{Er}}$, as well as the discipline (method) used in filter construction. Please note, also, that size reduction due to electromechanical coupling is phenomenal. These two disciplines, dielectric constant and electromechanical coupling, will rate heavily in the reduction of electric wave filter size in the future.

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SYMPOSIUM

on

SURFACE GEOLOGY, GLACIAL, AND PERIGLACIAL FEATURES
OF SOUTHWEST NORTH DAKOTA

Presiding: Clark Markell
Division of Science
Minot State College
Minot, ND

7. The Paleoenvironment of the Lange/Ferguson Clovis Kill Site in the Badlands of South Dakota and its Relationship to the Paleoenvironmental Succession of the Northern Great Plains
James E. Martin*
SD Geological Survey and SD School of Mines and Technology
Rapid City, SD

8. Glacial Cirques and Troughs in Central and Southwest North Dakota
Gordon Bell*
Bell Geophysics
Bismarck, ND

9. Permafrost Features in Southwestern North Dakota
John P. Bluemle*
ND Geological Survey
Grand Forks, ND

Lee Clayton
Wisconsin Geological and Natural History Survey
Madison, WI

10. Geomorphic History of Southwest North Dakota
Eric N. Clausen*
Minot State College
Minot, ND

11. The Oligocene Age and Fluvial Origin of the Chadron Formation Reaffirmed by Observations in the Little Badlands, Stark County, North Dakota
Allan C. Ashworth*
Geology Department, NDSU
Fargo, ND

12. Vertebrate Biochronology of Oligocene Sediments in Southwest North Dakota
Allen J. Kihm*
Earth Science Department
Minot State College
Minot, ND

George E. Lammers
Museum of Man and Nature
Winnipeg, Manitoba, Canada

(7) THE PALEOENVIRONMENT OF THE LANGE/FERGUSON CLOVIS KILL SITE IN THE BADLANDS OF SOUTH DAKOTA AND ITS RELATIONSHIP TO THE PALEOENVIRONMENTAL SUCCESSION OF THE NORTHERN GREAT PLAINS

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For the first time in the Dakotas, evidence of the Clovis Cultural Tradition and associated vertebrates and invertebrates has been found in the White River Badlands. The faunal remains have provided indications of the paleoenvironmental conditions at the site dated at 10,670±300 years b.p. (1). This evidence can be integrated with that from other sites containing fossils, resulting in a preliminary interpretation of the paleoenvironmental succession for the late Pleistocene-early Holocene of the northern Great Plains.

At the Lange/Ferguson locality, at least two individuals of Mammuthus, many of whose elements possess indications of butchering, and a Clovis point, in stratigraphic context with the bone accumulation, were recovered (1,2). Observations at the site indicate that an adult mammoth may have been mired and the dorsal elements removed. Fewer bones of the second, smaller elephant were found, but many bone flakes recovered from the site may represent elements of this younger individual. Besides the mammoths, both mollusks and vertebrates were collected.

The invertebrate taxa are primarily pelecypods and gastropods and have been surveyed by Leonard (3). He suggested that on the basis of the present habits of these taxa that the region surrounding the accumulation was a shallow lake bordered by wooded or brushy and grassy slopes. The geological and most of the vertebrate paleontological evidence supports this contention.

Twenty-six taxa of vertebrates were collected; six of which do not occur presently in the Badlands, which has a semi-arid climate. Almost all of these taxa, including fish, a great number of frogs, salamanders, water snakes, waterfowl, shrews, muskrats, the red-backed vole, and numerous meadow voles (2,4), suggests that the area was near water, profusely vegetated, and the climate was more mesic than that currently existing.

A mesic environment at this time corresponds closely with the environmental succession being assembled for the northern Great Plains. From approximately 15,000 years to 10,000 or 11,000 years, tundra conditions have been documented for the Bighorn Mountains and the Agate Basin area in southeastern Wyoming by Chomko and Gilbert (5) and Walker (6), respectively. This was succeeded by mesic environments that have been documented by Walker (6) for Wyoming, Agenbroad (7) for northwestern Nebraska, and by Semken (8) for Iowa. These conditions prevailed until 8400 years in Iowa (8,9) and until 10,300 years in Wyoming (6) when greater aridity commenced.

Overall, the mesic climate of the Lange/Ferguson mammoth kill site corresponds to the humid period following tundra conditions and preceding increasing aridity.

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(8) Glacial Cirques and Troughs in Central and Southwest North Dakota

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Introduction: Glacial cirques and U-shaped valleys are situated in some buttes and ridges of central and southwestern North Dakota. These land forms range from distinct cirqued valley heads in hard rimrock to subdued forms in less resistant softer claystone and shale with interbedded sandstone lenses of the underlying formations. The buttes considered here retain steep sides by possessing the required well-cemented cap rock underlain by soft silty claystone, and weakly cemented sandstone. The sides of the buttes recede by stream sapping, erosion, springs and mass wasting as the fluvial action undercuts the cap rock and removes the support. The nature of Pleistocene cirque erosion by nivation and plucking is different from fluvial processes and landslides.

The formations, quarried by nivation and general cirquing range in age from Cretaceous Fox Hills sandstone in Kidder County to Paleocene in Adams County, and Oligocene and Miocene in Slope County, south of Dickinson, North Dakota. These localities, in turn, range from 70 miles northeast of the recognized maximum advance or front of the continental Pleistocene ice sheets to 70 miles southwest of the continental glacier margin.

Black Butte: On the northeast side of Black Butte, in Slope County, V-shaped stream valleys with interlocking spurs have been eroded to steep-sided, broad-floored troughs having a U-shaped profile. Some of the cirques at Black Butte are joined to form a compound cirque. The compound cirque is well preserved in the 40-foot thick hard rimrock sandstone and conglomerate above less well developed and preserved basins or tarns. At Black Butte frost wedging and mass wasting landslides have produced a sharp ridge (arete) at the east side of the cirque. The lower valley reach is U-shaped to its junction with the extensive piedmont plain to the northeast. Characteristically, the piedmont area supports two sub-parallel northeast meandering ridges like eskers of sand and gravel with some boulders. (See the Black Butte, North Dakota USGS topographic quadrangle.) These land forms stand in contrast to the general caving, slumping and erosion characteristic of the receding buttes of the preglacial and present landscape.

Rocky Ridge: At Rocky Ridge, six miles north of Hettinger, North Dakota, there are prairie cirques 1 to 2 acres in size typically with blunt heads and U-shaped valleys. Most are carved in siltstone and shale. Associated terminal and recessional moraines are barely recognizable, but medial and lateral moraines are generally distinct. Stream valleys below the terminal moraines are commonly V-shaped and winding. Excellent examples of the prairie cirques are in a prominent rocky ridge at an altitude of 2900 feet in the N. 1/2 sec. 18, T.130 N., R. 95 W., about 6 miles north of Hettinger, Adams County, North Dakota. Masses of large (2 to 10 feet long) boulders of gray quartzite derived from the bedrock are concentrated at the head of the cirques and aligned below the cirques in lateral and medial moraines. The maximum relief is 150 feet in the 2-mile long northeast trending ridge. The ridge is capped by gray meta-siltstone or quartzite. This resistant cap rock was variously attacked by nivation, frost wedging and glacial flow that constructed moraines and boulder pavements in the cirques and along the sides of the moraines. Minor amounts of boulders are found below the cirques and troughs in the broad plain to the north.

Glacial troughs: Small glacial troughs, or U-shaped valleys occur down the southwest side of Sibley Buttes in Kidder County, North Dakota. The physiographic relief of Sibley Buttes is 120 feet. There is some evidence of nivation cirquing in the Cretaceous Fox Hills sandstone, but the till involved in the troughs indicate a relation with a larger mass of ice. There are additional troughs but the ones described here are of interest where the action faced the sun. Perhaps this indicated the troughs were nourished in a snow field during minor and local advances of the ablating continental ice sheet which had advanced at least 7- miles (airline) southwest.

Conclusions: I hypothesize that during maximum glaciation the plain in southwest North Dakota supported a snow and ice field which extended from the more mobile Canadian glaciers to the Black Hills uplift. This snow-ice field, like those in the higher latitudes today, nearly buried the preexisting landscape. In this environment of lower snow and frost line, snow, which accumulated on the landscape, was converted to beds of ice and nivation and ice movement quarried and eroded the basal preglacial rocks and sediments. Although this snow-ice field phenomenon and consequent small nivation cirques is well known and described by Hinds (1) and Flint (2), this paper may be the first attempt to qualify and quantify (clarify) the products of the processes in North Dakota.

In the snow-ice field with its perennial snow banks, small cirques are produced. Alternating freezing and thawing, and ice wedging aided by rills and solifluction, helped promote the down slope transfer of soil and rock debris by flowing ice. These are true glaciers and the heads of the deepened cirques developed bergschrunds which in turn promote frost wedging and plucking to the lower limits of crevassing aided by pressure-melting with changes in flow in the glacier. The Pleistocene cirques of southwestern North Dakota are identified by a combination of glacial features and apparently resulted from nivation and glacial ice and their associated forces. These forces were operative in protected valleys in the buttes and ridges above the general upland.

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(9) PERMAFROST FEATURES IN SOUTHWESTERN NORTH DAKOTA

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Although no direct evidence of glaciation has yet been found south and west of the known limit of glacial erratics in North Dakota, a variety of possible periglacial features do occur in the southwestern part of the state. Of these, the best-documented permafrost features in the area are fossil ice-wedge polygons. Cross sections of the fossil ice wedges have been observed in 20 gravel pits in upland areas, especially in the western part of the Cannonball River basin. Fossil ice wedges in fluvial gravel are zones, generally less than 1 m wide and more than 5 m deep, with the original bedding obliterated and with vertical foliation. Troughs about 2 m wide and 1 m deep developed on the gravel surface when the ice wedges melted. These troughs generally have no topographic expression because the gravel is overlain by 1 m to 2 m of loess. However, a polygonal pattern can sometimes be seen on air photos because the vegetation may be more lush where the loess is thicker over the troughs. Polygonal networks have been seen on 1:20,000 air photos at about 200 sites in southwestern North Dakota (Fig. 1). The polygons have four or five sides and are 10 m to 100 m in diameter. Most have been preserved on gravel terraces and pediments, where the soil is so permeable that no runoff, and therefore no erosion, has occurred.

The periglacial features found in southwestern North Dakota are almost certainly of various Pleistocene ages, but they cannot be dated exactly because the Pleistocene stratigraphy of southwestern North Dakota is largely unstudied. Polygons are not found on surfaces that were formed during latest Wisconsinan time throughout North Dakota. They do occur on stream gravel of the Napolean Glaciation, which may be as young as Early Wisconsinan. The Napolean outwash has undergone little or no erosion since it was deposited. Other, presumably much older, polygons are found on the tops of buttes such as Cow Butte in Adams County. The sides of these buttes must have undergone considerable erosion since the polygons formed. In addition to the fact that the buttes are today probably not large enough to support a water table high enough for polygons to form, their surface patterns, as seen on air photos, show no "edge effect" -- the polygon lines extend all the way to the edges of the buttes. This indicates that the polygons originally formed on much more extensive surfaces that have since been greatly reduced in size by erosion.

Climatic conditions suitable for the formation of permafrost features may have occurred in North Dakota several times during the Pleistocene, probably each time glaciers advanced into the area. In addition to polygons and frost wedges, abundant evidence of eolian activity in the form of blowouts and sand-blasted quartzite boulders occurs over upland areas that otherwise have had little erosion. This may indicate one or more episodes of dry, tundra climate, or perhaps arid, interglacial periods.

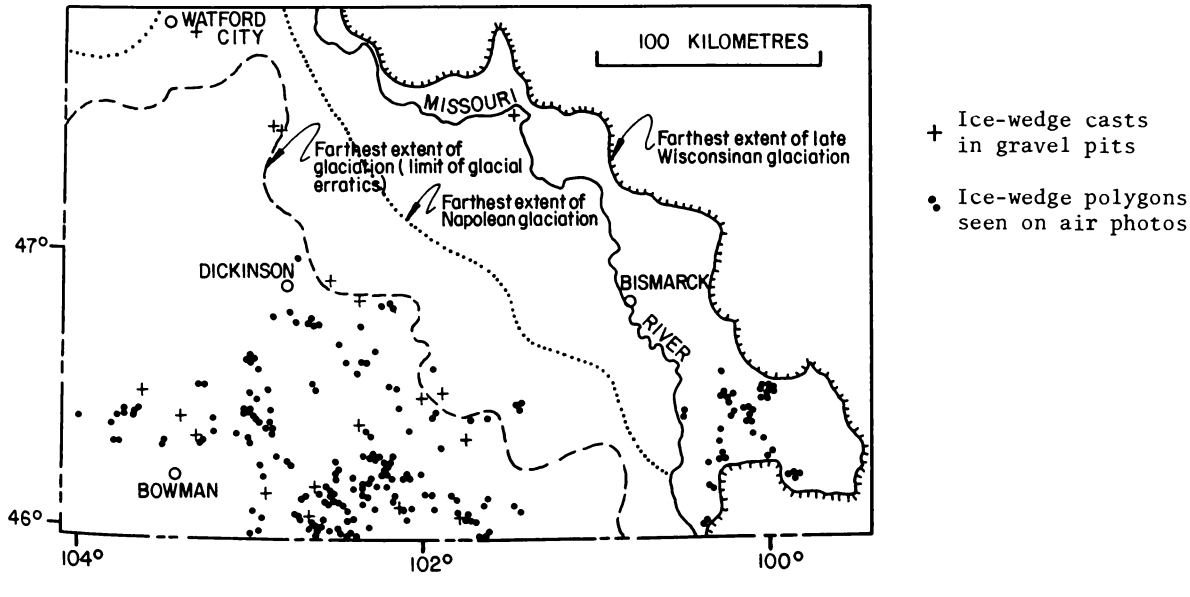

Figure 1. Locations where polygons and ice-wedge casts were seen in southwestern North Dakota.

(10) Geomorphic History of Southwest North Dakota

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This report outlines a model for the geomorphic history of the northern Great Plains region based on field evidence from southwest North Dakota. The model, proposed here, is an alternative to models presented or implied by other papers in this symposium. The first step in developing the new geomorphic model is to put events in sequence without reference to paleontologic or other absolute dates.

The first event in the geomorphic evolution of North Dakota, for which we have evidence, was a topographic surface equal to, or higher than, the tops of the highest buttes in southwestern North Dakota today. No date is given for this surface. The tops of many of the high buttes in southwest North Dakota and adjacent northwest South Dakota frequently are composed of lacustrine or alluvial sediments. If these butte tops were lakes or stream channels then the surrounding regions must have been higher in elevation. A chain of buttes extends in a south to north line from northwestern South Dakota into southwestern North Dakota. These buttes suggest a slight slope to the north while buttes in Carter County, Montana, suggest a slight slope to the northeast. The initial topographic surface probably cut across underlying geologic units and postdated geologic structures such as the Cedar Creek Anticline.

The second group of events, for which we have evidence, was the cutting of valleys by high energy rivers, which locally deposited, among other things, coarse-grained conglomerates with occasional granite and quartzite boulders up to 70 centimeters in diameter and more numerous cobbles of quartzite and igneous rocks, some of which can be traced to dikes and sills in the Beartooth Mountains (1, 2). Sediments (usually mapped as mid–Tertiary) were deposited in the valleys cut by these rivers, with remnants of the bedrock valley walls standing today as buttes. These buttes provide a measure of the local relief which strongly suggests the conglomeratic units were deposited in new, or rejuvenated, valleys carved in the easily–eroded bedrock. Trails of residual gravels and cobbles indicate some of these rivers may have flowed from eastern Montana southeastward into North and South Dakota (2). Cross bedding in the conglomeratic unit underlying White Butte, the highest point in North Dakota, indicates flow was to the southeast (3). A southeast–trending drainage system is found in much of the study region today, although this southeast–trending drainage pattern may be the result of still later events. The second group of events were concluded with finer–grained material being deposited on top of the conglomeratic units.

The third group of geomorphic events, for which we have evidence, resulted in the deposition of the recognized glacial erratics which are found south and west of the Missouri River. Evidence presented by Clausen (4) suggests these glacial erratics are residual deposits left after dissection of a high level topographic surface on which major end moraines had been deposited. The glaciers, which deposited the moraines, probably flowed on the initial topographic surface and may have been contemporaneous with the high energy rivers noted in stage two. Meltwater from these glaciers may have been the source of some of the rivers. Other rivers may have originated in the Rocky Mountains, flowed across the plains, were blocked by continental ice margins, and were diverted to the southeast along the continental ice margins(2).

The fourth group of events, for which we have evidence, was the lowering of the topographic surface probably aided by erosion from a new set of southeast-trending rivers to produce the present topographic surface of southwest North Dakota. The present day surface is some 100 to 300 meters lower than the tops of most buttes (including buttes composed of sediments deposited by rivers noted in stage two above).

The fifth major geomorphic event, for which we have evidence, was the establishment of the Little Missouri River as a north-flowing stream in the study region. The Little Missouri valley has an asymmetric drainage divide to the east and barbed tributaries enter the valley from the west. Alluvium from western sources, representing deposits of southeast trending rivers noted in stages two and four can be found covering highlands east of the present Little Missouri valley.

The sixth event, for which we have evidence, was diversion of the north flowing Little Missouri River to the east. The sharp eastward bend in the Little Missouri Valley, and the abandoned valley continuing north from the bend, provide evidence for this event. An abandoned valley, which continues north from the sharp bend, stands at a higher elevation than the bottom of the modern Little Missouri valley indicating downcutting has occurred since the eastward diversion.

The above model places several major geomorphic events in sequence. No absolute dates have been assigned to the events. This sequence of events must be accounted for in any attempt to explain the geologic history of southwest North Dakota.

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(11) THE OLIGOCENE AGE AND FLUVIAL ORIGIN OF THE CHADRON FORMATION REAFFIRMED BY OBSERVATIONS IN THE LITTLE BADLANDS, STARK COUNTY, NORTH DAKOTA

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The absence of glacial landforms and glacial deposits in southwestern North Dakota has been sufficient evidence for the region to be placed outside of the limit of Pleistocene glaciation (1); its landscape with preglacial remnants is considered the oldest in North Dakota. Clausen (2) challenged the established view with the claim that the landscape was younger and mostly sculpted by Pleistocene glacial meltwaters, originating from the Cordilleran ice sheet. In support of his hypothesis, Clausen (3,4) made the radical proposal that deposits previously interpreted as Oligocene fluvial sediments be regarded as Pleistocene glaciofluvial gravels. He also proposed that the direction of transportation of these sediments in North Dakota and in South Dakota was opposite to that previously described.

Lag accumulations of pebbles of Cordilleran lithologies are common on the erosional surfaces of the the Little Badlands, Stark County, North Dakota. The pebble accumulations are derived by erosion from a basal member of the Chadron Formation, referred to as the Chalky Buttes member (5). That accumulation is an on-going process can be demonstrated by greater lichen cover on the pebbles farthest from the erosional faces. The position of the Chadron Formation in the Little Badlands, above the unconformity on the Eocene Golden Valley Formation and below the Brule Formation, is easy to observe and has been adequately described (5,6). Well-preserved mammmalian, invertebrate, and plant fossils collected from the Brule Formation of the Little Badlands, including the Fitterer Ranch site (7),have counterparts in the well-studied Oligocene fossil assemblages of the Big Badlands of South Dakota and are considered to be of Orellan age. The evolutionary grade of the Brule fossils indicates that they are of middle Tertiary age. No fossils of Pleistocene or Holocene animals such as Bison have been found in sediments referred to as the Brule Formation, and yet their bones are abundant in the colluvium. In order to accept Clausen's claim for a Pleistocene age for the Chadron Formation, fundamental geological principles such as superposition and faunal succession would have to be abandoned.

Clausen (3) also proposed that northeastward-flowing meltwater was diverted southward into western North and South Dakota, with the continental ice-sheet acting as a barrier to the north and east. He cited evidence that the Slim Buttes Formation of South Dakota was deposited from a southeasterly-flowing river. The Slim Buttes Formation is of Eocene age and its stratigraphic equivalent in the Little Badlands (Golden Valley Formation) also had its source to the north. However, the pebbles that are claimed as evidence for glaciofluvial transport are from the younger Chadron Formation. Between the Eocene and the Oligocene the direction of the paleoslope was reversed. Cross-bedding measurements of the Chadron Formation in the Little Badlands indicates that sediment was being transported to the north.

Stone (5) argued for the source to be to the south in the northern Black Hills, whereas Denson and Gill (6) preferred a western source in the Absaroka and Beartooth Ranges to the west. Provenance remains a problem. Comparison of analyses of the feldspars in pebbles of the volcanic porphyry with those of the volcanic igneous rocks collected from the Black Hills does not preclude that region as the source. However, the presence of pebbles of the distinctive "Turritella" agate of the Bridger Formation in the Little Badlands suggests a southwestern source as distant as Wamsutter, southcentral Wyoming. The possibility that the pebbles from multiple upland sources were transported generally northeastward through the Powder River basin should also be considered. Classical fining-upwards sequences in the basal Chadron Formation of the Little Badlands are strong evidence that deposition, at least in the later stages, was from a meandering river. Occasional subrounded quartzite boulders, 50-cm diameter, imply transportation by flood waters. Volcanism, earthquakes, and glaciation in the uplands marginal to the valley could have created the conditions that resulted in periodic catastrophic flooding. There is no evidence in the Little Badlands (e.g. striated boulders, tillites etc.) to support an exclusive glaciofluvial origin of the Chadron Formation as claimed by Clausen (3).

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(12) VERTEBRATE BIOCHRONOLOGY OF OLIGOCENE SEDIMENTS IN SOUTHWEST NORTH DAKOTA

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Oligocene sediments in North Dakota have been known to be fossiliferous for over 100 years. Three rock units are typically recognized within the White River Group, the Chadron Formation at the base, the Brule Formation, and the Arikaree Formation at the top. Of these, the Brule is abundantly fossiliferous, producing a varied vertebrate fauna, but unfortunately, this fauna is largely undescribed. Only a few species have been dealt with in separate taxonomic papers (1-7). The only comprehensive faunal lists that have been published were the result of preliminary studies (8-10). Two species of fish (1) have been identified from a possible Chadron equivalent at Sentinel Butte (9). The Chadron Formation has yielded only snails and a few fragments of brontothere (9) and the Arikaree has produced only three species. A compilation of published and unpublished data was used to produce the faunal list given in Table 1.

This relatively limited data does, however, indicate some possibility for biozonation. The biochrons used in continental Cenozoic rocks are the North American Land Mammal Ages. The four recognized Oligocene biochrons are, from oldest to youngest, Chadronian, Orellan, Whitneyan and early Arikareean. The White River Group in North Dakota has indications of each of these. The brontothere fragments from the Chadron Fm. are indicative of the Chadronian. The diverse fauna from the lower Brule, including the Fitterer beds (10,16), is typical of the Orellan with comparable faunas in South Dakota, Wyoming, Nebraska, and Colorado. A possible Whitneyan fauna is indicated by the occurrence of Miohippus brachystylus ?, Leptauchenia, and ? Protoceras, forms which are typical of this biochron in South Dakota and Nebraska. Assignment of the material from the Arikaree Fm. to a specific biochron is difficult but the presence of Paleocastor sp. suggests an Arikareean age.

Recent publication of preliminary magnetostratigraphic data supports the identification of a middle to late Oligocene age for rocks of the Brule Formation in North Dakota with recognition of Magnetic Anomalies 10 and 11 (17). Correlation of these anomalies to radiometrically dated sequences indicate the approximate time of deposition of the Brule to be between 32.4 and 29.5 ma (18). Faunal correlation of the sequence indicates the time span of the White River Group as a whole to be slightly longer, perhaps 33.0 to 28.0 ma. Unconformities within the section probably account for much of this time.

Table 1: Vertebrate fauna from the White River Group of North Dakota

Class Osteichtyhes
1 or more spp (B)
Order Perciformes
Plioplarchus whitei (1) (C?)
P. sexspinosus (1)(C?)
Class Amphibia
Order Anura
Scaphiopus skinneri (6) (B)
Class Reptilia
Order Testudines
Gopherus sp (B)
Stylemys sp (B)
Order Squamata
1 or more spp (B)
Class Aves
1 or more spp (B)
Class Mammalia
Order Insectivora
Oligoscalops galbreathi (4) (B)
Leptictis (B)
Centetodon marginalis (7) (B)
? apternodontid (B)
? apatemyid (B)
Order Chiroptera
possibly represented (B)
Order Rodentia
Ischyromys and/or
Titanotheriomys (B)
Prosciurus (B)
? Cedromus (11) (B)
Protosciurus sp (B)
Paradjidaumo sp (B)
Adjidaumo douglassi (B)
Eumys sp (B)
Paleocastor sp (9) (A)
Order Lagomorpha
Palaeolagus (B)
Megalagus sp (B)
Order Creodonta
possibly represented (B)
Order Carnivora
Dinictis (B)
? Hoplophoneus (B)
? Eusmilus (B)
? amphicyonid (B)
Hesperocyon sp (B)
Order Perissodactyla
Mesohippus bairdii (13) (B)
Miohippus brachystylus ? (13) (B)
Hyracodon sp (11) (B)
Subhyracodon sp (12) (B)
? Caenopus (B)
Amphicaenopus sp (9) (A)
Diceratherium tridactylum (14) (B)
brontotheriid, genus idet (9) (C)
Order Artiodactyla
Entelodon (15) (B)
Archaeotherium sp (B)
Bothriodon sp (B)
Leptomeryx (B)
? Hypertragulus (9) (B,A)
Poebrotherium sp (B)
? Protoceras (11) (B)
Merycoidodon culbertsonii (5) (B)
M. (Anomerycoidodon) dana (5) (B)
Otionohyius wardi (5) (B)
O. (Otarohyus) bullatus (5) (B)
Genetochoerus (Osbornohyus)
norbeckensis (5) (B)
G. (O) geygani (5) (B)
G. (O) dickinsonensis (5) (B)
Paramerycoidodon georgei (5) (B)
P. (Barbourochoerus) sp (15) (B)
Miniochoerus starkensis (3) (B)
M. (Paraminiochoerus) helprini (3) (B)
Platychoerus heartensis (3) (B)

C=Chadron; C?=possible Chadron equivalent at Sentinel Butte; B=Brule; A=Arikaree. Numbers refer to cited references.

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SYMPOSIUM

on

COMETS: GIACOBINI-ZINNER (1985) AND HALLEY (1985-86)

Presiding: Franz Rathmann
Physics Department, NDSU
Fargo, ND

50. Comets. The Return of Halley's Comet
Franz H. Rathmann*
Physics Department, NDSU
Fargo, ND

51. Observations of the Comet Giacobini-Zinner
Larry E. Armfield*
and
Franz H. Rathmann
Physics Department, NDSU
Fargo, ND

52. Observation on Halley's Comet
Thomas R. Knutson*
Horace, ND

Franz H. Rathmann
Physics Department, NDSU
Fargo, ND

53. Comet Halley. Photographing Comet Halley
Iver Possehl*
Barnesville, MN

Franz H. Rathmann
Physics Department, NDSU
Fargo, ND

54. Sighting Halley's Comet
Steve Oakland*
Fargo, ND

Franz H. Rathmann
Physics Department, NDSU
Fargo, ND

55. Photographing Comet Halley
Mark A. Nook*
Physics Department
Concordia College
Moorhead, MN

56. The Flybys of Halley
Mark A. Nook and Diane Lee Hedin*
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(50) COMETS. THE RETURN OF HALLEY'S COMET

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As a six-year-old, I was allowed to stay up beyond my usual bed-time of seven-thirty to see Halley's Comet up above the old house to the south. There was the head, like a bright star, and then the tail, spreading out and behind. I cannot remember seeing any stars. Nor do I remember hearing at that time any details about the fears and superstitions of many people, the poisonous cyanide in the tails of comets. For on that occasion the Earth was to pass through the tail of the comet, or very nearly so. My knowledge of that came later, from reading about comets.

The Egyptians must have seen comets but did not record them. The philosopher Aristotle observed the comet of 371 B.C., the first comet on which we have any kind of carefully observed data.(1) Aristotle concluded that they were produced by the rising vapors of marsh gases(2), burning in the hot upper atmosphere. This belief in comets as atmospheric phenomena persisted for nearly 2000 years, associated with astrology--the belief that comets forecast great catastrophes. Thus, the comet of A.D. 451 (Halley) was associated with Attila, the Hun, the comet of A.D. 1066 with the death of Harold the Saxon and the victory of William, as depicted in the Bayeux Tapestry.

Leonard Diggs, an English Elizabethan Period writer, summarized these beliefs, "Comets signify corruption of the air, . . . a common death of man and beast." Giotto, in his Adoration of the Magi, based on the comet of 1301 (also Halley), portrayed the belief that the star of Bethlehem was a comet. Late in the sixteenth century Danish astronomer Tycho Brahe showed that the great comet of 1577 was at least four times as far from the Earth as was the Moon, and that comets were celestial rather than atmospheric. The Chinese recorded comets as far back as 1000 B.C., including those of 1057 B. C. and 467 B.C., both possibly Halley, and 239-240 B.C., definitely Halley. They concluded in A.D. 657--a thousand years ahead of Tycho Brahe--that the comets shone by reflected sunlight.

Following the Copernican concept of a heliocentric solar system (1543), Kepler developed elliptical rather than circular orbits. Isaac Newton, at the urging of Edmund Halley, published his Principia in 1686-1687. Both men observed the two bright comets of 1680 and 1682. Newton, convinced that his laws of motion and of gravitational attraction must apply to comets, urged Halley to carry out the calculations. Halley concluded that there were great similarities between those of 1682, 1607 and 1531, probably revisits by the same comet. He predicted the return in late 1758 or early 1759. Halley died in 1742. A German amateur astronomer did observe the return on Christmas Day 1758. Ever since, it has come to be known as Halley's Comet. Search through old records, literature, etc., has established that Halley's Comet has been observed somewhere or other, in China, Japan, the Middle East, Europe, on every one of its thirty returns since 240 B.C.

Most comets follow highly elongated elliptical orbits, with periods of many hundreds or millions of years, scarcely distinguishable from parabolas. So-called short period comets, like Halley, follow elliptical paths within the Solar System. Thus, Halley at perihelion is some 55,000,000 miles from the Sun, between the orbits of Mercury and Venus, while at aphelion it is some three and a half billion miles out, beyond the orbit of Neptune. Giacobini-Zinner, with a period of almost exactly $6\frac{1}{2}$ years goes out to the orbit of Jupiter but never gets closer to the Sun than the orbit of the Earth. Comet Halley is believed to have a "dirty snowball" nucleus of five kilometers diameter, and to have been in the solar system in its present orbit several hundred thousand years. Comets are highly sensitive to the gravitational attractions of the planets. Halley's Comet has been observed for over 2000, possibly 3000 years. Its orbital period has varied from $74\frac{1}{2}$ to $78\frac{1}{2}$ years. The orbit of Halley is inclined to the plane of the ecliptic by some $18\frac{1}{2}°$. Halley never gets closer to Jupiter than about 1.0 A.U. or 100,000,000 miles, and 2.0 A.U. to Saturn.

This is the least favorable return in over 2200 years. (3) October through December, Halley could be seen only through telescopes or a good pair of binoculars with a very small tail. Late in December, and to about January 20, it became visible to the naked eye for persons with perfect vision. In February it will be lost in the glare of the Sun (perihelion February 9, superior conjunction February 11), emerging from solar glare before dawn and sunrise late in February, early March, as a celestial object of magnitude about 3, possibly 2, but too low on the southern horizon for viewers this far north. After April 30 it will again be in the evening sky, ever higher and fainter, as it speeds outward on its way toward its farthest point, out beyond the orbit of Neptune, in 2024, to return to us and our grand and great grandchildren in 2062.

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(2) Halley Observer's Guide.
(3) I.H.W. = International Halley Watch.
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(51) OBSERVATIONS ON THE COMET GIACOBINI-ZINNER

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Giacobini-Zinner is a periodic comet discovered independently by M. Giacobini and Zinner in 1900 (1) with a period varying from 6.4 to 6.6 years, a perihelion distance of 0.93 to 1.03 A.U., an aphelion distance of 5.9 to 6.1 A.U., and a maximum magnitude on various returns from m = 20 up to m = 6, depending on the gravitational influence of close approaches to Jupiter. It has been observed on eleven returns since its discovery.

Using an eight-inch Criterion Schmidt-Cassegrain telescope with a focal length of 2.110mm on the N.D.S.U. campus, we made our first observations in July, but poor weather delayed our first clear view to August 7. Usually the seeing improved during the night hours, sometimes until dawn. We recorded the time, both local and U.T., current temperature, barometric pressure, humidity, wind speed and direction. I also made careful drawings of the star groups around the comet each time.

On August 7 Comet G.-Z. was between the Double Cluster in Perseus and the star Ruchbach in Cassiopeia, and slightly to the west of that line. Using a 30.0mm eye piece it was found easily despite a Half-Moon and appeared as a very faint fuzzy patch. The magnitude predicted by I.U.W. (2) was 9.6; I estimated m = 10.0.

The next good viewing night was on August 12. Using a 12.7mm eye piece, Comet G.-Z. was then in the constellation Perseus, at R.A. 2h. 54m. and Decl. +56.85°. It showed more detail, and the over-all shape was fan-like. The predicted magnitude was 9.3; I estimated 9.7. The coma showed a pinpoint of light as the nucleus.

By August 19 the comet was still in Perseus but had moved to R.A. 3h. 55m. and Decl. +51.5°. It did not appear any brighter than on the 7th and 12th but, while nearer to the Sun, it was farther from Earth. The nucleus appeared somewhat sharper, and there was less fanning of the coma.

Because of uncooperative weather little worthwhile observing could be done until the 27th of August with the comet at R.A. 4h. 42m. and Decl. 44.0°. It had now brightened to m = 8.0. The coma seemed to show two distinct bright pinpoints of light, lasting until dawn. Using a 12.7mm. eye piece, magnification ca.150, I was able to sketch the tail better than previously.

At the request of Dr. David Dunham of I.O.T.A. (3) we next observed the partial occultation or dimming of a sixth magnitude star SAO/BD 58030 when G.-Z. passed in front of it. On the night of September 4, one day before the perihelion passage of Comet G.-Z., four of us from the Moorhead-Fargo Astronomical Society went to the country home of Professor James Grier some 20 miles to the East-Northeast of Moorhead to observe the partial dimming. Others from the M.-F.A.S. observed from Fargo, from Concordia College, and from Christine, N.D. To me it seemed that when the comet coma passed over the star, the latter appeared somewhat brighter and sharper for about five minutes. Others did not see this, nor any dimming effect. We had no photo-electric equipment.

The results of our observations were immediately reported to Dr. Dunham and I.O.T.A. (3) for use in a final setting of the exact course of the U.S. satellite I.C.E. (International Cometary Explorer) in its passage through the coma of G.-Z., and eventually through the tail of Comet Halley in March 1986.

(1) Kronk, Gary W. COMETS. Enslow Publishers, Inc., Hillside, NJ. 1984. pp. 254-255.
(2) International Halley Watch. OBSERVERS GUIDE.
(3) International Occultation and Transit Timing Association, David Dunham, Secretary, private telephone call.

(52) OBSERVATIONS ON HALLEY'S COMET

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Our observations on Comet Halley began on the night of September 20-21, 1985 and will continue into May 1986, or as long as the comet is visible through our instruments.

We used a Celestron C-8 inch telescope, a four and one quarter inch wide-field telescope, and ten by fifty binoculars (Bushnell).

The star charts we used were the monthly Halley Notebook star charts in SKY and TELESCOPE magazine[1], the Comet Halley Ephemeris Computer Program and, later on, the tables, data, and charts in COMET HALLEY by the International Halley Watch (IHW)[3].

Our observations were made from a dark sky site on the banks of the Sheyenne River, two miles to the north of Horace, N.D.

We identified Comet Halley in the star-field by its fuzzy or "out of focus" appearance as contrasted to the sharp appearances of the stars when properly focused.

Halley was observed high in the southern sky in Taurus during September and October; then in the constellations Aries and Pisces during November and December, and in Aquarius in late December to mid-January.

It was above Aldebaran and just below the Pleiades in November, the circlet of Pisces, to the south, below Pegasus, during mid-December, and further west later in the month.

Within the limits of accuracy of the charts and of our instruments, and taking into account the six hour twenty-eight minute time difference between our mean solar time and universal time, (UT) the positions of Halley observed by us agreed with those of the charts and the Halley computer program[5].

Our observations agreed well with data on the charts. However, for September, Halley appeared somewhat fainter than predicted. During November we found Halley to be oval-shaped, possibly the beginnings of a short-tail. By mid-December the comet appeared egg-shaped, with the blunt end toward the sun, and possibly a tiny spike jutting out from the pointed end of the egg, and directed toward Aries and Aquarius and away from the sun.

Although Comet Halley appeared during September somewhat dimmer than predicted by the IHW, by mid-December it appeared somewhat brighter, by perphaps 0.5 magnitude, but still not as bright as predicted by Comet News Service (CNS).

We continued our observations to mid-January when Halley became lost in the evening twilight. Again, for a few weeks after perihelion on February 9, 1986, Halley was lost in the morning dawn. We resumed observations early in the morning late in February and early March 1986.

OBSERVATIONS ON COMET HALLY

Date	Local Time	U.T.	Conditions	Instr.	R.A.	Dec.	Comet.	Shape	mag.	Comments
Sept. 21 1985	3:00 a.m. CDST	8:00	good: limiting mag. 13.5	C-8	6h 16m	19° 42m	Taurus	round	13	very faint 20 arc sec. diam.
Oct 15	1:00 a.m. DCST	6:00	good: limiting mag. 13.5	C-8	6h 3m	20° 37m	Taurus	round	11.5	easily seen, no nucleus visible 45 arc sec. diam.
Nov 3-4	11:00 p.m. to 1:00 a.m.	5:00-7:00	last quarter moon limiting mag. 12	C-8	5h 14m	21° 59m	Taurus	round	8.5	bright, small nucleus visible
Nov. 13	11:00 CST	5:00	very good	4¼ in. f/4.5	4h 12m	22° 7m	Taurus	oval	8	nucleus slightly off-center to S.
Nov. 20	11:00 CST	5:00	1st quarter moon, good transparency	C-8	3h 5m	20° 34m	Aries	oval	7.5	nucleus off-center toward W-SW
Dec. 6	6:00 CST	0hr			0h 20m	9.9	Pisces		6.3	data from SKY & TELESCOPE Not observed this date.
Dec. 21	6:00 CST	0.40			22h 05m	1.1	Pisces			data from SKY & TELESCOPE. Unobserved on this date.
Jan. 4 1986	6:40 CST	0.40	hazy at lower altitudes.	C-8	22h 11m	-3.1	Aquarius	egg-shape, w/tail	5.5-6	tail about ca. 1.0° long, very straight
Jan. 6	6:30 CST	0:30	fair, some air-glow	C-8	22h 7m	-3° 26m	Aquarius	egg shape, w/tail	5.5	tail ½° long
Jan. 10	6:40 - 7:20	0:40 to 1:20	Clear, dark cloud on horizon	C-8 4¼"			Aquarius	Elongated	5.5	Tail, ca ½° long, or more
Jan. 12	6:50-7:00	0:50 1:10 U.T.	Clear, dark cloud on horizon 2-day crescent moon	C-8 Astroscan 4¼ in. binoculars			Aquarius	Elongated fuzzy end	5.5 to 5.0	Tail shorter than on Jan. 10. Naked eye visibility when location known

Observations made mainly by Mr. Tom Knutson, Horace, N.D. (suburb of Fargo) Sent in by Franz Rathmann President, Moorhead-Fargo Astronomical Society. South Engineering 207B, North Dakota State University Fargo, North Dakota 58105. Telephone (701)237-8974.

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(53) COMET HALLEY. PHOTOGRAPHING COMET HALLEY

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From Nov. 6, 1985 to Jan. 26, 1986, twelve observations of Comet Halley were made, most from Barnesville, MN, with some light pollution. Others were made at a darker site 2 miles southeast of town. A 7X50 momocular (mono.) and a home-made 4¼" Newtonian telescope (Newt.) were used for viewing. A few photos were taken with a 50mm lens working at f1.4 on a standard 35mm SLR camera. Some were stationary, others by piggy-backing the camera on the Newt. and hand-driving.

Several attempts to find Halley in October were unsuccessful. On Nov. 6, 1985 at 11:24 p.m. CST, using the mono. with averted vision, the comet appeared as a faint fuzzy spot slightly larger than the stellar images. Later it was found and seen easily in the Newt. The narrow field of the Newt. made searching against faint background stars too difficult. Halley appeared in the Newt. as a faint hazy area about 7'-10' in diameter with a brighter condensation in the center. The view with the Newt. on Nov. 14 at 7:10 p.m. and Dec. 2 at 10:07 p.m. was similar.

On Dec. 6 at 8:25 p.m. (see fig. 1) it was much easier to find and observe the comet with the mono. Bright background stars made fairly accurate positional sketches possible.

On Dec. 10, in spite of temperatures around -15°F, a 12 sec. exposure on Tri-X film (ASA 400) was made.

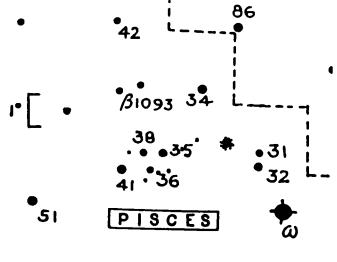
On Dec. 28 at 6:20 p.m. using the mono. it was quite obvious that the apparent size of the comet had decreased since Dec. 10.; it was moving away from Earth.

Jan. 4-6 (see fig. 2) was the only period when the comet was seen on consecutive nights. It was also the first time that the tail, extending about one degree from the head, could be seen with some certainty. The head looked nearly starlike in the mono. A photograph was taken on Jan. 4 at 7:46 p.m. using a 12 sec. stationary exposure on VR 400 color film. This photograph shows the comet as a faint speck with no tail.

Jan. 10 provided an exceptionally clear view of the tail at 8:10 p.m. in the mono. A 60 sec. exposure of the comet and tail was made on VR 400 film. Surprisingly, the comet appears greenish on the print. This was the last good view of Comet Halley before the Moon and evening twilight interfered.

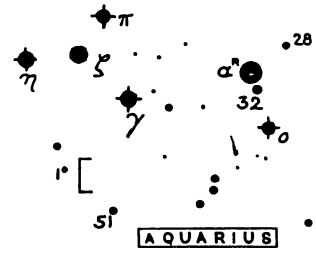
The comet was seen on Jan. 22nd and 26th, but these were very poor views.

Figure 1



Dec. 6, 1985, 8:25 CST

Figure 2



Jan. 4, 1986, 6:52 PM CST

ILLUSTRATIONS ADOPTED FROM NORTON'S STAR ATLAS
COMET HALLEY TO SCALE

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(54) Sighting Halley's Comet

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Most of our sightings of Comet Halley[1] were made from a dark site about 15 miles south-east of Breckenridge, MN. This location is about 60 miles south of Fargo. On Dec. 7th Halley was first spotted as a faint glow in Bausch & Lomb 7 x 35 (B-L) binoculars about seven degrees south and one degree west of Algenib in the Great Square of Pegasus. Switching to a 4 inch Schmidt-Cassegrain (S-C), 1 1/4 inch eyepiece, magnification of about 30, the view was much more exciting, the coma with many stars shining through, had no clear evidence of a tail. Switching to a 1 1/4 inch eyepiece, magnification of about 67, did not improve the view. Using averted vision, Halley was barely visible to the naked eye after 20 minutes of dark adaptation.

On the 14th Halley was more visible to the naked eye, but was also a nice view through binoculars. The coma appeared to be a little smaller since Halley was moving away from the earth towards perihelion. Switching to the S-C with a 1 1/4 inch eyepiece, mag. of 67, did not show much improvement of Halley.

Observations on December 21st using B-L zoom to 15 power gave a good view of several degrees of sky with Halley showing a more distinguished tail but a smaller coma. The air was still, and provided good, clear seeing.

On the 28th, when Halley was in the Water Jar of Aquarius, there was a very distinct tail extending across and beyond the whole field of view of the 1 1/4 inch eyepiece, widening slightly and pointing straight up. The tail appeared white with no other trace of color.

The sighting on January 7th was made from near Hickson, ND some 7 miles south of Fargo, about 6:45 P.M. near the end of evening twilight. Due to a 10-day moon far to the east and some haze on the horizon, Halley appeared faint but still visible to the naked eye with a tail pointing toward 1:00 O'clock.

We will try to see Halley fairly bright in the morning sky, barely above the southern horizon about March 20th,[2] and then, in the evening sky after April 20th, but rapidly getting fainter.

OBSERVATIONS OF HALLEY'S COMET

DATE -->	DEC 7 1985	DEC 14 1985	DEC 21 1985	DEC 28 1985	JAN 7 1986
Local Time	8:30 P.M. CST	8:00 P.M. CST	7:00 P.M. CST	7:00 P.M. CST	6:45 P.M. CST
U.T.	02:30 UT	02:00 UT	01:00 UT	01:00 UT	00:45 UT
Sky conditions	very good air still	good air still	good	appeared hazy	good some haze
Instrument used	Criterion 4000 4 IN.	Criterion 4000 4 IN.	7X35 Binoc BAU & LOMB	Criterion 4000 4 IN.	Criterion 4000 4 IN.
R.A.	00 h 3 m	23 h 18 m	22 h 47 m	22 h 25 m	22 h 2 m
Dec.	8d 6m	3d 45m	0d 39m	-1d 35m	-3d 52
Constellation	Pisces	Pisces	Pisces	Aquarius	Aquarius
Shape	round glow	round glow	round	oval more solid	oval solid
Tail	None seen	None seen	Faint tail	Tail at 11:00 pos.	Tail at 1:00 pos
Magnitude	6.3	6.0	6.0	6.0-5.5	6.0-5.5
COMMENTS					

Observations made by Steve Oakland 4405 Domingo Rd. Fargo, ND 58103
Observing site.....60 miles south of Fargo ND.
Latitude.....46 d 30 m
Longitude.....96 d 45 m

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(55) Photographing Comet Halley

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Comet Halley has inspired awe for centuries, but our ability to record the appearances of Halley's comet has been limited to drawings, paintings, needlework, and stone etchings. With the comet's return in 1910 we were finally able to record an image of Halley's on film. However, the only available methods at that time were black and white. These pictures were of high quality and did give a better representation of a comet than we had previously. However, these pictures have been eclipsed by photos of other bright comets.

It has been our aim to develop techniques to record the best possible images of Comet Halley in both color and black and white, and to generalize these procedures for amateur astronomers. We have used two telescopes, and four types of film at various observing sites.

The first of the telescopes is an 8 inch, f/10 Celestron which provides a narrow field of view of one-half degree and a good magnification (40x). The other telescope is one that we developed and built at Concordia. It is a 6 inch, f/2.5 refractor. A large format (3" x 4") camera is mounted on the telescope to provide a 13^{o} by 17^{o} field of view and a magnification of 6x. Each of these telescopes have advantages and disadvantages when it comes to cometary photography and are best utilized in tandem.

The four film types employed were selected for their high-speed, fine detail, and/or the versatility in processing them. 3M 1000 Chrome was selected for its ultra-high speed. This film can also be processed up to ISO 4000, making it one of the fastest films available. This film is especially well adapted to astrophotography for those who do not possess a drive motor for their telescope or camera. Kodak EES P800/1600 color film was selected for its moderate to high-speed, and its ability to be processed from ISO 400 to 3600. The large range in processing allows for more latitude in the photos. Kodak EES P800/1600 is a good film to experiment with in order to obtain a feeling for the differences that push processing and film speed can make. Verichrome 160 was selected for its fine grain. This film captures fine details more accurately and yields higher image quality when prints are enlarged than the other films. Kodak Tri-x black and white film was also selected for its processing versatility. This film also served as our standard to compare our work with that of others.

Photographs that were taken in late 1985 and early 1986 have established techniques that permit recording high quality color and black and white images of comets and other celestial objects. We are now awaiting the reappearance of Comet Halley to expand the knowledge already gained by this study.

(56) THE FLYBYS OF HALLEY

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In 1986, Halley's return from behind the sun will be waited for impatiently by thousands of professional and amateur astronomers. A series of satellites will be sent out to gather information about the comet.

This information is vital for our understanding of the origin of our Solar System. It is believed that comets are the most primitive and least evolved objects in our Solar System (1). Since comets have spent most of their lives in the "deep freeze" of space, beyond the edge of the Solar System, they have presumably retained their original chemical and physical properties. Comets may provide evidence for the composition of the original outer solar nebula (2). Comets could be the vehicles in which life itself began. They may have transported volatiles and organic molecules to the atmospheres of the terrestrial planets of which life itself is made.

In March of 1986, five satellites will make rendezvous with Comet Halley. The information gathered from the satellites should not be repetitive for each craft has a different emphasis.

The Soviets sent up two craft: Vega 1 and Vega 2. Their main goal is to take pictures of the cometary nucleus. Each Vega has a wide-angle and a narrow-angle camera. The field of view will correspond to an area on the nucleus of 150m x 200m at the closest approach distance of 10,000 km. Their goals are to determine the chemical and physical composition of the coma, the various velocities of the gas molecules, and the spectrum and polarization of light scattered from dust (3).

The Japanese have sent two satellites named Sakigake and Suisei. They will monitor the solar wind upstream from the comet. They each carry a spectrophotometer to map the distribution of atomic hydrogen and how that distribution changes with the heliocentric distance of the comet (4). As in all of the satellites, the information gathered from each will be used to monitor and redirect the satellites that have not yet reached the comet. The Japanese will use data collected by the Soviet satellites to increase the effectiveness of their craft. There is an International cooperation between countries in the information gathering of Comet Halley.

The European Space Agency has sent the craft Giotto to meet the comet. It will attempt to fly within 500 km of the nucleus. Giotto will attempt to photograph the comet's nucleus. It also carries a spectrophotometer to monitor the brightness of the coma, to measure polarization in emission lines, and to study the intensity of dust being emitted by the comet (5).

The information gathered from this cooperative satellite program, will further our knowledge of cometary science. By sending out satellites to fly by the comet, we will gain a better understanding of the origin of the Solar System in which we live.

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SYMPOSIUM

on

SALINE LAKE AND MARSH ECOLOGY

Presiding: Harry Holloway, Jr.
Biology Department, UND
Grand Forks, ND

57. The Ecology of Saline Lakes on The Canadian Plains with an Emphasis on Benthic Fauna
U. Theodore Hammer*
Biology Department
University of Saskatchewan
Saskatoon, Saskatchewan, Canada

58. Postglacial Environmental Changes in Devils Lake as Evidenced by Ostracoda
J.B. Van Alstine*
Geology Department
University of Minnesota-Morris
Morris, MN

59. Hydrologic Setting of Saline Wetlands in the Missouri Coteau
T.C. Winter*
U.S. Geological Survey
Denver, CO

60. Algal-Nutrient Interactions in Prairie Lakes
L. Elliot Shubert*
Biology Department, UND
Grand Forks, ND

61. Effects of Salinity on Survival and Reproductive Success of Fishes, Upper Great Plains
J.J. Peterka*
Zoology Department, NDSU
Fargo, ND

62. Parasites of Fishes in Prairie Lakes and Impoundments
H.L. Holloway, Jr.*
Biology Department, UND
Grand Forks, ND

63. Characteristics of Prairie Saline Lakes and Their Influence on Waterfowl Use
George A. Swanson*
Northern Prairie Wildlife Research Center
Jamestown, ND

THE ECOLOGY OF SALINE LAKES ON THE CANADIAN PLAINS WITH AN EMPHASIS ON BENTHIC FAUNA

(57)

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Most of the lakes in Alberta and Saskatchewan between 103° and 114°W Longitude and south of 54° N Latitude are saline. In Manitoba they are restricted to the southwestern corner. Poorly differentiated drainage and semi-arid to subhumid climates result in closed lakes. Although most of these lakes are relatively shallow, a few exceed 20 m in depth with a maximum of 48 m (Deadmoose Lake) (1). A few are as large as 300 km^2 (Big Quill, Old Wives) but most lakes have areas less than 50 km^2. They vary in salinity from subsaline to extreme hypersalinity, i.e., 0.5‰ to >350‰ salt (2). The chemistry of these lakes is dominated by sodium bicarbonate -carbonate at lower salinities but evapoconcentration results in sodium magnesium sulphate dominance at high salinities. Few lakes are sodium chloride dominant.

A survey of algae in Saskatchewan saline lakes (3‰ or more) with an emphasis on the plankton yielded 212 species and varieties distributed over 8 classes and 42 families (3). Diatoms, green and blue-green algae were dominant making up 38%, 24% and 19% respectively of the total species. Species richness is inversely related to water salinity. The most species (63) were present in marginally saline Wakaw Lake. Hypersaline lakes (>50‰) had from 4 (Patience) to 35 (Little Manitou) species and varieties each. Fourteen species, mostly diatoms, were restricted to hypersaline lakes. Over a broad spectrum of salinities, the most important community constituents were the green algae Ctenocladus circinnatus, Dunaliella salina and Rhizoclonium hieroglyphicum, the blue-green algae Lyngbya birgei, Microcystis aeruginosa, Oscillatoria tenuis, O. Utermoehli and Nodularia spumigena and the diatoms Melosira granulata, Stephanodiscus niagarae and Chaetoceros elmorei.

The primary productivity of eight saline lakes was determined (4, 5). Daily productivity ranged from 0.001 to 11.135 g C m^{-3} and 0.053 to 7.968 g C m^{-2} whereas annual production ranged from 29 to 673 g C m^{-2}. The highest productivity was characteristic of the least saline but most eutrophic lake (Humboldt) investigated. Spring blooms of diatoms and summer blooms of blue-green algae (mostly Aphanizomenon flos-aquae) dominated this lake. The lowest productivity was associated with the most saline lake (Patience) but meromictic Waldsea Lake had only slightly higher productivity.

Vascular aquatic macrophyte species richness decreases with increasing salinity. Only three species of submerged plants (Potamogeton pectinatus, Ruppia maritima, R. occidentalis) tolerate hypersaline conditions. Five emergent species (Scirpus maritimus var. paludosus, Distichlis stricta, Puccinellia nuttalliana, Scirpus americanus, Triglochin maritima) occur commonly over a range of saline lakes including hypersaline ones. Species tolerant of highly saline conditions usually occur over the entire salinity spectrum and even extend into subsaline (< 3‰) conditions. A major increase in species numbers occur below 5‰. In the lakes investigated angiosperm distribution was controlled by total ion concentration whereas substrate texture played no apparent role. Light usually limited the depth to which these plants grew except in Redberry Lake where light was non-limiting.

Only 23 species of macroinvertebrates occurred in the benthos of 22 saline lakes along the 53° N parallel. The amphipod Hyallela azteca and the chironomids Procladius freemani, Chironomus nr. muratensis and Cryptochironomus spp. were important at lower salinities (up to 12‰) whereas the chironomids Tanypus nubifer, Cricotopus ornatus and Chironomus nr. annularis dominated at moderate salinities (5-30‰). Dolichopodid and ephydrid dipterans were the only species in hypersaline lakes. Diversity decreased significantly with increased salinity.

Mean dry biomass ranged from 0-9.12 g m^{-2}, showing little correlation with salinity, though low salinity lakes often had elevated values and hypersaline lakes very low values. Shallow lakes (< 5 m had significantly lower standing crops. Over the last 45 years there have been changes in biomass due to cultural eutrophication or changes in salinity or depth. Chironomids dominated the biomass in salinities up to 50‰ above which dolichopodid and ephydrid dipterans dominated.
Three groups of lakes classified as hyposaline (3-28‰), mesosaline (20-50‰) and hypersaline (> 50‰) reflected the importance of salinity as a major controlling factor with respect to taxonomic groups and their abundance.

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(58) POSTGLACIAL ENVIRONMENTAL CHANGES IN DEVILS LAKE AS EVIDENCED BY OSTRACODA

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Several lakes within the Devils Lake basin, Northeastern North Dakota, have undergone drastic changes in salinity and depth during recorded history, as well as during the Pleistocene Epoch. These changes through time have been recognized in the geochemistry of lake sediment (1) and in the fossil diatom flora (2) contained in sediment cores of Devils Lake. The purpose of this study was to determine the vertical distribution, diversity, and paleoecology of ostracod populations in cores from lakes within the Devils Lake basin, and from a control lake outside of the basin. The environmental changes within the lake basin defined on the basis of Ostracoda, were compared to changes defined by diatoms and the environmental interpretations based on sediment geochemistry. Ostracods are very useful for paleoenvironmental interpretations. They are abundant, well preserved, and relatively easy to work with as a taxonomic group. The limiting factors in ostracod populations seem to be temperature and total dissolved solids. Total dissolved solids, and water depth appear to be the most significant factors fluctuating through time in the Devils Lake basin.

Sediment cores were taken from Main Bay and Creel Bay of Devils Lake and East Devils Lake within the basin, and from Red Willow Lake, outside the basin. The cores were taken with a piston coring apparatus to minimize disruption of the sediment. Through the use of casing and extension rods, continuous cores of up to 8.5-m in length were able to be recovered. The cores were sampled at 10-cm intervals.

Fifteen species of ostracods were present in the cores: 8 candonids, 1 cyclocyprid, 3 cyprids, and 3 limnocytherids. Two distinct faunas are recognized. The Devils Lake-East Devils Lake fauna consists of Candona lactea, C. rawsoni, Cyprinotus glaucus, Potamocypris smaragdina, Limnocythere (Limnocytherina) ceriotuberosa, and L. staplini. The Red Willow Lake fauna consists of Candona acutula, C. candida, C. caudata, C. decora, C. ohioensis, C. lactea, C. pronopa, C. rawsoni, Cypridopsis vidua, Cyclocypris ampla, and Limnocythere (Limnocytherina) itasca. Only two species are in common with the two faunas.

The paleoecology of the Devils Lake-East Devils Lake fauna indicates that the lakes within the basin have remained shallow, with little aquatic vegetation throughout the time period represented by the cores. Elevated levels of sulfates have always been present in the lakes, with levels of total dissolved solids always being greater than perhaps 10,000 ppm. Faunal diversity, similarity, equitability and simple abundance of species fluctuated greatly through time, but the fauna did not become more complex or diverse. Variations in these measured indices are used to interpret major episodes of environmental disruption. In the Devils Lake-East Devils Lake system, the nature of the disruption is interpreted to be periods of greatly increased salinity, probably related to dropping water levels or dessication. Using previously determined sedimentation rates for Main Bay of Devils Lake, the episodes of environmental disruption are interpreted to have occurred at 7,000, 1,500, 1,200, and 900 years before the present. Because of the lack of sedimentation rates for the other lakes, the time of the disruptive events in the other cores could not be determined.

The paleoecology of the Red Willow Lake fauna indicates that the lake has remained cool and relatively deep, with abundant aquatic vegetation through time. The sulfate concentration has always been low, and the levels of total dissolved solids have always remained below perhaps 6,000 ppm. The same indices of diversity and abundance were used to interpret changes recognized within the Red Willow Lake core. These indices fluctuated greatly throughout the length of this core as well. The nature of the environmental disruption is unknown, but is probably related to temperature fluctuations. There is no indication of elevated levels of salinity in the history of Red Willow Lake, and none of the episodes recognized in this core correlate with episodes recognized in the Devils Lake basin cores.

The paleoecology of the ostracods compares favorably with general paleoecological interpretations based on diatoms for the Devils Lake basin through time. Only two periods of environmental disruption, however, those at 7,000 and 1,500 years B.P., correlate with evidence from either diatoms or the geochemistry of the lake sediment.

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(59) HYDROLOGIC SETTING OF SALINE WETLANDS IN THE MISSOURI COTEAU

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The occurrence of saline lakes and wetlands in the northern prairie is commonly thought to be related to an excess of evaporation compared to precipitation. Although evaporation concentrates chemical constituents in prairie lakes over the course of a summer, evaporation alone does not explain fully the highly variable salinities and water chemical types in adjacent lakes and wetlands throughout the prairie landscape.

LaBaugh and others (1985) indicated that the differences in chemical characteristics of the lakes in the Cottonwood Lake area, a small area in Stutsman County, North Dakota, were due to the positions of the lakes relative to ground-water flow systems. Mixed potassium calcium bicarbonate water with small values of specific conductance occurred in lakes that recharge ground water. In contrast, the lake with the largest value of specific conductance was in an area of ground-water discharge and was characterized by a magnesium sulfate water type, similar to that of the adjacent ground water. Based on the evidence from the Cottonwood Lake area, it is likely that chemical differences between lakes in larger regions can be explained, in part, on the basis of the location of these lakes relative to local or regional ground-water flow systems.

To examine the relationship of ground-water flow systems to the chemistry of prairie lakes on a regional scale, Swanson and others (1986) studied the hydrogeologic setting of lakes and wetlands in Stutsman and Kidder Counties, North Dakota. They indicated, through analysis of vertical sections of ground-water flow, that a number of saline lakes in the Kidder County outwash plain, and lakes located in other topographic lows, receive ground-water discharge from large intermediate and regional ground-water flow systems. For example, lakes of high salinity in the Crystal Springs area receive discharge from large ground-water flow systems in the drift that are recharged to the east. In addition, these lakes also lie in a depression between major topographic highs to the north and south. Because of these topographic highs, it is likely that ground-water flow systems, even larger than those to the east of Crystal Springs, discharge ground water to the area from the north and south.

The hydrologic section indicates that some of the lakes near the Kidder-Stutsman county line might even be receiving discharge from bedrock water that moves through the drift before entering the lake. For example, Lake George, which is a deep lake that nearly reaches bedrock, at the eastern limit of the Fox Hills Formation, has specific conductance greater than 20,000 μS/ cm. Ground water discharging upward from the edge of the Fox Hills Formation is probably entering Lake George and affecting its chemistry.

Because of the scale of the regional hydrologic sections, it is not possible to show small, local ground-water flow systems. Therefore, regional sections are useful only to evaluate large ground-water systems that affect ground-water chemistry. The local ground-water flow systems that cannot be shown are highly dynamic spatially and temporally. Because of this, they have variable effects on the chemical characteristics of shallow ground water and lakes regardless of the regional topographic position of the local systems.

Differences in topographic position, even though small, present different opportunities for seepage from lakes. For example, within a regional topographic low, a lake that is slightly higher than an adjacent lake could have seepage from it during part of the year, whereas the lower lake might not have seepage out of it. Discharge by way of seepage out of one and not the other, together with different relative mixes of ground-water from local and regional flow systems, as pointed out above, could explain the greatly different water chemistry between adjacent lakes.

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(60) ALGAL-NUTRIENT INTERACTIONS IN PRAIRIE LAKES

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Algal-nutrient interactions have been extensively studied in aquatic ecosystems. Most studies have employed the algal bioassay method (5). This method is very useful in determining nutrient availability and/or toxicity.

Saline lakes afford an unique opportunity to study algal-nutrient interactions, since salinity conflicts with growth stimulating nutrients and modifies algal growth. Prairie lakes in North Dakota are characterized as shallow, closed saline ecosystems, which are subject to fluctuating water levels and salt inbalances such as, sodium sulfate.

Studies have been conducted on a very large (7 x 10.5 km) pothole (Devils Lake), (2,3), and a very small (0.4 x 1.2 km) pothole (Fox Lake), (1,4). Water quality analysis was conducted on both potholes. Devils Lake is dominated by phytoplankton and Fox Lake is dominated by periphyton.

The phenomena of these prairie lakes are hypertrophism (high algal productivity), lack of thermal stratification during the summer months and significant increases/ decreases in nutrient concentrations during the growing season. In addition, nutrient concentrations also fluctuate from year to year due to changing climatic conditinos (spring runoff and precipitation/evaporation rates). The "rise and fall" of Devils Lake over time is an example of a dynamic aquatic ecosystem (Fig. 1).

Cultural enrichment (sewage effluent and agricultural runoff) has increased the nutrient loading and magnified the problems associated with prairie lakes, since they act as "energy sinks." Consequently, phytoplankton or periphyton production is quite high, despite the high salinity (Table 1).

The high phosphorus (P) levels in Devils Lake have been correlated with a reduction in trace metal availability (iron), which was identified as a limiting factor in 1977 (2). Limiting factors were not determined for Fox Lake, although nitrogen (N) and P declined at the end of growing season, whereas most major cations increased as the water level decreased due to excessive evaporation. Silicon (Si) availability was important for early attachment by the diatoms.

Understanding the population dynamics of phytoplankton or periphyton requires elucidations of the fluxes of available nutrients in relation to the salinity factor. Inland prairie lakes while high in productivity are low in diversity of species, which is due in part to the high levels of N and P. However, these lakes are excellent models for testing limiting factors for growth at various trophic levels and studying nutrient dynamics of primary productivity.

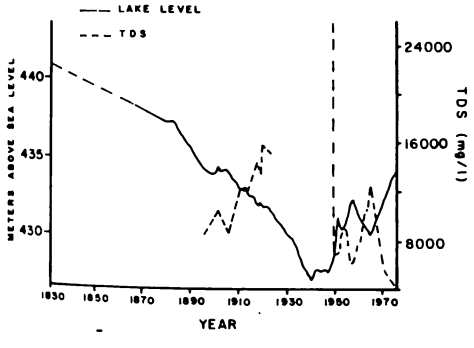

Figure 1. Historical elevations and total dissolved solids (TDS) of Devils Lake (3)

Chlorophyll a	Location
837 mg m^{-3}	phytoplankton, Devils Lake, August 1977
550 mg m^{-2}	periphyton, Fox Lake, August 1981

Table 1. Chlorophyll a concentrations contributed by phytoplankton in Devils Lake and periphyton in Fox Lake.

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(61) EFFECTS OF SALINITY ON SURVIVAL AND REPRODUCTIVE SUCCESS OF FISHES, UPPER GREAT PLAINS

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In the prairie pothole region (777,000 km^2) extending from northwestern Iowa to northwestern Alberta and in the sandhills region (52,000 km^2) of north central Nebraska are thousands of wetlands/lakes which contain water throughout the year and thus have some potential for supporting fishes. While some of these bodies of water -- generally those deeper than 5 m -- support game fish populations, many others -- generally those shallower than 5 m -- tend to winterkill, making them marginal habitats for fishes.

Major limiting factors to fishes besides winterkill and summerkill are high water salinities and closed drainage basins. Shallow water depths and eutrophic characteristics lead to winterkill and summerkill, high water salinities may limit reproductive success, and closed drainage basins limit dispersal.

Salinity is an important factor limiting fishes in wetlands in the prairie pothole region and Nebraska sandhills region. Based largely on field observations, the upper tolerance limit to salinity varies not only with the species but with the major ions in the waters (1,2,3). Fathead minnows were collected in sulfate waters of 12,000-17,000 mg/l in Saskatchewan and North Dakota, but not in bicarbonate waters greater than 2,000 mg/l in Nebraska. Native fishes with the greatest tolerance to sulfate saline waters are sticklebacks (brook and ninespine) and fathead minnows; the upper tolerance is 20,000 mg/l (ninespine sticklebacks) with several species (lake whitefish, common sucker, walleye, northern pike) tolerating 15,000 mg/l.

From reports in the literature, it is difficult to assess the relative toxicities of various kinds of salts. Some general observations are available. Burnham and Peterka (4) summarized their observations on the death of fathead minnow sac fry in water of 12,000 µmhos of the sodium-sulfate type in their studies and compared their findings with observations reported by other investigators. Burnham and Peterka (4) found fry did not survive when a) sulfates exceeded 8,000 mg/l; tolerance limits of fathead minnows were 7,500 mg/l in sulfate lakes in Saskatchewan (1), b) alkalinity exceeded 1000 mg/l; more than 2000 mg/l caused a sharp decline in spawning success of fatheads in Nebraska saline lakes (3), c) potassium exceeded 300 mg/l; potassium averaged 246 mg/l (extreme of 500 mg/l) in 16 Nebraska lakes where fatheads survived for 6 or more months (3), and d) calcium levels were less than 7-10 mg/l; low calcium may increase toxicity of other substances (5). High pHs of 9.2 - 9.3 were probably not at lethal limits as pHs as high as 9.4 (mean of 9.2) were observed in N. Alkaline Lake during ice-free periods 1969-70 (6).

From field observations and laboratory tests, adult fish tolerate higher salinities than sac fry (3,4). Burnham and Peterka (4) reported that sodium-sulfate type waters in North Dakota exceeding 7,000-8,000 µmhos may prevent successful reproduction of fathead minnows. Laboratory bioassays indicated that fry survive at 6,000 µmhos but not at 12,000 µmhos, and fathead minnow eggs spawned on floating boards placed in N. Alkaline Lake where lake water conductivity was 8,000 µmhos, lost their adhesiveness and were easily lost from boards; all eggs removed to the laboratory died. Adult fatheads survived in N. Alkaline Lake when winter conductivities were 16,000 µmhos with successful reproduction in the spring and early summer when conductivities ranged from 6,000 - 7,000 µmhos.

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(62) PARASITES OF FISHES IN PRAIRIE LAKES AND IMPOUNDMENTS

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While there has been considerable survey work on fish parasites in prairie lakes and impoundments (1,2, and 3) few ecological and geographical comparisons have been made. During 1975-77 nine water bodies occurring in three drainages were sampled for parasites and water chemistry data simultaneously collected. The water bodies were: Arrowwood, Audubon, Jim and Mud lakes and Jamestown reservoir in the Missouri river drainage; Ashtabula, Coal Mine and Tewaukon lakes and Harvey reservoir in the Hudson Bay drainage; and Devils lake, a closed basin. Arrowwood lake, an impoundment of the James river, has a surface area of 6 km^2 with a mean depth of 2 m. Lake Audubon, an impoundment of Snake creek arm of oligotrophic Lake Sakakawea, has a surface area of 89 km^2 with a maximum depth of 21 m. Jim and Mud lakes, small impoundments of the James river, have surface areas of 3 and 2 km^2 and mean depths of 2 and 1 m respectively. Jamestown reservoir, an imoundment of the James river, has a surface area of 8 km^2 with a mean depth of 4 m. Lake Astabula formed by an earth-filled dam has a surface area of 22 km^2 and average depth of 4 m. Coal Mine lake is a 2 km^2 impoundment of the upper Sheyenne river with a maximum depth of 3 m. Lake Tewaukon, a natural eutrophic lake with a surface area of 4 km^2 and maximum depth of 2 m, is on the upper Wild Rice river. Harvey reservoir, an impoundment of 1 km^2 surface area and maximum depth of 7 m, is on the Sheyenne river. Devils Lake, formed from old glacial lake Minnewaukan, has a surface area of 138 km^2 and maximum depth of 6.5 m. It is the largest natural lake in the state. It is widely recognized that prairie lakes tend to be saline. Devils lake has been recognized for some time for its high salinity. Salt concentrations and other chemical parameters were determined using principally standard methods(4). Young(5) concluded that the character of Devils lake biota is that of fresh water, but distinguished therefrom rather by the presence of many freshwater species, than by the presence of many brackish types. He noted the presence of several parasites but dismissed them as not being members of the fauna in a strict sense and not influenced by the physicochemical environment of the host.

Water in lakes of the Missouri drainage ($\bar{x}$ salinity 14.63 ppm) is somewhat fresher than in the Hudson Bay drainage ($\bar{x}$ salinity 20.72 ppm) or Devils lake ($\bar{x}$ salinity 295 ppm). Twenty-three parasite species recovered from lakes in the Hudson Bay drainage did not occur elsewhere. Similarly, 10 parasite species were found only in lakes of the Missouri river drainage. One parasite, a monogenetic gill trematode, Gyrodactylus hoffmani, was found on fathead minnows only in Devils lake. It was previously reported(6) from Cottonwood lake, McHenry county, ND, in the Hudson Bay drainage. Consequently, not one parasite species associated exclusively with brackish water hosts was recognized in the Devils lake fauna. The five parasite species from Devils lake fishes relate the fauna to fresh water.

The parasite species/host species ratio is lowest in Devils lake and lake Audubon. These low ratios probably arise from different conditions. The low diversity in lake Audubon may be associated with the drastic environmental changes resulting from the recent impoundment of Snake creek in establishing this eutrophic dead basin. The mean of the parasite species/host species ratios is lower in Devils lake(1.0) than in lakes in the Missouri river drainage(2.14) and Hudson Bay drainage(2.43). This is due to the absence of several parasite species from Devils lake which occur in fishes of fresher waters of the Hudson Bay and Missouri river drainages. There is a trend toward an inverse relationship between salinity and parasite diversity. The more alkaline water bodies (Devils lake, lakes Tewaukon and Audubon and Harvey reservoir) with high concentrations of chlorides and sulfates tend to have lower parasite species/host species ratios, except Coal Mine lake.

Several interrelated factors should be considered in explaining these results: degree of environmental change at impoundment; time frame within which changes occur; amount of communication of the impoundment and river environments after impoundment; drainage geography; degree of contact with potential sources of new parasites; water chemistry; fish stocking reports; and ability of individual parasite species to maintain continuity of infection after impoundment.

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(63) CHARACTERISTICS OF PRAIRIE SALINE LAKES AND THEIR INFLUENCE ON WATERFOWL USE

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Inland lakes that concentrate salts are found in areas where evaporation exceeds precipitation (1). Such saline lakes occur in south-central North Dakota in low-lying outwash basins or melt-water channels that function as ground water discharge areas. Dissolved salts transported by surface run-off and ground water accumulate as water is lost to the atmosphere. As salts accumulate, those that are highly soluble eventually dominate the water column. Cations and anions that dominate saline lakes vary with location (2) and are influenced by the geologic materials that interact with surface flow and ground water. Sodium is the dominant cation and sulfate the dominant anion in saline lakes found in the prairie pothole region of south-central North Dakota. Salt concentrations ranging from oligosaline to hypersaline (3) have been described in prairie lakes (4).

In lakes having elevated salt levels, salt-intolerant aquatic plants and invertebrates cannot survive and salt-tolerant species dominate (4, 5). Biotic changes due to salt concentration can determine waterfowl use by influencing availability of key food items and overwater cover. Emergent vegetation is absent and shorelines are devoid of vegetation in lakes having the highest salt levels. Spring seeps that occur along the shoreline of ground-water-dominated lakes provide the only emergent cover for broods.

Breeding pairs of dabbling ducks routinely feed on saline lakes where they consume crustaceans (Anostraca, Copepoda, Cladocera and Ostracoda), insects (Diptera and Coleoptera), filamentous algae and saltwater wigeongrass (Ruppia maritima) (5, 6). Breeding females tend to feed on invertebrates during laying. Gadwall (Anas strepera) are the dominant duck species during the breeding season (6, 7). Hens that hatch nests located on islands in saline lakes move their broods to fresh seeps that are of suitable water quality, or to fresh wetlands in nearby complexes.

Recently hatched ducklings cannot tolerate salt levels that exceed 20,000 µmhos/cm and some mortality was observed at 16,000 µmhos/cm (7). Growth rates of ducklings are significantly reduced at this level. When salt levels exceed 16,000 µmhos/cm, ducklings are restricted to saline lakes that contain spring seeps along the shore margin. Recently hatched ducklings are able to feed in saline lakes if fresh water is available from spring seeps. Some prairie lakes contain high concentrations of sulfates and magnesium that are not processed by the supraorbital salt glands of ducks as efficiently as sodium chloride is in marine water.

Fall-staging northern pintails (Anas acuta), blue-winged teal (A. discors), American wigeon (A. americana), and redheads (Aythya americana) are attracted to saline lakes that produce saltwater wigeongrass. Northern pintails and blue-winged teal glean the seeds whereas American wigeon and redheads consume leaves and stems. Fall-staging northern shovelers (Anas clypeata) are attracted to saline lakes that produce large standing crops of Copepoda. Lakes of intermediate salt level (5,000-15,000 µmhos/cm) dominated by sago pondweed (Potamogeton pectinatus) are attractive to migrating canvasbacks (Aythya valisineria) and tundra swans (Cygnus columbianus), which consume sago tubers. If salt levels increase or decrease in response to major water volume changes, other plant species that are more competitive at different salt levels will replace sago pondweed. Annual shifts in the use of prairie lakes by migrating canvasbacks and tundra swans are determined by the distribution of sago pondweed. Periodic changes in water volume that result from climatic trends are great enough to alter salt concentration and, subsequently, plant and animal communities (7).

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SYMPOSIUM

on

APPLIED REMOTE SENSING

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(99) Remote Detection of Thunderstorm Outflow Boundaries

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The purpose of this paper is to further investigate properties of outflow boundaries associated with convective storms. Information gathered by the University of North Dakota (UND) radar will be utilized to evaluate the wind fields associated with thunderstorm outflow.

The phenomenon of outflow boundaries or gust fronts is defined as the leading edge of a mesocyclone pressure dome followed by a surge of gusty winds on or near the ground. This gust front is often associated with a pressure jump, temperature drops, wind shear and/or heavy precipitation.

The instrumentation used in this investigation was a 5 cm C-band Doppler weather radar. The data was obtained from convective storms during the 1985 FAA-Lincoln Lab's Operational Wind Shear detection (FLOWS) project near Memphis, Tennessee. Data from June 11 and June 25 were chosen for analysis.

Both data sets depict the low level nature of gust fronts with depths extending from 0.5 km to 2.0 km above the surface. The strength of the storm outflow was found to relate directly to the strength of the downdraft producing the gust front. This downdraft strength correlates well with the maximum detectable height.

The June 11 gust front had strong surface winds reaching 27 m/s speeds over a broad region. The outflow boundary was associated with strong to severe thunderstorms which moved east-northeastward following the upper level steering winds. Wind within the cells averaged from 10 to 18 m/s. Reflectivity levels were only 15dBZ, but the radial shear across the front was significant, with southwesterly flow at 10 m/s ahead of the front, to northwesterly flow of >20 m/s behind the gust front. This front was a wet gust front as it was accompanied by heavy rain. Visually it could be seen as a swirling wall of rain rapidly advancing across the surface. This gust front extended to near 1.5 kilometers above surface.

The June 25th case involved a dry gust front associated with dissipating air mass thunderstorms. The environmental winds were light and easterly; as a result the cells had little movement. Between 2000 GMT and 2300 GMT as many as six unique gust fronts were detected by radar within an 80 kilometer radius. Once again they were low level features, generally below 1.0 kilometer in height. The reflectivities were low (<10dBZ). The storm outflow propagated isotropically from the generating cells due to the weak environmental flow. The intersection of the two boundaries produced enough lift to generate a new thunderstorm. Winds from these gust fronts were very light, mostly <5 m/sec. Doppler radar once again proved itself by detecting the gust, even though it was weak. In this case the only detectable properties in the outflow were dust and a change in the refractive index. The shear across the front was not significant at any level.

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(100) Detection of Clear Air Echoes by Doppler Radar

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This paper describes the use of a 5-cm Doppler radar to map wind profiles in a cloud free environment. The utility of Doppler weather radar to map a turbulent, precipitation-free environment has been demonstrated in recent years (1). Critical to the detection of clear air echo is the magnitude of the refractive index structure parameter, C_n^2, which is a basic characteristic of a turbulent random process having stationary first increments. Because the backscatter of the transmitted energy is proportional to the intensity of the refractive irregularities at a scale size one-half the radar's wavelength, C_n^2 is also sufficient to estimate the reflectivity of clear-air. Since the refractive index itself is a function of temperature and density of air, a knowledge of C_n^2 provides also a description of the state variables and their stratification.

The equipment used in this investigation was the University of North Dakota (UND) 5.4-cm Doppler radar. This radar is comprised of an Enterprise WR-1000 radar for reflectivity measurements. System parameters are given in Table I. The coherent signal is real-time processed to evaluate autocorrelations and Doppler spectral moments in the data to yield a filtered radial wind field (2). Using the parameters in Table I and assuming a modest summertime value of $C_n^2 = 3.9 \times 10^{-14} m^{-2/3}$ the maximum range expected for clear air echo return by the UND radar is 2.2 km. To test these values, data collected by UND under clear air conditions in Memphis, Tennessee on April 18, 1985 were examined. Radar scientist notes for this day indicated echo returns extending to a range of 40 km and to a height of 1.8 km. The vertical value lies within the permitted value under the assumed value of C_n^2. However, for a range of 40 km a value of $C_n^2 = 1.31 \times 10^{-11} m^{-2/3}$ is required. This large value is indicative of a moist maritime environment and has been theoretically been predicted by second-order turbulence closure models for such atmospheres (3).

The vertical Doppler wind profile derived from the data indicated a clockwise turning of the wind for the first 1.0 km with slight counter-clockwise turning for the next 0.8 km. The clockwise turning of the winds represents warm thermal advection which acts to destabilize the lower atmosphere by convective turbulence. The counter-clockwise motion strengthens the thermal inversion present at the top of the convective boundary layer and as such acts to limit the vertical extent of the turbulence.

Table I - UND Radar Parameters

average transmitter power	165 W
pulse width	0.6 μs
receiver bandwith	1.0×10^6 Hz
repetition period	909 μs
wavelength	5.38 cm^2
antenna area	4.7 m
system noise temperature	∿315 °K
aperture efficiency	∿0.6
dwell time	29 ms

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(101) Airborne Cloud Photogrammetry

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The University of North Dakota owns and operates a Cessna Citation II research aircraft which is equipped for a variety of atmospheric measurements including airborne cloud photogrammetry. Under the sponsorship of the Bureau of Reclamation, the aircraft was flown on the 1981 Cooperative Convective Precipitation Experiment to gather photographic data. Quantitative, time-lapse film data can be used to derive a number of cloud properties including cloud top and base heights, growth rates, cloud volume estimates, and location of cloud turrets. They may also provide a life history of specific cloud features and qualitative aspects of cloud system development. Although some of this information may be approximated from other measurements, the spatial and temporal resolution of visual quantitative observations makes this the optimum technique for determining these properties. This paper describes the methodology used at UND to prepare the data for analysis.

The location of an object in space can be accurately determined from photographic data given the location and orientation of the camera, the distance to the object and the calibration constants for the camera system. The conversion of cloud image data to cloud properties is essentially a geometric technique relating coordinates of the image on the film to the coordinates of the object in space (1). Assuming initially that the horizontal axes of the camera are parallel to the ground, the direction of the object from the camera, or aircraft, may be obtained from the heading of the aircraft, the attitude of the camera with respect to the aircraft and the displacement of the image from the center (principal) point of the film. If the distance to the object is known along with the location of the camera, the location of the object and its height relative to the camera may be determined (2). The distance to the cloud is often known from radar and aircraft positioning data. If this information is not available or appears to be in error, the distance may be calculated using photographs taken from two different locations (2). The height of the object above the earth can then be determined given the altitude of the aircraft and correcting for the effects of atmospheric refraction and the earth's curvature (3). Realistically, the camera is almost never level and the film image coordinates must therefore be transformed into earth coordinates in order to account for the orientation of the camera in space.

This transformation requires a knowledge of the angular relationship between the camera and the aircraft Inertial Navigation System (INS) coordinate systems. The accuracy of any quantities derived from the data can be no better than the uncertainty in these camera attitude angles. They define how the pitch, roll and yaw of the cameras are related to the roll, pitch and heading of the aircraft. Since it is not practical to directly determine this relationship the attitude angles must be derived from film images of objects whose orientation and location in space are known.

If the optic axes of the cameras are approximately perpendicular to the longitudinal axis of the aircraft, the camera roll angle may be determined by using the earth's horizon as a reference. The roll attitude angle is simply the angular difference between the aircraft pitch and the slope of the horizon on the the film image. Given the camera roll angle, the camera pitch and heading attitude angles may be found using photographs of the sun. This is done by applying the known roll and assumed pitch and heading angles to the film image data to calculate the sun's position in space. By varying the assumed angles in small increments, an array of calculated positions is generated and compared to the true position of the sun. The actual camera attitude angles yield the correct calculated position. The true elevation and azimuth of the sun can be determined for any date, time and location of the aircraft (4).

The general data reduction procedures employed at UND entail measuring the film coordinates of the cloud image and processing this information through computer programs which apply corrections and perform transformations. Since the film image itself is too small to allow direct measurements of cloud features, the image is magnified and projected on a NAC Film Analyzer/Digitizer. Reference points are taken from each study frame in order to locate the principal point and orient the x,y image axes. During the data processing these cloud image coordinates are combined with aircraft data and calibration constants and are transformed into earth coordinates. This permits the calculation of the desired cloud properties.

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(102) Olive Branch, Mississippi Microburst

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Microburst wind shear is a proven killer. In the past 13 years, 532 people have died in five major airline wind shear accidents in the United States, while many other close calls have gone unreported. Microbursts or downbursts were first introduced by Dr. T.T. Fujita (1) after the investigation of a plane crash at John F. Kennedy International Airport on June 24, 1975.

The microburst is characterized by a strong downdraft associated with either a thunderstorm or a weaker cumulus congestus cloud. The downdraft is always associated with precipitation. This precipitation may reach the ground or remain aloft (virga). The downdraft spreads at the ground into a quasi-horizontal flow, as required by mass continuity considerations. The average microburst has a horizontal dimension <4 km and a headwind/tailwind shear of 25 m/s with a mean lifetime of 10 minutes (2).

The majority of research conducted before 1984 examined microbursts of the type now being called "dry" or "virga" microbursts. A distinction must be made between these and the "wet" or "thunderstorm" microburst which have been under investigation since 1984 under the FAA/Lincoln Operational Weather Studies project (FLOWS) conducted by Massachusetts Institute of Technology (MIT) and the University of North Dakota (UND) in the vicinity of Memphis International Airport.

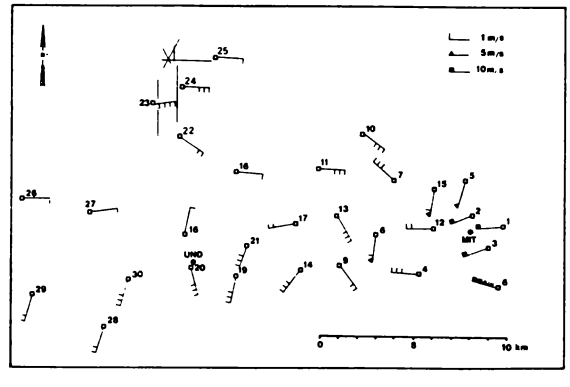
Microbursts occur under a variety of meteorological conditions. Mechanisms governing microburst formation include: subcloud cooling from evaporting precipitation; cooling from melting; frictional drag from falling precipitation; dynamically induced vertical pressure gradients; and downward transport of horizontal momentum (3).

Previous studies have not yet identified the source of the downdraft in wet microbursts. The scope of this study is to further examine the development and decay of a wet microburst with the use of UND's Doppler radar and surface mesonet data provided by MIT.

On August 24, 1985 at 1541 GMT a microburst was observed on Doppler radar 16 km east of the UND radar. Wind directions and speeds plotted on Figure 1 located the microburst just east of the MIT radar. MIT experienced heavy rain, however, surface winds remained below 9 m/s, while 2.5 km to the southeast (station #6) a peak wind of 28 m/s occurred. Severe tree damage occurred in an area from station #3 to 3 km south of station #6. All uprooted trees were laying in an east or southeast direction typical of straight line winds in microburst outflow.

Based on preliminary radar data analyses the mechanisms contributing to wet microburst development include the above mentioned with the exception of sub cloud cooling due to evaporation. A moist atmosphere from the surface to cloud base suppressed this process but a dry air intrusion into the thunderstorm at mid-levels was observed. This suggest that the necessary additional source of negative buoyancy might be the dry air entrainment into the rain shaft and/or the melting of a large quantity of ice and graupel.

Figure 1. Peak winds observed at 1541 GMT



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(103) MAPPING NORTH DAKOTA'S GRASSLANDS USING SATELLITE DATA AND COMPUTER MAPPING TECHNIQUES

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There has been a dramatic reduction of grasslands in the northern Great Plains over the last century. In the past, little attention was paid to the loss of grasslands as agriculture and other land uses were expanding within the region. In recent years, however, it has become quite apparent that grasslands are an important resource to be preserved and managed. At present, one of the greatest problems associated wtih the preservation and management of grasslands, is the difficulty of simply monitoring and assessing change in grassland area. Much of the remaining grasslands in North Dakota are under private ownership, making such assessment extremely critical. Fluctuating farm economies have often resulted in conversion of grasslands to cultivated land, leading to continued reduction of native grasslands in the region. Assessment of these reductions over small areas is relatively easy, however, such assessments over large areas, such as an entire county or more, are difficult, especially if such assessments are to be conducted at regular intervals with available personnel.

In October 1983, the University of North Dakota Institute for Remote Sensing began a project supported by the North Dakota Game and Fish Department, to develop techniques for mapping of grasslands in western North Dakota. Methodologies developed include the use of false-color, infrared, Landsat satellite imagery for detection of grassland areas and computer mapping programs which allow for the registration of satellite data on planimetrically correct base maps. A seventeen county area of western North Dakota was selected as the primary study area. Counties included, are those south and west of the Missouri River in addition to Williams, Divide, and Mountrail, in the northwestern corner of the state. Grassland cover-maps of each county were to be produced using the North Dakota State Highway Department map series as a base.

Production of each map requires several steps. The first step involves the "digitization" of county highway maps to a computer-compatible form for processing by CALFORM, a computer plotting program for producing shaded, conformant maps (1). In this initial stage of mapping, outline maps consisting of section boundaries and natural features are plotted at a scale of 1:250,000. After an outline map of a county has been produced the second phase of the process begins. In the second phase, false-color, infrared, Landsat satellite images are manually interpreted to discriminate between grassland cover and five other land cover classes, including cultivated, forest, water, badlands, and mixed (grassland + cultivated). These interpreted cover types are then directly transferred to an outline map overlay. The third step involves the computer coding of the classification data into the CALFORM mapping program. In this process, each cover class is assigned an arbitrary numerical value (e.g. grassland = 1, cultivated = 2, etc.) and the values are then assigned to each section polygon within the map. Final cover maps (Fig. 1) are then plotted, illustrating the distribution and extent of grassland cover for each county.

Results of this research will provide resource managers with a synoptic view of grasslands in the western part of the state, critical for assessments of wildlife habitat and grazing lands. In addition, it will provide a baseline for studying the impact of continued loss of grasslands.

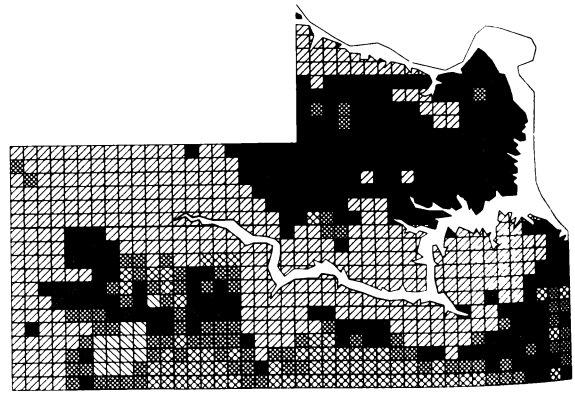

Figure 1. Cover map of the north half of Dunn County, North Dakota. Darkest areas represent grassland cover.

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(104) APPLIED NARROW-BAND VIDEO TECHNIQUES A RADIOMETRIC APPROACH

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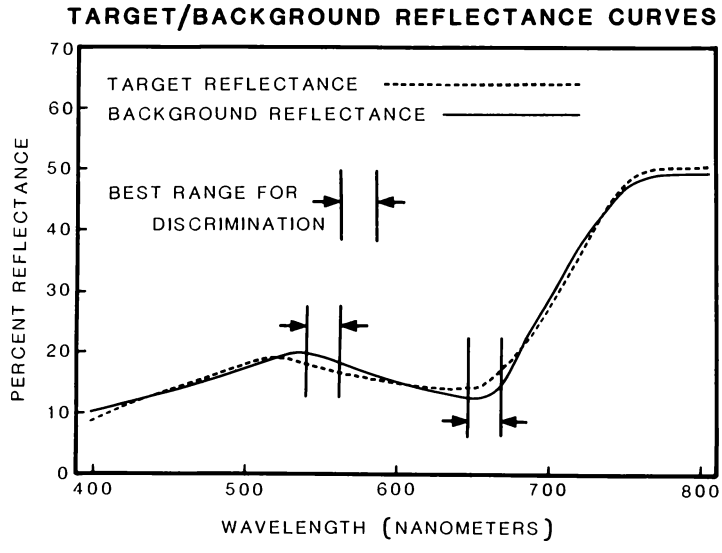
Research and application activities involving the use of airborne videographic equipment and techniques have increased significantly during the past five years. Video data are acquired in analog format, but can be converted should there be a need for digital processing. During acquisition, broad-band filters are often used with video cameras so that resultant data will approximate that obtained from Landsat. When video data are to be interpreted visually, color images are generally used because they are more compatible with the human eye. On the other hand, when video data are to be analyzed using computer techniques, black and white video data are generally preferred. The University of North Dakota Institute for Remote Sensing (UNDIRS) commonly applies digital processing algorithms to both video and Landsat acquired data to extract useful information. The quality of video data is inferior to the latter in terms of its resolution and geometry; however, video enjoys several advantages such as low cost, system availability and flexibility, and real time display. For some applications videography appears to be a viable alternative. During the past year UNDIRS has been engaged in research to determine if airborne video techniques can be used effectively to inventory shelterbelts in Grand Forks County.

In 1985 UNDIRS was invited to develop an inexpensive technique for locating and mapping regional shelterbelts. Information to be obtained must include tree types, number of tree rows per belt, and the condition of trees in each shelterbelt. These tasks generally can be accomplished using colored aerial photos and stereoscopy, but the cost of this approach is an important constraint. Is videography a viable alternative for this type of application? In an attempt to answer this question, UNDIRS employed more-or-less standard, broad-band video data acquisition equipment for research on selected regional shelterbelts. Although data were acquired during the summer, fall, and winter seasons, the discrimination of desired information was not entirely satisfactory. Another approach was needed if videography was to be found competitive.



The use of narrow-band aerial photography for the discrimination of subtle plant reflectance differences has been suggested by several researchers including Wenderoth (1975), Collins (1978), and more recently by Nixon (1985). Of particular interest to this research has been the recent development of interference filters that can now limit the range of energy admitted to the sensor to very narrow band widths (1 to 10 nanometers in the visible and near-infrared). How does one select the appropriate filter or combination of filters for a specific problem? Trial and error is a possibility, but this approach is inefficient. At this point in time, it would appear that the most rational approach would be to utilize a spectroradiometer to acquire data such as shown in the accompanying illustration. By comparing spectral curves for a target and its background, one could then select the appropriate filter(s) needed to discriminate the two. Research is continuing to determine if this approach is valid.

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SYMPOSIUM

on

WETLAND VALUES

Presiding: Bonnie Heidel
ND Game and Fish Department
Bismarck, ND

105. Classification Systems for Prairie Wetlands
Harold A. Kantrud*
Northern Prairie Wildlife Research Center
Jamestown, ND

106. Economics of Prairie Wetland Values
Jay A. Leitch*
Agricultural Economics Department, NDSU
Fargo, ND

107. Wetland Values -- A Citizen's Perspective
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111. Wetland Soils in Relation to Land Use
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A.J. Duxbury* and B.L. Heidel
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T.J. Malterer
Energy Research Center, UND
Grand Forks, ND

(105) CLASSIFICATION SYSTEMS FOR PRAIRIE WETLANDS

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In order to provide a framework for description of wetland functions and values, and for inventory purposes, several systems of classification have been developed for or applied to prairie wetlands. The origin and development of these systems is described in this paper.

During the past 70 years several classification systems have been applied to wetlands in the glaciated prairie region of the United States and Canada. The first crude system may be attributed to ornithologist Florence Bailey who differentiated grassy North Dakota "sloughs" from the deeper, more permanent "tule marshes" and noted that such marshes were locally termed "lakes" if central open water areas of sufficient width were present.[3] During an inventory of waterfowl food resources, Metcalf used a system based on salinity and vegetation to differentiate types of prairie ponds and lakes in North Dakota.[7] A system that followed the concepts of ecological succession classified Iowa wetland communities according to their position in the evolutionary sequence from early hydroseres to prairie climaxes.[5] A floral classification based on water chemistry was proposed for Minnesota lakes.[9] Bach described a system of wetland types in North Dakota on the basis of the permanency of their surface waters.[2] Shortly afterward, a "chain type" wetland classification employed Bach's[2] permanency types in combination with a series of other factors including density, distribution and species composition of marsh plants.[10]

The first wetland classification system for the United States[6] is based primarily on water depths during the growing season, cover interspersion and the occurrence of certain groups or species of hydrophytes. This system was used to classify prairie wetlands for many years and still has legal status in certain United States Laws and Provisos.

The regional classification system of Stewart and Kantrud[11] uses vegetative community types and cover interspersion to differentiate classes, subclasses, and cover types of basin wetlands in the glaciated prairies; classes and subclasses were based on hydrological and chemical (salinity) features respectively, but the cover types, a dynamic measure important to waterfowl use, were determined by both water depth and land use.

The national wetland classification system for Canada[12] is a hierarchy based on wetland physiognomy, surface morphology and plant physiognomy. An undefined fourth level is added to meet user needs. In a system developed specifically for prairie wetlands in Canada the vegetative components of Stewart and Kantrud[11] are modified, and codes for physical features of wetland basins, including size, depth, and position in the watershed are added.[8]

A special land cover classification developed for use with remote sensor data classifies wetlands on the basis of gross vegetational, hydrological and morphological features.[1]

The latest nationwide system for the United States[4] classifies wetland and deepwater habitat according to a hierarchy of systems and subsystems based on hydrologic, geomorphologic, chemical, or biological factors; at lower levels, classes and subclasses describe habitat in terms of dominant vegetative life form or physiography and composition of substrates. The lowest level is the dominant plant or animal form. The National Wetland inventory currently underway uses this classification system.

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(106) ECONOMICS OF PRAIRIE WETLAND VALUES

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Economics has been used, but mostly abused, by both advocates and adversaries of wetland preservation. It is widely underrated as a wetland science and is even maligned as part of the cause of wetland drainage. Headlines such as "Protecting Wetlands from Cars, People and Economics" [1] do little to promote the use of economic thought in wetland decision making. This is not due to a shortage of economic tools, but rather to poor application of established economic principles. Economics can provide a powerful analytical framework for examining the relationship between the wetland environment, on the one hand, and economic and political systems, on the other. Economics can assist in identifying circumstances that give rise to wetland use controversies, in discovering causes of these problems, and in searching for solutions [2].

Economics is a way to describe and analyze human behavior aspects of the allocation of scarce resources to produce alternative goods and services for which there are unlimited wants. Economics is not synonymous with the marketplace, which is where people trade goods and services that are priced in common money equivalents. Individually rational marketplace choices frequently differ from what would be considered socially rational, as is the case in many wetland conversions. There are decisions outside of the marketplace that are also based on economic principles. You do not need dollars to make economic decisions. Human behavior implies one perspective from which to assess value. "Scarce" means that resources are finite and there are not enough for all uses. And, "alternative goods and services" means that people must choose among various possible outputs.

As long as humans exist, their behavior will affect the environment. The issue, therefore, cannot be whether humans should have any impact on wetlands; rather, the issue is to define the optimal level of impact. To do this it is necessary to place some sort of value on service flows. In the economic point of view, this valuation is decidedly anthropocentric, or human-centered. Effects on wetlands are valued in terms of their ultimate effects on humanity. This perspective has been ignored in much of the wetlands valuation literature, resulting in a confusion of ecological values with economic values; for example, conversion of kilo calories of primary production to dollar values. Wetlands may have the highest rates of primary productivity among ecosystems, but that is an ecological function and not an economic value. In economics, wetland environments are viewed as a composite asset that can provide a variety of services, some directly consumed such as aesthetics, others indirectly consumed, such as wetland supported fish and wildlife. Wetlands may provide some functions that have no human use-value and thus, no economic value.

The services of wetlands are familiar to anyone who has read the wetlands literature. Some of the functions of natural wetlands are flood peak reduction, water quality improvement, fish and wildlife food and habitat, shoreline stabilization, and groundwater recharge [3]. Thus, in choosing among any of these services, some opportunities for alternative uses must be foregone. This is the opportunity cost of choice making an economic concept often ignored in arguments for carte blanche wetlands preservation.

Economic values of wetland services are difficult to estimate in money equivalents because of a poor understanding of the linkages between physical and biological services and human-use services. Proxies that may be used for estimating upper limits on human-use values of wetlands are (1) the cost to replace the wetland per se, and (2) costs to replace the service flows of the wetland. In any case, the value of wetlands cannot exceed the net service flow values lost if they are converted to an alternative use. In conclusion, the economic values of prairie wetlands are a function of the human use service flows provided by wetlands. The economics of wetland allocation involves a valid comparison, whether in dollar terms or not, of these service flows with and without the wetland.

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(107) WETLAND VALUES -- A CITIZEN'S PERSPECTIVE

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Professionals in such fields as the environmental and earth sciences have long recognized the many and varied values of wetlands in our environment. Many citizens, however, have in the past thought of wetlands merely in terms of wildlife or as waste lands to be drained. There has been a trend in recent years toward greater public awareness of the many values of wetlands, and more public involvement in efforts to secure a broader public policy on their use. Studies done in recent years by the League of Women Voters and The International Coalition are two examples of this trend.

The state League of Women Voters adopted a study of wetlands in 1979. The study concluded that wetlands are important not only as a resource for wildlife, but also in retention of floodwaters, groundwater recharge, pollution and sediment control, and aesthetics and nature study. We recommended that state policy recognize these multiple values. Water management decisions should consider entire natural watersheds, and not be based only on political boundaries. The state should become involved in wetland protection, by means of such programs as tax incentives, direct compensation (e.g., a state water bank program), enforcement of drainage regulations, and public education. The League has lobbied at the North Dakota Legislature for legislation to support these concepts.

Citizens are also represented in efforts of The International Coalition for Land and Water Stewardship in the Red River Basin. Citizens and policy-makers from Minnesota, North Dakota, and Manitoba have joined together to promote a basin-wide approach to water management, and have included wetlands protection and citizen education in their agenda. Such citizen involvement in natural resource issues can lead to recognition of wetland values by public officials, and a more comprehensive public policy on wetland issues.

(108) WETLAND HABITATS FOR BREEDING WATERFOWL

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Climatic patterns and glaciation have combined to produce ideal aquatic habitats for breeding waterfowl in an area referred to as the Prairie Pothole Region. The large number and high quality of wetlands in this region contribute to its value for breeding waterfowl. Climatic conditions featuring a moisture deficit have produced wetland complexes with basins that vary in hydroperiod and salinity. The majority of the basins are flooded temporarily or seasonally. The remaining basins are flooded primarily semipermanently and remain flooded year-round during periods of moderate to high levels of precipitation but are dry during periods of low precipitation. Semipermanent wetlands are often not integrated with surface water making them especially vulnerable to rapid changes in climatic conditions. During drawdown, vegetation is established on exposed mud flats and persists until drowned by high water. At different stages in the hydrologic cycle, plant and invertebrate foods become available to breeding pairs and broods.

Laying females and downy ducklings selected a diet dominated by invertebrates to satisfy their demand for a high protein diet (1, 2). Foods of laying dabbling ducks consisted largely of invertebrates: 72% in gadwalls (Anas strepera) (3); 77% in northern pintails (A. acuta) (4); 72% in mallards (A. platyrhynchos) (5); 99% in northern shovelers (A. clypeata) (3); and 99% in blue-winged teal (A. discors) (6). Insects, crustaceans, and gastropods were the dominant invertebrates consumed. Dabbling ducks (Anatinae) filter foods in shallow water or select food items, such as insects emerging from the water surface, by sight.

Most diving ducks nest over water in emergent vegetation and feed on benthos associated with the open-water zones of semipermanent wetlands. Foods of female diving ducks also consisted largely of invertebrates: 81% in redheads (Aythya americana) (7); 92% in canvasbacks (A. valisineria) (7); 98% in lesser scaup (A. affinis) (7); 63% in ring-necked ducks (A. collaris) (8); and 95% in ruddy ducks (Oxyura jamaicensis) (9). The major foods consumed were amphipods by lesser scaup, Trichoptera by redheads and ring-necked ducks, gastropods by canvasbacks, and chironomids by ruddy ducks.

Seasonally flooded wetlands are ideal habitats for breeding pairs because they provide isolation and high-protein foods for laying females. Early-hatched broods also use seasonally flooded wetlands. Each spring when temporary and seasonal basins reflood, a detritus food chain develops that provides an abundant, readily available food supply for breeding birds. As the season progresses, seasonally flooded wetlands become dry in most years and renesting females and broods shift to semipermanent wetlands. There they feed on invertebrates that are emerging from the water surface or are attached to vascular plants that have reached the surface.

Use of a wetland by breeding waterfowl is a function of the extent that the wetland meets nutritional requirements for reproduction, spacing requirements of breeding pairs, overwater nesting cover, escape cover for broods, and suitable drinking water. A complex of wetlands with basins that vary in hydroperiod and salinity provides the best combination of wetland habitats for supporting breeding waterfowl in the Prairie Pothole Region.

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(109) CRYSTAL LAKE - A CASE STUDY IN BALANCING WETLAND VALUES

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Wetland losses in North Dakota result primarily from small local drainage projects. The major purposes of local drains are to increase the agricultural land base, simplify farming logistics, and reduce local flooding. It is at the county level, through the county water management board, that drainage projects are organized and designed. Through a series of informal meetings and formal hearings the many values of wetlands are debated, evaluated and, in the short term, defined.

The Crystal Lake drainage project is located in Wells County, North Dakota, approximately eight miles north of Hurdsfield. The project watershed covers approximately 6.5 square miles on the northern edge of the Missouri Coteau escarpment. In 1985 the Crystal Lake watershed contained approximately 235 small wetlands totaling an estimated 511 acres. Under North Dakota drainage law all but perhaps 13 of the wetland basins could be legally drained, provided downstream interests were adequately protected. The original project design threatened to drain approximately 80% of the wetland basins and reduce wetland acreages by 70%.

At initial project hearings the Wells County Water Management Board agreed to attempt to modify the project based on objections brought by wildlife interests. Local interests concerned about time delays, cost of appeals, and potential litigation thought cooperation preferable to confrontation. What is unusual and interesting about this project is the cooperative framework within which all parties ultimately agreed to attempt to resolve their differences. A memorandum of agreement was developed with a goal to meet water management objectives with no net loss of wildlife resources. Within this framework the value of wetlands was negotiated and compromised.

The Crystal Lake Project results point to deficiencies in identification, assessment, and quantification of wetland values. North Dakota laws as well as legal and administrative processes by which wetland drainage projects are authorized do not recognize many wetland values and, therefore, fail to protect most wetlands. There is wide disparity between the legally recognized values of wetlands at the federal and state levels, which creates considerable conflict among state, local political subdivisions, the U.S. Fish and Wildlife Service, and other wildlife interests.

In spite of these deficiencies, the anticipated final design of the Crystal Lake Project will strike a compromise which meets the primary needs and objectives of the interest groups involved. It is expected that wetland losses will be reduced by 50 to 60% in the final project.

The fact that the compromise agreement includes a net loss of wetlands and wetland acreage, is disconcerting because wetland values are being sacrificed for other questionable values and benefits. The Crystal Lake Project illustrates that, if in fact substantial additional wetland values are being ignored or overlooked, then the scientific community and affected private and public interest groups must work much more actively through the legislative, administrative, political, and educational processes to increase wetland protection.

(110) PRAIRIE WETLANDS AND THE HYDROLOGIC CYCLE

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Wetlands are a highly visible feature of the prairie landscape. Casual observation of prairie wetlands indicates they have greatly variable water levels, that appear to be related most significantly to precipitation. Although precipitation is the major water input to prairie wetlands and evaporation is the major water loss, these small surface-water features serve a variety of hydrologic functions with respect to ground water. These functions are reflected in their water chemistry and aquatic biology.

Some wetlands are primarily ground-water recharge areas. These tend to be seasonal, holding water for only a few months each year, and the water is generally low in dissolved solids. Some wetlands are flow-through with respect to ground water. These receive ground-water inflow through parts of their bed and have outflow to ground water in other parts. Flow-through lakes and wetlands hold water over longer periods of time and they tend to have higher dissolved solids concentrations. Some lakes serve only as discharge areas for ground water. Lakes that receive discharge from both regional and local ground-water flow systems, and that do not lose water to seepage, are highly saline. Further, the water chemical type, based on major ion concentration, is commonly different for these different types of wetlands.

It is commonly assumed that ground-water recharge occurs on topographic highs and discharges in topographic lows. This is true on a regional basis; but, locally, ground-water recharge occurs in numerous locations throughout the landscape, regardless of regional topographic position. Differences in topographic position, even though small, present different opportunities for seepage from lakes within any regional topographic position. For example, within a regional topographic low, a lake that is slightly higher than an adjacent lake could have seepage from the higher lake part of the year, whereas the lower lake might not have seepage out of it. This opportunity to discharge water by way of seepage out of one of the lakes and not the other, together with different relative mixes of ground-water from local and regional flow systems, as pointed out above, could explain the greatly different water chemistry between adjacent lakes. In general, most ground water recharged locally near any surface-water body discharges into the lake, wetland, or stream nearest the shore. Therefore, it is not unusual to observe fresh-water springs discharging into saline lakes.

(111) WETLAND SOILS IN RELATION TO LAND USE

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This discussion is restricted to soils of the prairie pothole type of wetlands in North Dakota. Earlier work allows us to focus on electrical conductivity (EC), organic carbon (% OC) content, calcium carbonate equilvalent (CCE), and % clay as the soil-wetland properties of greatest interest (1). Salinity as measured by EC varies between wetlands and by vegetation zones in a given wetland. Percent OC is a function of vegetation, drainage, and profile depth in wetland soils. CCE depends on wetland type, and plant zonation within a wetland, while % clay varies by profile distribution in wetland types and as a function of depositional history (2).

Recharge wetlands contain highly developed soils with argillic horizons that are leached of $CaCO_3$ and more soluble materials to some depth. Flowthrough wetlands contain poorly developed soils with highly organic A-horizons that tend to have high subsurface CCE and gypsum contents. The clay percentage is lowest in the wet meadow zone around these wetlands but the pond interiors are nearly always fine textured (2). Productivity in flowthrough wetlands appears to be related to EC (3); vegetational zonation in these wetlands is related to water levels and CCE. Discharge wetland soils are the least developed, contain immaturely developed A-horizons and materials that are clearly stratified (4). Salinity, which is usually high, and water-level fluctuations govern type and amount of vegetation growth in these wetlands.

The soil properties that have the greatest influence on land use are soil aeration, salinity and texture (1,2,3). Soils of nearly all wetland types are high in fertility, but may lack oxygen for root respiration and may have toxic levels of salinity. Recharge wetlands have ephemeral water levels and low EC. The Bt-horizon clay restricts natural drainage but large amounts of native vegetation or hay can be produced. Artificial drainage results in lower % OC but removes excess water and increases oxygen levels allowing crops requiring tillage to be grown. Flowthrough wetlands are semipermanently ponded with a large range in salinity. For wildlife habitat and hayland, the zonation due to water level and salinity restrictions of plant growth are important. Because the margins of these wetlands tend to be saline (1,2), plowing in the wet meadow zones results in the formation of a surface salt crust which may increase in extent over time. Drainage of these wetlands is often unsuccessful in producing soil conditions that sustain crops because of salt accumulation after drainage. Although the water levels are lowered, soils of the former wetland interior now have a near-surface brackish groundwater which allows salt to accumulate by evapotranspiration.

In flowthrough wetlands, salinity and oxygen depletion affect plant growth. After tillage or drainage, oxygen depletion may be corrected, but salinization may increase from the wetland edge to the entire basin. In discharge wetlands, EC or salinity controls type, amount, or lack of vegetation. These soils are naturally saline and are used for hay and/or wildlife.

Land use can affect soils by altering % OC in soil profiles, either by removal as in the case of hay production, or by oxidation due to improved aeration after drainage. Drainage also broadens the marginal zone of salinity by lowering the water table below soils of flowthrough wetlands.

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(112) RARE FLORA OF NORTH DAKOTA'S CALCAREOUS FENS

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Fens are peatlands found in hydrologic settings in which saturated peat-forming conditions are maintained by ground waters enriched with calcium and bicarbonate ions and other nutrients. In the Great Plains and prairie regions of the Midwest, fens are commonly characterized by the calcareous nature of their waters and, in some instances, by high calcium carbonate concentrations at or near the peat surface (1). Plant species restricted to highly calcareous fen peats have been variously described as calciphiles, calcicoles, or fen obligates (2,3).

The purpose of this investigation was to identify the rare species associated with calcareous fens in North Dakota. Reports from field scientists and botanists provided initial fen locations. Additional fens were located through interpretation of aerial photos, soil surveys, and surficial geology publications. Prospective calcareous fens were found to occur within the Souris, Wintering, Sheyenne, and James River Valleys and in some geological settings in the Missouri Coteau. They ranged in size from a few to several hundred hectares.

Subsequent botanical surveys confirmed the occurrence of fen species that can be aptly described as calciphiles, calcicoles, or fen obligates (Table 1). Frequently these species have pronounced northern affinities, but are located outside their contiguous range of distribution. They are also often associated with specialized microhabitats. Some examples of these microhabitats are: small calcareous pools and pool margins (Utricularia minor, Utricularia intermedia, and Rhynchospora capillacea); carbonate-enriched peats or surficial carbonate precipitates with associations of low graminoids (Carex garberi, Juncus brevicaudatus, Eleocharis pauciflora, Carex simulata, Carex lasiocarpa, and Carex limosa); and string and flark formations (Eleocharis pauciflora).

The nature of these plant species and their associated habitats is only beginning to be understood. Although a great deal of information on the relative rarity of species residing in North Dakota remains to be gathered, research within the past decade suggests that North Dakota's fens are significant repositories of biological diversity.

Table 1. Notable Fen Obligates, Calcicoles, or Calciphiles

Carex sterilis Willd.	Rhynchospora capillacea Torr.
Carex garberi Fern.	Eleocharis pauciflora (Lightf.) Link
Carex lasiocarpa Ehrh.	Salix pedicellaris Pursh
Carex simulata Mack.	Utricularia intermedia Hayne
Carex limosa L.	Utricularia minor L.
Carex buxbaumii Wahl.	Juncus brevicaudatus (Engelm.) Fern.

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(24) MEANING OF HEALTH, PERCEIVED HEALTH STATUS AND PARTICIPATION IN HEALTH PROMOTING BEHAVIORS

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Current research indicates considerable interest in factors which influence health and quality of life. One area of concern is the extent to which lifestyle and health beliefs impact on health promoting behaviors.

This expost facto study looked at two groups. One group (N=480) living in Northeastern North Dakota and the second group (N-143) who were actively espousing a religiously based health code, lived in eastern North Dakota, North-eastern South Dakota and western Minnesota. The purpose of the study was to determine if differences existed between the two groups on measures related to perceived health status, meaning of health, self-concept and health promoting behaviors.

The Pender Health Promotion Model (1) provided the conceptual basis for this study. It encompasses several motivational aspects related to health promotion participation which theoretically and positively impact on length and quality of one's life. This model is based on the premise that health promoting behaviors are almost always continuing activities that must be an integral component of an individual's lifestyle.

All participants completed the Laffrey Health Conception Scale, the Philadelphia Geriatric Center Multilevel Assessment Inventory, the Rosenberg Self-Esteem Scale, and Pender's Health Promoting Lifestyle Profile.

A two-tailed t-test was used with both a pooled and separate variance estimate. The two groups were compared measures of perceived health, self-concept, total health profile, and on six aspects of the health profile: nutrition and weight control, sense of purpose, interpersonal support, exercise, stress management and sleep and health monitoring. Exercise and perceived health status were identified as factors which contributed the most significant effect on having a healthy lifestyle. Regular participation in exercise was found to have the highest t value ($t = 6.54$, $p = 0.000$).

Perception of present health status was the second highest measure of difference between the two groups ($t = 5.36$, $p = 0.000$). Group I (N=480) also had significantly higher scores on measures of self-acceptance ($t = 3.21$, $p = 0.001$), and total profile of lifestyle ($t = 3.40$, $p = 0.001$).

No significant differences were noted on measures of health monitoring, sense of purpose, stress management and sleep, conception of health or nutrition and weight control. These findings may suggest that perceived health status, and exercise are not necessarily critical aspects for adherence to the definitive health code of Group II. While for Group I health status and exercise are highly valued as an important aspects of their overall lifestyle.

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(25) BOVINE LUNG HEPARIN VERSUS PORCINE MUCOSAL HEPARIN IN PATIENTS UNDERGOING CORONARY ARTERY BYPASS SURGICAL PROCEDURES

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Heparin, a natural anticoagulant, is obtained from animal sources such as bovine lung tissue or porcine intestinal mucosa. The process by which clotting is inhibited occurs through complex reactions in which heparin binds with a portion of antithrombin III (a natural anticoagulant), resulting in anticoagulation. Heparin is most effective when an activated clotting time (ACT) between 350 and 450 seconds is maintained (1). In coronary artery bypass graft (CABG) surgery, blood is removed from the patient while mechanical support systems maintain the bodily functions of oxygenation and circulation, so that the surgeon is provided with a bloodless field (2). During this procedure, heparin is administered to effect anticoagulation -- crucial to the preservation of life. Even though both porcine and bovine based heparins are widely used during CABG procedures, the efficacy of one type over the other has not been established (3). The purpose of this study was to determine whether the action of bovine lung heparin was different from porcine mucosal heparin when used in patients undergoing coronary artery bypass graft (CABG) surgical procedures.

Fifty subjects (mean age 64, SD = 9.1) who underwent coronary artery bypass graft surgery were randomly selected from a North Dakota hospital. Twenty-six subjects received bovine lung heparin and twenty-four received porcine mucosal heparin during their CABG procedures which ranged from single vessel to six vessel bypass. A patient data sheet elicited demographic data such as age, sex, weight, height, and employment; anticoagulant values were determined by measures of hemoglobin, hematocrit, platelet counts, bleeding time, prothrombin time, and partial thromboplastin time. In addition, the protamine to heparin ratio was graphed along with the activated clotting time to assess degree of anticoagulation. The mean sensitivity values for patients who received bovine and porcine heparin appear, empirically, to be about the same (Figure 1).

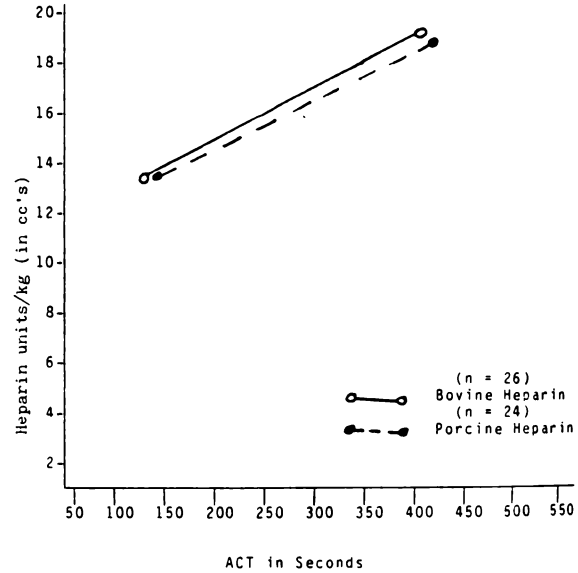

Figure 1. Mean sensitivity values for patients who received bovine and porcine heparin at the beginning and 5 minutes after heparinization for their CABG procedures.

Analysis of the results via two-way ANOVA's indicated that those who received porcine heparin had greater amounts of circulating heparin than those who received heparin derived from bovine. Main effects for sex that influenced blood values during the intra-operative and post-operative periods, were thought to be related to the high ratio of males to females (i.e. 3:1) in the study. However, length of hospital stay appeared to be less for those who received porcine heparin. Based on the findings of this study, further investigation of both heparins as used during CABG procedures appears to be warranted.

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(26) THE NEUROENDOCRINE CONTROL OF INFLAMMATION AND THE ETIOLOGY OF RHEUMATOID ARTHRITIS

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The hypothesis on the etiology of rheumatoid arthritis (R.A.) developed in our Laboratory has five major tenets:

1. R.A. is inflammation out-of-control,
2. the R.A. subject's immune system is functioning properly,
3. the glucosteroids are the endogenous agents to control inflammation,
4. the R.A. subject has a malfunction in the nervous system and/or hypothalamic/anterior pituitary/adrenal cortex axis which results in an inability to produce sufficient quantities of the glucosteroids over normal, plasma levels at appropriate times, and
5. R.A. has multiple bursts of antigens.

The injection of the inflammatory agent carrageenan into the rat paw causes a pulse of corticosterone to occur in the blood plasma 20 minutes later (Fig. 1). Therefore, the hypophyseal axis is activated when an inflammatory agent is present in the rat's body.

There was no swelling in the paw of rats in which the two major nerves of that leg had been severed. This implies the nervous system participates in the course of inflammation.

To determine if rats with an injured hypothalamic axis are more prone to exaggerate inflammatory responses than normal rats, carrageenan was injected into the hind paws of two rat groups. The rats with the anterior pituitary removed, i.e., hypophysectomized, swelled more intensely and for a longer duration than those without the surgery (Fig. 2). The paw swelling induced in carrageenan-injected, hypophysectomized rats was moderated by a simultaneous or subsequent intraperitoneal injection of cortisol. However, the timeliness of the injection was important. With simultaneous injection, the cortisol was able to virtually eliminate the swelling normally caused by carrageenan. Longer time gaps between the two injections reduced the moderating influence of cortisol. When cortisol was given one hour after carrageenan, swelling occurred similar to the response of control, carrageenan-injected, hypophysectomized rats. However, the swelling subsided in a moderated manner compared to that of control, carrageenan-injected, normal rats without added cortisol; when the cortisol was added two hours after carrageenan in hypophysectomized rats, the cortisol had a smaller, moderating effect on reducing the swelling than that of the one-hour treated animals. When carrageenan was injected every two hours for a total of four times in hypophysectomized rats, the degree of swelling was limited by the tension placed upon the skin. Cortisol nearly eliminated the swelling caused by carrageenan injected simultaneously or subsequent to the introduction of cortisol in these multiple carrageenan-injection tests, but not before. Thus the hypothalamic axis does influence inflammatory responses in the rat's body. Presumably, a hypoactive hypothalamic axis in humans would cause inflammation control problems like those experienced by hypophysectomized rats.

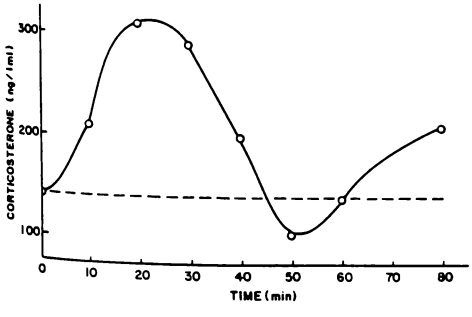

Figure 1. The rat blood plasma corticosterone pulse resulting from a carrageenan injection in the paw.

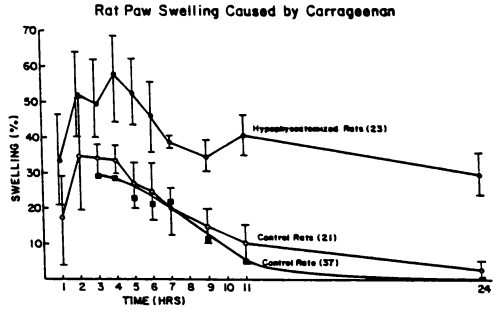

Figure 2. The more intense swelling of hypophysectomized rat vs. control rat in response to a carrageenan injection in the paw.

(27) MULTIPLE SCLEROSIS EXACERBATIONS AND CLIMATE: IS THERE A RELATIONSHIP?

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Multiple sclerosis (MS) appears more frequently in the eastern than in the western part of North Dakota (1). Differences in the distribution of this disease may be climate-related (2). In what ways climate-related events affect the individual with MS is not known. The purpose of this study was to examine meteorologic-climatic-elements for their affects on the exacerbation of symptoms in patients with MS. Variables examined were: daily temperatures, diurnal temperature ranges, mean 24-hour barometric pressures, three hourly humidity averages, wind speed and its direction, hours of sunshine, precipitation, and sky cover for each 24-hour period. The recording weather station located at Grand Forks, North Dakota (latitude 47° 56' N; longitude 97° 05' W) had a ground elevation of 830 feet above mean sea level. Thirty-one MS patients and 31 age- and sex-matched nonfamilial normal-healthy controls were studied for six months (February 1 through July 31, 1985) during which time eight MS exacerbations occurred.

Subjects consenting to participate were interviewed and background data were obtained. When a MS patient had an exacerbation, defined as new or accentuated symptoms lasting more than 24 hours, which had been confirmed by a neurologist, information on habitat, emotional response, behaviors and medical complaints occurring within two weeks of the MS event, along with perception of the weather on the day MS symptoms were first experienced was obtained from the subject via the telephone. The control subject was asked similar questions also by phone.

A forward stepwise discriminant analysis revealed background differences between patients and controls. These differences were that patients avoided beer and wine and were less likely to be exposed to extreme cold than the controls ($R = .58$, $p < .001$). It would seem that persons with MS avoided extremely cold temperatures, a facet of North Dakota winters, and refrained from drinking beer and wine as a means of staying healthy. This avoidance of noxious stimuli could be interpreted as an attempt by these patients to control perceived stressors within their environments.

Discriminant analysis of data two weeks prior to MS exacerbation showed that patients stayed indoors, perceived the weather as normal for the season and were more frustrated than the controls ($R = .89$, $p < .001$). Differences in perception of the weather might be related to the fact that patients stayed indoors and were thus less aware of macroclimatic events. In turn, as assistive devices for ambulation purposes were used by these patients, their chance of staying indoors increased which may help account for their frustration. The degree of frustration expressed by these subjects, however, was not thought to be sufficient to precipitate a MS attack.

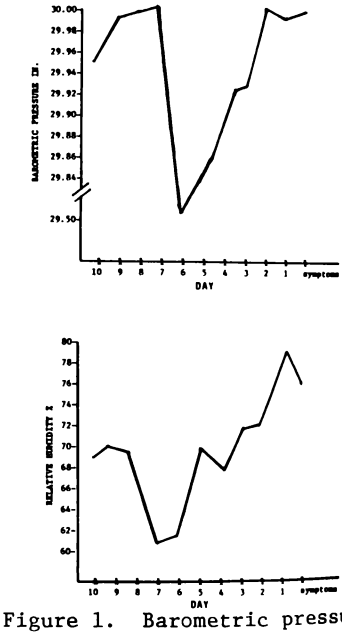

Figure 1. Barometric pressure and relative humidity averages 10 days before MS events.

A time series analysis of all meteorological variables for the study period revealed first ($R = .25$) and second ($R = .39$) degree trends for barometric pressure. First degree trends were also noted for relative humidity ($R = .41$), wind velocity ($R = .32$), wind gusts ($R = .29$), and snow accumulation ($R = .25$). Decreases in barometric pressure with concomitant increases in relative humidity were thought to reflect the affect of low pressure systems (Figure 1). Empirical analysis of weather maps 10 days prior to, and day of, MS attack revealed that low pressure systems were present in the area five to six days, and day before, patients experienced symptoms.

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(28) USE OF THE TETRAPOLAR BIOELECTRICAL IMPEDANCE METHOD TO DETERMINE HUMAN BODY WATER COMPARTMENTS

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Determination of total body water (TBW), and its components of extracellular (ECF) and intracellular (ICF) fluid volumes, is an important aspect of assessing human body composition. Traditionally, techniques of isotope dilution have been used to measure these fluid volumes in a variety of physiological and pathological conditions. Although recent technological advances have improved the safety of procedures to estimate these water compartments by using non-radioactive tracers, these laboratory methods are time consuming, expensive, and impractical for routine use. Thus, there is a need for a safe, non-invasive method that is fast and convenient, and provides acceptably accurate estimates of TBW, ECF, and ICF outside of the laboratory. The tetrapolar bioelectrical impedance method may meet this need. This method is based upon the conduction of an applied radio-frequency signal in the body (1). Because body fluids solely are responsible for electrical conduction in the body, we hypothesized that the bioelectrical impedance method may be useful in assessing body water compartments in humans.

Thirty-five healthy adults, 18 females and 17 males, aged 19-62 yr volunteered to participate. All measurements were made after an overnight fast. Determinations of TBW and ECF were made by deuterium (2) and bromide (3) dilutions, respectively. Plasma concentrations of deuterium and bromide were determined after a 3-hr equilibration period. ICF was determined indirectly as TBW-ECF. Total body bioelectrical impedance was measured by introduction of 800 microamps of alternating current at 50 kilohertz into the body using surface electrodes placed at the hands and feet (1). This method provides a deep homogenous electrical field in the variable conductor of the body. The voltage drop along the transmission axis was measured, and electrical impedance was determined by Ohm's Law. The geometric components of impedance, resistance, and reactance were quantitated using phase-sensitive electronics.

The measured values of TBW, ECF, and ICF were 40.3 ± 2.0 (mean ± SEM), 16.0 ± 0.6, and 24.3 ± 1.4 L, respectively. Conductance, defined as height^2/resistance, was the best ($p < 0.0001$) single predictor of TBW ($r = 0.972$), ECF ($r = 0.940$), and ICF ($r = 0.952$). A step-wise multiple regression analysis produced the following models that incorporated impedance measurements for predicting body water compartments:

$$TBW(L) = 0.743 \text{ conductance} - 0.221 \text{ height} - 0.109 \text{ age} + 0.119 \text{ weight} + 27.82 \quad (R^2=0.970, SEE=2.16)$$

$$ECF(L) = 0.145 \text{ conductance} + 0.047 \text{ weight} - 0.055 \text{ reactance} + 7.03 \quad (R^2=0.926, SEE=0.94)$$

$$ICF(L) = 0.575 \text{ conductance} - 0.126 \text{ age} - 0.205 \text{ height} + 0.069 \text{ weight} + 23.75 \quad (R^2=0.949, SEE=2.05)$$

These results indicate the importance of resistive and reactive impedance measurements in estimating body water compartments, and they emphasize the significance of these predictors over traditional predictive variables such as age, height, and weight (4). The practicality of the bioelectrical impedance method in terms of safety, cost, and convenience makes it suitable for routine clinical and field use. These findings also suggest an important clinical use of the bioelectrical impedance method to monitor water volumes in individuals with water accumulation and distribution disturbances associated with various pathological disorders.

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(29) THE RELATIONSHIP OF SKINFOLD THICKNESS, BIOELECTRICAL IMPEDANCE, AND HYDRODENSITOMETRIC MEASUREMENTS TO THE COMPONENTS OF SOMATOTYPE

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The components of somatotype have been described by Heath and Carter (1) as endomorphy (relative fatness), mesomorphy (lean body mass), and ectomorphy (relative linearity). Since relative body fat and lean body mass are components of body composition, such a description implies a relationship between somatotype and body composition. Attempts to quantify the relationship between body composition and somatotype have been limited by either sample size, tests, measurement technique or all of these. The purpose of this study was to determine the relationship between the measurements from three independent tests of body composition, predicted body composition variables, and the calculated components of somatotype.

Somatotype was measured by the Heath and Carter method (1). Body composition was estimated by skinfold thickness (2), bioelectrical impedance (3), and hydrodensitometry (4). A heterogeneous sample of 144 subjects (67 females and 77 males) participated in the study. Both groups included non-athletic and athletic participants. Age of the subjects was 27.0 ± 6.0 (mean ± SD) yr for females and 27.0 ± 7.0 yr for males. Body weight, percent fat and fat free mass were 61.8 ± 10.5 kg, 25.1 ± 6.6%, and 46.0 ± 6.7 kg, respectively, for females and 85.7 ± 18.3 kg, 17.7 ± 7.3% and 69.8 ± 12.8 kg, respectively, for males.

Measurements from the three tests were correlated with the calculated somatotype components. The anthropometric measurements were positively correlated with the mesomorphic and endomorphic components and negatively correlated with the ectomorphic component. The bioelectrical impedance measurements, reactance and resistance, were negatively correlated with endomorphy and mesomorphy and positively correlated with the ectomorphic component. The hydrodensitometric measurement of underwater weight was negatively correlated with the endomorphic and mesomorphic component and positively correlated with the ectomorphic component.

Coefficients of determination (R^2 x 100) were computed to determine the association between the estimates for body composition and the somatotype components. Percent fat by skinfold, bioelectrical impedance, and hydrodensitometry accounted for 90, 58, and 56%, respectively, of the variance associated with the female endomorphic component and 86, 67, and 74%, respectively, of the male endomorphic component. Fat free mass was not associated with the female mesomorphic component but did account for 46, 38, and 37% of the variance associated with the male mesomorphic component. Percent fat plus fat free mass, by the three methods, accounted for 45, 48, and 46%, respectively, for the variance associated with the female ectomorphic component and 55, 51, and 52%, respectively, with the male ectomorphic component.

The results of this study indicate that, except for the relationship between fat free mass and mesomorphy among females, the measurements and estimates of body composition are related to the description of the somatotype components. Since the estimates for fat free mass by the three tests were consistent, (47.0, 46.3 and 46.0 kg for females and 73.2, 70.2 and 69.8 kg for males), the low relationship between the mesomorphic component and body composition apparently indicates a lack of validity for the measurements used to estimate mesomorphy.

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(30) A COMPARATIVE STUDY OF WIDOWS AND WIDOWERS UPON MEASUREMENTS OF GRIEF AND SOCIAL SUPPORT

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The purpose of this descriptive study was 1) to describe the social supports available to widows and widowors; 2) to determine if there are differences between widows and widowers on a psychological variable (grief) and a sociological variable (social support); and 3) to determine if there are relationships between the expressions of grief and perceived social support. The theoretical framework for the study linked the concepts of grief (1); social support (2, 3) and gender role (4).

The design was both exploratory and descriptive and utilized a convenience sample of thirty widows and thirty widowers who were experiencing their first year of bereavement. Sander's Grief Experience Inventory, Norbeck's Social Support Questionnaire and a semi-structured interview schedule were used to collect the data. Descriptive statistics were used to describe the social supports available to widows and widowers. A one way multivariate analysis of variance (MANOVA) was used to test for differences on measurements of grief and social support between the sexes and a Pearson product moment correlation was used to test for a linear relationship between the two variables, grief and social support.

The two groups did not differ in a multivariate sense on the two dependent variables-grief and social support, but widowers did score significantly higher than widows on the guilt scale. There was a significant linear relationship between support (affect, aid, and affirmation) and loss of control and somatization. There was also a significant linear relationship between total network and loss of control and somatization.

Widows valued support in the form of advice more than men, had more circles of friends, were more likely to have a confidant, the confidant was more likely to be of the same sex and identified the church as their most important circle of friends. Widowers had higher incomes, more education and were less likely to have a confidant. They valued recreational sources such as bowling, golfing, hunting, and fishing as their most important circle of friends.

The study supported Parkes' definition of grief as being stressor-specific with common reaction patterns found in both widows and widowers and these common stressor-specific reactions outweighed the person-specific influences. However, the kinds of support offered and valued differed with the gender of the bereaved spouse, and the amount of support available affected the expression of grief in both widows and widowers.

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(31) THE SOCIAL PSYCHOLOGY OF GROUP RAPE

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Group rape, multiple offenders against one victim, accounts for an estimated one-third of reported and three-fourths of all rape offenders, yet is probably the most understudied behavior among serious criminal offenses. This study reviews current social psychological knowledge on group rape; larger cultural attitude toward rape; and presents results of an empirical analysis of police perceptions of group and solitary rapes.

This study examined the relationships between subjects' perceptions of group rape, rapists and victims, acceptance of rape myths, sexist attitudes toward women, and sex stereotyped personal characteristics. Perceptions of group rape and rape crisis experience were measured by a researcher developed tool, with a alpha reliability of .88. Sexist attitudes were measured utilizing Benson & Vincent's (1980) Sexist Attitudes Toward Women Scales. Attitudes toward rape were measured by Field's (1978) Attitudes Toward Rape Questionnaire. Machismo was measured by the Personal Attributes Questionnaire as developed by Spense & Helmreich (1978).

Since police officers are the first persons within the judicial system to whom the rape victim turns for help, we were interested in assessing the extent to which officers accurately perceive group rape, its victims and perpetrators. Specifically, it was hypothesized that inaccurate perceptions of the serious nature of group rape would be associated with pro-rape attitudes in general, a belief in the normality of group rapists and negative attitudes toward group rape victims. Further, we expected a relationship between tolerance for group rape, sexist attitudes toward women and self-endorsement of sex stereotyped masculine traits. It was also hypothesized that experience with rape victims, both personally and professionally, would result in more realistic perceptions of the crime.

Completed questionnaires were returned by 35 officers of a urban, southern city with a population of over 50,000. The return rate was 58%. Since there were only 5 female respondents, gender differences in perceived severity of rape could not be assessed.

Analysis of data revealed a high rate of inaccuracy in perceptions of group rape. Overall accuracy in perception of the differences between single and multiple-offender rape was 19%. We next attempted to assess whether these perceptual inaccuracies by officers were associated with experiential and background characteristics or related to attitudinal variables. Inaccurate perception of group rape was associated with the perceived psychological ($r = -.31$) and sexual normality of ($r = -.27$) of group rapists. However, inaccuracies were only marginally related to machismo ($r = .23$, $p = .10$) and sexist attitudes toward women ($r = .13$, N.S.) and related in an opposite direction with pro-rape attitudes ($r = -.28$). They also perceived the group rape victim as less responsible for prevention ($r = .35$) and more credible ($r = .46$) than single offender rapes. Thus, though those officers were inaccurate in their perceptions of group rape, they do not seem to have particularly negative attitudes toward group rape victims, nor do they have more general pro-rape attitudes.

Experience with group rape victims did not seem to provide much in the way of increased accuracy of knowledge on the topic, but was associated with the belief that group rapists are more violent ($r = .31$, $p < .05$), less motivated by sexual needs ($r = -.32$, $p < .05$), and more sexually maladjusted ($r = .35$, $p = .03$) than single offenders. Experience with group rape victims resulted in the accurate prediction that group rapists are more likely to have planned the rape in advance ($r = .42$, $p = .01$).

Other correlations too numerous to discuss in this abstract were noted in the study. In summary, widespread misconceptions and misinformation about group rape were present in one sample of police officers as indicated by an overall accuracy rate under 20%. Respondents' inaccuracy was associated with a macho ethic consisting of endorsement of masculine stereotyped traits and a belief in the psychological and sexual normality of rapists.

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(32) FOCAL UTERINE SOFTENING IN PREGNANT WOMEN

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Though Dickinson described focal uterine softening (Dickinson's sign) almost 100 years ago (1), the fact such local softening was not a universal feature of pregnancy meant it became an interesting but none-too-useful phenomenon. More recently, Munsick (2) generated interest in Dickinson's sign as an indication of where the developing embryo is not located. More specifically, since the existence of a uterine pregnancy all but precludes tubal pregnancy, and Dickinson's sign confirms uterine pregnancy, finding the sign means both physician and patient know there is extremely little likelihood of a life-threatening tubal pregnancy.

The problem is that not all uterine pregnancies are accompanied by Dickinson's sign, and the question is one of how likely it is a pregnant woman will show focal uterine softening. To answer this question, Munsick collected data on a series of over 1000 women with confirmed pregnancies. Unfortunately, complete data (on parity--whether a woman has had children--and weeks since last menses) were not available on all of them. Further, Munsick did no analysis beyond computing mean rates of appearance of Dickinson's sign as a function of parity and weeks, and while these means varied from one another, he was unable to attribute this variation to error or systematic differences due to parity and weeks since last menses.

Our study remedied this last deficiency by constructing a linear model predicting the likelihood of the sign's appearance from the independent variables identified. This was accomplished by (i) using only those 752 cases for whom complete data existed, (ii) performing an analysis of variance (ANOVA) with weeks and parity as fixed main effects, and (iii) performing post hoc analyses to identify those weeks most responsible for observed differences. To facilitate this task, cases were contrast coded and least squares procedures were used for computing sums of squares.

ANOVA results in Table 1 indicated that both weeks and parity were significant while the interaction was not. Examination of the means for the various weeks indicated that the sign was most likely to be seen early in pregnancy, very infrequently later. Further, we were able to collapse weeks into three periods (6-11, 12-14, and 15-18 weeks) which varied significantly from one another (collapsing in this way resulted in only a 1.2% decrease in variation accounted for). With T_1 being the first time period, T_2 being the second, and T_3, the third; P_o representing nulliparous women and P_p representing those who already had children, the equation for likelihood of Dickinson's sign became

$$\hat{Y} = .28 + .19T_1 + .26T_3 - .02P_o + .02P_p \quad \text{(Note the coefficient for } T_2 = 0.00\text{)}$$

This equation can be used by clinicians to reduce the number of patients suspected of tubal pregnancies requiring expensive (and sometimes invasive) procedures. Specifically, it tells clinicians that of their patients who are 6-11 weeks since their last menses, .47 to .49 can be screened by physical examination in the office and not required to undergo additional procedures since the existence of a tubal pregnancy can be all but eliminated.

Table 1. ANOVA Summary Table

Source of Variation	Sum of Squares	DF	Mean Square	F-Ratio
Purity	1.3360	1	1.3360	7.92
Weeks	27.9872	9	3.1097	18.43
P x W	1.1289	9	.1254	F<1
Error	123.4774	732	.1687	

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(33) THE RELATIONSHIP BETWEEN PROFESSIONALIZATION OF NURSING FACULTY, LEADERSHIP STYLES OF DEANS AND FACULTY SCHOLARLY PRODUCTIVITY

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A literature review indicates that the most effective leadership style is contingent upon situational variables and that style may be associated with subordinate productivity. Related to that, the following research question was explored: What is the relationship between the professionalization of faculty teaching in doctoral nursing programs, deans' leadership styles, and doctoral faculty scholarly productivity.

The theoretical framework for this study was based on Situational Leadership Theory (1), Greiner's Theory of Organizatioal Life Cycles (2) and Mintzberg's Theory of a Professional Bureaucracy (3). The major concepts extracted from those theories and examined in this study were leadership styles, professionalism and productivity and, as varables, were measured by three data collection instruments. In addition to a leader behavior scale and a professionalism inventory the third tool, the Scholarly Productivity Index corrected (SPIC), was developed by the researcher as a measure of the average amount of research activity, publication and editorial work completed per year during one's professional career under the current dean. Prior to data collection, items from the SPIC were ranked, via a care sort method and subsequently weighted.

All doctoral nursing programs in the United States with currently enrolled students were invited to participate in the study. Of the 26 programs eligible, 21 agreed to participate. 393 questionnaires were mailed to doctoral nursing faculty teaching in those programs. A total of 215 questionnaires were returned resulting in a response rate of 66%.

Using the collected data, a factor analysis extracted three factors with eigenvalues greater than 1.0. Oblique rotation produced three clearly delineated factors which were utilized as subscales labeled: 1) Prepublication and Research Activities; 2) Publication Activity: and 3) Editorial Activity. The three subscales were significantly correlated with the total SPIC ($r=.82$, .80 and .37, respectively; $p<.001$). Correlations between the subscales were significant with one exception; the correlation between the subscales Publication Activities and Editorial Activities was not significant ($r=.12, p>.05$). Given that all three subscales had few items (ranging from 3 to 6), two of the three subscales showed good reliability (i.e., $r=.75$ for Research/Prepublication activities; $r=.86$ for Publication Activities, $r=.52$ for Editorial Activities). The reliability coefficient for the total SPIC was .88.

Regression analysis was used to determine whether one continuous variable, faculty professionalism, and one categorical variable, with four categories representing the four leadership styles, had a significant effect on the dependent variable, scholarly productivity. The regression analysis also tested for interaction between faculty professionalism and deans' leadership style. The regression analysis was repeated with each of the three subscales of the SPIC as the dependent variable. The only significant finding from these analyses was that faculty professionalism was significantly related to the editorial activities subscale of the SPIC ($F=4.98$, $p<.03$). This one significant finding should be interpreted cautiously because of the number of F-tests calculated (i.e., 12). Overall, the results of the regression analysis did not support the hypothesis that faculty professionalism and deans' leadership style, either solely or through interaction, was significantly related to scholarly productivity.

With regard to additional findings, no differences were found in scholarly productivity (as measured by the SPIC) between faculty in research and nonresearch universities.

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(34) FORMALIZATION AND SATISFACTION IN SCHOOLS OF NURSING

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The purpose of this study was to analyze the impact of formalization and general satisfaction in Texas schools of nursing with baccalaureate programs. Literature reveals formalization, the extent of job behavior which is described by rules and regulations, is associated with member satisfaction. Therefore, the research question investigated was what is the relationship between formalization and general satisfaction in schools of nursing. No studies which concurrently measured these organizational variables in nursing education settings were found in the literature.

The research instrument consisted of three sections. Section I was demographic data. Section II consisted of a formalization scale originally developed by Aiken and Hage (1) and modified to fit nursing education organizations. Section III was a scale which measured general satisfaction and was a shortened version of a tool used previously in other studies (2,3). Standardized alpha coefficients were: formalization subconstructs--job autonomy (5 items) = .88 (N = 196), surveillance (2 items) = .87 (N = 207) (computed using the PANDORA system of interactive analysis) and, job specificity (6 items) = .64 (N = 203); total formalization (15 items) = .68 (N = 187); and general satisfaction (9 items) = .82 (N = 205). Content and construct validity were also established.

Questionnaires were sent to 24 eligible schools. Twenty of these schools indicated an interest in participating in the study; data were returned from 18 schools (90%). A total of 403 questionnaires were mailed to the 20 schools; 208 subjects participated (52%). Data were analyzed according to individual respondents, three organizational positions within schools (administration, faculty, and administration/faculty), and schools. Results of zero order correlations between total formalization and satisfaction were negative, showing that increased formalization was associated with decreased general satisfaction. The low correlations for individuals, $r = -.25$ ($p \leq .01$; N = 208 subjects) sharply contrasted with the $-.93$ correlation ($p \leq .01$; N = 6 schools) for administration. The wide discrepancy in the above correlation can be explained, in part, by the weak, nonsignificant correlations between the subconstructs of rules manual and job description and general satisfaction; and 2) moderate and strong negative correlation of job autonomy ($r = -.64$; $p \leq .01$; N = 18; $r^2 = .41$) and surveillance ($r = -.91$; $p \leq .001$; N = 18 schools; $r^2 = .83$). According to school data analysis, nurse educators in the study were more satisfied where procedures defining jobs were spelled out ($r = .71$; $p \leq .001$; N = 18) but were very dissatisfied with close supervision ($r = -.91$; $p \leq .001$; N = 18). See Table 1.

Table 1

Correlations Between Formalization Subconstructs and General Satisfaction by Schools

	r	p	N
Job Autonomy	-.64	**	18
Surveillance	-.91	***	18
Rules Manual	.06	NS	18
Job Description	.12	NS	18
Job Specificity	.71	***	18
Total Formalization	-.27	NS	18

** $p \leq .01$; *** $p \leq .001$

In conclusion, nurse educators seem to be striving for higher job autonomy with less monitoring of rule observation. Further, the presence of rules manuals and job descriptions appear to be perceived as more meaningful for administrators than for other nurse educators. This may be explained in that nurse administrators probably use rules manuals and job descriptions more frequently than do faculty for practice guidelines and policy interpretation.

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(35) Germination of Resting Spores of Entomophaga grylli, Pathotype 2, in Different Temperature-photoperiod Combinations

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Entomophaga grylli is a fungal pathogen of grasshoppers which can cause natural epizootics. E. grylli is composed of several pathotypes which can be distinguished by differences in their life cycles, host ranges, and isozyme banding patterns (1). This organism is currently being evaluated as a potential biological control agent for grasshoppers.

The objectives of the present study were to test the effects of different temperature-photoperiod combinations on E. grylli, Pathotype 2, resting spore germination. Spores were produced and prepared by procedures described by Nelson et al. (2). Petri dishes containing 1.5% water agar were seeded with spores and incubated at combinations of five temperatures (16, 19, 22, 25 and 28°C) and six photophases (0, 4, 8, 12, 16 and 24 hrs/day). Resting spore counts were made on 5, 9 and 15 days post-inoculation. The number of germinated spores was expressed as a percent of the total spores counted.

Germination began 3 days post-inoculation. Temperature and light had significant effects on germination (Table). In general, spore germination rates increased with increased exposure to light and with increased temperatures up to 25°C. Spores germinated the most rapidly and with the greatest percent germination at 25°C and photophases of 12 hrs/day or longer.

At any given temperature, resting spores exposed to light had germination rates 1.5 to 15 times higher than those in the dark. This effect was more pronounced at lower temperatures than at higher ones.

This information will aid other investigators in laboratory manipulation of the fungus, help to develop a consistent bioassay, and contribute to a better understanding of fungal-environmental interactions.

Mean Percent Germination of Entomophaga grylli, Pathotype 2, Resting Spores at Selected Temperature-Photophase Combinations

		Days		
		5	9	15
Temp. (°C)	Photophase (hrs/day)	Mean*# (n=12)	Mean (n=12)	Mean (n=12)
16	0	0.00 e	1.68 j	3.83 l
	4	0.00 e	3.09 hij	5.82 kl
	8	0.00 e	4.56 ghij	8.44 ijkl
	12	0.03 e	6.61 ghij	12.70 ghijkl
	16	0.17 e	9.97 efghij	18.47 efghij
	24	0.43 e	16.49 cdef	23.78 bcdefg
19	0	0.20 e	2.25 ij	2.67 l
	4	1.07 e	3.60 hij	6.45 jkl
	8	1.80 e	6.01 ghij	11.55 hijkl
	12	2.60 e	12.17 defghi	20.54 defgh
	16	3.47 de	19.26 bcde	25.61abcdef
	24	5.44 de	24.24abc	32.12abc
22	0	0.27 e	3.41 hij	8.45 ijkl
	4	2.09 de	8.19 fghij	15.68 fghijk
	8	5.66 de	16.64 cdef	27.68abcde
	12	7.77 cde	24.76abc	32.96abc
	16	11.33 bcd	29.87ab	34.36ab
	24	15.79abc	29.78ab	31.50abcd
25	0	2.74 e	14.90 cdefg	21.17 cdefgh
	4	4.48 de	20.59 bcd	27.12abcdef
	8	11.08 bcd	29.38ab	34.52a
	12	15.70abc	33.55a	35.15a
	16	17.69ab	34.35a	34.17ab
	24	20.61a	30.43a	32.65abc
28	0	0.92 e	7.52 fghij	12.49 ghijkl
	4	2.46 e	13.68 defgh	18.60 efghi
	8	7.28 cde	24.38abc	31.32abcd
	12	12.99abc	29.84ab	31.94abcd
	16	17.13ab	29.55ab	28.45abcde
	24	16.64ab	24.30abc	25.30abcdef

* Means for each day, compared using Least Square Means in the General Linear Model Procedure. Values followed by same letter are not significantly different (P = .05).

\# Standard Error (based on Mean Square Error in ANOVA)=1.63 for day 5, 1.93 for day 9 and 2.12 for day 15.

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(36) EFFECT OF TEMPERATURE ON GERMINATION OF CONIDIA OF GLOEOSPORIUM ARIDUM

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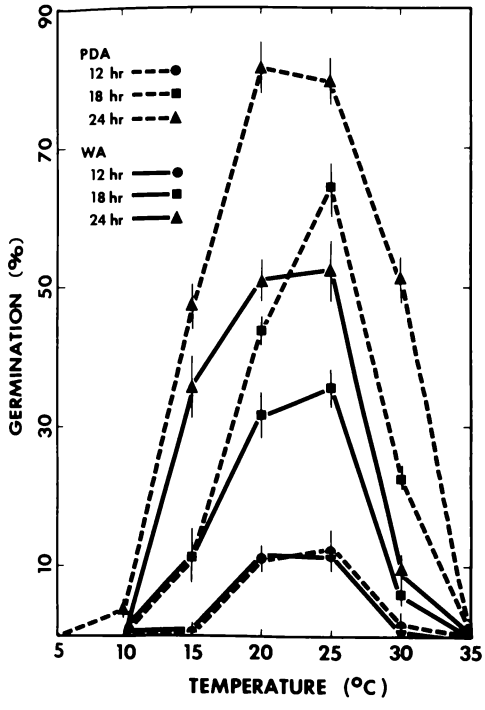
Anthracnose caused by the parasitic fungus Gloeosporium aridum Ell. & Holw. is a foliar disease that may cause extensive defoliation on green ash (Fraxinus pennsylvanica Marsh.) (1). In previous work Snyder (2) found that its greatest rate of growth in culture occurred at 25 C, similar to that of the fungus causing walnut anthracnose (3) and higher than those for the fungi causing sycamore and oak anthracnose (4). The purpose of this research was to determine the optimum temperature for spore germination of G. aridum (Fig. 1).

In these experiments, germination of conidia was evaluated on Potato Dextrose Agar (PDA) and on Water Agar (WA) in petri dishes. Conidia were washed from three-week-old cultures with sterile distilled water. Concentration was adjusted to 7.8 X 10^6 conidia per ml. Two ml of suspension was applied to the agar surface in each dish. The dishes were swirled to give uniform distribution. After 15 seconds, the excess liquid was poured off. Four replicate plates of each medium were placed into 5, 10, 15, 20, 25, 30 and 35 C incubators and incubated in the dark. Blocks of agar (15 mm square) were removed after 12, 18 and 24 hours, and examined under the microscope at 450X. The percentage of germinated conidia was calculated by examination of ten microscope fields (ca 60 spores/field) per agar block. A conidium was considered germinated when the length of at least one germ tube was equal to or greater than the length of the conidium (ca 10 um).

Figure 1. Germination of G. aridum conidia



PDA=Potato Dextrose Agar; WA=Water Agar.
Germination was 0 at 5 and 35C for all treatments.
Lines connecting zero values not shown.
Vertical bars indicate standard errors.

In a preliminary study not reported here, germination of G. aridum spores was evident after 10 hours at 20 C. In the present experiment, germination increased over the period from 12 to 18 to 24 hours at all temperatures where germination occurred. Maximum germination was at 20 and 25 C. Germination was greater on PDA than WA after 18 or 24 hours but not after 12 hours at the optimum temperatures. There was no germination at 5 or 35 C and germination at 10 C was very low even after 24 hours. The greatest difference in germination between the two media occurred after 24 hours at 30 C (8.8% versus 51.2% for WA and PDA respectively) (Fig. 1).

There have been no prior reports on optimum temperature for spore germination of G. aridum sources from the central United States. We found germination of G. aridum at 20 and 25 C not significantly different. Our results are similar to those found by researchers in California who found that optimum spore germination of G. aridum occurred between 21 and 27 C (5). This strong effect of temperature on germination of G. aridum conidia may help to explain the year-to-year variation in occurrence of ash anthracnose. The optimum spore germination temperatures presented here usually occur during moist periods in North Dakota only after green ash shoot growth has begun and leaves are expanding. This may explain why the predominant site of infection found in North Dakota is on leaves rather than on buds or shoots.

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(37) AN ELECTRON MICROSCOPY STUDY OF BIOTIN TRANSPORT IN ACTIVATED AND REPRESSED CELLS OF LACTOBACILLUS PLANTARUM

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The functioning of the cell membrane is essential to all organisms. One of the functions of the cell membrane of Lactobacillus plantarum is to regulate the entry of biotin. Under conditions where the level of biotin in the environment is low the cell expends energy to activate a transport system that has a higher capacity for biotin accumulation. When environmental biotin is plentiful the organism does not require such an efficient transport mechanism and represses its synthesis thereby conserving energy for other metabolic functions.

The properties of the biotin transport system in activated and repressed cells of L. plantarum have been previously characterized (1). Cells grown for 20 hours in a modified Wright-Skeggs medium containing 0.7 ng biotin/ml accumulated about 50 ng biotin/mg cells. These cells exhibited maximal uptake capacity and were termed activated cells. Cells grown for 20 hours in a modified Wright-Skeggs medium containing 15 ng biotin/ml accumulated only about 2.5 ng biotin/mg cells. These cells exhibited the minimal uptake capacity and were termed repressed cells.

Activation of the biotin transport system was studied by harvesting repressed cells, washing them, and placing them in Wright-Skeggs medium without added biotin. As the cells grew in the biotin free medium the transport system progressively increased in its capacity to take up biotin. Repression of the biotin transport system was studied by placing, harvested and washed, activated cells in Wright-Skeggs medium that contained 15 ng biotin/ml. As the cells grew in the high biotin medium the transport system was progressively repressed.

Studies using chloramphenicol showed that both activation and repression of the transport system required protein synthesis before they occurred. Treatment with mitomycin-C indicated that cell division or new DNA synthesis was not necessary for either activation or repression (1). The results of studies with iodacetate and cold temperature (2C) indicated that both activated and repressed cells had an energy requirement for transport activity (2). The same studies also showed that activated cells had a 4 to 5 fold greater level of transport activity in the absence of available energy. It was postulated that this energy-free biotin uptake was the loading of biotin on available transport sites.

In the present study, immunochemical techniques were used to try and locate the position or distribution of biotin transport sites in L. plantarum. Activated and repressed cells were exposed to different biotin-avidin-ferritin conjugates and evaluated by both scanning and transmission electron microscopy methods. Theoretically, the activated cells should contain 4 to 5 times the number of biotin transport sites if the previous hypotheses were valid. Once methodology for this procedure is standardized, one can evaluate the transition phases, activated to repressed or repressed to activated, of biotin transport in L. plantarum.

Scanning electron micrographs of L. plantarum cells with an activated biotin transport system did not reveal any differences between immunochemically-stained preparations and unstained control organisms. These results were not unexpected since the biotin transport phenomenon is membrane associated and it is unlikely that differences would be apparent on the external surfaces of the cell wall. Transmission electron micrographs of L. plantarum cells with an activated biotin transport system did, however, reveal differences between immunochemically-stained preparations and unstained control organisms. An increased density of ferritin deposits are evident in several areas of the cell membrane and cytoplasm for cells with an activated biotin transport system. Using these data, it is not possible, however, to quantitate the biotin transport sites. By using radioactive, ^{14}C, biotin and autoradiography techniques suited for electronmicroscopy we hope to quantitate and specifically locate the membrane transport sites for biotin in L. plantarum.

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(38) CHARACTERIZATION STUDIES OF SEX-LIMITED ESTERASES AMONG BEETLES OF THE GENUS DIABROTICA (COLEOPTERA, CHRYSOMELIDAE).

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Electrophoretic surveys of isozyme variation revealed the presence of a sex-limited esterase locus (Est-m) among species of the virgifera group of the beetle genus Diabrotica occurring in the United States. Est-m electromorphs are expressed in zymograms of adult males only and given species are either monomorphic or polymorphic for the putative allelic variants (1 null and 4 active) of the locus. Studies were initiated to investigate the functional significance or role(s) of Est-m heterogeneity in and among individuals and populations since the geographic and species distribution patterns of alleles suggested that selection was important to the evolution and maintenance of Est-m variation within the species complex. Initial efforts in this regard have involved investigations of the tissue distribution patterns and physical properties of the Est-m system in the western corn rootworm, Diabrotica virgifera virgifera LeConte. This species was chosen as a model for Est-m characterization purposes because it is 1) easily reared in the laboratory, 2) economically important, and 3) monomorphic for a single Est-m form. Dissection studies coupled with electrophoretic analyses demonstrated that Est-m expression is localized in the accessory glands of virgin male beetles 2-14 days old. The enzyme has been categorized as a carboxylesterase acting on short-chain aliphatic esters based on the results of Est-m inhibitor and variable substrate tests (1). Thus, Est-m staining activity on acrylamide gels was inhibited by the presence of Diisopropyl fluorophosphate (DFP), but not by carbaryl, eserine, or p-hydroxymercuribenzoate (1×10^{-4} M concentrations in dye solutions). Additionally, the Est-m electromorph was resolved on gels when α- or β-naphthyl acetate, α-naphthyl propionate, or indoxylacetate were used as substrates in the dye formulations. Conversely, gel staining activity was reduced or absent in substrate tests involving β-naphthyl propionate, α-naphthyl butyrate, α-naphthyl myristate, naphythol AS benzoate or naphthol AS phenylpropionate. The presence of a carbohydrate moeity on the enzyme was confirmed by Schiff's staining of Est-m on acrylamide gels (2) and by the use of a lectin binding assay (3) directed against Est-m immobilized on nitrocellulose (NC). The molecular weight of the Est-m form was estimated to be 78,000 ± 8,680 using gel filtration chromatography in conjunction with electrophoresis of known protein standards. Hybridoma cell lines secreting anti-Est-m antibodies have been recovered using a horseradish peroxidase ELISA assay directed against Est-m bound to NC. Selected antibodies will be used for 1) immunocytological studies of Est-m activity, 2) affinity purification and large scale recovery of Est-m enzymes, and 3) epitope mapping for comparisons of intra- and interspecific Est-m variants.

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(39) OCCURRENCE OF LIRULA MACROSPORA ON SPRUCE IN NORTH DAKOTA WITH NOTES ON ITS BIOLOGY

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Lirula needle blight, caused by the fungus Lirula macrospora (Hartig) Darker, was identified on spruce (Picea) in North Dakota in 1981. By 1983, reduction of aesthetic value and lower branch dieback caused by this fungus were sufficient to cause concern. Here we report the distribution and extent of damage by the disease and a possible source of the fungus.

Spruce plantings in nine counties in northeast and north central North Dakota were surveyed for the disease. Several types of spruce plantings (including farmstead windbreaks, field shelterbelts, urban landscape plantings, and cemetery plantings) of various ages, species, and planting density were examined. Age of trees and source of seedlings were recorded if that information was available. Presence of the disease was determined by close observation of individual trees at each site for the characteristic gray needles that remain attached to branches for several years. A disease severity rating system was adapted from a published system (1). Individual trees were visually divided into quarters by height. Symptoms on third-year needles on shoots in each quarter of every tree were rated. A tree was considered lightly, moderately, or severely infected if a trace to 9%, 10 to 49%, or 50 to 100%, respectively, of the third-year needles in at least one quarter of the crown were symptomatic.

L. macrospora was found on spruce at 17% of 83 sites examined and in five of nine counties surveyed. The author was notified of four additional sites in two additional counties in northeast North Dakota. Of the 18 sites where the fungus is currently known, 14 are farmstead windbreak plantings, two are urban plantings, and two are block plantings. L. macrospora was found on Colorado spruce (P. pungens Engelm.) at six sites and on white spruce (P. glauca (Moench) Voss) at 17 sites. Where both hosts were infected (5 sites), infection level was higher on P. glauca than on P. pungens.

Infection on individual trees at the 18 sites ranged from light to severe (Fig. 1). Where severe infection was found, large differences in infection level within and between species of spruce were evident. The fungus was sometimes present on separate plantings at individual sites and was found on young trees planted near older infected trees. Establishment time of infected plantings ranged from 1934 to 1967. At least 15 of the infected plantings were established before 1957 and two of the plantings were established after 1960.

Results of the survey indicate that L. macrospora is generally at a low level of incidence and damage, but the fungus is distributed throughout the area and some sites have significant disease levels. The amount of damage on individual trees at sites where some trees were significantly damaged was highly variable, with some severely infected trees immediately adjacent to lightly infected or noninfected trees. The cause of these differences may be variability in resistance.

There is no known native host for this fungus in North Dakota. If L. macrospora was introduced to each site on its host, the nursery where the seedlings were produced must be considered a possible source. It appears likely the fungus was introduced to most sites from a single nursery which had sold trees for planting in farmstead windbreaks before 1957. It does not appear that the fungus is being introduced from current nurseries. The threat from the disease lies in potential damage to plantings where it presently exists and in the possibility of spread to nearby plantings. The practice of transplanting trees from infected sites could introduce the fungus to new areas. Cases of this are known and may account for infection in the younger infected plantings that have been found.

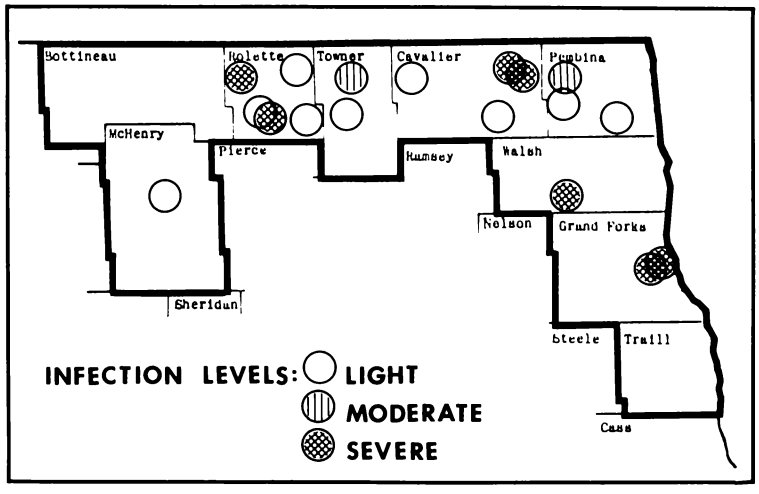

Figure 1. Known distribution of lirula needle blight on spruce in North Dakota and maximum infection at each site.

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The assistance and cooperation of the North Dakota Forest Service and the North Dakota State University Plant Diagnostic Laboratory are gratefully acknowledged.

(40) IMPACT ON RANGE PLANT COMMUNITIES BY PHYLLOPHAGA SPP. (COLEOPTERA: SCARABAEIDAE)

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During the summer of 1985 extensive denuded areas were noticed on the Central Grasslands Research Station resulting from Phyllophaga spp. infestations. These infestations were associated with Symphoricarpos occidentalis communities which occupy over 22 percent (%) of the native plant communities on the station (1). Poa pratensis is the major graminoid associate of these communities, and may account for over 60% of the total graminoid production (2). The objective of this study was to assess the change in botanical composition and production resulting from these infestations.

During June 1985 twenty pairs of permanent transects were subjectively located within infested areas and adjacent non-infested areas of similar soils with a botanical composition approximating vegetation present on infested areas prior to infestation. Within each transect, one 0.25 square meter (m^2) quadrat was clipped at ground level during June and September to estimate production. Samples were sorted into categories, oven-dried, and weighed to the nearest 0.1 gram (g). Larval densities were determined by checking the upper 7 centimeters (cm) of the soil profile in June clipped quadrats. Six pairs of the transects were chosen for detailed analysis of botanical composition. Within each transect twenty 0.1 m^2 quadrats were used to determine forb and shrub densities. Graminoid densities were determined by counting culms within nested 0.01 m^2 quadrats. A standard t-test was used to determine significant differences for parameters between infested and non-infested transects.

Larval density per m^2 in infested areas (47.0 $\pm$ 4.8) was significantly greater ($p<.0001$) than in non-infested areas (1.6 $\pm$ 1.6). Production data are summarized in Table 1. During both clipping periods all graminoid categories were significantly lower on infested areas ($p<.05$). Forb production was significantly different only during the September clip. We attribute this, in part, to invasion of annual forbs on infested areas. Annual forb density per m^2 on infested and non-infested areas was 203 and 17 respectively. This contributed to the lack of a significant difference in total production of the September clip.

Graminoid density in infested and non-infested areas averaged 291 and 3396 culms/m^2 respectively. Species exhibiting significantly lower densities in infested areas ($p<.05$) were: Agropyron smithii, Bouteloua gracilis, Carex eleocharis, Carex heliophila, Koeleria pyramidata, Poa pratensis, and Stipa comata. Chenopodium leptophyllum and Conyza canadensis (annual forbs) showed significantly higher densities ($p<.05$) in infested areas. Only one perennial forb, Helianthus rigidus showed a significantly higher density in infested areas ($p<.05$).

Table 1. Production (kilograms per hectare) for Phyllophaga spp. infested and non-infested areas on the Central Grasslands Research Station, 1985.

Category	Mid June		Late September	
	Non-Inf.	Inf.	Non-Inf.	Inf.
Poa pratensis	1052 $\pm$ 145	54 $\pm$ 16*	1413 $\pm$ 115	129 $\pm$ 57*
Other grasses	546 $\pm$ 98	44 $\pm$ 10*	542 $\pm$ 92	56 $\pm$ 48*
Carex spp.	140 $\pm$ 29	48 $\pm$ 7*	227 $\pm$ 64	52 $\pm$ 18*
Forbs	180 $\pm$ 36	227 $\pm$ 43	142 $\pm$ 48	1836 $\pm$ 222*
Symphoricarpos occidentalis	97 $\pm$ 33	132 $\pm$ 53	248 $\pm$ 56	161 $\pm$ 43
Total	2016 $\pm$ 103	506 $\pm$ 68*	2571 $\pm$ 111	2234 $\pm$ 209

*Denotes significant differences within category within sampling period. (t-test, 19 df. $p<.05$)

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(41) Effect of temperature on regulation of glycerol levels in cold hardened purple martin fleas, Ceratophyllus idius

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Ceratophyllus idius is an ectoparasite of purple martins (Progne subis) and tree swallows (Iridoprocne bicolor) in temperate North America, and commonly inhabits nest material of these birds. In the Upper Midwest, purple martins migrate in late August and return in mid- or late April, thus separating the fleas from their hosts for 7½ to 8 months. Despite the host's absence and harsh northern winters, some portion of the adult flea population survives to reinfest returning birds (1). Many cold tolerant insects, including C. idius, produce glycerol as a biological antifreeze. Glycerol's role as a cryoprotectant in fleas was first suggested by Pigage and Larson who noted elevated levels in siphonapterans exposed to cold temperatures (2). The present paper reports a small portion of an extensive project on cold hardiness of C. idius. Of specific interest was the effect of short-term, but large and abrupt temperature changes on the flea's glycerol levels.

Nest material from purple martin bird houses was collected September 3-5, 1985, in and around Grand Forks, North Dakota. Fleas were held at room temperature (22 C) until about 5,500 were isolated, randomized and packaged 55 fleas per cloth covered vial. Beginning September 10, the vials were cooled 3 C every 4 days until reaching 1 C. The 20 vials used in this specific portion of the experiment were then placed in a freezer at -6 C and held until needed. At times indicated in Figure 1 several vials of fleas were allowed to warm to room temperature. Survivors were immediately freeze-killed, placed in double sealed containers and stored at -25 C until analyzed. They were then sorted by sex, weighed and homogenized in either 80% methanol (glycogen assay) or distilled/deionized water (glycerol assay). Glycogen was hydrolyzed by amyloglucosidase (3) and read as glucose units by colorimetric methods (Sigma: technical bulletin No. 510). Glycerol was analyzed indirectly by UV methods (4). All assays were read on a Beckman DU-7 spectrophotometer and calculated as µmoles/g wet weight.

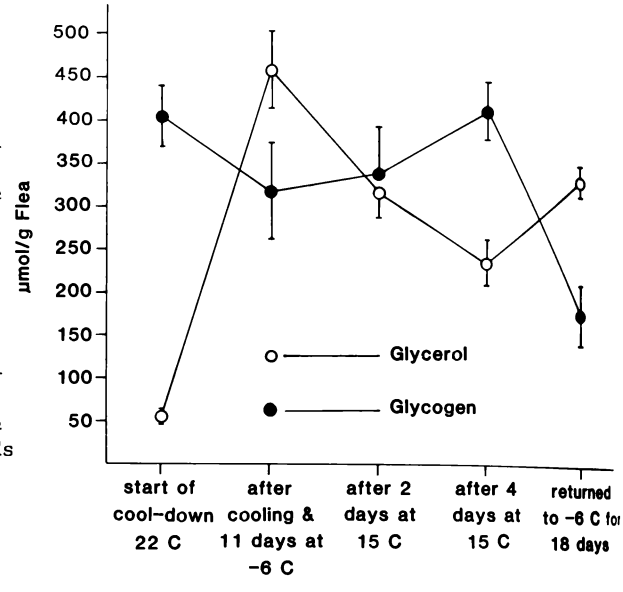

Figure 1. Glycerol and glycogen levels as functions of time and regime. Pooled data for both sexes: results as means ± SEM. Glycogen expressed as µmol glucose after enzymatic hydrolysis.

After 32 days of cool-down and 11 days at -6 C storage, there was a large increase in glycerol with a concurrent drop in glycogen (Fig. 1). This suggests that glycogen is the major carbon source for glycerol synthesis and agrees with earlier reports (2,5). Preliminary data from the cool-down process indicate that glycerol production is induced by temperatures of 10 C or lower. By returning -6 C fleas to 15 C, the system reversed with a substantial drop in glycerol within 2 days. By day 4 glycerol levels were down 43%. A rise in glycerol and drop in glycogen when fleas were returned to -6 C further confirmed the temperature dependence and reversibility of the system. Since the fleas were held in total darkness throughout the experiment, possible effects of photoperiod were avoided.

Brief mid-winter thaws in the region seldom exceed 4-6 C, but large temperature oscillations in the spring and fall probably cause major fluctuations in glycerol levels. It appears that C. idius possesses an effective and reversible system of cryoprotection for dealing with such problems.

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(42) BIOLOGICAL ACTIVITY OF SUBUNITS FROM TOXOPLASMA GONDII

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Toxoplasma gondii is an obligate intracellular protozoan parasite that causes toxoplasmosis, a disease of humans, domestic livestock and other vertebrates. Infections in livestock may result in economic losses due to abortions and stillbirths. In humans, while most infections are mild, even asymptomatic, those transplacentally acquired may result in spontaneous abortion, stillbirth or cause numerous congenital defects, most often neurological in nature. In the immunoincompetent host, especially in patients with lymphomas or AIDS, secondary or reactivated infections often lead to fatal encephalitis. Past research on development of an effective vaccine and the nature of the toxic aspects of the organism has been mainly unproductive. It would be of significant value to medical and veterinary sciences to develop a subunit vaccine as well as a diagnostic test capable of differentiating infected from vaccinated animals. Past and present research in our lab has resulted in some progress in these areas.

An antigenic, toxic mixture of proteins, given the name of T. gondii exotoxin, was prepared from the cell-free supernatant of the peritoneal exudate from Toxoplasma-infected Swiss/Webster (S/W) mice (1). Proteins were precipitated using either 35% ammonium sulfate saturation (Exo-35) or 55% ammonium sulfate saturation (Exo-55). Exo-35 has three basic biological properties: toxicity, immunogenicity and the ability to hemagglutinate mouse RBC's. Intravenous injection of mice with Exo-35, 7.56 mg/25g body weight, caused tetanus-like convulsions followed by death within 1 min. Mice immunized with sublethal doses of Exo-35 were subsequently resistant to a T. gondii tachyzoite challenge. Exo-35 is capable of spontaneously hemagglutinating mouse RBC's and this phenomenon can be used as the basis for a hemagglutination/inhibition test to measure antibody titers against T. gondii (2). Exo-55 had all of the biological properties associated with Exo-35 but to a much lesser degree.

When Exo-35 was run on non-reduced 6.5% PAGE gels, it was shown to contain about 15 distinct protein bands. Of these, the uppermost high molecular weight protein bands were found to be the most immunogenic. Exo-55 run on non-reduced 6.5% PAGE gels was found to show banding patterns slightly different from Exo-35. Exo-55 samples run on 6.5% non-reduced PAGE gels contained a band 1.5 cm from the top of the gel. This band appeared to cause a suppressed immune response in mice when compared with other Exo-55 components. This immunosuppressive component may contribute to the reduced immunogenic potential of Exo-55 since the band is apparently absent in Exo-35.

Exo-35 has been shown to agglutinate mouse and rat RBC's (2). Although S/W mouse RBC's have been found to absorb out some protein components of Exo-35, no intimate relationship was found to exist between the hemagglutinating and immunogenic phenomena. These results, although preliminary, may provide the basis for a valuable diagnostic method to differentiate Exo-35 subunit-vaccinated animals from those infected with T. gondii.

A preliminary test with Protein A-absorbed Exo-35 indicates that Ig-Ag complexes in Exo-35 may be responsible for a significant portion of this immunogenic potential.

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(43) OBSERVATIONS ON THE MORPHOLOGY AND PATHOLOGY OF KIDNEY FLUKES IN SOUTH POLAR SKUAS

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The existing literature reveals no known kidney trematodes from naturally infected birds within the Antarctic Circle. Renicola sloanei, recorded from South Georgia, proximal to 60 S., was recovered from a host that had been confined to the London Zoo for a period of 18 months (1). These data appear to indicate that the infection originated in the zoo.

Digenetic trematodes were collected by teasing from 3 of 24 (12.5%) south polar skuas (Catharacta maccormiki) and examined at Hallet Station (72° 18'S., 170° 18'E.), Antarctica during the the austral summer of 1965-1966. Our infected skuas harbored 6 to 25 (x=17) flukes each. Standard laboratory methods were employed throughout this investigation. Our specimens and the existing descriptions of known species of Renicola were morphologically and metrically analyzed using several general parameters (body size, egg size, oral/ventral sucker magnitude, pharynx dimensions) and various specific features. Comparative study revealed that the specimens collected at Hallett Station were most closely related to eight known forms of Renicola. Further comparisons were made utilizing the shape of the gonads, sucker ratios, posterior extent of the vitellariae, shape of the excretory vesicle, and degree of caudal prolongment.

Fifteen specimens of Renicola from south polar skuas were selected for species determination. The distinguishable features of these worms include the O:V sucker ratios, the posterior extent of the caeca, position and extent of the vitelline glands, presence of a short esophagus, and the shape/relationship of the reproductive organs. These specimens do not appear to be represented, in the literature available to us, by any of the known members of the genus Renicola.

Contrary to some authors (2), but in agreement with others (3,4), a cirrus pouch does seem to be present. Renal tubules containing the encysted pairs of worms become greatly dilated and possibly occluded. There is a general compression of the neighboring tubules due to pressure. The low cuboidal cell lining of the tubule appears to have normal looking nuclei and cytoplasm, with a thin layer of connective tissue surrounding the perimeter. Pyknotic changes in the nuclei were not observed. Thus, what has been termed a cyst by previous authors is in reality a dilation of a renal tubule. There is apparently little or no host tissue reaction to the presence of the worms in our material. A pronounced eosinophilia is absent and lesions are not present. Light infections are probably insignificant to host survival. Infections that are more advanced (5) have been observed to invoke severe host tissue reactions in several species of birds, but the state of our material is such that any host tissue reactions appear minimal.

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(44) EFFECT OF LEGUMES IN ROTATIONS ON YIELD AND QUALITY OF WHEAT

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Crop rotations are believed to have existed in the first century B.C. The value of legumes in rotations was studied extensively prior to the advent of cheap commercial nitrogen (N) source in the 1940's. Generally, early trials indicated that green manured sweetclover (Melilotus officinalis (L.) Lam.) plots produced equal to fallow plots in high soil moisture environment but less in low moisture environments. Miller and Dexter (1982) reported fertilized wheat (Triticum aestivum L.) produced 40% more than continuous wheat when grown on soybean (Glycine max (L.) Merr.) land and 13% more than any other previous crop treatments. The amount of nitrogen incorporated into the soil by seeding-year alfalfa stand ranges from 35 to 305 kg/ha. However, the amount of legume N added to the soil via seeding-year alfalfa (Medicago sativa L.) had little influence on subsequent nonlegume crop yields. This contrasting result could be due to high initial soil nitrogen, environmental conditions, soil moisture, and stand age effects. Little information is available on other legume effects in crop rotations in the Northern Great Plains region. Therefore, our objective was to determine the effects of grain and forage legumes on yield and quality of the subsequent wheat crop.

Experiments with seven grain legumes [soybean, lentil (Lens culinaris medic), field pea (Pisum sativa subsp. arvense (L.), faba bean (Vicia faba L.), and pinto bean and navy bean (Phaseolus vulgaris L.)] and five forage legumes ["annual" and perennial alfalfa, sweetclover, hairy vetch (Vicia villosa Roth.), and red clover (Trifolium pretense L.)] were initiated in 1984 at Fargo, Prosper, and Langdon, North Dakota. Forage legumes were managed as green manure and/or forage crops. Grain legumes were harvested for grain and the residue removed. Continuous wheat crop and wheat-summerfallow (fallow) were considered checks. Available soil N was determined by the NDSU Soil Testing Lab before seeding in spring of next season. Protein percent of wheat grain was determined by Near Infra Red (NIR) procedure

Randomized complete block design with three replicates was used in 1984. Three nitrogen levels (0, 75, and 150 kg N/ha) were applied randomly to each experimental unit in 1984 in a split plot arrangement for the wheat crop in 1985. Grain yield, grain protein, tiller number, 1000 kernel weight, and test weight were determined on all experimental units in 1985.

Wheat grain yield in 1985 varied significantly by previous cropping treatment at Prosper (Table 1). Wheat grown on fallow, grain legumes, green manured, or forage crop land yielded similar to or greater than wheat grown on wheat land fertilized with 75 to 150 kg N/ha at Prosper. All non-fertilized legume treatments had wheat yields similar to or greater than fallow treatment without fertilizer except red clover plots harvested for forage. Most fertilized legume treatments generally had wheat yields equal or slightly less than fertilized fallow treatments possibly indicating a moisture deficiency in some treatments for greater wheat production on legume plots.

Wheat yields at Langdon were similar on continuous wheat, fallow, grain legumes, and green manured plots, but forage crop plots produced significantly lower wheat yield. Nitrogen treatment effects were significant at the 10% level only due to the high initial soil nitrogen level. A high soil N reduced dinitrogen fixation by Rhizobium bacteria in 1984, thereby no difference in soil nitrogen was found among treatments in 1985. Soil nitrogen levels at Prosper were low at the initiation of the experiment (Table 1). Thus, significant differences in the nitrogen levels under different legume treatments were found after growing the various legumes. Higher soil N was found on fallow, alfalfa, hairy vetch, and sweetclover plots than other treatments. Wheat yields by treatment were not different at Fargo also due to a high initial soil N level.

The quality of wheat (% protein) increased significantly with both green manured and forage crop legume treatments compared to continuous wheat, fallow, and grain legume treatments at Prosper. There was no difference in percentage protein of wheat with legume treatments at Langdon and Fargo due to the high soil N concentration. But, the protein percentage increased significantly with increased levels of nitrogen fertilizer at all locations regardless of the previous cropping treatment.

Table 1. Wheat yield in 1985 as influenced by the legume crop grown in 1984 at Prosper, North Dakota.

Previous crop	Soil nitrogen	Nitrogen rate kg/ha			
		0	75	150	Mean
	(kg/ha)	----------Wheat yield kg/ha @ 12% moisture----------			
Wheat	37b†	2430b	3305b	3914b	3216b
Fallow	99a	3450a	4691a	5164a	4435a
Grain legumes	48b	3403a	4149a	4508ab	4020a
Green manure crop	67ab	3843a	4348a	4530ab	4240a
Forage crop	51b	3337a	4212a	4704a	4084a

† Means within a column followed by different letters differ significantly (P<0.05).

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(45) SITE FIDELITY IN CALCARIUS ORNATUS

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The dispersal patterns of organisms are an integral part of a population's dynamics and can have a major influence on breeding site stability, mate aquisition, and reproductive success. Site fidelity, the opposite of dispersal, may be divided into two major components: 1) natal fidelity, the return of young birds to the hatch area to breed, and 2) breeding fidelity, the return of breeding adults to the same site in successive years (1).

Avoidance of inbreeding depression is a selective force promoting dispersal (2,3). This factor, and others, tend to set the overall dispersal pattern for a species or population. Individual variation, on the general pattern, may result from an unfavorable experience, such as extreme predation, severe competition, or low availability of mates, food, or cover.

Table 1. General Return Rate
Banded Adults

	BOTH	MALES	FEMALES
1982	50.0% 7/14-40	100% 2/2-20	41.7% 5/12-20
1983	30.6% 11/36-51	46.7% 7/15-28	19.0% 4/21-23
1984	29.0% 9/31-32	33.3% 6/18-19	23.1% 3/13-13
1985	56.5% 13/23-23	66.7% 8/12-12	45.4% 5/11-11

Table 2. Fidelity - Site Experience
(Return Frequency by Year Class)
1981 - 1985

	Second Year	Third Year	Fourth Year
FEMALES	26.1% 12/46	33.3% 3/9	100% 2/2
MALES	45.2% 14/31	60.0% 6/10	75.0% 3/4

In birds, where the dominant social system involves resource defense, site fidelity is often male biased, with females being more prone to disperse (1). Since 1981 research has been conducted on a banded population of Chestnut-collared Longspurs, Calcarius ornatus, in Grand Forks County. The study site consists of a half section of native prairie interspersed with sumps and surrounded by agricultural fields. The "General Dispersal-Fidelity Pattern" observed in this population involves natal dispersal and breeding fidelity, for both sexes. Only one hatchling, a female, of the 140 that successfully fledged, has returned to breed at the natal site. General return rates for banded adults, both sexes combined, ranged from 29% in 1984 to 56.5% in 1985, with males exhibiting a higher degree of fidelity than females each year (Table 1).

Male fidelity was found to be directly influenced by pairing success. Unmated males failed to return to the breeding site in subsequent years, while 56.1% of mated males returned. Reproductive success, rearing fledglings, did not significantly influence male return rates (47.4% of unsuccessful males returned, 50.0% of successful ones). Returning males arrived earlier on the breeding site, exhibited strong territory fidelity, at least initially in the season, and had a 95.7% chance of acquiring a mate. New arrivals exhibited a mate acquisition rate of 76.7%.

Female fidelity, in contrast, was strongly influenced by reproductive success. Females that successfully fledged young returned at a 45.7% rate, while only one unsuccessful female returned, a 4.5% rate. That individual, however, had been successful in a previous season. Experienced females, unlike males, exhibited a high degree of territory shifting upon their return. Both sexes were characterized by increased site fidelity with experience (Table 2).

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(83) PURIFICATION AND HIGH PRESSURE LIQUID CHROMATOGRAPHY ANALYSIS OF PHOSPHOENOLPYRUVATE CARBOXYKINASE ISOENZYMES

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Gluconeogenesis maintains the level of blood glucose during starvation and diabetes (1). The enzyme phosphoenolpyruvate carboxykinase (PEPCK) catalyzes a key step in this pathway. PEPCK activity in mammals is found mainly in the liver and kidneys, but its subcellular distribution in liver is species dependent (2). PEPCK activity has been found in both the cytoplasm and mitochondria of human and rabbit liver (2). We have set out to purify the cytoplasmic (C) and mitochondrial (M) PEPCK isoenzymes from rabbit liver and to analyze their physical characteristics using high pressure liquid chromatography (HPLC). These investigations hopefully will lead to a better understanding of why there are two isoenzymes of PEPCK and how each is involved in the regulation of gluconeogenesis in humans.

We have purified the cytoplasmic and mitochondrial PEPCK isoenzymes from rabbit liver to homogeneity. Cytoplasmic PEPCK is purified by the adsorption of the enzyme from 100,000 x g cytosol onto aminohexylsepharose and eluting with 50 mM NaCl, followed by chromatography on hydroxyapatite and Reactive Blue 2-agarose with IDP elution. Mitochondrial PEPCK has been purified as follows: Extracts from hypotonically shocked mitochondria were chromatographed on Reactive Blue 2-agarose with 0.15 M NaCl elution, followed by QAE-Cellulose and hydroxyapatite chromatographies. The purification of M PEPCK using Tris-Cl buffer pH 8.5 through the first two steps yielded two distinct peaks of PEPCK activity (M-I and M-II) eluting from QAE-Cellulose. It was found that a single peak of mitochondrial PEPCK activity can be obtained by lowering the pH of the system to 7.4 using triethanolamine-chloride buffer pH 7.4. Regardless of the pH used in the first two purification steps each form of M PEPCK enzyme can be purified to homogeneity on hydroxyapatite with a phosphate gradient as the final step.

High pressure liquid chromatography was used to characterize the differences between cytoplasmic and mitochondrial PEPCK isoenzymes as well as to differentiate between the two peaks of M PEPCK activity (M-I and M-II) obtained from purification at pH 8.5 and the single peak of M PEPCK activity obtained from purification at pH 7.4. HPLC is a rapid and sensitive method to separate and analyze proteins with excellent resolution. Homogeneous cytoplasmic and mitochondrial PEPCK samples were chromatographed on SynChropax AX 300, a weak anion exchange HPLC column. A 20 minute linear gradient, 40 ml of 0-0.25 M sodium acetate (NaAc),in 20 mM Tris-acetate, pH 7.4, was used to elute enzyme activity. The absorbance of the eluate was monitored at 280 nm, and 1 ml fractions were collected and assayed for PEPCK activity. M-I eluted at a NaAc concentration of 110 mM while M-II eluted at 170 mM NaAc. The single peak of M PEPCK activity obtained by purification at pH 7.4 eluted at the same NaAc concentration as M-II. The C PEPCK enzyme was more anionic than M PEPCK since it eluted at a NaAc concentration of 240 mM. The data presented above show that the single M PEPCK enzyme activity obtained at pH 7.4 is the same as M-II PEPCK enzyme obtained at pH 8.5. M-I may be an artifact of the purification.

We now plan to analyze the isoenzymes of PEPCK further by chromatofocusing using high pressure liquid chromatography. (Supported by a grant from the North Dakota Affiliate of the American Diabetes Association and a BRSG grant from the University of North Dakota School of Medicine.)

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(84) IMMUNOCHEMICAL CHARACTERIZATION OF CYTOPLASMIC AND MITOCHONDRIAL HEPATIC PHOSPHOENOLPYRUVATE CARBOXYKINASES FROM RABBIT

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Gluconeogenesis, found predominantly in the liver and kidney cortex, is the metabolic pathway in humans and nonruminants that produces glucose from noncarbohydrate precursors during periods of starvation and diabetes (1). Phosphoenolpyruvate carboxykinase (PEPCK) is a principal enzyme in this pathway catalyzing the decarboxylation of oxaloacetate to phosphoenolpyruvate. Subcellular compartmentalization of hepatic PEPCK varies greatly in species. Rat contains ninety percent of its hepatic PEPCK activity in the cytoplasm (C) while ninety-five percent of PEPCK activity in chicken liver is confined to the mitochondria (M). Hepatic PEPCK activity in rabbits and humans is divided between the C and M (2). It is difficult then, if not impossible, to correlate data obtained with animals possessing either C or M PEPCK to data obtained with the human. The rabbit is used as our mammalian model to analyze the enzyme in such a way that results may be correlated with that of human PEPCK functions. In order to further determine and compare the physical similarities and differences that occur between the C and M isozymic forms of hepatic PEPCK from a single species, we have recently immunochemically characterized both forms of the hepatic enzyme from rabbit.

Two one-year old pgymy goats were respectively inoculated with the purified C or M form of the enzyme to develop IgG specific antibodies against both forms of the hepatic PEPCKs. Animals were immunized with an initial intramuscular injection of one mg purified enzyme in Freund's complete adjuvant to the fore and hind quarters with subsequent injections every three weeks of one mg purified enzyme in Freund's incomplete adjuvant over a six week period. Five days prior to final bleeding, a booster of 0.5 mg purified enzyme in Freund's incomplete adjuvant was administered. In order to determine the serum titer of the antigen-antibody reaction, a Dot Enzyme-Linked Immunosorbant Assay (Dot-ELISA) specific for PEPCK was developed. Serum titer measurements of both C and M PEPCK increased from zero to 1/1024. After final bleeding the goat serum was partially purified by precipitation in forty-five percent ammonium sulfate and subsequent chromatography of the solubilized precipitate on DEAE cellulose. The resultant polyclonal IgG fractions had titers greater than 1/2048.

Studies were performed to determine the inhibitory capability of the two preparations of IgG antibody fractions against their respective purified antigens. Results indicate that fifty percent inhibition of enzymatic activity contained in ten µg C PEPCK is obtained with 12 mg of C PEPCK antibodies. Fifty percent inhibition of enzymatic activity in ten µg M PEPCK is obtained with ten mg of M PEPCK antibodies. Additional studies were performed to determine the cross-reactivities of both antibodies against the antigens. Varying concentrations of C PEPCK antibodies were incubated with ten µg M PEPCK and differing concentrations of M PEPCK antibodies were incubated with ten µg C PEPCK. Results indicate that no inhibition of M PEPCK is observed with C PEPCK antibodies nor is inhibition of C PEPCK seen with M PEPCK antibodies. Preincubation of two mM $MnCl_2$, a known activator of PEPCK's enzymatic activity, with ten µg of either PEPCK and varying concentrations of its antibody indicate an enhancement of the inhibitory effects of antibody against its respective antigen.

The ability of M PEPCK antibodies to inhibit the catalytic activity of M PEPCK and not C PEPCK and the additional finding that C PEPCK antibodies inhibit the enzymatic activity of C PEPCK and not M PEPCK suggests major physical differences between the two isozymes. Previous analyses by our group of peptide sequences generated by trypsin and cyanogen bromide cleavage of C and M PEPCKs provide additional evidence supporting this conclusion. All of our results taken together show that major differences do indeed exist in the primary structure between the two enzymes. In addition to primary structure differences, immunochemical characterization also provides data that the tertiary structures of the two isozymes are quite distinct. Even though these isozymes catalyze the same reaction it is apparent that their respective primary, secondary and tertiary structure differ.

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(85) MITOCHONDRIAL PHOSPHOENOLPYRUVATE CARBOXYKINASE AND ITS POSSIBLE ROLE IN LIPOGENESIS

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Glucose is an essential body fuel. During periods of starvation when glycogen stores are depleted, required glucose is synthesized from amino acids and lactate from muscle, as well as other non-carbohydrate precursors. This process is termed gluconeogenesis and occurs primarily in the liver. Phosphoenolpyruvate carboxykinase (PEPCK) is one of the enzymes required for gluconeogenesis. Cytoplasmic (C) and/or mitochondrial (M) isozymes of PEPCK exist in different distributions in liver depending on the species. Most mammals tested, including rabbit and man, have both isozymes. M and C forms of PEPCK are both generally thought to be involved in gluconeogenesis. PEPCK has been considered a unidirectional enzyme catalyzing the conversion of oxalacetate (OAA) to phosphoenolpyruvate (PEP), (the first committed step in gluconeogenesis).

$$OAA + GTP \xleftarrow{\text{PEPCK}} PEP + GDP + CO_2$$

However, some recent studies have suggested that the reaction catalyzed by PEPCK may not be regulatory and may be near equilibrium (1,2). If so, the net reverse reaction could possibly occur, and this reaction might play a role in other metabolic processes, such as lipogenesis. Accordingly, we propose a theory that reversal of the M PEPCK reaction, as opposed to the combined reactions of pyruvate kinase (PK) and pyruvate carboxylase (PC), generates OAA which could then proceed through the currently accepted reactions for lipogenesis. This pathway would spare the cell one equivalent of ATP, and might also explain the observation that species with a predominant amount of M PEPCK carry out lipogenesis primarily in liver.

The purpose of our work was to investigate the feasibility of reversing the M PEPCK reaction *in vitro*, by demonstrating the conversion of PEP to OAA (or products derived therefrom) in rabbit liver mitochondria, and to further characterize the metabolic role and regulation of the M isozyme.

Reactions were initiated by the addition of mitochondria (isolated from rabbit liver) to the appropriate medium. After incubation for 15 minutes at 37°C, reactions were terminated with 15% perchloric acid (w/v), and the neutralized extracts were assayed for metabolites using standard enzymatic methods. Mitochondrial protein content was determined using the Biuret method. The basic incubation medium included: 3.35 mM PEP, 20 mM $NaHCO_3$, 0.1 mM $MnCl_2$, 7.5 mM $MgSO_4$, 10 mM β-hydroxybutyrate, 1 mM NaCN, 100 mM MOPS buffer (pH 7.1), and 0.25 M sucrose. Because of the difficulty in measuring OAA, our system was geared for the reduction of OAA to malate by the inclusion of β-hydroxybutyrate as a source of reducing equivalents. A pyruvate trap (0.16 mM NADH and 3.2 units/ml lactate dehydrogenase) was added to prevent OAA production from PEP by contaminating PK in concert with M PC activities.

Results from a representative experiment for the production of malate, in nmoles/15 min/mg mitochondrial protein were as follows: no additions, 18; 0.5 mM IDP, 34; 0.5 mM GDP, 48; 0.5 mM GDP + 10 mM malonate, 63; and 0.5 mM GDP + 500 μM 3-mercaptopicolinate, 27. The influence of various nucleotides on the system was investigated. Whereas the addition of 0.4 mM ADP had only marginal effects, IDP and to a greater extent GDP, stimulated the production of malate. Malonate, a competitive inhibitor of succinate dehydrogenase, also caused an increase in the amount of malate, presumably by inhibiting its equilibration with succinate. It follows that in the absence of malonate, any estimation of total metabolites from PEP based on malate alone is probably minimal. Malate production was PEP dependent, and the addition of 3-mercaptopicolinate (a specific inhibitor of PEPCK) substantially decreased malate production. Also, a cross species comparison using rat mitochondria, which possess primarily the C isozyme of PEPCK, yielded only minimal malate production. These facts strongly suggest that malate production in our system is attributable to reversal of the M PEPCK reaction.

In conclusion, our studies demonstrate the reversibility of the reaction catalyzed by M PEPCK in rabbit liver *in vitro*, consistent with our theory for its possible role in lipogenesis.

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(86) THE SIGNIFICANCE OF 'ACTIVATION ENTROPY' TO THE UNDERSTANDING OF ENZYME REACTIONS

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Entropy concepts have been used to interpret solvent isotope effects on the rates of hydrolytic reactions (1). A similar approach can be used to explain the catalytic efficiency of enzymes; especially the initial 'driving force', which attracts the substrate to the enzymatic site. Solvent changes during enzyme-substrate formation are given by the equation,

$$S(H_2O)_y \xrightarrow{E} ES(H_2O)_{y-w} + (H_2O)_w \quad . \qquad [1]$$

The substrate, S, is assumed to be solvated with y molecules of water and is stripped of w molecules of water, when complex formation (ES) occurs, because of the hydrophobic nature of the enzymatic site. For enzyme-substrate dissociation, into products, the reverse is true as given by,

$$EP(H_2O)_{y'-w'} + (H_2O)_{w'} \xrightarrow{-E} P(H_2O)_{y'} \quad . \qquad [2]$$

In this case, the product, P, takes on a sheath of w' molecules of water when it is released from (EP) the hydrophobic site. The above solvent processes can be examined using the expression for the translational entropy (S_{tr}) change of a substance with mass (M) (2),

$$S_{tr} = R[5/2 \ln T + 3/2 \ln M] - 2.31 \quad , \qquad [3]$$

where R = gas constant, and T = K. When this equation is applied to the above solvation problem, only the mass term remains. The resultant equations for complex formation and breakdown are as follows:

$$\Delta S^*_{ES} = 2.98 \ln [18w(M_s + 18(y-w))/(M_s + 18y)] - 2.31 \qquad [4]$$

$$\Delta S^*_p = 2.98 \ln [(M_p + 18y')/18w'(M_p + 18(y'-w'))] + 2.31 \quad , \qquad [5]$$

where ΔS^*_{ES} and ΔS^*_p are the translational entropy changes of solvation corresponding to equations [1] and [2], respectively. For the substrate (eq. 4), M_s = mass, y = number of moles of water for solvation, w = number of moles of water lost upon complex formation, and 18 is the mass of water. For the product (eq. 5), M_p = mass, y' = number of moles of water for solvation, and w' is the number of moles of water gained after release from the enzymatic site.

Table I, lists entropy values calculated using equations [4] and [5]. In Table II is tabulated entropy and enthalpy of activation data for different kinds of enzyme systems (3). An examination of the values for entropy is quite convincing. The pepsin system is an excellent example. Even though the enthalpy of activation for complex formation is greater than for its breakdown to products, the rate constant is 500 times faster. Thus, the driving force for rapid complex formation is due to the positive entropy change when the substrate is stripped of solvent. For product release, the negative entropy of re-solvation is a major factor, which controls enzyme productivity.

Table I. Calculated Values for the Translational Entropy of Solvent Changes (cal mol^{-1} K^{-1}).

Molecules of Water (w or w')		Formation (Eq. 4)	Breakdown (Eq. 5)
50	Ms = Mp = 300; y = y' = 100	16.29	-16.29
30		15.55	-15.55
20		14.67	-14.67
10		12.90	-12.90

Table II. Entropy and Enthalpy of Activation Values for Some Enzyme Systems.

System	Complex Formation		Complex Breakdown	
	ΔS^*_{ES}	ΔH^*	ΔS^*_p	ΔH^*
Pepsin (3)	14.1	23.1	-6.5	20.7
Trypsin (3)	8.5	16.3	-16.5	11.2
Myosin (3)	44.0	21.0	-8.0	13.0

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(87) Glucose Uptake by the Cellulolytic Rumen Anaerobe, Bacteroides succinogenes

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We have investigated U-[^{14}C]-glucose uptake in Bacteroides succinogenes S85 to describe carbohydrate transport systems in rumen cellulolytic bacteria, since these have not been studied previously. Bacteroides succinogenes was grown on glucose-containing medium, modified slightly from Miller (1). The bacterium showed two patterns of glucose uptake depending on it's growth phase. Cells in transition from the lag to log phase (0.35 absorbance, 660 nm; transition cells) showed greater total glucose uptake (300-400 nmoles/mg protein) than did log phase cells (0.8 absorbance; 90 nmoles/mg protein). Log cells required osmotic stabilization with 0.5 M sucrose in order to detect glucose uptake, whereas transition cells did not. Part of the difference in glucose uptake ability between transition and log cells was accounted for by a sensitivity of the latter to refrigeration during harvesting. Log cells harvested at 22°C showed twice as much glucose uptake as those harvested at 10°C. In contrast, harvest temperature had no effect on glucose uptake by transition cells. Both cell types incorporated glucose into a cold, trichloroacetic acid-insoluble fraction consistent with the presence of a polyglucose reserve in B. succinogenes (2).

Glucose uptake by B. succinogenes was not sensitive to competitive inhibition by a variety of sugars including α-methylglucoside, β-methylglucoside, maltose, mannose, galactose, fructose, cellobiose, and 2-deoxyglucose. However, the last two sugars did inhibit glucose uptake when preincubated with the cells. This pattern of inhibition was the same with either transition or log cells. These results suggest that metabolism of the sugars is required to inhibit glucose uptake. Cellobiose can be hydrolyzed by the constitutive cellobiase of B. succinogenes (3) but the metabolic fate of 2-deoxy-glucose is not known.

A number of metabolic and electron transport inhibitors were also tested for their effects on glucose uptake by B. succinogenes. With the exception of antimycin A, the inhibition patterns were the same for transition and log cells. Glucose uptake was inhibited by iron-chelating compounds, inhibitors of electron transport (2-heptyl-4-hydroxyquinoline-N-oxide, acriflavin), and sulfhydryl reagents ($HgCl_2$, but not p-chloromercuribenzoate). Exposure to O_2 (air) inhibited glucose uptake by 75%. Proton- and metal-conducting ionophores were potent inhibitors of glucose uptake (Table 1). These results indicate that glucose uptake in B. succinogenes is an active process and does not appear to be a group translocation. The driving force for glucose transport may be an ion gradient generated, in part, by the fumarate reductase electron transport system (4).

Table

Effect of Proton and Metal Ionophores on Glucose Uptake

Compound (mM)	Transition Cells (% Control)
Control (5% v/v ethanol)	100
2,4-Dinitrophenol (0.4)	84
Carbonyl cyanide-3-chloro-phenylhydrazone (0.05)	12
Pentachlorophenol (0.05)	34
Monensin (0.01)	18
Lasalocid (0.01)	10

Cells were preincubated (37°C) with the inhibitors for 10 minutes. Glucose uptake by the control was 293 nmoles/5 min/mg cell protein.

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(88) Contribution of Erythrocytes to Glucose Uptake by Perfused Rat Livers

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Katz & McGarry have reviewed studies of net glucose uptake by perfused livers (1). At substrate concentrations below 15 or 20 mM they found the majority of the studies concluded there was little or no net glucose uptake. They pointed out that glucose uptake could be demonstrated at lower glucose concentrations in studies when perfusion media contained washed erythrocytes. Recently it has been suggested that glucose may be converted to hepatic glycogen through an indirect pathway (1). Glucose is converted to three-carbon intermediates via glycolysis in peripheral tissue. These compounds are converted in the liver via gluconeogenesis to glucose-6-phosphate which is then diverted in a glucose-concentration-dependent fashion to hepatic glycogen. Essential to the indirect pathway concept is the inhibition of hydrolysis of hepatic glucose-6-phosphate generated from three-carbon intermediates, directing glucose-6-phosphate away from glucose release toward glycogen formation. This inhibition, possibly by some as yet unidentified gluconeogenic intermediate, is dependent on the presence of both glucose and a gluconeogenic substrate such as lactate.

We chose to investigate the possibility that glucose utilization by the indirect pathway could have significantly contributed to net glucose uptake and elevated hepatic glucose-6-phosphate concentration seen in our earlier perfusion studies which had included erythrocytes (2). The activity of glucokinase, the enzyme considered essential for initiating glucose utilization via the direct, hepatic pathway (glucose → glucose-6-phosphate) was lowered through a 48-hour fast of liver donors and/or inclusion in the perfusate media of the specific competitive inhibitor, N-acetylglucosamine (GlcNAc)(3).

Net glucose uptake by perfused livers was determined in our recirculating system containing approximately 20 ml of packed red blood cells made up to a total of 100 ml with Krebs Ringer bicarbonate buffer. Rates of net glucose uptake by livers (n = 6-12) of fed animals were inhibited significantly by GlcNAc at a concentration approximately equal to that of glucose (5.07 ± 0.55 to 3.09 ± 0.47 $\mu moles \cdot min^{-1}$, glucose and GlcNAc approximately 15 mM; or 10.96 ± 0.88 to 4.42 ± 0.44 $\mu moles \cdot min^{-1}$, glucose and GlcNAc approximately 30 mM). GlcNAc did not significantly inhibit rates of net glucose uptake by perfused livers from 48-h fasted rats (3.57 ± 0.57 to 3.47 ± 0.70 $\mu moles \cdot min^{-1}$, glucose and GlcNAc approximately 15 mM; or 4.63 ± 0.49 to 3.77 ± 0.32 $\mu moles \cdot min^{-1}$, glucose and GlcNAc approximately 27 mM).

Lactate production in the system in the absence of liver was found to be constant (1.51 ± 0.08 $\mu moles \cdot min^{-1}$) at glucose concentrations of 14 and 26 mM in the presence and absence of 15 and 28 mM GlcNAc respectively. This corresponds to a rate of glucose utilization of 0.76 $\mu moles \cdot min^{-1}$. Thus the indirect pathway contributed a maximum of 17% to total net glucose uptake in the system incorporating livers from fed rats. The percent contribution increased when hepatic glucokinase was reduced through fasting or inhibition by GlcNAc. However it was too small to explain observed overall rates of net glucose uptake.

In earlier studies (2) we found an increase in hepatic glucose-6-phosphate concentration following addition of glucose to the perfusate. Since livers perfused according to a similar protocol (above) were shown to be supplied with lactate from erythrocyte glucose metabolism, the possibility that lactate as well as glucose was responsible for the observed rise in hepatic glucose-6-phosphate levels was investigated. Perfusion of livers from 48-hour fasted rats with 20 mM glucose produced an increase in hepatic glucose-6-phosphate concentration from 0.049 ± 0.006 to 0.088 ± 0.010 μmoles/g wet liver. Exogenous 5 mM lactate did not significantly increase glucose-6-phosphate concentration. Addition of 5 mM lactate along with 20 mM glucose led to a markedly greater increase in hepatic glucose-6-phsphate concentration than did glucose by itself (0.088 ± 0.010 vs. 0.151 ± 0.022 μmoles/g wet liver).

We propose that in addition to glucose utilization via the indirect pathway in our type of system, the presence of erythrocytes may also promote net glucose uptake by the direct, hepatic pathway. An enhanced inhibition of hepatic glucose-6-phosphate hydrolysis by some intermediate metabolite generated in the presence of lactate infusion from erythrocytes, may promote net glucose uptake independently of the mechanism of residual hepatic glucose phosphorylation.

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(89) EFFECT OF PLATELET CONTAMINATION ON QUANTITATION OF LEUKOCYTE CONSTITUENTS

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The quantitation of minerals, enzymes, and other biochemical components in leukocytes (WBC) can be complicated by platelet (PLT) contamination of the isolated WBC fraction (1). Historically, the quantitation of the mineral content of WBCs has been plagued by PLT contamination causing erroenously high mineral estimates and cell clumping. Although PLTs are much smaller than WBCs, their number in blood is many times greater, thus their total mineral content is much greater than that of WBCs. For example, PLTs account for about 60% of the zinc content of the "buffy coat". We have found that the apparent zinc content of WBCs is directly related to the number of contaminating PLTs in the preparation. Thus, a method for separating WBCs with minimal PLT contamination was needed for zinc assessment. The use of a two gradient system of Percoll allowed separation of whole blood into three cellular fractions: erythrocytes, (RBCs), polymorphonuclear leukocytes, (PMNs), and mononuclear leukocytes, (MNCs), that were contaminated with PLTs. We developed a three gradient system to stop the penetration of PLTs into the layers containing suspended cell fractions. This reduced the PLT contamination of the MNCs, gave more accurate mineral values for our WBC fractions, and allowed quantitation of PLT mineral content. Initial removal of PLT rich plasma followed by separation over the tertiary gradient provided a more complete elimination of the PLTs and reduced the analyzed mineral values for our WBC fractions. The mineral contents of the PLTs, MNCs and PMNs isolated by this technique are shown in Table 1.

Table 1. Mineral Contents of Purified Blood Fractions (All values ng/10^6 cells)

	P	Mg	K	Fe	Ca	Cu	Zn
PMN	1080±120[a]	61.6±13.6	511.5±184.8	28.51±15.12	15.15±5.68	0.75±0.52	4.68±1.06
MNC	1140±140	62.5±12.0	508.3±189.3	21.77±9.09	21.36±13.18	0.84±0.55	5.92±1.43
PLT	20.50±3.93	1.71±0.36	17.7±4.58	0.19±0.09	5.82±1.57	0.029±0.012	0.22±0.04

[a]10% trimmed mean ± SD of 56-70 samples

These values show significantly lower mineral concentrations in the MNC and PMN fractions than previously reported. For example, 14.0 ng Zn/10^6 MNC was a previously cited 'normal' zinc value. The other elements show similarly improved results. The contamination of white cell fractions by PLTs not only caused the high mineral values noted above, but also may have been responsible for trends in studies that compared samples from "normals" and groups manifesting increased WBC counts or PLT aggregation inhibition effects. Dennes et al (2) and Kanter et al (3) noted an apparent 50% reduction of WBC zinc in various types of leukemia. This may not represent actual depressions in the zinc content of the leukocytes in leukemic patients because the values in the most severe cases are still within the range of our "normal" WBC values. Their controls apparently show the effect of PLT contamination. The diminishment of the effect of PLT contamination is due to the increased number of WBCs, symptomatic of leukemia, relative to the number of PLTs. In these and conditions such as pregnancy, where the white cell count increases and the apparent zinc content drops, the actual explanation may be a dilution effect indicative of undetected contamination.

Conditions exhibiting decreased aggregability of PLTs may allow reduced contamination of the WBC fraction, again showing reduced WBC mineral concentrations. Examples of these illnesses include: uremia, liver diseases, and zinc deficiency. In each of these conditions there have been reports of decreased zinc contents in the WBCs. However, using the above technique we were unable to detect changes in the zinc content of the blood cellular fractions in severely zinc deficient rats (4). It is possible that in some of these conditions there may be actual decreases of zinc content, but because of the presence of the PLT contamination, the effects may be less pronounced than previously considered.

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(90) INORGANIC CO-PRECIPITATION GOVERNS TRACE METAL SOLUBILITY IN MILK

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Solubility of a mineral is a prerequisite for bioavailability (1). We have previously shown that zinc in human milk is soluble over a wider pH range than zinc in bovine milk (2,3). Since citrate and magnesium have been detected in milk calcium phosphate (4), we suggested that co-precipitation of zinc with calcium phosphate was responsible for diminished zinc solubility (2,3). Here, we present evidence for such co-precipitation of zinc as well as evidence of similar solubility control for iron and copper.

The rationale behind the methodology is that pH changes of digestion are mimicked by initial acidification followed by alkalization. Once pH-dependent effects on metal solubility are known, then studies can be expanded to include intestinal secretions and products of enzymic degradation. In our studies, solubility of a metal is equated with the ability of such metal or metal-ligand complex to pass through a membrane of 10,000 dalton nominal exclusion size (Amicon PM10).

Fresh, whole bovine milk was acidified to pH 4 with HCl. The fat layer and precipitated protein were removed by centrifugation. The remaining defatted supernatant fraction was divided into eight 25-ml aliquots. Each aliquot was adjusted to a pH between 4 and 7 with KOH. Aliquots above pH 5.7 showed a precipitate which was pelletted by centrifugation. The resulting supernatant fractions of these aliquots and total aliquots below pH 5.7 were filtered through an Amicon PM10 membrane at 50 psi, 4°C. The filtrate (F) was collected in ten 1-ml fractions. Retentate (R) was also saved for analysis. The pellets from aliquots above pH 5.7 were resuspended in 10 ml of a Tris-HCl solution, pH 7.0. After centrifugation the supernatant fractions of the wash (S) were removed and the pelletted precipitate (P) was dissolved in 10 ml of 1% HNO_3. Samples of F, R, S and P were appropriately diluted for analyses.

As the pH increased above 5.7, most of the insoluble zinc appeared in the precipitate (P) of the bovine milk (see Figure 1). Above pH 6.5 over 90% of the zinc in bovine milk co-precipitated with calcium phosphate. The solubility of iron diminished with increasing pH. As with zinc, this was accompanied by greater amounts of iron in the precipitate. Above pH 6.5 about 60% of the iron co-precipitated with calcium phosphate. The solubility of copper also diminished above pH 5.7. However, the degree of decline in solubility was less marked than with iron or zinc. Accordingly, less copper was found in the calcium phosphate precipitate. All calcium, magnesium, zinc, iron, inorganic phosphate, and citrate which left the soluble fraction (F) of milk were accounted for in the retentate (R), precipitate (P), or supernatant fractions of the washed precipitate (S).

Based on previous work and the evidence presented here, we propose that trace metal solubility is governed by co-precipitation with calcium phosphate. Such co-precipitation is a function of pH and is modulated by competition for a metal between ligands and calcium phosphate.

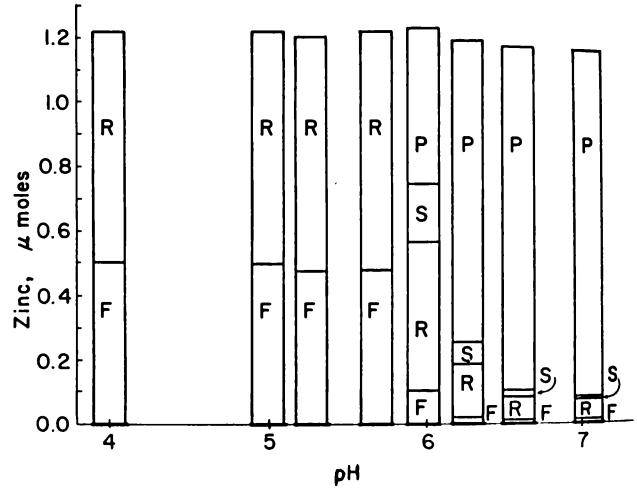

Figure 1. Zinc in 25-ml Aliquots of Bovine Milk. Milk was de-caseinated by acidification and centrifugation. Bars indicate micromoles of zinc in each fraction of milk, and in the entire portion of milk at a specific pH.
F: filtrate through PM10 membrane.
R: retentate of PM10 membrane.
S: supernatant fraction of washed precipitate.
P: precipitate.
Standard errors are within the thickness of the lines marking the means (n=3-9).

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(91) INTERACTIONS AMONG BORON, CALCIUM, AND MAGNESIUM IN RATS: PLASMA AND BONE MINERAL CONTENT

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Elsewhere in these proceedings, findings are described that are consistent with boron (B) affecting calcium (Ca) and magnesium (Mg) nutrition and metabolism, possibly through an effect on parathormone action (1). An interaction among B, Ca and Mg affected the kidney wt/body wt ratio, and an interaction between B and Ca affected liver wt/body wt ratio, spleen wt/body wt ratio and plasma alkaline phosphatase. Possibly some of these effects were the result of, or produced, changes in the mineral element distribution in the body. Therefore, we decided to ascertain the elemental profile of plasma and various organs in rats fed variable B, Ca and Mg. Some selected findings are presented.

Male weanling Sprague-Dawley rats were assigned to groups of six in a fully-crossed, three way 2x2x2 design. The methionine supplemented diets were supplemented with B at 0 and 3 µg/g, with Mg at 100 and 400 µg/g, and with Ca at 2.5 and 5.0 mg/g (2). Environmental conditions have been described (3). The rats were fed their respective diets for seven weeks, fasted overnight, weighed, anesthetized and decapitated. Plasma and bones were obtained and frozen. The samples were prepared by our usual methods for mineral element analyses using a Perkin-Elmer ICP/6500 system (4).

Effect in Rats of Dietary B, Ca, Mg and Their Interaction on Mineral Content of Plasma and Bone

Treatment, µg/g Diet			Element/ml Plasma			Element/g Dry Bone			
B	Mg	Ca	Ca µg	Mg µg	P µg	Ca mg	Mg mg	P mg	B µg
0	100	2500	98.1	10.34	91.6	169.9	1.47	70.5	ND
0	100	5000	103.0	6.69	85.3	229.6	1.12	100.8	0.903
0	400	2500	96.1	17.95	88.9	228.7	4.22	94.5	0.006
0	400	5000	99.5	19.18	91.3	210.2	4.39	95.5	0.101
3	100	2500	100.8	10.28	88.5	209.9	1.59	84.0	ND
3	100	5000	101.8	6.44	80.1	226.3	1.29	92.5	1.038
3	400	2500	95.6	18.30	88.8	229.1	4.11	90.6	0.077
3	400	5000	100.0	19.88	95.2	221.4	4.51	98.6	0.223
			Analysis of Variance - P Values						
B effect			NS	NS	NS	0.02	0.04	NS	NS
Ca effect			0.002	0.04	NS	0.01	0.004	0.0001	0.0001
Mg effect			0.004	0.0001	0.06	0.008	0.0001	0.0002	0.0001
B x Ca			NS	NS	NS	NS	NS	0.06	NS
B x Mg			NS	NS	NS	NS	0.06	NS	NS
Ca x Mg			NS	0.0001	0.02	0.0001	0.0001	0.0003	0.0001
B x Ca x Mg			NS	NS	NS	0.008	NS	0.0005	NS

Dietary B did not affect plasma Ca, Mg or phosphorus (P) in this study. However, Mg deficiency depressed Mg and P, and elevated Ca in plasma. Ca deficiency depressed Ca in plasma. Ca deficiency also elevated P and Mg in the plasma of Mg-deficient rats. In contrast to plasma, dietary B affected bone mineral content. B deprivation depressed Ca and Mg in bone. The depression in Ca was most marked when the diet was deficient in both Ca and Mg. Ca deficiency reduced bone P. In the B supplemented rats, the reduction in bone P by Ca deficiency was apparently unaffected by Mg deprivation; in the B deprived rats, the reduction was more marked in the Mg-deficient rats. Ca deficiency markedly depressed B in bone; especially when the diet was low in Mg. The results show that dietary B, Ca and Mg and their interaction markedly affect the bone mineral profile in the rat. The finding further supports the hypothesis that B has an essential function in the rat that affects Ca, P, and Mg metabolism.

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(92) BORON AFFECTS MAGNESIUM DEPRIVATION AND ALUMINUM TOXICITY IN RATS

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Recent preliminary experiments with rats suggested that the indirect influence of boron on major mineral metabolism in the rat was the result of altered parathormone activity (1). Dietary boron markedly affected the response of rats to treatments that supposedly cause changes in parathormone activity. These manipulations included magnesium deprivation and high dietary aluminum. The following experiment was done to confirm that dietary boron affects the response of rats to those manipulations and that the response is influenced by methionine status.

Male weanling Sprague-Dawley rats were assigned to groups of six in a fully crossed, four-way, 2x2x2x3 design. The treatments were the supplementation of the methionine-supplemented basal diet (1) with boron (as boric acid) at 0 and 3 µg/g, magnesium at 100 and 400 µg/g, aluminum at 0 and 1000 µg/g, and amino acids intended to give three different states of methionine nutrition. The amino acid variables were no additional amino acid supplement, 2.5 mg methionine/g diet, and 5 mg arginine/g diet. Environmental conditions have been described (2). The rats were fed their respective diets for seven weeks, weighed, fasted overnight, anesthetized, and decapitated. Selected parameters listed in the table were determined by our usual methods (1,2).

Effects in Rats of Dietary Boron, Magnesium, Aluminum, and Methionine and Their Interaction on Growth and Liver Wt/Body Wt (LW/BW), Spleen Wt/Body Wt (SW/BW) and Kidney Wt/Body Wt (KW/BW) Ratios

Dietary Supplements								Dietary Supplements							
B	Mg	Al	AA	Wt	LW/BW	SW/BW	KW/BW	B	Mg	Al	AA	Wt	LW/BW	SW/BW	KW/BW
µg/g	µg/g	µg/g	µg/g	g				µg/g	µg/g	µg/g	µg/g	g			
0	100	0	Arg	244	2.97	0.36	0.33	3	100	0	Arg	287	2.80	0.28	0.30
0	100	0	-	239	3.10	0.29	0.35	3	100	0	-	275	2.78	0.32	0.32
0	100	0	Met	233	3.18	0.33	0.37	3	100	0	Met	236	2.98	0.28	0.34
0	100	1000	Arg	242	3.00	0.37	0.33	3	100	1000	Arg	221	3.20	0.36	0.34
0	100	1000	-	232	3.13	0.43	0.33	3	100	1000	-	228	3.26	0.40	0.34
0	100	1000	Met	230	3.19	0.38	0.34	3	100	1000	Met	217	3.01	0.35	0.33
0	400	0	Arg	302	2.95	0.20	0.30	3	400	0	Arg	293	2.78	0.23	0.29
0	400	0	-	288	2.83	0.21	0.31	3	400	0	-	305	2.90	0.22	0.30
0	400	0	Met	295	2.95	0.22	0.30	3	400	0	Met	302	2.78	0.19	0.32
0	400	1000	Arg	253	2.90	0.20	0.31	3	400	1000	Arg	289	2.88	0.25	0.32
0	400	1000	-	283	2.88	0.21	0.30	3	400	1000	-	261	2.80	0.19	0.32
0	400	1000	Met	258	2.82	0.20	0.31	3	400	1000	Met	272	2.72	0.20	0.31

Analysis of Variance - Significant Effects ($P < 0.05$ or lower)

Growth: Boron, Magnesium, Aluminum, Amino Acid, B x Mg x Al, B x Al, B x Mg x Al x AA
LW/BW: Boron, Magnesium, Aluminum, Al x AA, B x Mg x Al, B x Al, Mg x Al, B x Mg x Al x AA
SW/BW: Magnesium, Aluminum, B x Mg, B x Al x AA, B x Mg x AA, Mg x Al
KW/BW: Magnesium, Amino Acid, B x Mg, Al x AA, B x Mg x Al, B x Al

Magnesium deprivation depressed growth and elevated SW/BW, LW/BW and KW/BW ratios. The changes were more marked in boron-deprived than boron-supplemented rats; the differences due to dietary boron were the greatest when methionine status was marginal or possibly deficient (arginine-supplemented). High dietary aluminum depressed growth; the depression was most marked when the diet contained low dietary magnesium and supplemental boron. Apparently, the more marked growth depression caused by magnesium deficiency precluded some of the effect of aluminum on growth of the boron-deprived rats. The findings indicate that the response of rats to high dietary aluminum and magnesium deprivation, as well as the relationship between magnesium and aluminum, is influenced by dietary boron and methionine status. The findings support the hypothesis that boron is an essential element that might be involved in parathormone function in the rat.

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DIETARY BORON AFFECTS MOLYBDENUM AND MAGNESIUM METABOLISM IN THE CHOLECALCIFEROL DEFICIENT CHICK

(93)

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Boron has several characteristics of an essential element, i.e., it is ubiquitous in the earth's crust and sea water, and has a low molecular weight. Also, it is an integral part of at least two naturally occurring biological substances. The low order of toxicity of boron in animals is well documented and homeostatic mechanisms for boron in animals are implied by rapid excretion rates and lack of excessive accumulation. Previous findings from our laboratory indicated that, in the growing chick, interactions occur among dietary B, Mg, Ca, and cholecalciferol (vit. D_3) and that dietary B affects plasma Mo levels. This study was done to confirm and extend those findings.

In a fully crossed, 2x2x2 factorially arranged experiment, day-old cockerel chicks (19 per group) were fed a ground corn-casein-corn oil based diet (1) (containing 0.850 mg B, 0.319 mg Mo, and 125 IU vit. D_3/kg) supplemented with B at 0 or 3; Mo at 0 or 20; and Mg at 300 or 500 mg/kg. Environmental conditions have been described (2). The chicks were fed their respective diets for four weeks, weighed and decapitated. Selected parameters listed in the table were determined by our usual methods (2,3).

Effects of Dietary Boron, Magnesium and Molybdenum and Their Interactions on Selected Parameters

Treatment, mg/g			Body	Brain wt. / Body wt. x 100		Glucose,	Plasma Uric
B	Mg	Mo	Weight, g		Hct, %	mg %	Acid, mg %
0	300	0	418	0.480	31.3	409	7.99
0	500	0	553	0.369	26.2	505	8.25
3	300	0	426	0.449	31.7	380	8.48
3	500	0	491	0.451	29.0	403	6.44
0	300	20	430	0.449	32.6	412	9.59
0	500	20	559	0.371	28.1	379	6.68
3	300	20	482	0.438	30.8	337	6.94
3	500	20	503	0.424	28.1	404	6.45
			Analysis of Variance - P Values				
Mg			0.0002	0.005	0.0001	NS	0.0044
B			NS	NS	NS	0.05	0.02
Mg x B			NS	0.013	NS	NS	NS
Mo			NS	NS	NS	NS	NS
Mg x Mo			NS	NS	NS	NS	NS
B x Mo			NS	NS	NS	NS	NS
Mg x B x Mo			NS	NS	NS	NS	0.009

After four weeks, vit. D_3 deficiency had a debilitating effect on growth and physical appearance. Inadequate dietary magnesium, regardless of dietary boron levels, depressed growth and elevated hemoglobin, hematocrit, plasma uric acid (PUA) and the brain wt/body wt ratio. Boron deprivation elevated serum glucose and PUA levels. This latter PUA effect was most marked in molybdenum-supplemented chicks fed inadequate magnesium and in molybdenum-deprived chicks fed adequate magnesium. Boron deprivation elevated or depressed the brain wt/body wt ratio in chicks fed inadequate or adequate Mg respectively. Only inadequate dietary magnesium significantly affected growth. The findings indicate that physiological levels of dietary boron affect a wide range of physiological parameters, thus supporting the hypothesis that it is an essential element.

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(94) EFFECTS OF DIETARY GUANIDOACETIC ACID ON ARSENIC DEPRIVATION IN CHICKS

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Since 1975 evidence has emerged from two laboratories which shows that arsenic is an essential element for several animal species (1). Signs of arsenic deprivation have been described for the chick, rat, hamster, goat, and minipig. The findings that suggest arsenic is essential do not clearly define its metabolic role. Thus, the mode of action of arsenic is open to conjecture. In microorganisms and animals, methylation of inorganic arsenic apparently is an important step in arsenic metabolism. Possibly the physiologically active form of arsenic is a methylated species or arsenic plays a role in methyl metabolism. Therefore, a study was designed to determine the effect on arsenic deprivation in chicks of methyl depletion, induced by feeding guanidoacetic acid (GAA).

Day-old cockerel chicks were assigned to groups of similar weight in a fully-crossed, three-way, two-by-two-by-two design. The diet (containing about 15 ng arsenic/g) was supplemented with $Na_2HAsO_4 \cdot 7H_2O$ to give either 0 or 2 µg/g As. GAA was supplemented to the diet at levels of 0 or 5 g/kg. Choline was supplemented to the diet at levels of 0.65 or 1.3 g/kg. Dietary zinc was 40 µg/g and Ca was 1.5%. The acid-washed corn, high-protein casein based diet and environmental conditions have been described (2). After 28 days the chicks were weighed and decapitated after cardiac exsanguination with a heparin coated needle and syringe. Several organs were removed and weighed. Microhematocrits and hemoglobins were determined. Plasma creatine and urea were determined using standard procedures (2). Selected findings are summarized below.

Effects of Arsenic, Guanidoacetic Acid, Choline and Their Interaction on Body Weight, Hematocrit, Hemoglobin and Plasma Creatine

Treatment			Body Weight	Hemoglobin	Plasma Creatine	Plasma Urea
As	GAA	Choline				
µg/g	g/kg	g/kg	g	g/100 ml	mg/100 ml	mg/100 ml
0	0	0.65	1007	9.11	0.83	0.29
2	0	0.65	962	9.23	0.74	0.24
0	0	1.30	1027	9.08	0.83	0.40
2	0	1.30	1031	9.28	0.78	0.36
0	5	0.65	612	5.62	5.05	0.76
2	5	0.65	754	6.37	4.28	0.53
0	5	1.30	645	5.27	4.32	0.62
2	5	1.30	765	6.38	3.62	0.45
			Analysis of Variance - P Values			
Arsenic effect			0.010	0.0002	0.012	0.019
GAA effect			0.0001	0.0001	0.0001	0.0001
Choline effect			NS	NS	0.038	NS
As x GAA			0.0004	0.008	0.036	NS
As x Choline			NS	NS	NS	NS
GAA x Choline			NS	NS	0.025	0.027
As x GAA x Choline			NS	NS	NS	NS

Regardless of the choline level, GAA markedly depressed growth, hemoglobin and hematocrit in chicks; arsenic deprivation exacerbated the depression. GAA supplementation elevated plasma creatine and urea; this elevation was enhanced by choline deprivation.

GAA, an intermediate in creatine synthesis, is methylated via S-adenosylmethionine to form creatine and S-adenosylhomocysteine. Thus, feeding GAA can result in depletion of methyl groups. Present findings indicate that arsenic is important physiologically as a methylated compound or is involved in labile methyl metabolism. It is also possible that arsenic has a role related to creatine metabolism.

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(95) THE INFLUENCE OF ZINC DOSE, SOURCE, AND STATUS ON ZINC BIOAVAILABILITY IN RATS

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Information on the bioavailability of nutrients from various foods is needed for determining recommended dietary allowances and improving the nutritional quality of diets. The bioavailability of zinc from a meal may depend upon the dose and source of zinc fed, as well as upon the zinc status of the experimental animal. These relationships were examined in a series of experiments monitoring the whole body retention of an extrinsic ^{65}Zn tracer added to a test meal.

Male Long-Evans rats, about 32 days old, were meal-fed (4 hours daily) a maintenance diet for 20 days, consumed a test meal on day 21, and resumed the same maintenance diet ad libitum for three more weeks. The maintenance diet was formulated according to American Institute of Nutrition guidelines, but with modified zinc content. Test meals contained sucrose, corn starch, corn oil, and ^{65}Zn tracer with the desired dose of zinc added as $ZnCl_2$ or as various foods. Retention of ^{65}Zn in each animal was monitored in a small animal whole body gamma counter at regular intervals for three weeks after the test meal. Absorption was calculated by extrapolating to zero time on a plot of ln percent retention versus time, according to the method of Heth and Hoekstra (1). The slope of this retention plot represents the short-term ^{65}Zn turnover rate.

In rats fed 12 ppm zinc and test doses of 6 to 275 µg zinc, absorption decreased from 80 to 50%, and the average amount absorbed increased quadratically ($r^2 = 0.998$), but turnover was unaffected. In rats fed 12.2, 14.6, 17.4, 26.4, or 151.3 ppm zinc and a test dose of 14 µg zinc, the average absorption decreased from 87 to 46%, and the average retention slope decreased quadratically ($r^2 = 0.990$) from -0.008 to -0.021, indicating increased turnover.

In two experiments using maintenance diets of 12 or 38 ppm zinc, rats were given doses of 16 or 98 µg zinc using $ZnCl_2$ or various foods. The results are shown in Table 1.

Table 1. Percent zinc absorption from several zinc sources, as affected by maintenance diet and test meal zinc dose.

	12 ppm Zinc Experiment		38 ppm Zinc Experiment	
Zn Source	16 µg Zn dose	98 µg Zn dose	16 µg Zn dose	98 µg Zn dose
$ZnCl_2$	88	70	57	51
Chicken	88	84*	73*	67*
Milk with lactase	--	--	75*	65*
Milk	87	85*	72*	57
Peanut butter	87	83*	72*	57
Oysters	85	61	65	49
Navy Beans	68*	56*	51	45
Soy flour	69*	54*	--	--
Root MSE	7.29		7.63	

*Indicates absorption was significantly different, $p<0.05$, from $ZnCl_2$ under same conditions

Absorption of zinc from chicken, milk, or peanut butter was higher than that from $ZnCl_2$, except in rats with the lower zinc dose and status. Perhaps rats maintained on 12 ppm zinc diets absorbed the lower dose of $ZnCl_2$ so efficiently that further enhancement of absorption was not possible. Reduced absorption of zinc from navy beans was more evident at the lower zinc status. Traditional methods of determining the bioavailability of zinc measure growth response to foods supplying growth-limiting amounts of zinc in an otherwise adequate diet. Such methods may not detect factors in foods which enhance zinc absorption, since the conditions are similar to the lower dose and lower zinc status in the above experiments.

In conclusion, absorption of zinc depends on the zinc dose, source, and status of the experimental animal. Body turnover of a zinc tracer is affected by the zinc content of the maintenance diet, but not by the zinc dose or source in the labeled meal. Relative zinc absorption between foods varies with the experimental conditions.

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(96) AVAILABILITY OF SOYBEAN HULL ZINC TO RATS

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Dintzis, Watson and Sandstead (1) studied the mineral content of brans passed through the human gastrointestinal (GI) tract and found that the zinc content of soy hulls was greater after the soy hulls had passed through the GI tract than before they were ingested; apparently soy hulls acquired zinc in passage. Therefore, they speculated that zinc availability from soy hulls may be low.

Eighteen male, weanling, Long-Evans rats were randomly assigned to 3 groups and, in a meal training scheme, fed for 20 days a standard American Institute of Nutrition diet containing 38 parts per million zinc. Then each rat was fed a labeled meal containing a trace amount of Zn-65; 1 μCi in extrinsically labeled soy hulls (Zn-65 added to the soy hulls during diet preparation), 0.05 μCi in intrinsically labeled soy hulls (Zn-65 injected into soybean plants during growth), or 1 μCi $ZnCl_2$. Each labeled meal contained 0.45g corn starch, 1.5g sucrose and 0.15g corn oil. The labeled soy hull meals each contained 0.4g soybean hulls providing 16 μg zinc according to measurements with unlabeled soy hulls. Zinc content was the same for the $ZnCl_2$ meals. After an over-night fast the rats were fed the test meals and the ingested Zn-65 activity of each rat was determined using a small animal whole body counter. After an initial whole body count each rat was returned to its pre-test meal diet and its retained Zn-65 activity was measured again on day 5 and twice weekly up to 23 days. Plots of the natural logarithm of retained activity versus time were linear for rats fed the extrinsically labeled diets but apparently were bi-phasic for rats fed the intrinsically labeled soy hulls. The mean absorption values from the extrinsically labeled soy hull and $ZnCl_2$ meals and the intrinsically labeled soy hulls are shown in Table I.

Table I

Retention and Absorption of Zn-65 in Rats Fed Intrinsically and Extrinsically Labeled Soy Bean Hulls and ZnCl

Group	Slope of ln of Retention vs Time (1/day)	Absorption (%)
Extrinsic hulls (Q)	-0.025 ± 0.003	64 ± 05
Intrinsic hulls (R)	-0.022 ± 0.003	30 ± 04
Zinc chloride (S)	-0.026 ± 0.003	61 ± 04

Using an one way analysis of variance, it was found that the slope for the R group was different from those of the Q and S groups ($p<0.04$), and that the absorption for the R group was different from those of the Q and the S groups ($p<0.0001$).

The observed differences in retention/absorption as determined by the method of Lukaski, et al. (2), may have been due to differences between soy hulls used in the extrinsic and intrinsic labeling because they were grown under different conditions at different locations, and thus may have had different zinc binding characteristics or concentrations. The intrinsically labeled soybean plants were grown in individual pots in a green house and, when the pods were filling, were labeled twice, with a one week interval between labelings, by stem injection of 9 μCi Zn-65 in 25 μl of $^{65}ZnCl_2$. After labeling there was an extended period of overcast days and, although grow lamps were used, it was 61 days before the beans could be harvested. The quality of the beans appeared to be poor, relative to those used for the extrinsic label, when plumpness and bean size were used as criteria.

These results suggest that soybean hulls may inhibit zinc absorption in rats.

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(97) ASSESSMENT OF MONTHLY, WEEKLY, AND DAILY VARIABILITY OF MINERAL INDICES OF WOMEN FED CONSTANT OR SELF SELECTED DIETS

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The variability of indices related to trace metal nutriture was assessed at monthly, weekly, and daily intervals in free-living and institutionalized women age 23-44 years. Five women resided in a metabolic ward and ate a typically mixed western diet served in 3 day cycles. There were no constraints as to diet, exercise, or medication on the free living women. During the study, the weight of women fed a constant diet varied less than ±2%, whereas the free-living women had a maximum ±4.6% weight change. Sixty mls of blood were drawn from an anticubal vein of fasting subjects after a 10 minute rest. All test and control samples were run in duplicate. The study of women fed a constant diet was terminated before the 5 daily draws because of undesirable depressions in iron indices. The diet contained 14.5 to 17.2 mg of iron which, with the continued blood loss, was not sufficient to maintain optimal iron status.

Table 1. Biological and Analytical Variation of Mineral Indices in Women

SAMPLE	TESTCV[a]	CTRLCV[b]	CVID[c]	CVP[d]	%ERROR REDUCED
		MONTHLY			
Zinc (CD)[e]	7.3	4.5	6.5	4.7	35.6
(FL)[f]	9.8	4.7	9.6	7.9	19.4
Iron (CD)	26.8	2.6	26.4	26.1	2.6
(FL)	43.0	3.0	42.9	42.7	0.7
Calcium (CD)	6.3	3.0	5.7	4.9	2.6
(FL)	5.9	3.0	5.5	4.7	20.3
Magnesium (CD)	8.7	7.6	8.4	7.3	16.1
(FL)	7.9	6.6	6.3	5.6	29.1
Transferrin (CD)	14.1	7.2	13.0	10.6	24.8
(FL)	14.8	10.1	13.5	10.6	28.4
		WEEKLY			
Zinc (CD)	6.0	3.5	5.2	5.3	13.1
(FL)	8.4	2.7	7.9	8.3	1.1
Iron (CD)	19.5	2.9	19.1	18.4	5.6
(FL)	34.0	2.7	33.9	33.6	1.2
Calcium (CD)	6.8	3.0	5.8	5.0	26.5
(FL)	9.0	2.9	8.1	8.5	5.6
Magnesium (CD)	6.3	4.8	4.6	4.5	28.6
(FL)	6.1	4.7	4.5	4.5	26.2
Transferrin (CD)	15.4	4.7	14.3	13.6	11.7
(FL)	14.7	2.5	14.0	13.3	9.5
		DAILY			
Zinc (FL)	4.8	0.0	4.3	4.3	10.4
Iron (FL)	43.6	2.0	43.4	41.0	0.7
Calcium (FL)	3.4	0.9	3.0	2.9	14.7
Magnesium (FL)	5.6	2.0	2.0	4.7	16.0
Transferrin (FL)	10.8	0.0	10.6	10.6	1.9

[a]TESTCV = uncorrected coefficient of variation of test samples; [b]CTRLCV = uncorrected coefficient of variation of control values; [c]CVID = intraindividual coefficient of variation corrected for duplicate samples; [d]CVP = intraindividual (personal) coefficient of variation corrected for long term analytical variation; [e]CD = control diet subjects (5 completed monthly and weekly draws); [f]FL = free living subjects (8 completed monthly & weekly draws; 5 completed daily draws)

We correlated the mean sample value with the mean control value of each run to ascertain whether control values can be used to assess long term variability. If the correlation coefficient was not marginally significant ($p < 0.25$), then it seemed inappropriate to use the control to assess long term variability (1). This occurred with retinol binding protein, ceruloplasmin, and copper. We could remove variability inherent to duplicate samples, but were unable to assess long term variability. In some instances the CVID is smaller than the CVP. It would seem that this could not be possible because any subtraction of an error estimate should reduce each succeeding number; however, some negative error estimates were obtained. This could occur when an individual's biological control is tighter than the analytical control. Reductions ranging from 0.7% to 35.6% in the variance estimates were observed upon subtracting the analytical variance. If laboratory results obtained periodically from a subject are to be compared over a protracted period, evaluation of long term reproducibility and accuracy of test procedures becomes very important.

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(98) RADIOISOTOPE DILUTION METHOD FOR THE DETERMINATION OF TRUE CU ABSORPTION IN THE RAT

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Several experiments were conducted to determine the effects of different carbohydrates, especially fructose (FR), on Cu absorption in rats. Reiser et al. (1) has found that rats fed FR become Cu deficient faster than rats fed sucrose (SU) or cornstarch (CS). We wished to determine whether this was a consequence of decreased availability of the Cu, or accelerated biological turnover of absorbed Cu, in rats on a FR diet.

The isotope dilution method of Wiegand and Kirchgessner (2), which accounts for endogenous excretion (EE), was adapted for use with Cu. Rats were injected with ^{67}Cu and balance (B) was measured for several days. Feces were analyzed for total Cu (F) and ^{67}Cu activity, and specific radioactivity (Sf) was calculated. At the end of B, rats were killed and specific activities of tissues (Sm) were found. Total Cu intake (i) was also measured and true absorption (A) of Cu from the diet was calculated using the formula at right. The third term in the numerator corrects for the turnover and excretion of absorbed Cu.

$$A = \frac{i - f + (f \cdot \frac{Sf}{Sm})}{i}$$

A preliminary experiment was conducted to determine the time after injection that ^{67}Cu is equilibrated. Twenty five male, Long Evans rats about 5 weeks old were injected intramuscularly with ^{67}Cu. Five rats were killed at 4, 6, 8, 11 and 14 days postinjection and specific activity of ^{67}Cu in each of 8 tissues (heart, kidneys, pancreas, spleen, liver, leg muscle, small intestine, and whole blood) was determined. At 8 days postinjection ^{67}Cu was most evenly distributed between these tissues, suggesting that balance in subsequent experiments should be over this time.

Two similar experiments utilizing diets containing 0.5 or 4.0 ppm Cu were conducted. In each experiment, 24 male Long Evans weanling rats were divided into 4 groups by weight and fed a diet containing a single carbohydrate source (SU, Glucose (GL), FR, or CS). After approximately 2 weeks, rats were injected with ^{67}Cu and balance measured days 6 thorough 8 postinjection. Animals were then killed and specific activities of kidneys and liver were calculated, with Sm being the average. A, EE, and B were calculated for each animal. Means and standard deviations for each group are given in Table 1.

Table 1. Absorption, Endogenous Excretion and Balance Values

Dietary carbohydrate	Cu Level mg/kg diet	A %	EE µg Cu/d	B µg Cu/d
Cornstarch	5.0	39 ± 7	21 ± 4	20 ± 7
Sucrose	5.0	22 ± 8	8 ± 5	10 ± 9
Fructose	5.0	19 ± 5	5 ± 2	11 ± 5
Glucose	5.0	7 ± 3	7 ± 2	-2 ± 4
Cornstarch	0.4	32 ± 10	1.3 ± 0.3	0.58 ± 0.49
Sucrose	0.4	19 ± 23	1.1 ± 0.4	-0.14 ± 1.84
Fructose	0.4	20 ± 16	1.1 ± 0.3	-0.22 ± 0.82
Glucose	0.4	28 ± 13	1.0 ± 0.1	0.44 ± 0.83

In rats fed the 5 ppm Cu diet, A, EE and B were greatest for CS animals. There were no significant ($p>.05$) differences in A, EE or B between FR and SU rats. B and A were lower for GL rats, but EE was the same as FR and SU rats. In rats fed diets containing 0.4 ppm Cu, there were no significant differences in A, EE or B between any of the groups. Apparently, the accelerated appearance of Cu deficiency in rats fed fructose is not the result of alterations in Cu absorption or endogenous excretion.

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(113) CONDENSED MATTER EQUATIONS-OF-STATE FROM FIRST PRINCIPLES

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A long-standing problem in physical science is that of determining the macroscopic properties of a given many-particle system from its microscopic characteristics. In other words, given the interactions at the atomic level, what is the system behavior on the bulk, or laboratory, scale?

We address two general classes of physical systems: a) a classical (i.e., room temperature) monatomic substance and b) a quantum (e.g., zero absolute temperature) substance.

Within the former class we limit ourselves to seek a basic understanding of the problem of sphere packings. This has important applications not only in physics, but also in chemistry, biology, metallurgy, ceramics, soil science, as well as many branches of engineering. We are concerned with the well-defined value of the density at which equal rigid spheres will close pack in a random way. Empirically this is, in units of maximum (regular) closest packing, about 86% for three[1]- and 90% for two[2]-dimensions, i.e., for spheres and disks, respectively. We study both phenomena in terms of microscopic many-body theory, namely classical statistical mechanics. The random close packing configuration can be considered the ultimate density of the amorphous solid phase of the system, just as the regular close packing configuration represents the ultimate density of the crystalline solid phase.

Many-body theory for quantum systems also leads to so-called low-density expansions (where the problem is in principle apparently exactly soluble). Mathematical extrapolations under the name of Pade approximants[3] serve to extend the results to finite, i.e., non-zero, densities where real matter actually occurs. The problem is thus reduced to a systematic approximation scheme whereby one solves first the case of purely repulsive particles and then adds in the mutual attractions as pertubrations to any order. Algebraic manipulation computer schemes, like e.g., MACSYMA, turn out to be extremely convenient for such calculations.

Usual perturbation treatments in many-body science are based on the ideal gas system of the real substance as the unperturbed state. Our expansions lead rather to the perturbation scheme whereby the unperturbed state is the imperfect gas of purely repulsive particles, a state of considerably greater physical richness than the ideal gas state. The resulting scheme we call van der Waals perturbation theory since he suggested it more than a hundred years ago. However, it was not formulated in detail until very recently[4] when it has been applied to classical fluids, including liquids. The scheme has come to be taken as the most successful theory of the classical liquid state, inspite if its having been implemented only through 2nd order, and then with serious attendant technical deficiencies. The quantum van der Waals scheme we are applying is free of these limitations and can moreover be carried out to any order without undue effort.

To cite but a few examples of results we mention that the random close packing for bosons discovered by our techniques is about 35% of the regular (closest) packing value for hard spheres. For two-species fermions it is 17.3% while for four-species fermions it is 17.4%. These results are entirely within physical expectations based on quantum diffraction as well as statistics effects not present in the classical case.

Knowledge thus gained of various many-body system equations-of-state can therefore be obtained reliably. As a single example of their usefulness, knowledge of the nuclear matter equation of state is of critical importance for understanding portions of the universe remote in space and time, such as the "big bang", supernova explosions and the interior of neutron stars.

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(114) MATRIX ISOLATION VERSUS THE LIGHT PIPE AS AN INTERFACE FOR GAS CHROMATOGRAPHY/ FOURIER TRANSFORM INFRARED SPECTROMETRY

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The application of infrared spectroscopic techniques to the identification of material eluted from a gas chromatographic column has become a powerful tool for the analytical chemist (1, 2). In this investigation, we have compared two gas chromatography/Fourier transform infrared spectrometry (GC/IR) interfaces, the light pipe and matrix isolation, by obtaining comparable infrared spectra on both.

Absorption spectra of matrix-isolated materials were measured on a gas chromatography/matrix isolation/infrared spectrometry (GC/MI/IR) system developed at Argonne National Laboratory (3-5). The system is comprised of a Nicolet Model 6000 infrared spectrometer interfaced with a Perkin-Elmer Model Sigma 2000 gas chromatograph. In this technique, the effluent from a capillary gas chromatographic column flows through a splitter. The splitter divides the effluent sending 10% of the flow through a flame ionization detector. The rest travels through a heated, fused-silica, capillary transfer line into the matrix-isolation unit. The effluent is sprayed onto a gold-plated carousel which is housed in a vacuum chamber (1×10^{-6} torr). During deposition, this chamber is cooled to 12K with a closed-cycle helium refrigerator.

The gas chromatograph carrier gas is helium containing 2.0% argon. The matrix is collected on the gold-plated, mirrored surface as the carousel is slowly rotated by a computer-controlled stepping motor. This technique yields a frozen strip of argon that contains all the sample components eluted from the gas chromatograph. Every eluted sample molecule is completely surrounded by condensed argon atoms. The IR spectrum of each component is then measured by rotating the cold mirror and positioning the desired portion of the argon matrix at the focus of the IR beam. The solid argon matrix is stable for hours. Four wavenumber resolution and a liquid-nitrogen-cooled mercury-cadmium-tellurium IR detector were used to collect the IR spectra.

On the other hand, GC/IR by the light-pipe technique requires the effluent from the GC column to travel through a gold-plated tube called the light pipe (6, 7). The light pipe used in this study has an internal diameter of 1.5 mm and a length of 10 cm. All the effluent from the GC travels through the light pipe, which is heated, to a flame ionization detector. The IR spectra are obtained "on the fly" as the sample travels the length of the light pipe. The higher temperatures required for less volatile compounds reduce the sensitivity of this method by creating high background noise in the IR spectra. The GC/IR using the light-pipe technique involved a Nicolet 60SX system interfaced with a Hewlett-Packard 3880 gas chromatograph.

By injecting decreasing amounts of various compounds, including isobutyl methacrylate, into both instruments, the detection limits of the two techniques were compared. In our experience, the limit of detection for most compounds is about 1 ng with the matrix-isolation technique. On the other hand, the limit of detection for the light-pipe method is about 20 ng for compounds that are good IR absorbers and fairly volatile. However, with poor absorbers and less volatile components, the limit of detection is 500 ng or higher.

One microliter of a standard mixture containing seven components, with about 500 ng each, was injected into both instruments. As estimated from the absorbencies of the IR spectra obtained from the two methods, the matrix-isolation interface is about two orders of magnitude more sensitive than the light-pipe interface. In addition the increased detail and sharpness of the absorption bands with the matrix-isolation technique are impressive, particularly in the fingerprint region.

The light-pipe interface excels in three categories: (1) The light-pipe interface provides real-time data as opposed to postrun data for the matrix-isolation interface. (2) The light-pipe interface can be used to identify nontarget components; the light-pipe spectra are standard vapor-phase spectra for which several suppliers provide extensive libraries. This is not the case for matrix-isolation spectra, which are similar to vapor-phase spectra but are not identical. There is currently no commercially available library of matrix-isolation spectra. This limits matrix isolation to target compounds for which standards are available. (3) The cost of the light-pipe is much less than that of a matrix-isolation interface. The light-pipe interface is also easier to operate and can be run by a skilled technician. The matrix-isolation interface requires fairly sophisticated training to maintain and operate.

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(115) IRON SULFIDE STOICHIOMETRY AND THE HYDROCRACKING CATALYSIS OF DIPHENYL ETHER AND DIPHENYLMETHANE

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The effects of iron sulfide catalysts on coal liquefaction processes are of interest since iron sulfides are inexpensive and are endogenous to coals. The predominant form of iron sulfide in coals is pyrite (FeS_2); however, this form is not thought to catalyze coal liquefaction processes since it rapidly decomposes to pyrrhotite at high temperatures and in the presence of H_2.

In order to determine the activities of various iron sulfide catalysts towards coal conversion processes, the conversion rates of the model coal compounds, diphenyl ether (DPE) and diphenylmethane (DPM), were determined and compared to the form of iron sulfide present during the reaction. The experiments were performed in batch autoclaves, and pyrrhotite was the catalyst charged in all cases. The factor varied was the partial pressure of H_2S and H_2 constituted the remainder of the atmosphere. The iron sulfide stoichiometry present in the reactor depends on the concentrations of H_2 and H_2S employed (eq. 1 and 2).

$$Fe_{1-x}S + H_2 \rightleftarrows 1\text{-}xFe + H_2S \qquad [1]$$

$$Fe_{1-x}S + H_2S \rightleftarrows 1\text{-}xFeS_2 + H_2 \qquad [2]$$

Earlier studies (1-3) correlated conversions of the model compounds, diphenyl ether and diphenylmethane, with catalyst compositions. To obtain a more accurate measurement of the iron sulfide's activity, the rates of side reactions occurring under the employed conditions must be incorporated into the rate equations. The observed rate of reaction in the presence of the added catalyst, k'_{obs}, is a function of the uncatalyzed rate, k'_1, and the catalyzed one, k'_2, (eq. 3-5).

$$DPE, DPM + H_2 + H_2S \xrightarrow{k_1} \text{products} \qquad [3]$$

$$DPE, DPM + H_2 + H_2S \xrightarrow[Fe_{1-x}S]{k_2} \text{products} \qquad [4]$$

$$k_2' = k'_{obs} - k_1' \qquad [5]$$

The results of this study are shown in Tables 1 and 2. These data show that the activity of the iron sulfide catalyst, k_2', increases with increasing hydrogen sulfide pressures for both model coal compounds. When the partial pressure of H_2S is increased beyond 5%, the activity of the iron sulfide catalyst increases only minimally. Mössbauer analysis of the equilibrated iron sulfide under the given conditions shows that reduced forms of the iron sulfide (FeS) correlate with low conversions. Pyrrhotite ($Fe_{1-x}S$) is present when the conversion rates are maximum. The presence of pyrite (FeS_2) does not dramatically change the activity of the catalyst.

Table 1. Pseudo-first order rate constants for the reaction of DPE in the presence of added pyrrhotite.[a]

P_{H_2S} %	$k_2' \times 10^6$ (sec^{-1})	Recovered catalyst, Mössbauer analysis (2)
0	2	FeS, $Fe_{1-x}S$, Fe_3O_4
1.0	14	$Fe_{1-x}S$
4.9	30	$Fe_{1-x}S$
9.9	35	$Fe_{1-x}S$, FeS_2

[a]Temperature 450°C, total pressure 1485 psi.

Table 2. Pseudo-first order rate constants for the hydrocracking of DPM in the presence of added pyrrhotite.[a]

P_{H_2S} %	$k_2' \times 10^6$ (sec^{-1})	Recovered catalyst, Mössbauer analysis (2)
0	120	Dominant:FeS phase
2.8	230	Dominant:FeS phase
5.5	390	$Fe_{1-x}S$
9.6	390	-
13.3	380	$Fe_{1-x}S$, FeS_2

[a]Temperature 450°C, H_2 pressure 1800 psi.

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(116) FRIEDEL-CRAFTS POLYMERIZATIONS OF FLUORENE AND BIPHENYL

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For the past few years, we have been interested in developing efficient, one-pot syntheses of novel polymers which are comprised of homocyclic and heterocyclic aromatic nuclei linked by methylene groups (polybenzyls). Previous reports from our laboratory have been chiefly concerned with insoluble materials obtained from facile reaction of dibenzofuran (1), fluorene (2) and carbazole (3) with various chloromethylating agents in the presence of aluminum chloride. Herein we report preliminary results from experiments directed towards the preparation of soluble, linear polybenzyls from fluorene and biphenyl.

In Table 1 are shown the reaction conditions and results for these experiments. The strength of the Lewis acid has a profound effect on the outcome of the reactions. With aluminum chloride as the Lewis acid, biphenyl is converted to a mixture of insoluble, crosslinked material and soluble low molecular weight oligomers (entry 5). Under similar conditions, the weaker Lewis acid stannic chloride was not able to effect a reaction (entry 6). Even with the more reactive alkylating agent, methoxyacetyl chloride (MAC), the majority of product was recovered starting material (entries 7 and 8). The effect of Lewis acid strength was also observed for fluorene (cf. entries 1 and 3). Unlike with biphenyl, however, stannic chloride was a sufficiently strong Lewis acid to promote alkylation with the more reactive MAC (entry 4). This points out an inherent difference in the reactivity of the two substrates. The latter reaction employed a stoichiometry designed to yield insoluble, crosslinked polymer, specifically to determine whether such a reaction would occur.

Interestingly, a good yield of soluble polymeric or oligomeric material for fluorene was obtained not from a traditional Friedel-Crafts type reaction, but from an acid-catalyzed formaldehyde condensation (entry 2). This reaction is known to give product which contains not only the desired methylene bridges but also dimethylene ether bridges. Thus, we are not vigorously pursuing an investigation of this reaction.

Further work remains to be completed. In the future, we wish to examine more fully the effects of stoichiometry, particularly for the fluorene/stannic chloride/MAC reaction, solvent and reaction temperature.

Table 1. Polymerization Conditions and Results

Entry No.	Substrate (mol ratio)	Lewis Acid (mol ratio)	Alkylating Agent (mol ratio)	Time (h)	Results
1	Fluorene (1)	$AlCl_3$ (1)	CH_2Cl_2 (excess)	2	99% insoluble, infusible powder; 1% soluble low MW oligomers.[a]
2	Fluorene (1)	H_2SO_4 (cat)	CH_2O (1)	2	65% insoluble, infusible powder; 35% soluble low MW oligomers.
3	Fluorene (1)	$SnCl_4$ (1)	CH_2Cl_2 (excess)	4	No reaction.
4	Fluorene (1)	$SnCl_4$ (1)	MAC[b] (2)	4	95.7% insoluble, infusible powder; 4.3% soluble low MW oligomer.
5	Biphenyl (1)	$AlCl_3$ (1)	CH_2Cl_2 (excess)	2	43% insoluble, infusible powder; 57% soluble low MW oligomers.
6	Biphenyl (1)	$SnCl_4$ (1)	CH_2Cl_2 (excess)	2	No reaction.
7	Biphenyl (1)	$SnCl_4$ (1)	MAC (1)	2	96% biphenyl, 4% soluble dimer.
8	Biphenyl (1)	$SnCl_4$ (1)	MAC (1)	19	73% biphenyl, 27% soluble dimer.

[a] MW = molecular weight as determined by gel permeation chromatography (GPC)
[b] MAC = methoxyacetyl chloride

We wish to acknowledge the capable assistance of J.K. Argasinski in providing the GPC MW analyses.

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(117) ESR SPECTRA OF COAL RADICALS GENERATED BY PYROLYSIS IN INORGANIC AND ORGANIC SOLVENTS

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In order to understand the pyrolytic generation of radicals during liquefaction of coals, the technique of electron spin resonance was used. This technique allows the measurement of total electron spin density within the solid samples. For this study, the spin density, signal form (line width) and signal position (g-value) was measured as a function of the media contents: H_2S, H_2, CO, H_2O and 9,10-dihydrophenanthrene. The reactions were performed with ZAP lignite with the temperature programmed 300-500°C over the period of 1 hr in batch autoclaves. The line shape, concentration of unpaired electrons, linewidth and g values were all found to vary with the reducing gas (Table 1). The other experimental conditions are listed in the Table 1. The reaction mixtures were vented of gases at 500°C. Both positive and negative signals were observed when the coal has reacted with H_2S (Figure 1). The positive signal is attributed to a combination of coal-derived and organo-sulfur radicals. The negative signal is attributed to protonated disulfide radical anions. These spectra are compared to the ESR spectra of the pyrolysis product formed from ZAP lignite with 9,10-dihydrophenathrene.

In H_2S-H_2 or H_2S-CO atmospheres significant differences occur in ESR spectra of ZAP lignite. The line shape varies and is characterized by the disappearance of the negative signal and the appearance of a narrow peak with a short width of line ~ 1 G and a broad one. The sharp component is postulated to be some fusinite materials (1) or tars (2). At this resolution, the appearance narrow linewidth and simultaneously lower value of g = 2.0010 suggests the occurrence of a fusinition process (3). The spin concentration in H_2S-CO atmosphere is lower than in H_2S-H_2 or H_2S. Therefore, CO decreases the probability of the carbon sulfur bonds formation.

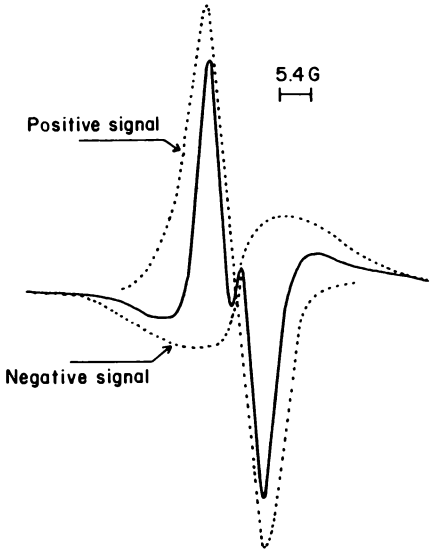

Figure 2. ESR spectrum of ZAP lignite after reaction with H_2S.

Table 1. ESR Spectral Data and Distillate Conversion Results for ZAP Lignite.

Pressure of gases (MPa)	g-Value	Linewidth (G)	Spin density x 10^{19} spins g^{-1}	Distillate conversion, %
Pyrolysis	2.0011	6.8	20.2 ± 1.9	NA
H_2S = 17.5	2.0035	two signals (+,-)	45.0 ± 3.5	20.0
H_2S = 17.5; H_2, CO = 34.4	2.0012	two signals (+,+)	6.2 ± 2.0	47.8
CO = 70; H_2O = 0.8 g	2.0016	4.4	3.2 ± 0.2	60.9
CO = 70; H_2O = 0.8 g; H_2S = 17.5	2.0018	2.2	2.2 ± 0.4	78.1

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SOURCES OF SULFATE IN WET DEPOSITION, NORTH UNIT OF THEODORE ROOSEVELT NATIONAL PARK, NORTH DAKOTA (118)

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From June through December 1985, a wet-deposition collector was operated adjacent to the National Atmospheric Deposition Program site in the North Unit of Theodore Roosevelt National Park in western North Dakota. Sampled rainfall and snowfall from wet-deposition events exceeding 0.5 inch were analyzed for isotopic ratios of oxygen and sulfur and for selected trace-element concentrations to determine general sources of atmospheric sulfate that might affect the Park's natural habitat.

Sulfate present in wet deposition may be derived from a variety of natural and anthropogenic sources. The principal natural sources of sulfur compounds to the atmosphere are oxidation of sulfur-bearing biological materials, microbial sulfate reduction, and volcanic exhalations. The principal anthropogenic source is combustion of fossil fuels.

The isotopic composition of natural sources of sulfate to the atmosphere varies widely but generally is enriched in sulfur-32 relative to the Canyon Diablo meteoritic triolite standard. Most terrestrial plant material is characterized by sulfur isotopic ratios of +4 to +8 per mil. Unless microbially mediated, sulfur gases produced by the decomposition of organic matter are slightly lighter than the parent matter; however, microbial action can produce gases 11 to 46 per mil more enriched in sulfur-32. Because production of sulfur gases from organic matter effectively stops during periods of snow cover, differences in sulfur isotopic ratio between summer and winter months may be used to estimate biogenic sulfate contributions to the atmosphere. At Theodore Roosevelt National Park, a maximum difference of 3.2 per mil was observed between sulfur isotopic ratios of summer and winter wet-deposition events -- a fractionation corresponding to between 7 and 29 percent biogenically contributed sulfate, depending upon the fractionation factor assumed. Biogenic sulfate contributions from the prairie-pothole region of central North Dakota were reported to be approximately 3 percent greater (1).

In contrast, at the temperature of volcanic activity, sulfur isotopic fractionations are minimal and the sulfur isotopic ratios of emitted sulfur gases are similar to those of parent magma, approximately 0 per mil. Because the volcanic contribution to sulfate in wet deposition cannot be determined isotopically, trace-element indicators were used as indexes. Lutetium is present in North Dakota lignites in concentrations less than 50 micrograms per kilogram, and approximately 98 percent is retained in ash following combustion (2). Lutetium has not been detected in Williston basin oil or gas. However, lutetium is present in volcanic emissions in concentrations ranging from 10 to 50 micrograms per gram and in regional soils at concentrations averaging 430 micrograms per gram. Aluminum is a relatively conservative indicator of soil contributions to atmospheric chemistry. Lutetium-aluminum ratios in wet deposition were greater than those of average soil by less than 1 percent, indicating volcanic contributions of sulfate probably also were insignificant.

If the natural sources account for only 7 to 29 percent of the sulfate, anthropogenic sources must account for the remaining 93 to 71 percent. Sulfur gases produced by the combustion of Williston basin oil and gas have an isotopic ratio of +18 to +32 per mil, and those produced by combustion of North Dakota lignite of +6 to +20 per mil. Because of the large range in the sulfur isotopic ratio of natural sulfate contributions, mass-balance calculations using sulfur isotope data are not sufficient to independently estimate the relative contributions of these two anthropogenic sources.

The relative amounts of primary sulfates (formed before emission to the atmosphere) and secondary sulfates (formed by conversion from other sulfur compounds in the atmosphere) in wet deposition indicate the relative importance of local versus distant sources of sulfate. Because atmospheric conversion of sulfur compounds to sulfate occurs gradually, the relative concentration of secondary sulfate increases with distance from the principal sulfate source. Oxygen isotopic ratios may be used to determine the relative importance of local versus distant sources, because the oxygen isotopic ratio of primary sulfate is 18 to 44 per mil more enriched in oxygen-18 than secondary sulfate (3). Sulfate in wet deposition at the park was characterized by oxygen isotopic ratios ranging from +10 to +16 per mil, consistent with primary sulfate contributions of 24 to 29 percent. Assuming local natural contributions are relatively uniform over central North America, approximately 31 to 58 percent of the sulfate in wet deposition at the Park was derived locally.

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(119) BORON IN NORTH DAKOTA RIVERS USED FOR IRRIGATION

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Chemical determinations on more than 9000 water samples from 83 rivers analyzed by the U. S. Geological Survey between 1949 and 1982 were used to establish the patterns of salt accumulation in North Dakota rivers. The concentrations of the principal anions and cations, and SAR values were related to total salinity (EC, dS m^{-1}) for each river. Based on these relationships, eight groups of river waters were established (Maianu, 1985). They are distributed according to the map in Fig. 1. This paper presents the probable impact that the boron content of the rivers in the eight groups may have on soils and crops if the water is used for irrigation.

From the total of 9000 water samples, 7244 were analyzed for dissolved boron. The distribution of samples by groups and their minimum, maximum and average contents as well as the frequency of the samples in different classes of boron concentration are presented in Table 1. Only those classes of boron content were selected which represent a significant hazard of boron accumulation in soils (Branson et al., 1960) and for tolerance of crops (Wilcox, 1960) that are common to North Dakota. These classes are: (1) B < 0.75 mg/L can be used continuously on all soils and with all crops in North Dakota; (2) B = 0.75-2 mg/L can be used continuously on sandy and loamy soils with semi-tolerant crops; (3) B = 2-4 mg/L can be used continuously on sandy and loamy soils with tolerant crops; (4) B = 4-10 mg/L can be used up to 20 years on fine-textured soils with very tolerant crops; and (5) B > 10 mg/L cannot be used for any soil or crop.

The average value of all water samples in North Dakota rivers is well below the limit of boron that would preclude their use for irrigation from the point of view of boron accumulation in soil and plant tolerance. As for the average values by groups, only the waters in group 1 (1.05 mg/L) have potential problems.

Table 1. Content and frequency of dissolved boron in the rivers. by groups.

Groups of Rivers	Total No. of Samples	Boron Content (mg/L)			Boron frequency by classes				
		Min.	Max.	Ave.	<0.75 mg/L	0.75-2 mg/L	2-4 mg/L	4-10 mg/L	>10 mg/L
1	29	0.04	14.0	1.05	22	6	0	0	1
2	79	0	1.1	0.21	78	1	0	0	0
3	1748	0	20.0	0.22	1725	20	1	1	1
4	990	0	3.3	0.28	973	14	3	0	0
5	915	0	2.1	0.13	816	99	0	0	0
6	945	0	0.8	0.32	942	3	0	0	0
7	1555	0	1.7	0.70	1471	84	0	0	0
8	983	0	6.6	0.02	706	250	22	5	0
1-8	7244	0	20.0	0.309	6733	477	26	6	2

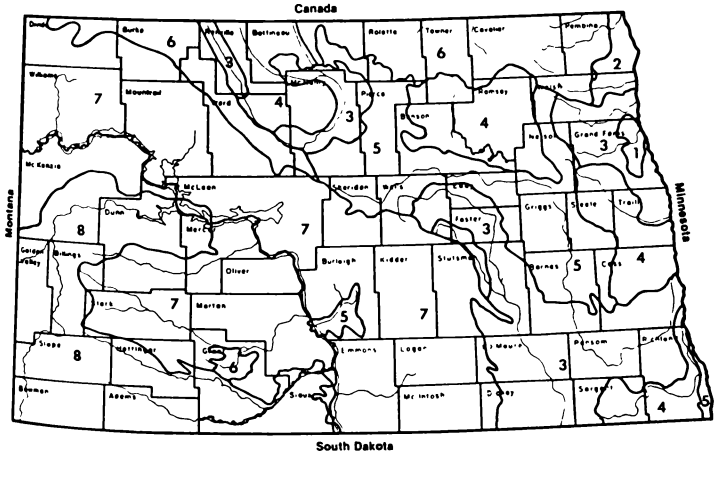

Fig. 1. Groups of rivers according to their chemical composition.

Boron concentrations of individual river waters have maximum values that exceed tolerable limits. This is true mainly of the waters in groups 1, 3 and 8 (Table 1). In group 1, only one of 29 samples is in the class which imposes restriction on both soils and crops. In group 3, 20 out of 1748 samples have limited restrictions, and 3 samples are in the 3 classes with the highest restrictions. As for group 8, about 25% of the samples (250) have limited restrictions, 2% (22 samples) have medium restrictions and 0.5% (5 samples) have serious restrictions. Finally, about 10% of the waters in groups 5 and 7 may impose limited restrictions on semi-tolerant crops and fine textured soils.

Rivers that have boron concentrations greater than 4 mg/L include: Turtle (group 1), Sheyenne (group 2) and Buffalo Creek (group 8).

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(120) THE MODIFICATION OF ERIOCHROME CYANINE R METHOD IN DETERMINATION OF ALUMINUM

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Standard Methods[1] recommends Eriochrome Cyanine R Colorimetry method for aluminum determination. The Eriochrome Cyanine R is a visible spectrophotometric method; a Bausch and Lomb Spectronic 2000 was utilized for this study. The procedure given in the Standard Methods was modified. Standard Methods on page 170, under section 3. Reagents, part 6. Working Dye Solution states "Working solutions are stable for at least 6 months". In the course of this study, it was noticed that the color of the working dye solution was not stable and faded away. A working dye solution was prepared and stored in two bottles, one colored and one clear. At certain interval times, four samples (10,100 ppb aluminum, blank, and EDTA) were prepared by using the stored working dye solutions, and were run against deionized water. Two other objectives were achieved. First, the effect of colored versus clear bottles was studied; second the effects of different aluminum concentration on absorbance were observed. Figures 1 and 2 represent the absorbance of four samples versus time for the working dye stored in clear and colored bottles, respectively. The working dye stored in the clear bottle shows loss of adsorptivity after 20 hours, compared with 100 hours for the colored bottle. This shows that light affected the dye. The sample containig 100 ppb aluminum shows higher loss of absorbance compared with other three samples. Thus, one can conclude that the samples containing high aluminum concentrations are more affected by the fading of the working dye. The results indicated that the working dye solution was not stable for more than four days even with storage in a colored bottle. Therefore, each working dye solution must be tested for absorbance stability.

The conventional method for preserving samples is done by the addition of a strong acid (1 percent in the volume) to the sample immediately following the collection of sample. It was noticed that by the addition of 0.5 ml concentrated nitric acid to a 50 ml sample, the suggested buffer could not maintain a pH of 6.0. Shull and Guthan[2] have shown that, as pH decreases, absorbance of the aluminum-dye complex increases. However, that does not mean that the accuracy of measurements would increase by lowering pH. Shull recommended a pH of 6.0 for the best result. This issue was investigated in an experiment and the results are presented in Figure 3. The samples with a pH of about 6 show a linear relationship between aluminum concentration and absorbance, while the samples with a pH of about 5 and 4 are constant and independent of aluminum concentration. Therefore, it is recommended to analyze the samples freshly and not preserved them.

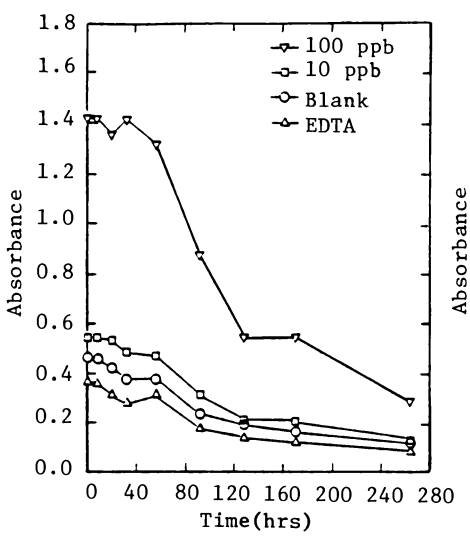

Fig.1- The Absorbance of Samples of Dye Stored in Clear Bottle vs Time.

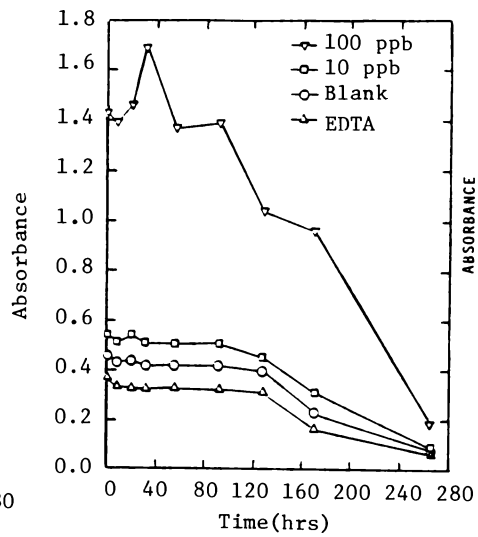

Fig.2- The Absorbance of Samples of Dye Stored in Color Bottle vs Time.

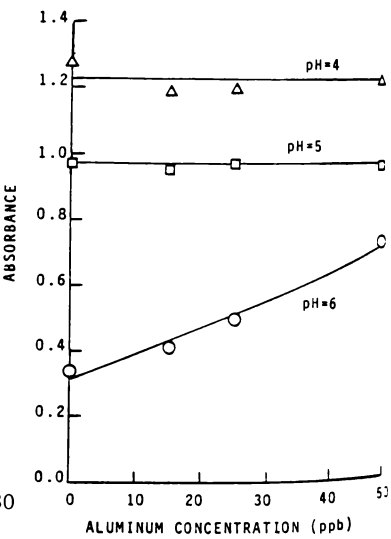

Fig.3- Effect of pH on The Absorbance of Samples.

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[2]Schull, K.E. and Guthan, G.R. (1976) J. Am. Water Works Assoc., 59, 1456-1468

(121) CHEMICAL CHARACTERIZATION OF PRECIPITATOR ASHES FROM PRESSURIZED HYDRATED-LIME INJECTION TESTS

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Pressure-hydrated lime injection tests were run at the 50 M-W Hoot Lake Utility Plant near Fergus Falls, Minnesota (1). Direct injection of hydrated lime and other calcium compounds into utility furnaces may be able to significantly reduce sulfur dioxide emissions to the atmosphere. The commercial feasibility of these processes will partially depend on the disposal requirements of the solid wastes. Four ashes from the plant's electric precipitator were characterized: a baseline ash from the Beulah, North Dakota lignite without hydrated-lime addition and three ashes under varying injection rates of Ca/SO_2 of 0.5, 1.1, and 3.5. The Ca/SO_2 ratios are based on the moles of calcium injected to the moles of SO_2 in the gas just prior to lime injection.

The bulk chemistry of the ashes was determined by X-ray fluorescence. All leachates were analyzed by Inductively Coupled Argon Plasma and Atomic Absorption Spectrometry. Sulfate was determined by a turbidimetric method with barium chloride. Batch and column leaching tests were used to evaluate the soluble concentrations of selected elements in the ashes. None of the ashes produced EP or ASTM batch leachates that exceeded federal standards for As, Ba, Cd, Cr, Pb, or Se (2,3).

Mineralogical analyses of the fly ashes using X-ray diffraction methods indicated that significant amounts of ettringite phases ($Ca_6 Al_2 (SO_4)_3 (OH)_{12} \cdot 24 H_2O$) formed in the samples during the column leaching tests. (Ettringite is known to be associated with the cementitious reactions which occur in Portland cement.) The formation of ettringite in the fly ash samples caused an increase in the compressive strength and a decrease in the permeability of the material over the course of the column leaching tests. Ettringite formation also appears to have complexed some of the sulfate and borate in the fly ash, since these compounds were not found in the lime injection ash leachates after approximately 30 pore volumes had passed through the columns (4). Figure 1 shows the column leaching data for sulfate. Barium leaching however, was enhanced in the lime injection fly ashes due to the complexation of the sulfate. Figure 2 shows the barium column leaching data, and it illustrates quite clearly that barium leaching begins only after sulfate is immobilized. Barium sulfate is extremely insoluble and it is reasonable to expect barium to be non-leachable in the presence of dissolved sulfate.

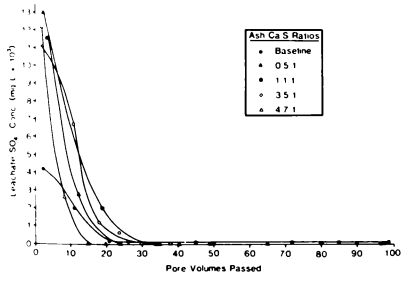

Figure 1. Sulfate Concentrations (mg/L) in the Column Leachates

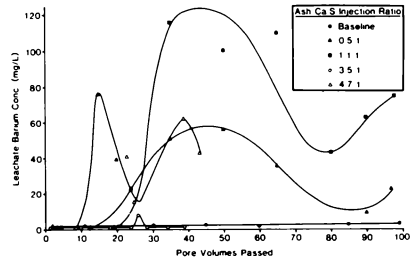

Figure 2. Barium Concentrations (mg/L) in the Column Leachates

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(122) THE COMPARISON OF EXPERIMENTAL AND THEORETICAL EQUILIBRIUM CONSTANT VALUES FOR ALUMINUM SPECIES

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The hydrolysis of Aluminum has been studied extensively by Black and Chen[1], Stumm and O'Melia[2], Hayden and Rubin[3], and reviewed by Base and Mesmer[4]. There were other studies, but those were either performed at vastly different ionic medium or did not report any equilibrium constants. Even with these four investigators, there is no agreement between the hydrolysis species nor the magnitude of the equilibrium constant.

If aluminum hydroxide solid exists, then the following reaction can be written: $Al(OH)_3 + 3H^+ = Al^{3+} + 3H_2O$ with a solubility product of ${}^*K_{so} = \{Al^{3+}\}/\{H^{+3}\}$. Other hydrolysis species in equilibrium with $Al(OH)_3(S)$ would just be a simple function of $\{H^+\}$. For example: $\{AlOH^{2+}\} = {}^*K_{so}\,{}^*K_1\{H^{+2}\}\,S_o$, if $Al\,OH^{2+}$ is the major dissolved species, a plot of log (dissolved aluminum concentration in M) versus pH gives a slope of -2; if $Al(OH)_2^+$ is the major species, a slope of -1 is achieved; if $Al(OH)_3$ is the major species, it produces a slope of zero; and if $Al(OH)_4^-$ is the major species, it gives a slope of +1. In this study, where total aluminum added (3.2 mg/l) is much greater than the total dissolved aluminum (10 to 100 ppb), the slope of the aluminum/pH plot suggests the presence of $AlOH^{2+}$, $Al(OH)_2^+$, $Al(OH)_2$, and $Al(OH)_4^-$. Although the extensence of polymeric aluminum species such as $Al_8(OH)_{20}^{4+}$ has been reported by Hayden and Rubin,it should be noted that such species are probably important in the initial stages of color coagulation, and at pH values less than 5.[5] The various reported hydrolysis species of aluminum and their reported equilibrium constants are shown in Figure 1, as well as the measured solubility from this study. Curve 1 is calculated with the data of Hayden and Rubin, curve 2 from the data of Black and Chen and curve 3 from Base and Mesmer . Curves 1 and 2 assumed the presence of amorphous $Al(OH)_3(s)$ while curve 3 assumed the presence of the mineral gibbsite. The results of an average run do not correspond well with curves 1,2 and 3, although the measured soluble aluminum for pH$\geq$6.4 is close to curve 2. The equilibrium constant values reported for ${}^*\beta_4$ are in a range of 10^{-23} to 6.9×10^{-21} which is close agreement. Therefore a value of ${}^*\beta_4 = 10^{-23}$ reported by Hayden and Rubin was used in this study. ${}^*K_{so}$ and ${}^*\beta_2$ can be computed by using ${}^*\beta_4 = 10^{-23}$. As an example, the solubility product ${}^*K_{so}$ and β_2 values for this study are 8.05×10^9 and 2.6×10^{-10}, respectively. The average ${}^*K_{so}$ value was 10^{10} and this is in correspondence with the numbers reported by different investigators (1.3×10^9 to 2.5×10^{10}). The reported ${}^*\beta_2$ is 5×10^{10} which is in agreement with the computed ${}^*\beta_2$ values for this study.

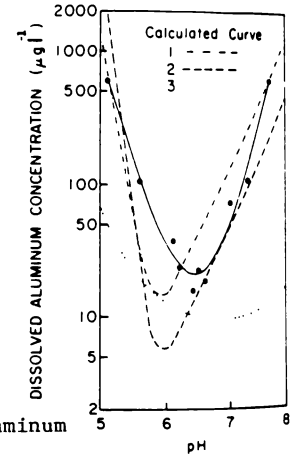

Figure 1- Calculated and Measured Aluminum Solubility Curves.

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(123) EFFECT OF BIO-AUGMENTATION ON OXYGEN UTILIZATION IN POTATO WASTEWATER TREATMENT USING WARBURG RESPIROMETRIC TECHNIQUE

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The Warburg respirometer is used to measure the oxygen uptake of wastewater due to bio-oxidation. The rate of aerobic respiration is directly proportional to the oxygen utilization. The method has been used to determine the biological treatability of municipal and industrial wastewaters and to determine the effect of toxic substances present in the wastewaters on the biological treatment. The objective of this study was to determine the effect of bacterial culture product addition on the oxygen utilization of potato wastewaters.

Wastewaters used in this investigation was the potato juice prepared from potato tubers. The stock feed solution contained a COD (chemical oxygen demand) concentration of 8000 mg/l. The feed solution was diluted to four levels of COD concentration of 200, 400, 600, and 1000 mg/l. The LLMO (liquid live micro-organisms) manufactured by the General Environmental Science, Cleveland, Ohio, was used as the bacterial culture product addition. Four levels of LLMO dosage used in this investigation consisted of 0.1, 0.2, 0.3, and 0.5 ml per 3 ml of total liquid volume. The Warburg experiment in the study was designed to determine the effect of bacterial culture addition for two different conditions. These included variable feed COD with constant LLMO dosage, and constant feed COD with variable LLMO dosages (1). The water bath temperature was maintained at 25°C for the Warburg run. The experiment lasted for a period of 10 days. A total of 18 flasks were used in this study. Manometric readings were taken at different time periods. Table 1 presents the results of the Warburg respirometric study. For the flasks with constant LLMO dosage of 0.5 ml and various COD concentrations, total oxygen consumption increased with an increase in COD concentration up to 600 mg/l. At the end of 260 hours of Warburg run, the total oxygen utilization was 17.47, 18.94, and 23.76 mg/l for an initial COD concentration of 200, 400, and 600 mg/l. When potato wastewater COD increased to 1000 mg/l the total oxygen consumption was less than those for the other COD concentrations. This indicates that LLMO alone without activated sludge addition could perform bio-degradation in potato wastewaters with a feed COD of 600 mg/l. For flasks with a constant COD of 1000 mg/l and various LLMO dosages, the total oxygen consumption was the highest for the lowest LLMO dosage of 0.1 ml. As LLMO dosage increased, the total oxygen consumption decreased. The total oxygen consumption was 42.18, 17.4, 17.4, and 14.72 mg/l for the flask with LLMO dosage of 0.1, 0.2, 0.3, and 0.5 ml, respectively. The oxygen uptake constant was also determined using the daily difference method. For varying feed COD concentration and a constant LLMO dosage, the maximum oxygen uptake constant of 0.0090 per day was observed for the flask with a feed COD of 600 mg/l. For a constant COD and varying LLMO dosages, the maximum oxygen uptake rate constant of 0.0098 per day occurred at the lowest LLMO dosage of 0.1 ml. This indicates that LLMO addition alone even at high concentrations but without activated sludge addition may not be able to form the proper system required for bio-oxidation for potato wastewater treatment.

Table 1 Summary of Warburg Data

Time	Oxygen Utilization (mg/l) for COD - LLMO							
(hr)	0-0.5*	200-0.5	400-0.5	600-0.5	1000-0.5	1000-0.1	1000-0.2	1000-0.3
11	0.10	0.36	0.36	0.61	0.46	1.44	1.08	0.72
39	0.74	2.85	3.83	6.34	2.50	3.58	2.14	1.57
87	4.89	7.97	8.79	9.06	7.42	19.48	4.16	5.69
135	6.86	10.28	11.18	16.03	8.36	25.87	5.47	7.65
179	9.51	11.71	14.20	16.91	11.06	34.28	11.79	12.41
207	10.55	12.63	16.40	18.76	12.52	37.54	12.98	14.79
260	15.06	17.47	18.94	23.76	14.72	42.18	17.41	17.45

* Feed COD (mg/l) & LLMO dosage (ml)

Based on the results of this study, it is concluded that bacterial culture product addition alone may not be feasible for potato wastewater treatment. At a constant LLMO dosage and varying feed COD concentrations, the total oxygen consumption increased with an increase in feed COD concentration up to 600 mg/l. At a constant COD concentration and varying LLMO dosage, the total oxygen consumption decreased with an increase in LLMO dosage. It is recommended that for the biological treatment of potato wastewaters, activated sludge supplemented with bacterial culture addition should be examined.

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(124) THE EFFECTS OF ALUM COAGULATION ON THE ALUMINUM LEVELS IN THE WATER TREATMENT PROCESS

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Alum is widely used as coagulant in water treatment to remove turbidity and color. Recent studies indicated that there is a good probability the aluminum concentration of finished water can be increased above the original raw water by the process of coagulation with alum. High levels of aluminum has been linked to several medical disorders such as Alzheimer's disease, Dialysis Encephalopathy and Renal Failure in man.

Because of the ever increasing concern over the health effects associated with aluminum, this study was designed to determine the behavior of aluminum in a water treatment plant using alum in the coagulating process. The plant chosen was the Arthur Rollins Water Treatment Facility located in Durham, New Hampshire. The Arthur Rollins Water Treatment Plant is a 1.5 MGD facility that treats surface water from a storage reservoir impounded on the Oyster River. Treatment includes alum coagulation, flocculation, sedimentation, and rapid sand filtration followed by chlorine disinfection and fluoridation. Weekly samples were taken from the end of August 1983 to the beginning of February 1984. These were taken from the raw water intake, after sand filtration, and prior to distribution. The standard water quality parameters: temperature, pH, alkalinity, color, and turbidity were determined along with aluminum. Aluminum was determined using the Eriochrome Cyanine R Method (1) which can detect aluminum in the low ppb range. During this period, the raw water had the following characteristics: temperature varied from 1 to 20° C, color varied from 30 to 120 cu, alkalinity varied from 7 to 40 mg/l as calcium carbonate, turbidity varied from 1.8 to 41.0 NTU, and the raw water pH varied from 6.2 to 7.2. The pH of the water emerging from the sand filters had a pH range of 5.3 to 6.7, while the pH of the finished water ranged from 6.5 to 8.9. The variation of total and dissolved aluminum and temperature of the raw water for this period are shown in Figure 1. The total aluminum concentration was generally low, below 50 ppb and most of it was in dissolved form. The level of dissolved aluminum is not unusual at this pH, and is indicative that it is controlled by solubility with respect to aluminum oxides or alumino-silicates. At the time of overturn of the reservoir, the amount of total aluminum in raw water increased significantly and 74 percent of it appeared in the particulate form. Figure 2 shows the behavior of total aluminum concentration in raw and finished water for this period. Throughout this period, the finished water showed higher total aluminum concentration compared to the raw water. The average concentration of total aluminum in the finished water was 194 ppb compared to 30 ppb for the raw water. During the same period, it was estimated that the average alum dosage ranged from 23 to 90 mg/l as aluminum sulfate. (i.e., 2.1 to 8.1 ppm as aluminum.) While one expect the final aluminum concentration to be a function of alum dose, such a relationship did not appear to be evident. Given this dosage and operating pH range (i.e., 5.3 to 6.7), the water treatment facility was deemed to be utilizing the sweep coagulation zone (2) as the major operation for color and turbidity removal. The aluminum addition is an order of magnitude greater than the natural occurrence of the element, and it is not totally surprising that the total aluminum leaving the plant is usually higher than the intake concentration. The monitoring of the water treatment plant confirms that the total aluminum concentration in the finished water was usually well above that of the raw water.

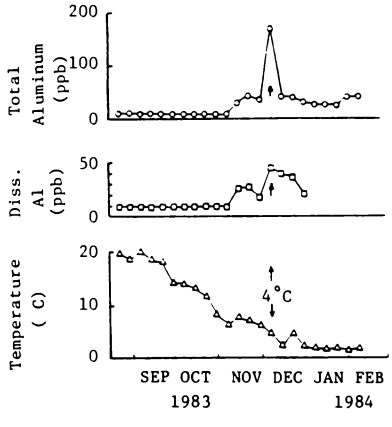

Fig.1- The Behavior of Raw Water

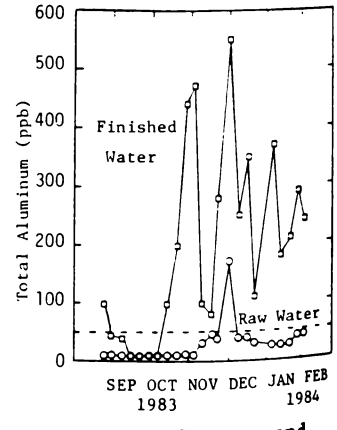

Fig.2- Finished vs Raw Water.

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(125) A METHOD FOR CONCENTRATING LIPTINITE MACERALS FROM LIGNITES

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One of the major constituents of lignites and other coals is the hydrogen-rich maceral-group, liptinite. Liptinite is composed of waxes, fats and oils (1) primarily from plant cuticles, as well as spore and pollen exines (palynomorphs). Liptinite is being mechanically separated from North Dakota lignites as a means of better understanding coal chemistry and the coalification process.

The basic procedure consists of first collecting a lignite sample which has been visually determined to be rich in the lithotype durain, and is therefore more likely to contain a relatively high percentage of liptinite macerals. The lignite sample is then ground to -325 mesh (<45 microns) by standard procedures, followed by further pulverizing to approximately 3 microns average particle diameter in a Micron-Master jet pulverizer. Depending on the actual operating conditions and properties of the particular coal used, this may take three runs in the jet pulverizer before the small particle size needed is reached.

Although the majority of the coal particles average 3 microns in diameter, most of the liptinite macerals (especially palynomorphs) tend to remain much larger (typically from 5 to 40 microns in size). Many palynomorphs are morphologically intact, displaying complex exine morphologies, often allowing for detailed taxonomic assignments. It may be that the palynomorphs retain a larger size through the pulverizing process due to their elastic nature when compared to other coal macerals. This apparent elasticity allows for a more complete liberation from the relatively brittle coal matrix.

After the coal has been sufficiently pulverized it is thoroughly suspended in an aqueous $ZnCl_2$ solution which has a specific gravity of 1.25. Suspension is achieved by first thoroughly mixing the coal and the $ZnCl_2$ solution then agitating the mixture in an ultrasonic bath for approximately 10 minutes. The mixture is centrifuged for approximately 1/2 hour at approximately 3,000 revolutions per minute. After collecting and filtering the supernatant, the solids from the filtration are then resuspended in an aqueous $ZnCl_2$ solution (specific gravity 1.25) and the centrifugation step repeated. When this procedure was performed on North Dakota lignites, the supernatant was filtered and the resulting residue was found to be rich in liptinite macerals, especially palynomorphs. Listed in Table 1 are petrographic analyses for durain-rich Hagel lignite collected in the Center Mine, Oliver County, North Dakota.

The procedure outlined above is a relatively quick and easy way to produce concentrations of liptinite macerals. This procedure may be further refined in the future, to produce even higher concentrations of macerals. Dyrkacz and Horwitz (2) have described a complex maceral separation method used for bituminous coals. However, it appears that the macerals present in North Dakota lignites are easier to separate. Low-rank coal macerals have remained more distinct entities, perhaps making them easier to separate from each other, than macerals from coals of higher rank.

Table 1
Petrographic Analysis

Hagel Lignite (Durain-rich) Before Separation			
Huminite Group Macerals			74.4%
Liptinite Group Macerals:	Sporinite		5.2%
	Others		12.7%
Inertinite Group Macerals			5.9%
Hagel Lignite (Liptinite Concentrate) After Separation			
Liptinite Macerals			87%
Morphologically Recognizable Palynomorphs		56%	
Other Liptinite Material		31%	
Other Maceral Fragments			13%

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(126) MICROSCOPIC EXAMINATION OF LIGNITE ASH AND SILICA SAND AGGLOMERATES FORMED IN A 2-INCH FLUIDIZED BED REACTOR

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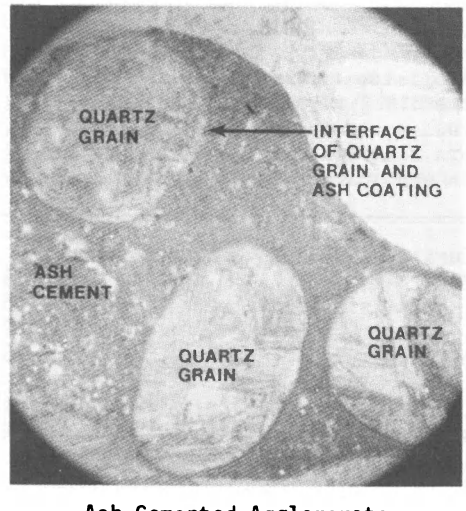
Fluidized bed combustion of North Dakota lignite may result in severe agglomeration of ash and bed material. Extensive tests at the University of North Dakota Energy Research Center (UNDERC) have shown that the nature of mineral impurities, operating temperatures, gaseous environment, and bed material composition are significant factors which influence agglomerate formation (1). Tests were performed in a 18-inch fluid bed combustor (FBC) at UNDERC using a wide range of low-rank coals and various bed materials (2).

More recently, a 2-inch fluidized bed reactor was constructed and operated to evaluate interactions of North Dakota lignite ash and silica sand bed material at typical combustor operating temperatures. Each test was performed by precharging the reactor with 240 g of sand and 40 g of lignite ash. The mixture was fluidized in air or air/sulfur dioxide and heated at the desired temperature for up to 150 hours. Samples of ash and bed materials were removed periodically to characterize the increase in particle diameter caused by deposition of ash on the bed particle surface. Samples of the bed material were prepared in polished thick sections for optical and electron microscopy. Their morphology and bulk chemical composition resembled those of actual combustor agglomerates. Detailed analysis by energy dispersive x-ray spectrometry and scanning electron microscopy showed that when sulfur dioxide was present in the gas stream, calcium, sulfur, and silica were present at the boundary between the silica sand particle and its ash coating. The ash coating consisted of discrete fly ash particles in a homogeneous matrix. The photomicrograph below was taken of a cross-section of an agglomerate formed at 1450°F when sulfur dioxide was added. The particle diameter is more than twice that of the initial silica sand grain. In contrast, a very thin ash coating resulted when sulfur dioxide was not present in the fluidizing gas, and cemented agglomerates consisting of several sand grains, such as that depicted below, were not observed.

The significance of this work relates to the need for understanding mechanisms by which agglomeration occurs in fluidized bed combustion. Using a small bench-scale system allows for careful control of experimental variables at a reasonable cost. The results of an experimental program such as that described here may be used by utility, engineering, and mining firms to assess the potential for serious agglomeration when combusting a fuel with high ash content or "bad acting" minerals in a fluidized bed.



Ash Cemented Agglomerate

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(127) PEATLAND SOILS ASSOCIATED WITH THE SOURIS RIVER, McHENRY COUNTY, NORTH DAKOTA

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Most of the wetlands in North Dakota are climatically and hydrologically unsuited for peat accumulation. Periodic dry conditions cause wetlands to dry up, resulting in oxidation of dead wetland plants and very little or no peat accumulation. However, along the Souris River in McHenry County, a unique hydrologic setting encourages peat formation.

The purpose of this research was to identify areas of peat occurrence, sample and characterize representative peat soils, and identify important peat formation processes. Through the interpretation of aerial photographs and topographic maps and information contained in soil survey (1) and geology (2) publications, the locations and geologic settings of the peatlands were identified. Two larger peatlands, the Denbigh Fen (400 ha) (Sec. 25, T155N, R77W) and the Towner Fen (100 ha) (Sec. 18, T157N, R75W), were selected for more detailed study. A selected transect was made across (perpendicular to the grain or slope) each peatland so that elevation changes and vegetation differences were representative of the peatlands as a whole. Selected sites, along the transects, were sampled with a Macaulay peat sampler, soil profiles were described, and the surface vegetation identified. Peat samples from two sites were analyzed by standard USDA soil characterization methods (Table 1).

Both the Denbigh Fen and the Towner Fen lie on a slightly elevated, flat floodplain of the Souris River, with deeper peat accumulation in former river channels. Saturation of the peat is maintained by continual discharge of ground water from adjacent upland outwash soils. Surface vegetation (Carex lasiocarpa, Carex aquatilis, Betula glandulosa) is indicative of a calcareous rich environment. Although the peat soils are relatively high in ash content (Table 1), the fiber contents, $Na_4P_2O_7$ extract colors, and water contents are characteristic of only moderately decomposed peat. The soils also have unusually high pHs and contain carbonates at all depths. Both peat soils are underlain by lake sediment, probably deposited in an oxbow lake associated with channel abandonment. The characteristic nature of the sediment (Lco) is revealed in Table 1 for the lower depths of the Towner Fen.

The Denbigh and Towner Fens are representative of a large (1000 ha), unique peat-forming environment along the Souris River. The presence of carbonates and the fibrous nature of the peat suggest that the peat-forming environment is continually being saturated by active groundwater enriched in calcium and bicarbonate ions.

Table 1

Morphological, physical, and chemical data for two peat soils located near the Souris River

Site	Horizon	Depth (cm)	Field Color (Munsell)	Fiber Content Unrub (%)	Fiber Content Rub (%)	$Na_4P_2O_7$ Extract Color (Munsell)	pH (1:1) H_2O	pH (1:1) 0.01M $CaCl_2$	Water Content (%)	Ash Content (550°C; % O.D.)	Calcium Carbonate Equiv. (%)
Denbigh Fen	Oek	0-35	10 YR 4/2	40	28	10 YR 8/1	7.5	7.1	86.6	50.1	39.2
	Oe2	35-55	10 YR 3/2	36	30	10 YR 8/1	7.4	7.2	90.1	19.4	1.9
	"	55-75	10 YR 3/2	46	36	10 YR 8/1	6.7	6.5	87.9	20.2	1.0
	"	75-95	10 YR 3/2	40	36	10 YR 8/1	7.5	7.1	87.7	20.3	4.0
	"	95-140	10 YR 3/2	40	26	10 YR 8/1	7.7	7.2	88.2	22.0	3.6
	Oe3	140-155	10 YR 3/2	28	24	10 YR 7/2	7.6	7.4	87.3	19.5	1.0
	Oe4	155-180	10 YR 3/2	44	36	10 YR 7/2	6.4	6.3	85.7	20.1	1.6
	"	185-195	10 YR 3/2	40	28	10 YR 8/2	6.7	6.6	86.3	21.0	1.1
Towner Fen	Oe	30-50	10 YR 3/2	44	28	10 YR 8/1	6.9	6.6	91.5	17.8	1.2
	"	85-100	2.5 Y 3/0	40	28	10 YR 8/1	7.0	6.8	93.1	29.6	0.4
	Lco1	140-155	2.5 Y 2/0	(silt loam)		10 YR 7/2	7.5	7.3	74.1	74.5	25.4
	"	195-210	2.5 Y 2/0	(silt loam)		10 YR 7/2	7.2	7.1	54.1	89.9	25.0
	Lco2	250-265	2.5 Y 3/0	(silt loam)		10 YR 6/2	7.5	7.5	44.3	91.3	19.6

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(128) ON OPTIMIZING COEFFICIENTS OF THE MUSKINGUM FLOOD ROUTING MODEL

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The Muskingum method of flood routing through river and channel reaches is based upon the linear relationship given in Eqn. [1].

$$S_t = K[xI_t + (1-x)O_t] \quad [1]$$

S_t, I_t and O_t are the simultaneous storage, inflow and outflow during the passage of a flood and K and x are the parameters to be determined from past flood inflow and outflow hydrographs through the reach (1). K can be physically interpreted as the travel time of a flood wave through the reach while x is a weighting factor associated with the wedge storage within the reach. It can be shown that the value of x has to be between 0 and 0.5. Traditionally the parameters are determined by using a graphical method (1). However, more objective methods using multiple linear regression and other statistical criteria have also been used in the past (2,3). In this paper, the parameter estimation problem is formulated as a Linear Program (LP) given below to minimize the maximum absolute deviation between the observed storages and the ones computed by using Eqn. [1]. I_t, O_t and S_t are previously defined, A = Kx, B = k(1-x) and Y is the maximum absolute deviation. N is the total number of ordinates of observed inflow and outflow hydrographs. Constraints [2] and [3] ensure that the deviations between observed and computed storages stay within the maximum absolute deviation Y. The restriction on x is brought in through constraint [4]. The last inequality ensures the non-negativity of the variables Y, A and B. The problem can then be solved by using any commercially available LP software.

Min: Y

Subject to

$$Y+[AI_t + BO_t] \geq S_t, \quad t = 1,2,.....,N \quad [2]$$

$$Y-[AI_t + BO_t] \geq -S_t, \quad t = 1,2,.....,N \quad [3]$$

$$A-B \leq 0 \quad [4]$$

$$Y, A \text{ and } B \geq 0 \quad [5]$$

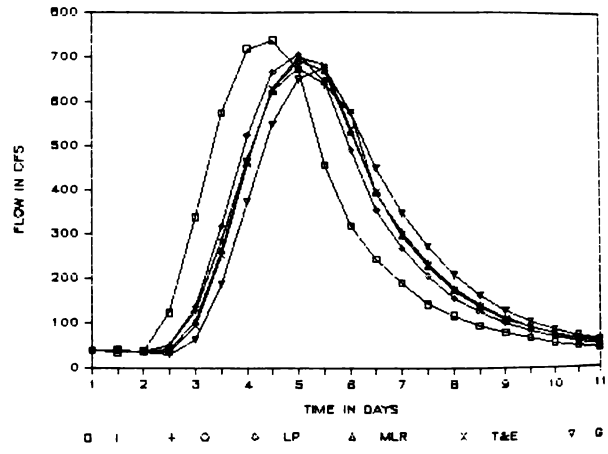

Fig. 1. Inflow and Outflow Hydrographs

The LP method is applied to an example problem (1) and the results are compared with the graphical (G), multiple linear regression (MLR) and a trial and error (T&E) method (1,2,3). The inflow (I) and outflow (O) hydrographs of the examples along with the routed outflow hydrographs by using values of K and x determined from the different methods are shown in Fig. 1. The key to the symbols in the figure appears at the bottom of the figure. The graphical solution is clearly subjective and time-consuming with no definite advantage in terms of accuracy. The LP method is a viable alternative and can be easily implemented on a personal computer. Since there are many LP programs available for personal computers, one can use the LP method with relative ease.

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(129) HUMAN CAUSES OF THE RIVERDALE, ND SLUMP

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Slumping is a slope failure in which a mass slides along an arcuate failure surface such that the block acquires a backward rotation as it moves downward (1). Slumping along the shores of Lake Sakakawea is relatively rare; most failures are planar. An extensive area near Riverdale, ND has failed and continues to fail by slumping. When the area was first examined in the spring of 1983 a large failure had only recently occurred.

In early spring 1985 a series of smaller slump failures occurred immediately up lake from the 1983 slump. Examination of the bank exposure showed extensive groundwater discharge in that area from lignite beds. Nowhere else along the lake were similar discharges found; the site is unique despite the fact that numerous exposures of lignite form the banks all along the eastern half of the 286 km-long lake.

Examination of piezometer data from the vicinity of the slump shows a rise in the water level in the late spring of 1982, 1983, and 1984 (Fig. 1). The question is whether or not these peaks are related to the slumping. The possible reasons for each peak are:

1) They are the result of a seasonal rise due to precipitation. Figure 1 includes the antecedent precipitation available prior to the peak rise in piezometer head. Although the peaks for 1982 and 1983 are identical, the precipitation that fell during the preceding 7 months was 62 and 208mm, respectively. In addition, the 192 mm precipitation that preceded the 1984 peak is correlated with a significantly lower piezometric head. It does not appear that precipitation is the primary variable controlling the piezometric head.

2) The peaks are controlled by fluctuating pool levels. In each case the peak head precedes the peak pool level. If pool levels affect the piezometric head at this site there should be a rise following the pool level rise. Pool level fluctuations are therefore not the cause of the head changes.

3) The spring increase in head is the result of reduced evapotranspiration over the winter. If this is the cause, other piezometers with a similar head and in the same area ought to show the same rise; they do not. Nearby piezometer PO-11, which is screened at about the same level, shows a head peak in late July 1982 and after a low the next month steadily rose to a peak in late July 1983. The head continued to drop all through 1985, with no winter or spring peak. Reduced evapotranspiration is not the answer, either.

4) The peaks are affected by local water use, periods of increased lawn and garden sprinkling and water tower spills. During summer 1983, one of two water towers at Riverdale was observed to be overflowing from the top, dumping about 90,000 gallons (340 cu metres) onto the ground below. The discharge lasted several hours. It was subsequently verified that such discharges had occurred occasionally in the past due to an open valve (2), but by 1984 the problem had been corrected by switching to the newer tower. Lawn and garden watering is the other factor. Because water is so abundant and inexpensive at Riverdale and because the residents are required to meet Army inspection standards, water use is excessive. During the summer Riverdale residents use 6 times more water than nearby Garrison residents.

The location of the slump in a groundwater discharge area directly downgradient from Riverdale, in combination with the evidence of unusually high discharge from lignite beds exposed in the reservoir banks, strongly suggests that the slope instability is caused by artificial groundwater recharge. Failures will continue as long as excessive water use continues.

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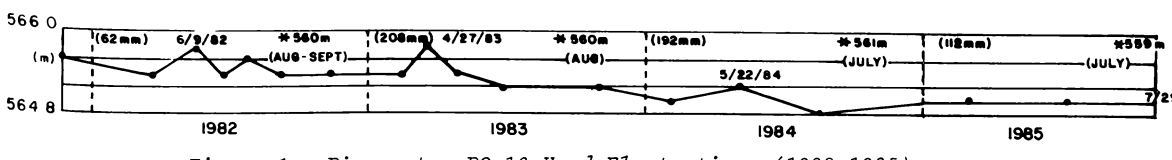

Figure 1. Piezometer PO-10 Head Fluctuations (1982-1985). (is the peak pool level that summer; ( ) = precipitation, Oct-April.)*

(130) MEASURING BASIC PLACE NAME VOCABULARY AMONG UNIVERSITY STUDENTS IN INTRODUCTORY GEOGRAPHY CLASSES

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Geography has a tradition of studying places (1,2). Prior to World War Two, most geographers emphasized the study of landscapes and locational attributes with minor attention to explanation of spatial variables (4,5). Regional geography was the unifying approach in the discipline until the 1950's and 1960's when quantitative geography started to become a more dominant approach with its focus upon spatial analysis as opposed to simple geographic description (6). Consequently, development of basic place name vocabulary received decreasing attention in university-level geography courses while mathematical modelling was incorporated increasingly in the geography curriculum of the 1970's (5). By the 1980's, learning basic place name vocabulary had become so de-emphasized that geographers teaching university-level courses started to assess the high degree of geographic illiteracy of undergraduates (3), a condition recognized as early as 1952 (9).

While geographers interested in determining basic place vocabulary recognition at pre-collegiate levels can rely upon standards from the International Geographical Union's (IGU) World Basic Place Vocabulary Test (8), a university-level instrument has yet to become available. Because of previous use of IGU's test with seventh graders in North Dakota (7), curiousity existed as to how well university students at the Grand Forks campus could handle basic place names. Testing first was done in AY 1984-85, but serious examination of results did not occur until AY 1985-86. During the Fall of 1985, students in two introductory geography courses were given that test twice. Undergraduates in GEOG 161 (World Regional) and GEOG 151 (Cultural) were evaluated at the beginning of the semester and at the end of the semester.

It was hypothesized for the pre-test that university students would recognize only fifty percent of the fifty place names and that locations in Africa and Asia would be less well identified than those in Europe and the Western Hemisphere. Furthermore, it was hypothesized for the post-test that students taking the world regional geography course with its emphasis upon bi-weekly atlas reading would do better on the post test than cultural geography students who simply were exposed to maps that accompanied their tri-weekly text readings.

Pre-test results and post-test results are as follows. Undergraduates from both classes averaged 38.5 points on the 50 point test at the beginning of the semester, 13.5 points higher than anticipated. While African and Asian locations were frequently misplaced, South American places also were not well known by those who took the pre-test. The post-test showed an increase in basic place vocabulary. GEOG 161 students averaged 47.7 points, while GEOG 151 students improved only to an average of 42.5 points. Identifying Third World locations improved for most students.

While this instrument is not totally satisfactory for evaluating basic place vocabulary for university-level students, it can be used for rudimentary evaluation of geographic illiteracy in introductory geography courses. A benchmark has been established for future testing at the University of North Dakota. Eventually, a national test must be created and adopted so that diagnosis of geographic illiteracy can be standardized across undergraduate courses on campuses throughout the United States.

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(131) EXAMINATION OF IMPACTS OF A DRAINAGE PROJECT

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Natural wetland depressions are regular features of much of the North Dakota landscape, especially in glaciated areas. These depressions are capable of storing large quantities of runoff from melting snow and heavy rainfall events. Considerable drainage of these depressions began in 1900's in the Red River valley and gradually became common place in other parts of the state. The potential impacts of drainage in terms of increased flooding and sediment transport downstream of the drained area continues to be of concern (1-3). However, so far the impacts of drainage have not been analyzed in-depth mainly due to paucity of data.

In this paper, the impacts of Russell Diversion Project in north western North Dakota is examined in the light of available data. The Russell Diversion area lies on the relatively flat Souris Plain in Southern Bottineau and northern McHenry counties of North Dakota. The diversion area has lacustrine sediment deposits of 20-50 feet thickness. The outlet from the Russell Diversion is a small first order stream called Russell channel that lies in Section 36, T160N, R79W. The head of the stream ends in Section 36 but an upland swale continues eastward across Section 35. The original drainage area was 611 acres. The stream starts in the lacustrine plain and ends in Deep River at the level of the Souris River entrenchment. The introduction of a new drain increased the drainage area to 12220 acres. Except for farmsteads and a small amount of pastureland in the southern and western part of the project area, all land is under cultivation. Typically 70 to 80 percent of the cropland is planted to small grains, 10 to 20 percent is fallow and about 10 percent is winter wheat or sunflower. Normally one or two primary tillage operations are preformed in the Fall consisting of plowing or one or two operations with a chisel plow. Many of the soils are high in silt and fine sand and therefore erodible materials (4). Because of steep slopes water erosion is a major problem on much of Section 36.

Geologic instability of the Russell Diversion Project area was clearly apparent by geologic comparisons with LaPorte coulee drainage basin located 2.5 miles north of the Russell Channel, measured erosion loss and excessive velocities in the Russel Channel. The current Russell Diversion Project area will erode 100,000 tons of sediment to reach the profile of the LaPorte coulee but would still not be stable because the Russell Diversion now drains five times the area of the LaPorte coulee. The average annual sediment load is estimated around 1000 tons. The sediment deposits are evidenced by the formation of a delta where the drain enters Deep River. Channel velocities are likely to exceed two to three times allowable limits for a critical runoff event. Water entering the road ditch on Section 36 from the ditch on Section 35 must pass through a 4 feet diameter culvert. Depending on the magnitude of runoff event, this situation can cause back-up of water upstream of the culvert. The system will typically contribute 1000 to 1300 acre-feet of runoff annually with events of 2000 to 3000 acre-feet possible. The flows of the Russell Project are significant with respect to the pool capacities of the J. Clark Salyer National Wildlife Refuge. A 10 year snowmelt event will generate 1482 acre-feet runoff from the project and this will raise the level of the pool 332 of the refuge by 4.38". It takes 15 days to drain this quantity of water from the pool. This results in a delay in the establishment of desired pool elevations and can impact wildlife nesting. The management cycle of the refuge can be affected considerably due to the increase in flow into the pools. Water quality changes that are likely to occur due to the drainage of wetlands which previously acted as nutrient sinks for the local runoff were not investigated in this study for want of sufficient data.

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(132) SENSITIVITY ANALYSIS OF A COMPUTER MODEL OF SOLUTE TRANSPORT IN GROUNDWATER FLOW

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Although several analytical models of solute transport in groundwater flow have been developed in the past, they are often found to be limited for practical application. It is difficult to accomodate the complex boundary conditions and spatial variability of aquifer properties. However, numerical formulations of these models have the capability of overcoming the above difficulty; but computers with large memory are needed to implement them. Since the advent of the digital computers, a large number of numerical models have been in wide use (1,2,3). Validation and calibration of these models are important steps before applying them to specific situations. In addition, sensitivity studies on the model are essential to determine the model parameters having the greatest influence on the outcome of the model and therefore to determine which parameters need to be estimated more accurately (4). Also, these studies will enable one to become more knowledgeable about the possible margin of errors in the model- predicted values due to inputing inaccurate estimates of the parameters; particularly because of the inherent variability in estimating aquifer properties.

The results of a sensitivity analysis of the United States Geological Survey (USGS) 2-Dimensional Finite Difference Model are presented in this paper. This model is capable of predicting the movement of non-reactive contaminants in aquifers, given the location and strength of the source and aquifer properties. The details of the model and the numerical schemes used are described in ref. 3. Sensitivity is defined here as the change in the outcome of the model due to a unit change in the parameter. A hypothetical contamination situation of transport of chlorides through the West Fargo aquifer near the Old Fargo landfill was used for this study. Chloride was chosen because of its non-reactive property. Sensitivity of the model was studied in relation to transmissivity (T), longitudinal dispersion (D_L) and ratio of transverse to longitudinal dispersion (D_T/D_L) of the aquifer. Realistic values of T, D_L and D_T/D_L applicable to West Fargo Aquifer were used (5).

Results indicated T as the most sensitive parameter. D_L and D_T/D_L were sensitive only at high values of transmissivity. There was considerable variation of sensitivity temporally and spatially (6). The changes that would result in the model-predicted concentration levels due to a 10% error in estimating T, D_L and D_T/D_L are given in Table 1. For D_L and D_T/D_L, a 10% error is the least that can be expected in estimating them. The changes in predicted values given in Table 1 refer to the change in concentration of chloride at a point 570' downgradient from the center of the source after 5 years of contamination.

Table 1. Sensitivity of the Model to the Parameters

Parameter	Estimated Value	%error in the parameter	Change in predicted value mg/1 and %
T	0.232 ft^2/S	+10	36.0 (9.2%)
D_T/D_L	0.3	+10	-5.7 (1.4%)
DL	100	+10	-6.5 (1.6%)

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(13) COMPLEXED METAL ION BINDING TO POLY(ACRYLIC ACID) (PAA). A SIMPLE MODEL FOR IN VIVO METAL ION BINDING.

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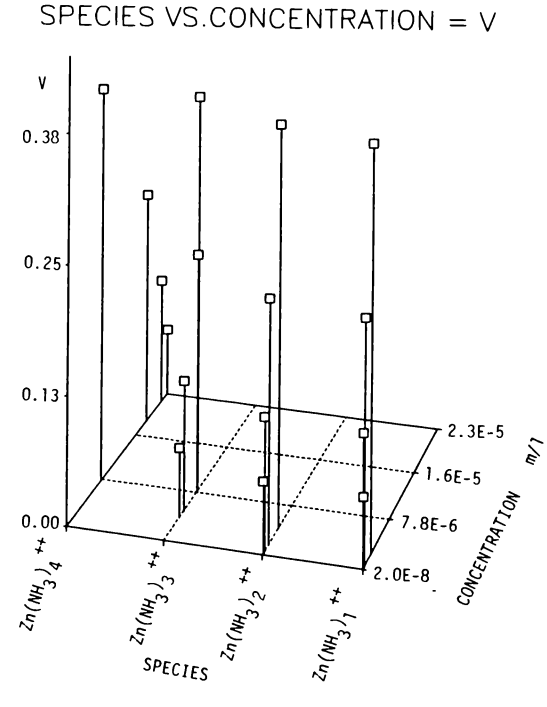
The interactions between water-soluble polyelectrolytes (Pe) and small-molecule cosolutes are biochemically and pharmaceutically important.

From a biochemical standpoint, many reversible binding complexes between biopolymers and small-molecule cosolutes are formed in living systems. They include enzyme/substrate, enzyme/inhibitor, hemoglobin/oxygen, serum proteins/metal-ion systems and others.

In pharmaceutical applications, Pe/cosolute interactions can precipitate a drug to render it biologically inactive, reduce its activity by complexation or increase its solubility and provide a reservoir from which it can be slowly released.

Synthetic Pe provide a simple model system to study Pe/cosolute interactions. In this research modified gel chromatography was used to measure Pe/metal-ion interactions. The technique has been used by others to determine metal-ligand binding constants (1). The Pe is chromatogramed on a gel column with an eluant that contains the metal ion, or the metal ion complex to be studied. As the large Pe migrates down the column, it binds metal from the eluant until its equilibrium binding potential has been met. At the exit port of the column, the metal ion concentration is monitored by Atomic Absorption Spectrophotometry. A peak in the base line metal concentration signifies one or more metal species binding to the Pe. The peak area is approximated using Simpson's Rule, and this number can be converted to the moles of zinc bound to the Pe. The moles of Pe and moles of zinc bound are used to calculate V, the moles of zinc bound per site. V, and its relationship to species concentration has been determined for a zinc-acetate system, and a zinc-amine system using PAA as a model Pe. Results for the acetate system were obtained by increasing Zn(II) concentration. These results show the log K° by Scatchard's method for free Zn(II) binding to PAA is 3.52. Similar results for poly(methacrylic acid) have been reported at log K° = 3.95 (2). The major zinc species in the acetate system was hydrated Zn(II).

The amine system is much more complicated, it contains four zinc-amine species. V's for the PAA/zinc-amine system were measured by varying pH between 8.5 and 10.0, keeping zinc and ammonia concentration constant. This varied the concentration ratio of the four zinc amine species. The figure below graphically represents the effect that species concentrations have on V. As the zinc tetramine concentration increases, V decreases, therefore, it is not bound to PAA. The zinc mono-, di-, and triamine concentrations all increase as V increases, but the diamine concentration increase (16.4 times) best explains the increase in V (5.82 times). Therefore, the zinc diamine is the major species bound to the PAA. The monoamine concentration increase (115 times) and the triamine concentration increase (2.2 times) do not parallel the increase in V as well as the zinc diamine.



An initial estimate of log K° for the zinc diamine binding to PAA is 5.8, 2 orders of magnitude greater then free zinc's binding constant, determined eariler. This clearly shows that Pe/metal-ion interactions are very complicated, and if meaningful binding constants are to be obtained, the form of the metal-ion on the Pe must be known.

This work was supported by two Johnson Wax Fund, Inc., Fellowships awarded to R.W. Ames.

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(14) STEROID PULSE RESULTING FROM INDUCED INFLAMMATION

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The timely release of the glucocorticosteroids by the adrenal cortex in response to an inflammatory agent is an essential key in understanding inflammation. These initial experiments have led us to propose the existence of a neuroendocrine control of inflammation. Ultimately these studies are leading the way for the development of new therapies in treating inflammatory-related diseases [1].

If there is a neuroendocrine control mechanism of inflammation, there should be a glucocorticosteroid response to an inflammatory agent. Consequently, the concentration of corticosterone was measured in rat blood plasma after an injection of carrageenan into the rat's paw. Corticosterone is the principal glucocorticosteroid in rats. The steroid concentration was measured using radioimmunoassay (RIA) [2].

A volume of 0.1 ml of carrageenan solution was injected into normal rats (32) Male Sprage Dawley Hap:(SD)f rats, weighing 220 to 250 grams. Each rat was anethesized. Blood samples were taken from the heart and collected with heprinized equipment. To remove the red blood cells, the samples were centrifuged and then frozen until use. The samples corresponding to the same elapsed time after injection of carrageenan were pooled. The pooled samples were diluted and run through the radioimmunoassay. The concentration of corticosterone versus time elapsed after carrageenan injection was plotted (Fig. 1). The data is consistent with the hypothesis of the neuroendocrine system controlling the inflammatory response.

From earlier data, the carrageenan-induced inflammation in hypophysectomized rats was more intense and persistent than in control rats. Although the hypophysectomized rats would not be affected by the stress of handling for lengthy periods of time, the control rat might, (Fig. 2). If this stress were eliminated, the curve of the control rats might look more like that of the hypophysectomized rats.

The paw volume of control rats (37) were measured with a plethysmograph [3,4]. Each rat was injected in the right hind paw with a 0.1 cc aliquot of a 1% suspension of carrageenan in a 0.85% saline solution. After a specific duration of time, each rat was measured only once more with the plethysomograph. The average percent increase in paw volume was graphed with the actual range of values shown, (Fig. 2). Thus, the original data was validated and hypophysectomized rats do indeed swell more intensely and for a longer duration of time to a carrageenan injection than control rats do.

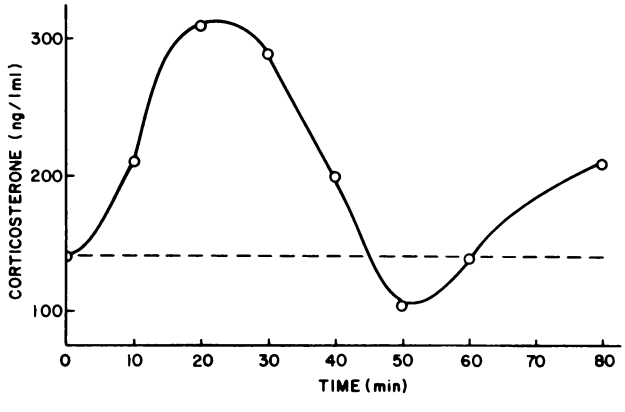

Fig. 1 Corticosterone Concentration in Rat Blood Plasma Caused by Carrageenan.

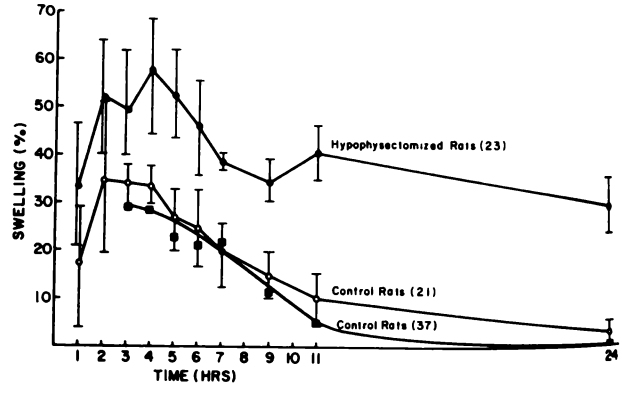

Fig. 2. Rat Paw Swelling Caused by Carrageenan.

ACKNOWLEDGEMENTS: This work was supported in part by the Faculty Research Fund of the University of North Dakota. We gratefully appreciate the assistance given by J. Hapenau, Dr. S.S. Parmar and Dr. K.J. Lee.

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(15) SECONDARY AMINE NUCLEOTIDE LINKAGE

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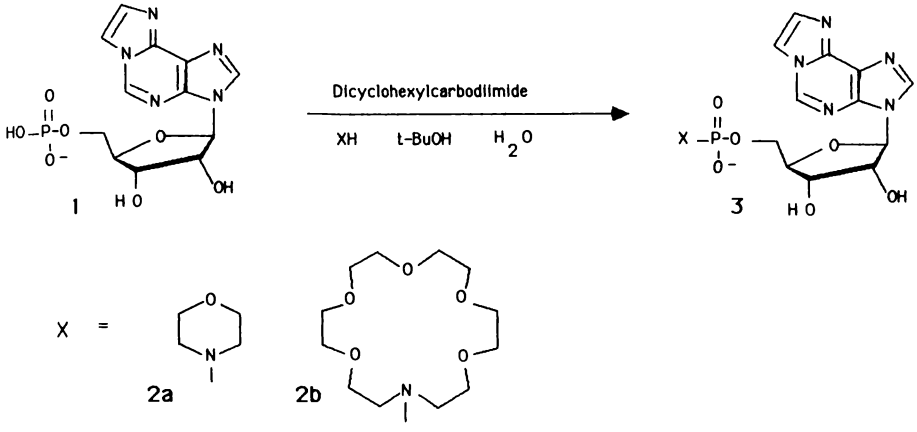
A model system connecting a lipophilic unit to a nucleotide will be used to study the feasibility of nucleotide transport through a biological membrane. The nucleotide linkage is designed to bury the anionic phosphate group within a lipophilic environment on passage through a lipid bilayer. A linkage was chosen that would cleave either by enzymes catalysis or chemically inside the cell milieu. The synthesis of the primary target molecule, a secondary amine-linked ε-adenosine 5'-monophosphate, 3, is illustrated in scheme A.

Scheme A



The crown ether molecule, 2b, monoaza-18-crown-6, was prepared by a convergent approach in a series of nucleophilic substitution reactions (1,2). Tetraethylene glycol bis-ditosylate isolated as a viscous yellow oil from a reaction between tetraethylene glycol and p-toluenesulfonyl chloride in pyridine medium, was combined with N-benzyl-diethanol amine and sodium hydride in THF to yield N-benzyl-aza-18-crown-6. Catalytic hydrogenation of the crown ether over palladium/carbon afforded the free ligand, 2b, in about 50% yield. The fluorescent nucleotide analog, ε-adenosine-5'-monophosphate (ε-AMP), 1, was constructed by reaction of adenosine-5'-monophosphate and aqueous chloroacetaldehyde. Thin layer chromatographic (tlc) analysis showed complete conversion of the starting material to 1.

The final linkage of the morpholine or the crown ether moiety to the phosphorus of ε-AMP was done by adopting the experimental procedure (3) described by J.G. Moffat and H.G. Khorana for reaction of 5'-AMP. In the presence of N,N'-dicyclohexylcarbodiimide, ε-AMP reacted with amine 2 to give compound 3. Preparative anionic exchange chromatography (DEAE Sephadex, triethylammonium bicarbonate gradient elution) allowed separation of the product 3 from the starting material 1. An alternative method (4) for the synthesis of 3a required reacting triphenylphosphine and dipyridyl disulfide with 1 and morpholine 2a.

The reaction progress of the aforementioned synthetic routes was monitored by tlc. Structures of products and intermediates were characterized by appropriate spectroscopic means including ^1H NMR, IR and ^{13}C spectra. In the ^1H NMR spectrum the two methylene groups adjacent to the nitrogen in the secondary amine component of the product 1 showed a triplet at 3.10 ppm. However, the corresponding methylene protons in the starting aza-18-crown-6 gave a triplet at 2.80 ppm. This shift confirmed formation of the P-N bond.

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(16) A REVISION OF THE GENERA COPABLEPHARON AND PROTOGYGIA (LEPIDOPTERA: NOCTUIDAE)

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The genera Copablepharon Harvey and Protogygia McDunnough were proposed before the advent of modern taxonomic tools such as cladistic and anagenic analysis, (1) and before the importance of internal reproductive structures was fully recognized for the classification of Lepidoptera (2).

Copablepharon was proposed for Ablepharon absidum Harvey in 1878 (3). As of 1983, there were 12 known species in the genus (4). Protogygia was proposed in 1929 for a group of 8 species, the type being Agrotis lagena Grote (5). Currently, 9 species have been assigned to it (4). These 2 genera have been placed in different tribes, but both possess characters such as a coiled vesica and sclerotized strap along the vesica which indicate a closer relationship. This study was undertaken to clarify the relationship.

Both cladistic and anagenic analyses were utilized to evaluate the problem. Cladistic analysis establishes nested sets of synapomorphic signifer states (shared derived characters) to produce a cladogram. Anagenic analysis entails weighting signifer states by the number of subtended taxa and by the inverse of the number of times the state occurs on the cladogram such that the occurrence of each signifer state and of all internodal distances sums to unity. The resultant phylogram then illustrates the evolutionary distance between taxa.

Originally 19 signifers were examined and placed in plesiomorphic (primitive) to synapomorphic sequences. Two characters were later discarded: harpe length and harpe orientation were redundant, while noctuoid pattern development could not be scored due to parallelisms.

The most important characters were: clavus development (CLD), harpe orientation (HAO), uncus shape (UNS), uncus length (UNL), and valve shape (VAS).

Sequences were determined by comparison to a paraphyletic taxon, the outgroup. The outgroup for this work was the genus Agrotis Ochsenheimer. Representatives of 14 other genera were dissected and characterizations from the literature of an additional 11 genera were also considered in choosing the outgroup.

Anagenic analysis has revealed four species groups. Group 1 is nominate Protogygia, which contains 2 species. Group 2 is nominate Copablepharon, which includes 13 species. Group 3 contains 5 species of "aberrant" Copablepharon and Protogygia. Group 4 contains only P. milleri (Grote). This species has not been placed on the cladogram (Fig. 1) because it is not a cladistic member of the holophyletic group to which Protogygia, Copablepharon, and their sister taxon Feltia Walker belongs. Four species of Protogygia were not yet available for examination.

Each species group is of generic rank since any definition for a single broadly construed genus would, at least, include Feltia.

Conclusions: A. Protogygia has been previously misassigned to the tribe Aniclini. It will become a member of the Agrotini. B. Both Copablepharon and Protogygia are at least diphyletic. C. this complex consists of 4 genera, 2 of which are undescribed. D. In the course of this work 4 undescribed species have been discovered.

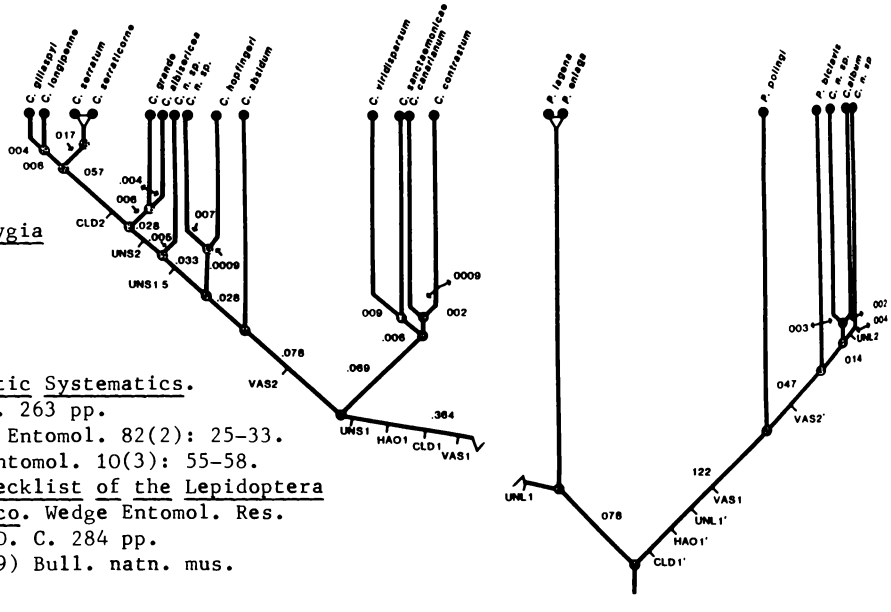

Fig. 1. Cladogram of the Copablepharon - Protogygia complex.

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THE EFFECTS OF 6-DIAZO-5-OXO-L-NORLEUCINE (DON) ON IN VITRO DEVELOPMENT OF THE OTIC PLACODE IN THE CHICK

(17)

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Surface coat material (SCM) composed of glycoconjugates has been demonstrated at apical cell surfaces of epithelia during several key morphogenetic events such as: gastrulation; neural tube formation; invagination of the otic, lens, and nasal placodes; and palatal shelf closure (1). It has been suggested that the SCM mediates the invagination, adhesion, and subsequent fusion of epithelial surfaces during morphogenesis (2, 3).

The otic placode (presumptive inner ear) develops as a thickening of the surface ectoderm overlying the hindbrain. The experiments currently reported were performed to test the role of SCM associated with normal otic placode invagination in vitro. The specific aim was to prevent or reduce SCM synthesis by exposing embryos to 6-diazo-5-oxo-L-norleucine (DON), a glutamine analog which inhibits glutamine transfer reactions and thus suppresses synthesis of glycosaminoglycans and glycoproteins (4). Chick embryos (stage 11-14; 40-53 hours) were removed from eggs and the portion caudal to the heart was removed from each embryo by transection. Control embryos were placed in Eagle's minimal essential medium; experimental embryos were placed in the same medium containing DON (85μg/ml). Culture dishes were then placed in a CO_2 incubator (95% O_2, 5% CO_2) at 37°C for periods ranging from 6-30 hours. The embryos were then removed from the incubator, rinsed of any remaining medium and prepared for scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

Specimens for SEM were fixed in 0.2 N cacodylate buffered 2% glutaraldehyde with or without the addition of 0.5% cetylpyridinium chloride (CPC). CPC precipitates polyanionic substances, including glycoconjugates of the SCM, and prevents their extraction during fixation. TEM specimens were fixed in cacodylate buffered 1.25% glutaraldehyde with or without the addition of 4500 ppm ruthenium red (RR). RR binds nonspecifically to polyanions and allows their visualization in TEM.

An SEM analysis of CPC-precipitated SCM glycoconjugates on the cultured otic placodes revealed little difference in SCM production between DON-exposed and control embryos. TEM evaluation showed RR staining only on control embryos, with no detectable stain on DON-cultured placodes (Table I). The adjacent normal surface ectoderm possessed less SCM as revealed by both RR and CPC. In addition, exposure to DON did not inhibit otic placode invagination in culture, although the embryos did appear to require approximately 6 hours to equilibrate and their subsequent growth was retarded under in vitro conditions. Despite the differences in SCM localization using RR and CPC, culture with DON had no apparent effect on the ability of the otic placode to invaginate. These data suggest that although increased amounts of SCM are associated with the developing otic placode it does not appear to directly support the process of epithelial invagination.

TABLE I.	CPC/SEM		RR/TEM	
	DON cultured	controls	DON cultured	controls
Otic placode precipitate	+++	++++	0	+++
Surface ectoderm precipitate	+	++	0	+
Inhibition of invagination	0	0	0	0

Table I. Relative effects of DON on otic placode invagination and ectodermal SCM production.

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(18) COMPARATIVE STUDIES OF THE METAL ACTIVATION OF THE CYTOPLASMIC AND MITOCHONDRIAL FORMS OF PHOSPHOENOLPYRUVATE CARBOXYKINASE IN RABBIT LIVER

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The cytoplasmic and mitochondrial isozymes of phosphoenolpyruvate carboxykinase (PEPCK), found primarily in liver and kidney, catalyze the reversible reaction:

$$OAA + GTP \text{ (or ITP)} \longleftrightarrow PEP + GDP \text{ (or IDP)} + CO_2$$

The forward reaction is an essential component of the gluconeogenic pathway. Whether the reverse reaction is important *in vivo* has yet to be determined. Considerable evidence indicates that the PEPCK isozymes are different proteins originating from different genes (1). The short term regulation of the PEPCK isozymes is not well understood but evidence points to a regulatory role for divalent cations. In addition to Mg(II) which serves to complex with the nucleotide, micromolar concentrations of a second activating cation appear to be necessary for maximum activity with Mn(II) or Fe(II) being the chief contenders for the role of physiological activator (2). It is the purpose of this research to compare the effects of metal activation on the forward and reverse reactions of cytoplasmic and mitochondrial PEPCK purified from rabbit liver.

The standard spectrophotometric assays used to measure PEPCK activity cannot be used in iron activation studies because iron absorbs at 340 nm. We therefore developed a new method of assaying PEPCK. This method relies on the separation of IDP and ITP by reverse phase high pressure liquid chromatography (HPLC) and the resulting assays for PEPCK are linear up to a 15% conversion of IDP to ITP and a 30% conversion of ITP to IDP. The metal activation assays were performed at 30°C. The assay mixture for the forward reaction contained in a 0.5 ml volume 50 mM Hepes/NaOH, pH 8.0, 2 mM ITP, 2 mM $MgCl_2$, 1.5 mM OAA, 0.8 mM DTT and variable micromolar concentrations of $FeCl_2$ or $MnCl_2$. The assay for the reverse reaction contained 110 mM Imidazole/HCl, pH 5.8, 45 mM $NaHCO_3$, 2 mM PEP, 1 mM IDP, 2 mM $MgCl_2$, 0.8 mM DTT and variable micromolar concentrations of metal at a final pH of 6.8. The reaction was initiated by the addition of enzyme followed immediately by the activating metal and terminated after 3 to 7 minutes by the addition of 1.2 M formic acid to give a final concentration of .05 M. This dropped the pH to approximately 3.5 and effectively stopped the reaction. IDP and ITP were eluted isocratically from a Beckman Ultrasphere-IP reverse phase column in the presence of the ion pairing agent tetrabutylammonium phosphate. The HPLC system was interfaced to an Apple IIe computer fitted with a program which allowed for the integration of peak areas.

In the forward direction both PEPCK isozymes exhibited substantial activity with Mg(II) as the sole cation. The addition of 10 μM Mn(II) to cytoplasmic PEPCK activated the enzyme 2.5 fold. The maximum activation was 2.8 fold at 25 μM and remained steady thru 200 μM Mn(II). Activation with Fe(II) was lower than with Mn(II). At 10 μM Fe(II) the activation was 1.2 fold and maximum activation was seen at 150 and 200 μM Fe(II) with 1.7 fold activation over the basal Mg(II) rate. Mitochondrial PEPCK responded to activation with Mn(II) with a maximum 1.4 fold activation while Fe(II) slightly inhibited activity. In the reverse direction both isozymes exhibited very low activity in the presence of Mg(II) alone. Micromolar concentrations of Fe(II) or Mn(II) added to the assay resulted in maximal 70 to 80 fold activation. Plots of activity versus metal concentration yielded sigmoidal curves with a lag in activation at the lower metal concentrations for cytoplasmic PEPCK and hyperbolic curves with no lag for mitochondrial PEPCK. Half maximal activation was reached at 2 and 25 μM Mn(II) with mitochondrial and cytoplasmic PEPCK, respectively. With Fe(II) half maximal activation was achieved at 25 and 50 μM with mitochondrial and cytoplasmic PEPCK, respectively.

At optimal conditions, the ratio of the rates of the forward to the reverse reaction was 1.6 for mitochondrial PEPCK and 11.1 for cytoplasmic PEPCK, indicating that mitochondrial PEPCK is more easily reversible than cytoplasmic PEPCK. The difference in the response of the PEPCK isozymes to low micromolar concentrations of Mn(II) or Fe(II) contributes to the difference in their reversibility. In the forward reaction cytoplasmic PEPCK is more responsive than mitochondrial PEPCK to low micromolar concentrations of Fe(II) or Mn(II) whereas in the reverse reaction the mitochondrial isozyme is more responsive.

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(19) PLASMID DIVERSITY IN NORTH DAKOTA STRAINS OF *RHIZOBIUM PHASEOLI*, THE SYMBIOTIC DINITROGEN-FIXING BACTERIUM OF BEANS

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Nitrogen must be supplied to plants as nitrate or ammonia. In nitrogen-poor soils, these forms of nitrogen are often added via costly commercial fertilizers which require enormous amounts of natural gas for their industrial synthesis. Biological nitrogen fixation also makes nitrogen available to plants. *Rhizobium phaseoli* symbiotically fixes atmospheric dinitrogen while living within root nodules of the bean plant, *Phaseolus vulgaris* L. Previous work has shown that genes for nitrogen fixation (*nif* genes) in *R. phaseoli* reside on large extrachromosomal DNA molecules called plasmids (1). Further investigation of the genetics of the symbiotic association may provide knowledge that will allow us to improve the effectiveness of the *Rhizobium*-legume symbiosis.

In this study, 17 *R. phaseoli* strains from uninoculated North Dakota bean cultivars were examined for plasmid content by an in-gel lysis technique (1). Then, plasmids in the agarose gels were denatured and electrophoretically transferred to nylon membranes. Plasmids containing *nif* genes were detected by DNA-DNA hybridization using a biotinylated *nif* probe; the probe, plasmid pRmR2, is a recombinant DNA molecule containing cloned *nif*KDH genes of *Rhizobium meliloti* (2).

The results in Table 1 show that each indigenous strain had at least three large plasmids, with sizes ranging from 65 to >700 megadaltons (Md). One strain contained nine plasmids, one had eight plasmids, and three strains each carried seven plasmids; the greatest number of plasmids for any *Rhizobium* strain described in the literature is six (1). One plasmid per strain, 190 to 260 Md in size, hybridized to the biotin-labeled *nif* probe. Similar hybridization results have been obtained by others for different rhizobia using ^{32}P-labeled *nif* probes (1).

Table 1. Plasmid sizes and *nif* gene locations

Strain	Estimated plasmid sizes (megadaltons)
ND101	135, 255[a], >700
ND111	75, 130, 150, 175, 210[a], 315
ND201	125, 160, 220[a], 300, 340
ND311	85, 120, 150, 185, 220[a], 305, 355
ND312	85, 160, 185, 205, 235[a], 325, 510
ND401	125, 155, 245[a], 355, 450
ND402	65, 250[a], 290, 630
ND411	80, 85, 130, 140, 150, 195, 225[a], 280, 325
ND801	135, 180, 210[a], 255, 520
ND802	130, 260[a], 300, 370, 425
ND803	90, 225[a], 270, 690
ND804	65, 135, 150, 205, 260[a], 270, 310, 440
ND805	85, 120, 145, 225[a], 265, 290
ND806	80, 190[a], 260, 620
ND807	80, 140, 215[a], 265, 650
ND808	100, 160, 225[a], 310, 685
ND810	90, 125, 155, 180, 240[a], 305, 360

[a]Hybridized with *nif* probe pRmR2

R. phaseoli plasmid profiles seem to be strain-specific and may allow for differentiation between indigenous rhizobial strains and inoculant strains. The use of biotin to label probes, besides being safer, is ultimately less expensive and faster than the use of radioactivity. This relatively new method may allow increased use of DNA-DNA hybridization techniques, especially for identification of rhizobia, because specialized radioisotope equipment and training are not needed. Plasmid profiles and *nif* gene locations, therefore, have revealed remarkable diversity in this agriculturally important bacterium.

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(20) FACILILATORY MEDIATION OF SEROTONIN IN ANTICONVULSANT ACTIVITY OF DIPHENYLHYDANTOIN

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Convulsions demonstrate an involvement of neurotransmitter activity (1,2). An alteration of this activity modifies or prevents the induction of convulsions. Neurotransmitters are proposed to be mediators of anticonvulsant compound activity (3). We have earlier demonstrated a role for serotonin (5-hydroxytryptamine) on anticonvulsant activity of benzodiazepines in a pentylenetetrazol model of convulsions (4).

This study continues our evaluation of serotonin as a mediator for anticonvulsant activity of 5,5-diphenylhydantoin (DPH, phenytoin) in a Maximal Electroshock Seizure (MES) model.

Male ICR white mice in groups of ten and weighing 25-35 g were used in these experiments. The anticonvulsant activity of DPH was determined by intraperitoneal (ip) injection of DPH in doses of 1.4 mg/kg, 2.7 mg/kg, 3.9 mg/kg and 8.1 mg/kg followed by MES test and observance of specific seizure activity.

The role of serotonin as a mediator of anticonvulsant activity of DPH was evaluated by pretreatment of mice with agents known to selectively affect the central nervous system activity of serotonin. Following DPH administration the MES test was again applied and seizure activity was observed. The serotonergic altering agents alone were found to provide no protection from convulsions. The percent protection was determined for all groups with occurance of seizure recorded only if hind limb extension was observed. Dose-response curves were generated and the dose providing 50 percent protection (ED_{50}) was determined for groups receiving only DPH (control) and those receiving a serotonin altering agent and DPH prior to MES (Table I).

Pretreatment with agents known to increase serotonergic acitivity like tryptophan (100 mg/kg, ip, 1 hr), 5-hydroxytryptophan (50 mg/kg, ip, 2 hr) or p-chlorophenylalanine (50 mg/kg, ip, 2 hr), decreased ED_{50} value of DPH and thus reflected an increase in anticonvulsant activity of DPH. Pretreatment of mice with p-chlorophenylalanine (300 mg/kg, ip, 48 hr) or methysergide (10 mg/kg, ip, 0.5 hrs), known to decrease serotongeric activity, resulted in increased ED_{50} values for DPH and indicated decrease in anticonvulsant activity of DPH.

Table I

Treatment[1]	Anticonvulsant Activity of Diphenylhydantoin Percent Protection[2]	ED_{50} (mg/kg)[3]
DPH	81	4.83
DPH+tryptophan	90	4.33
DPH+5-hydroxytryptophan	100	3.68
DPH+p-chlorophenylalanine-2 hr	95	4.72
DPH+p-chlorophenylalanine-48 hr	85	5.98
DPH+methysergide	64	6.64

[1]Pretreatment was carried out as described in the text.
[2]Percent protection provided by 8.1 mg/kg 5,5-diphenylhydantoin.
[3]ED_{50} values were determined from dose-response curves.

The results have provided evidence for the facilitatory role of serotonin in the anticonvulsant activity of DPH and that increase in serotonergic activity enhances anticonvulsant activity which was reflected by decreased ED_{50} values.

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(21) SYNTHESIS OF FLUORESCENT NUCLEOTIDE INSERTANES AS FACILITATORS OR PROBES FOR CELL MEMBRANE TRANSPORT

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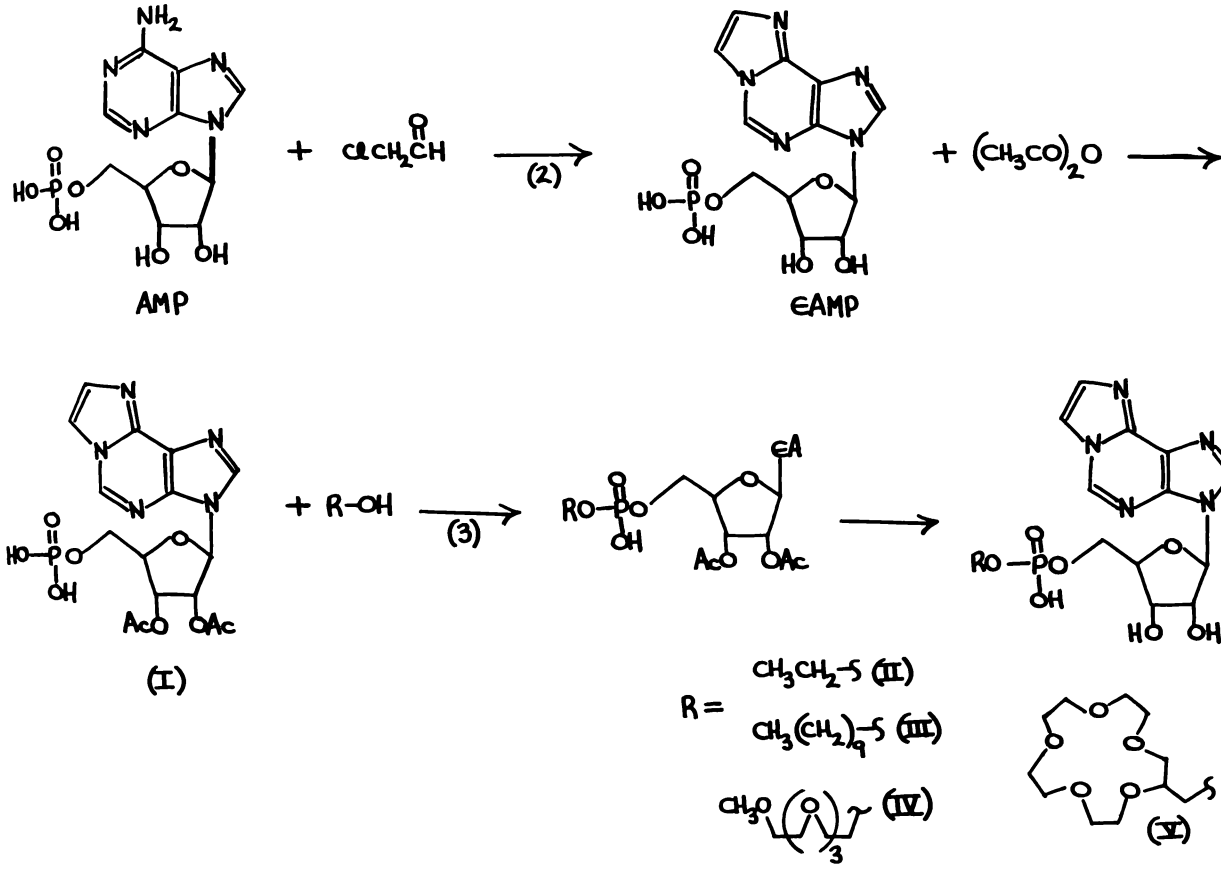
The goal of the study is to create molecular structures to facilitate the transport of biologically significant molecules across cell membranes. Specifically, we focus on the problems of transporting modified nucleotides by linking them to a series of molecules that are rapidly incorporated into cellular lipid bilayers.

Some of the exploratory chemistry, as illustrated below, is concerned with crown ether linked nucleotides. A number of nucleotide insertanes (II,III,IV,V) are being synthesized in order to test for which is the best linkage to phosphorus and optimum phosphate masking group. Overall yields are about 30% after purification beginning from adenosine 5'-monophosphate (AMP) via intermediate (I).



A general contribution to biological transport problems is being made. Our approach, even if limited to nucleotides, may point the way for others to follow since the development of an effective method to rapidly insert normally non-transportable nucleotides into cells may have profound implications for chemotherapy by nucleoside and nucleotide analogues.

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(22) SEDIMENTOLOGY OF BOULDER GRAVELS DEPOSITED BY FLOODS FROM GLACIAL-LAKE OUTBURSTS

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In the northern Great Plains, where the trend of pre-Pleistocene drainage paths was to the northeast, glacial meltwater ponded along the southern margin of the Laurentide Ice Sheet forming large glacial lakes. The dynamic nature of the glacial environment made these glacial lakes highly unstable and, as a result, catastrophic drainings of glacial lakes was common. Complete drainage of these lakes occurred within weeks and caused discharges in excess of 10^5 m^3/s (1). The erosional power of the glacial-lake outbursts was tremendous: huge spillway valleys, over 1 km wide and 80 m deep, were created in a geologic instant. The outburst floods are manifested not only as trench-shape valleys, but also as huge boulder-gravel bars; these bars are relatively scarce due to the erosive nature of the discharges.

The Souris, Des Lacs, and Moose Mountain spillways, located in north-central North Dakota and southeast Saskatchewan, formed from the catastrophic drainage of glacial lakes. Boulder-gravel bars deposited by these floods generally formed at two locations within the spillways: 1) at the inside of meander bends, and 2) adjacent to landslide deposits in the valley sides. The landslides were triggered when rapid incision of the spillways, by the outburst discharges, reached the till-bedrock contact.

The bars present at the inside of meanders are similar to gravel bars in the Channeled Scabland that formed as a result of very deep, turbulent catastrophic dischages from glacial Lake Missoula (2). The bars that are located adjacent to landslides formed as landslide debris was removed by erosion; this process caused channel widening, flow-velocity reduction, and finally, gravel deposition.

The external dimensions (~1 km length; ~30 m thick) and internal structures of both bar types are very similar. The bars consist of homogeneous masses of structureless, very poorly sorted cobble gravel and contain boulders up to 3 m in diameter. Individual gravel bars exhibit a decrease in maximum grain size in the downstream and spillway-side directions (approximately a 60% decrease per km). Between bars, however, there is no decrease in the maximum grain size in the downstream direction; 3 m boulders have been observed in flood deposits at Elcott, Saskatchewan and Minot, North Dakota which is 160 km downstream. This pattern demonstrates little loss of flow energy and is characteristic of nonaggradational fluvial systems.

An objective of this study was to determine the hydrodynamic character of the outburst-flood discharges; this was primarily accomplished by analyzing the flood deposits in order to interpret the mechanics of sediment transport and deposition. Within the flood deposits, the boulders and cobbles are supported by sand and pebbles; this characteristic, coupled with the structureless, homogeneous, poorly sorted nature of the flood deposits require that all the sediment was deposited simultaneously and that no sediment, once deposited, was re-entrained into flow. Simultaneous deposition of sediment is most likely when particles are deposited from suspension; sediments deposited from bedload lead almost invariably to some type of bedding structure.

It is, therefore, hypothesized that all particles in the flood deposits, including the boulders, were transported suspended in the outburst discharges for relatively long distances high above the channel bottom. The presence of fragile clasts in the flood deposits, including of chunks of clay, till, and lignite, support this interpretation because it is unlikely that they could have survived bedload transport where particles are continually impacted and abraded. Suspended load transport of boulders is also corroborated by a theoretical study (3), which demostrated that the dimensionless shear stress required to transport boulders in suspension is equal to that required for coarse sand. From this work, it may then be shown that a boulder 1 m in diameter would require a shear stress of appoximately 130 kg/m^2 to remain in suspension. While the value is high, it is not unattainable; values of this magnitude have been suggested for several Pleistocene floods (2).

In summary, glacial-lake outburst floods were common and had tremendous erosional power. Flood discharges transported most all material eroded in suspension and, where deposition was triggered by flow expansion, formed huge bars of poorly sorted cobble gravel.

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White Grubs (Coleoptera: Scarabaeidae: Phyllophaga spp.) Attacking Corn in Southeastern North Dakota: Adult Emergence Patterns

(23)

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Larvae of the genus Phyllophaga (Coleoptera: Scarabaeidae) are commonly referred to as white grubs. The C-shaped larvae inhabit the soil and feed on the roots of grasses and other plants. They can be very destructive to lawns, pastures, and crops such as corn, small grains, strawberries, and potatoes (1). The adults, or June beetles, feed at night on foliage.

In 1984 economic infestations of third instar larvae were detected in three fields in Southeastern North Dakota. Representatives were identified as Phyllophaga implicita (Horn). P. implicita has not been a commonly reported pest of corn in North Dakota, although preliminary studies had suggested that this was one species of a white grub complex associated with corn (2).

Species determination is more difficult using larvae than adults, so a two year trapping study was initiated to confirm which species of Phyllophaga were attacking corn. The trapping was conducted in five corn fields in Richland and Ransom counties of North Dakota, using Japanese beetle and ultraviolet light traps.

The Japanese beetle traps were suspended two feet above the soil surface in weedy margins of corn fields. They were placed in the field on May 11, 1984 and May 5, 1985. Four lures were used in the Japanese beetle traps: caproic acid, valeric acid, Japanese beetle pheromone lure, and Japanese beetle floral lure. Each lure was replicated twice along each field margin. The lures were replenished and traps emptied weekly in 1984. Due to the heavy emergence in 1985, it was necessary to empty the traps twice weekly. The beetles were returned to the laboratory and identified using the genital structure (3). Adults were collected from May 9 to July 26, with 66% (3473) of the beetles collected from May 20 to May 28, 1985.

Over both years, a total of 5302 Phyllophaga implicita were collected in the Japanese beetle traps. Of the lures, Japanese beetle floral lure captured 51.5% (2732) of the beetles, while Japanese beetle pheromone, valeric acid, and caproic acid captured 21.3% (1130), 16.1% (854), and 11.0% (586), respectively. Other Phyllophaga spp. collected included 14 P. anxia (LeConte), 10 P. rugosa (Melsheimer), 5 P. tristis (Fabricius), and 1 P. fusca (Froelich).

Of the 5302 P. implicita collected in the Japanese beetle traps, 65.1% (3449) were males and 34.9% (1853) were females. Initially males were much more common, comprising 85% of those beetles collected over the first two weeks. However, on May 28, 1985, and on all collection dates from June 11 to July 26, 1985, more females were collected than males. In the last 3 weeks of trapping the collections consisted primarily of females (96%).

Ultraviolet light traps were used on four occasions in 1984 and once in 1985. The traps were utilized for several hours beginning at dusk. Beetles were hand picked from the ground in the vicinity of the light. In 1984 ultraviolet light trap collections were small, consisting of 12 P. implicita females, 4 P. implicita males, and 19 P. rugosa males. Collections in 1985 consisted of 625 P. implicita females, 163 P. implicita males, 7 P. rugosa males, and 1 P. anxia male. The sex ratio of P. implicita differed depending on the sampling technique. Females comprised 79.2% of the ultraviolet light trap collections and only 34.9% of the Japanese beetle trap collections. It is believed females are attracted to blacklight traps only after they have completed oviposition (4).

Lago (5) reported P. fusca, P. anxia, and P. rugosa to be the most abundant species in North Dakota based on diverse collections. Our study indicates that P. implicita is the predominant species emerging from corn fields in Southeastern North Dakota, comprising 99% of all adults collected.

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(64) JUNIOR HIGH/MIDDLE SCHOOL EARTH SCIENCE IN NORTH DAKOTA

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The National Science Commission on Precollege Education in Mathematics, Science, and Technology has echoed the concern of Presidents, the National Science Foundation, and many scientific societies in stating that it must be a primary national goal to strengthen elementary and secondary science and mathematics education in the United States. It is a crisis of national security and national scientific prestige. Young minds with the ability and the drive to become scientists are choosing other fields. They must experience the thrill of scientific discovery and the excitement of scientific research, certainly at the college level; but it needs to begin early at the junior high level or even in the elementary school. These problems are recognized within every major scientific society. Yet, sound and statistically accurate data are not available for all geographic regions and all areas of science. Mail questionnaire surveys provide a valid scientific methodology for unraveling questions about science. With funding from the National Science Foundation, the first professionally designed and scientifically administered national survey of secondary earth science meteorology/climatology is currently underway, an area where practically no data exists. This research is part of the NSF Meteorology-Climatology Project, a National Science Foundation Grant of the Department of Geography, University of North Dakota (1). Presented here is a model of teachers of junior high/middle school earth science in North Dakota, a model characterized by the state's rural nature and geography.

An eight page questionnaire was mailed in November, 1985, to all teachers of earth science in North Dakota according to a list furnished by the North Dakota Department of Public Instruction. In all, 49.3% of the 304 current science teachers responded to the survey. Questions about teacher, school, and community characteristics were included in the survey and provide a basis for a profile of earth science teachers in the state. North Dakota earth science teachers are four times more likely to be male. Their average age is 37.3, and they range from 23 to 62 years old. They have been teaching an average 13.2 years (range: 1-36 years), and they have been at their present school an average ten years. Academic backgrounds of teachers of earth science are quite diverse, some with majors in very unrelated non-science areas. By far the most frequent major is biology (32%), followed by general or composite science (15%), elementary education (12%), physical education (11%), earth science (9%), mathematics (7%), and chemistry (6%). Multiple majors and minors are a fairly popular trait with 46% of the teachers reporting two majors and 24% with two minors. Regional North Dakota colleges are the major supplier of teachers of earth science. Seventy-nine percent of North Dakota's earth science teachers received their degree from a North Dakota institution; 13% from Minnesota. Mayville State College leads the list of college where these degrees were obtained with 17.6% for the whole state and 23% in the eastern half of the state. This is followed by Valley City State (14.9%), NDSU (12.2%), Minot State (10.8%), Dickinson State (10.1%), and UND (7.4%).

The rural nature of North Dakota sets the character of its school with 75.5% of the responding teachers at schools in a rural or farming community. Consequently, these schools are small in size with 57.7% of 250 students or less. Thirty-one percent been between 251 and 650 students. Teachers in these rural schools are required to teach a range of science courses which explains the diversity of majors teaching earth science. These subjects include physical science where 45.9% teach at least one class in this subject, biology (40.5%), chemistry (39.2%), physics (25.0%), mathematics (13.5%), and social studies (9.5%). Earth science represents only a small portion of most teacher's load, 59% teach only one section and 18% teach only two sections. Diversity in the background of earth science teachers, combined with the range of courses taught, illustrate the extreme to which some districts must go to find a teacher who will be assigned the earth science classes. This creates an unstable situation; a fact supported by the withdrawal of 52 teachers and the addition of 75 new teachers to the Department of Instruction's current list of earth science teachers. When it comes to specific subject areas, such as meteorology/climatology, nearly fifty-nine percent evaluated their own background as adequate or poor. Despite the circumstances in which North Dakota earth science teachers operate, the survey results indicate a strong desire for self-improvement which is put into practice. Sixty-five percent took a college course in 1985, and 30% participated in a science workshop or took a science course in the last year. In North Dakota, science teachers must be generalists; this is a fact of demographics, geography, and economics. Science teacher preparation programs in North Dakota must recognize this fact and require coursework in all areas of science. In addition, extra educational and material support, such as the NSF Meteorology/Climatology Project, must be provided to assist in specific subject areas. It would also seem, according to the results of this survey, that regional North Dakota colleges are the key to this support of North Dakota science education because these are the institutions currently supplying the teachers.

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(65) The North Dakota Science Fair - Its' History and Survey of Participants

by D. R. Scoby and Linda S. Olson*

Since the North Dakota Science and Mathematics newsletter disbanded in 1981, North Dakota Science and Engineering Fair (NDSEF) finalists have not been recorded in any definitive publication. To faciliate this problem, a study was undertaken to compile a complete list of International Science and Engineering Fair (ISEF) participants from North Dakota, study their geographical distribution, and survey this group to determine benefits associated with participation in science fairs and whether this activity influences college and/or career choice. The study was also designed to write a historical development of the North Dakota Science and Engineering Fair.

Finalists' names and affiliated schools were obtained from the North Dakota Record (1), North Dakota Science and Mathematics Newsletters (2) and from the ISEF in Washington D.C. Subsequent phone calls were made to schools to obtain parents/relatives names and from these sources many of the finalists' addresses were made available. A questionnaire was developed and sent to 213 individuals and returned by 80% of the finalists. The results of the survey were analyzed with Telofax 2 software at North Dakota State University.

Most of the sample group have remained in North Dakota (42%), although 11% reside in Minnesota, 7% in California, 4% in Colorado, 3% in Washington, and 2% in Texas. Their professional statuses were divided into science and nonscience categories. Fifty-one percent chose science professions while 49% chose nonscience professions. Both those who volunteered and those who were required to participate in science fairs were asked to indicate whether they agreed, disagreed, or had no opinion about five benefits associated with participation in science fairs. The benefit that was agreed with most frequently was that of providing travel (97% of those required, 88.9% of those who volunteered). The challenge of a professionals' evaluation was agreed with by 83.7% of those required and 82.1% of those volunteering to do science projects. Poise with evaluators was agreed with by 86.0% of those required to do projects and 78.4% if those volunteering. Association with peers was a benefit agreed with by fewest of either group (62.8% of those required, 69.4% of those who volunteered). In both required and volunteer groups, of ISEF participants, science fair participation offered travel, poise, and the challenge of a professional appraisal. Other benefits included self-confidance/self esteem, development of research and experimental design skills, communication skills, and respect of peers.

North Dakota ISEF participants were found to be educated. Sixty-seven percent had earned a minimum of a Bachelors Degree, while 25% were enrolled in college persuing Bachelors, an well as graduate and professional degrees, as of 1985. Choice of college was indicated as not being influenced by science fair participation, while 73.5% of the respondents said career choice was influenced at least somewhat by science fairs. The value of science fair participation was rated high by 96.2% of all respondants, medium by 3.8% and low by 0.0%. All participants indicated that they would encourage their children or other students to participate in science fairs.

Personal contact was made with many of the individuals responsible for the success of the North Dakota Science and Engineering Fair. Their enthusiasm about this study reiterated many positive statements concerning this function. A 1968 finalist residing in Nebraska wrote, ". . . as a current rural elementary teacher, my students rated their previous science fair experience preferred to their track meet experiences." A 1964 finalist, living in Washington state adds, "It was clearly a highly rewarding experience - motivating me strongly to go to college. (It) gave me an awareness of career options."

Many prior finalists are still associated with fairs as judges, coordinators and parents. One gentleman, a 1955 and 1956 science fair participant who is employed by a pulp manufacturer, writes, "I've judged our local fairs . . . in Washington State (which are) not nearly as well-coordinated as North Dakota was in the early '50's when I attended two National Fairs."

It can be said without reservation, that this activity has many beneficial outcomes. A finalist currently residing in Alaska, writes, "Attending the National Science Fair was the highlight of 18 years of schooling. It was a big deal -- not only the fair itself, but the banquet and entertainment provided. Friends from across North Dakota were made . . . many lasting memories remain, both of projects and the traveling experience." An Albany, NY, resident and former 1966 finalist says, "It (science fair participation) was a rare and precious opportunity for a rural, isolated student to become exposed and involved in academics on a National/International level . . . (it) was a priceless, motivating event for me."

A newspaper publisher from Houston, Texas, who participated in science fairs in 1956, sums the whole affair up nicely. "My science fair experiences were all very positive. And even though I have not ended with a career in the science fields, I consider the learning, doing, and competing all helpful in my success as an adult."

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(66) THE MICROBIOLOGY OF TOPSOIL STORAGE AT A NORTH DAKOTA STRIPMINING SITE

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Stripmining for lignite coal in western North Dakota has disturbed many acres of land used for crop land or grazing. State and federal laws require that mined land be returned to original productivity levels. Early stripmining operations involved the storage of subsoil and topsoil haphazardly mixed together in a single pile. These spoil banks had properties very detrimental to plant growth and the original productivity of the site was not regained. Presently, topsoil and subsoil are stored in separate piles during the mining operation. When the coal has been extracted, these piles are respread over the site and revegetation is attempted. However, prolonged storage of topsoil in piles has been shown to adversely affect physical, chemical, and biological properties of the soil[1,2]. These changes can, in turn, affect plant growth in the soil. Since microbial populations participate in many nutrient cycles in the soil, it is important to study them in stored topsoil. The research presented here measures the effects of storage on soil enzymes and several microbial populations.

Topsoil pile R26T03 is located on the Baukol-Noonan Mine near Center, ND. This pile was formed in July 1983 and vegetative cover was established on the surface. Soil cores were obtained at the site in May 1984 and June 1985. Samples were taken from depths of 0-7.6 cm and 114-122 cm. Surface samples represent the microbial response to revegetation. The samples taken at depth show the effects of storage on microbial populations. If it is considered that the topsoil pile was essentially homogeneous at the time of formation, surface and depth samples can be compared to note the effects of revegetation and storage.

Table 1 summarizes the results obtained. Counts of bacteria and actinomycetes were similar in all samples, while fungi decreased with storage. Organisms important in the nitrogen cycle of soil are nitrite-oxidizing bacteria, ammonia-oxidizing bacteria, and nitrogen-fixing bacteria. Nitrite-oxidizing bacteria and ammonia-oxidizing bacteria decreased with storage of topsoil, but nitrogen-fixing bacteria were actually more numerous at a depth than at the surface of the pile. This unexpected result has been confirmed and similar situations were found at other topsoil piles (unpublished data). Preliminary investigation reveals many facultatively-anaerobic and spore-forming organisms.

Since there are many inherent difficulties involved in plate counting of soil bacteria, activity of soil enzymes is often a more accurate indication of the overall activity of microbial populations. Alkaline phosphatase and dehydrogenase measure microbial potential and biomass of the soil. The activity of both enzymes decreased at depth and showed further decline after 24 months of storage.

Vesicular-arbuscular mycorrhizae (VAM) enhance plant uptake of nutrients, especially phosphorus. VAM propagules were measured in a corn bioassay. Corn plants were grown in the soil sample, roots were stained and the percent infection was determined. VAM propagules decreased with storage, but increased at the surface due to continued vegetative growth.

The pH of the topsoil pile does not appear to be adversely affected by storage and has remained near neutrality.

Future research efforts in this area will involve determining what effect these altered microbial populations will have on the plant growth potential of stored topsoil.

Table 1. Baukol-Noonan topsoil pile # R26T03.

Sample Date	Depth	Bacteria	Fungi	Actinomycetes	Nitrite-oxidizing Bacteria	Ammonia-oxidizing Bacteria	Nitrogen-fixing Bacteria	Alkaline Phosphatase	Dehydrogenase	VAM	pH_w
	cm	# per gram soil						µg PNP/g	µg TPF/g	% infection	
May 1984	0-7.6	$36x10^6$	37,000	$6.3x10^6$	33,000	490	95,000	456	66	13	6.4
	114-122	$16x10^6$	1400	$2.0x10^6$	330	93	430,000	289	12	2	6.5
July 1985	0-7.6	$41x10^6$	170,000	$7.3x10^6$	21,000	1700	23,000	228	42	27	6.2
	114-122	$88x10^6$	2000	$4.0x10^6$	1100	330	460,000	164	6	3	6.7

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(67) Synthesis of Fluorinated Nucleotide Analogs

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The incorporation of fluorine into biologically important molecules often has a pronounced effect on *in vivo* activity. Nucleotide analogs in which difluoromethylene units ($-CF_2-$) are incorporated as *isosteric* replacements for oxygen on phosphorus may be biologically active as inhibitors of nucleic acid biosynthesis.

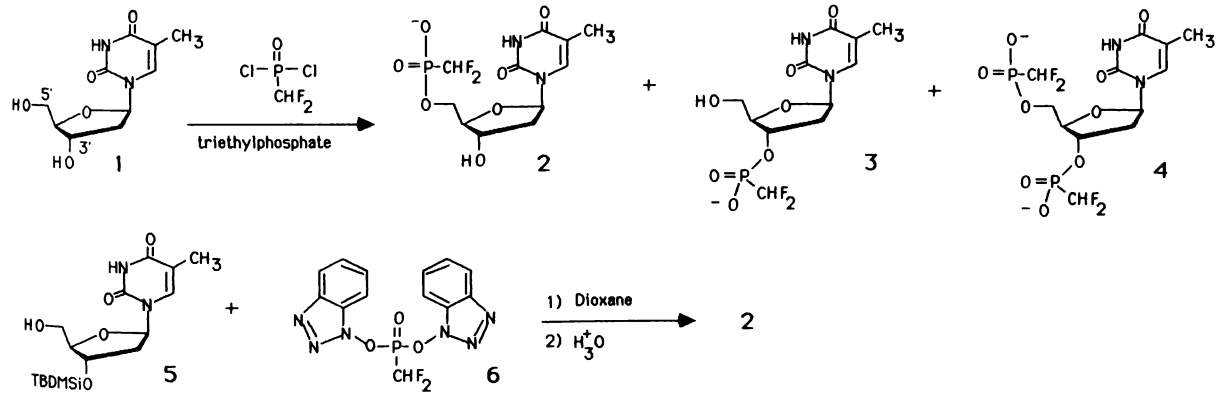
The synthetic strategies employed to obtain the difluoromethylphosphonate analogs paralleled well established routes in oligonucleotide synthesis, namely the Yoshikawa procedure (1) and the van Boom method (2). The Yoshikawa procedure transforms nucleosides to nucleotides by reaction with phosphorus oxychloride ($POCl_3$). The van Boom method uses a modified phosphorylating agent generated *in situ* from $POCl_3$ and hydroxybenzotriazole (HOBT). These procedures were followed with HCF_2POCl_2 *in place* of $POCl_3$ and with thymidine and the mono-silylated regioisomers of thymidine as the nucleoside components.

Phosphonylation of thymidine with HCF_2POCl_2 and work-up by preparative anion exchange chromatography (Diethylaminoethyl (DEAE) Sephadex) gave a mixture of the thymidine 5'-O- and 3'-O-monophosphonates (**2** and **3**, respectively) and thymidine 3'-O-,5'-O-diphosphonate **4** in relatively equal amounts. By analytical high performance liquid chromatography (HPLC) the relative proportion of **2** to **3** was 70:30. Resolution of these two regioisomers was not complete and hence isolation of either one was not achieved. Consequently, the mono-silylated nucleosides were phosphonylated by the same method to selectively obtain only one of the regioisomeric monophosphonates. Nevertheless the Yoshikawa method yielded a similar product mixture because of cleavage of the silyl protecting groups during phosphonylation.

In contrast to the above procedure, the van Boom method gave a relatively clean product mixture. Use of the *in situ* phosphonylating agent **6** under basic conditions with the silyl-protected thymidines yielded their respective difluoromethylphosphonates which appeared relatively free of any diphosphonate product by preparative anion exchange chromatography and free of any regioisomeric monophosphonate by HPLC. Nuclear magnetic resonance (NMR) studies - ^1H, ^{19}F, ^{13}C - confirmed the structures.

The variety of products in the two phosphonylation methods differed significantly. The Yoshikawa procedure did not give a regioselective phosphonylation with either the unprotected or silyl-protected nucleosides because of silyl ether cleavage. However, the van Boom method did not lead to silyl ether cleavage and hence a single product was obtained in good yield in each case.

Scheme I.



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(68) PREDICTION OF BANK RECESSION, LAKE SAKAKAWEA, ND

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Shoreline erosion along Lake Sakakawea has been evaluated over the past three years (1) to provide the U.S. Army Corps of Engineers (Corps) with a fundamental and relatively simple equation to relate the current and historic recession rate to other measurable factors and, from this, predict the extent of bank recession through time. Twenty erosion stations were established along the eastern end of the lake. Field work included recession pin measurements and bank and offshore profiling. Laboratory analysis involved sediment texture, wave energy calculations, and statistical analysis. Historical shoreline recession data were available from previous Corps surveys.

Shoreline recession occurs throughout the year; in the warm season wave action is the driving force, accounting for 78% of yearly recession. Cold weather recession usually occurs as result of freezing and thawing. The most significant variables along Lake Sakakawea are: effective fetch, bank height, offshore slope, beach width, bank orientation, and areal percentage of coarse beach clasts. Effective fetch is correlated to such wave parameters as height and period. Offshore slope defines how close waves can approach the shoreline before breaking. The bank orientation factor for summer involves the angle between the shoreline and the most dominant wind direction. For winter recession, the orientation factor is related to solar energy. In contrast to the above variables, a wide beach and a high percentage of coarse beach material tend to reduce bank erosion.

The average recession rate for all stations ranged from 0.2 to 4.3 and averaged 1.6 m/yr. Differences can be caused by many factors, such as joint and shear strength of the sediment, which are not easily quantifiable. The resulting bank recession equation assumes non-linearity of the data:

$$Rt = 12\ [\ x + (0.0023x)(\text{bank height} + \text{bank orientation})],$$

where Rt is the yearly rate of erosion at the selected site, and $x = 141.53 - [\ 17.2\ (A)^{\frac{1}{2}} + 8.44\ (B)^{\frac{1}{2}} + 25.08\ (C)^{\frac{1}{2}} + 10.4\ (D)^{\frac{1}{2}}\ ]$,
in which A = sine of the angle between the bank orientation and the dominant wind direction,
B = bank height, C = offshore slope angle, and D = beach width.
The coefficients for each variable were determined through regression analyses. The equation has a F-ratio value of 3.64 with a 95% probability value. The resulting Goodness of Fit (r^2) is 0.5928.

For projection into the future, it is necessary to take into consideration any extreme conditions, plus a declining rate of recession. The total recession, for a specific time in the future, $R^* = C\ (Rt)(T)^{\frac{1}{2}}$, where Rt is the present recession rate, T, is the projected time, and C is an empirical coefficient that depends on such extremes as effective fetch, beach width, and the presence of loose sand units.

Many previous studies have analyzed shoreline recession, but none has been as detailed as this previous study, the first to develop a statistically valid bank recession equation that can project total recession into the future. Spoeri and others (2) tried to develop a simple predictive equation for shore erosion on Chesapeake Bay, MD, using statistical modelling comparing historic recession rates with such coastal parameters as shoreline type, 100-year storm surge, and mean tide range. The resulting analyses yielded an r^2 value of 32.9% (compared to 59.28%).

Although this equation needs further testing, it can be useful to both the Corps and landowners in identifying sections of shoreline where future property damage is likely; the Corps can save money by buying only land that is predicted to be eroded. For private landowners, as well as state-owned property, such endangered shoreline can be saved, using protective measures such as rip-rapping. Also, by confidently predicting which shores would be subjected to low, medium, and high rates of potential recession, future shoreline development (such as at Pick City) could be planned at locations safe from future recession.

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(69) BODY COMPOSITION CHANGES SUBSEQUENT TO PHYSICAL TRAINING IN COLLEGE-AGE SUBJECTS: A META-ANALYSIS

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Determination of human body composition permits an estimation of fat free mass (bone, muscle and viscera), fat mass (stored triglyceride), and body fatness (fat mass x 100%/body mass). Knowledge of fat mass and body fatness is important because of the known association between excessive accumulation of fat and increased future risk of chronic and degenerative diseases. The American College of Sports Medicine (1) has suggested that a program of controlled aerobic exercise is important in reducing levels of body fat.

A multitude of research data is available on the effects of aerobic physical training on changes in body composition of adults from various groups. A large portion of this work focuses on separate comparisons of changes in body composition among college-age male and female non-athletes and athletes. To date, these data have not been summarized.

Data from fourteen studies of collegiate athletes, 95 females and 216 males, measured before and after participation in a competitive season, and from eighteen studies of non-athletes, 243 females and 343 males, measured before and after physical training, were analyzed using the meta-analysis method (2).

To determine the effect of training on body mass, fat mass, percent body fat, and fat free mass, this analysis computes an effect size for each group in each study by dividing the difference between the before and after training means by the before training standard deviation of the variable and then multiplying by Glass' constant (3) to correct for sample size bias. The magnitude of training effect sizes were analyzed in a 2 (male versus female) x 2 (athlete versus non-athlete) factorial design. Analysis of variance indicated significant decreases in fat mass ($p = 0.023$) and percent body fat ($p = 0.012$) and significant increases in fat free mass ($p = 0.0009$) for non-athletes, and no significant changes for athletes. Changes in body weight were not significant ($p > 0.05$) for either group. Females and males experienced similar ($p > 0.05$) changes in body weight and body composition after training. The mean changes in body mass, percent body fat, fat mass and fat free mass are in Table 1.

Table 1. Body Composition Changes with Physical Training (mean ± SD)

	Body Mass (kg)	Percent Body Fat	Fat Mass (kg)	Fat Free Mass (kg)
Athletes				
female	0.5 ± 1.2	0.1 ± 1.9	0.1 ± 1.1	-0.1 ± 1.0
male	-0.2 ± 1.2	-0.8 ± 0.8	-0.6 ± 0.7	0.3 ± 0.7
Non-athletes				
female	-0.3 ± 1.0	-1.9 ± 2.6	-1.4 ± 2.1	1.1 ± 0.8
male	-0.6 ± 1.6	-2.0 ± 1.1	-2.0 ± 1.5	1.7 ± 0.9

These results support a general hypothesis that percent body fat, fat mass and fat free mass, but not body mass, are changed in college-age non-athletes after physical training. Participation in a sport season does not appear to result in measurable changes in body composition.

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(70) KINETICS AND MECHANISM OF DIPHENYL ETHER REDUCTIVE CLEAVAGE

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The ether linkage, particularly that of the diaryl ethers, is one of the most inert bonds in organic molecules. The importance of diaryl ether linkages in naturally occurring products; lignin, peat, and low-grade coals (e.g. lignite), has been documented (1). The complexity of these materials makes the analyses of the functionalities unattainable by direct spectroscopic techniques. One approach to the analysis of the ethers in these complex samples is to selectively cleave or "depolymerize" the large complex molecules into smaller, more tractable compounds. A very promising means of cleaving the carbon-oxygen bond in the diaryl ethers is by reductive techniques, i.e., the formation of reactive radical anions or dianions. However, these reactions cannot be rationally applied to the macromolecular structures found in naturally occurring materials until the behavior of the diaryl ether linkage is understood in simpler chemical systems.

A simple diaryl ether is diphenyl ether (DPE). Therefore, this compound was thought to be a good starting point for the study of these ether linkages. Cyclic voltammetry (CV) and homogeneous redox catalysis, using acenaphthalene (P) as mediator, were used to determine the kinetics of DPE radical anion cleavage. The proximity of the direct reduction of the DPE to the reduction of background necessitates these techniques. Previously it has been reported the disappearance of the radical anion is first order (2); therefore, the mechanism for this system is:

$$P + e^- \rightleftarrows Q \qquad (1)$$

$$Q + PhOPh \underset{k_2}{\overset{k_1}{\rightleftarrows}} P + PhOPh^{\bullet -} \qquad (2)$$

$$PhOPh^{\bullet -} \xrightarrow{k} PhO^- + Ph^{\bullet} \qquad (3)$$

Detailed kinetic analysis was carried out using the above catalytic scheme. Experiments were performed in N,N-dimethylformamide, with 0.2 M tetra-n-butylammonium perchlorate as supporting electrolyte. The value for k_1 is $3 \times 10^2 M^{-1}s^{-1}$ with acenaphthene as the redox mediator. The cleavage of DPE radical anion is at a rate, k, of $6 \times 10^5 s^{-1}$. This is consistent with the upper and lower limits of 10^3 and $10^7 s^{-1}$, respectively, determined by low temperature and fast scan CV.

Having learned the rate of decomposition, the mechanism needed to be verified, i.e. does cleavage produce phenoxide and the phenyl radical? Controlled potential electrolyses were employed and indirect detection of the phenyl radical was used to reach the conclusion in eq. 3.

An intramolecular radical trap was used to confirm the intermediacy of the phenyl radical. The o-(3-butenyl)phenoxybenzene (OBDPE) is reduced to the radical anion and cleavage occurs. The o-(3-butenyl)phenyl radical can subsequently undergo cyclization to the final product of 1-methylindan (cyc) (4), the uncyclized product is 3-butenylbenzene (uncyc). The kinetics and deuterium incorporation in benzene indicate that the phenyl radical formed upon cleavage is not further reduced to the phenyl anion, thus cyclization of the phenyl anion is not a significant contribution to the cyclized product. Phenyl radical formation was confirmed from the ratio of cyc:uncyc products, and a decrease in the ratio when a species that inhibited cyclization was added, see Table 1.

Table 1. Electrolysis results for DPE and OBDPE.

Type of reduction	added species	starting material*	phenol*	benzene*	ratio cyc:uncyc
direct DPE (45.3mM)	none	50%	46%	42%	--
direct DPE (31 mM)	0.2M D_2O	11%	81%	76% (15% d_1)[a]	--
direct OBDPE (10mM)	none	23%	45%	27%	13
direct OBDPE (10mM)	0.4M D_2O	30%	39%	29%	13
direct OBDPE (10mM)	0.14M $NaOCH(CH_3)$	8%	47%	31%	5

*other products were recovered and are not list listed in Table 1.
[a]% mono deuterated benzene

The data conclusively points toward intermediacy of the phenyl radical. The ratio cyc:uncyc is not decreased by a proton source D_2O, which will inhibit phenyl anion cyclization. The addition of sodium isopropylate, a good H atom source, decreases the cyclization. The DPE radical anion cleaves at a rate of $6 \times 10^5 s^{-1}$ to form phenoxide and phenyl radical.

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(71) REACTIONS OF $(C_5H_5)W(CO)_3SC_6H_5$

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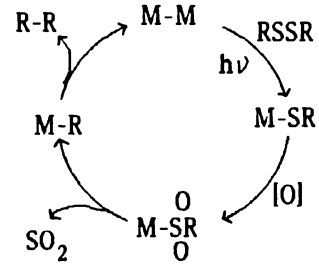
Due to its abundance and availability, coal has the potential to be the major energy source of the United States. One reason this potential has not been reached is due to the high levels of sulfur found in coal. These levels are usually between 1 and 3 wt.% but the Environmental Protection Agency limits total sulfur content in coal used for combustion to 0.7% so as to prevent sulfur emissions from rising above acceptable levels [1]. Thus development of more efficient desulfurization techniques would enhance the commercial usability of coal.

One new technique which can be envisioned is to use organometallic complexes as catalysts in a desulfurization cycle. A schematic of one possible cycle is shown to the right. Earlier work in our group has shown that visible light irradiation of $[CpW(CO)_3]_2$ (Cp = $\eta^5C_5H_5$) and diphenyl disulfide (PhSSPh) efficiently synthesizes the complex $CpW(CO)_3SPh$ (I). The tungsten dimer was chosen because only visible light is necessary to initiate the reaction and the disulfides are being studied initially because they constitute a major form of organic sulfur present in low-rank coal.



The reaction of (I) with the oxidizing agent m-chloroperoxybenzoic acid yields the known [2] sulfinato complex $CpW(CO)_3S(O)_2Ph$ (II). Grazinani et al. has shown [3] that when $CpMo(CO)_3S(O)_2CH_2Ph$ is photolyzed, the resulting product $CpMo(CO)_3CH_2Ph$ arises from extrusion of SO_2. However, when (II) is photolyzed, the only gas evolved is CO and the only identifiable organometallic product is a trace amount of (I).

The chemistry of the alkyl and aryl thiolates $CpM(CO)_3SR$, M=Mo,W, has been investigated but, in the case of the tungsten complexes, characterization of their reaction products has at times been ambiguous. Since the thiolates are an important step in this cycle, a more complete understanding of their chemistry is required.

Thiolates undergo CO loss when photolytically or thermally excited. The products depend upon reaction conditions. When $CpW(CO)_3SPh$ is photolized in toluene, a complex which we formulate as $[CpW(CO)_2SPh]_2$ is produced. This novel complex was reported by Havlin and Knox [4] but no physical data was ever published. Watkins and George reported [5] the preparation of $[CpW(CO)_2SC_6H_4CH_3]_2$ but comparison of the infrared carbonyl stretching frequencies of the two analogous complexes show a vast dissimilarity.

Since Brandenburg has found [6] that substitution of either electron withdrawing or electron donating groups on the phenyl ring shifts the carbonyl stretching frequencies by only 10 cm^{-1}, it is reasonable to conclude that the two compounds are not both dicarbonyl dimers.

Alway and Barnett have studied [7] the reaction of $CpW(CO)_3X$ (X=Cl,Br,I) with PPh_3 and noted that the product $CpW(CO)_2(PPh_3)X$ arises from photochemical loss of CO followed by nucleophilic attack of PPh_3. We find that photolysis of PPh_3 and (I) produces the novel complex $CpW(CO)_2(PPh_3)SPh$. The reaction should be mechanistically similar to the tungsten halide substitution reaction of Alway and Barnett.

Thus, we have found that the oxidation of $CpW(CO)_3SPh$ to $CpW(CO)_3S(O)_2Ph$ is efficiently accomplished by m-chloroperoxybenzoic acid; however, attempts to photochemically extrude SO_2 have proven unsuccessful. We also note that the chemistry of $CpW(CO)_3SPh$ is dominated by the loss of CO as evidenced by the formation of both coupling and substitution products.

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(72) BORON AFFECTS MAGNESIUM AND CALCIUM METABOLISM IN THE RAT

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Recent preliminary experiments with rats suggested that boron indirectly affects the metabolism of calcium, phosphorus, or magnesium by altering parathormone activity (1,2). In those experiments, dietary boron markedly affected the response of rats to treatments that supposedly cause changes in parathormone activity. These manipulations included magnesium deprivation and high dietary aluminum. Another manipulation that apparently affects parathormone activity is low dietary calcium. Therefore, we decided to ascertain whether dietary boron affects the response of magnesium-deprived and magnesium-adequate rats to low dietary calcium.

Male weanling Sprague-Dawley rats were assigned to groups of six in a fully-crossed, three-way 2x2x2 design. The treatments were the supplementation of the methionine-supplemented basal diet (1) with boron (as boric acid) at 0 and 3 µg/g, with magnesium at 100 and 400 µg/g and with calcium at 2.5 and 5.0 mg/g. Environmental conditions have been described (3). The rats were fed their respective diets for seven weeks, weighed, fasted overnight, and decapitated. Selected parameters listed in the table were determined by our usual methods (1,3).

Effects in Rats of Dietary Boron, Magnesium, Calcium and Their Interaction on Selected Parameters

Treatment, µg/g diet B	Mg	Ca	Mean wt. g at 7 weeks	Liver wt / Body wt x 100	Kidney wt / Body wt x 100	Spleen wt / Body wt x 100	Plasma Alkaline Phosphatase units
0	100	2500	270	2.74	0.322	0.273	0.91
0	100	5000	233	3.18	0.370	0.328	0.76
0	400	2500	286	2.92	0.330	0.195	1.18
0	400	5000	295	2.95	0.297	0.215	0.96
3	100	2500	285	2.86	0.353	0.278	0.86
3	100	5000	236	2.98	0.337	0.283	0.86
3	400	2500	278	2.85	0.313	0.210	0.92
3	400	5000	302	2.78	0.316	0.193	1.02
				Analysis of Variance - P Values			
B effect			NS	NS	NS	NS	NS
Ca effect			NS	0.007	NS	NS	NS
Mg effect			0.0001	NS	0.0005	0.0001	0.0002
B x Ca			NS	0.02	NS	0.01	0.007
B x Mg			NS	NS	NS	NS	NS
Ca x Mg			0.0001	0.003	NS	NS	NS
B x Ca x Mg			NS	NS	0.004	NS	NS

Magnesium deprivation depressed the growth of rats fed adequate calcium, but not the growth of rats fed inadequate calcium. Similarly, calcium deprivation depressed growth only when magnesium was adequate. Apparently the adverse effect on growth of magnesium deprivation is negated by calcium deprivation and vice versa. Boron did not affect growth. Calcium deprivation depressed the liver wt/body wt ratio; the effect was most marked when dietary magnesium or boron was low. Magnesium deprivation elevated the kidney wt/body wt ratio; the elevation was more marked in calcium-adequate rats when dietary boron was low, but more marked in calcium-deprived rats when dietary boron was high. Magnesium deprivation, regardless of dietary boron, elevated spleen wt/body wt ratio and depressed plasma alkaline phosphatase activity. In contrast, calcium deprivation depressed spleen wt/body wt ratio and elevated plasma alkaline phosphatase activity only in boron-deprived rats. Generally, the findings indicate that magnesium deprivation is more detrimental to boron-deprived than boron-supplemented rats; calcium deprivation tended to reduce this difference. In addition, the results show that boron status influenced the response of rats to low dietary calcium. Thus, the findings are consistent with boron affecting calcium and magnesium, possibly through affecting parathormone action.

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(73) The Conglomeratic Unit of the White River Group, Chalky Buttes, Slope County, North Dakota.

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The White River Group in southwest North Dakota includes a highly cross-bedded conglomeratic unit measuring 8-75 feet in thickness. Denson and Gill (1) propose cobbles in this conglomerate came from the Beartooth–Absaroka mountains and entered North Dakota from the southwest. Stone (2) proposes these sediments came from the Black Hills and entered North Dakota from the south. Clausen (3) suggests the sediments originated in the Beartooth Mountains, but entered North Dakota from the northwest. The purpose of this research is to resolve the controversy by determining current directions shown by the cross bedding of the conglomeratic unit.

Strike and dip readings were taken on the cross-bedded unit in the area extending approximately two kilometers from White Butte south to Rattlesnake Butte in Slope County, North Dakota (Sections 25 and 26, Range 101 West, Township 134 North). Readings were taken with a Brunton compass. At each location two sets of independent readings were taken to facilitate reliability and accuracy. Readings were taken in three separate areas.

The first area is located to the northeast and southeast of White Butte. This area is the northernmost location of the three areas in this study and exhibits high angle planar cross-bedding. Gravels occur in abundance both within the conglomeratic unit and at the base of the unit. A large granitic boulder measuring 62 cm x 62 cm x 62 cm was found at the base of the conglomeratic unit. A quartzitic boulder of similar size was found nearby. Several large cobbles were also noted at the base of the unit. Dip readings in this northern area display a strong southeast trend and sediment was poorly sorted. A rhyolite porphyry present in the gravels has been traced to the Beartooth Mountains (3).

Located midway between White Butte and Rattlesnake Butte is the second study area. This area displays medium to low angle planar cross-bedding. Gravel is present sporadically and occurs typically in lenses rather than in thick accumulations as noted in the first area. Lag gravels are less prevalent in the intermediate area than near White Butte. Dip readings in this area were more divergent than at White Butte to the north.

The third area encompasses the southern end of Rattlesnake Butte. This area exhibits low angle cross-bedding. Gravel occurrences in the conglomeratic unit are rare. Dip readings in this area are divergent.

The following conclusions may be drawn. Cross-bedding in the White Butte area shows a strong southeast dip indicative of a current direction originating from the northwest. A braided stream pattern is suggested. The northern area, near White Butte, has poorly sorted material and contains abundant cobbles and occasional boulders. To the south sediments become progressively finer. In the other two areas gravels are much less abundant. The strong southeast trend in the cross bedding near White Butte is not as obvious in the areas to the south. I do not have an explanation for the boulders at this time.

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(74) Stimuli Influencing Male Dominance in Orange-Spotted Sunfish, Lepomis humilis (Pisces, Centrarchidae)

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INTRODUCTION Sunfish, like other social animals, occupy rank in a hierarchial society (1). Henderson and Chaszar proposed existence of other contributors to dominance besides size and age in Lepomis macrochirus (2). Agonistic behavior and body color were necessary in the maintenance of cichlid territory, where fleeing individuals demonstrated submissive vertical body bars (3)(4). The social organization of Lepomis humilis, the orange-spotted sunfish, was investigated to determine the elements which maintain hierarchial order.

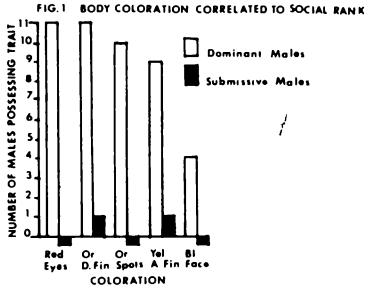
METHODS Lepomis humilis, held in a 39.5 l (10 gal) community tank, were tested in 75.7 l (20 gal) aquaria. Dominant stimuli were depicted in oil base paint on plexiglass silhouettes (10 x 4.5 cm). Orange dorsal fin margin, yellow anal fin, and red eyes were tested as the stimuli determining social rank.

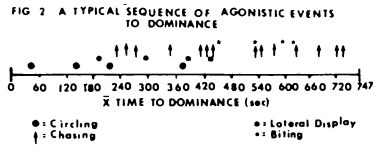
RESULTS Preliminary observations suggested that social position in humilis was a function of color. Initial experiments defined the coloration associated with dominant behavior. Two randomly selected males were introduced into a test aquarium and acclimated approximately one hour. Color patterns expressiong dominance were recorded. Dominant males displayed red-rimmed eyes, an orange margin of the dorsal fin, orange body spots and a yellow anal fin (Fig. 1). Subordinate males lacked these dominant traits as well as displaying dark rimmed eyes and dark vertical body bars(variable in size, approximately five in number).

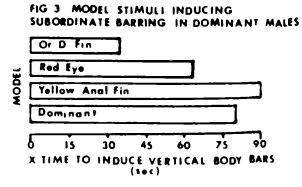
The second experimental series specified the agonistic behaviors which lead to male dominancy, and determined if those events were sequential. The behavior of male pairs, when placed in a common aquarium, was recorded until dominance was reached. Chasing was the criteria for male dominance. Agonistic behaviors included circling, lateral displays, chasing, and biting. The time to dominance ranged from 2:20 to 28:40 min. ($\bar{X}$ = 12.45 min.). A temporal pattern was suggested progressing from circling, to lateral displays, to chasing, and to biting (Fig. 2).

To elicit the submissive response, dominant test males were stimulated by models depicting each dominant trait and the color phases were recorded over time. Vertical barring was found to be significantly affected by various dominant stimuli while loss of red eye rims was not corrrelated to model stimulus (Kruskal-Wallis test, P 0.05). The orange margined dorsal fin proved to be the most intense dominant trait.

CONCLUSION Lepomis humilis, like congeneric cyanellus and machrochirus, supported a hierarchial social system. Common agonistic behavior was utilized by humilis to maintain rank order. A temporal sequence of agonistic events was observed beginning with circling, progressing through lateral displays, chasing, and concluding in biting. Gerald indicated that humilis displayed sound production in courtship (5) but this investigation noted no sonic communication. Status of individual males was correlated with coloration. Dominant males display bright orange hues on body spots, eyes, and dorsal fin margin. Subordinates were drab and possessed dark vertical body bars and eyes. Model analysis revealed the orange margin on the dorsal fin to be the most intense dominant stimulus.







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(75) PALEOENVIRONMENTAL IMPLICATIONS OF INSECT REMAINS FROM THE SEMINARY SITE, CASS COUNTY, NORTH DAKOTA

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During the Moorhead Phase of Lake Agassiz (ca. 10,800 - 9900 yr B.P.), the southernmost portion of the Lake Agassiz Basin was subjected to prolongued subaerial exposure as drainage for the lake was temporarily directed northeastward across a lower divide (1). During this period, plant and animal communities invaded the newly-exposed sediments of the southern Basin (2, 3). Fossil evidence of these communities occurs discontinuously within the region; perhaps nowhere are remains better preserved than in an organic zone exposed near the eastern margin of Cardinal Muench Seminary at Fargo. Spruce (Picea) and tamarack (Larix laricina) wood from this unit have a radiocarbon age of 9900 ± 400 yr B.P. (W-993) (3). Although the placement of this organic horizon chronologically within Lake Agassiz history was at first controversial (3, 4), the prevalent opinion now is that these organics accumulated when rising waters inundated the southern Basin during the transition to the Emerson Phase of the lake (2, 5).

Despite the significance, preservation, and continual accessibility of materials within this horizon, no additional comprehensive studies of these organics have been undertaken since those of McAndrews (3). He then described a pollen and plant macrofossil assemblage whose affinities were "boreal" and that represented a mixture of upland and aquatic elements, with the remains from a spruce-dominated forest interspersed with those of open-water, marsh, and wet meadow herbaceous plant communities.

In late 1984, we resampled the Seminary organics, collecting ca. 40 kg of sediments with the objective of obtaining invertebrate (primarily insect) remains from this 16.5 cm-thick horizon for paleoenvironmental analyses. Our samples were processed for insect remains using standard (6) separation techniques. Snails were also found, but were too fragmented or immature for identification. Remains of ostracods, arachnids, and other invertebrates, which normally would have been isolated as well by these techniques, were not encountered in any of our samples.

The insect remains were derived from an apparently diverse fauna, but were so highly-fragmented that most were unidentifiable to the generic or specific level. Of those that could be determined, most were of Coleoptera associated with aquatic or marsh habitats; these include the rove beetle Olophrum rotundicolle (C.R. Sahlb.), the ladybird beetle Anisosticta bitriangularis (Say), and the ground beetle Bembidion pseudocautum Lth. A single elytron of the bark beetle Hylastes was the only fragment of an upland insect identifiable in the assemblage; beetles of this genus are common today on conifers, mostly pine (7).

All of the insects identified from this horizon occur today in the southern boreal forest zone of central Canada. This interpretation generally coincides with the analogue previously proposed (3) from analyses of the site's pollen and plant remains. The degree of fragmentation of the fauna, together with the worn condition of the associated wood, suggests that all of the organics may have been transported to this locality. We therefore believe that the organics accumulated in a wave-washed, shoreline environment during the rise of water levels leading into the Emerson Phase.

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(76) COMPARISON OF ALUM AND PRE-FORMED ALUMINUM HYDROXIDE FOR TURBIDITY AND COLOR REMOVAL DURING THE COAGULATION PROCESS

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The objective of this research was to conduct a comparison study of the coagulants, alum and pre-formed aluminum hydroxide, for turbidity and color removals in water treatment. By examining the pH and coagulant dosage parameters, a specific pH and coagulant dose were determined where effective color and turbidity removals occured. This optimum operating point was defined for both coagulants after which they were compared and conclusions made.

To study and compare the performances of the coagulants, a series of Laboratory Jar Tests were conducted following the procedures outlined in Standard Methods (1). The coagulation process involved rapid mix, flocculation and settling steps after which samples were taken and tested for color and turbidity. Two types of jar tests were run. First a pH controlled test examined a range of coagulant doses at a defined pH and secondly, a pH varied test involved a selected pH range with a constant coagulant dose. Coagulant doses were measured in terms of aluminum content (i.e., 40 mg alum/l = 3.2 mg aluminum/l and 5.0 mg pre-formed $Al(OH)_3$ /l = 3.2 mg aluminum/l). The tests were performed using synthetic water solutions termed Colored Model Water (CMW). The CMW was prepared with 55 mg/l of sodium bicarbonate (for alkalinity) and 5.6 mg/l of humic acid (for natural color). The resulting CMW possessed an alkalinity of 35-40mg/l as $CaCO_3$, a color of 80 color units, a pH of 6.0 and a temperature of 24 °C. CMW behaves similiarly to natural water in relation to organic removals and aluminum solubilities.

The resulting color and turbidity removals are presented in Tables I and II. In both cases, greater color removals were associated with larger coagulant doses. For alum, good color removals of over 90% were found with doses of 3.2 mg Al/l. At 8 mg Al/l, slightly higher removals occurred but at a much larger dose. This indicates that the increase of alum concentration beyond a certain point, proves to be ineffective in color removal. For effective color removal with alum, the pH range must be 5.4 to 6.9. Larger pre-formed aluminum hydroxide doses were needed to match the color removal efficiencies of smaller alum doses. For pre-formed aluminum hydroxide, desireable color removal of 92 % was obtained with a dose of 14.08 mg Al/l. The effective pH range for color removal is 5.4 to 7.3. The larger turbidity removals for alum depict better settling chracteristics than those shown by aluminum hydroxide. Turbidity removals increased as the coagulant dose increased.

The optimum operating point for alum is at a pH of 6.4 with a dose of 3.2 mg Al/l which produces 92% color removal and 47% tubidity removal. The optimum pH for pre-formed aluminum hydroxide is at 5.8 where 82% color removal was obtained with 3.84 mg Al/l dose. The highest color removal of 92% occurred with a dose of 14.08 mg Al/l at a pH of 6.4. Higher removal is possible if the optimum pH of 5.8 was used.

TABLE I. ALUM

pH	Dosage mg Al/l	% color removal	% turbidity removal
5.7	0.8	18	0
6.9	0.8	18	0
7.4	0.8	18	5
6.4	3.2	92	31
6.6	3.2	91	52
5.9	3.2	91	51
5.7	3.2	97	42
7.1	3.2	86	46
6.2	8.0	94	68
6.9	8.0	97	67
5.8	8.0	93	68

TABLE II. PRE-FORMED ALUMINUM HYDROXIDE

pH	Dosage mg Al/l	% color removal	% turbidity removal
6.5	1.28	30	0
6.4	3.84	61	17
6.4	6.40	65	15
6.4	8.96	74	17
6.4	11.52	75	21
6.4	14.08	92	22
5.4	3.84	72	14
5.8	3.84	82	19
6.2	3.84	80	14
7.0	3.84	72	10
7.3	3.84	72	10

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(77) An Invertebrate Faunule from the Rierdon Formation, Little Rocky Mountains of Montana, and it's Paleoecological Implications

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The middle Jurassic Rierdon Formation of the Little Rocky Mountains of central Montana is abundantly fossiliferous. A stratigraphically controlled collection of fossils from a single locality in the middle of the formation was analyzed for faunal content, as well as biostratigraphic and paleoecological interpretation.

A series of seventeen beds were identified, consisting of alternating indurated siltstone and clayey, fissile shale. A collection of all surface fossils was then made from each of the beds over a fifteen foot linear span of exposure. A variety of invertebrate fossils were identified with a faunal list presented in Table 1. Most abundant among these is Gryphaea nebrascensis, numbering more than 50, followed by Pentacrinus whitei. All other species were represented by one or two identifiable specimens.

Standard biozonation of the Jurassic is based on ammonite cephalopods (1,2). Although ammonites were collected, the nature of fossilization was such that the suture pattern was not preserved. As such, we were unable to determine the specific biozone represented by our section. However, the presence of G. nebrascensis suggests the beds are early Callovian. This agrees with the generally recognized age for the Rierdon (1).

The beds identified differ in thickness as well as in lithology. The indurated siltstone beds range from five inches to two feet, but are typically only five to eight inches thick. The fissle shales range from three to fourteen feet, but show a general increase in thickness upsection. The indurated beds were found to be more fossiliferous, containing most of the G. nebrascensis specimens as well as a more diverse fauna (Table 1), with the abundance of Gryphaea decreasing upsection. In contrast, the fissle beds were not as fossiliferous and contained a more restricted fauna. Pentacrinus whitei was the most abundant species from this lithology and was found only in the upper half of the section. The reasons for the fossil distribution could be related to 1) the two lithologic types represent sedimentological changes, i.e. rate of sedimentation as well as type of sediment, 2) changes in water chemistry, i.e. salinity, and 3) changes in turbidity. The fauna can be divided into three groups. The first, filter feeders, includes Gryphaea, Astarte, and Nucula. The second includes Pentacrinus and ? Serpula which are suspension feeders. The third includes mobile scavengers represented by an indeterminate decapod, Bactryllium, and possibly the indeterminate ammonite (3). Within the section, the filter feeders were not confined to, but were most abundant in the indurated beds, whereas the suspension feeders were typically found in the fissle beds. Potentially this distribution may indicate that during deposition of the fissle beds, water was more turbid making the filter feeding more difficult. The greater thickness of the fissle beds may also indicate a greater rate of sedimentation, suggesting greater turbidity.

Our studies were based on evidence collected at one site. Further investigations of laterally equivalent exposures, and beds above and below those studied here, are needed to test our interpretation of the paleoenvironment. Additional data would also serve to refine the biozonation, and expand the known fauna of the formation.

TABLE 1: Fauna of the Rierdon Formation
Little Rocky Mountains, Montana

Phylum Mollusca	
Gryphaea nebrascensis	(I,F)
Astarte sp. cf. A. livingstonensis	(I,F)
Nucula sp ?	(I)
ammonoid, genus indeterminate	(I)
Phylum Echinodermata	
Pentacrinus whitei	(1,F)
Phylum Annelida	
? Serpula	(F)
Phylum Arthropoda	
decapod, genus indeterminate	(F)
Trace Fossil	
Bactryllium sp.	(I)

I=Indurated Bed, F=Fissle Bed

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(78) THE ROLE OF DELTA AND MU RECEPTORS IN OPIATE INDUCED ANALGESIA

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Several receptor types are believed to play a role in the mediation of the effects of opioids. Although it is generally held that the mu opioid receptor is responsible for analgesic effects, there has been much controversy as to the role of delta opioid receptors. We attempted to approach this problem by using highly selective delta drugs in newly developed genetic strains of mice.

Three drugs were tested in mice on the hot-plate assay (52.5°C) following intracerebroventricular (i.c.v.) injection by the method of Laursen and Belknap (3). The mice used were selectively bred for 14 generations to genetically and phenotypically differ in their analgesic response to levorphanol, a morphine-like analgesic. The high response line (lineage) of mice were bred to be highly sensitive to the effects of levorphanol, whereas the low response line was bred to be very resistant (1). These animals are useful in screening new types of analgesics. For example, if the analgesic differences bred into the high and low lines with levorphanol are also evident with a new drug, then that drug and levorphanol have the same mechanism of action. In contrast, if a new drug produces analgesia that does not differ between lines, it can be concluded that the mechanism of action is completely different from that of levorphanol and similar morphine-like analgesics. The drugs used in this experiment were levorphanol (a relatively specific mu-agonist); DADLE, [D-Ala^2, D-Leu^5] enkephalin a delta-agonist with 3-4 times more specificity for delta receptors than mu, and DSLET, [D-Ser^2, Leu^5] enkephalin-Thr^6, a delta agonist with about 40 times more specificity for delta than mu receptors. DADLE and DSLET are analogs of endogenous enkephalins that are resistant to degradation. The addition of a Thr^6 to DSLET makes it highly specific for the delta receptor. Doses ranged from zero (saline only) to a dose that produced scores about 7-fold greater than saline scores.

TABLE 1 REGRESSION (dose-response curve)

	HI	LO	b_{HI}/b_{LO}	Mu/delta ratio*
Levorphanol	11.2	0.5	22.3	13:1
DADLE	58.6	34.5	17.0	0.4:1
DSLET	172.0	35.9	4.8	0.05:1

*The data represented here are from rat brain homogenates Chang & Cuatrecasas (2)

Table 1 summarizes the important comparisons between these agents. Column one indicates the regressions of the dose-response curves of the three compounds in the high response line of mice, while column two does the same for the low response line. Column three shows the ratios of the regressions of the highs over the lows and column four includes data from the literature concerning receptor specificity (2).

The largest differences between the lines were seen with levorphanol. The smallest differences were seen in DSLET. One can conclude that DSLET produces analgesia via a much different mechanism compared to levorphanol and is not just a "carbon-copy" of levorphanol. We can presume from the literature that since DSLET is highly delta specific, the mechanism of analgesia is probably also delta. DADLE was found to be intermediate, both in terms of the difference between the high and low lines and in its delta specificity. Therefore the present study suggests that highly specific delta enkephalins are novel analgesics that are different in their mechanism of action from the traditional morphine-like opioids such as levorphanol, and that this difference is most plausibly attributable to action at delta sites.

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(79) MEDIATORS FOR THE REDUCTIVE CLEAVAGE OF DIPHENYL ETHER

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Coal is thought to contain diaryl ether linkages. In order to better understand coal structure, a means to quantitatively cleave aryl ether linkages is desirable. The reductive cleavage of diphenyl ether to phenol and benzene with alkali metal dissolved in liquid ammonia or in hexamethylphosphoramide (HMPA) is well documented (1,2). The characteristic blue solutions obtained when alkali metals are dissolved in these solvents are thought to contain solvated electrons which facilitate the cleavage (2). Handling problems with $NH_3(\ell)$ and HMPA (3) warrant investigation into other mediators (or electron transfer reagents) to carry out the cleavage. We report here several mediators that were found to accomplish diphenyl ether cleavage.

All reactions were carried out under an inert atmosphere (N_2). The mediators used were purified by vacuum distillation from sodium hydride or calcium hydride. The solvent, THF, was used freshly distilled from sodium metal. The mediator, THF, and sodium metal were stirred under N_2 for several hours before the diphenyl ether was added. The mediator to diphenyl ether ratio (mmole) in all reactions was approximately 10:1. All reactions, except the low temperature DMEU and DMPU runs, were run for convenient lengths of time. Gas chromatography was used to quantitate phenol with naphthalene as the internal standard. The results are presented in the table.

Compound	reaction conditions[b]	% cleaved[a]
N-Methyl-2-pyrrolidinone	B	94
1,1,3,3-Tetramethylurea	B	100
N,N-Diethylacetamide	A,B	100
N,N-Dimethylpropionamide	A	91
N,N-Diethylpropionamide	A	90
N,N'-Dimethyl-N,N'-propyleneurea	A,B	100
N,N'-Dimethyl-N,N'-ethyleneurea	A,B	100

[a] as measured against naphthalene, the internal G.C. standard
[b] (A) room temperature, (B) THF reflux

The mediators of interest were all amides and fall into two classes: open chain and cyclic amides. Ureas form a subclass of both general types. Sodium metal has been found to dissolve in the open chain amides N,N-diethylacetamide (DEA), N,N-dimethylpropionamide (DMP), and tetramethylurea (TMU), forming blue solutions of varying stability (4). Diphenyl ether was cleaved in 100% yield using TMU and DEA, whereas only 91% cleavage was found using DMP. With diethylpropionamide 90% of diphenyl ether was cleaved.

Sodium metal in N-methyl-2-pyrrolidinone and THF cleaved diphenyl ether to give 94% phenol. Under similar reaction conditions, N-isopropyl-2-pyrrolidinone gave only 10% phenol. Larger N-substituents gave no cleavage at all. This suggests that the larger N-substituents may sterically hinder the approach of the mediator about the electron.

N,N'-Dimethyl-N,N'-propyleneurea (DMPU) which has properties similar to HMPA (5) was found to cleave diphenyl ether in 100% yield. The five-membered ring analogue, N,N'-dimethyl-N,N'-ethyleneurea (DMEU) was also found to give 100% phenol under similar conditions. Both mediators were subjected to low temperature cleavage conditions. At -78°C DMPU did not significantly cleave diphenyl ether. Because of its low solubility in THF at low temperatures, DMEU was used at 0°C yielding almost complete cleavage after 7 hr.

Of the mediators tried DMEU appears to be the best replacement for HMPA. Although its solubility at low temperatures does present some problems, it cleaves diphenyl ether essentially to 100% phenol at all temperatures tried. DMEU, sodium metal and THF formed very stable (up to 48 hr) dark blue solutions indicative of the solvated electron.

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(80) RESERVOIR CHARACTERISTICS INFLUENCING PETROLEUM PRODUCTION

Madison Formation, Northeast Foothills Field, Burke Co., ND

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This study is focused in the Northeast Foothills Field located in Burke County in the north-central part of the Williston Basin, northwestern North Dakota. It examines reservoir characteristics of the upper Mississippian Midale, Nesson (aka Rival), and Bluell Subintervals of the Frobisher-Alida Interval, Mission Canyon Formation, Madison Group.

The first petroleum production from the Northeast Foothills Field began in 1959. However, penetration was limited to the Midale and Nesson until the 1981 discovery of oil in the deeper Bluell Subinterval. Currently, relatively little field data is available on the Bluell. This study begins to examine the variation in reservoir characteristics within the field. Available field completion and production data was reviewed and the most recently drilled well in the field selected as a Case Study Well. Mud cuttings and core samples were reviewed. The open-hole logging was observed, the electric log data interpreted and water saturations calculated using the Archie Equation. After casing was run, perforation and matrix acidization of the Bluell and Nesson was observed. Initial production began December 15, 1985 at 100 barrels of oil per day.

Carbonate reservoirs are characterized by extreme heterogeneity related to the complexities of the original depositional environment and the diagenetic influences that modify original textures. The Mission Canyon is a carbonate laid down during a time of predominantly open marine deposition which gradually changed to evaporite deposition. During the rise in sea level, there was deposition of the oolitic and algal limestone, i.e. Bluell and Nesson; during lowering of the seas there was deposition of argillaceous limestone, i.e. Midale.

RESULTS

MIDALE: Dolomitization occurred in the Midale and caused almost complete obliteration of primary sedimentary structures and resulted in an increase in porosity. Porosity of the Midale is intergranular and intercrystalline (1). In this study electric log data from the Case Study Well was used to calculate porosity of approximately 25% with calculated water saturation at 65%. Core data shows permeability of 0.01 to 0.04 millidarcies. In this field, permeability of the matrix is generally not sufficient to account for the quantities of oil produced from the Midale. Therefore, the presence of fractures is assumed (2).

NESSON: The Nesson is an intercalated limestone and anhydrite. The porosity in the Nesson is secondary porosity due to voids between ooliths and possible minor dissolution and etching. Electric log data analyzed in this study from the Case Study Well shows porosity of approximately 8% with calculated water saturation at 45%. Core data shows permeability of 7.14 millidarcies.

BLUELL: The Bluell is a limestone with primary intergranular and microcrystalline porosity and some secondary porosity due to pisolitic packing. Electric log data from the Case Study Well shows porosity of approximately 5% with calculated water saturation of 59%. Core from this zone was not recovered; therefore permeability can only be inferred.

SUMMARY STATEMENT

The Mission Canyon is a complex carbonate reservoir due to original deposition and diagenesis. As indicated by this study, there is significant variation in characteristic lithology, porosity, permeability, and water saturation within the subintervals of production. The high production figures from the Nesson and Bluell Subintervals in the Case Study Well coupled with results of this study strongly suggest that variation in lithology, porosity, permeability, and water saturation; or some yet to be identified reservoir characteristic may be significant within the field. An increased knowledge of this variation could potentially lead to identification of additional zones of production and therefore will be the focus of continued study.

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(81) THE FATE OF CATECHOLS IN COAL GASIFICATION CONDENSATE WATERS

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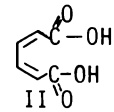
The treatment of wastewater from the coal gasification process is an important aspect of coal research. The objective is to remove potentially hazardous compounds so that the wastewater may be reused or disposed of without polluting the environment. Presently, the wastewater treatment involves four processes. The first step is solvent extraction to remove the organics, then steam stripping to remove ammonia, biological treatment, and finally, carbon filtration. Even after the wastewater has been subjected to this rigorous cleaning, many chemicals still remain. In order to remove these compounds, they must be identified. Catechol is a compound which appears in the condensate water and, because its concentration changes, its fate is somewhat uncertain.

Catechol (1) is a polar, weakly acidic compound that equilibrates between mono- and dianions in aqueous solution. This dihydroxybenzene is a useful reducing agent and undergoes halogenation, nitration, and many other substitution reactions easily.

I



II

Many dihydric phenols, such as catechols, are readily found in plants or are easily obtained by the breadkown of naturally occurring substances. Catechol and its derivatives are present in plant and tree extracts in the form of lignin, wood tar, and other wood products (1). In medicine, catechol compounds are used as important components of many pharmaceutical preparations. Catechols are also used in astringents, antiseptics, inks, dyestuffs, and for photography, electroplating, and some organic syntheses on the industrial level (2).

Catechol can be oxidized to give a quinone, via a radical under alkaline and acidic conditions. Quinones form unstable addition products which can polymerize to create dimers. Further oxidation can lead to large polymeric chains, such as the humic acids in soil. Some enzymes and specific chemicals will cause a more drastic oxidation, opening the ring to form muconic acid (II) (3).

Catechol is being studied due to its appearance in the condensate waters of slagging and fixed-bed gasifiers. The catechol concentrations change between condensate water samples due to variable gasification conditions. The amount of this compound has been difficult to determine since the concentration rapidly decreases in a short period of time. Previous work has shown that the catechol concentration can be stabilized when the sample is acidified and kept from light and air. These precautions suggested that the compound was being oxidized and/or polymerized (4).

In recent experiments modeling the condensate water conditions, catechol solutions were aerated in the presence of ammonia. Upon acidification of the solutions, a polymer precipitates. This polymer was compared to the black compound isolated from the condensate water by spectral and elemental analyses. The structures of the two polymers were reasonbly similar. The kinetics of oxidation, as determined by the uptake of oxygen, indicates that the reaction was first order in catechol and oxygen. The rate was significantly enhanced by an increase in pH (5). Assuming that catechol is the only subunit of the polymers isolated from the different condensate waters, calculations would indicate that the initial catechol concentration varies from 440 to 1700 ppm.

An attempt is being made to account for all of the carbon that appears in the water from the gasification process. Presently, only 60% to 70% of the carbon-containing products have been identified. Part of the remaining total organic carbon can be accounted for by by the catechol polymer. Studying the fate of catechol in the coal gasification condensate water will help to develop an environmentally and financially feasible treatment of the wastewater.

* Advisor - Dr. James Worman

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(82) PHOTOLYSIS AND XENON FLASH PYROLYSIS OF COAL-DERIVED WASTES

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At present, coal-derived wastes such as gasification condensate waters are treated with time-consuming and energy-intensive methods to remove both inorganic and organic contaminants. It is attractive to think that coal-derived wastes could be converted to useful fuels by means of irradiation with solar energy. This would eliminate the expensive, time-consuming clean-up methods and would also provide an alternate source of energy.

In the last decade, photocatalysis has been used to produce many chemical conversions. This process involves the continuous excitation of the catalyst surface which, by means of free radical and electron transfer mechanisms, converts reactants into different species.

We wish to report that one can irradiate coal gasification condensate waters under basic conditions using a platinized titanium dioxide photocatalyst and visible or ultraviolet light to give H_2 and CO_2 as the only two gases. Irradiation with solar energy also shows an initial decrease in total organic carbon of aproximately twenty percent.

$$\text{Condensate Water} \xrightarrow[\text{Visible or U.V. light}]{TiO_2/Pt} H_2 + CO_2$$

In recent years, flash pyrolysis using high-energy xenon light has been used for the conversion of biomass to a number of different gases. The first flash pyrolysis of coal produced many useful fuel gases such as hydrogen, acetylene, and CS_2 to mention only a few (1). More recent investigations have concentrated on the conversion of biomass to useful fuels (2). Little or no information exists on the radiant flash pyrolysis of biosludge. Work at Princeton is being designed to accomplish this feat on sewage sludge (3) and, in fact, may have been accomplished at this writing.

In our investigations and experimentation, biosludge obtained from the biodegradation of stripped-gas liquor was in the form of an aqueous slurry and was dehydrated by heating at 110°C in a drying oven for several hours. The sample was then pulverized and sieved to give a constant particle size of 200 to 400 u. Samples of approximately 0.5 grams were placed in a reaction tube and then placed in the Xenon flash pyrolysis cell. Helium gas was allowed to pass through the cell continuously at 120 cc/min during the entire experiment. A Tenax trap was then attached to the exit line of the pyrolyisis cell. The Xenon flash was adjusted to give approximately 15,000 joules/pulse in 10 msec. Three consecutive pulses were delivered to the sample, and the exit gases were collected on the Tenax trap. The GC/MS data was obtained by thermally desorbing the trap at 200°C for ten minutes into a DB-5 column held at -50°C. The GC/MS spectrum indicates the presence of a multitude of compounds, of which benzene and tolene were the major components.

Results show that coal gasification condensate water can be converted to hydrogen gas by irradiation in the presence of a semiconducting photocatalyst. The efficiency of this process, the lifetime of the catalyst, and the adaptability to solar irradiation are a few aspects which still need to be investigated. Flash pyrolysis of coal-derived biosludge gives some useful fuel gases along with oils which offer a potential source as fuel additives.

* Advisor - Dr. James Worman

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3) Urban, D.L. and M.J. Antal, Jr. Fuel, (1982), 61, 799.

VERA L. FACEY
(June 6, 1909 - December 15, 1985)

Vera Facey was born in Halifax, Nova Scotia, Canada and received her Bachelor of Science degree with highest honors in biology from Kings College of Dalhousie University, Halifax. She received her M.A. and Ph.D. degrees in botany from the University of Toronto where her dissertation earned her the Wintercorbyn Prize for "research in botany of most use in agriculture or medicine."

Following receipt of her Ph.D. she taught for six years in the public schools of Nova Scotia and served as a lecturer in botany at Dalhousie University and the Nova Scotia Agricultural College for four years. She joined the University of North Dakota Biology Department in 1947 and retired as professor emeritus in 1979.

Facey's major professional interest was in natural resource conservation, particularly North Dakota's prairie environment. She specialized in plant physiology and ecology. In addition to her teaching duties at UND, she served as curator of the University Herbarium. She volunteered as a judge at high school science fairs throughout the state, translated scientific articles in French, German, and Russian, and traveled widely.

Dr. Facey was active in local organizations and served a term as President of the Grand Forks Chapter of Zonta International. In 1960 she became the first woman elected President of the University of North Dakota Chapter of Sigma Xi. An Academy member since 1948, she served as President of the North Dakota Academy of Science in 1960-61.

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WAYNE ROBERT KUBE
(May 3, 1922 - November 9, 1985)

Wayne Kube was born in Mancelona, Michigan and received his bachelor's and master's degrees in chemical engineering from Michigan Technologic University. He and his family moved to Grand Forks in 1948 where he was employed at the U.S. Bureau of Mines Lignite Laboratory, now the University of North Dakota Energy Research Center. He was appointed a member of the UND chemical engineering faculty in 1952, but continued close association with the Bureau of Mines. He retired as Professor of Chemical Engineering in 1985.

Kube was well known throughout the nation and world for his studies on lignite. He was elected a fellow of the American Institute of Chemical Engineers in 1980 in recognition of his life-long work. He served on many governmental energy advisory committees, and accumulated a lengthy list of publications. He co-founded the International Biennial Lignite Symposium which has attracted outstanding investigators from throughout the world.

Kube was a member of the North Dakota Academy of Science from 1949 until the time of his death.

C. ARTHUR WARDNER
(July 13, 1904 - July 13, 1985)

Arthur Wardner was born in Fisher, Minnesota and after graduating from Fisher High School and Concordia Academy he studied at the University of North Dakota. He received his bachelor of science degree in chemistry from UND in 1927 and a master of science degree from UND in 1929. His doctorate in organic chemistry was awarded by the University of Pittsburgh in 1932.

Wardner began employment as a research chemist with Sonneborn Chemical and Refining Company of Petrolia, PA, in 1932 and in 1937 joined Flaat Farms of Grand Forks as Technical Director and President. He returned to academe in 1958 when he joined the UND Chemistry Department as an Assistant Professor. He retired from teaching in 1971 as Professor of Chemistry. For five years (1966-1971) Wardner directed the UND summer and academic year science institutes for high school science teachers.

Wardner was a member of the North Dakota Academy of Science from 1958 until his death and served as Academy President in 1962-63. He also served on Grand Forks Chamber of Commerce committees and on the YWCA Building Fund Drive.

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LONG. KEVIN	808 FIRST AVENUE NORTHWEST	MINOT	ND 58701
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MAHALKO. JANET	1513 BARON BOULEVARD	GRAND FORKS	ND 58201

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MARTIN. JAMES E.	SD SCHOOL OF MINES/TECHNOLOGY	RAPID CITY	SD	57701
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MELDRUM. ALAN	512 COLUMBIA ROAD	GRAND FORKS	ND	58201
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