Proceedings of the NORTH DAKOTA Academy of Science

87th Annual Meeting

April 1995 Volume 49

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PROCEEDINGS of the NORTH DAKOTA ACADEMY of SCIENCE is published annually. This issue contains communications (from Symposia, from Professional Contribution sessions, and from Collegiate Competition sessions) representing papers submitted and accepted for oral presentation at the April annual meeting of the ACADEMY. The PROCEEDINGS appears in April of each year.

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PROCEEDINGS

Volume 49 April 1995

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NORTH DAKOTA ACADEMY of SCIENCE

(Official State Academy 1958 Founded December 1908)

1994 95

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87th ANNUAL MEETING

20 - 21 April, 1995

Bismarck, North Dakota

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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 for the Fortieth Annual Meeting, 2 and 3 May, 1947. Through Volume XXI the single yearly issue of the PROCEEDINGS included both Abstracts and Full Papers. Commencing with Volume XXII, the PROCEEDINGS was published in two parts. Part A, published before the meeting, contained an Abstract of each paper to be presented at the meeting. Part B, published later, contained full papers by some of the presenters.

Commencing in 1979 with Volume 33, the PROCEEDINGS changed to the present format. It is produced from camera-ready copy submitted by authors, and is issued in a single part to be distributed initially at the Annual Meeting in late 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 actual 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 49 of the PROCEEDINGS contains presentations from the Symposium offered at the 87th Annual Meeting of the Academy in honor of the Centennial year of the North Dakota Geological Survey held in Bismarck, 20 - 21 April, 1995. These papers are organized in the same sequence as presented at the meeting.

The second section of this volume contains the communications presented in the Professional sections of the meeting. All Professional Communications were reviewed for conformity with the instructions to authors by the Editorial Committee prior to their acceptance for presentation and publication herein. The professional communications have been grouped together in order of the oral presentation at the Annual Meeting.

The third section of this volume presents the Collegiate Communications representing all 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 student competitors were required to prepare a communication similar to those prepared by their professional counterparts, these communications were not reviewed prior to publication herein. The Denison Awards Committee judges the oral presentation and the written communication in arriving at their decision for first place and runner-up awards in both the graduate and undergraduate student competitions. In this section the first group of papers are from the undergraduate competition and the second group of papers are from the graduate competition.

Readers may locate communications by looking within the major sections of these PROCEEDINGS (see the table of contents), or by referring to the author index for a page number reference to this volume.

This issue of the PROCEEDINGS also includes the *Constitution and Bylaws* of the ACADEMY, a list of *Officers and Committee Membership* for the May 1994 - April 1995 year, a list of all *Academy members* as of 1 March, 1995, and a copy of the most recent (1994) *financial statement* summarizing the evolutionary status of the Academy.

Roy Garvey
Editor

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RULES for PREPARATION of PROCEEDINGS COMMUNICATIONS

Submission.

1. Papers presented at the Annual Meeting of the ACADEMY must be represented by **single** page communications in the PROCEEDINGS. At least one author must be a member in good standing of the Academy. This includes A Rodger Denison student research competition papers. Exceptions are made in the case of participation in Symposia.

2. Only communications intended for presentation at the Annual Meeting will be considered for publication. They must present **original research** in a concise form. Quantitative data should be presented with statistical analysis (means with standard errors). The communication should include the purpose of the research, the methodology, results, and conclusions. Papers which merely summarize conclusions or ideas without supporting data are discouraged and will not normally be accepted.

3. Communications must be submitted on a single 8.5 x 11.0 inch page of white bond paper. the full surface area of the page may be used for text and figures. Send the **original** and **four legible photo copies** to the Editor, PROCEEDINGS of the North Dakota Academy of Science. The original must not be folded; a cardboard stiffener should be used to avoid damage. As a final step, the Editor will "paste" your submission to a 'blue line communications form' adding the necessary "headline and footer". The PROCEEDINGS will be published by direct photo offset of the submitted communication with a reduction to 80% of the original size to accommodate margins). No proofs will be prepared.

4. 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.

Manuscript.

5. Authors are encouraged to utilize the full space available on an 8.5 x 11.0 inch page in order to provide sufficient information to fully describe the research reported. One or two line top and bottom margins and 1 to 3 character right and left hand margins are recommended (as appropriate to your "laser Printer"). The material you submit on this page must be "camera-ready" since it will be photographed and reproduced directly in the PROCEEDINGS. Text should be presented using no smaller that "elite" (12 character per inch) fonts and single line spacing (6 lines per inch). This should allow for approximately 62 lines of 100 characters each. Unless your printer/word processor uses "micro justification", DO NOT right justify your text. Begin paragraphs with a 3 character space indentation. Use a typewriter with carbon or good quality black silk ribbon, or a "laser printer" set for the narrowest margins which will retain the printed characters on the face of an 8.5 by 11.0 inch page. Special symbols not available on the fixed character printer must be hand lettered in black ink. Dot matrix print of less than "letter quality" is not acceptable.

6. Text, tables and diagrams reproduced on white bond paper, and high contrast photographs may be secured to your original page of text using "Tack Note" by Dennison or with two sided mounting tape. Tape should NOT show on the top side of the bond paper or photograph being mounted. All typing, drawing and secured art or photographic materials must be within the boundaries of the single 8.5 x 11.0 inch page. Brief descriptive captions or titles must accompany each figure and table.

7. *Heading*: The title of the communication, typed in capitalized characters, should be centered as the first line(s). 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 of these as practicable. Titles normally should not exceed 140 characters in length. 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. A blank line should follow immediately after the title.

The names of the authors should be centered on the line immediately following the blank line after the title of the communication. Full first names are encouraged; however, the author should use initials if he/she normally uses that form in other publications. Indicate the author to present the communication by an asterisk * after that person's name. The business or institutional address of the author(s) should be centered on the line immediately following the line listing the name of the author. Typical entries might be:

Department of Chemistry, North Dakota State University, Fargo, ND 58105
Energy and Environmental Research Center, University of North Dakota,
Grand Forks, ND 58202
USDA/ARS, Human Nutrition Research Center, Grand Forks, ND 58202
USDA/ARS, Biosciences Research Laboratory, Fargo, ND 58105
North Dakota Geological Survey, 600 East Boulevard, Bismarck, ND 58505

8. *References*: Only essential references should be cited, and each should be indicated in the text by a number enclosed in parentheses; this number should be on the same line as the rest of the text (e.g. "This topic has been discussed by Smith (5, 6)"). Note that a space is left between words and the parenthetical citation and that there is a space between numbers in multiple citations. References are to be assembled, arranged numerically in order of first appearance in the text, and placed at the end of the communication under a two inch line of _____. In the Literature Cited the reference numbers are followed by a period and are placed flush with the left margin; if the reference exceeds one line, the succeeding line or lines should be indented 5 spaces. The following form of citation should be used. Note that periods after abbreviations for Journal titles and spaces between initials for authors names have been omitted to conserve space.

_____

1. Neary, D., Thurston, H. and Pohl, J.E.F. (1973) Proc ND Acad Sci 40, 83.
2. Batsone, G.W., Blair, A.W. and Slater, J.M. (1971) A Handbook of Pre-Natal Pediatrics, pp 83-90. Medical and Technical Publishing, Lancaster.
3. Farah, A.E. and Moe, G.K. (1970) in Pharmacological Basis of Therapeutics, 4th edition (Goodman, L.S and Gilman, A, eds), pp 677-709. MacMillan, New York.
4. Rajewsky, M.F. (1973) Abstr 2nd Meeting European Association of Cancer Research, Heilelberg, Oct 2-5, pp 164-5.

9. *Abbreviations*: Only standard abbreviations should be used, and should be written out the first time used with the abbreviation following in parentheses. The North Dakota Academy of Science (NDAS) for example.

10. *Session Assignment*: To assist the Program Committee in organizing the presentations, please indicate in a cover letter your 1st, 2nd and 3rd preferences for the topical classification of your paper.

RULES for ORAL PRESENTATION of PAPER

1. All papers are limited to 18 minutes total time for presentation and discussion. It is suggested that the presentation be limited to twelve minutes with an allowance of five 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 specialized terminology as may be judged to be indispensable to the presentation.

3. Projectors for 2 x 2 inch slides and "overhead transparencies" will be available in all session rooms. Opaque projectors and video playback equipment will be made available as required if advanced notice of need is given. Only visuals which can be read easily on projection should be used. Authors who desire suggestions for preparation of slides are referred to Smith, H.W. (1957) "Presenting Information with 2 x 2 Slides", Agron J 49, 109-13.

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.

5. Moderators are bound to remain on a strict time schedule in order that members of the audience can easily move among sessions to attend papers of special interest.

Friday, 21 April

Undergraduate. Room: __ A __ Presiding: Lyle Prunty, NDSU

Assisting: _____

8:00
The Influence of the Coteau des Prairies on the Formation of a Boulder Pavement.
Asuka Tsuru*
Geosciences, North Dakota State University, Fargo, 58105 5517

8:20
Biodegradation of Alkanolamines in Soil.
Steven S Philbrick* and John R Gallagher
Energy and Environmental Research Center, University of North Dakota, Grand Forks 58202

8:40
Measurement of alpha Particle Emissions from Lead Surfaces.
James Schmaltz* and Glenn I Lykken
Physics, University of North Dakota, Grand Forks 58202 7129

9:00
Reconstructing the Turonian Age Elasmobranchii Population of the Cretaceous Seaway Using Fossils Collected from the Cold Spring Quary at Millbank, South Dakota.
Michelle Taylor*
Geosciences, North Dakota State University, Fargo 58105

THE INFLUENCE OF THE COTEAU DES PRAIRIES ON THE FORMATION OF A BOULDER PAVEMENT

Asuka Tsuru, Department of Geosciences, North Dakota State University, Fargo, ND 58105-5517

Boulder pavements are planar, single-stone thick concentrations of glacially modified clasts. The upper faces of boulders are faceted in such a manner that they resemble stone pavement (Fig.1). The size and lithology of boulders vary, thus the bottom faces of boulders are often irregular. The faceted faces are frequently striated, indicating the direction of ice flow.

In the region of the Coteau des Prairies, northeastern South Dakota (Fig.2), boulder pavements are found on both western and eastern Coteau flanks at the elevations between 430 and 460 meters. The upper face of boulders mark the base of the New Ulm Till (Des Moines Lobe).

The purpose of my study was to investigate the northern part of the Coteau, which has been understudied despite many studies done on the both flanks, and to determine the influence of the Coteau to the formation of boulder pavement, if any.

At the northern tip of the Coteau, just north into North Dakota, no exposure of boulder pavement was observed. However, a large concentration of boulders occurs at elevations where boulder pavements would be expected. Here, these boulders are also within the base of the New Ulm Till, rather than marking the base. As one traverses southward from this point along either flank of the Coteau, several trends are observable. The ratio of limestone to igneous and metamorphic rocks decreases southward. The number of boulders with faceted faces increases southward. Stratigraphy below the boulders changes from the New Ulm Outwash to Cretaceous shale. Finally, the boulders become more ordered southward, grading into a boulder pavement..

As the Coteau inhibited ice flow, sliding velocity decreased, causing deposition of larger clasts at the northern tip of the Coteau. Some of the boulders were re-entrained by ice and dragged along the Coteau flanks to be embedded onto lower stratigraphic members. Those boulders transported furthest south underwent the greatest stress and abrasion. Mechanically-resistant lithologies were more likely to survive abrasion, thus increasing in dominance in boulder concentrations southward.

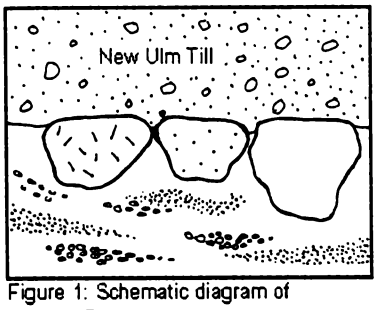


Figure 1: Schematic diagram of Boulder Pavement.

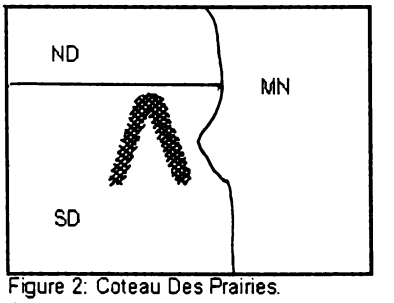


Figure 2: Coteau Des Prairies. (study site)

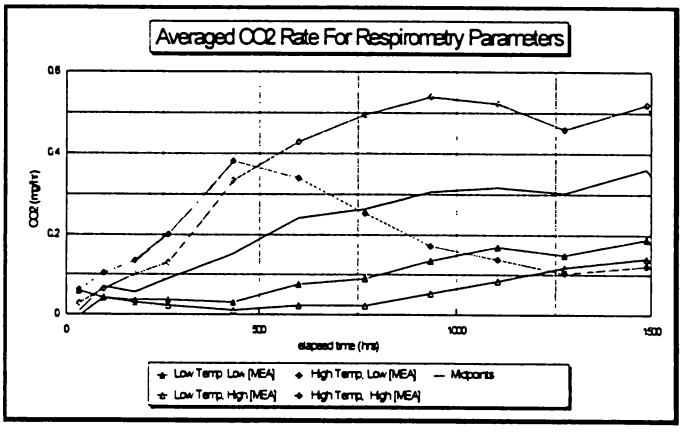
BIODEGRADATION OF ETHANOLAMINE IN SOIL

Steven S. Philbrick* and John R. Gallagher
Energy and Environmental Research Center, Univ. of North Dakota, Grand Forks, ND 58202

Alkanolamines are widely used in the natural gas industry for the removal of acid gases. These compounds have locally contaminated soils through spills and through the disposal of wastes from the acid gas process. Knowledge of the behavior of potential contaminants in the subsurface is critical to 1) understanding the concentration and distribution patterns of those substances where information of that type is available, 2) predicting the fate of those same substances, 3) evaluating the risk that those substances pose, and 4) when necessary, choosing the most effective and economical means for reducing unacceptable risk related to those substances.

The fate of alkanolamines in the environment is of concern because they are highly water-soluble, poorly sorbed, may act as a cosolvent for other contaminants, and present analytical difficulties. Two soils were collected from a natural gas processing plant site near Calgary, Alberta., one with prior alkanolamine exposure and one that had no previous exposure. Alkanolamine exposure was verified via gas chromatography/ mass spectrophotometry. The effects of temperature and concentration on the biodegradation of ethanolamine (MEA) were evaluated using soil respirometry, a technique in which evolved carbon dioxide is captured, measured, and directly related to microbial activity. Ethanolamine was evaluated because it was used exclusively at the site and the data obtained will be applicable to a number of other areas.

MEA concentrations representing those found after a spill or some other event were tested to assess biodegradation rates, temperature dependence, lag times (acclimation), and toxic effects. Temperature was the greatest factor in determining biodegradation rates and acclimation times. The tested variables for this study were MEA concentrations of 500, 1000, and 1500 ppm and temperatures of 6, 14, and 25°C.



It may be seen from the accompanying figure that low temperature resulted in lag times of approximately 450 hours, while the high temperature trials began utilizing the MEA immediately. The high concentration of MEA was inhibitory under the conditions tested, reducing biodegradation rate and increasing acclimation times. The temperature dependence of these data indicates that ethanolamine spills in the environment are likely to persist much longer than room temperature data suggests. The natural biodegradation rate, as determined in this study, is low due to both temperature and apparent toxicity.

MEASUREMENT OF ALPHA PARTICLE EMISSIONS FROM LEAD SURFACES[1]

James Schmaltz* and Glenn I. Lykken
University of North Dakota, Physics Department
Grand Forks, ND 58202-7129

Lead-based ceramics and solders contain alpha particle (α)emitting daughters. These daughters are members of the uranium-238, actinium (U-235), and thorium-232 radioactive decay series which terminate in stable isotopes of lead: lead-206, lead-207, and lead-208, respectively. Alpha particles affect the reliability of semiconductor memories and devices by introducing spurious signals(soft errors). Therefore, a need to measure α-emissions from lead ores used in integrated circuit packaging and terminals (solder) exists. This need prompted the development of an accurate method to detect and analyze α-emissions from lead ores used in these products.

Lead samples were shaped by a "press and roll" technique developed in this laboratory. A lead sample ($\approx$1.8 g) was cut from an ore casting with a band saw. The sample was placed between two stainless steel plates (5x10x0.2 cm), positioned in a hydraulic press and pressed to a diameter of $\approx$1.1 cm and a thickness of $\approx$1.1 mm. The plates with sample (blank) were then rolled alternately in perpendicular directions in a roller press to a uniform thickness ($\approx$0.55 $\pm$ .02 mm). The blank was placed on a Plexiglas surface covered with a sheet of white paper and a sample of diameter $\approx$25 mm was stamped out. The edge was trimmed with a scissors, and the sample was stored in a labeled plastic petri dish. The stainless steel plates, punch, and scissors were washed with methanol after each new blank had been pressed.

Each sample was placed in a 50mL beaker containing <10mL methylene chloride (EM Industries., Gibbstown, NJ) and wiped repeatedly with a cotton swab (Chesebrough-Ponds USA Co., Greenwich, CT). The sample was removed, cleaned on one side with a cotton swab saturated with acetic acid (97.7% concentration, Fisher Scientific Co., Chicago, IL), and subsequently dried in a stream of nitrogen gas. After drying the samples, they (up to 5) were placed in an alpha spectrometer (Ortec, model 576A, Oak Ridge, TN) and counted for 24 to 240 h (86400-864000 s). The α-emission spectra were summed for gross α-counts and net α-counts (gross counts - background counts) The α-spectra were stored in a computer memory, plotted in graph form, labeled, and filed for future reference.

Nineteen lead castings from different lead ore lots were received from The Doe Run Company (Herculaneum, MO) and 3 similar lead castings were received from Balzers (Hudson, NH). Samples formed from these lots were analyzed and α-counts [counts/s$\cdot$cm^2 (C)] of $(4.8\pm4.4)\times10^{-5}$ C and $(4.9\pm1.8)\times10^{-5}$ C were recorded, respectively. Alpha-peaks containing a relatively high number of net counts >3 were attributed to contaminants (notably U, Pa, & Po) which have comparable α-emission energies (CRC Handbook, Boca Raton, FL). Alpha-counts of $(0.8 \pm 3.3)\times10^{-4}$ C were recorded and α-peaks corresponding to radioactive daughters from naturally occurring radioactive decay series (Th, Pa, & Po) were observed. A duplicate set of samples was made to compare the effect of a lubricant (JB-80, Justice Brothers, Duarte, CA) on sample production and analysis. One set was formed in the normal method while a second was formed with JB-80 applied to the lead/stainless steel interfaces. The lubricant allowed better "flow" during pressing and rolling so that thinner (0.27$\pm$.01 mm) blanks with nearly circular shapes were produced. No detectable α-counts could be attributed to the JB-80 lubricant [normal, $(3.8\pm1.5)\times10^{-5}$ C, JB-80, $(3.8\pm1.1)\times10^{-5}$ C]. Thicker stainless steel plates (3.3 mm) were obtained so that similar samples could be formed without the use of JB-80 except when less malleable samples of recycled lead from a whole body counter steel room (USDA Grand Forks Human Nutrition Research Center, Grand Forks, ND) were formed. Four samples from this lead were counted and $(7.9\pm3.4)\times10^{-4}$ C were measured after counting times of 432000 s.

Alpha-particle spectroscopy was used to measure α-emissions from lead. Lead samples counted contained more α-emitting nuclei than Al_2O_3 and AlN samples.

[1]This work was made possible under Science Bound, a program funded by The North Dakota Experimental Program to Stimulate Competitive Research (ND EPSCoR).

Reconstructing the Turonian Age Elasmobranchii Population of the Cretaceous Seaway Using Fossils Collected From the Cold Spring Quarry at Millbank, South Dakota

Michelle Taylor
Geoscience Department
North Dakota State University
Fargo, North Dakota 58105

During the Cretaceous period, North America was covered by a great seaway which extended from the Gulf of Mexico to the Arctic Sea, leaving thousands of feet of marine sediments[1]. Most of the evidence for this great sea has been buried by subsequent glacial activity. Quarrying at Millbank, South Dakota has unearthed some of these sediments. Samples taken from this site have proven prolific in fossil Elasmobranchii (sharks, rays & skates) teeth as well as other marine fossils. Further examination and identification of these fossils has led to the belief that the beach sediments that were deposited on the granite at Millbank are of Turonian age (92 to 86 mya)[2]. If this is proven true, it would represent one of the easternmost extents of the Cretaceous Seaway.

Samples of eroded beach sediment were collected from the Cold Spring Quarry near Millbank. The samples were washed and sieved. They were then sorted. The fossils were cleaned with an Acetic Acid bath, followed by a soap and water bath. Extremely dirty specimens were treated with Amway Stain Remover. Once cleaned, the fossils were sorted and identified.

Found in the beach sediment were sharks of the order Hybodontiformes, Lamniformes, and Rajiformes. The sediment also contained fossil crocodile teeth, fish teeth, Mosasaur teeth and vertebrae, various other vertebrae, and snails. The Presence of *Ptychodus whipplei* as the only representative of the order Hybodontiformes and the family Ptychodontidae has led to the conclusion that the beach sediments were deposited in the Turonian. If this is proven true it will be definitive proof of the elusive eastern shore of the Cretaceous Seaway. This find will help Geologists better define the extent of the Cretaceous Seaway as well as shedding light on some of the shark populations of the past.

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1)Welton, B.J. and Farish, R.F. 1993. The Collectors Guide to Fossil Sharks and Rays From the Cretaceous of Texas: Before Time, Lewisvile 204p.
2)AAPG Contributions to the Geologic Time Scale: Studies in Geology #6: American Association of Petroleum Geologists, Tulsa, P.271.

Friday, 21 April

Graduate. Room: __ B __ Presiding: Dorothy Johansen, Mayville

Assisting: Danial Mott, DSU _____

Eileen Starr, VCSU _____

8:00
Cross-Ristance to Adriamycin in Cadmium-Resistant Human Lung Carcinoma A549 Cells.
Emiko L Hatcher* and Y James Kang
Pharmacology and Toxicology, UND School of Medicine, Grand Forks 58202 9037

8:20
The Evidence that Acetylator Phenotype is a Risk Factor in Rapid and Slow Acetylator Inbred Rats Administered 3,2'-dimethyl-4-aminobiphenyl.
Wen Jiang*, Yi Feng, David W Hein
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037

8:40
Analysis of RNA Induction by Cadmium in the Green Alga *Chlamydomonas acidophila*.
Scott A Hoffman* and Jonathan G Spanier
Microbiology and Immunology, University of North Dakota, Grand Forks 58202

9:00
Effects of Adriamycin on Concentrations of Metallothionein and Glutathione in the Liver of Mice.
Qiangrong Liang*, Yan Chen, Y James Kang
Pharmacology and Toxicology, UND School of Medicine, Grand Forks 58202 9037

9:20
Mitogen-Induced PIM-1 Gene Expression: A Potential Suppressor of Toxin— and Drug-Activated Apoptosis.
Matthew A Leff*, Donna J Buckley, Arthur R Buckley
Pharmacology/Toxicology, UND School of Medicine, Grand Forks, 58202 9037

9:40
Interaction of Mitochondrial Phosphoenolpyruvate Carboxykinase (PEPCK) with Several Enzymes of the Krebs Cycle.
Bruce J Watkins* and P D Ray
Biochemistry and Molecular Biology, UND School of Medicine, Grand Forks, 58202

10:00
A Spatial Analysis of Tornado Hazard Preception in Fargo and West Fargo, North Dakota
Thomas J Williams*
Geography, University of North Dakota, Grand Forks 59202 9020

10:20
Ecological Implications of Fossil Mollusca from the Fossil Lake Beds (Late Pleistocene), Lake County Oregon
Guy Hanley* and B Peter Ladendorf
Earth Science, Minot State University, Minot 58701

10:40
Land Use Change: A Case Study of the Spatial Impact Resulting from Development of the Fringe Regions of the Bob Marshall Wilderness, Montana
Brian W Savage*
Geography, University of North Dakota, Grand Forks, 58202

11:00
Multi-species Grazing using Goats and Cattle to Control Leafy Spurge.
Chad Prosser*, Kevin Sedivec, William Barker
Animal and Range Sciences, North Dakota State University, Fargo 58105

11:20
A Floristic Inventory of Camp Grafton South, Eddy County, North Dakota.
Edward DeKeyser* and William T Barker
Animal and Range Sciences, North Dakota State University, Fargo 58105

11:40
Metabolic Role of Phosphoenolpyruvate Carboxykinase (PEPCK) in Rabbit Enterocytes.
Sherry A Wuensch* and Paul D Ray
Biochemistry and Molecular Biology, UND School of Medicine, Grand Forks, 58202 9037

12:00
Glycolytic Enzyme — Cytoskeleton Interactions in *Saccharomyces Cerevisiae*.
Carol D Gustafson* and Harvey Knull
Biochemistry and Molecular Biology, UND School of Medicine, Grand Forks 58202 9037

CROSS-RESISTANCE TO ADRIAMYCIN IN CADMIUM-RESISTANT HUMAN LUNG CARCINOMA A549 CELLS

Emiko L. Hatcher* and Y. James Kang
Department of Pharmacology and Toxicology, University of North Dakota School of Medicine
Grand Forks, ND 58202

The clinical application of Adriamycin (ADR), a widely used chemotherapeutic agent that is highly effective against a broad spectrum of cancers, is often obviated by the development of drug resistance. Enhanced antioxidant capacity and induction of a membrane glycoprotein (P170) are among the recognized mechanisms of ADR resistance. The environmental contaminant cadmium (Cd) is highly toxic at relatively low concentrations and potentially carcinogenic. Although its mechanism of toxicity remains unknown, several mechanisms of cadmium resistance have been identified. Among them are altered cadmium uptake and induction of the metal chelator metallothionein (MT). The protective mechanisms elicited by environmental stresses and xenobiotics such as cadmium may exhibit cross-resistance to anticancer drugs. Therefore, the role of acquired resistance to environmental toxins in clinical drug resistance is becoming of increasing importance to the treatment of neoplastic diseases. In the present study, we examined whether cross-resistance to ADR exists in cadmium-resistant tumor cells.

We selected two subclones of human lung carcinoma A549 cells, which exhibited a 5-fold difference in cadmium resistance, to determine ADR toxicity by a 10-day colony formation assay following 8 hr ADR treatment. The results showed that the cadmium-resistant cells were significantly less sensitive to ADR than the cadmium-sensitive cells. We then investigated possible factors responsible for the cross-resistance. The activities of the antioxidant enzymes superoxide dismutase (SOD), catalase, glutathione peroxidase (GSHpx) and glutathione reductase (GR), as well as concentrations of cellular glutathione (GSH) and MT, and the capacity of MT induction were compared between the two sublines. As shown in Table 1, among these important resistance-related factors, only GSH concentrations significantly ($p<0.01$) differed between the two sublines. Previous studies have demonstrated that depletion of cellular GSH sensitizes numerous tumor cells to both cadmium[1] and ADR.[2] Therefore, elevation of GSH concentrations is likely responsible for the Cd-ADR cross-resistance. It is important to determine the possible mechanism for the elevation of cellular GSH concentrations. We thus measured the relative amount of steady-state mRNA for γ-glutamylcysteine synthetase (γ-GCS), which catalyzes the rate-limiting step in *de novo* GSH synthesis. As also shown in Table 1, the Northern blot analysis revealed that the mRNA content in the resistant cells was significantly ($p<0.01$) elevated, suggesting that the increase in cellular GSH concentration resulted from enhanced expression of γ-GCS.

Table 1. Comparison of resistance-related factors between Cd/ADR-sensitive and Cd/ADR-resistant cells.

	Cd/ADR-sensitive	Cd/ADR-resistant
SOD (U/mg protein)	1.39 ± 0.20	1.26 ± 0.09
Catalase (μmol H_2O_2/min•mg protein)	43.87 ± 2.48	42.15 ± 8.48
GSHpx (nmol NADPH/min•mg protein)	9.72 ± 1.71	11.21 ± 0.74
GR (nmol NADPH/min•mg protein)	103.70 ± 16.50	114.30 ± 16.00
MT, basal (nmol/mg protein)	1.49 ± 0.02	1.304 ± 0.03
MT, induced (nmol/mg protein)	3.09 ± 0.16	2.73 ± 0.09
GSH (nmol/mg protein)	206.43 ± 36.45	323.42 ± 13.77 *
γ-GCS mRNA (optical density)	1.00 ± 0.04	3.53 ± 0.41 *

* $p<0.01$

The data obtained from this study demonstrated that cross-resistance to ADR exists in cadmium-resistant A549 cells. Among the possible mechanisms responsible for both cadmium- and ADR-resistance, elevation of cellular GSH concentrations is likely involved in the development of cadmium-ADR cross-resistance. Furthermore, the elevated GSH content is likely due to the enhanced γ-GCS expression. Future studies will examine the roles of ADR uptake, P170 expression and the detoxification enzyme glutathione-S-transferase (GST) in the sensitivity of cadmium-resistant cells to ADR. Supported in part by grant RR-05407 from NIH.

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THE EVIDENCE THAT ACETYLATOR PHENOTYPE IS A RISK FACTOR IN RAPID AND SLOW ACETYLATOR INBRED RATS ADMINISTERED 3,2´-DIMETHYL-4-AMINOBIPHENYL

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The etiology of several human cancers such as bladder cancer, colon cancer, breast cancer,and prostate cancer may involve exposure to aromatic and heterocyclic arylamines found in industry, cooked foods, and the environment. Arylamine chemicals require host-mediated metabolic activation to ultimate carcinogens which interact with macromolecules such as DNA to induce a heritable event, perhaps a somatic mutation or deletion, to initiate the process of tumorigenesis. Acetylation of arylamines is catalyzed by N-acetyltransferases termed NAT1 and NAT2. N-acetylation capability in human and other mammalian species such as rat, hamster, and rabbit, is subject to a genetic polymorphism resulting in rapid, intermediate, and slow acetylator individuals. Human epidemiological studies have shown strong associations between acetylator status and some cancers. Genetic regulation of activation and/or deactivation pathways play a role in corresponding differences in arylamine induced tumor incidence between tissues, species, or between individuals within a species. One of two doses (50 mg/kg and 100 mg/kg) of 3,2´-dimethyl-4-aminobiphenyl (DMABP) were administered intraperitoneally to five rapid(F-334) and five slow(WKY) acetylator inbred rats. Livers, urinary bladders, colons, prostates, and hearts were collected at 48 hours. DNA from those organs was isolated by phenol/chloroform extraction and DNA adduct levels were quantitated by 32P-postlabeling and thin layer chromatography analysis. No DNA adducts were detected in vehicle-treated animals. However, two DNA adducts were identified in experimental animals administered DMABP which corresponded to the authentic standards N-(deoxyguanosin-8-yl)-DMABP and 5-(deoxyguanosin-N2-yl)-DMABP (Figure 1). In both rapid and slow acetylator rats, the total DMABP-DNA adduct levels were highest in liver and lowest in heart following injection of either 50 (Figure 2) or 100 (Figure 3) mg/kg DMABP. In addition, acetylation phenotype affected the level of total DMABP-DNA adduct at both dose levels. At both 50 mg/kg (Figure 2)and 100 mg/kg (Figure 3), total DMABP-DNA adducts were consistently higher in slow (ss) versus rapid (rr) acetylators, although the difference was not significant in every tissue. This difference in capability for catalyzing the metabolic activation of this arylamine to DNA adducts suggests that rapid acetylator rats detoxified more readily, and formed less DNA adducts than slow acetylator rats. Additionally, distribution differences in DNA adduct formation were readily observed between the different organs, suggesting that the N-acetylation polymorphism influences not only individual but also tissue susceptibility to arylamine carcinogens. This preliminary result supports our hypothesis that a polymorphism in N-acetylation capacity contributes to the tissue- and species-specific differences in arylamine induced tumor incidence and predisposes to cancers from arylamines in slow acetylators. Partially supported by USPHS grant CA-34627.

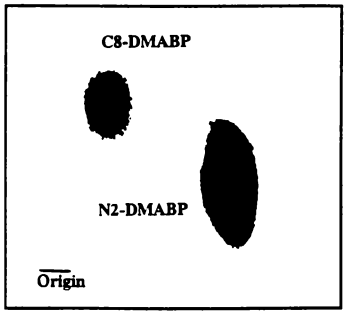

Figure 1 (DMABP-DNA Adducts)

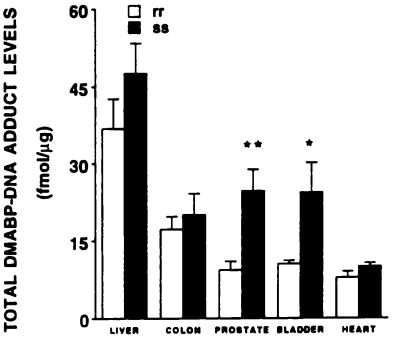

Figure 2 (50 mg/kg)

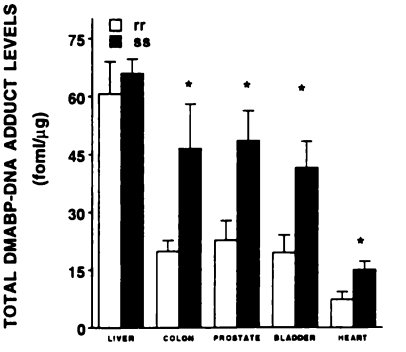

Figure 3 (100 mg/kg)

ANALYSIS OF RNA INDUCTION BY CADMIUM IN THE GREEN ALGA *CHLAMYDOMONAS ACIDOPHILA*

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Chlamydomonas acidophila is a biflagellated green alga that typically inhabits acidic environments. A previous investigation demonstrated that *C. acidophila* isolated from acidic and copper contaminated soils were copper tolerant (1). Recent work in our laboratory has provided evidence that *C. acidophila* amplifies a segment of DNA in response to cadmium exposure. The DNA is roughly 20 kb in size, circular and has been named pAL. It is reasonable to hypothesize that pAL may encode genes involved in heavy metal tolerance and that these genes may be inducible by exposing the alga to cadmium. To determine if the hypotheses were correct, we decided to investigate *C. acidophila* mRNA transcript production, in the presence of cadmium, by Northern analysis.

Initial restriction enzyme studies showed that pAL could be cut into about 10 fragments with *Hind* III. Three of these fragments (approximately 5, 1.7 and 1.6 kb in size) were ligated into a single vector. The resultant plasmid, pJB1, was used to probe total RNA. *C. acidophila* cells were treated with a range of cadmium concentrations (0μM-200μM) and total RNA was isolated chemically over an 8hr time period. The RNA was then electrophoresed and transferred to nylon membranes. These membranes were probed with ^{32}P labeled pJB1, autoradiographed, and quantitated by densitometer analysis.

The results showed that three *Hind* III fragments of pAL contain, at least in part, a number of expressible genes. One of the transcripts was shown to be strongly induced. This message increased fifty fold over time with a 100μM cadmium treatment. Further analysis showed this transcript to be encoded by the 4.5 kb fragment of pAL. This data suggests that pAL encodes genetic information that responds to heavy metal insult, although the precise nature of this response is unknown.

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EFFECTS OF ADRIAMYCIN ON CONCENTRATIONS OF METALLOTHIONEIN AND GLUTATHIONE IN THE LIVER OF MICE

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Adriamycin (ADR) is one of the most widely used anticancer agents for the treatment of a variety of human neoplasms. However, its clinical application is limited by its toxicity and the development of drug resistance. Previous studies have shown that the cytotoxic effect of ADR is mediated, at least in part, by the production of reactive oxygen species during its intracellular metabolism. The cardiac toxicity of ADR has been extensively studied, while little is known about its effect on the liver. Of the available information is that the liver is relatively resistant to the damage induced by either acute or chronic ADR applications,[1] which may be due to higher antioxidant enzyme activities (superoxide dismutase, catalase and glutathione peroxidase) and higher levels of non-enzymatic antioxidant components such as metallothionein (MT) and glutathione (GSH) in the liver than in the heart.[2] MT is involved in cellular protection against oxidative stress, and GSH functions in ADR detoxification.[3] The present study was undertaken to determine whether MT and GSH concentrations are altered in the liver of ADR-treated mice to examine the possible mechanisms of the liver's resistance to ADR.

FVB mice at age 7-weeks were treated with ADR (dissolved in 0.9% saline) by ip at 20 mg/kg and the controls received the same volume of saline. The livers from both ADR-treated and control mice were removed at day 4 after drug or saline injection. MT and GSH concentrations in the liver homogenates were determined by cadmium hemoglobin affinity assay and DTNB-GSSG reductase recycling assay, respectively. The total RNA was isolated from the livers with a method using RNA zol B, electrophoresed on agarose gel, then subjected to Northern blot analysis. The probes were a 1185- bp Hind III and Bgl II fragment of mouse MT-I cDNA and a 764-bp Pst I fragment of human γ-glutamylcysteine synthetase (γ-GCS) cDNA. The enzyme γ-GCS catalyzes the rate-limiting step in *de novo* GSH synthesis.

The determinations revealed that ADR treatment induced a 6-fold increase in the hepatic MT concentrations. In contrast, GSH concentrations in the liver were not altered by this ADR treatment. The Northern blot analysis showed that the relative amount of steady-state mRNA for MT-I was significantly elevated in the ADR-treated livers. The mRNA content for the γ-GCS was not altered, corresponding to the unchanged GSH concentrations. The results demonstrate that ADR is an effective inducer of MT synthesis in the mouse liver. The corresponding increases in both MT protein and mRNA strongly suggested that the MT induction resulted from enhanced gene expression. Further studies will focus on the role of MT induction in hepatic protection against ADR toxicity. Supported in part by grant 94007070 from the American Heart Association National Center and grant CA63752 from NIH.

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MITOGEN-INDUCED PIM-1 GENE EXPRESSION: A POTENTIAL SUPPRESSOR OF TOXIN- AND DRUG-ACTIVATED APOPTOSIS

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The prolactin (PRL)- and interleukin-2 (IL-2)-dependent rat Nb2 node lymphoma is an invaluable T-lymphocyte model for the study of hormone and cytokine-dependent proliferation. Moreover, recent evidence has demonstrated the utility of this paradigm for the investigation of molecular mechanisms governing apoptosis. Thus, the PRL-dependent Nb2-11 line is exquisitively sensitive to dexamethasone (DEX)- and polyhalogenated aromatic hydrocarbon (PAH)-activated programmed cell death, a process which is blocked by mitogen-stimulation in these cells. In contrast, an autonomous subline, Nb2-SFJCD1, is completely resistant to DEX- and PAH-provoked cytotoxicity. Therefore, it was of interest to investigate molecular mechanisms which underlie mitogen-stimulated suppression of apoptosis in Nb2-11 cells and the resistance observed in the Nb2-SFJCD1 line. Toward this end, we assessed whether expression of bcl-2, a protooncogene which blocks apoptosis in several systems, mediates suppression in Nb2 cultures. However, the bcl-2 transcript was undetectable by northern blot analysis under a variety of experimental conditions suggesting that suppression of apoptosis in Nb2 cells is most likely independent of bcl-2.

Pim-1 is a protooncogene that encodes a cytosolic serine/threonine protein kinase which is specifically expressed in hematopoietic tissues. Importantly, its expression has been linked to modulation of apoptosis. Therefore, experiments were conducted to assess pim-1 expression in each of the Nb2 lines at the mRNA and protein levels. In initial experiments, the time course for mitogen-stimulated pim-1 mRNA expression was evaluated by northern blot analysis. Nb2-11 cultures, which had been growth-arrested early in the G_1 phase of cell cycle, did not express the pim-1 transcript. However, mitogenic stimulation with either PRL or IL-2 rapidly induced pim-1 gene expression within 2-4 hrs; a second peak of expression was also detected by 12 hrs. In contradistinction, the Nb2-SFJCD1 subline constitutively expressed the pim-1 transcript. Mitogenic stimulation in this line further enhanced its expression also at 2-4 and 12 hrs. Results from mRNA stability studies indicated the $t_{1/2}$ for the pim-1 transcript in Nb2-11 cells to be 76-99 min at each time point. Interestingly, the $t_{1/2}$ for its expression in Nb2-SFJCD1 cultures was 322 and 80 min at 2 and 12 hrs, respectively. These data suggest that post-transcriptional regulation of pim-1 at its initial peak of expression is differentially modulated between the growth factor-dependent and autonomous lines. Pulse-chase experiments, utilizing ^{3}H-thymidine incorporation into DNA as an index of S phase transition, were conducted to determine the temporal relationship between PRL-stimulated pim-1 mRNA expression and cell cycle progression in Nb2-11 cells. Results from these experiments demonstrated that the initial peak of pim-1 expression occurs early during the G_1 phase of cell cycle. Notably, its second peak follows a nadir at 8 hrs and is co-incident with the onset of PRL-stimulated DNA synthesis at 8-12 hrs. Finally, translation of the Pim-1 protein was investigated in PRL-stimulated, ^{35}S-methionine prelabeled Nb2-11 cells by immunoprecipitation and SDS-PAGE. Expression of the pim-1 kinase, similar to its mRNA expression, exhibited a biphasic response. Maximal levels of the protein were observed at 6 and 24 hrs. From these results, we conclude that pim-1 mRNA: (1) is constitutively expressed in autonomous Nb2-SFJCD1 cultures, whereas, its expression in growth factor-dependent Nb2-11 cells is dependent upon mitogen stimulation; (2) expression appears to be differentially regulated between each of the cell lines; and (3) as well as protein expression appear to be regulated in a cell cycle specific manner in the PRL-dependent line. We suggest that the pattern of pim-1 expression observed in each of the Nb2 cell lines is consistent with a suppressive role for this protooncogene in the regulation of apoptosis. This work was supported in part by grants from the National Institutes of Health (DK44439) and The American Cancer Society (RD-383).

INTERACTION OF MITOCHONDRIAL PHOSPHOENOLPYRUVATE CARBOXYKINASE (PEPCK) WITH SEVERAL ENZYMES OF THE KREBS CYCLE

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Oxalacetate(OAA) + GTP$\rightleftharpoons$Phosphoenolpyruvate(PEP) + GDP + CO_2

PEPCK which catalyzes the above reaction exists in two different isoforms in mitochondria and cytoplasm of rabbit liver. Cytoplasmic PEPCK is essential to hepatic gluconeogenesis. No essential role exists for mitochondrial PEPCK so we are looking for pathways in which it might participate. We have suggested that mitochondrial PEPCK could convert PEP to OAA which could react with acetyl CoA to form citrate which could provide carbon and/or NADPH for cytoplasmic lipogenesis. Mitochondrial OAA can be a substrate and/or product of PEPCK and also of the Krebs cycle enzymes, malate dehydrogenase (MDH) and citrate synthase (CS). Enzymes in several metabolic pathways have been shown to interact with one another to facilitate metabolite flux and it is hypothesized that if the pathway we propose occurs, then the participating enzymes should interact. Thus, our goal is to investigate interactions of mitochondrial PEPCK, MDH, CS, and fumarase (FUM), another Krebs cycle enzyme.

The enzymes PEPCK, FUM, MDH and CS have each been highly purified from rabbit liver mitochondria by using various combinations of dye, affinity, and anion exchange chromatography. Overall yields (based on recovery of total activity) are: PEPCK-27%; MDH-23%; CS-20%; and FUM-12%. SDS-PAGE electrophoresis of each enzyme indicates a single band accounting for >95% of the protein applied to the gel as visualized by Coomassie blue staining.

One common method for demonstrating interaction between enzymes is to quantitate the activity(ies) of the enzyme(s) in both supernate and pellet after incubation (alone and in various combinations) in a "crowding agent" such as polyethylene glycol (PEG) followed by centrifugation since interacting enzymes would pellet out. Enzymes alone in 40 or 80 ug amounts, and in combinations using 40 ug of each enzyme are incubated in 0.2 ml of 14% PEG in 0.5 mM $MgSO_4$, 0.1 mM EDTA, and 5 mM KH_2PO_4/K_2HPO_4 buffer, pH 7.4. Specificity of the interactions is evaluated by testing for interaction of each enzyme with triose phosphate isomerase (TPI), a "non-interacting" cytoplasmic enzyme. Our experiments to date have shown no significant pelleting of 40 or 80 ug of PEPCK, MDH, CS, FUM, or TPI each incubated alone in 14% PEG; also no significant pelleting was observed when 40 ug of PEPCK, MDH, CS, or FUM were incubated with 40 ug of TPI. Additional interactions are currently being investigated.

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A SPATIAL ANALYSIS OF TORNADO HAZARD PERCEPTION IN FARGO AND WEST FARGO, NORTH DAKOTA

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It is important that natural hazards are recognized, and to educate the populations of high-risk areas about what can be done to offset potentially disastrous consequences as a result of living in such areas. The United Nations has declared the 1990's as the International Decade for Natural Disaster Reduction, and has invested much time and capital into improving safety and living standards by educating populations at risk. The United States is also taking part in this movement, committing itself to revamping the Emergency Broadcast System and the way federal monies are used in natural hazards mitigation. As long as the human population grows, disasters caused by natural hazards will steadily increase; they must somehow be alleviated in such a way as to lessen their effects.

Our home planet, Earth, is an active body in the solar system. Natural processes from within the planet, as well as on its surface, help to continuously shape it into the home we know. However, when people get in the way of these processes, the results can be devastating. When this happens, the processes are referred to as natural hazards. Natural hazards abound at every point on Earth, some more readily visible than others. The recent earthquakes at Kobe, Japan, and Los Angeles; the great midwestern floods of 1993; the volcanic eruption at Rabaul, Papua New Guinea; and Hurricane Andrew are all obvious examples of how dynamic, and dangerous, our home is. Other natural hazards, such as lightning, fog, and frost heaves may not be as obvious, but can be just as detrimental to humans and their activities.

North Dakota is not immune to natural hazards. Tornadoes are one type of hazard that occurs in the state. These powerful storms touch down in North Dakota on the average of 18-20 a year. Most of these travel across the open landscape, doing no harm. However, if a tornado were to strike a city, town, or any other populated area in the state, a catastrophe would result. This study investigates tornado hazard perception in Fargo/West Fargo, and addresses four major questions. First, does the perception of hazard vary between men and women? Second, is there a significant variation between zones of residential location and feelings of need for more shelter? Third, how do different age and sex groups respond to tornado warnings? Finally, how does gender and religious fatalism towards the tornado hazard interact?

A survey consisting of 33 questions was mailed out to 600 randomly-selected residential addresses throughout both cities. A total of 222 surveys (37%) were returned within a month. The data were coded and analyzed using SAS software on the mainframe computer.

The null hypothesis states that there is no difference between gender and the belief that destructive tornadoes are the result of God's will. A chi-square (X^2) analysis was performed, resulting in a calculated X^2 of 0.561 (df = 2). This fails to reject the null. Fargo is divided into three ZIP Code areas, north (58102), central (58103),and south (58104). West Fargo has its own code (58078). There was a wide range among responses to the question regarding the need for shelter, from strong agreement that shelters should be built, to strong disagreement of the same. For these two variables, the calculated X^2 = 15.188 (df = 6). The analysis shows a significant difference between the need for shelter and locale. This leads to the rejection of the null hypothesis, which states the magnitude of the frequency counts between area and shelter need is insignificant. There was also a significant difference in gender and the need for shelter, leading to rejection of the null hypothesis. Males and females were compared to the responses of the shelter need question. The X^2 analysis came up with a calculated value of 4.832 (df = 2). The ages indicated on the returned surveys ranged from 21 to 84, with a mean age of 42.997 years. The ages were combined into two groups: ages below the mean, and ages above the mean. The responses dealing with what a person does when the warning sirens are sounded were derived from an open-ended question. These responses were then grouped, as closely as possible, into three different categories. A X^2 analysis of these variables shows a calculated value of 0.504 (df = 2). This fails to reject the null hypothesis, which states that there are no significant differences between age groups and the way people respond when the sirens go off.

The preliminary results of this study show that an overwhelming majority of the residents of both cities (85%) were concerned about the threat of tornadoes in their areas. As expected, the residents of mobile homes and apartment complexes strongly supported the idea of a need "for more shelter" in their districts. There is a positive correlation between population density and desires for more protection against natural hazards such as tornadoes. It is also shown that there is no difference between men and women of various age groups in responding to tornado warnings. When the full results of this analysis are out, officials in the cities of Fargo and West Fargo will have access to information about vulnerable locations and groups, and the best ways to warn people in case of an emergency. It will help them to efficiently plan for mitigating the adverse effects of natural hazards, such as tornadoes, in these communities.

ECOLOGIC IMPLICATIONS OF FOSSIL MOLLUSCA FROM THE FOSSIL LAKE BEDS (LATE PLEISTOCENE), LAKE COUNTY OREGON

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Fossil Lake is located in the eastern portion of the Fort Rock-Christmas Lake Basin in northern Lake County, Oregon. The lake beds are known to produce a diverse Pleistocene vertebrate fauna (1). The invertebrate fauna is less diverse, a maximum of six mollusk species has been interpreted, all of which are extant (2, 3). The sediments were deposited during the late Pleistocene as the lake fluctuated in size and depth. This study presents the results of the first stratigraphically controlled collection of mollusks from the Fossil Lake beds. A total of 343 specimens were collected from five localities representing four distinct layers (Table 1). The samples included all observed varieties at each of the localities.

Twelve layers have been identified in the Fossil Lake sequence, not all are fossiliferous, but at least three distinct volcanic events are recorded by ash-rich layers in the sequence, the upper white ashy layer, pumice ash, and light tan clay with ash. The ash-fall from these eruptions may have profoundly affected the invertebrate fauna.

Table 1. Stratigraphic distribution and relative abundances of molluscan species

Bed Description / Species	H. trivolvis	H. newberryi	V. effusa	L. stagnalis	Pisidium sp.
white clay					
brown clay					
iron-stained sand	21	10			
sand and gravel					
light tan clay with ash					
sand and gravel					
brown silt					
pumice ash					
upper gravel		45			
upper white ashy layer	12	74	2	9	6
transition layer					
gray brown sand (site f)	1	92		2	
gray brown sand (site g)		69			

The stratigraphically controlled collection includes four species of snails, *Helisoma trivolvis*, *H. newberryi*, *Vorticifex effusa* (Family Planorbidae), *Lymnaea stagnalis* (Family Lymnaeidae), and one species of clam, *Pisidum* sp. (Family Sphaeriidae). In addition, a fifth species of snail, *Valvata virens* (Family Valvatidae) was recovered from anthills in the lower portion of the section (site g, cf. gray brown sand). Because of the nature of anthill collections, the precise stratigraphic provenance of these specimens is uncertain. The absence of *V. virens* in the surface collections is probably due to sampling error.

The most striking feature of the stratigraphic distribution of the species is the relative abundance's of the species. The greatest diversity occurs in the upper white ashy layer with four species of snails and one species of clam (Table 1). The presence of the clam in this layer may be intrusive as sphaeriids are burrowing forms (4). Throughout the lower portion of the section, *Helisoma newberryi* is the most abundant species (Table 1). In the upper portion of the section *Helisoma trivolvis* is the most abundant species. The remaining species, *V. effusa*, *Lymnaea stagnalis* and *Pisidium* sp., were less common, their presence or absence may be related to an ecologic cause or may be due to sampling error.

Planorbids and lymnaeids are able to survive adverse water conditions, in part because they are able to breathe free air (5). Members of these families are also able to aestivate, and have been kept in the laboratory for more than three years (6). The distribution of species in the Fossil Lake beds suggests the following scenario. Colonization and diversity in Pleistocene Fossil Lake reached a maximum at the time of deposition of the upper white ashy layer. The ash-fall caused a deterioration of water quality and a local extinction of all but the most abundant species, *H. newberryi*. The absence of all but *H. newberryi* in the upper gravel reflects this local extinction. The eruption which produced the pumice ash may have eliminated *H. newberryi*. Following the third eruptive event (light tan clays with ash), two snail species, H. trivolvis and H. newberryi were re-established in the lake, but conditions favored *H. trivolvis* over *H. newberryi*.

This hypothesis needs further testing. Efforts in the upcoming field season will concentrate on locating snail producing localities in the middle portion of the section and in sampling additional localities. Collections used in this study were made in cooperation with the Bureau of Land Management.

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LAND-USE CHANGE: A CASE STUDY OF THE SPATIAL IMPACT RESULTING FROM DEVELOPMENT OF THE FRINGE REGIONS OF THE BOB MARSHALL WILDERNESS, MONTANA

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PURPOSE

The Bob Marshall Wilderness (BMW) covers an area of just over 3000 square miles and is located in northwestern Montana. Designated as the Nation's first wilderness area, the BMW contains extensive tracts of virgin forests, pristine rivers and streams, and abundant wildlife and fauna. With the exception of this nation's national parks, the wilderness areas are the final vestiges for preservation. It is suggested that with increased development in the fringe regions (Figure 1), inadequate management policies, and continued leasing/privatizing of National Forest lands, the wilderness area itself may be adversely affected by air, water, and noise pollution resulting in the inability to obtain a desirable wilderness experience as defined by the Wilderness Act. The research examines these effects by assessing several Forest Service wilderness management models. The project contains three parts. First, to familiarize the reader with the study site; define the components of the wilderness area; and define the fringe parameters. Second, to explore wilderness management theories and policy; examine the various aspects of infringement; and explain the emotional and symbolic attachment to place. This was accomplished by reviewing existing works on wilderness management and infringement issues including land-use and planning, tourism, recreation, and federal/state land policy. And third, to provide a careful examination of encroachments within the Eastern, Southern, and Western Fringe Regions.

METHODOLOGY

Field surveys of the fringe regions surrounding the BMW were implemented in 1993 and 1994. This project focuses on wilderness land-use policy issues relating to the BMW, chiefly, the policies of the U.S. Forest Service. The majority of the maps analyzed were BLM Surface Management Status Maps, USGS Quadrangles, and a Geologic/Mining Map of Montana. A comparison of a "standard landscape," which involves a comparison/contrast study between the Eastern (the Choteau and Augusta areas) and Western (the eastern shore of Flathead Lake and the Hungry Horse Reservoir Region including the developing centers of Whitefish, Columbia Falls, Kalispell, and Polson) fringe regions was performed. The major emphasis of the study consists of assessing various levels of fringe encroachment, especially land-use patterns in the Western Fringe Region. These patterns were then synthesized into new land-use maps of the fringe regions. The major models employed demonstrate the procession of development through predetermined "rings" or "zones" (Figure 2) within the fringe areas and how this may affect the Forest Service wilderness policies of "limits of acceptable change" (LAC) and the "potential threats matrix." The primary concentration is on human encroachments including recreation/tourism and economic development activities.

RESULTS

Preliminary results indicate that generally there is only slight development (zones 1 and 2) of the Eastern Fringe Region which could change depending on pending legislation to allow gas, oil, and mineral exploration. The Southern Fringe Region is experiencing moderate development (zone 3) primarily from the logging and mining industries. The Western Fringe Region is experiencing substantial development (zones 4 and 5) from extensive logging practices and large population influxes into the area demonstrated by the increased frequency and size of urban areas (housing projects) and greater numbers of resorts. The Seeley and Swan Lake areas of the Western Fringe, located less than 10 miles from the western boundary of the BMW, are being heavily promoted for tourists. Numerous resorts, RV parks, and other forms of development are proliferating in this region. U.S. Highway 93 is a major thoroughfare for recreationists/tourists traveling north from Missoula and Interstate 90 to the Flathead Lake region which is quickly becoming a major tourist setting. Traffic along U.S. Highway 93 is intense from Missoula to Polson. The Polson area, which is located within the Flathead Indian Reservation, revealed major encroachments into the fringe region including housing and commercial development and new road construction. The stretch of Montana Highway 35 which runs from Polson north along the east side of Flathead Lake, revealed substantial encroachments into the fringe. Large RV parks and resorts are observed along the eastern shore of Flathead Lake.

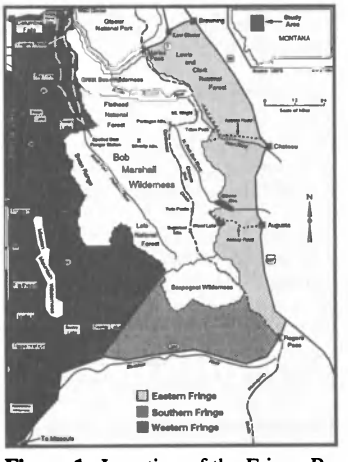

Figure 1. Location of the Fringe Regions surrounding the Bob Marshall Wilderness.

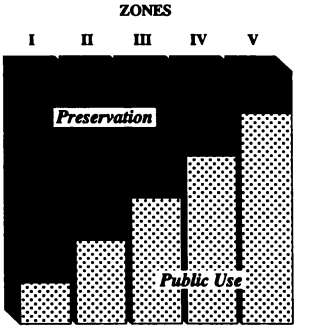

Figure 2. The relative emphasis on preservation and public use in the fringe zoning system.

CONCLUSIONS/RECOMMENDATIONS

Significant fringe encroachments, especially in the Western Fringe of the Bob Marshall Wilderness have, and will continue to affect the pristine nature of the wilderness area and the overall ability to obtain a desirable wilderness experience. The future implementation of the zone encroachment model, coupled with a GIS of land-use and potential threats to the wilderness area would greatly enhance the Forest Service's efforts to monitor excessive development within the fringe regions.

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MULTI-SPECIES GRAZING USING GOATS AND CATTLE TO CONTROL LEAFY SPURGE

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Leafy spurge (*Euphorbia esula* L.), a herbaceous, deep-rooted, dicotyledonous, perennial, is a noxious weed which infests at least 458 counties in 26 states and six Canadian provinces (1). Leafy spurge is distributed on several habitats ranging from xeric to subhumid, and from subtropical to subarctic. This plant since introduced from Eurasia, has become a troublesome weed in the Great Plains region of North America where it grows largely devoid of insect and disease pests which keep leafy spurge controlled in its native habitats (2). The weed, extremely persistent and competitive, contributes to significant economic losses to livestock producers.

Angora goats were introduced to Camp Grafton South in southeastern Eddy county as a biological control for leafy spurge. Project objectives were to determine 1) if angora goats will significantly reduce leafy spurge stems and herbage density, 2) if angora goat grazing will stimulate growth of graminoids through reducing the leafy spurge canopy, 3) if angora goat grazing leafy spurge infested pastures will improve cattle utilization of graminoids and 4) if multi-species grazing with goats and cattle will differ in forage utilization compared to goats and cattle only.

The study area consisted of a 85.5 hectares located in Sections 12 and 13, T. 149 N., R. 63 W. on Camp Grafton South in southeastern Eddy county. The 85.5 hectares was divided into a 37.3 ha cattle only treatment (CO) and a 41.4 ha cattle/goats (multi-species) treatment (CG). Goats only treatment bordered the CG and CO treatments, consisting of two replications (GO1, GO2) of 3.5 and 3.2 hectares.

Leafy spurge stem counts were conducted prior to the introduction of angora goat grazing in late May, 1993 and 1994 to achieve initial stand counts and differences after one year of grazing. Stems were counted using $0.1m^2$ ($1ft^2$) frames on ten line transects. Paired-plot clipping technique was used to determine forage production and degree of use for leafy spurge, graminoids, shrubs and other forbs. Leafy spurge stem counts were tested using standard analysis of variance procedures.

The cattle only pasture was grazed by 21 cow/calf pairs from 6/15 to 11/1, with a stocking rate of 0.39 ha/AUM for both years. The goats only treatment were grazed by 15 and 16 angora goat nannies per cell in 1993 and 1994, respectively. The stocking rates for the goats only trials were 0.42 ha/AUM and 0.38 ha/AUM, respectively, in 1993 and 1994. The grazing dates were May 27 through September 11 in 1993 and June 1 through September 1 in 1994. The CG treatment consisted of 41.4 hectares and grazed by 21 cow/calf pairs from 7/15-11/1 (0.55 ha/AUM) and 6/1-11/1 (0.39 ha/AUM) in 1993 and 1994, respectively. A total 191 (0.36 ha/AUM) and 156 (0.43 ha/AUM) angora goats grazed from 5/27-9/11 and 6/1-9/24 in 1993 and 1994, respectively.

Leafy spurge stem densities were reduced from 12.8 stems to 11.6 stems per $0.1m^2$, or a 9.4 percent reduction after one year of grazing, however, no significant ($P>0.05$) differences were noted in the CO treatment (Table 1). The leafy spurge stem densities were reduced ($P>0.05$) from 12.9 stems to 8.9 stems or a reduction of 31.5 percent. Stems densities were reduced ($P>0.05$) in the CG treatment from 12.5 stems to 9.4 stems with a reduction of 24.8 percent. However, differences were noted between treatments (CO vs. GO, CO vs. CG, GO vs. CG).

Table 1. Initial leafy spurge stem density counts (stems/$0.1m^2$) prior to goat turnout at Camp Grafton South, for 1993 and 1994.

Treatment	Stem Density[1] 1993	SE	Stem Density 1994	SE	Percent Reduction
Cattle Only	12.8^{ax}	1.8	11.6^{x}	1.0	9.4^{b}
Goats Only	12.9^{ay}	1.3	8.9^{y}	0.9	31.5^{c}
Cattle/Goats Together	12.5^{az}	1.2	9.4^{z}	0.8	24.8^{d}

[1]Percentages with the same letter are not significantly (P>0.05) different.

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2. Messersmith, C.G., and R.G. Lym, and D.S. Galitz. 1985. Biology of leafy spurge. pp. 42-45. in A.K. Watson, ed. Leafy Spurge. Weed Sci Soc of America. Champaign, Il.

A Floristic Inventory of Camp Grafton South, Eddy County, North Dakota.

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The vascular flora of Camp Grafton South in Eddy county, North Dakota was surveyed during the growing seasons of 1993 and 1994. Previous collections and inventories done near the study area provided an initial checklist of 559 different species (1). The collections compiled during this survey added 55 species to the initial list, bringing the total to 614 different species existing in the area (Table 1). These species include native and naturalized species, and a few species that escape cultivation.

The floristic inventory will provide the North Dakota National Guard, owners of Camp Grafton South, an essential part of an environmental assessment. Environmental assessments are needed whenever government owned land has a potential of being subjected to some kind of disturbance that could be considered damaging to the surrounding environment. Parts of the training carried out by the National Guard on Camp Grafton South could be considered damaging by some, thus the need for the environmental assessment.

Camp Grafton South occupies approximately 8500 acres of southeastern Eddy county, and is situated centrally in a vegetation zone known as the Transition Grasslands. The Transition Grasslands is an area of overlap between the western Mixed-grass Prairie and the eastern Tallgrass Prairie. In the Transiton Grasslands plant species characteristic of the Mixed-grass Prairie are usually found on high xeric conditions, and the plant species characteristic of the Tallgrass Prairie are usually found in lower more mesic conditions.

The area has a variety of vegetation types which include high prairie, mid-prairie, low prairie, wet meadows, shallow and deep marsh zones, fens, boggy areas, permanent open water, lakeside woodlands, and woody to shrubby draws (2). The unique location and different vegetation types provides a good representation of the plant species found in North Dakota.

Although there were no new species recorded for North Dakota, there were a number of new species recorded for Eddy county. Some of the species collected were also considered rare to the state; such as, *Aster lucidulus* (A. Gray) Wieg., *Carex buxbaumii* Wahl., *Carex pseudo-cyperus* L., and *Cypripedium candidum* Muhl. ex Willd. These rare plant species collections and additions to the flora of Eddy county give a better understanding of plant distribution across the state and the Northern Great Plains.

Table 1. Summary of the vascular flora of Camp Grafton South broken into tracheophyta divisions with families, genera and species listed.

Tracheophyta	Families	Genera	Species
Pteridophytes	4	4	7
Conifers	2	2	2
Dicotyledons	64	220	426
Monocotyledons	16	73	179
Totals	**86**	**299**	**614**

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METABOLIC ROLE OF PHOSPHOENOLPYRUVATE CARBOXYKINASE (PEPCK) IN RABBIT ENTEROCYTES

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Dept. Biochemistry and Molecular Biology, University of North Dakota School of Medicine, Grand Forks, ND 58202.

Two isoforms of PEPCK exist in mitochondria and cytoplasm respectively and are present in variable amounts in liver and kidney (both gluconeogenic tissues) of different species. The cytoplasmic isoform of PEPCK is essential to gluconeogenesis but no essential role has been assigned to the mitochondrial isoform. Since PEPCK is also present in mucosal scrapings of rabbit small intestine (1) which is not known to be gluconeogenic, we are interested in its role in this tissue. We reported previously on the isolation of highly viable enterocytes (>90% trypan blue exclusion) in which >90% of the PEPCK activity is mitochondrial (2).

Enterocytes isolated from 24 hr fasted rabbits and incubated with oxygenated, Krebs-Heinseleit-HCO_3^- buffer (pH 7.4), make glucose from fructose and dihydroxyacetone, (180 ± 26 and 92 ± 58 nmoles/min/10^8cells, respectively). Consistent with its lack of particularly significant amounts of α-glycerol P dehydrogenase, pyruvate carboxylase and cytoplasmic PEPCK activities (2), the small intestine of rabbits does not make glucose from lactate, aspartate, malate, glutamate, glutamine, α-ketoglutarate or glycerol and is thus not a gluconeogenic tissue.

Mitochondria obtained by homogenization (in Hepes, sucrose, EGTA, pH 7.4) and differential centrifugation of enterocytes from 24 hr fasted rabbits make citrate from exogenous PEP and acetyl carnitine,(2.40 ± 0.29 nmoles/min/mg protein). Citrate synthesis is increased consistently by GDP and especially GTP but not by ADP nor ATP. Enterocytes isolated from fed rabbits contain ATP:citrate lyase, malic enzyme, NADP:isocitrate dehydrogenase and glucose 6 P-dehydrogenase activities in a relationship of 1/2/10/1.

These data suggest that mitochondrial PEPCK could convert exogenous PEP to oxalacetate which could combine with acetyl CoA to form citrate for export to cytoplasm to provide carbon and/or NADPH for lipogenesis.

(Support by a Patricia Roberts Harris Fellowship, NIH 5-R01 DK41631 and NSF EPSCOR OSR 9108770 to North Dakota)

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1. Wiese, T.J., Lambeth, D.O. and Ray, P.D. (1991) Comp. Biochem. Physiol., 100B, 297-302.
2. Wuensch, S.A. and Ray, P.D. (1993) Proc. N.D. Acad. Sci., 47, 41.

GLYCOLYTIC ENZYME-CYTOSKELETON INTERACTIONS IN *SACCHAROMYCES CEREVISIAE*

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Actin and tubulin are major cytoskeletal and structural proteins found in the cytoplasm of all eucaryotes. Both rabbit muscle actin and bovine brain tubulin previously have been shown to interact with the glycolytic enzymes (1). Organizing the cytomatrix through interaction with cytoskeletal proteins is indicated by the localization of glycolytic enzymes in the thin filament (actin) region of the muscle sarcomeres (2). Rabbit muscle and yeast actin show considerable sequence homology. However, it is not known if yeast actin is as capable as rabbit muscle actin in organizing the cytomatrix (e.g. binding of the glycolytic enzymes). This study compares enzyme-actin interactions using yeast and muscle systems.

Yeast cells were grown to log phase and isolated by centrifugation. The cell walls were disrupted by glass beads and a bead beater. The homogenate was centrifuged, the supernatant was concentrated using G-25 Sephadex, applied to a DNase I column (affinity chromatography), eluted with formamide onto a DEAE-Sephacel column and eluted with 500 mM KCl. SDS-gel electrophoresis resulted in a single band that stained positively for actin in a Western blot. Rabbit muscle actin (Rma) was purified according to (3). Both filamentous (F-) and globular (G-) forms of rabbit muscle and yeast actin (Ya) (approx. 12 mg of each) were crosslinked to one gram CnBr activated Sepharose following the procedure of (4). Two ml columns of each form of actin were equilibrated with column buffer (20 mM Tris-Acetate pH 6.5, 1 mM $MgCl_2$, 5 mM β-mercaptoethanol). Each glycolytic enzyme (0.5 mg) was applied to the columns and bound enzyme eluted with a linear gradient of column buffer which included 300 mM KCl. Fractions were collected, enzyme activity was determined (5), and eluant conductivities were determined.

The results from the present studies suggest that binding differences are due primarily to the sequence differences between the glycolytic enzymes and not the actins. When sequences of the glycolytic enzymes between rabbit (Re) and yeast (Ye) are compared, aldolase shows very little sequence homology especially in the regions where binding to the actin occurs. Aldolase binding is shown in Fig. 1A. Glyceraldehyde 3-phosphate dehydrogenase, shows sequence conservation suggesting that the binding to both types of actin should nearly be the same as was observed. Binding increased when 4% Polyethylene glycol (PEG) was included in the column buffer (Fig. 1B). PEG induces macromolecular crowding, a condition that exists in the cytoplasm which promotes greater interaction than is found in the dilute conditions of affinity chromatography where the protein concentrations of less than 2 mg/ml are far less than the 20% protein concentration of the cell (6). The enzymes bound to the filamentous form to a greater extent than the globular form which is relevant to the cytoplasm where considerable amounts of the actin are in the filamentous state. Yeast phosphoglycerate kinase also bound to actin. These results indicate that enzyme-cytoskeleton interactions are important in yeast as well as mammalian cells.

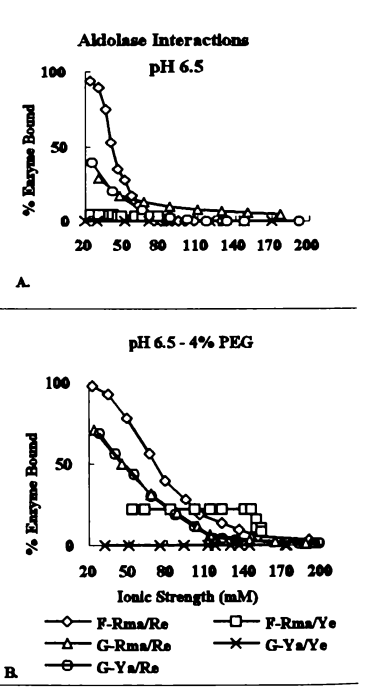

Figure 1

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Thursday, 20 April

1:00 *GENERAL ASSEMBLY* Auditorium

Come one, Come All !

B Cu Fe Se and others. Room: _ **B** _ Presidor: Curtiss D Hunt

1:20
Boron Improves Body Weight of Broiler Chickens, Possible Evidence of Boron Essentiality.
Yisheng Bai* and Curtiss D Hunt
USDA/ARS Human Nutrition Research Center, Grand Forks 58202 9034

1:40
Copper Deficiency Induces Apoptosis in the Heart of Rats.
Xianhua Yin*, Jack T Saari, Y James Kang
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037
and USDA Human Nutrition Research Center, Grand Forks, 58202 9034

2:00
Impaired Thermoregulatory Function of Copper-Deficient (CuD) and Copper-Supplemented (CuS) Rats Acutely Exposed to Cold.
K G Michelsen*, C B Hall, M E Sleeper, H C Lukaski
USDA/ARS Human Nutrition Research Center, Grand Forks 58202 9034

2:20
Dietary Iron and the Duodenal Enterocyte: Aconitase Activity and Cellular Iron.
E A Droke*, M E Sleeper, H C Lukaski
USDA/ARS Human Nutrition Research Center, Grand Forks 58202 9034

CONVERSATION BREAK

3:20
Dietary Selenium and Mood States in Healthy Young Men.
James G Penland* and John W Finley
USDA/ARS Human Nutrition Research Center, Grand Forks 58202 9034

3:40
"Crepe" - A New Moisture Conserving Food Texture in Experimental Feeding of Laboratory Rodents.
Berislav Momcilovic*
USDA/ARS Human Nutrition Research Center, Grand Forks 58202 9034

4:00
Waist:Hip Ratio and Regional Body Composition Changes Caused by Caloric and Exercise Intervention.
W A Siders* and H C Lukaski
USDA/ARS Human Nutrition Research Center, Grand Forks 58202 9034

BORON IMPROVES BODY WEIGHT OF BROILER CHICKENS, POSSIBLE EVIDENCE OF BORON ESSENTIALITY

Yisheng Bai*, and Curtiss D. Hunt
USDA/ARS, Human Nutrition Research Center, Grand Forks ND 58202

Previous research has shown that boron is essential for higher plants; however, only circumstantial evidence exists to indicate that boron is essential for animals (1). Two studies were conducted to further investigate the possibility of boron essentiality.

In Expt 1, day-old male Hubbard broiler chicks were fed a corn-casein-corn oil basal diet (boron<0.18 mg/kg); dietary treatments were boron (0 and 3 mg/kg) and vitamin D3 (VitD, 0, 125, 625 ICU/kg). Expt 2 was the same except that day-old male Arber Acres broiler chicks were used and VitD supplements were 0, 200, 625 ICU/kg. Chicks were raised in an all-plastic environment. Chicks had free access to diets and de-ionized water. Lighting was 24 hours/day.

Table 1. Effects of dietary boron and vitamin D3 (VitD) on body weight of broiler chicks

Boron	VitD	Expteriment 1 (g)			Experiment 2 (g)		
mg/kg	ICU/kg	13d	21d	27d	8d	21d	26d
0	0	239	329	373	204	269	251
0	125, 200	271	460	564	279	470	577
0	625	293	583	962	311	555	787
3	0	224	342	402	233	281	230
3	125, 200	271	554	914	299	535	701
3	625	265	561	918	338	620	882
Analysis of variance P-values							
Boron		0.09	0.09	0.00	0.01	0.07	0.17
VitD		0.00	0.00	0.00	0.00	0.00	0.00
Boron x VitD		0.37	0.01	0.00	0.90	0.69	0.53

In Expt 1 (Table 1), supplemental boron enhanced body weight of chicks fed diets supplemented with 125, but not 0 or 625 ICU VitD/kg diet. In Expt 2, supplemental boron improved body weight of chicks fed 200 or 625 ICU VitD/kg diet. Supplemental boron improved feed efficiency in Expt 1 but not Expt 2 (data not shown). All VitD supplements improved body weight and feed efficiency in both experiments. Supplemental boron also improved leg conditions (as indicated by chick mobility) and increased the concentration of serum ionized calcium in chicks fed either 125 or 200 ICU VitD/kg diet. These results suggest that boron is essential for broiler chick growth. Further study is needed to determine whether boron enhances VitD absorption or activities of VitD hydroxylases.

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1. Nielsen, F.H. (1991) Current Topics in Plant Bioch. and Phys. 10:274.

COPPER DEFICIENCY INDUCES APOPTOSIS IN THE HEART OF RATS

Xianhua Yin,[1]* Jack T. Saari[2] and Y. James Kang[1]
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The selective damage to the heart resulting from dietary copper deficiency has long been recognized, and oxidative stress has been suggested to be involved in the pathogenesis. In our previous studies (1), we have observed that a low antioxidant capacity exists in the heart of rodents and this makes the heart a target for damage in copper-deficient rats. However, the mechanism by which this copper deficiency-related oxidative stress causes the damage to the heart is unknown. Oxidative stress has been reported to be a mediator of apoptosis (programmed cell death) in cell cultures (2). Apoptosis, which is characterized by cell shrinkage, chromatin condensation and DNA fragmentation, has been suggested to be a central mechanism of many pathological processes. In the present study, we determined whether apoptosis is involved in the copper deficiency-induced heart damage in rats.

Male, weanling Sprague-Dawley rats were fed a purified diet deficient in copper (0.4 μg/g diet) or one containing adequate copper (6.0 μg/g diet) for 4 weeks. The status of minerals including copper in the plasma and tissues including liver was determined by inductively-coupled argon plasma emission spectroscopy. A most-recognized characteristic molecular and biochemical alteration of apoptosis is chromatin condensation and DNA fragmentation, which can be detected by gel electrophoresis of DNA. Therefore, a gel electrophoresis method (3) was used in the present study to determine the occurrence of apoptosis. DNA was extracted from the heart according to a previously described method (4) and subjected to a 1.6% agarose gel electrophoresis.

The animals on the copper-deficient diet showed typical changes of copper deficiency at the end of 4-weeks feeding. These included depressed plasma and tissue copper concentrations, reduced activities of copper-dependent enzymes, decreased hematocrit and hemoglobin concentrations, and cardiac hypertrophy. The electrophoretic pattern of DNA extracted from the copper-deficient heart revealed a ladder-like distribution, characteristic of the production of nucleosome-sized fragments and strongly indicating the occurrence of apoptosis.

The results indicate that apoptotic cell death is likely a mechanism involved in the copper deficiency-induced heart damage. Further studies are required to determine the histological and electron-microscopical apoptotic changes in the copper-deficient heart. It is also important to identify the cell types that undergo apoptosis in the heart, and the possible genes involved in the copper deficiency-induced apoptosis in the heart.

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(2) Buttke. T. M. and Sandstrom, P. A. (1994), Immunol. Today, 15:7-10.
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IMPAIRED THERMOREGULATORY FUNCTION OF COPPER-DEFICIENT (CuD) AND COPPER-SUPPLEMENTED (CuS) RATS ACUTELY EXPOSED TO COLD

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Copper (Cu) is an essential mineral element that is required for a variety of metabolic functions, including thyroid hormone metabolism. CuD rats have decreased plasma thyroxine (T_4) and a blunted response to exogenous thyrotropin stimulating hormone (1). We conducted a factorial experiment to assess the effects of dietary Cu and temperature on a serum T_4 and triiodothyronine (T_3) concentrations and thermoregulatory performance.

Weanling, male Sprague-Dawley rats (n=42) were matched by weight and fed diets otherwise adequate in essential nutrients but with different amounts of Cu. One group was fed a Cu adequate diet (6 ppm Cu; CuA) and another was fed a CuD diet (0.6 ppm Cu) for 5 wk. A third group (CuS) was fed the CuD diet for 31 d, then given the CuA diet for the remaining 4 d. One wk before the end of the experiment, a transmitter for the measurement of body temperature was implanted surgically into the abdomen of each rat. After an overnight fast, rats from each group randomly were assigned to either remain at room temperature (27°C; RT) or be placed in a cold environment (4°C). After 8 h, the rats were killed by decapitation.

As compared to CuA, rats fed CuD diet weighed less and had classic signs of Cu deficiency: increased heart/body weight, hypercholesterolemia, and reduced hepatic Cu concentrations (Table 1). CuS ameliorated some of the adverse effects of CuD.

Table 1. Physical and Biochemical Indices of Copper Status

	Weight, g		Heart, % Wt		Liver [Cu], μg/g		Cholesterol, mg/dL	
	RT	Cold	RT	Cold	RT	Cold	RT	Cold
CuA	237	231	3.60	3.57	15.5	15.7	134	147
CuD	196	206	5.79	5.67	1.2	1.4	212	210
CuS	222	218	4.61	4.78	8.9	8.3	141	146
					ANOVA Results (p values)			
Diet	0.0001		0.0001		0.0001		0.0006	
Temp	0.95		0.964		0.904		0.706	
Int	0.55		0.803		0.718		0.911	

CuD rats had reduced circulating T_4 and T_3 and blunted response to cold exposure (Table 2). CuS had greater T_4 and T_3 values than CuD, but less than CuA. A greater rate of body temperature decline was experienced by CuD, as compared to CuA and CuS, when exposed to cold.

Table 2. Thyroid Hormone Concentrations and Regression Coefficients Relating Body Temperature as a Function of Time

	T_4, nmol/L		T_3, nmol/L		Slope, °C/h		Intercept, °C	
	RT	Cold	RT	Cold	RT	Cold	RT	Cold
CuA	62	104	0.94	1.56	.003	-.003	38.6	38.1
CuD	55	66	0.79	0.99	-.022	-.267	38.2	36.6
CuS	61	95	0.87	1.41	-.001	-.019	38.3	37.9
			ANOVA Results (p values)					
Diet	0.0004		0.003		0.002		0.0001	
Temp	0.0001		0.0001		0.001		0.0001	
Int	0.002		0.003		0.0012		0.023	

These findings indicate that reduced Cu nutriture is associated with impaired thyroid hormone status and results in an inability to maintain body temperature during acute cold exposure. Thus, CuD impairs thermoregulatory performance during acute cold exposure.

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DIETARY IRON AND THE DUODENAL ENTEROCYTE: ACONITASE ACTIVITY AND CELLULAR IRON

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Grand Forks, ND 58202

Humans and animals respond to dietary iron (Fe) restriction and blood loss by regulating Fe uptake from the intestinal lumen. Cellular Fe metabolism of absorbing enterocytes may be regulated by similar mechanisms found in other cells. Posttranscriptional regulation of ferritin, 5-aminolevulinate synthase (ALAS, hemoglobin synthesis) and transferrin receptors (TfR) occurs in response to intracellular Fe concentrations (1). The iron responsive element-binding protein (IRE-BP), a cytoplasmic nucleic acid-binding protein, is important in this regulation. When intracellular Fe is high, the IRE-BP has a decreased affinity for IREs located in the mRNAs for ferritin, ALAS and TfR, and functions as a cytosolic aconitase. When intracellular Fe is low, the IRE-BP has an increased affinity for the IREs and less aconitase activity (Acon). The increased affinity of the IRE/IRE-BP interaction prevents degradation of the TfR mRNA and inhibits synthesis of ferritin and ALAS. IRE-BP activity in duodenal enterocytes and its relationship to Fe absorption and body Fe stores is not clear. Acon may serve as an index of IRE-BP activity in the enterocyte.

Therefore, an experiment was conducted with male weanling Sprague-Dawley rats to determine Acon in response to dietary fat and Fe. Rats were fed diets varying in amount (7 and 15%) and type of fat (Saff, safflower oil; SA, stearic acid; BT, beef tallow; and, CB cocoa butter), and amount of non-heme Fe (10 and 35 μg/g). Rats were made Fe deficient (FeD) by feeding them a low-Fe, high-Saff diet for 14 d. Rats were then matched by weight and Hct, and placed into dietary treatment groups (5/group). Rats were fed their respective diets for 3 d, then fed a test meal of ^{59}Fe to assess Fe absorption as ^{59}Fe retention. They remained on their respective diets for 4 wk.

Baseline values for rats sacrificed after the initial 14 d indicated they were FeD (Hct, 19.6 ± 1.7%; Hgb, 54.3 ± 5.7 g/L; Acon, 1.6 ± 1.0 mU/mg protein). Acon data was log transformed for statistical analysis and is presented as the mean:95% confidence interval. Acon (3.9:3.3, 4.6 vs 7.3:6.2, 8.6 mU/mg protein) and the change in Hgb from baseline (ΔHgb; 28.5 ± 1.5 vs 88.8 ± 0.9 g/L) were less ($p<0.001$) and absorption (84.0 ± 6.1 vs 79.4 ± 5.7%) was greater ($p<0.001$) in rats fed low dietary Fe (FeD) than in rats fed the higher dietary Fe (Fe adequate, FeA). Absorption was greater ($p<0.05$) in SA- and CB- than Saff-fed FeD rats. Absorption was similar ($p>0.05$) for SA-, BT- and CB-fed FeD rats. Fe absorption also was affected ($p<0.05$) by interactions between dietary Fe and amount of fat, and fat type and amount. ΔHgb was greater ($p<0.05$) in SA-fed FeD rats than in Saff-, BT- or CB-fed FeD rats. SA-fed FeA rats had greater ($p<0.05$) liver Fe (μg/g) than Saff- or BT-fed FeA rats. Liver Fe was similar ($p>0.05$) in SA-fed and CB-fed rats. Enterocyte cytosolic Fe (CFe) was less ($p<0.001$) in FeD than in FeA rats (9.2 ± 3.46 vs 52.7 ± 3.55 ng Fe/mg protein).

Rats fed low dietary Fe had hematological values indicative of FeD. The opposite was observed for rats fed higher dietary Fe. FeD rats had greater Fe absorption, less Acon and CFe than FeA rats. These data suggest that CFe may regulate Acon, which may be an index of IRE-BP activity. IRE-BP activity in the enterocyte may be important in the regulation of Fe absorption by altering cellular Fe metabolism in response to body Fe stores. These results may help elucidate the mechanism(s) for regulation of Fe absorption.

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DIETARY SELENIUM AND MOOD STATES IN HEALTHY YOUNG MEN

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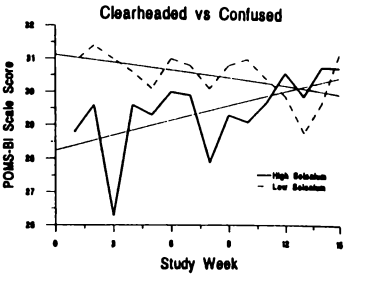
Selenium (Se) is necessary for the metabolism of several enzymes and proteins, and functions *in vivo* as an antioxidant (1). Se concentration in the rat brain varies with the amount of Se in the diet (2). Further, Se apparently has a role in dopamine (3) and prostaglandin (1) metabolism, and in thyroid function (4). Se deficiency in humans has been associated with cardiac pathology (1). In a recent study (5), a double-blind, crossover design was used to supplement 33 women and 17 men with 100 µg Se/day or a placebo for 5 weeks, with a 6-month washout period between treatments. Baseline Se intakes were estimated to be 60 µg/day. Higher Se intakes were related to less anxiety, less depression and more energy. The study reported here was designed to investigate the effects on mood states of a much longer period of dietary Se supplementation and deprivation.

Thirty healthy men, aged 21-44 years (29±6 years), were recruited from the local community and randomly assigned to one of two dietary groups. One group was fed a mixed Western diet luxuriant in Se (180 µg/2500 kcal), while the other was fed a diet relatively deficient in Se (21 µg/2500 kcal). The RDA for Se is 70 µg/d. Average intake was 3325 kcal/day. Diets were supplemented as necessary to achieve nutritional adequacy, except Se. Groups were fed their respective diets for 15 weeks. Weekly throughout the study, subjects were administered the Profile of Mood States - Bi-Polar Form (POMS-BI) (6). The POMS-BI is a standardized questionnaire containing 72 adjectives which the respondent rates by using a 4-point scale from "much like this" to "much unlike this" to describe his or her mood state; it requires 5-10 minutes to complete. The POMS-BI yields 6 specific measures of mood state, agreeable-hostile, clearheaded-confused, composed-anxious, confident-unsure, elated-depressed, energetic-tired, and a general measure labeled total mood disturbance (TMD). Because analysis showed that the two groups of men were not equivalent in many mood states at the beginning of the study, further analyses utilized changes from initial mood states to determine effects of Se intakes. Data from the first and last weeks of the study were excluded and, for each of the 7 measures, means were calculated for weeks 2-5 and 11-14 to obtain a more stable measure. Student's *t* test was used to contrast the mood states of the two dietary groups. To determine whether biochemical indices of Se status might correlate with mood states in these men, blood drawn on week 0 and every 3 weeks thereafter was analyzed for Se and glutathione peroxidase (GSH-Px; a Se-dependent enzyme) in plasma, platelets and erythrocytes. Pearson correlation coefficients were computed for biochemical indices with the measures of mood state, and tested for significance.

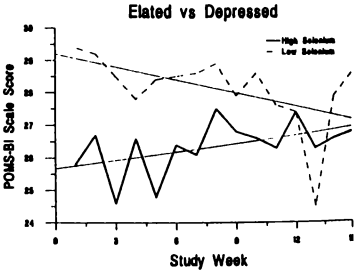


POMS-BI SCALES AND TOTAL MOOD DISTURBANCE[a]

DIET	Agreeable -Hostile	Clearheaded -Confused	Composed -Anxious	Confident -Unsure	Elated-Depressed	Energetic -Tired	Total Mood Disturbance
High Se	102±13[b]	106±11[c]	106±17	105±10	107±19[c]	109±20	87±41
Low Se	98±12	96±15	97±17	99±16	94±14	97±20	122±102

[a]percent change [(Weeks 11-14)/(Weeks 2-5)x100]; [b]mean±standard deviation; [c]significant ($p<0.05$) dietary Se effect

Dietary Se resulted in significantly different changes in confusion and depression over the course of the study (figures at right). Men fed high Se reported less and those fed low Se reported more confusion and depression with time on diet. Initial differences between groups were overcome by study end. Tabled data show percent change in mood states from the first to the fourth months of the study; excepting TMD, numbers greater than 100 indicate improvement. Although dietary effects were apparent for all mood states, high variability in reported mood states made most of these differences unreliable. Within the group fed low Se, GSH-Px activity in platelets was significantly correlated with all 7 measures of mood states; higher activity was associated with more positive mood states. There were no other consistent relationships between the biochemical indices of Se status and mood states. The groups fed high and low Se differed in plasma Se (125.9±316.0 vs 118.2±2.0; $p<0.009$) and platelet GSH-Px (316.0±8.4 v 288.8±9.2; $p<0.04$). Values for both groups were within normal limits. The present findings are remarkably consistent with those from a recent study by W.C. Hawkes (in press, Biol Psychiatr). In that study, 11 healthy men living on a metabolic research unit were fed either 13 or 356 µg Se/day for 99 days. Although Se intakes were not significantly related to mood states, a significant positive relationship was found between erythrocyte Se concentrations and elated and agreeable (vs hostile) mood states in the group fed low Se. Further study is required to identify the mechanism through which Se status or intakes influence mood states in otherwise healthy adults.



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"CREPE" - A NEW MOISTURE CONSERVING FOOD TEXTURE IN EXPERIMENTAL FEEDING OF LABORATORY RODENTS

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Minerals are better absorbed from a liquid than from a crude diet (1). In a pilot experiment, body growth appeared to increase when rats were fed AIN-76 diet (2) spread over a cellulose tissue, moisturized, and rolled into a "crepe". The aim of this experiment was to compare the effect of providing the AIN-93G diet (3) in three different textures: moisture conserving "crepe", paste, and standard dry powder, on body growth and mineral composition of femur (F) and incisors (I). Weanling male rats in groups of 8 were randomly divided into : (1) Powder, AIN-93G diet, (2) Paste, AIN-93G moisturized with 20% wt/volume of deionized water (DW), (3) "Crepe 9%", AIN93-G uncorrected for the amount of cellulose in crepe (total = 9%), and (4) "Crepe 5%", AIN-93G corrected for the amount of cellulose provided by the crepe (total = 5%). To "crepe", about 5g of diet was spread upon a standard, soft cellulose tissue, moistened with 20% wt/volume with DW, and rolled into the crepe.

Table 1. Body weight and mineral content of femur and incisor fed "Crepe" with normal (F5%) and high (F9%) fiber, Powder, and Paste (moisturized Powder)

Tissue		Crepe F5%	Crepe F9%	Powder F5%	Paste F5%
Body Weight (g)					
	Initial	52.0 ± 3.3	52.1 ± 2.8	51.8 ± 2.1	51.6 ± 3.6
	Final	372.6 ± 22.6	367.8 ± 36.3	378.0 ± 34.4	403.5 ± 33.0
	Gain	320.7 ± 22.6	315.7 ± 34.7	326.3 ± 33.1	351.9 ± 31.2
	Femur (mg)	553 ± 34	549 ± 39	575 ± 42	563 ± 43
	Incisor (mg)	64 ± 6	65 ± 6	63 ± 3	65 ± 4
			µg/g		
$Cax10^{-5}$	Femur	2.26 ± 0.06	2.12 ± 0.22	2.26 ± 0.04	2.21 ± 0.20
	Incisor	2.65 ± 0.04	2.63 ± 0.05	2.68 ± 0.03	2.65 ± 0.05
$Px10^{-5}$	Femur	1.10 ± 0.03	1.03 ± 0.11	1.10 ± 0.02	1.07 ± 0.09
	Incisor	1.36 ± 0.02	1.35 ± 0.04	1.37 ± 0.01	1.36 ± 0.02
$Mgx10^{-4}$	Femur	0.37 ± 0.03	0.35 ± 0.04	0.38 ± 0.03	0.38 ± 0.04
	Incisor	1.36 ± 0.08	1.36 ± 0.07	1.39 ± 0.09	1.40 ± 0.04
$Nax10^{-3}$	Femur	5.74 ± 0.14	5.29 ± 0.54	5.66 ± 0.32	5.56 ± 0.43
	Incisor	7.18 ± 0.34	7.17 ± 0.41	6.91 ± 0.26	7.20 ± 0.59
$Kx10^{-3}$	Femur	5.69 ± 0.58	5.48 ± 0.65	6.14 ± 0.42	5.44 ± 0.60
	Incisor	2.09 ± 0.24^{a}	1.86 ± 0.12^{b}	1.74 ± 0.09^{b}	1.87 ± 0.14^{b}
$Znx10^{-2}$	Femur	2.19 ± 0.10	2.10 ± 0.10	2.09 ± 0.11	2.13 ± 0.14
	Incisor	1.46 ± 0.04	1.41 ± 0.06	1.44 ± 0.13	1.44 ± 0.12
$Fex10^{-2}$	Femur	0.61 ± 0.11	0.62 ± 0.07	0.60 ± 0.10	0.53 ± 0.05
	Incisor	2.91 ± 0.36	2.83 ± 0.64	3.05 ± 0.28	2.85 ± 0.28
Cu	Femur	1.32 ± 0.13	1.26 ± 0.07	1.28 ± 0.10	1.31 ± 0.11
	Incisor	5.23 ± 0.52	5.00 ± 0.65	5.07 ± 0.23	4.93 ± 0.32
Mn	Femur	0.69 ± 0.06^{b}	0.75 ± 0.09^{b}	1.06 ± 0.36^{a}	0.96 ± 0.27^{ab}
	Incisor	1.17 ± 0.15	1.26 ± 0.14	1.61 ± 0.29	1.63 ± 0.56

[ab]Means (±SD) bearing different superscripts in the same row differ significantly ($p<0.05$) by Ryan-Einot-Gabriel-Welsh multiple F test.

The change in texture of the AIN-93G diet did not change the growth or Ca, Cu, Fe, Mg, Na, P, and Zn distribution in F and I ($P>0.05$, Table 1); "crepe" has no advantage when compared to powder or paste. A minor decrease in F Mn and increase in I K in "Crepe 5%" was within the expected statistical limits for the large number of means and chosen level of probability. In contrast to the AIN-76 pilot experiment, the animals on AIN-93G diet extensively shredded the "crepe;" the different behavior is presumably because of the high sucrose content in the former as compared to starch in the later. The observed change in feeding behavior may serve as an additional indicator for the assessment of the nutritional quality of the diet. Similarly, the difference in the I/F mineral ratios (Fe>Cu>Mg>Mn>Na>P>Ca>Zn>K; where only Zn and K were F>I, and where only Ca/P=1) points to the different calcification mechanism and requirements in I and F.

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WAIST:HIP RATIO AND REGIONAL BODY COMPOSITION CHANGES CAUSED BY CALORIC AND EXERCISE INTERVENTION

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The ratio of waist to hip circumferences (WHR), a commonly used indirect index of central obesity, has been associated with the risk factors for metabolic disorders, cancer, and cardiovascular disease (1). To examine if differences in WHR affect regional body composition changes during weight loss, 22 women (age 21-39 years) volunteered to participate in a five month metabolic study of reduced energy intake (50% baseline) and supervised exercise (2 hours/day). Body composition was assessed during the baseline month and each month thereafter by anthropometry (including WHR in fasting state) and dual x-ray absorptiometry to determine bone mineral content (BMC), body fat and fat-free, mineral-free (FFMF) weight.

Table 1. Summary of Initial and Changes Body Composition (n=22, mean±SD)

	Baseline	Change
Age, yrs	28.1 ± 3.5	
Height, cm	167.6 ± 4.2	
Weight, kg	99.0 ± 16.3	-10.9* ± 11.8
WHR	0.92 ± 0.08	-.0015 ± .036
Arms		
BMC, g	376 ± 69	-27* ± 43
Fat, kg	6.08 ± 1.58	-1.69* ± 1.24
FFMF, kg	4.22 ± 0.87	0.16* ± 0.74
Trunk		
BMC, g	683 ± 93	13 ± 51
Fat, kg	26.00 ± 7.31	-7.40* ± 5.90
FFMF, kg	23.54 ± 3.76	1.94* ± 3.23
Legs		
BMC, g	997 ± 124	31* ± 75
Fat, kg	17.04 ± 3.89	-3.11* ± 2.63
FFMF, kg	14.93 ± 5.23	0.58 ± 1.90

Note: * change different than 0, p<0.05

The four month period of caloric and exercise intervention resulted in some significant changes in body composition (Table 1). While there was no change in WHR, there were significant losses of body weight, arm BMC and arm, trunk and leg fat and gains of arm and trunk FFMF weight and leg BMC.

The baseline WHR assessment was used to classify the women into two groups: one group with less central fat (WHR < 0.9) than the other (WHR > 0.9). ANOVAs were applied to the body composition data to determine whether the two groups differed at the beginning of the study, whether body composition changes were significant for each group, and whether the changes were different between the two groups. The results of the ANOVAs indicate that the two groups differed in WHR and in FFMF weight of the trunk and legs at baseline (Table 2).

Table 2. Descriptive Statistics and 4-Month Changes (mean±SD)

	WHR < 0.9 (n=10)		WHR > 0.9 (n=12)	
	Baseline	Change	Baseline	Change
Age, yrs	29.2 ± 3.5		27.2 ± 4.7	
Height, cm	168.9 ± 7.3		166.6 ± 6.8	
Weight, kg	100.1 ± 19.8	-18.4* ± 3.8	98.1 ± 13.6	-7.57† ± 13.3
WHR	0.86 ± 0.04	-0.022 ± .039	0.99† ± 0.02	-0.007 ± 0.033
Arms				
BMC, g	367 ± 44	-29* ± 23	384 ± 86	-28 ± 52
Fat, kg	5.72 ± 1.84	-2.13* ± 0.65	6.38 ± 1.33	-1.28* ± 1.43
FFMF, kg	4.58 ± 0.78	-0.10 ± 0.54	3.92 ± 0.85	-0.14 ± 0.69
Trunk				
BMC, g	697 ± 79	-18 ± 38	672 ± 105	25† ± 53
Fat, kg	24.59 ± 8.72	-10.43* ± 2.02	27.1 ± 6.0	-3.91† ± 6.83
FFMF, kg	25.40 ± 3.28	-0.75 ± 1.94	22.0† ± 3.5	0.62 ± 1.77
Legs				
BMC, g	1030 ± 109	7 ± 37	969 ± 133	42 ± 89
Fat, kg	15.96 ± 4.97	-4.51* ± 1.57	17.9 ± 2.6	-2.16*† ± 2.92
FFMF, kg	16.33 ± 2.37	-0.20 ± 1.43	13.8† ± 2.1	-0.01 ± 1.82

Note: * change different than 0, p<0.05
† < 0.9 mean different than > 0.9 mean, p<0.05

The group with the lower WHR lost more weight though the WHR did not change for either group with weight loss. Both groups lost a significant amount of arm and leg fat though the low WHR group lost more leg fat. The low WHR group lost a significant amount of arm BMC and trunk fat.

In conclusion, premenopausal women with a tendency for increased central deposition of body fat may be impaired in their ability to lose weight, particularly fat in the trunk region, with caloric restriction and exercise. This conclusion has profound implications for weight loss as a successful health intervention, especially for women with a marked central fat deposition.

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Thursday, 20 April

Whole Body Counter PHANTOM. Room: _ **A** _ Presidor: Glenn I Lykken

1:20
A Modular Distributed Source Whole Body Counter Phantom ("Fuzzy") I. Preliminary Modeling.
Stephen L Cassola*, Glenn I Lykken, Berislav Momcilovic
Physics, University of North Dakota, Grand Forks 58202 7129

1:40
A Modular Distributed Source Whole Body Counter Phantom ("Fuzzy") II. Measurements
Liqiang Tao*, Glenn I Lykken, Berislav Momcilovic
Physics, University of North Dakota, Grand Forks 58202 7129
and USDA/ARS Human Nutrition Research Center, Grand Forks 58202 9034

Science Learning. Room: _ **A** _

2:20
Elementary Teachers' Needs for Additional Learning Regarding Science.
Carolyn R Brauner*
Education and Psychology, Valley City State Univesity, Valley City 58072

Societal Concerns. Room: _ **A** _ Presidor: Part of ND Geographers Meeting ?

3:00
Inequality among Equals: A Multivariat Analysis of Quality of Life in the Islamic World.
Mohammad Hemmasi and **Jeff Ueland***
Geography, University of North Dakota, Grand Forks 58202 9020

3:20
Iran's Nuclear Power Industry.
Mohammad Hemmasi*
Geography, University of North Dakota, Grand Forks 58202 9020

A MODULAR DISTRIBUTED SOURCE WHOLE BODY COUNTER PHANTOM ("FUZZY") I. PRELIMINARY MODELING

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The principal goal of this study was to determine how the upper detector array of a human whole body counter[1] (HWBC) "sees" radioactive sources placed at different positions on the HWBC bed. The HWBC detection system consists of two 16-detector [10x10x40 cm, NaI(Tl), Bicron Corp., Newbury, OH] planar arrays each of which provides 0.40 x 2.0 m of detector surface. A 2.0x0.75m plexiglas board was marked in a rectangular design with 75, 169cm^2 adjacent square areas described by longitudinal coordinates i=1-15 and transverse coordinates j=1-5. Zinc-65 gamma emissions from: (a) point sources beneath 0.775L water containers and (b) uniformly distributed (isotope-water mixture) sources in 0.775L isotope/water containers located at various locations (i,j) on the board were measured. An empirical model that allows determination of the total number of gamma ray counts received in the HWBC upper array detectors from ^{65}Zn sources [as a function of source coordinates (i,j)] was developed. This model was based on two experimental findings: (1) Radioactive emissions from within a 0.775L container can be approximated by a single radioactive point source located at the center of mass of the container (2) Emissions from ^{65}Zn sources placed at random locations (i,j) on the plexiglas board, in the absence of scattering and attenuation, produce counts in the individual detectors that are a linear superposition of individual container emissions. The total counts received, (N_n; n=1-16), in any given detector n from any number of sources m located at (i,j) can be described mathematically by the expression: $N_n=\Sigma_m[a_m A\epsilon f(\theta_n)_{ij} T/4\pi(r_n)_{ij}^2]\exp[-\mu d_n(\theta_n)_{ij}]$. In this expression a_m is the activity of the m^{th} source, A is the surface area of a single detector, and T is the total counting time. It was assumed that the gamma radiation has an inverse square dependence upon r and that each detector had a mean photon efficiency ϵ (valid for all sixteen detectors), and a general dimension-less response function $f(\theta_n)_{ij}$ dependent upon detector number n and source coordinates (i,j). The values of $f(\theta_n)_{ij}$ were calculated and least squares fit to the quadratic form: $f(\theta_n)_{ij} = -2.83 + 3.11\cos(\theta_n)_{ij} - 1.85\cos^2(\theta_n)_{ij}$ where $(\theta_n)_{ij}$ is the angle from vertical to $(r_n)_{ij}$, the vector from the source to the center of the detector of interest. The mathematical model was tested by counting four ^{65}Zn (isotope-water mixture) containers, and one ^{65}Zn point source with a deionized water container centered directly on the source. Radioactive emissions from each of the five sources were summed to form the total response to the distribution. One configuration of the ^{65}Zn isotopes with container sources located at [(4,3); (6,3); (10,3); (12,3)] and a point source located at [(8,3)] was analyzed and the percent difference between measured and predicted counts for each of the sixteen detectors was determined (Table 1). The root-mean-square value of the %difference (a relative measure of model accuracy) was determined to be 2.3.

Table 1: Measured and Predicted Detector Counts (% difference)

n	N_{meas}	N_{model}	Difference(%)	n	N_{meas}	N_{model}	Difference(%)
1	6407	6255	2.4	9	20852	21362	-2.4
2	8715	8275	5.0	10	21293	21275	0.1
3	10696	10637	0.6	11	20457	20409	0.2
4	13442	13112	2.4	12	18616	19438	-4.4
5	15492	15352	0.9	13	17258	17030	1.3
6	17225	17082	0.8	14	14289	14678	-2.7
7	18882	19140	-1.4	15	11618	11645	-0.2
8	20260	20634	-1.8	16	8724	8842	-1.3

[1]Use of the USDA, ARS Grand Forks Human Nutrition Research Center whole body counter under a Specific Cooperative Agreement 58-5450-3-109 is acknowledged.

A MODULAR DISTRIBUTED SOURCE WHOLE BODY COUNTER PHANTOM ("FUZZY")
II. MEASUREMENTS

Liqiang Tao*, Glenn I. Lykken and Berislav Momčilović
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Human whole body counters (HWBC) are used to measure gamma ray emissions from humans and to determine the activities of gamma ray emitting radioisotopes located in the body. The radioactive emissions from the human body that the HWBC "sees" depend upon gamma ray self-absorption within the body and distribution of gamma ray emitters within the body. Historically, HWBC phantoms have been fabricated from synthetic containers modeled after the human body to compensate for the three-dimensional geometry. In some instances these phantoms contain regions filled with radioactive liquids to mimic the anatomical structure of target organs in the body while the remainder of the phantom was filled with tissue equivalent fluid or material. These phantoms are relatively expensive, bulky, difficult to clean, extremely fragile and are prone to leak. Furthermore the regional activities can not be accurately standardized to allow grid-structured resolution. Because of the detector configuration and scattering/attenuation of internally-emitted gamma rays the HWBC "sees" the human body as more or less uniform radioactive sources i.e., it does not have the resolving power to discern the differences in local radioisotope distribution and therefore can only see them as "fuzzy" at the best of circumstances. The USDA/ARS Grand Forks Human Nutrition Research Center HWBC[1] consists of two 16-detector [10x10x40 cm, NaI(Tl), Bicron Corp., Newbury, OH] planar arrays each of which provides 2.0 x 0.40 m of detector surface. A rectangular 2.0x0.75m plexiglas board distributed with a number of 0.775L containers on the "Fuzzy" rectangular design on 75, 169cm^2 adjacent square areas was utilized in this work. To comply with the two fold symmetry of the human body, the "Fuzzy" was divided by the Golden section at the umbilical point (↓U) between rows 5 and 6 to match with the Golden section point of 2 m HWBC bed length (37.5% as measured from the cranial side). The radioactive source containing 1.2μCi ^{65}Zn was divided into 12 equal doses in a 0.775L conical cup (h, 9.5 cm; r_1 4.45 cm; r_2, 5.71 cm), and placed in positions indicated in Table 1. Zinc-65 containers on the "Fuzzy" were strategically placed to match anatomically important areas which vaguely outline the contour of the human body; hence "Fuzzy". The contribution (%) of each of 12 containers [(0.1±0.001 μCi ^{65}Zn, mean±SD)] to the total activity (1.2 μCi) of the 12 containers was measured by library least squares analysis (LLSQ) for two different radioisotope (containers) configurations. The results of these measurements are compared in Table 1. The relatively constant contribution to the measured phantom activity should allow use of a "Fuzzy" phantom to calibrate individual organ detectors and thus determine local activities in the body.

Table 1. Localized radioactive source relative contribution (%)

"Fuzzy"

Normal				
		7.2		
	8.8		8.6	
		9.8		
	9.6	↓U	9.1	
		10		
	9.7		9.4	
		9.9		
		9.8		
		9.4		
Mean ±SD:		9.3±.08		

Obese				
		5.8		
6.2				5.7
		8.6		
7.1		↓U		6.6
		9.6		
7.8				6.4
		9.6		
		9.4		
		9.2		
Mean ±SD:		7.7±1.5		

←(0.65 m)→ Bed (2 m)

└"Fuzzy" (1.95 m)

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[1]Use of the USDA, ARS Grand Forks Human Nutrition Research Center whole body counter under a Specific Cooperative Agreement 58-5450-3-109 is acknowledged.

ELEMENTARY TEACHERS' NEEDS FOR ADDITIONAL LEARNING REGARDING SCIENCE

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In the spring of 1994 an Elementary Teacher Science Survey (1) was conducted for the North Dakota Department of Public Instruction. It consisted of seven parts: 1) demographics, 2) science curriculum and grading practices, 3) need for additional learning concerning science information (physical science, life science, and earth science) and scientific processes, 4) need for additional ways to teach/encourage habits of mind (scientific attitudes), 5) need for additional learning regarding assessment, 6) pedagogy, and 7) perceptions of the relative importance of fostering the aspects of science and information regarding the application of grading practices to these aspects of science. This paper addresses results from parts 3-5: the needs for additional learning of science information and processes, scientific attitudes, and assessment.

Data for this survey were gathered using a mailed survey instrument to 995 elementary teachers of grades K-6 in North Dakota. Needs were assessed by means of a four-point scale: Definite Need, Strong Need, Some Need, and No Need. Data were analyzed using descriptive statistical techniques and content analysis of open-ended questions.

The findings showed that less than 35% of the teachers indicated a definite or strong need for additional learning of science information (content knowledge) in the areas of physical, life, and earth/space sciences. Approximately half indicated some need for additional learning in these areas.

A majority of teachers indicated a definite or strong need for additional learning in many of the areas regarding scientific processes, with the greatest percentage of teachers indicating a definite or strong need in the areas of hands-on activities/experiments (62%), creating models of systems or natural phenomena (55%), and computer technology (60%). Almost one half indicated a definite or strong need for learning about identifying variables (48%) and interpreting data (45%).

Regarding information related to science, about two thirds of the teachers indicated a definite or strong need for learning about both science field trips and science speakers for their geographic areas (64%) and for learning about new videos/software (67%). About one half of the teachers indicated a definite or strong need for learning about societal issues and science (51%) and the latest goals of elementary science education (54%). Almost one half indicated a strong or definite need for learning regarding common themes in science (48%).

More than 41% of the teachers indicated a definite or strong need for additional learning of ways to teach or encourage all of the areas listed under habits of mind/scientific attitudes). A majority of teachers indicated a definite or strong need in the area of inventiveness (57%) with 41%-48% indicating a definite or strong need in the areas of curiosity, openness to new ideas, objectivity, willingness to suspend judgment until enough facts are known, recognizing assumptions in science, insisting on evidence, being skeptical, and being responsible in science decisions.

In the area of assessment, nearly half of the teachers indicated a definite or strong need for learning additional ways to assess the different aspects of science: science process skills (50%), science knowledge (48%) and scientific attitudes/characteristics (48%). Over one third (39%) indicated a definite or strong need for learning additional ways to determine science grades. On a 0–10 continuum scale, over three fourths (76%) of the teachers derived all or a major part of their final grades in science from science content information (scientific products), with none or a minimal part from scientific attitudes. Most (90%) of the intermediate teachers used A-F grades, whereas 69% of primary teachers used S/U grades.

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INEQUALITY AMONG EQUALS: A MULTIVARIATE ANALYSIS OF QUALITY OF LIFE IN THE ISLAMIC WORLD

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According to the Koran, all men are equal in front of Allah (God) and everything on earth belongs to Allah. It is our duty to be stewards of all the things that belong to Allah and to preserve them for the next generation. It was partly on these principles that the Organization of the Islamic Conference (OIC) was founded in 1969. At that time, the OIC had 24 members and currently has 48. Their charter, written in 1972, states that the major function of the OIC was to promote economic, cultural, and humanitarian co-operation and solidarity throughout the Islamic World. The purpose of this study is to asses quality of life (QOL) and its variations among 44 OIC members at two periods in time (1980 and 1990). It also examines the gap between those countries at the high end of the quality of life spectrum and those at the low end. In this investigation the QOL Index (QLI) include 14 variables for 1990 and 10 variables for 1980 in major categories of development, poverty, and demographic indicators. These variables were selected on the basis of availability for both periods of time and their relevancy to assessing the overall condition of the countries being studied.

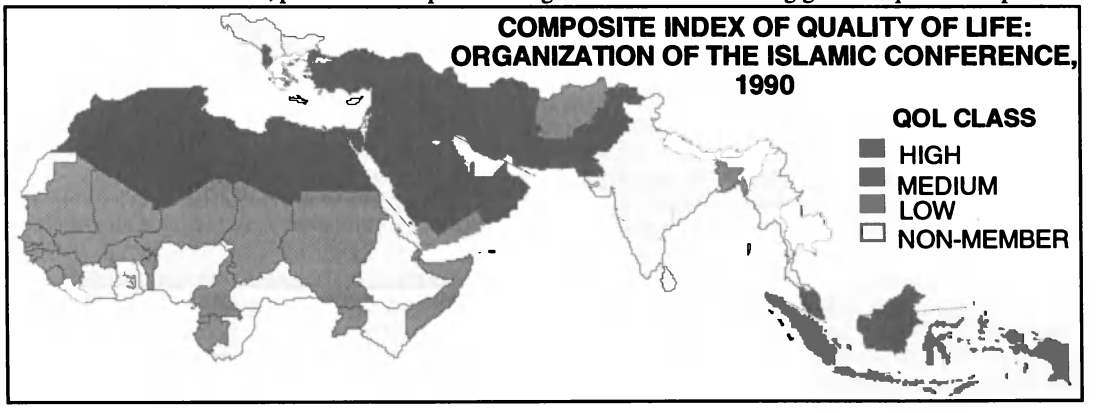
A scaling method known as the composite index of quality of life will be used to convert variables into scores that range between 0 (worst) and 100 (best). The scores were determined by using the following formulas:

$$I=((R - R_w) / (R_b - R_w)) * 100 \text{ and Total QLI} = \Sigma I / 14$$

Where I is the index score. R is the variable score being converted. R_w is the worst score in the variable category. R_b is the best score in the variable category. For Total QLI formula, all I scores are averaged for a particular country to give a over all indication of quality of life within the context of all the countries that were evaluated. For this study only 44 of the 48 countries were evaluated due to lack of data on the four remaining countries (2 Soviet Republics, PLO*, and Zanzibar). If a country has the best performance in every variable, it should have a Total QLI of 100, and if a country has the worst performance on all variables it would have a Total QLI of 0. After a Total QLI has been attained, the countries will be grouped into three classes (High QOL, Medium QOL, Low QOL) using the jenk's, or optimal method. The Jenk's method maxamizes homogeneity within the classes.

In 1980, all the African Countries had a Low QLI. Only three Asian countries; Afghanistan,Bangladesh, and Yemen were in this category. The more developed countries with High QLI include Albania, Malaysia, Indonesia, and Turkey with a relatively balanced agricultural/industrial economies. The oil producing countries fell in the medium category, which is a clear indication of their situation during the 1970s when the oil wealth had just began to trickle down to the masses. Thus, the overall QOL was more homogenous among OIC members during the 1970s than during the 1980s, which was considered the "lost decade" of development everywhere. The gap between the poor and rich OIC members widened significantly during this decade. A number of countries were devastated because of internal unrest and international wars (i.e. Iran-Iraq, Afghanistan, Lebanon), while some of the oil producing countries prospered. This is reflected in a significant increase in the Coefficient of Variation (CV) which increased from 32% in 1980 to 48% in 1990. Afghanistan with a QLI of 10 is the poorest Islamic nation followed by a host of Sub-Saharan African countries who maintained this low status over the two decades that were examined. In 1990 the small oil exporting countries such as Qatar, UAE, and Kuwait emerged as the most developed states (Figure 1.).

Our preliminary analysis reveals several interesting points. First, there is a wide gap between the OIC members in terms of economic development and well-being. Second, in recent years the gap between the OIC "haves" and "have nots" has widened. Third, despite some flow of wealth among OIC members in the form of migrants' remittances, loans, grants, and humanitarian aid, the poverty of African members remained unchanged. Forth, in dealing with economic and welfare matters, political issues precede religious brotherhood causing gross inequalities to persist.



*Not a country

Figure 1.

IRAN'S NUCLEAR POWER INDUSTRY

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This study examines the obstacles often encountered by less developed countries (South) while trying to acquire sophisticated technology from more developed countries (North). Iran's experience is an example of complex barriers, delays, and financial losses involved in the process of transferring technology from the North to South. The rising price of oil in the 1970s led the Pahlavi regime to search for new sources of energy to meet the growing needs of energy-intensive industries such as basic metals and petrochemicals. The original plan envisaged 20 nuclear power stations with a total capacity of 23,000 MW to be built within 15 years. In an effort to promote nuclear energy research and power production, the Atomic Energy Organization of Iran (AEO) was established in 1974. Germany and France won the contract to build two nuclear power plants in the southern port city of Bushehr. To have access to needed input materials, Iran invested in France and Namibia's uranium production industries.

The German company Siemens started building the power station before the 1979 Revolution. In May 1979, the Provisional Government decided to abandon the nuclear program on the grounds that Iran lacked the infrastructure, the sophisticated technology, and even the need for nuclear power. Reasons cited were: 1) existence of massive oil, gas, and coal reserves; 2) the hazards associated with nuclear plants; and 3) the financial costs of such an expensive technology. During the Iraq-Iran war, both sites were repeatedly bombed by the Iraqis, causing substantial damage to them. Iran had already paid billions of dollars on the project and many electronic parts of the plants had already been built and stored in Europe.

After the ceasefire in 1988, the Islamic Republic decided to pursue nuclear power development by inviting Siemens to finish the Bushehr project. The company under various pretexts refused to resume the work, causing Iran to seek arbitration. Despite a subsequent ruling in Iran's favor, KWU (a subsidiary of Siemens) did not comply. The matter is still being negotiated. The dispute with the French company was finally settled in 1992, both sides claiming substantial losses. In search of alternative contractors the AEO contacted companies in Switzerland, Spain, India, China, and Russia. Recently China sold two small reactors for research to Iran. In 1992, Iran and Russia had signed an agreement to cooperate in development of peaceful use of nuclear technology. An important added difficulty to Iran's effort is the fact that "A major part of the U.S. program is directed to keeping outside assistance and nuclear weapons from getting to Iran (1)".

Finally, the Russians, who have a surplus of nuclear scientists and sever cash problems, agreed to help Iran to complete the project. In January 1995, the Russians and Iranian authorities signed an agreement on construction of the first phase of the nuclear power station at Bushehr. The Russians will also provide the needed enriched uranium for operating the plant. It is estimated that it will take four years and $10 billion to finish the first plant. Although Iran signed the nuclear Non-Proliferation Treaty in 1970 and the International Atomic Energy Agency (IAEA) teams have regularly inspected its nuclear installations, still it is accused of trying to make atomic bomb. However, the latest report of IAEA, as well as a joint statement from the U.S. and Israeli officials--two major accusers--concur that the Iranians are still "many, many years" from developing an atomic bomb (1, 2).

Production of 1000 MW of electricity hardly justifies spending over $10 billion. However, the lessons learned from dealing with international corporations and experiences of 500 Iranian engineers who are in Russia now will help Iran's future development of nuclear power industry urgently needed for operating the desalination plants and other industries in south of Iran.

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2. May, M. M. (1994) American Scientist 82, pp 526-537.

Friday, 21 April

Toxicological Studies. Room: _ A _ Presidor: _____

9:40
Overexpression of Catalase in the Heart of Transgenic Mice Provides Protection Against Adriamycin Cardiotoxicity.
Yan Chen*, Paul N Epstein, Y James Kang
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037

10:00
The Status of Glutathione Redox Cycle and Fumonisin B_1 Toxicity in Pig Kidney (LLC-PK_1) Cells.
Judith M Alexander* and Y James Kang
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037

10:20
The Efficacy of Transgenic Yeast Hexokinase and Glucokinase in Pancreatic Islets.
Bo Xu*, Sanjau Arya, Paul N Epstein
Pharmacology and Toxicology, UND School of Medicine, Grand Forks 58202 9037

10:40
DNA Adduct Formation in Target and non-Target Tumor Organs of Rapid and Slow Acetylator Congenic Hamsters Administered 3,2'-dimethyl-4-aminobiphenyl.
Yi Feng*, Wen Jiang, David W Hein
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037

11:00
Relative Selectivity of Recombinant Human Polymorphic NAT2 to Catalyze the Metabolic Activation of N-hydroxy-2-aminofluorene and N-hydroxy-4-aminobiphenyl to DNA Adducts.
David W Hein*, Mark A Doll, Timothy D Rustan
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037

11:20
Recombinant Expression of Syrian Hamster NAT2*15, NAT2*16A, and Chimeric Constructs: Effects of Specific NAT2 Mutations on N- and O-acetyltransferase Activities.
Mark A Doll*, Ronald J Ferguson, Timothy D Rustan, David W Hein
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037

11:40
Cloning and Recombinant Expression of Human N-acetyltransferase Gene NAT2*14B: Comparison to Human NAT2*4 and NAT2*14A.
David W Hein*, Mark A Doll, Ronald J Ferguson, Timothy D Rustan
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037

12:00
Cloning, Sequencing, and Expression of Rapid and Slow Acetylator rat NAT1 and NAT2 Acetyltransferase Genes: Identification of Four Mutations in Slow Acetylator Rat NAT2
Mark A Doll* and David W Hein
Pharmacolory and Toxicology, UND School of Medicine, Grand Forks, 58202 9037

OVEREXPRESSION OF CATALASE IN THE HEART OF TRANSGENIC MICE PROVIDES PROTECTION AGAINST ADRIAMYCIN CARDIOTOXICITY

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Grand Forks, ND 58202-9037

Adriamycin (ADR) is an important anticancer agent. However, the clinical use of ADR is limited by its undesirable side effects, especially cardiotoxicity (1). One of the most likely mechanisms for the toxicity of ADR is the production of reactive oxygen free radicals during its cellular metabolism (2). Catalase is a major enzyme involved in detoxification of hydrogen peroxide, an important species of the reactive oxygen free radicals. The activity of catalase per g tissue in the heart is very low, being only about 2% that of liver in the mouse (3). This relative deficit in the heart in its ability to dispose of reactive oxygen species may be responsible for the high sensitivity of the heart to ADR. The objective of this research is therefore to determine whether elevation of catalase activity specifically in the heart of transgenic mice can provide protection against ADR toxicity.

A transgene for overexpression of catalase in the heart of transgenic mice was constructed. This transgene contains fragments from the rat catalase cDNA ligased behind the alpha cardiac myosin heavy chain promoter. A 600-bp genomic fragment of the rat insulin II gene was included behind the catalase sequence to provide polyadenylation and termination signals. This transgene was then modified and injected into mouse embryos. The embryos were implanted into Avertin-anesthetized pseudopregnant females and allowed to come to term. The transgenic mice were identified using Southern blot, Dot blot, and PCR procedure. Catalase activities and its mRNA levels in the heart and other organs were measured. After identified, the transgenic mice were used to determine the effect of elevation of catalase activity in the heart on ADR-induced cardiotoxicity. ADR was dissolved in physiological saline and administered by ip at a dose 20mg/kg body weight. At day 4 after injection, the cardiotoxicity of ADR was evaluated by measuring lipid peroxidation (TBARS) (4) in both transgenic and control hearts.

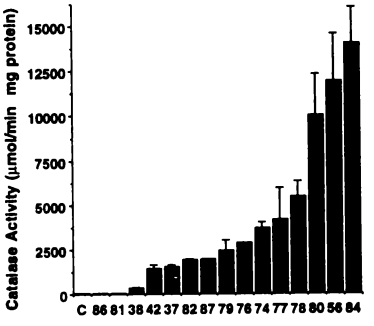

Fig.1. Elevated catalase activities in the heart from each (n=6) of the 15 different transgenic mouse lines in comparison with that from the controls.

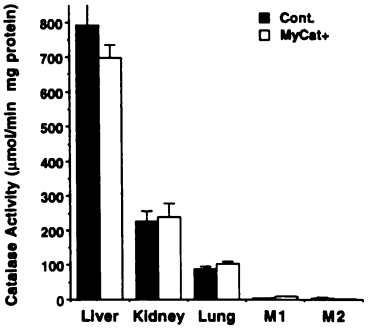

Fig.2. Comparison of catalase activities in the liver, kidney, lung, and skeletal muscles from the leg (M1) and stomach (M2) of 5 transgenic mouse lines.

Table 1. Effects of elevated catalase activities on Adriamycin-induced lipid peroxidation in the heart.

	lipid peroxidation (% of control)	Catalase (μmol/min mg protein)
Control (n=8)	--	22.3
Adr (n=12)	138.4*	22.3
738 Adr (n=4)	134.9*	322.6
742 Adr (n=3)	106.9**	1456.7
782 Adr (n=2)	98.3**	1894.2
776 Adr (n=5)	87.4**	2859.1
777 Adr (n=8)	97.4**	4150.2

*Significantly different from control ($p<0.01$).
**Significantly different from the control Adr-treated ($p<0.01$).

As shown in Fig.1, we have produced 15 transgenic mouse lines in which only catalase, not other antioxidant components including glutathione (GSH), GSH peroxidase, GSH reductase, metallothionein, and superoxide dismutase (data not shown), is altered in the heart. Each transgenic line exhibits a stably elevated catalase activity, ranging from 2- and 500- fold higher than normal. This enzyme activity is not altered in any other organs including liver, kidneys, lung, and skeletal muscles (Fig. 2). As shown in Table 1, the level of ADR-induced lipid peroxides in the catalase-overexpressed transgenic hearts was significantly ($p<0.01$) decreased. The suppression of lipid peroxidation was roughly proportional to the levels of the increased catalase activities in the heart, although 100-fold elevation seemed to exhibit a maximal effect. The results demonstrate that catalase is importantly involved in cellular protection against ADR toxicity. The low catalase activity in the heart is at least partially responsible for the ADR-induced cardiac damage. Furthermore, the cardiac catalase-overexpressed transgenic mice is a valuable model for studying the role of catalase in cardiac protection against damages induced by numerical physical and chemical agents.
Supported in part by grant #CA63752 from NIH and #94007070 from the American Heart Association National Center.

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THE STATUS OF GLUTATHIONE REDOX CYCLE AND FUMONISIN B_1 TOXICITY IN PIG KIDNEY (LLC-PK_1) CELLS

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Glutathione (GSH) is a highly conserved non-protein thiol in animal cells. It functions in many cellular processes. Importantly, GSH is a key antioxidant. Together with other components of the GSH redox cycle including glutathione peroxidase (GSHpx) and glutathione reductase (GR), GSH plays a central role in cellular protection against toxicities of many xenobiotics. Fumonisin B_1 (FB_1), produced by *Fusarium moniliforme*, has been shown to be a causative agent of equine leukoencephalomalacia, porcine pulmonary edema, and rat liver tumors and chronic nephritis. In addition, the incidence of *Fusarium moniliforme* infection of home-grown corn is correlated with the high incidence of human esophageal cancer in China and in southern Africa. At present, the mechanism of action of FB_1 is unknown.

Studies with a pig kidney cell line (LLC-PK_1) (1) showed that FB_1 is a potent and specific inhibitor of sphingosine and sphinganine N-acyltransferase, a key enzyme in the pathways for *de novo* sphingolipid biosynthesis and turnover. As a result, free sphinganine accumulates intracellularly and this elevation correlates with the FB_1-induced inhibition of proliferation and cell death. However, a mechanistic relationship between the sphinganine accumulation and the FB_1 cytotoxic effect has not been demonstrated. It is possible that accumulation of sphinganine and its metabolites results in enhanced free radical generation, potentially leading to enhanced oxidative stress and ultimately producing cell injury. Such a change would alter the status of the GSH redox cycle, resulting in suppression of antioxidant function. The present study was undertaken to examine the effects of FB_1 on the status of the GSH redox cycle and of modulation of the GSH redox cycle on FB_1 toxicity in LLC-PK_1 cells.

LLC-PK_1 cells were cultured in Dulbecco's modified Eagle medium with nutrient mixtures and supplemented with 5% fetal calf serum. Cellular GSH levels were measured using a glutathione reductase recycling assay (2). GSHpx and GR activities were measured by colorimetrical assays. The FB_1 cytotoxicity was determined by a tetrazolium reduction (MTT) and a long-term survival assay. The cells were treated with FB_1 at 4 mg/ml, then collected at 24-h intervals for 96 h. This treatment did not change the activity of GSHpx, but slightly increased the activity of GR. It significantly decreased cellular GSH concentrations. We next determined whether modulation of cellular GSH status can alter FB_1 cytotoxicity. Treatment of LLC-PK_1 cells for 12 h with 0.1 mM buthionine sulfoximine (BSO), a selective inhibitor of the enzyme γ-glutamylcysteine synthetase that catalyzes the rate-limiting reaction in *de novo* GSH synthesis, decreased cellular GSH levels to about 20% of that found in the non-BSO treated cells. This BSO treatment, however, did not affect the cell viability. The cells pretreated with 0.1 mM BSO for 12 h and controls treated with the same volume of saline were then exposed to varying concentrations of FB_1. Both MTT and long-term survival assays revealed that the LC_{50} value of FB_1 for the BSO-treated cells was significantly lowered ($p<0.01$). N-acetylcysteine (NAC) has been shown to increase GSH concentrations in many cell types. It was thus used in the present study in an attempt to increase cellular GSH. Treatment with 0.1 mM NAC, however, did not increase cellular GSH concentrations in these cells. Nor did this treatment prevent the FB_1-induced GSH depletion.

The results demonstrated that FB_1 toxicity is associated with alteration of the GSH redox cycle status, namely, decreased GSH concentrations. This decrease may reflect participation of GSH in detoxification of FB_1. In addition, depletion of cellular GSH sensitized the cells to FB_1 toxicity, further suggesting that GSH plays a role in cytoprotection against FB_1 toxicity. In this study we also found NAC did not increase GSH concentrations in LLC-PK_1 cells, although it does so in other cells. NAC is currently used as an antioxidant in other cultured cells. It did not enhance the resistance of LLC-PK_1 cells to FB_1 toxicity, suggesting that this antioxidant does not perticipate in the FB_1 cytoprotection. Supported in part by USDA grant NDR-9304125.

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THE EFFICACY OF TRANSGENIC YEAST HEXOKINASE AND GLUCOKINASE IN PANCREATIC ISLETS

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It is well established that glucose metabolism levels in pancreatic B-cells determine insulin secretion. Mammalian B-cell contains four different kinds of hexokinase. Among them glucokinase (ATP D-glucose 6-phosphotransferase, EC 2.7.1.2), a glucose 6-phosphotransferase characterized by low affinity for glucose plays a critical role for regulation of glucose metabolism. It has further been proposed that unique amino acid sequence of islet glucokinase are important for glucokinase function by forming association with other B-cell components, such as GLUT 2. In our previous work (1) , we made a transgenic model which expressed yeast hexokinase in mouse pancreatic B-cells. The yeast hexokinase with little direct sequence homology to glucokinase has high affinity for glucose. The transgenic yeast hexokinase elevated B-cell hexokinase activity (increased glucose metabolism) and increased insulin secretion in low glucose.

The purpose of present study was to test the hypothesis that islet specific sequences of glucokinase determine the efficacy of glucokinase. We did a quantitative comparison of efficacy of glucose metabolism and insulin secretion by transgenic hexokinase and endogenous glucokinase. Islets were isolated from 9 to 14 days old transgenic and normal mice. Islets were assayed for hexokinase activity, glucose flux and insulin secretion. All parameters were measured at six glucose concentrations between 0.5 and 20 mM glucose. Transgenic islet hexokinase activity exceeded normal islet hexokinase activity by approximately two-fold at low glucose concentration and by about 50% at high glucose concentration (fig. 1). The relative increase in glucose flux of transgenic islets paralleled the increase in transgenic hexokinase activity (fig. 2). Basal insulin secretion of perifused transgenic islet did not appear greater than basal insulin secretion of normal islet but the glucose concentration for threshold stimulation was clearly lower in transgenic islets. These results do not support the hypothesis that islet specific glucokinase sequences are important in glucokinase function. Rather, they suggest that glucose phosphorylation from any active hexokinase is equivalent in regulation B-cell function.

Figure 1 HEXOKINASE ACTIVITY

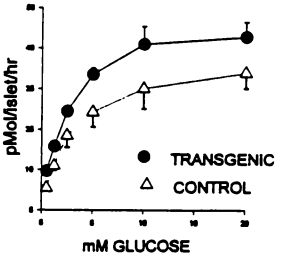
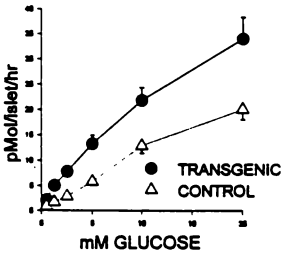


Figure 2 GLUCOSE FLUX



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DNA ADDUCT FORMATION IN TARGET AND NON-TARGET TUMOR ORGANS OF RAPID AND SLOW ACETYLATOR CONGENIC HAMSTERS ADMINISTERED 3,2´-DIMETHYL-4-AMINOBIPHENYL

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School of Medicine, Grand Forks, ND 58202-9037.

3,2´-Dimethyl-4-aminobiphenyl (DMABP), a genotoxic arylamine carcinogen, reportedly causes a very high incidence of urinary bladder cancer and relatively low incidence of colon cancer in Syrian hamsters. DMABP, like other arylamines, undergoes metabolic activation and/or deactivation catalyzed by various enzymes subject to polymorphic genetic control. It is bioactivated to a proximate carcinogen, N-hydroxy-DMABP, by hepatic cytochrome P-4501A2. Following glucuronidation, the N-hydroxyarylamine glucuronide conjugates are transported via urine and bile to the urinary bladder or colon, respectively. The acidic urine or bacterial β-glucuronidase can cleave the N-glucuronides to regenerate N-hydroxyarylamines. The N-hydroxyarylamines are further activated by urine acidity or acetyltransferase enzyme(s) to electrophilic arylnitrenium ions which bind to DNA covalently and cause mutagenic and carcinogenic lesions. Human epidemiological studies suggest that slow and rapid acetylators are at higher risks for urinary bladder cancer and colon cancer, respectively. In this study, rapid and slow acetylator Syrian hamsters congenic at the *NAT2* locus were administered DMABP to measure DNA adduct levels in tumor-target organs (urinary bladder and colon) and non-target organs (liver, prostate, and heart) and to assess the role of *NAT2* acetylator genotype on DMABP-DNA adduct formation.

A single dose of 33 mg/kg (low) or 100 mg/kg (high) DMABP was administered s.c. to rapid (Bio. 82.73/H-*Pat*^{r}) and slow (Bio. 82.73/H-*Pat*^{s}) acetylator Syrian hamsters congenic at the *NAT2* locus. Urinary bladder, colon, liver, prostate, and heart were collected at 6, 18, 24, and 48 hr post-injection from low dose treated animals and at 48 hr post-injection from high dose treated animals. DNA was isolated by phenol/chloroform extraction and DMABP-DNA adduct levels in these organs were measured by ^{32}P-postlabeling assay.

Two DNA adducts, N-(deoxyguanosin-8-yl)-3,2´-dimethyl-4-aminobiphenyl (C8-DMABP) and 5-(deoxyguanosin-8-yl)-3,2´-dimethyl-4-aminobiphenyl (N2-DMABP), were detected in urinary bladder at the low dose and in urinary bladder, colon, liver, prostate, and heart at the high dose. No DNA adduct was detected in colon, liver, prostate, and heart at the low dose and in vehicle-treated animals. Urinary bladder C8-DMABP and N2-DMABP levels increased up to 48 hr post-injection in rapid acetylators while in slow acetylators, the DNA adduct levels increased to a peak at 18 hr post-injection, then fell off at 24 hr post-injection, and peaked again at 48 hr post-injection after the low dose. After 48 hr of the high dose exposure, C8-DMABP and N2-DMABP levels were significantly higher in urinary bladder (major tumor-target organ) than in liver, prostate, colon, and heart in both rapid and slow acetylators. C8-DMABP levels were significantly higher in liver and prostate than in colon and heart in rapid and slow acetylators, while N2-DMABP levels were significantly higher in prostate than in colon and heart in both rapid and slow acetylators. The DNA adduct levels did not differ between rapid and slow acetylator congenic hamsters in urinary bladder following either the low or high dose exposures and in other organs after the high dose exposure.

In summary, DNA adduct formation was significantly higher in the major tumor-target organ than in minor and non-target organs in Syrian hamsters administered DMABP, and *NAT2* acetylator genotype did not play a significant role in DMABP-DNA adduct formation in this study. Partially supported by USPHS grant CA-34627.

RELATIVE SELECTIVITY OF RECOMBINANT HUMAN POLYMORPHIC NAT2 TO CATALYZE THE METABOLIC ACTIVATION OF N-HYDROXY-2-AMINOFLUORENE AND N-HYDROXY-4-AMINOBIPHENYL TO DNA ADDUCTS

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Rapid acetylator phenotype has been associated with higher rates of colorectal cancer in human populations. N-acetyltransferases (E.C.2.3.1.5) catalyze the metabolic activation of N-hydroxyarylamine carcinogens by O-acetylation to electrophilic intermediates that mutate DNA and initiate tumors. Humans express two N-acetyltransferase isozymes (NAT1 and NAT2) which differ in genetic regulation. NAT2 is the isozyme associated with the classical acetylation polymorphism, which segregates individuals into rapid, intermediate, and slow acetylator phenotypes. Human epidemiological studies have shown higher incidences of colorectal cancer in rapid acetylators, suggesting a role for NAT2 in the activation of N-hydroxyarylamine carcinogens. To test this hypothesis, we cloned human wild-type *NAT1 (NAT1*3)* and wild-type *NAT2 (NAT2*4)* and expressed them in an *Escherichia coli* JM105 expression system to assess the relative affinity of carcinogenic N-hydroxyarylamines for recombinant human NAT1- and NAT2-catalyzed O-acetylation. Both recombinant NAT1 and NAT2 were detected by Western blot using a anti-human NAT2 rabbit antiserum (Figure 1). Recombinant NAT1 and NAT2 also both activated N-hydroxy-2-aminofluorene and N-hydroxy-4-aminobiphenyl to DNA adducts. However, recombinant NAT2 had over an 11-fold higher affinity for both N-hydroxyarylamines than did recombinant NAT1 (Table 1). These results suggest relative selectivity for NAT2-dependent metabolic activation of carcinogenic N-hydroxyarylamines *in vivo* which may contribute to higher rates of colorectal cancer from activation of N-hydroxyarylamines in rapid acetylators. Partially supported by USPHS grant CA-34627 and USEPA grant R821836.

Table 1. Relative affinity of N-hydroxy-2-aminofluorene and N-hydroxy-4-aminobiphenyl for recombinant human NAT1 (NAT1 3) and NAT2 (NAT2 4)

	Apparent Km (μM)		
	NAT1	NAT2	NAT1/NAT2
N-hydroxy-2-aminofluorene	276 ± 88	24.3 ± 7.0	11.4
N-hydroxy-4-aminobiphenyl	145 ± 65	12.7 ± 0.5	11.4

All assays were carried out at initial acetyl coenzyme A concentrations of 300 μM except NAT2-catalyzed activation of N-hydroxy-2-aminofluorene carried out at 1000 μM.

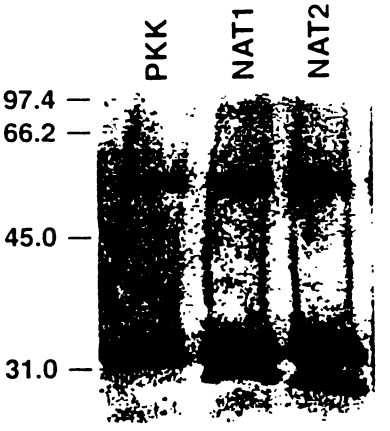

Figure 1. Western blot detection of recombinant NAT1 and NAT2 proteins. PKK represents JM105 pKK223-3/without insert. NAT1 and NAT2 represent JM105 pKK223-3/NAT1 and /NAT2, respectively. 50 μg of protein were added to each lane, and molecular weight markers (kDa) are shown at left. Following densitometry, NAT1 immunoreactive protein was 88.1% of NAT2.

RECOMBINANT EXPRESSION OF SYRIAN HAMSTER *NAT2*15, NAT2*16A,* AND CHIMERIC CONSTRUCTS: EFFECTS OF SPECIFIC *NAT2* MUTATIONS ON N- AND O-ACETYLTRANSFERASE ACTIVITIES

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Arylamine N-acetyltransferase (E.C.2.3.1.5) catalyzes both the N-acetylation (deactivation) and O-acetylation (activation) of arylamine carcinogens and metabolites. N-acetylation capacity in humans and other mammalian species such as hamster is subject to a genetic polymorphism, segregating individuals into rapid, intermediate, and slow acetylator phenotypes. Polymorphic arylamine N-acetyltransferase (NAT2) is regulated by a single gene (*NAT2*) containing a single coding exon of 870 base pairs. Our laboratory has constructed two sets of homozygous rapid and slow acetylator Syrian hamster lines which are congenic at the *NAT2* locus. *NAT2* from each of the lines was cloned, sequenced and expressed in a *E. coli* JM105 expression system. The hamster slow acetylator *NAT2* (*NAT2*16A*) coding region differs from the rapid acetylator *NAT2* (*NAT2*15*) coding region by three mutations at nucleotide positions 36, 633 and 727. The purpose of this study was to evaluate the Michaelis-Menten kinetic constants of recombinant NAT2 proteins expressed from rapid and slow *NAT2* alleles. We also constructed and expressed chimeric *NAT2* alleles containing all combinations of 36, 633 and 737 nucleotide mutations in order to determine the specific role of each mutation on N- and O-acetyltransferase catalytic activities and substrate affinities. As shown in Tables I-III below, the $C^{727}T$ mutation, which creates an opal stop codon (at codon 243) in slow acetylator *NAT2* showed a significant ($p < 0.01$) reduction (but not complete loss) in N-hydroxyarylamine O-acetyltransferase (Table I) and arylamine N-acetyltransferase (Table II) activities. This mutation was also solely responsible for a slight increase in substrate affinity (Table II). Thus, the $C^{727}T$ mutation is the sole mutation responsible for the decreases in both N- and O-acetyltransferase activities as well as the slight increase in substrate affinity (Table III). Partially supported by USPHS grants CA-34627 and RR-05407.

TABLE I. O-Acetylation Activities of Wild-Type, Mutant, and Chimeric Recombinant Syrian Hamster NAT2 Allozymes

Hamster *NAT2* Allele	N-OH-AF O-Acetyltransferase Activity (pmol/min/mg DNA/mg)
wt	1562 ± 144
36	1383 ± 161
633	1232 ± 113
727	6.75 ± 4.66*
36/633	1459 ± 114
36/727	2.86 ± 2.34*
633/727	2.53 ± 6.53*
36/633/727	26.9 ± 22.7*

Table values represent Mean ± S.E. for three individual determinations. *Significantly lower than *wt* ($p < 0.01$)

TABLE II. Michaelis-Menten Kinetic Constants of Wild-Type, Mutant, and Chimeric Recombinant Syrian Hamster NAT2 Allozymes

Hamster *NAT2* Allele	2-Aminofluorene N-Acetyltransferase Activity	
	Vmax (nmol/min/mg)	Km (μM)
wt	7,381 ± 1781	462 ± 51
36	6,846 ± 905	374 ± 29
633	7,571 ± 1009	364 ± 19
727	0.352 ± 0.039*	191 ± 35*
36/633	7,760 ± 789	402 ± 27
36/727	0.259 ± 0.025*	190 ± 34*
633/727	0.309 ± 0.043*	205 ± 22*
36/633/727	0.354 ± 0.033*	184 ± 37*

Table values represent Mean ± S.E. for three individual determinations. *Significantly lower than *wt* ($p < 0.01$)

TABLE III. Syrian Hamster *NAT2* Mutations and Their Effects on Michaelis-Menten Kinetic Constants

Nucleotide Position	Base Change	Amino Acid Change	Catalytic Effect	Affinity Effect
36	T→C	Silent	None	None
633	A→G	Silent	None	None
727	C→T	Opal stop codon	Substantial Reduction	Slight Increase

CLONING AND RECOMBINANT EXPRESSION OF HUMAN N-ACETYLTRANSFERASE GENE *NAT2*14B*: COMPARISON TO HUMAN *NAT2*4* AND *NAT2*14A*

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Human polymorphic N-acetyltransferase (NAT2) catalyzes the N-acetylation of arylamine carcinogens and the metabolic activation of N-hydroxyarylamine and N-hydroxyarylamide carcinogens by O- and N,O-acetylation, respectively. Rapid and slow acetylator phenotype is regulated at the *NAT2* locus, and has been associated with predisposition to cancer from arylamine chemicals. Fifteen different *NAT2* alleles have been identified in human populations, including the *NAT2*4* allele which is associated with rapid acetylator phenotype (*Pharmacogenetics* 5: 1, 1995). The *NAT2*14A* allele has base pair substitution $G^{191}\rightarrow A$, and the *NAT2*14B* allele has base pair substitutions $G^{191}\rightarrow A$ and $C^{282}\rightarrow T$ in the *NAT2* coding region. The $C^{282}\rightarrow T$ substitution is silent on the amino acid level, but the $G^{191}\rightarrow A$ substitution changes Arg^{64} to Gln and thereby changes a basic amino acid in the highly conserved Arg^{64}-Gly^{65}-Gly^{66}-Trp^{67}-Cys^{68} peptide sequence common to all mammalian N-acetyltransferases. Cys^{68} is at the active site involved in the formation of the acetyl-cysteine enzyme intermediate (*J. Biol. Chem.* 267: 7381, 1992). *NAT2*14B* has been associated with human slow acetylator phenotype *in vivo* (*Carcinogenesis* 14: 1689, 1993), but the recombinant NAT2 14B allozyme has yet to be expressed and characterized. We cloned and expressed *NAT2*14B* in an *Escherichia coli* JM105 expression system, and compared acetyltransferase catalytic capabilities of NAT2 14B with those of fifteen other recombinant human NAT2 allozymes, including NAT2 4 and NAT2 14A. Recombinant expression of *NAT2*14A* and **14B* yielded amounts of immunoreactive protein equivalent with *NAT2*4* (data not shown). However, the 2-aminofluorene N-acetyltransferase, N-hydroxy-2-aminofluorene O-acetyltransferase, and the N-hydroxy-2-acetylaminofluorene N,O-acetyltransferase catalytic activities of the recombinant NAT2 14A and 14B allozymes were substantially reduced from NAT2 4 (Table 1). These results suggest that *NAT2*14A* and **14B* are associated with human slow acetylator phenotype. Partially supported by USPHS grant CA-34627 and USEPA grant R821836.

Table 1. Recombinant human NAT2 acetyltransferase activities

Allozyme	N-acetyltransferase (nmol/min/U)	O-acetyltransferase (pmol/min/mg DNA/U)	N,O-acetyltransferase (pmol/min/mg DNA/U)
NAT2 4	9490 ± 190	188 ± 14	27.1 ± 5.4
NAT2 14A	2435 ± 193**	20.3 ± 13.9**	13.0 ± 3.6
NAT2 14B	1948 ± 69**	32.1 ± 5.2**	6.4 ± 1.0*

Table values represent Mean ± S.E.M. for 3-5 separate determinations. N-acetyltransferase activities represent apparent Vmax. O-Acetyltransferase and N,O-acetyltransferase activities represent initial velocities. All acetyltransferase activities were normalized to arbitrary units (U) of immunoreactive protein following Western blots. Statistical differences from NAT2 4 were tested by one-way analysis of variance *$p<0.05$; **$p<0.01$.

CLONING, SEQUENCING, AND EXPRESSION OF RAPID AND SLOW ACETYLATOR RAT *NAT1* AND *NAT2* ACETYLTRANSFERASE GENES: IDENTIFICATION OF FOUR MUTATIONS IN SLOW ACETYLATOR RAT *NAT2*

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Aromatic and heterocyclic arylamines found in food, cigarette smoke and other sources have been shown to cause cancer in humans. Arylamine acetyltransferases catalyze both the activation (O-acetylation) and deactivation (N-acetylation) of these arylamine carcinogens. Like humans, rats express two N-acetyltransferase isozymes. The *NAT1* gene is thought to be monomorphic and expressed at similar levels from individual to individual. However, the *NAT2* gene has been shown to be polymorphic, resulting in rapid, intermediate and slow acetylator phenotypes. This interindividual variance in *NAT2* expression is believed to be responsible for a differential risk to certain types of cancers. In the present study, we have cloned, sequenced and expressed both the *NAT1* and *NAT2* genes from homozygous rapid and slow acetylator inbred rats. Jones and coworkers isolated and sequenced two rat liver *NAT* cDNAs from Sprague-Dawley rats (Genbank U17260 and U17261). Primers for the polymerase chain reaction were synthesized corresponding to areas that flank the two coding regions. PCR products (909 bp) containing 870 bp coding regions were amplified via genomic DNA template from homozygous rapid and slow acetylator inbred rat and identified as rat *NAT1* and *NAT2*, respectively. The rat *NAT1* and *NAT2* PCR products were cloned and sequenced. Two *NAT2* alleles were identified: one from the homozygous rapid acetylator (*NAT2*^{r}) rat which was identical to U17261 and the other from the homozygous slow acetylator (*NAT2*^{s}) rat. The rat slow acetylator *NAT2*^{s} allele (Genbank U19272) had four point mutations compared to *NAT2*^{r}: $G^{361}A$ ($Val^{121}\rightarrow Ile$), $G^{399}A$ (silent), $G^{522}A$ (silent) and $G^{786}A$ ($Val^{266}\rightarrow Ile$). The rat *NAT1*^{r} and *NAT1*^{s} alleles were identical. We expressed the rapid and slow acetylator rat *NAT1* and *NAT2* alleles in an *E. coli* JM105 expression system. Recombinant NAT2^s catalyzed arylamine N-acetyltransferase activities at rates substantially below NAT2^r (Table I). However, recombinant NAT2^s had over 6-fold higher affinity for 2-aminofluorene than did recombinant NAT2^r (Table II). Immunodetection of rat recombinant NAT1^r, NAT1^s, and NAT2^r was achieved by Western blot with anti-human NAT2 antibody. However, there was a complete loss of immunoreactive protein in NAT2^s. Partially supported by USPHS CA-34627 and USEPA-R821836.

TABLE I. Recombinant Rat N-acetyltransferase Activities

Allozyme	2-Aminofluorene	3,2'-Dimethyl-4-aminobiphenyl	p-Aminobenzoic Acid
		(nmole/min/mg protein)	
NAT2^r	311 ± 7	106 ± 3	4632 ± 503
NAT2^s	5.63 ± 0.42*	1.27 ± 0.04*	136 ± 1*
NAT1^r	6.86 ± 0.25	5.21 ± 0.35	1.02 ± 0.06
NAT1^s	8.18 ± 0.14	6.13 ± 0.28	1.23 ± 0.05

Table values represent Mean ± S.E. for 3 individual determinations. Activity for NAT2^s is significantly ($p<0.01$) lower than NAT2^r using Student's t-test.

TABLE II. Michaelis-Menten Kinetic Constants for 2-Aminofluorene N-acetylation

Allozyme	Apparent Vmax (nmole/min/mg protein)	Apparent Km (μM)	Apparent Clearance (Vmax/Km)
NAT2^r	431 ± 13	631 ± 34	0.683
NAT2^s	6.97 ± 0.31*	98.2 ± 6.1*	0.071
NAT1^r	20.8 ± 1.1	25.9 ± 4.5	0.803
NAT1^s	21.5 ± 1.0	26.5 ± 3.6	0.811

Table values represent Mean ± S.E. for 3 individual determinations. Apparent Vmax and Km values for NAT2^s are significantly ($p<0.01$) lower than NAT2^r using Student's t-test.

Friday, 21 April

Natural Science. Room: _ B _ Presidor: Om Madhok, Board Chairman

First North Dakota Research Foundation Supported Project.

2:00
Distribution of the Burrowing Owl (*Athene cunicularia*) in Billings County, North Dakota.
Michelle K Davidson*, Amy J Quick, Stacy L Adolf, Donna M Bruns Stockrahm
Biology, Moorhead State University, Moorhead, MN 56563

2:30
Evolutionary Response of Eocene and Oligocene Bivalves to Naticed Gastropod Predation.
Patricia Kelley, Thor A Hansen, **Vicky D Andrews***
Geology and Geological Engineering, University of North Dakota, Grand Forks 58202
Geology, Western Washington University, Bellingham, WA 98225

2:50
The *Gnaphosidae (Araneae)* of North Dakota.
Daniel J Mott*
Biology, Dickinson State University, 58601

3:10
Survey of North Dakota Earthworms (*Lumbricidae*).
Rodney A Utter*, Edward J Deibert, Donald P Schwert
Soil Science and Geosciences, North Dakota State University, Fargo 58105

DISTRIBUTION OF THE BURROWING OWL (*ATHENE CUNICULARIA*) IN BILLINGS COUNTY, NORTH DAKOTA

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Donna M. Bruns Stockrahm
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Burrowing owls (*Athene cunicularia*) occur in various grassland habitats in southwestern Canada through the western United States and a few other areas. Despite their wide distribution and habitat usage, their numbers are declining. In North Dakota, prime burrowing owl habitat coincides with black-tailed prairie dog (*Cynomys ludovicianus*) colonies where the owls utilize abandoned prairie dog burrows. One of the highest concentrations of remaining prairie dog colonies in the state occurs in the North Dakota Badlands, specifically in Billings County. The burrowing owl is on North Dakota's "Watch List" (1). Current information on the status of this species is needed so that it might be used to insure the continued existence of burrowing owls in this state. The purpose of our study was to determine the distribution, numbers, habitat affinities, and nest burrow characteristics of the burrowing owl in Billings County.

From 12 June to 1 September 1994, sites from a compiled list of prairie dog colonies were systematically searched for owls and/or evidence of their presence. Locations and numbers of all owls were noted. If possible, owls were observed for up to 2 hours. If an owl nest burrow was located, measurements were taken on the diameter and height of the mound encircling the nest burrow and the diameter of and angle of entry into the nest burrow. Vegetation in the immediate area around the nest burrow was qualitatively described. Using the point-quarter method, the mean distance from the nest burrow entrance to the 4 closest prairie dog burrow entrances was calculated; these means were then used to calculate an overall mean for all nest burrows. Location of each nest burrow within the prairie dog colony was noted.

A list of 52 sites, i.e., prairie dog colonies, was compiled; 25 of these sites were checked for burrowing owl activity. Some sites (n = 27) were either inaccessible or unable to be found. Most of the sites were clustered in or around the South Unit of Theodore Roosevelt National Park, but owls were found at only 1 site within the park. Of the 25 sites checked, a total of 29 owls were found on 7 sites for a mean of 4.14 owls per site (S.E. = 0.99, range = 1 - 8). There appeared to be 13 adults and 16 immatures, but ages were sometimes difficult to distinguish in late summer. Owls were found in pairs on 6 of the sites, with 5 pairs appearing to have offspring. A singlet was found on the remaining site. The number of offspring per pair appeared to range from 1 to 6, but occasionally it was difficult to determine if a lone owl near a nest pair was an immature offspring or an adult singlet.

Only 5 nest burrows were found, each on different colonies and each on the colony periphery. The mean diameter and height of the mounds encircling the nest burrow were 1.44m (S.E. = 0.21, n = 5) and 0.34m (S.E. = 0.17, n = 5), respectively. The mean diameter of and angle of entry into the nest burrow entrances were 0.12m (S.E. = 0.02, n = 5) and 29.8 degrees (S.E. = 3.26, n = 5), respectively. The vegetation in the vicinity of each nest burrow was short and sparse. The overall mean distance between nest burrow entrances and the 4 closest prairie dog burrow entrances was 7.76m (S.E. = 1.58, n = 5).

Scattered populations of burrowing owls exist in Billings County, but densities were low in all areas studied. The impact of past prairie dog poisoning and the development of oil fields in western North Dakota on burrowing owls is unknown, but they have possibly contributed to the owl decline in this state. Secondary poisoning of owls due to rodenticide application has been documented (2). As found elsewhere (3), burrowing owls in North Dakota seem to prefer open areas of short vegetation around their nest burrows. Hopefully, the information from our study will contribute to a management plan to maintain minimum viable populations of burrowing owls in North Dakota.

We gratefully acknowledge the financial support of the North Dakota Research Foundation for our study.

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EVOLUTIONARY RESPONSE OF EOCENE AND OLIGOCENE BIVALVES TO NATICID GASTROPOD PREDATION

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Naticid gastropods are shell-drilling, burrowing predators that have been an important cause of mortality for molluscs since the Cretaceous. We have used the record of naticid drilling to test Vermeij's (1) controversial "hypothesis of escalation." This hypothesis states that biologic hazards such as predation have increased through geologic time, along with adaptations to those hazards. The hypothesis predicts that naticid drilling frequencies increased through time, and that prey responded with antipredatory adaptations (such as increased armor). A comprehensive survey of naticid predation on North American Coastal Plain mollusc assemblages corroborated escalation of drilling frequencies during the Cretaceous and Paleogene (2). In the present study, we examine details of the escalation process by considering evolutionary responses to predation within individual prey species.

Prey choice by extant naticids is determined by cost-benefit ratios; cost of a prey item is controlled by shell thickness and benefit is based on biomass (i.e., internal volume of the shell). We predicted that prey species should respond to naticid predation by increasing their cost-benefit ratio through time. This response may involve an increase in shell thickness and/or decrease in internal volume.

To test this hypothesis, we examined the evolution of six common prey species from the Eocene and Oligocene of the Gulf Coastal Plain. We determined patterns of temporal change in internal volume (IV), thickness (TH), and cost-benefit ratio (TH:IV).

Four species showed development of antipredatory characteristics through time. Two of these species were from the Eocene Moodys Branch Formation. Nuculana multilineata decreased in internal volume and increased in thickness and cost-benefit ratio; Glycymeris idonea also decreased in IV and increased in TH. Scapharca leseuri from the Byram Formation of Mississippi (Oligocene) increased in cost-benefit ratio by increasing shell thickness. Corbula rufaripa (Oligocene Red Bluff Formation of Mississippi) decreased in internal volume, with a consequent increase in cost-benefit ratio. In contrast, Corbula laqueata (Byram Formation) and Spisula jacksonensis (Moodys Branch) did not evolve consistently with our predictions. For instance, although C. laqueata decreased in IV, thickness also decreased, producing an overall decrease in cost-benefit ratio.

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THE GNAPHOSIDAE (ARANEAE) OF NORTH DAKOTA

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The family Gnaphosidae or Ground Spiders consists of medium to large, nocturnal spiders. Their daylight hours are spent in silken retreats in ground litter or under stones or logs. Because of these secretive habits they are most often collected by pitfall traps or by hand collecting in litter. The North American fauna is reasonably well known due to the work of Platnick at the American Museum of Natural History (AMNH) which began in the 1970s and culminated with "The Ground Spiders of Canada and Alaska" published in 1992. A survey of the literature shows that 13 gnaphosid genera containing 31 species occur in North Dakota. The state also lies within the range of an additional 17 species. These figures are similar to the surrounding states and Canadian provinces; South Dakota (14 genera with 53 species), Minnesota (14 genera with 42 species), Montana (12 genera with 56 species), Saskatchewan (12 genera with 45 species) and Alberta (10 genera with 44 species).

The primary collections in North Dakota consist of the Joe Davis collection from Divide County in the 1930s, the Karl Stone collection from around Ward County in the 1970s, the Richard Sauer (state-wide) collection in the late 1960s, the collections of Post and others in the southeastern part of the state in the 1950s and 1960s and the DSU collection from southwest section in the 1990s. The Davis collection has been cited several times in AMNH publications, but has probably been integrated into their general collection and is not available. The Stone collection is housed at the Florida State Collection of Arthopods in Gainesville, both the Sauer and Post collections are in the Entomology Department at NDSU.

The Sauer, Post and DSU collections contain 51 species in 11 genera for a total of 3241 gnaphosid specimens. Included are the genera *Callilepis* (1 species, 352 specimens), *Cesonia* (1 species, 1 specimen), *Drassodes* (3 species, 638 specimens), *Drassyllus* (7 species, 563 specimens), *Gnaphosa* (4 species, 269 specimens), *Haplodrassus* (4 species, 385 specimens), *Herpyllus* (1 species, 20 specimens, *Micaria* (12 species, 195 specimens), *Nodocion* (2 species, 51 specimens), *Sergiolus* (6 species, 43 specimens) and *Zelotes* (10 species, 724 specimens). The specimens in these collections were taken from 32 North Dakota Counties. The DSU collection (10,975 specimens) shows that gnaphosids are the most common family of ground dwelling spiders in the Badlands, making up 40.6% of the total. In prairie grasslands, however, gnaphosids comprise only 13.2% of the total fauna, behind lycosids (45.2%) and thomisids (24.7%). Forty-three of the 51 species reported appear to be restricted to the western half of the state and the other 8 species occur statewide. North Dakota is part of the range of 9 species for which there are no collection records; *Gnaphosa clara*, *G. mima*, *G. microps*, *Herpyllus hesperolus*, *Micaria longispina*, *M. aena*, *Sosticus loricatus*, *Urozelotes rusticus*, and *Orodrassus coloradensis.*

SURVEY OF NORTH DAKOTA EARTHWORMS (LUMBRICIDAE)

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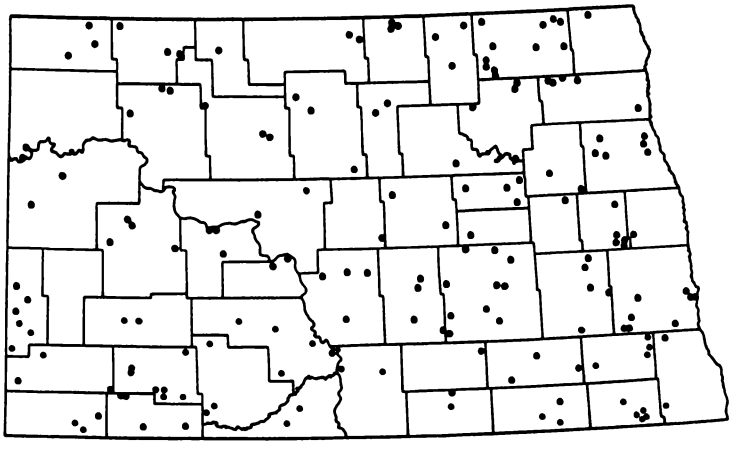
Earthworms are of biological importance as a source of food for birds, mammals, reptiles and amphibians, and also contribute to nutrient cycling in soils. Identification of earthworm species and their statewide distribution in North Dakota soils is incomplete. A survey in eastern North Dakota of agricultural and nonagricultural lands by Utter et. al.(1) identified three new species for this area. This survey identified *Aporrectodea* (*Ap.*) *tuberculata* and *Ap. trapezoides* as the most abundant species present in the soils. Deibert and Utter(2) found these same two species to be biologically active in minimum tillage fields with average total populations of 580 earthworms and cocoons per meter squared.

To provide information on Lumbricidae and their distribution, the survey in North Dakota was expanded statewide. Sites in the survey included private residences and farmland, State Experimental Research land, and North Dakota Game and Fish Department public land. All locations were hand sampled with a spade and sorted for mature earthworms. Specimens bagged in site soil and kept cool during transportation were refrigerated until anesthetized in 70% ethanol and fixed with 10% formalin. The external morphology of sexually mature earthworms was used to identify the species, using Schwert(3) and Reynolds(4) as references and identification guides.

Table 1. Earthworms of North Dakota

Genus species	Number of sites	Positive Earthworm Sample Sites
Aporrectodea caliginosa[1] (Savigny, 1826)	5	
Aporrectodea trapezoides[2] (Dugés, 1928)	109	
Aporrectodea tuberculata[3] (Eisen, 1874)	133	
Dendrobaena octaedra[3] (Savigny, 1826)	5	
Dendrobaena rubida[1] (Savigny, 1826)	1	
Eisenia fetida[4] (Savigny, 1826)	1	
Eisenia rosea[3] (Savigny, 1826)	2	
Eiseniella tetraedra[1] (Savigny, 1826)	3	
Lumbricus rubellus[1] (Hoffmeister, 1843)	2	
Lumbricus terrestris[2] (Linnaeus, 1758)	4	
Octolasion tyrtaeum[2] (Savigny, 1826)	13	



[1]Confirmed new species identified for North Dakota.
[2]Prior new species for state, identified by authors.
[3]Species identified in state by Reynolds and confirmed by authors.
[4]Species identified in state by Reynolds only (5).

The expanded state survey of earthworms identified four more species in the state. This is the first record of *Ap. caliginosa, Dendrobaena rubida, Eiseniella tetraedra* and *Lumbricus rubellus* in North Dakota. *Ap. trapezoides* and/or *Ap. tuberculata* are present in all counties in the state except Billings Co. where no positive Lumbricidae samples have been found to date. The remaining species were found in local habitats that supported their growth and development.

ACKNOWLEDGMENTS: The authors thank the North Dakota Game and Fish Department, numerous private land owners, and the State Agricultural Experimental Research Stations for their cooperation in this study.

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1895 - North Dakota Geological Survey's Centennial Year - 1995

The North Dakota Geological Survey was created by an act of the North Dakota Legislature in 1895, six years after statehood. The Geological Survey was directed to make a

> *... complete account of the mineral kingdom ... including the number, order, dip and magnitude of the several geological strata, their richness in ores, coals, clays, peats, salines and mineral water, marls, cements, building stones and other useful materials, the value of said substances for economic purposes, and their accessibility.*

Such studies continue, but over the years the Geological Survey's mission has grown and is now three-fold: to investigate the geology of North Dakota; to administer regulatory programs and act in an advisory capacity to other state agencies; and to provide public service and information to the people of North Dakota.

The Geological Survey serves as the primary source of geological information in the State. A large amount of geological information can be obtained from NDGS publications; comprehensive collections of cores, samples, and fossils; oil and gas records; coal and subsurface mineral records; and through our affiliate office of the nationwide Earth Science Information Center.

A Symposium on

NORTH DAKOTA GEOLOGY: IN RECOGNITION OF THE NORTH DAKOTA GEOLOGICAL SURVEY CENTENNIAL

North Dakota Academy of Science 1995 Annual Meeting
North Dakota Heritage Center, Bismarck

Symposium Coordinator and Editor
John W. Hoganson
North Dakota Geological Survey

Symposium Agenda
April 20, 1995

INTRODUCTION

(1:20-1:30): Introduction to the North Dakota Geology Symposium: ***John W. Hoganson****, North Dakota Geological Survey*

HISTORY OF NORTH DAKOTA GEOLOGY

(1:30-2:00): Opening Remarks — 1895-1995--North Dakota Geological Survey's First Century:
John P. Bluemle*, North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840*

(2:00-2:20): Paleocene Paleontology and Stratigraphy in North Dakota: Early Contributions by A. G. Leonard:
Joseph H. Hartman*,* Energy and Environmental Research Center, University of North Dakota, Grand Forks, ND *58202*

(2:20-2:40): History of Coal Mining and Utilization in North Dakota:
Dean A. Moos* and David Bickel*, Reclamation Division, North Dakota Public Service Commission, Bismarck, ND 58505*

(2:40-3:00): History of Glacial Research in North Dakota:
John R. Reid*[1] and John P. Bluemle[2]*, [1]Department of Geology and Geological Engineering, University of North Dakota, Grand Forks, ND 58202-8358; [2]North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840*

(3:00-3:20): Coffee and Discussion Break

SUBSURFACE GEOLOGY

(3:20-3:40): The Newporte Structure: The First Petroliferous Basement Impact Crater:
Nels F. Forsman*[1] and Timothy R. Gerlach[2]*, [1]Department of Geology and Geological Engineering, University of North Dakota, Grand Forks, ND 58202-8358; [2]Energy and Environmental Research Center, University of North Dakota, Box 9018, Grand Forks, ND 58202*

(3:40-4:00): Depositional Environments and History of the Winnipeg Group (Ordovician), Williston Basin, North Dakota:
Jonathan B. Ellingson* and Richard D. LeFever*, Department of Geology and Geological Engineering, University of North Dakota, Grand Forks, ND 58202-8358*

(4:00-4:20): Diversity and Distribution of Lodgepole Buildups in the Williston Basin and Central Montana:
Randolph B. Burke* and Paul E. Diehl*, North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840*

Symposium Agenda (Continued)
April 21, 1995

STRATIGRAPHY/PALEONTOLOGY

(8:00-8:20): A Specimen of *Plioplatecarpus* from the Upper Cretaceous Pierre Shale, Cedar Creek Anticline, southwestern North Dakota:
Nancy Overland Schaefer*[1], Terry Schaefer[1], G. L. Bell[2], and Bruce A. Schumacher[2]*, [1]Pioneer Trails Regional Museum, Bowman, ND 58623; [2]Museum of Geology, Rapid City, SD 57701*

(8:20-8:40): **Cartilaginous Fishes from the Fox Hills Formation (Cretaceous: Maastrichtian), North Dakota:**
John W. Hoganson[*1], J. Mark Erickson[2], and F. D. Holland, Jr.[3], [1]North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840; [2]Geology Department, St. Lawrence University, Canton, NY 13617; [3]Department of Geology and Geological Engineering, University of North Dakota, Grand Forks, ND 58202-8358*

(8:40-9:00): **Hell Creek Formation (Cretaceous: Maastrichtian) Microsite Faunas; Their Potential as Paleoenvironmental Change and Extinction Indicators:**
Dean A. Pearson, Department of Paleontology, Pioneer Trails Regional Museum, Bowman, ND 58623

(9:00-9:20): **A *Tyrannosaurus rex* from the Hell Creek Formation (Cretaceous: Maastrichtian), Bowman County, North Dakota and Observations on its Depositional Setting:**
Laura Oakland and Dean A. Pearson, Department of Paleontology, Pioneer Trails Regional Museum, Bowman, ND 58623*

(9:20-9:40): **Bird Tracks from the late Paleocene of North Dakota:**
Allen J. Kihm[*1] and Joseph H. Hartman[2], [1]Department of Earth Science, Minot State University, Minot, ND 58707; [2]Energy and Environmental Research Center, University of North Dakota, Grand Forks, ND 58202*

(9:40-10:00): **Coffee and Discussion Break**

(10:00-10:20): ***Champsosaurus gigas* Erickson: A Restored and Mounted Skeleton (ND94-225.1) in the North Dakota State Fossil Collection:**
Johnathan M. Campbell and John W. Hoganson, North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840*

(10:20-10:40): **The Medicine Pole Hills Local Fauna: Chadron Formation (Eocene: Chadronian), Bowman County, North Dakota:**
Dean A. Pearson[*1] and John W. Hoganson[2], [1]Department of Paleontology, Pioneer Trails Museum, Bowmcn, ND 58623; [2]North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840*

(10:40-11:00): **Urban Outcrops: Building Stones of the North Dakota Capitol Grounds:**
Robert F. Biek, North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840

(11:00-12:00): **WALKING FIELD TRIP--BUILDING STONES OF THE STATE CAPITOL**
Robert F. Biek, North Dakota Geological Survey

(12:30-2:00): **LUNCH**

ENVIRONMENTAL GEOLOGY/GEOARCHEOLOGY

(2:00-2:20): **Use of Electric Pulse Disaggregation to Liberate Fossils from North and South Dakota Sediments:**
Bernhardt Saini-Eidukat[*1], Brenda Pederson[1], and Paul W. Weiblen[2], [1]Department of Geosciences, North Dakota State University, Fargo, ND 58105-5517; [2]Department of Geology and Geophysics, University of Minnesota, Minneapolis, MN 55455*

(2:20-2:40): **Ground Water Flow System Response to Opening and Closure of the J. K. Ranch Lignite Mine, Dickinson, North Dakota:**
David Bickel, Reclamation Division, North Dakota Public Service Commission, Bismarck, ND 58505

(2:40-3:00): **Slope Stability in the Bismarck-Mandan Area:**
Edward C. Murphy, North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840

(3:00-3:20): **Going with the Flow?: Geotechnical Implications of Land Use Decision-Making, Red River Corridor, Fargo, North Dakota, and Moorhead, Minnesota:**
Donald P. Schwert, Geosciences Department, North Dakota State University, Fargo, ND 58105-5517

(3:20-3:40): **Flakable Lithic Resources in North Dakota:**
Mark R. Luther[*1] and Robert C. Christensen[2], [1]North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505-0840; [2]North Dakota Department of Transportation, 608 East Boulevard Ave., Bismarck, ND 58505*

CLOSING REMARKS

(3:40-3:50): ***John P. Bluemle, State Geologist, North Dakota Geological Survey***

1895 - 1995 — NORTH DAKOTA GEOLOGICAL SURVEY'S FIRST CENTURY

John P. Bluemle
North Dakota Geological Survey
600 East Boulevard Ave., Bismarck, ND 58505-0840

The North Dakota Geological Survey (NDGS), was created by an act of the North Dakota Legislature in 1895, six years after statehood. The position of State Geologist was to be held by the Professor of Geology at the University. The Geological Survey was directed to make a *"... complete account of the mineral kingdom...including the number, order, dip and magnitude of the several geological strata, their richness in ores, coals, clays, peats, salines and mineral waters, marls, cements, building stones and other useful materials, the value of said substances for economical purposes, and their accessibility."*

Over the years the NDGS mission has grown and is now three-fold: to investigate the geology of North Dakota; to administer regulatory programs and act in an advisory capacity to other state agencies; and to provide public service and information to the people of North Dakota.

The first State Geologist, Earle J. Babcock, a University of North Dakota chemistry professor, was appointed in 1895. Babcock used the first Survey appropriation to publish the First Biennial Report in 1901 — a report containing information on the topography and geology of North Dakota, water, clay, lignite, and an optimistic discussion of future natural resource possibilities.

Arthur Gray Leonard became State Geologist of North Dakota in 1903 and continued in the position until 1932. Leonard is considered to be the father of geologic study in North Dakota. During his 30-year tenure, Leonard conducted extensive studies and systematic mapping of lignite, clays, cement rock, and water resources with little or no appropriations. The first NDGS geologic map of North Dakota was published in 1906 in the Fourth Biennial Report, an issue devoted to clay deposits and brick manufacturing.

Wilson M. Laird became State Geologist in 1941 and served until 1969. In 1941 too, the State Legislature enacted an oil and gas conservation law and designated the State Geologist as enforcer of the regulations. The discovery of oil in North Dakota in 1951 brought about an increase in funding and personnel for the Survey. In 1981, the NDGS built the Wilson M. Laird Core and Sample Library at UND to house samples recovered during oil and gas exploration.

In 1989, the State Legislature removed the Geological Survey from the jurisdiction of the Board of Higher Education, placed it completely under the Industrial Commission, and clarified its mission regarding natural resource development and conservation. Following this legislation, the Survey was moved to Bismarck.

In 1989, the Geological Survey was directed to establish a State Fossil Collection, and this is housed in the North Dakota Heritage Center in Bismarck. In 1991, the Legislature directed the NDGS and State Water Commission to undertake a four-year evaluation of the State's landfills. The Survey's Geographic Information System was also installed in 1991. In 1993, the Survey began a new, detailed surface mapping program, initially concentrating in urban areas.

PALEOCENE PALEONTOLOGY AND STRATIGRAPHY IN NORTH DAKOTA: EARLY CONTRIBUTIONS BY A.G. LEONARD

Joseph H. Hartman

Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND 58202

The North Dakota Geological Survey was founded with the intention that it be involved in the practical utilization of the state's energy and mineral resources. Almost from the inception of the Survey, Arthur Gray Leonard, its second director, devoted much of his life to the field study and interpretation of the lignite deposits of North Dakota. This communication focuses on Leonard's contribution to an understanding of western North Dakota's Paleocene stratigraphy on the basis of his coal bed observations and mollusk collections. Leonard's work on coal stratigraphy represented the framework upon which immediate subsequent research would build. Interestingly, Leonard, and thus North Dakota's fossils and rocks, rendered a formative role in the contentious debate on the age and relations of strata on either side of the Cretaceous-Tertiary boundary (K/T).

After his appointment as State Geologist in 1903, Leonard conducted field studies from 1904 to 1909 in the Paleocene coal-bearing strata of western North Dakota. His extensive stratigraphic work resulted in the recognition of coal bed sequences, tied to lithic units, that were of far greater detail and correlative value than his predecessors (1). Leonard first designated coal beds by letter or name (e.g., Bed I or Harmon coal) to facilitate correlation and discussion of regional extent and resource potential. In addition, Leonard (2) organized coal sequences into named groups. One such designation, the Sentinel Butte coal group, would serve as the basis for distinguishing the Sentinel Butte Formation as the upper unit of the Fort Union Group.

Leonard's collections of freshwater mollusks, found mostly in the Bullion Creek and Sentinel Butte Formations in Billings, Golden Valley, McKenzie, Morton, McLean, and Burleigh Counties, were frequently tied to stratigraphic markers, representing the first stratigraphically controlled collections available for more rigorously documented biostratigraphy (3). The locations of earlier collections made by F.V. Hayden (3) are difficult to relocate and use with high confidence. Leonard's published data (4), field notes (5), and fossil locality field labels (6) permit extensive use of his observations and collections (3). The mollusks collected by Leonard were examined by T.W. Stanton, paleontologist for the U.S. Geological Survey. Stanton's identifications were reported by Leonard in a number of publications and used to confirm the "Fort Union" (Paleocene) age of the strata in the badlands of the Little Missouri River and rolling hills and drainages of the southeastern portion of the Williston Basin. Also, Leonard's pre-Lake Sakakawea measured sections and collections are important as a source of now unobtainable data (7).

In 1907, Leonard (2, 8) discovered oysters on the high bluffs on the west side of the Little Missouri River, in Slope County (this occurrence is probably in sec. 10 and not sec. 16 as reported, in T. 135 N., R. 105 W.). This discovery represented the first record documenting a tongue (Three V Tongue) of the Cannonball Formation. As far as Stanton was concerned, the oysters were proof-positive that no significant unconformity or hiatus existed at the Fox Hills-Lance (= Hell Creek) formational contact and that the strata below the Fort Union, including the oysters, should be included in the Cretaceous Lance Formation (9, 10). Leonard (2) had distinguished an underlying "somber-" and overlying light-colored separation of the Fort Union Formation, which represented all post-Fox Hills strata. His placement of the contact between his F (= Yule, 11) and G (= H, 11) coal beds approximates the Slope-Bullion Creek formational contact of today. Leonard did not recognize a lithic break or sedimentological change between dinosaur-bearing beds (= Hell Creek Formation) and the overlying nondinosaur-bearing Tertiary strata (2), which included the oyster deposits. Without the expected unconformity (and concomitant hiatus), the general absence of freshwater shells typical of the Fort Union Group in the lower part of the section, and the presence of marine shells in "somber beds" indicating a supposed extension of Cretaceous deposits, a number of decades would lapse before the presence and absence of dinosaurs and coal deposits would be established as a useful method for recognizing the K/T boundary. Thus besides providing an important and detailed account of the economic resources of North Dakota, Leonard contributed, if inadvertently, to the debate on the age of strata now interpreted to be of lower Paleocene age.

This research was supported by the Philip McKenna Foundation and the U.S. Bureau of Mines.

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1. Leonard, A.G., Babcock, E.J. and Dove, L.P. (1925) ND Geol Sur Bull 4. **2.** Leonard, A.G. (1908) ND Geo Sur Fifth Biennial Rept, pp 27-114. **3.** Hartman, J.H. (1984) PhD Diss, Univ Minnesota, Minneapolis. **4.** Scott, M.W. (1972) ND Geol Sur Misc Ser 49. **5.** Univ ND Chester Fritz Library, Grand Forks. **6.** U.S. National Museum Paleobiology Collections. **7.** Hartman, J.H., Roth, B. and Kihm, A.J., (1993) Proc ND Acad Sci 47, 50. **8.** Leonard, A.G. (1911) Jour Geol 19, pp 507-547. **9.** Stanton, T.W. (1909) Proc Washington Acad Sci 11, pp 239-293. **10.** Stanton, T.W. (1910) Amer Jour Sci 30, pp 172-188. **11.** Hares, C.J. (1928) US Geol Sur Bull 775.

HISTORY OF COAL MINING AND UTILIZATION IN NORTH DAKOTA

Dean K. Moos* and David Bickel
Reclamation Division, North Dakota Public Service Commission
Bismarck, ND 58505

Lignite, a low-grade coal, has played an important role in North Dakota's history. Approximately 15 billion tons of mineable lignite lay beneath the surface of western North Dakota. The resource was used very little by early explorers and the military but significant utilization began before statehood and continues to the present. A lignite mining industry followed extensive settlement of western North Dakota. The first commercial mine began near Sims in Morton County in 1873, and the industry expanded driven by home heating and railroad fuel needs. Mining operations were primarily underground and ranged from one-man household mines to large commercial enterprises. By 1900, 73 mines were producing approximately 130,000 tons annually (1). Railroads, newspapers, land agents, and the territorial and early state government heavily promoted the coal resource.

The commercial segment of the industry expanded rapidly from 1900 to 1920. Many towns came into existence or grew as mining centers. By 1920, 136 mines, primarily underground operations, were producing nearly 900,000 tons annually. This expansion influenced state government policy toward the industrial sector of the economy, and the first state laws dealing with mine safety and child labor were passed during this time period. In addition, state government directly or indirectly supported research to encourage lignite resource development. State funded coal research facilities were constructed at Hebron and at the School of Mines at the University of North Dakota in 1908. Much of the research focused on lignite beneficiation and utilization, primarily briquetting and gasification technology. As a result of this research, the first commercial lignite briquetting plant opened in 1913 near Minot.

Mechanized surface mining and electric power generation appeared as elements in the industry between 1920 and 1940. Development of the steam shovel and other earth moving equipment allowed for a relatively fast transition to surface mining of the thick, flat-laying coal seams of western North Dakota. In 1920, there were only 12 surface mines in the state, but by 1939, surface mines outnumbered underground operations. During this period, the role of lignite began to switch from home heating use to electrical generation. During the 1920's, steam generation electrical plants were constructed by utility companies near several of the larger mines. In addition, many municipal utilities constructed small generating facilities to serve their respective communities. By 1940, the majority of North Dakota's lignite production was being used for electrical generation.

The total number of mines operating in the state peaked in 1940 at 320 (1) and the number declined steadily during the next 25 years and by 1965, only 38 mines were operating. A number of factors contributed to the decline including increased use of oil and natural gas as heating and transportation fuels, changes in electric power distribution, and the competitive advantage of larger surface mines in local markets. During this period, coal production fluctuated from year to year and ranged from approximately 2 million to over 3 million tons per year. During the early 1960's, uraniferous lignite and carbonaceous shale was mined in several southwestern counties. These low-grade uranium ores were burned and the ash residue shipped to processing facilities.

The first large-scale coal fired generating station designed to supply electric power to a large regional market began operating near Stanton, North Dakota in 1966. The energy crisis of the early 1970's stimulated the construction of additional coal-fired generating stations, the nation's first coal gasification facility near Beulah, North Dakota, and the large-scale lignite mines that supply them. Currently there are 5 active mines located near Beulah, Center, Reeder, and Underwood, North Dakota producing approximately 32 million tons of lignite annually. Because North Dakota lignite has been unable to compete with higher rank coals in supplying customers over long rail distances, nearly all lignite produced in North Dakota is used at mine-mouth conversion facilities. The probable future of North Dakota lignite production is increased production from a few large "captive" mines serving electric generating and coal conversion facilities. Two operations near Hettinger and Williston, North Dakota currently produce very small amounts of leonardite, a shallow, naturally oxidized lignite, which is used as a drilling mud additive and soil amendment.

1. Oihus, C.A. (1983) A History of Coal Mining in North Dakota, 1873-1982, Educational Series 15, North Dakota Geological Survey, pp 2-61.

HISTORY OF GLACIAL RESEARCH IN NORTH DAKOTA

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[2]North Dakota Geological Survey
600 E. Boulevard Ave., Bismarck, ND 58505-0840

Four landforms attracted the early scientists passing through what is now North Dakota: the eastern lake plains, the Turtle Mountains, and the Prairie and Missouri Coteaux. Following Agassiz's (1) conclusion of a former Ice Age climate, mapping of glacial drifts progressed exponentially across North America. James Hector, with the Palliser expedition, interpreted the Turtle Mountains as being composed of drift (2). Others followed, but it was Chamberlin (3) who laid the groundwork for glacial research in North Dakota (ND) by mapping the Altamont Moraine. Warren Upham's detailed mapping of Glacial Lake Agassiz (4) was yet another major contribution toward deciphering the glacial history of North Dakota.

These studies opened the door to further research by numerous geologists in ND and adjacent states and culminated in two significant studies in Minnesota (5) and in South Dakota (6), which, in turn, resulted in a glacial map of ND (7). By that time, the "Clayton era" had already begun, with a major interpretation that a vast expanse of detached ice, covered by drift, was responsible for much of the topography of ND (8). That study, as well as several earlier and numerous subsequent ones were a result of a cooperative agreement between the North Dakota Geological Survey (NDGS), the U.S. Geological Survey and the State Water Commission, with the NDGS taking the lead in geological mapping. Over the next 30 years, 1:125,000-scale geologic maps and reports were produced for each of ND's 53 counties. Clayton's interpretations and field techniques guided these studies. In 1980 Clayton and others (9) completed a new geologic map of ND. As the county studies approached completion, Clayton, teaming up with Stephen Moran, initiated the next phase of glacial research, differentiation of tills (10) and chronologies based on radiocarbon dates (11).

The present phase of glacial research continues along several lines, including more detailed quadrangle mapping (along the lines established by Deal (12)), till stratigraphy (especially by Harris), and both direct (13) and indirect (14) effects of glaciation. Throughout the past eight decades, it has been the NDGS that has been primarily responsible for the accomplishments in understanding the glacial history of North Dakota, either through direct mapping or by support of student theses.

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2. Palliser, Capt. J. (1863) Brit. Parliamentary Papers, London, p 41.
3. Chamberlin, T. C. (1883) U.S. Geol. Survey, 3rd Ann. Report, pp 291-402.
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5. Leverett, F. and Sardeson, F.W. (1932) U.S. Geol. Surv., Prof. Paper 161, 149p.
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8. Clayton, Lee (1963) N.D. Geol. Surv., Bull. 37, 96p.
9. Clayton, Lee, Moran, S.R., Bluemle, J.P., and Kelly, C.G. (1980) U.S. Geol. Surv., Geol. Map of ND.
10. Harris, K.L. (1973) Univ. North Dakota, unpubl. M.S. thesis.
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12. Deal, D.E. (1972) N.D. Geol. Surv., Bull. 58, 89p.
13. Bluemle, J.P. and Clayton, Lee (1984) Boreas, v.13, pp 279-299.
14. Brevik, E. and Reid, J.R. (1994) Proc. N.D. Acad. Sci., V.48. p 80.

THE NEWPORTE STRUCTURE: THE FIRST PETROLIFEROUS BASEMENT IMPACT CRATER

Nels F. Forsman*[1] and Timothy R. Gerlach[2]
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[2]Energy and Environmental Research Center, University of North Dakota,
Box 9018, Grand Forks, ND 58202

The Newporte structure, a subsurface, 3.2 km diameter, bowl-shaped structural anomaly in the Williston Basin, has been determined to be an impact crater. The structure lies at a depth of approximately 2850 m (9500 ft) just south of the Canadian border in northwestern Renville County, North Dakota. The Newporte field was first drilled in August 1977 into a geophysically identified structural depression known to include early Paleozoic sedimentary strata and probably also the Precambrian basement. Early drillsites were associated with low-relief structural closures atop or near the "rim" of the structure. Oil and gas production from the Newporte field derived from the Cambro-Ordovician Deadwood Sandstone and from underlying highly fractured Precambrian gneiss-schist. Early workers ascribed a non-impact origin to the Newporte structure, favoring instead a puzzling explanation involving localized differential basement faulting. Donofrio (1) suggested that, with further study, the Newporte structure could become recognized as the first discovered petroliferous basement impact crater.

No wells have penetrated the central portion of the structure and original numerical seismic data were not available for this study. Thus, computer-generated synthetic seismograms were constructed, using sonic log information from wells near seismic lines, to enable assessments of thickness variations between key seismic reflectors to be made across the structure. Maps generated using the thickness data reveal a 3.2 km diameter circular depression with a positive-relief rim (Figure 1).

The first report of detailed study of core samples from the Newporte structure was that of Gerlach (2). The Precambrian basement in the Newporte region consists of granite and gneiss, with lesser amounts of schist, amphibolite and greenstone. The basement is highly brecciated in some wells, with clasts ranging in size from pebbles to boulders, and with a finer "matrix" composed of pulverized basement materials. In one well, the Deadwood Sandstone overlying basement is strongly disturbed and contains an 8.5 m (28 ft) breccia interval consisting of abundant clasts of basement materials mixed with Deadwood Sandstone. Flat-bedded Deadwood overlies this mixed-breccia interval. Abundant visual evidence of shock metamorphism is seen in thin sections of basement clasts. Planar deformation features (PDF's) were seen in quartz and feldspar grains, with up to 5 directional sets visible within a single grain (Fig. 2).

The impact event that formed the Newporte structure occurred between Late Cambrian and Early Ordovician time, as revealed by the presence of ejected basement materials mixed with Deadwood Sandstone, followed by flat-bedded Deadwood Sandstone within the western rim of the structure. The recent growth of evidence relating subsurface impact structures to hydrocarbon resources is enhanced by the recognition of an impact origin for the Newporte structure.

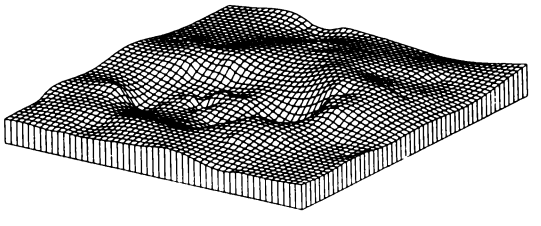

Figure 1. Computer-generated representation of the Newporte on seismic basement. View to northwest. Vertical exaggeration 2½ x.

Figure 2. Photomicrograph of multiple sets of shock lamellae (arrows) seen in feldspar grain from breccia clast. Bar scale = 30 microns.

1. Donofrio, R.R. (1981) Journal of Petroleum Geology 3, pp 279-302.
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DEPOSITIONAL ENVIRONMENTS AND HISTORY OF THE WINNIPEG GROUP (ORDOVICIAN), WILLISTON BASIN, NORTH DAKOTA.

Jonathan B. Ellingson* and Richard D. LeFever
Department of Geology and Geological Engineering, University of North Dakota
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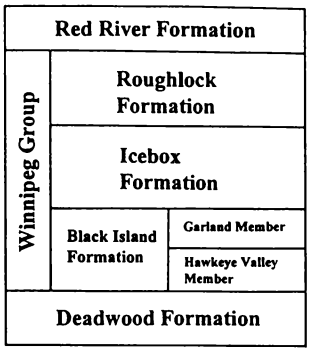
Renewed interest in deeper drilling targets in the North Dakota part of the Williston Basin has produced considerable new data and made it possible to reevaluate the Winnipeg stratigraphy and depositional interpretations. The primary sources of data for this study were well logs and cores maintained by the North Dakota Geological Survey at the Wilson M. Laird Core and Sample Library at the University of North Dakota. A total of 380 logs and 44 cores were examined, which represent all of the available cores and logs. In addition, 90 logs from Saskatchewan, Manitoba, Montana, and South Dakota were examined for additional control.

The Winnipeg Group (Middle Ordovician) unconformably overlies the Deadwood Formation (Cambrian - Lower Ordovician) over most of North Dakota, except in the extreme eastern part, where it lies directly on Precambrian basement rocks. The Winnipeg is conformably overlain by the Red River Formation (Upper Ordovician) (Figure 1). The Winnipeg reaches a maximum thickness of 448 feet (136.6 m) in the center of the basin, in Williams County. The Winnipeg Group consists of three units, the Black Island, Icebox, and Roughlock Formations. The authors have proposed names for the previously unnamed members of the Black Island Formation, the Hawkeye Valley and Garland Members (in press, 1995 Williston Basin symposium volume).

The Hawkeye Valley Member consists of two lithofacies: a red-bed lithofacies and a green quartz wacke lithofacies. The red-bed lithofacies consists of two lithotypes: a red quartz arenite and a red clayshale. The Hawkeye Valley Member reaches a maximum thickness of 128 feet (39 m) in Williams County and is restricted to the western half of North Dakota and the immediately surrounding areas. Abundant desiccation cracks and the distinctive red color strongly suggest that the red-bed lithofacies was deposited in a subaerial environment. The red-bed lithofacies represents a fluvial/deltaic environment and the green quartz wacke lithofacies represents a nearshore marine or lagoonal environment. The Garland Member consists of two lithofacies: a quartz arenite lithofacies and a green quartz wacke lithofacies. The green quartz wacke lithofacies is similar in character to the green quartz wacke lithofacies found within the Hawkeye Valley. The quartz arenite lithofacies consists of three lithotypes: a bioturbated quartz arenite, a structured quartz arenite, and a structureless quartz arenite. The Garland Member reaches a maximum thickness of 169 feet (52 m) in McKenzie County. Prominent sedimentary structures and good sorting in the structured quartz arenite indicate that deposition occurred in an active foreshore or nearshore environment. The high degree of bioturbation and lack of sedimentary structures in the bioturbated quartz arenite lithotype indicate deposition in a relatively low-energy environment below normal wave base. The lithofacies found within the Garland Member thus represents a shallow marine environment.

The Icebox Formation is a fossiliferous, bioturbated shale with minor sandstones, and represents an offshore deposit. The Icebox Formation reaches a maximum thickness of 167 feet (51 m) in Grand Forks County; the maximum thickness in the center of the basin is 156 feet (48 m) in McKenzie County. The Roughlock Formation is a fossiliferous, calcareous shale deposited in a deeper marine environment. The Roughlock reaches a maximum thickness of 95 feet (29 m) in the extreme eastern part of North Dakota and gradually thins west. The contacts between all of the units within the Winnipeg are intertonguing and gradational.



At the end of the Early Ordovician there was a major sea level drop, causing erosion of much of the Deadwood Formation. Sea level rose again during the Early Ordovician, and the Hawkeye Valley was deposited unconformably on the Deadwood. As sea level continued to rise, the Garland was deposited, followed by offshore marine Icebox shales. Local topographic highs probably had sufficient relief to cause the formation of sand bodies during the Icebox deposition. Still further offshore, where the influx of clays was minor, the calcareous shales of the Roughlock were deposited, and finally deposition of the Red River limestones.

(Figure 1 : Generalized stratigraphic column of the Winnipeg Group)

DIVERSITY AND DISTRIBUTION OF LODGEPOLE BUILDUPS IN THE WILLISTON BASIN AND CENTRAL MONTANA

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Recent discovery of the first Waulsortian-type mound in the subsurface of the North Dakota portion of the Williston Basin is a scientific and economic success (1, 2). Not only does this discovery confirm the postulated presence of mounds in North Dakota, but also, it makes the previously marginally productive Lodgepole Formation economically viable to the petroleum industry. This event prompted a re-evaluation of the Lodgepole in general, and of Waulsortian facies in particular. A Waulsortian mound is a geometric form of Waulsortian facies that is defined as "massive lime mudstone containing scattered crinoid and bryozoan fragments and forming lens-like buildups and mounds" (3). To understand the Lodgepole in the Williston Basin the study includes outcrops in central Montana because, as the only exposed buildups in the region, they provide abundant sedimentologic and stratigraphic information.

Examination of studied and unstudied exposed Lodgepole buildups in central Montana, a review of the regional literature, and study of cores and wireline logs from recent wells indicate these buildups are more common than previously recognized. The buildups occur with diverse architectural styles and compositional variations. The term "buildup" is used because the variability is sufficient to question the appropriateness of using the term "Waulsortian" mound for all these structures.

Buildups crop out at seven locations in three mountain ranges in central Montana. Six of these exposures were examined in varying detail during August 1994. At five of these locations there are multiple exposures, or clusters, of buildups. In some cases it is difficult to ascertain whether the exposures are parts of a single buildup or are individual groups of smaller mounds. There may be from one to as many as four individual buildups exposed at each location. In the Big Snowy Mountains (BSM), there are four locations of exposed buildups (4). Geographic spacing between these locations is 2.5, 0.85, and 3.6 miles. Outcrops occur in Swimming Woman Canyon (SWC), Bad Canyon (BC), Green Ashley Gulch (GAG), and in Horse Thief Canyon (HTC). Multiple exposures are found in SWC, and in GAG, whereas only a single outcrop was observed in BC. Time constraints and poor weather prevented us from locating the buildup reported in HTC. In the Bridger Range (BR) there are multiple exposures of buildups about 3500' south 20° east of Sacagawea Peak (SP) and also 7.1 miles south southeast near Saddle Peak. In the Little Belt Mountains (LBM), coral, crinoid, bryozoan grainstone (CCBG) buildups were examined at two locations separated by two miles. These buildups differ from others by their abundance of diverse coral types comprising a significant component of the buildup.

These data indicate the stratigraphic variability of buildups within the Lodgepole. The subsurface Dickinson Lodgepole mound (DLM) occurs at the base of the Lodgepole. SWC and SP mounds rest on thickened submound facies. SWC mound is within 25' of the underlying black Cottonwood Shale, whereas the SP mound is 115' above the base of the Lodgepole. The CCBG buildup in the LBM occurs 270' above the base of the Lodgepole and is reported to be in the Woodhurst Member (5). Mounds in Saskatchewan occur high in the section in the Whitewater Lake Member (middle Lodgepole) (6).

Available core from the DLM is limited to 21' of the total 296' thick mound. In addition to the occurrence of "clean", light colored carbonate, identification of organically constructed buildups requires recognition of distinctive depositional and early diagenetic fabrics in order to distinguish these buildups from similar "clean" but hydrodynamically deposited, more laterally continuous carbonates within the Lodgepole. The DLM is predominantly limestone with dolomite occurring as fracture and vug filling cement.

Compositional types of buildups and their architecture are not well defined. They appear to span the spectrum from mud dominated mounds with few crinoid and bryozoan grains at SP, to coral, crinoid, bryozoan grainstone buildups in the LBM. The highly fossiliferous wackestone-boundstone textures of SWC, the dolomitized BCM, and sparse subsurface data from Saskatchewan and from the Dickinson Lodgepole field suggest these buildups fall somewhere between the end members.

This spectrum of buildup types was deposited at different times and occur at different stratigraphic levels within the Lodgepole. This suggests that various types of buildups may be encountered at many stratigraphic positions within the Lodgepole. Compositional type, buildup architecture, and stratigraphic position will be a function of the paleodepositional setting at each location.

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A SPECIMEN OF *PLIOPLATECARPUS* FROM THE UPPER CRETACEOUS PIERRE SHALE, CEDAR CREEK ANTICLINE, SOUTHWESTERN NORTH DAKOTA

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A partial mosasaur skeleton was recently discovered in the upper Pierre Shale, Bowman County, North Dakota. The specimen consists of fragmentary cranial and post-cranial elements. Skull elements include portions of the frontal, parietal, postorbitofrontals, maxillae, right angular, right dentary, and quadrates. Post-cranial elements include cervical vertebrae, scapula, coracoid, phalanges, and ribs. The presence of a large parietal foramen bordered anteriorly by the frontal (figure 1) definitely identify the specimen as *Plioplatecarpus* (1, 2). The fragmentary quadrates recovered compare favorably with *P. primaevus*, to which the specimen is provisionally referred. Laboratory preparation of jacketed portions revealed a small lamnid shark tooth in association with the specimen. Rib fragments were sent to the University of South Alabama, per Dr. Gordon Bell, for protein and cross section analysis. The specimen, V93019, is on display and in the reference collection at the Pioneer Trails Regional Museum, Bowman, North Dakota.

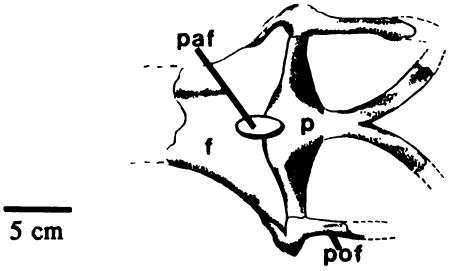

Figure 1. Dorsal view of the back part of the mosasaur specimen skull showing large parietal foramen. Abbreviations are as follows: f, frontal; p, parietal; paf, parietal foramen; pof, post-orbitofrontal.

A portion of the skeleton was found in a slump block of black shale, in direct contact with a bentonite stringer. A large percentage of the specimen occurred as float, indicating that it had been eroded out for some time. Work in the Pierre Shale in this area is preliminary, and precise stratigraphic details are yet to be determined. Invertebrate material in the area is abundant, and ammonite specimens near the mosasaur indicate a late Campanian age, probably within the *Didymoceras cheyennense* or *Baculites compressus* zone (3).

The skeletal remains of the mosasaur represent the first reported occurrence of the genus *Plioplatecarpus* from the Pierre Shale in North Dakota.

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CARTILAGINOUS FISHES FROM THE FOX HILLS FORMATION (CRETACEOUS: MAASTRICHTIAN), NORTH DAKOTA

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Exposures of the Late Cretaceous (Maastrichtian) Fox Hills Formation, consisting mostly of sandstones and siltstones deposited in shallow marine and lagoonal settings, are found in south-central and southwestern North Dakota. The invertebrate fauna of the Fox Hills Formation is well known but little previous work has dealt with the vertebrate fossils occasionally found. Feldmann and Palubniak (1) illustrated a shark tooth and a ratfish dental plate from the formation and Hoganson, et al. (2) identified the reptile fauna of the Fox Hills Formation in North Dakota. Here we discuss the rather diverse cartilaginous fish fauna of the Fox Hills Formation in North Dakota.

Several hundred isolated teeth of cartilaginous fish have been recovered from 33 localities in south-central and southwestern North Dakota (Bowman, Morton, Sioux, Emmons, and Logan Counties) by examining outcrop surfaces and by wet sieving. At least twenty cartilaginous fish taxa, representing 14 families, have been identified from this collection (Table 1). This fauna includes the remains of Angel, Nurse, Sand Tiger, Thresher, Leopard, and extinct Cow Sharks, Guitarfish, Stingrays, Ratfish, and extinct Sawfish.

Collectively these cartilaginous fish taxa corroborate a Maastrichtian age for the Fox Hills Formation in North Dakota established previously by invertebrate biochronologic indicators. This will likely represent a range extension for three of the taxa recognized. This chondrichthian fauna is markedly different from the known fauna of the Cannonball Formation (Paleocene) with four genera in common (3). It also suggests that the Fox Hills Seaway that covered North Dakota was shallow and warm.

Table 1. List of cartilaginous fish taxa from the Fox Hills Formation, North Dakota.

CLASS Chondrichthyes (Cartilaginous Fishes)
SUBCLASS Elasmobranchii (Sharks, Skates, Rays)
ORDER Hybodontiformes
FAMILY Hybodontidae (Extinct)
Hybodus sp.
ORDER Squaliformes
FAMILY Squatinidae (Angel Sharks)
Squatina sp.
ORDER Orectolobiformes
FAMILY Ginglymostomatidae (Nurse Sharks)
Ginglymostoma sp.
ORDER Lamniformes
FAMILY Carchariidae (Sand Tiger Sharks)
Carcharias cf. *C. tenuiplicatus* (Cappetta and Case, 1975)
Carcharias sp.
FAMILY Odontaspididae (Sand Tiger Sharks)
Odontaspis sp.
FAMILY Serratolamnidae (Extinct)
Serratolamna serrata (Agassiz, 1843)
FAMILY Alopiidae (Thresher Sharks)
Paranomotodon? sp.
FAMILY Anacoracidae (Extinct Cow Sharks)
Squalicorax pristodontus (Agassiz, 1843)
ORDER Carcharhiniformes
FAMILY Triakidae (Leopard Sharks)
Archeotriakis sp.
Galeorhinus? sp.
Paleogaleus sp.
ORDER Rajiformes
FAMILY Rhinobatidae (Guitarfish)
Rhinobatidae gen. and sp. indet.
Rhinobatoidea incertae sedis
Pseudohypolophus mcnultyi (Thurmond, 1971)
Myledaphus bipartitus Cope, 1876
FAMILY Sclerorhynchidae (Extinct Sawfish)
Ischyrhiza mira Leidy, 1856
Ischyrhiza texana Capetta and Case, 1975
Ptychotrygon triangularis (Reuss, 1844)
ORDER Myliobatiformes
FAMILY Dasyatidae (Stingrays)
Dasyatis sp.
SUBCLASS Holocephali
ORDER Chimaeriformes (Ratfish)
FAMILY Edaphodontidae
Edaphodon priscus (Leidy, 1856)

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HELL CREEK FORMATION (CRETACEOUS: MAASTRICHTIAN) MICROSITE FAUNAS; THEIR POTENTIAL AS PALEOENVIRONMENTAL CHANGE AND EXTINCTION INDICATORS

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Examination of 32 microsites stratigraphically positioned within the Hell Creek Formation in southwestern North Dakota has produced 6,512 identifiable vertebrate fossil specimens. These sites are located within the Hell Creek Formation from 331 cm below the upper contact to 132 cm above the base of the formation. The high number of sites and abundant fossils recovered has allowed me to compare taxa appearances, disappearances, and abundances, and to assess their potential as indicators of paleoenvironmental changes (1) during the time of Hell Creek deposition in southwestern, North Dakota.

Faunas from 11 of the 32 sites were used for paleoenvironmental analysis because they yielded high numbers (>150) of comparable taxa. The occurrence and abundance of 5 fish, 5 amphibian, 5 non-dinosaur reptile, 9 dinosaur and mammal taxa were compared between sites. Each taxon was categorized as either an indicator of a marine/brackish water habitat or a fresh water/terrestrial habitat. The results suggest that the faunas located 9 m below and again 24 m below the Hell Creek/Ludlow formational contact indicate increases in marine/brackish water environments and nearness of a marine shoreline. Faunas between 11 and 18 meters below the Hell Creek and Ludlow formational contact indicate increasingly more abundant fresh water environments implying a more distant marine shoreline. Johnson (2) noted a floral change 15-17 meters below the Hell Creek/Ludlow contact which may have been influenced by this fluctuating marine shoreline.

The faunas of all 32 sites were analyzed for indications of taxa extinctions. A total of 46 vertebrate taxa belonging to 19 orders and 35 families were identified from the 32 sites. Only two taxa, the dinosaurs *Thescelosaurus* and *Troodon*, which appear above the base of the Hell Creek Formation and disappear below the top of the formation. Their late appearance and subsequent early disappearance in the Hell Creek Fm. in southwestern North Dakota may possibly be attributed to changing environments rather than extinction. The remaining 44 taxa are present throughout the formation. Analysis of these microsite faunas suggests that no notable extinctions occurred within these faunas throughout the duration of Hell Creek Fm. deposition in southwestern North Dakota.

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A *TYRANNOSAURUS REX* FROM THE HELL CREEK FORMATION (CRETACEOUS: MAASTRICHTIAN), BOWMAN COUNTY, NORTH DAKOTA AND OBSERVATIONS ON ITS DEPOSITIONAL SETTING

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The remains of at least a partial skeleton of the carnosaurian dinosaur *Tyrannosaurus rex* are being excavated from the Late Cretaceous Hell Creek Formation in Bowman County, southwestern North Dakota. The site is located 31 meters below the formational contact with the overlying Paleocene Ludlow Formation. This specimen represents the first in-place, associated, skeletal remains of *T. rex* reported from North Dakota.

To date, only associated trunk elements, constituting about 5 percent of the entire skeleton, have been found. These remains include ribs, gastralia, vertebrae, and pubes. Identification of the specimen was based on the pubes. Preservation of the bones varies from excellent to fair depending upon the type of matrix in which they are found. None of the bones were encased in ironstone as is the situation with many Hell Creek Fm. dinosaur remains. The bones range in size from gastralia fragments a few centimeters in length to the pubes at 100 centimeters in length. Scratch marks on some of the rib elements suggest predation or scavaging prior to burial of the carcass.

The specimen is found in an iron-stained, organic-rich siltstone. Near-bituminous grade remains of woody plants, seeds, and amber are found associated with the bones. These observations suggest that the *T. rex* remains are found in low-energy, flood plain deposits (1, 2). Sequential sub-sets of pedogenic-like structures and organic accumulations associated with in-situ root horizons were noted throughout the measured section. Growth of vegetation on this flood plain was periodically interrupted by standing water both before and after entombment of the *T. rex* skeleton.

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BIRD TRACKS FROM THE LATE PALEOCENE OF NORTH DAKOTA

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Fossil birds are relatively rare, and Paleocene forms are particularly so. Worldwide, only 11 genera are known (1, 2). In addition to the body fossils, only three bird track sites of Paleocene age, all of which are from North America , have been reported (3-5). This communication is a report of the first fossil bird tracks known from North Dakota and the second record of birds in the Paleocene of the state. The tracks were first noted by Perkins (6) during a sedimentological study of the Bullion Creek Formation, but he made no attempt to collect or identify them.

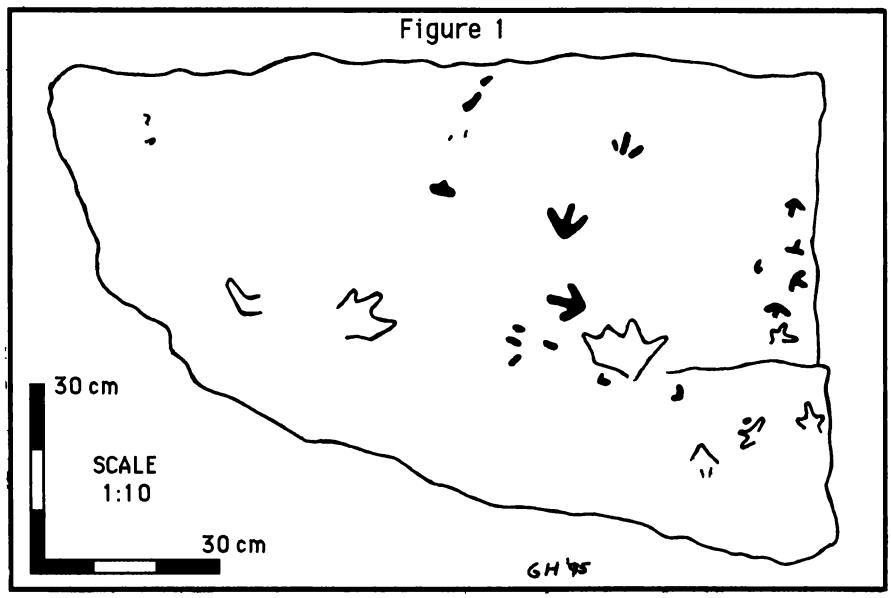
The fossils are preserved on the upper surface of a very fine-grained, quartzose, silty sandstone. The block that holds the prints was not in place, but its exact provenance could be determined. The locality (L6421) is in Billings County (sec. 27, T. 142 N., R. 102 W.), an estimated 35 m below the Bullion Creek–Sentinel Butte formational contact. The sandstone is laterally persistent and approximately 0.3 m thick. Preliminary reconnaissance did not locate tracks at other exposures of the sandstone. The age of the locality is interpreted to be Tiffanian 4 (late Paleocene) based upon the presence of *Plesiadapis churchilli* at Wannagan Creek Quarry (7, 8). Wannagan Creek Quarry, also in Billings County, is approximately 20 m below the top of the Bullion Creek Formation and has produced the only other record of Paleocene birds from North Dakota (9, 10).

There are two distinct sizes of tracks (Figure 1). Three larger tracks (Type 1) range from 70 to 77 mm long (measured along the axis of digit III) and 70 to 72 mm wide (maximum width between digit II and digit IV). There is no indication of webbing on any of the Type 1 tracks, and there is no clear indication of a hallux . The deepest of the tracks has only a faint indentation in the area of the hallux, but it is not entirely clear that it is part of the same track. The divergence angle (angle between digit II and digit IV) is relatively low, ranging from 84° to 90°. In addition to the measurable Type 1 tracks, there are two wide, poorly defined prints of the same general size. These may be overprints, where the foot was placed in nearly the same position more than once, or they may have been made if some of the mud matrix adhered to the foot when it was lifted, obscuring the imprint. The smaller tracks (Type 2) are more numerous and more variable. There are five measurable tracks, ranging from 38 to 40 mm long and from 45 to 55 mm wide. None of the Type 2 tracks show any indication of webbing or of a hallux imprint. The divergence angle ranges from 89° to 147°. There are several additional prints of the same general size as Type 2 tracks. In some cases these are impressions of one or two toes. In two cases, the prints are poorly defined, suggesting that these are overprints or that mud adhered to the foot when it was lifted.

In addition to the bird tracks, the bedding surface preserves numerous small invertebrate traces, possibly representing the food that attracted either or both of the bird species. Several deeper impressions on the surface do not appear to be foot prints. A set of three closely spaced triangular gouges could represent marks made during feeding, perhaps by the larger species.

Suggestions on the identity of the track makers can be made. The Charadriiformes (plovers and sandpipers) are known from the Late Cretaceous (1). The Gruiformes (rails and cranes) are known from the Paleocene (2). Species from either of these groups could have made either or both types of tracks. Particularly intriguing are the occurrences of *Dakotornis cooperi*, an ibis-like bird, along with possible charadriid and rallid species from the Wannagan Creek Quarry (9, 10). Although it is not possible to say that the bird tracks represent the same species as the body fossils found at Wannagan Creek Quarry, taken together they do indicate a moderately diverse avian fauna in the late Paleocene of North Dakota.

The specimen was collected under a permit issued by the Custer National Forest of the US Forest Service (AJK). Support for the collection of the specimen was provided by the Energy & Environmental Research Center, University of North Dakota, where the specimen will be displayed.



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CHAMPSOSAURUS GIGAS ERICKSON: A RESTORED AND MOUNTED SKELETON (ND94-225.1) IN THE NORTH DAKOTA STATE FOSSIL COLLECTION

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Isolated postcranial bones of the large, late Paleocene freshwater eosuchian reptile *Champsosaurus gigas* Erickson are commonly found throughout western North Dakota in the Bullion Creek and Sentinel Butte Formations. In the late summer of 1993 a site in the Sentinel Butte Formation was discovered containing the remains of champsosaurs, crocodilians, turtles, fish, and freshwater mollusks. The site, located on U. S. Forest Service (USFS) land in Billings County is called the Tracy Mountain Site.

A nearly complete, although mostly disarticulated, *Champsosaurus gigas* skeleton (ND94-225.1) was excavated at the site in 1994 from a 20-cm-thick carbonaceous claystone. *C. gigas* is the largest of the *Champsosaurus* species and one of the last of the group to become extinct (1). Because of the completeness of the skeleton (about 85%) and excellent preservation of the bones, it was decided to restore the skeleton for display in the forthcoming Corridor of Time exhibit at the North Dakota Heritage Center, Bismarck. Only about a half dozen mounted skeletons of *Champsosaurus* exist, and no other specimens of *C. gigas* have ever been restored in a three dimensional skeletal mount. Descriptions and illustrations of *C. gigas* remains by Erickson (1, 2) and examination of prepared specimens in the paleontology collection at the Science Museum of Minnesota were relied on for fabrication of missing and broken skeletal elements.

Vertebral centrums were present from cervical 1 to about the middle of the tail. Six caudal vertebrae are estimated to be missing from the back part of the tail. If this estimate is correct, tails of *Champsosaurus gigas* would have been shorter (a total of 34 caudal vertebrae) than previously thought (1). The skull is complete although it was badly crushed and fused to the lower jaws as a result of compaction. Separation of the skull from the lower jaws and reinflation of the skull was accomplished by slowly prying apart and removing bone pieces and gluing them back together with either Super Glue or 5-minute epoxy. Most limb bones were present. Parts that had to be fabricated were broken or missing pieces of the pectoral and pelvic girdles, neural arches, ribs, chevrons, and foot bones. These were made from Plaster of Paris with internal wire supports. Critter Clay was tried, but was found to be structurally inferior and its use was limited to small areas of non-support.

Champsosaurus gigas is believed to have been an aggressive aquatic predator with large, powerful back legs, therefore, the specimen was posed as if it were springing off the bottom of a pond after a fish as depicted by Erickson (1).

This specimen was discovered by Chris Quinn (Dickinson, ND) and Mark Luther (North Dakota Geological Survey). Funding for preparation and mounting of the specimen by Johnathan Campbell was from the State Historical Society of North Dakota and the U. S. Forest Service through a grant to the North Dakota Geological Survey.

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THE MEDICINE POLE HILLS LOCAL FAUNA: CHADRON FORMATION (EOCENE:CHADRONIAN), BOWMAN COUNTY, NORTH DAKOTA

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Vertebrate fossils have been found at only six Chadron Formation sites in North Dakota (1). Erosional remnants of the Chadron Fm., varying in thickness from a few inches to less than 15 feet, cap the low lying hills in the Medicine Pole Hills area of Bowman County, North Dakota and unconformably overlie the Paleocene Bullion Creek Formation. Fossils, including brontothere remains, were first discovered in the Chadron Fm. at this site by Leonard (2) and have been noted in subsequent reports (1, 3). Screen-sifting of poorly consolidated sandstones and conglomerates at this site has yielded the most abundant and diverse vertebrate fossil assemblage yet discovered from the Chadron Fm. in North Dakota. This fossil assemblage is called the Medicine Pole Hills local fauna.

Isolated skeletal elements of 31 mammal (11 orders, 22 families), 5 fish, 2 amphibian, and 10 reptile taxa have so far been identified from the Medicine Pole Hills site (Table 1). These taxa indicate a Chadronian age for the Chadron Formation in this area. Preliminary indications suggest that the Medicine Pole Hills local fauna may have affinities with the Chadronian Calf Creek local fauna of the Cypress Hills Formation in Saskatchewan. It is anticipated that additional taxa will be recovered as work progresses on the site.

Table 1. List of vertebrate taxa from the Medicine Pole Hills local fauna.

CLASS Osteichthyes
ORDER Lepisosteiformes
FAMILY Lepisosteidae
Lepisosteus sp.
ORDER Amiiformes
FAMILY Amiidae
Amia cf. *A. scutata*
Kindleia fragosa?
ORDER Siluriformes
FAMILY Ictaluridae
Ictalurus sp.
Osteichthyes gen. and sp. indet.
CLASS Amphibia
ORDER Anura
Anura gen. and sp. indet.
ORDER Caudata
Caudata gen. and sp. indet.
CLASS Reptilia
ORDER Chelonia
FAMILY Trionychidae
cf. *Trionyx* sp.
FAMILY Testudinidae
Stylemys sp.
Chelonia gen. and sp. indet.
ORDER Squamata
FAMILY Iguanidae
Aciprion sp.
cf. *Aciprion* sp.
FAMILY Anguidae
Glyptosaurus sp.
FAMILY Xenosauridae
Exostinus sp.
FAMILY Varanidae
cf. *Saniwa* sp.
Squamata gen. and sp. indet.
ORDER Crocodylia
Crocodylia gen. and sp. indet.
CLASS Mammalia
ORDER Multituberculata
FAMILY Neoplagiaulacidae
Ectypodus lovei
ORDER Marsupialia
FAMILY Didelphidae
Herpetotherium valens
Didelphidectes sp.
ORDER Apatotheria
FAMILY Apatemyidae
Sinclairella sp.
ORDER Lepictida
FAMILY Leptictidae
Leptictis sp.
ORDER Insectivora
FAMILY Dormaaliidae
cf. *Ankylodon* sp.
FAMILY Geolabididae
Centetodon chadronensis
Centetodon magnus
FAMILY Soricidae
Domina sp.
ORDER Chiroptera
Chiroptera gen. and sp. indet.
ORDER Carnivora
FAMILY Canidae
Hesperocyon cf. *H. gregarias*
FAMILY Amphicyonidae
Daphoenus sp.
ORDER Rodentia
FAMILY Cylindrodontidae
Cylindrodon cf. *C. collinus*
FAMILY Eomyidae
Centimanomys sp.
Paradjidaumo cf. *P. trilophus*
Paradjidaumo cf. *P. hansonorum*
Yoderimys cf. *Y. stewardii*
ORDER Lagomorpha
FAMILY Leporidae
Palaeolagus cf. *P. timnodon*
Megalagus cf. *M. brachyodon*
ORDER Artiodactyla
FAMILY Leptochoeridae
Stibarus montanus
FAMILY Anthracotheriidae
Anthracotheriidae gen. and sp. indet.
FAMILY Camelidae
cf. *Poebrotherium* sp.
FAMILY Leptomerycidae
Leptomeryx cf. *L. yoderi*
Leptomeryx sp.
ORDER Perissodactyla
FAMILY Equidae
Mesohippus cf. *M. proprinquus*
Mesohippus cf. *M. westonii*
FAMILY Brontotheriidae
Brontotheriidae gen. and sp. indet.
FAMILY Amynodontidae
Toxotherium sp.
FAMILY Rhinocerotidae
Trigonias sp.

1. Murphy, E. C., Hoganson, J. W. and Forsman, N. F. (1993) ND Geol Sur Rept of Investigation 96, 144p.
2. Leonard, A. G. (1922) ND Quarterly Jour 12, pp 27-114.
3. Pearson, D. A. (1993) Marshall Lambert Symposium, ND Geol Soc pp 24-25.

URBAN OUTCROPS: BUILDING STONES OF THE NORTH DAKOTA CAPITOL GROUNDS

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In few places other than urban areas can one see such a great variety of stone, in such a small area, in such good exposures. Rocks that formed under completely different conditions, in different parts of the world, at vastly different times are juxtaposed in urban areas. Urban areas are — though one does not often think of them as such — veritable geological museums.

Building stone provides a focal point for geological fieldtrips and is especially useful in many midwestern cities, where instructive exposures are few and many landforms are difficult to appreciate except from the air. Building stone is well suited for this lead role as it has two equally important histories: geologic and human. Geologists are interested in the origin and composition of the stone — of what minerals is it composed and under what conditions did it form? Yet when human hands work the stone, it gains a rich, new history grounded in economic, architectural, and artistic concerns. Guidebooks to building stones, such as that recently published for the North Dakota State Capitol Grounds, weave these histories together and provide teachers and students with a valuable resource for fieldtrips in convenient and familiar settings.

Building Stones of the North Dakota Capitol Grounds

Geologic Name/*Trade Name*	Principal Use	Source	Age
Yellowstone Travertine	Interior walls SCB	Gardiner, MT	Pleistocene?
Italian Travertine	Main corridor walls LMB	Central Italy	Pleistocene?
Tavernelle Claire Marble	Stairway handrail LMB	Italy	Tertiary
Knowles Granodiorite/*Sierra White Granite*	All Veterans Memorial	Raymond, CA	Cretaceous
Salem Limestone/*Indiana Limestone*	Exterior HB,HC,LMB,SCB	Bloomington - Bedford, IN	Mississippian
Napolean Gray Marble	Interior wall trim LMB	Green Co., MO	Mississippian
Belgium Black Marble	Memorial Hall wall and trim SCB	Namur region, Belgium	Dev./Miss.
Holston Fm./*Tennessee Marble*	Interior floors SCB	Knoxville area, TN	Ordovician
Oneota Dolomite/*Kasota Marble*	Foyer walls LMB	Kasota, MN	Ordovician
Mellen Gabbro/*Wisconsin Black Granite*	Exterior basal trim SCB	Ashland Co., WI	Precambrian
Marcy Anorthosite/*Mountain Green Granite*	West entrance HB	Jay, NY	Precambrian
Rockville Granite/*Rockville Beige Granite*	Plaza and steps SCB, base LMB	Rockville, MN	Precambrian
Rockville Granite/*Diamond Pink Granite*	Pioneer Family Statue	Rockville, MN	Precambrian
Reformatory Granite/*Charcoal Black Granite*	Exterior walkways	St. Cloud, MN	Precambrian
Nero Black Granite	Peace Officers Memorial	Mutoko, Zimbabwe	Precambrian
Milbank Granite/*Carnelian Granite*	Arboretum trail markers	Milbank, SD	Precambrian
Glacial Erratics	Cornerstone SCB, statue pedestals	North Dakota	Precambrian

Highway Building (HB), Heritage Center (HC), Liberty Memorial Building (LMB), State Capitol Building (SCB)

Use of Electric Pulse Disaggregation to Liberate Fossils from North and South Dakota Sediments

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A novel method has been developed for liberating fossils from their rock matrices. The method, called Electric Pulse Disaggregation, is being applied using newly constructed instrumentation at the Department of Geology and Geophysics at the University of Minnesota, Minneapolis.

Electric pulse disaggregation replaces the compressive forces of normal mechanical crushing with tension, introduced by the application of an electric current to whole rock samples immersed in a fluid (in this case, water). At low voltages (<50 kV), the spark discharges through the water, circumventing the sample. However, at voltages greater than 50 kV, the rock breaks down electrically before the water. According to Rudashevsky et al. (1), this breakdown forms a plasma, leading to an explosion which preferentially takes place along zones of weakness of the solid material. In the case of rocks, these zones of weakness seem to be along grain boundaries of mineral phases, particularly when the minerals have different dielectric constants. The discharge may move through the rock preferentially along grain boundaries because of the presence of better conducting paths there, possibly in the form of interstitial fluids or ions. The result is unbroken, individual mineral grains in their original shape, form, and grain size.

Research done to date has focused on separating trace minerals from igneous or metamorphic rocks. We applied this technique for the first time to a variety of fossiliferous sediments from North and South Dakota to investigate its possible use in fossil liberation. Run products were size classified and examined using optical and scanning electron microscopy.

A drill core sample of Cretaceous Mowry Formation (2) from Burleigh County, ND, was subjected to electric pulse disaggregation. Numerous macrofossils were found including belemnite fragments, fish teeth and scales, and delicate scale casts. No microfossils have been found to date in this sample.

Samples of the Carlisle Formation (3), a shark tooth-bearing limestone of Cretaceous (Turonian?) age from near Milbank, SD, were also subjected to electric pulse disaggregation. Although some of the cm-size shark teeth suffered breakage or charring from electric pulse disaggregation, the method worked well to liberate a diverse pyritized microfossil assemblage (0.2 - 0.6 mm) including juvenile ammonites, possible larval clams, snails, ostracodes, foraminifera, and unidentified spheroids (perhaps plant spores?). The large difference in electric conductivity between the pyritized fossils and their matrix is probably responsible for the excellent physical separation achieved by electric pulse disaggregation — the microfossils were completely freed from their matrix with delicate three-dimensional surface features perfectly preserved. This preservation is demonstrated in the recovered ammonitellas from the Milbank sample, which clearly show the prosuture and primary constriction at the aperture, suggesting they were newly hatched (4).

Samples of the Cretaceous Minnelusa Formation of SD were also investigated using electric pulse disaggregation, and non-pyritized conodont fragments were recovered from them.

Electric pulse disaggregation shows promise as a new tool of fossil liberation. It should be viewed as a complement to existing methods, rather than as a replacement, because not all fossils are amenable to its use. Considerable instrument development needs to occur before the method can become widespread.

1. Rudashevsky, N.S., Burakov, B.E., Lupal, S.D., Thalhammer, O.A.R., and Saini-Eidukat, B. (in press) Trans Inst Mining Metall.
2. Well Kleven #1A, NDGS Well #4592, sampled at 2,887 feet (880.0 m).
3. As assigned by E.A. Merewether (1983) Outcrop B, Table 2, USGS Prof Paper 1253.
4. N. Landman, personal communication, 1994.

Funding from ND NSF-EPSCoR/ASEND is gratefully acknowledged. D. Schwert and A. Ashworth (NDSU) provided samples for experimentation, and J. Hoganson (ND Geological Survey) provided the Kleven #1A drill core sample.

GROUND WATER FLOW SYSTEM RESPONSE TO OPENING AND CLOSURE OF THE J. K. RANCH LIGNITE MINE, DICKINSON, NORTH DAKOTA.

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The J. K. Ranch Mine pit, located about 6 mi north of Dickinson, North Dakota (NE¼ Section 3, T140N, R96W), was opened between May and September, 1988 by Royal Oak Enterprises to replace a depleted mine southeast of Dickinson. All lignite was used to produce char for manufacture of charcoal briquettes at plants in Dickinson and elsewhere. The mine was small by North Dakota standards, producing about 250,000 tons per year from a well-designed blade and scraper surface mining operation. Royal Oak Enterprises ceased production at the mine and commenced pit backfilling and final reclamation late in 1990, ending a long history of lignite mining in the Dickinson area. J. K. Ranch Mine was not a typical North Dakota lignite mine in size, mine life, operation or market. It is significant as the only record to date in the Williston Basin of ground water monitoring before opening and continuing through closure of a large-scale lignite mine in a flow system otherwise unaffected by mining.

The data set consists of monthly and quarterly water levels from 15 monitoring wells installed in 1986 prior to excavation of the boxcut pit and 24 wells installed in 1989 after drawdowns extended beyond the original monitoring wells. Additional stratigraphic control is provided by logs from 13 coal exploration holes drilled by Royal Oak and 31 coal exploration logs from within a 10 mi radius of the mine on file at the North Dakota Geological Survey.

The mine site is in a shallow ground water flow system extending at least from the Russian Spring Creek drainage divide in southern Dunn County to south of the J. K. Ranch Mine. Principal hydrostratigraphic units of the area are within the Paleocene Sentinel Butte Formation. Thin Quaternary sediments occur along the Green River drainage south of the mine site. Water-bearing units disturbed by mining consist of 9-84 ft of uppermost silty sandstone under water table conditions which directly overlies an upper lignite in a portion of the mine area but is separated from it by 8-20 ft of silty clay in most other areas. The upper mined lignite, averaging 5 ft thick, is separated from a 20 ft thick lower lignite by 5-10 ft of silty clay in the mine area. This interburden ranges to 48 ft thick away from the mine area. The lower lignite is separated from a deeper sandstone aquaclude by a 20-40 ft thick silty clay. The clays function as aquitards keeping the lower lignite and deep sandstone under confined conditions. Head gradients indicate ground water flow is generally southeastward. The upper sandstone and upper lignite subcrop updip in the Green River valley about 1.5 mi west of the mine and probably have variable hydraulic connections to the stream and Quaternary sediments along the valley south of the mine. The lower lignite evidently continues under confined conditions beneath Green River valley at least to the Heart and lower Green River valleys nearer Dickinson. Vertical flow is downward through the upper sand. Hydraulic head on the lower lignite is above those of overlying units under natural conditions, and flowing wells are common in this unit south of the mine.

Mining opened east-west oriented pits about 1600 ft long by 150 ft wide to the base of the lower lignite. Successive pits advanced mining about 600 ft northward by concurrent excavation and backfilling. Pit dewatering caused head losses in the range of 70 ft in the lower lignite 400 ft from the pit. The water table in the upper lignite and overlying upper sandstone dropped about 30 ft at this distance. Dewatering reversed the head differential between the lower lignite and the deep sandstone in the pit area, and head losses up to 20 ft in the deep sandstone indicated upward flow to the pit. A monitoring well nest 2000 ft north of the initial pit showed head loss of only 1 ft in the deep sandstone but loss of about 60 ft on the lower lignite. Logs show the upper sandstone and upper lignite hydraulically connected in the pit area but separated by 16 ft of silty clay north of the pits. The upper sandstone at the north monitoring site developed no significant water level response to pit operations whereas the upper lignite had over 10 ft of head loss. Ground water relationships in the upper sandstone are more locally variable than log correlations suggest. Pit inflow posed water treatment problems to operations, and Royal Oak adjusted operations to minimize exposure of the lower lignite. Head responses suggest these efforts were partly successful. Final reclamation began in November, 1990 with complete pit backfilling to approximate original topography, soil respreading and revegetation. Pit backfilling was reflected in head recovery in about 2 years for the confined lower lignite and deep sandstone, with slower recovery occurring in the upper sandstone and upper lignite, presumably influenced to some degree by drought conditions.

SLOPE STABILITY IN THE BISMARCK-MANDAN AREA

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The near-surface geology of the Bismarck-Mandan area consists of a veneer of glacial sediment, primarily till, overlying the Cannonball Formation (Paleocene). Ludlow (Paleocene) and Hell Creek (Cretaceous) strata underlie the Cannonball Formation and are exposed along the bluffs overlooking Apple Creek at the University of Mary. The primary topographic features of the area are the Missouri River, Heart River, and Apple Creek Valleys. The near-surface strata are generally stable over areas of low relief. However, in areas of high relief, shear zones may develop along the lithologic contacts between alternating beds of sandstone, siltstone, mudstone, claystone, and in the case of the Ludlow and to a lesser degree the Hell Creek, lignites. Corrective action to halt or reduce slope movement has been attempted at several sites in this area including: the Sunny slide, the Bismarck railroad bridge slide, and the University of Mary slide.

The Sunny slide is located along the north edge of the Heart River Valley approximately 3.5 miles west of Mandan. Movement was first detected along US Highway 10 at the Sunny slide in 1953, approximately 6 years after highway construction was completed. The highway is located at the head of the slide and the Burlington Northern railroad tracks are adjacent to the toe of the slide, below the highway. In 1956, in response to concern about the stability of this site, the railroad installed a warning system to halt trains in the event that a slide overrode or otherwise damaged the tracks. Inclinometers and drill holes were used to define the geology and to determine the exact position of the shear zones that had developed beneath three separate scarps. Horizontal drains were placed around the site in a futile attempt to halt the movement. An investigation by the writer in 1979 determined that the highway had been constructed upon an ancient landslide and activities leading to both construction of the highway and the railroad added to the instability. The shear zones at this site are entirely within the Cannonball Formation and commonly occur along bedding planes between sandstones and mudstones. The area has continued to experience slope failure requiring additional subsurface investigations in recent years.

Shortly after it was completed in 1883, the east pier of the Northern Pacific Railway bridge at Bismarck began moving toward the river. For the next 70 years the railroad attempted corrective actions, including: removal of material from the head of the slide and weighting of the toe; construction of a cofferdam; keying the slide; construction of an 1100-foot tunnel connected to 18 drain wells; and sliding the pier back into position. In 1951, world renowned civil engineer, R.B. Peck, was consulted. Peck implemented a plan that included the rerouting of the east approach and the removal of approximately 760,000 cubic yards of sedimentary rock. The shear zone at this site occurs within a carbonaceous claystone at, or near, the Ludlow/Cannonball formational contact. The slide has continued to move over the last forty years, but at a much slower pace. Plans have been proposed to extend Edwards Avenue to River Road. This extension would bring the road across the north and west end of the slide area which might expose the city to future liability if the slide is ever reactivated.

For decades, the east edge of the Missouri River trench below the University of Mary displayed warning signs of impending slope failure. Numerous small slumps and erosional pipes developed on the steep, poorly vegetated 200-foot ridge and springs emanated from the middle and lower portions of the cliff face. In the fall of 1987, the slope failed and a large slide developed that eventually grew to be 1300 feet long and 700 feet wide. The scarp was located approximately 150 feet from the west edge of a dormitory, but a series of concentric cracks, precursors of future movement, developed above the scarp much closer to the building. That winter, Twin City Testing drilled several holes to determine the subsurface lithology and the position of the shear zone. The results of these tests were used by Swenson, Hagen & Company to determine the appropriate corrective actions. In 1989, the slope was reshaped, an earthen buttress was constructed, and horizontal drains were placed in the area of the buttress. The consulting engineer determined that there were two major man-made contributing factors to the slide: open-bottomed manholes, that received runoff from the campus, and leakage from the University's indoor swimming pool. These factors, along with lawn watering, increased the amount of water infiltrating into the subsurface below the campus. Problems with the swimming pool and storm sewer have since been corrected, and the area has been relatively stable since the completion of the corrective actions.

In 1989, the Bismarck city planner contacted the ND Geological Survey to discuss potential problems associated with the construction of a large fountain or development of a ski area just north of the railroad bridge in the area known as the Bismarck State College "bowl". I told him that both projects would directly or indirectly cause additional water to infiltrate this area, adding more instability to an already unstable area. Both projects were abandoned. Of more concern in recent years has been the construction of residential homes on steep hillsides in northwest Bismarck and overlooking the Heart River on the west end of Mandan. Several slumps have developed along 14th Avenue NW in Mandan that have destroyed landscaping, removed portions of yards, and caused the abandonment of at least one home. No evidence of unstable ground has yet been reported in the Country West addition or along Overlook Road in Bismarck, but, as development continues to alter natural drainage patterns and lawn watering increases infiltration, slope stability problems, may arise.

GOING WITH THE FLOW?: GEOTECHNICAL IMPLICATIONS OF LAND USE DECISION-MAKING, RED RIVER CORRIDOR, FARGO, NORTH DAKOTA, AND MOORHEAD, MINNESOTA

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Twenty-one years have passed since the North Dakota Geological Survey published its report on physical conditions for land use planning in the Fargo-Moorhead region (1). Since that time, the geotechnical data base for these cities has so vastly expanded that a comprehensive, three-dimensional projection of regional conditions is now possible. The need for such analysis is evident: Fargo is the fastest growing city in the state, yet some land use decisions are being made in ignorance of the magnitude or even the existence of potential geotechnical problems.

For the Red River Corridor, itself, the key word is "flow": both flow of the river and flow of the soil. While channel migration rates of the Red River are evidently low, cutbank destabilization is nonetheless progressive and inevitable. Here, soils of high plasticity are unconfined and susceptible to outward flow.

Central to the problem are fat clays of the Brenna Formation, which in Fargo-Moorhead subcrop in the Red River channel just below mean water level. Typical of the Brenna are those engineering properties measured from soil borings at the construction site of the Fargo Water Treatment Plant, adjacent to the river in south Fargo (2). Here, the uppermost Brenna (elev. 888 - 883 ft; 271 - 269 m) yields N values of 3, soil moistures of 79%, and Q_u of 1720 psf. From a second borehole (elev. 898 ft; 274 m) at this site, LL and PI values are 85% and 56%, respectively.

Channelward flow of the uppermost Brenna is particularly accelerated when high soil moisture conditions are coupled with low water plane levels and consequently low hydrostatic pressures. Overlying sediments are often carried along rigidly, as evidenced by often severe tensional rifting of land surfaces, streets, and structures (e.g. Elm Street Dike at 15th Ave. N., Fargo; Fig. 1). Emplacement of such weighted structures at critical settings not only accelerates the problem but results in severe damage to these and associated structures. All too often, the response has been simply to rebuild, without mitigation or sometimes even recognition of a problem.

Some proposals for development of the Red River Corridor in Fargo-Moorhead emulate the "San Antonio" model, with walkways, pavilions, and restaurants bordering the Red River. These models ignore both soil and flooding conditions. Geotechnically, a better alternative would be the zoning and enhancement of the Red River Corridor as a greenbelt: a community resource of low-maintenance and one that accommodates soil and water flow.

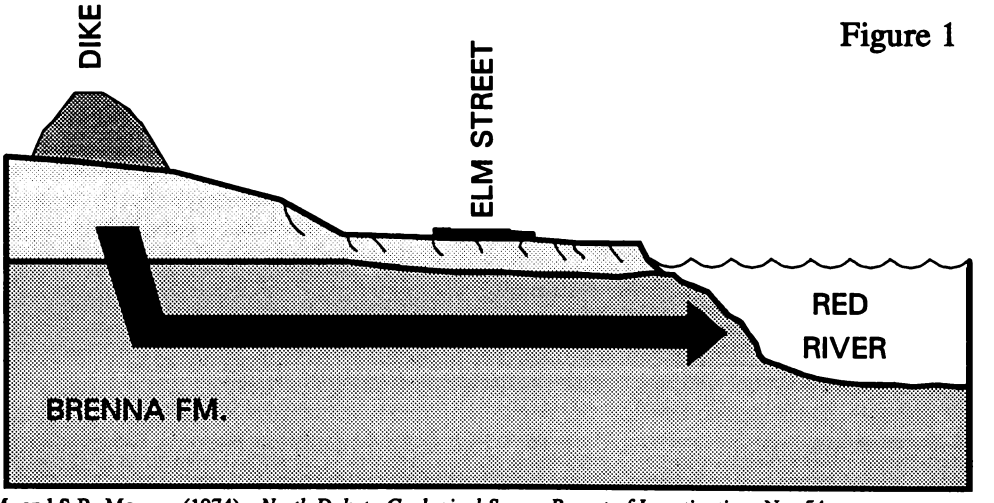

Figure 1

1. Arndt, B.M. and S.R. Moran. (1974). *North Dakota Geological Survey Report of Investigations* No. 54.
2. Midwest Testing Job 5769, test boring 10; Twin City Testing Job 5300-91-81, test boring 2.

FLAKABLE LITHIC RESOURCES IN NORTH DAKOTA

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Archeologists seek to reconstruct the history of past cultures by studying the material remains of those cultures. One of the materials that is most commonly preserved at archeological sites (frequently the only cultural material preserved), are stone tools; most frequently, flaked stone tools (Figure 1). Knowledge of the sources of raw materials suitable for the manufacture of stone tools, provides the archeologist with a means of determining movements of, and trade between, cultures that are long gone. Thus, it is important that a thorough cataloging of flakable stone material sources for an area be conducted.

The ongoing study, "Flakable Lithic Resources in North Dakota", seeks to locate all substantial sources of raw, flakable stone, and to characterize the individual sources using, macroscopic- and microscopic-based descriptions, UV fluorescence response, and primary geological and archeological occurrence. To date, fifteen distinct flakable material types originating in North Dakota have been found and described (Table 1). Several of these are newly described, however, some have appeared in archeological literature with names different than those listed below. Typically, this has been due to mineralogical misidentification (i.e., chert vs chalcedony), or improper geological association (i.e., Tongue River Silicified Sediment and Taylor Bed Silcrete). This study strives to introduce new material sources, and to clarify terminology and associations of previously known sources.

Figure 1. Flaked stone tool.

TABLE 1. FLAKABLE RAW MATERIALS WITH PRIMARY OCCURRENCE IN NORTH DAKOTA
Knife River Flint (KRF)
Fort Union Porcellanite
Tongue River Silicified Sediment (Rhame Bed Silcrete)
Taylor Bed Silcrete
Rainy Buttes Silicified Wood
Silicified Wood
Sentinel Butte Nodular Chert (generally subsurface)
Fort Union Vitreous Porcellanite
Turtle Valley Chert
Sentinel Butte Tabular Chert/Chalcedony (generally surface material)
Charlie Creek Chert
Antelope Quarry Chert
Little Badlands Chert/Silicified Limestone
Little Heart Chalcedony
Chalky Butte Chert

CONSTITUTION of the NORTH DAKOTA ACADEMY of SCIENCE

(Founded 1908, Official State Academy 1958)

ARTICLE I - **Name** and **Purpose**

1. This association shall be called the NORTH DAKOTA ACADEMY of SCIENCE (NDAS).

2. The purpose of this association shall be to promote and conduct scientific research and to diffuse scientific knowledge.

ARTICLE II - **Membership**

1. Membership in the NDAS shall be composed of persons active or interested in some field of scientific endeavor. Candidates for membership may be proposed by any active member of the NDAS by submitting the candidate's name to the chairman of the Membership Committee for approval. Specific categories of membership shall be defined in the bylaws of the NDAS.

2. Annual dues for the various categories of membership shall be determined by the members present at the Annual Meeting.

ARTICLE III - **Officers**

1. The Officers of the NDAS shall be a President, President-Elect, and the Secretary-Treasurer who shall perform the duties usually pertaining to these offices. The President-Elect shall be chosen by ballot at the Annual Meeting and will hold the office for one year and then assume the office of President for one year. The Secretary-Treasurer shall be appointed for a three-year term by the Executive Committee.

2. The Executive Committee, consisting of the above-named officers, the retiring President, and three members-at-large, shall have charge of the ordinary executive duties. The members-at-large shall be elected for a three-year term on a rotating basis.

ARTICLE IV - **Meetings**

1. There shall be an Annual Meeting each year held at such time and place as the Executive Committee may determine.

2. Special meetings shall be called by the President upon the request of ten percent of the active members. Only matters specified in the call can be transacted at a special meeting.

3. Ten percent of the active members shall constitute a quorum at the Annual Meeting. Special meetings require twenty percent of the active members for a quorum.

ARTICLE V - **Miscellaneous**

1. In the event of dissolution of the NDAS, any remaining assets shall be distributed to organizations organized and operated exclusively for educational and scientific purposes as shall at the time qualify as exempt organizations under Section 501(c) (3) of the Internal Revenue Code of 1954.

2. No substantial part of the activities of the NDAS shall be the carrying on of propaganda, or otherwise attempting to influence legislation, and the Academy shall not participate in or intervene in, any political campaign on behalf of any candidate for public office.

3. No part of any net earnings shall inure to the benefit of, or be distributable to, NDAS members or officers, or other private persons, except that the academy may authorize the payment of reasonable compensation for services rendered.

ARTICLE VI - **Amendments**

1. This Constitution may be amended at any Annual Meeting of the NDAS by a two-thirds vote. Proposed amendments shall be submitted in writing to the Secretary who shall send them to the members at least two weeks before the meeting at which such amendments are to be considered.

2. Bylaws may be adopted or repealed at any regular meeting by a two-thirds vote.

B Y - L A W S of the NORTH DAKOTA ACADEMY of SCIENCE

1. The NDAS official guide for parliamentary procedure shall be the "Standard Code of Parliamentary Procedure" by Alice F. Sturgis. (1965 Revision)

2. The annual dues shall be determined by a two-thirds vote at an Annual Meeting. These dues are payable January 1 of each year. (1965 Revision)

3. Members shall be dropped from the active list on 31 December following the nonpayment of dues during the membership year commencing the previous 1 January. A member may return to the active list by paying the current year dues and a membership renewal charge of $5.00. (1975 Revision)

4. Every member in good standing shall receive a copy of the annual Proceedings of the North Dakota Academy of Science. (1965 Revision)

5. Special offices such as Historian may be created by the unanimous vote of the members at the Annual Meeting. (1965 Revision)

6. The Executive Committee shall annually appoint an Academy representative to the National Association of Academies of Science and to Section X (General) of the American Association for the Advancement of Science. (1979 Revision)

7. The Committee structure of the NDAS shall be as follows, the President appointing the members and chairpersons for all except the Executive Committee:

   a. **Executive Committee.**
   Membership: Past-President, President, President-Elect, Secretary-Treasurer, three members-at-large. Three-year terms.

   Duties: The Executive Committee shall be the governing board of the NDAS, responsible only to the membership. It shall arrange for programs, approve committee appointments, be responsible for the fiscal affairs of the Academy, and transact such business as necessary and desirable for function and growth of the NDAS.

   b. **Editorial Committee.**
   Membership: Three members. Three-year terms.

   Duties: The Editorial Committee shall develop and recommend the NDAS publication program and policies to the Executive Committee. It will assist the Editor in reviewing manuscripts for the Proceedings.

   c. **Education Committee.**
   Membership: Seven members, two shall be high school teachers. Five-year terms.

   Duties: The Education Committee shall work with high school students and teachers in the state, in visitation programs, Science Talent Search programs, and other programs to stimulate an interest in science by the youth of the state. It shall operate the Junior Academy of Science program and administer the AAAS high school research program.

   d. **Denison Awards Committee.**
   Membership: Six members. Three-year terms.

   Duties: The Denison Awards Committee shall have as its prime duty the judging of student research and paper competitions, both undergraduate and graduate, and any other similar competitions. The committee shall also maintain the criteria to be used in the judging and selection of papers, such criteria to be circulated to prospective competitors. (1985 Revision)

e. **Necrology Committee.**
Membership: Three members. Three-year terms.

Duties: The Necrology Committee shall report to the annual meeting on those departed during the preceding year. Obituaries may be included in the minutes of the annual meeting and/or published in the Proceedings.

f. **Nominating Committee.**
Membership: The five most recent past-presidents.

Duties: The Nominating Committee shall propose a slate of at least two nominees for each of the offices as needed. The committee report shall be submitted to the President prior to the annual meeting as well as reported to the membership at the appropriate time for action.

g. **Resolution Committee.**
Membership: Three members. Three-year terms.

Duties: The Committee on Resolutions shall prepare such resolutions of recognition and thanks as appropriate for the annual meeting. Further, the Committee shall receive suggested resolutions for the membership and transmit such resolutions and the Committee recommendation to the membership.

h. **Membership Committee.**
Membership: Unlimited number. Appointed annually.

Duties: The Membership Committee shall promote membership in the NDAS. It shall conduct an annual canvass of the Institutions of Higher Education, Government Agencies, and other related organizations for the purpose of providing opportunity for prospective members to join the NDAS. Further, this Committee shall make recommendations to the Executive Committee of potential candidates for emeritus and honorary memberships.

8. The Nominating Committed shall be responsible for all nominations to elective office and shall be required to advance at least two names for each open position. Academy members shall have been encouraged to suggest nominees to the committee prior to the Committee submitting its report. A ballot, incorporating brief biographical information, shall be distributed by the Secretary-Treasurer to all members prior to the Annual Meeting. Those ballots may be returned by mail, or in person at the Annual Meeting, until the announced deadlines. The results of the election shall be announced at the Annual Meeting.

9. Categories of Membership:
   a. *Active members* -- shall be persons interested or actively participating in some scientific endeavor. Active members may participate in all activities of the NDAS.
   b. *Student members* -- shall be graduate or undergraduate College students in some field of science. Student members may participate in all activities of the NDAS, with the exception of holding office.
   c. *Sustaining members* -- are persons or organizations interested in the activities of the NDAS. Sustaining members may participate in all activities of the NDAS, with the exception of voting or holding office. Sustaining members may be of three types: Individual, Corporate, or Institutional. (1965 Revision) This bylaw is implemented by the following action of the Executive Committee (10-25-85):

There shall be two categories of Corporate Sustaining Membership, *Patron* members and *Sponsor* members. The annual membership fee shall be $100 for Patron members and $50 for Sponsoring members. Benefits accruing to Corporate Sustaining Members include:
1. Positive public relations through support of science and technology in North Dakota
2. Preference in mounting commercial displays at the annual meetings of the NDAS.
3. Early access to research results and early awareness of research programs through first hand association with scientists and engineers.

4. Improved commercial opportunities through association with members, institutions, and other sustaining members.
5. Improved future commercial opportunities through exposure to students contemplating careers in science or technology.

Until action is taken otherwise, the Corporate Sustaining Membership fees shall be placed in the North Dakota Science Research Foundation for the support of scientific research.

d. *Emeritus Membership*. Any member in good standing upon formal retirement is eligible for emeritus membership. Nominations may be forwarded to the Membership Committee by any member, and it shall be the responsibility of the membership committee to review the membership list for possible candidates. The Executive Committee shall approve nominations. Emeritus members shall retain all rights of active members but will be exempt from payment of dues. (1973 Revision)

e. *Honorary Membership*. The Academy may recognize, by awarding honorary membership, any person (nonmember or member) who has in any way made an outstanding contribution to science. It shall be the responsibility of the Membership Committee to be aware of individuals whom it would be fitting for the NDAS to honor in this fashion. Any member may submit nominations along with supporting data to the Membership Committee. Approval of nominations shall be by a two-thirds majority of those attending the annual meeting. (1973 Revision)

10. The President, with the approval of the Executive Committee, shall appoint members to serve on ad hoc committees. Reports of ad hoc committees shall be presented to the Executive Committee or to the annual meeting. Ad hoc committees serve only during the tenure of the president who appointed them. (1965 Revision)

11. The Executive Committee shall appoint an Editor who shall edit the PROCEEDINGS. The Editor shall be appointed for a three-year term. The salary of the Editor shall be set by the Executive Committee. (1975 Revision)

12. The annual dues shall be $15.00 per year for professional members, with $2.00 designated for the North Dakota Science Research Foundation, and $5.00 per year for student members. (1994 Revision)

13. The Executive Committee is empowered to charge a publication fee of authors of up to $10.00 per page. (1965 Revision)

14. All student research participants shall receive a properly inscribed certificate and be invited to the dinner as the guests of the NDAS. (1965 Revision)

15. All activities of the Academy, including grant applications, are to be handled through the Academy Offices from now on. (1966 Revision)

16. The Executive Committee of the NDAS is instructed to establish a J Donald Henderson Memorial Fund and to administer this fund so that the proceeds will be used to promote science in North Dakota. (1967 Revision)

17. The fiscal year of the North Dakota Academy of Science, for the purpose of financial business, shall be 1 January to 31 December. (1973 Revision)

18. The NDAS establishes the North Dakota Academy of Science Achievement Award to be given periodically to a NDAS member in recognition of excellence in one or more of the following:
    a. Nationally recognized scientific research.
    b. Science education.
    c. Service to the NDAS in advancing its goals.

The Nominating Committee will administer the selection process, will develop a separate funding source for a monetary award, and will develop, for Executive Committee approval, the criteria for the award. (1988 Revision)

19. The **North Dakota Science Research Foundation** is established as an operating arm of the NDAS. The purposes of the Foundation are: (1) to receive funds from grants, gifts, bequests, and contributions from organizations and individuals, and (2) to use the income solely for the making of grants in support of scientific research in the State of North Dakota. Not less than 50% of the eligible monies received shall be placed in an endowment from which only the accrued interest shall be granted.

The Foundation shall be responsible for soliciting the funds for the purposes described. The Foundation funds shall be in the custody of the Secretary-Treasurer of the NDAS and shall be separately accounted for annually.

The *Foundation Board of Directors* shall be comprised of five members of the NDAS, representing different disciplines. Members shall be appointed by the President for staggered five year terms. The chairperson of the Board shall be appointed annually by the President. The Board shall be responsible for developing operating procedures, guidelines for proposals, evaluation criteria, granting policies, monitoring procedures, and reporting requirements, all of which shall be submitted to the Executive Committee for ratification before implementation.

The Foundation shall present a written and oral annual report to the membership of the NDAS at each annual meeting, and the Secretary-Treasurer shall present an accompanying financial report. (1989 Revision)

Last Revised, May 1994

EXECUTIVE COMMITTEE

Glen Statler, Past President -95
Department of Plant Pathology
North Dakota State University
Fargo, ND 58105 237-7058
Laison to Education Committee

Eileen Starr, President Elect -97
Division of Sciences
Valley City State University
Valley City, ND 58072

Carolyn Godfread, President -96
216 West Avenue F Bismarck, ND 58501 223-2546

Roy Garvey, Secretary-Treasurer -96
Department of Chemistry
North Dakota State University
Fargo, ND 58105 237-8697
NU025304@NDSUVM1

Daniel Mott, Member at Large -97
Division of Science
Dickinson State University
Dickinson, ND 58601 4896 227-2111

Patricia Kelly, Member at Large -96
Department of Geology/Geo Enginr
University of North Dakota
Grand Forks, ND 58202 777-2811

Gilbert Kuipers, Member at Large -95
Department of Science
Valley City State University
Valley City, ND 58072
VC005323@NDSUVM1

EDITORIAL COMMITTEE

John Hammen -96
University of North Dakota
James Lindley, Chairman -95
North Dakota State University
? ? ? ? -97

RESOLUTIONS COMMITTEE

John Reid, Chairman -95
University of North Dakota
David Hein -96
University of North Dakota
? ? ? ? -97

NOMINATING COMMITTEE

David Davis -95
USDA Biosciences Research Lab
Clark Markel -96
Minot State University

Forrest Nielsen -94
USDA Human Nutrition Research Center
John Brauner, Chairman -98
Jamestown College

EDUCATION COMMITTEE

Om Madhok -95
Minot State University
State Science Fair
? ? ? ? -98

Dennis Disrud -96
Minot State University
? ? ? ? -98

State Science Olympiad
? ? ? ? -95

Robert Biek -96
North Dakota Geologic Survey

AAAS Mini-Grant Coordinator
Junior Academy Coordinator
Marla Behm -97
Bismarck, ND

Harold Fish -97
Watford City

NECROLOGY COMMITTEE

Michael Thompson, Chairman -95
Minot State University

? ? ? ? -96

DENISON AWARDS COMMITTEE

Lyle Prunty -96
North Dakota State University

Daniel Mott -96
Dickinson State University

? ? ? ? -97

? ? ? ? -97

Dorothy Johansen, Chair -95
Mayville State University

Eileen Starr -95
Valley City State University

NORTH DAKOTA SCIENCE RESEARCH FOUNDATION BOARD of DIRECTORS

Om Madhok, Chairman -95
Minot State University

David Berryhill -96
North Dakota State University

Jim Walla -97
University of North Dakota

? ? ? ? -99

Ray Taylor -98
North Dakota State University

MEMBERSHIP COMMITTEE

Gary Clambey
North Dakota State University

Vernon Feil
USDA- Bioscience Research Laboratory

Myron Freeman
Dickinson State University

Carolyn Godfread
Bismark

Janet Hunt
Human Nutrition Research Center

Richard Baltisberger
University of North Dakota

Joseph Stickler
Valley City State University

Michael Thompson
Minot State University

Dorothy Johansen
Mayville State University

David Berryhill
North Dakota State University

LOCAL ARRANGEMENTS COMMITTEE -- Bismarck/Mandan

Facilities:		A V:	
Housing/Parking:		Banquet:	
Lunch/Refrehments:		Tours:	
Keynote Speakers:		Social Hours:	
Funding:		Public Relations:	
Registration:	Roy Garvey	Coordinator:	

P A S T P R E S I D E N T S
and
Location of the Annual Meeting
of the
NORTH DAKOTA ACADEMY of SCIENCE

1909	M A Brannon	Grand Forks
1910	M A Brannon	Fargo
1911	C B Waldron	Grand Forks
1912	L B McMullen	Fargo
1913	Louis VanEs	Grand Forks
1914	A G Leonard	Fargo
1915	W B Bell	Grand Forks
1916	Lura Perrine	Fargo
1917	A H Taylor	Grand Forks
1918	R C Doneghue	Fargo
1919	H E French	Grand Forks
1920	J W Ince	Fargo
1921	L R Waldron	Grand Forks
1922	Daniel Freeman	Fargo
1923	Norma Preifer	Grand Forks
1924	O A Stevens	Fargo
1925	David R Jenkins	Grand Forks
1926	E S Reynolds	Fargo
1927	Karl H Fussler	Grand Forks
1928	H L Walster	Fargo
1929	G A Talbert	Grand Forks
1930	R M Dolve	Fargo
1931	H E Simpson	Grand Forks
1932	A D Wheedon	Fargo
1933	G C Wheeler	Grand Forks
1934	C I Nelson	Fargo
1935	E A Baird	Grand Forks
1936	L R Waldron	Fargo
1937	J L Hundley	Grand Forks
1938	P J Olson	Fargo
1939	E D Coon	Grand Forks
1940	J R Dice	Fargo
1941	F C Foley	Grand Forks
1942	F W Christensen	Fargo
1943	Neal Weber	Grand Forks
1944	E A Helgeson	Fargo
1945	W H Moran	Grand Forks
1946	J A Longwell	Fargo
1947	A M Cooley	Grand Forks
1948	R H Harris	Fargo
1949	R B Witmer	Grand Forks
1950	R E Dunbar	Fargo
1951	A K Saiki	Grand Forks
1952	Glenn Smith	Fargo
1953	Wilson Laird	Grand Forks
1954	C O Clagett	Fargo
1955	G A Abbott	Grand Forks
1956	H B Hart	Jamestown
1957	W E Cornatzer	Grand Forks
1958	W C Whitman	Fargo
1959	Arthur W Koth	Minot
1960	H J Klosterman	Fargo
1961	Vera Facey	Grand Forks
1962	J F Cassel	Fargo
1963	C A Wardner	Grand Forks
1964	Fred H Sands	Fargo
1965	P B Kannowski	Grand Forks
1966	Paul C Sandal	Fargo
1967	F D Holland, Jr	Grand Forks
1968	W E Dinusson	Fargo
1969	Paul D Leiby	Minot
1970	Roland G Severson	Grand Forks
1971	Robert L Burgess	Fargo
1972	John C Thompson	Dickinson
1973	John R Reid	Grand Forks
1974	Richard L Kiesling	Fargo
1975	Arthur W DaFoe	Valley City
1976	Donald R Scoby	Fargo
1977	Om P Madhok	Minot
1978	James A Stewart	Grand Forks
1979	Jerome M Knoblich	Aberdeen, SD
1980	Duane O Erickson	Fargo
1981	Robert G Todd	Dickinson
1982	Eric N Clausen	Bismark
1983	Virgil I Stenberg	Grand Forks
1984	Gary Clambey	Fargo
1985	Michael Thompson	Minot
1986	Elliot Shubert	Grand Forks
1987	William Barker	Fargo
1988	Bonnie Heidel	Bismark
1989	Forrest Nielsen	Grand Forks
1990	David Davis	Fargo
1991	Clark Markell	Minot
1992	John Brauner(elect)	Grand Forks
1993	John Brauner	Jamestown
1994	Glen Statler	Fargo/Moorhead
1995	Carolyn Godfread	Bismarck

End of Fiscal Year STATEMENT of FINANCIAL STATUS BALANCE SHEET > 1

Fiscal Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
ASSETS	31483.43	30902.44	33655.5	34486.88	38027.91	36264.02	32697.24	30766.5	30766.5
Operating Accounts									
Checking	2579.2	611.27	1741.74	3381.24	3205.93	1575.30	1930.74		
Savings / Certificates	7634.09	6625.74	6232.93	2000.00					
Trust Accounts									
Scholarship Principal	15361.13	16505.83	17166.26	19536.06	23953.30	23358.98	19113.39	19113.39	19113.39
Research Foundation	5909.01	7159.60	8514.57	9569.58	10868.68	11329.74	11653.11	11653.11	11653.11
LIABILITIES	26106.64	26958.71	28165.83	30865.64	37261.98	35388.72	31006.50	30766.50	30766.50
Advanced Dues Payments	1585.00	1285.00	585.00	760.00	1540.00	700.00	240.00		
Restricted Purpose Funds									
Scholarship Principal	15361.13	16505.83	17166.26	19536.06	23953.30	23358.98	19113.39	19113.39	19113.39
AAAS Grant	900.00		1900.00	1000.00	900.00				
Research Foundation	5909.01	7159.60	8514.57	9569.58	10868.68	11329.74	11653.11	11653.11	11653.11
Cash	2351.50	2008.28							
ACCUMULATED SURPLUS	5376.79	3943.73	5489.67	3621.24	765.97	875.30	1690.74		
CHANGE in SURPLUS		-1433.06	1545.94	-1868.43	-2855.31	109.37	815.44	-1690.74	
OPERATING CASH FLOW									
CASH on HAND 1 January	10135.49	10292.90	8415.30	8027.02	5381.24	3205.93	1575.30	1930.74	1930.74
RECEIPTS for Year	14258.92	9748.43	11173.58	9021.40	8144.73	6329.45	9227.03		
RESOURCES Available	24394.41	20041.33	19588.88	17048.42	13525.97	9535.38	10802.33	1930.74	1930.74
DISBURSEMENTS	14101.51	11626.03	11561.86	11667.18	10320.04	7960.08	8871.59		
CASH BALANCE 31 December	10292.90	8415.30	8027.02	5381.24	3205.93	1575.30	1930.74	1930.74	1930.74
Increase over Year	157.41	-1877.60	-388.28	-2645.78	-2175.31	-1630.63	355.44		
MEMBERSHIP									
Emeritus	60	58	59	54	56	57	58		
Students	43	53	61	104	41	47	47		
Professional	283	290	290	312	210	211	202		
Deliquent				86	115	163	151		
Dropped		58			86	55	78		
Other						13	18		
TOTALS	386	459	410	556	508	546	554		

End of Fiscal Year STATEMENT of FINANCIAL STATUS OPERATING INCOME > 2

Fiscal Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
DUES	3617.00	2992.00	2680.00	2755.00	3320.00	1806.00	2560.02		
Reinstatements	67.00	50.00	90.00	20.00	90.00	50.00	37.00		
Current year	1965.00	1657.00	2005.00	1975.00	1690.00	980.00	2156.00		
Future years	1585.00	1285.00	585.00	760.00	1540.00	700.00	240.00		
Sponsor/Patron						76.00	127.02		
INSTITUTIONS	1950.00	2200.00	2200.00	1200.00	200.00	200.00	390.08		
U N D	1000.00	1000.00	1000.00						
N D S U	750.00	1000.00	1000.00	1000.00			90.08		
Minot State	200.00	200.00	200.00	200.00	200.00	200.00	300.00		
Jamestown College									
INDUSTRY				200.00					
Basin Electric				100.00					
Red River Sugarbeet Grow				100.00					
ASSOCIATES									
ANNUAL MEETING	6398.20	3460.00	3613.04	2286.00	2252.00	2998.00	3820.00		
Registration Fees	1800.00	2810.00	2191.00	1377.00	1729.00	1970.00	3400.00		
Banquet Ticket Sales	1965.00			809.00	423.00	350.00	370.00		
Assocn ND Geographers		50.00			50.00	50.00	50.00		
Sigma Xi -- UND	50.00	50.00	50.00	50.00	50.00				
Sigma Xi -- Minot		50.00		50.00					
Sigma Xi -- NDSU		100.00	150.00						
SD Academy	233.20								
ND Geol Society	50.00	100.00	100.00						
Subsidy	2000.00					28.00			
RRV Amer Chem Sco	300.00	300.00	350.00						
NDSU Engineering			772.04						
Jamestown College						600.00			
AWARDS PROGRAMS	1647.50	481.78	2375.20	2355.65	2226.40	1473.51	2756.35		
AAAS Sec Schl Research	900.00		1900.00	1000.00	900.00		900.00		
Scholarship Dividends	747.50	481.78	475.20	612.15	372.40	708.45	818.45		
ND Research Foundation				743.50	954.00	765.06	1037.90		
PUBLICATION SALES	167.00	123.00	102.00	52.00	106.00	154.00	179.50		
INTEREST on SAVINGS	479.22	491.65	203.34	172.75	40.33				
TOTAL INCOME	14258.92	9748.43	11173.58	9021.40	8144.73	6631.51	9705.95		

Fiscal Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
ANNUAL MEETING	6708.68	3564.03	3928.22	3007.59	2915.66	2563.36	1833.57		
Speakers Expenses	2651.40	973.83	1122.07	514.00	918.16	513.80			
Meals/Refreshments	2734.36	1856.30	1929.39	1903.95	1656.30	838.50	1455.32		
Printing				589.64	320.20	448.30			
General Expenses	1322.92	733.90	876.76		21.00	762.76	378.25		
AWARDS PROGRAMS	1360.00	1725.00	1100.00	1975.00	1750.00	1600.00	2075.00	850.00	850.00
AAAS Sec Schl Research	710.00	900.00	700.00	1200.00	900.00	800.00	800.00		
ND Science Olympiad				100.00					
ND Science/Engineer Fair	25.00			50.00	50.00	50.00	50.00	50.00	50.00
Denison Awards	500.00	450.00	400.00	300.00	400.00	300.00	450.00	400.00	400.00
ND Jr Academy Awards				325.00	400.00	450.00	375.00	400.00	400.00
Dunbar/Henderson Award	125.00	175.00							
Abbott Scholarship		200.00							
Research Fdn Grant							400.00		
PUBLICATIONS	2353.84	2836.65	3883.37	2883.28	2704.00	2406.00	3369.00		
Proceedings	2103.84	2586.65	3133.37	2633.28	2704.00	2406.00	3369.00		
Editor Fees	250.00	250.00	750.00						
Dakota Science Teacher				250.00					
PROGRAM OPERATIONS	475.60	55.80	471.55	132.76	255.19	41.75			
Junior Academy			350.00	132.76					
Exec Committee	475.60	55.80	121.55		255.19	41.75			
OFFICE EXPENSES	2171.92	2376.25	1199.49	1857.55	1648.59	1103.97	1487.85	49.00	49.00
Postage	762.72	403.16	550.56	1194.95	924.08	702.54	589.68		
Post Office Box Rental	39.00	39.00	39.00	39.00	49.00	49.00	49.00	49.00	49.00
Duplicating	218.68	215.08	208.42	324.95	392.26	300.56	631.00		
Supplies	414.02	349.01	259.01	228.65	98.25	51.87	87.40		
Clerical Assistance	137.50	170.00	92.50	70.00	185.00		125.00		
Sec Treas Fee	600.00	1200.00	50.00						
Phone							5.77		
MISCELLANEOUS	1031.47	1068.30	979.23	1811.00	1046.60	245.00	106.17	86.00	86.00
Fidelity Bond	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00
AAAS Delegate Expenses	960.57	1000.00	911.73	1000.00					
NAAS Dues	44.90	42.30	41.50	41.50	66.60	60.00	60.00	60.00	60.00
Funds Transfers				743.50	954.00	159.00			
Other							20.17		
TOTAL DISBURSEMENTS	14101.51	11626.03	11561.86	11667.18	10320.04	7960.08	8871.59	985.00	985.00

Fiscal Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
SCIENCE RESEARCH FOUNDATION									
CASH INCOME									
Donations from Members	279.00	296.50	270.00	261.50	303.00	159.00	159.00		
Allocations from Dues	678.00	544.00	438.00	482.00	651.00	304.00	400.00		
Intrest Accrued	250.57	310.09	396.97	311.51	345.10	302.06	478.90		
Sponsors / Patrons	300.00	100.00	250.00						
Other Sources									
TOTAL	1507.57	1250.59	1354.97	1055.01	1299.10	765.06	1037.90		
CASH EXPENSE									
Grants							400.00	500.00	
Awards									
Interest Compounding	250.57	310.09	396.97	311.51	345.10	302.06	302.39		
Other Disbursements	1257.00	940.50	958.00	743.50	954.00	159.00			
TOTAL	1507.57	1250.59	1354.97	1055.01	1299.10	461.06	702.39	500.00	
in checking NET CHANGE						304.00	335.51	-500.00	
ASSETS									
Pass Book Savings 31 Dec	4401.44	5909.01	7159.60	8514.57	9569.58	11329.74	1653.11	1653.11	1653.11
Investment 1							T-Note		
Book Value							10000.00	10000.00	10000.00
Investment Value TOTAL	5909.01	5909.01	8514.57	9569.58	10868.68	11329.74	11653.11	11653.11	11653.11
CHANGE	1507.57	1507.57	1250.59	1354.97	1055.01	461.06	323.37		
SCHOLARSHIP FUND									
CASH INCOME									
S D G E Dividends	257.50	267.50	270.00	205.00	70.00	407.00	415.25	400.00	
I E S Industries	490.00	214.28	205.20	216.00	302.40	407.20	403.20	400.00	
CD Interest					13.59				
AAAS Sec Schl Research	900.00		1900.00	1000.00	900.00		900.00		
TOTAL	1647.50	481.78	2375.20	1421.00	1285.99	814.20	1718.45	800.00	
CASH EXPENSE									
Denison Awards	500.00	450.00	400.00	300.00	400.00	300.00	450.00	400.00	400.00
Junior Academy Awards				325.00	400.00	500.00	375.00	400.00	400.00
AAAS Mini Grant	710.00	900.00	700.00	1200.00	900.00	800.00	800.00		
ND Science/Engineer Fair	25.00			50.00	50.00	50.00	50.00	50.00	50.00
Dunbar / Henderson Award	125.00	175.00							
Abbott Scholarship		200.00							
TOTAL	1360.00	1725.00	1100.00	1875.00	1750.00	1650.00	1675.00	850.00	850.00
NET CHANGE	287.50	-1243.22	1275.20	-454.00	-464.01	-835.80	43.45	-50.00	-850.00
ASSETS									
SDGE Shares (1983) 250	277.06	289.48	302.00	315.18	657.40	694.36	725.68	725.68	725.68
Price 18.50	38.25	45.13	43.63	45.00	29.50	25.00	19.63	19.00	19.00
Value 4625.00	10597.55	13064.23	13176.26	14183.10	19393.30	17359.00	14241.39	13787.84	13787.84
IES Industries (1990)			120.00	192.00	192.00	192.00	192.00	192.00	192.00
Price 120 @ 31.63			33.25	27.88	23.75	31.25	25.38	25.00	25.00
Value 3795.60			3990.00	5352.96	4560.00	6000.00	4872.00	4800.00	4800.00
TOTAL Investment Value	10597.55	13064.23	17166.26	19536.06	23953.30	23359.00	19113.39	18587.84	18587.84
CHANGE		2466.69	4102.03	2369.80	4417.24	-594.30	-4245.61	-525.55	

In REMEMBRANCE

Warren WHITMAN,

Professor Emeritus, North Dakota State University, died at the age of 83 on Monday, 22 August, in Fargo. Dr Whitman retired from NDSU in 1976 and was a member of the Academy since 1950. Dr Whitman left his notes and research data of grazing use and conservation of native North Dakota grasslands, dating back to the 1930's, with the University. Dr Whitman was also remembered for his long-term microclimate studies from the late 60s and 70s. Seen as one of the early conservationists of native rangelands, Dr Whitman introduced species in combination with native range land and/or annual crops for supplemental pasture and forage. His establishment of standards for the proper utilization of native rangelands, and the selection of methods of range utilization that can be successfully applied to North Dakota rangelands continue as the standard against which new recommendations are measured.

Dr Whitman is survived by his wife, Florence; two sons, Daniel C (Pat), Fargo, and Mark W (Judy), Minto, North Dakota; a brother, Newton, Orlando, Florida; and four grand children.

Charles A Hoffman,

Member of record since 1958.

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