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# Proceedings
## of the
# North Dakota Academy of Science

Volume 56 April 2002

NORTH DAKOTA ACADEMY OF SCIENCE
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2001-2002



**94th Annual Meeting**
April 25–26, 2002
Memorial Union - University of North Dakota
Grand Forks

## HISTORY

The *Proceedings of the North Dakota Academy of Science* (NDAS) was first published in 1948, with Volume I reporting the business and scientific papers presented for the 40th annual meeting, May 2–3, 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 prior to the annual 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.

In 1979 (Volume 33) the *Proceedings* changed to the present 8 ½ x 11-inch format. It was produced from camera-ready copy submitted by the authors and issued in a single part to be distributed initially at the annual meeting. Commencing with Volume 51 all submissions were on computer disk; the entire *Proceedings* was then assembled by desktop publishing software. This approach allowed the Editor control over all formatting; many of the papers are reformatted, in order to give the *Proceedings* a more consistent look. Also, incorporating all of the submissions on computer allowed production of an electronic copy of the *Proceedings* for the first time.

## VOLUME 56 ORGANIZATION

The communications of this volume of the Proceedings are presented in three sections. The first section contains invited papers describing the contributions to the symposium offered at the 94th Annual Meeting in Grand Forks. These papers are organized in the same sequence as presented in the respective symposia. The second section contains the collegiate communications presented in the A. Rodger Denison Student Research Paper Competition. The third section of this volume contains the communications presented in the professional sections of the annual meeting. Readers may locate communications by looking within the major sections of these Proceedings (see table of contents) or by referring to the author index on page 87.

### Symposia Communications

The symposia presented in this volume represent a variety of strategies to convey information to other scientists, scholars, students, and the public. As a result, greater flexibility was required in organizing symposia agenda (verbal presentations) with respect to written communications; thus please note that there is not necessarily a one-to-one match between titles of verbal and written communications. Commencing with the 88th annual meeting [Volume 50], presenters of Symposia annual meetings are given the opportunity to contribute an expanded or full-length article consisting of a multiple-page contribution, thus providing a presentation of much greater depth and scope than possible in a singe-page communication.

This approach has allowed speakers to present more educationally oriented lectures or workshop-type discussions and still provide a rigorous or more technical professional paper to the Proceedings. In a few cases, a speaker does not have a written communication. Again, this approach was taken to allow the symposia convenors the greatest flexibility possible in organizing speakers for the benefit of the audience.

### Collegiate and Professional Communications

Each Collegiate and Professional presentation at the annual meeting is represented by a full-page communication which is more than an abstract, but less than a full paper. The communications contain results and conclusions, and permit data presentation. The communication conveys much more information to the reader than does an abstract, and yet still provides the advantages of timeliness and ease of production.

### Constitution and Bylaws

This issue of the Proceedings also contains the Constitution and Bylaws of the Academy, a list of officers and committee members, a list of all current dues-paying members of the Academy as of March 2002, a copy of unapproved minutes from last year's annual business meeting, a listing of past presidents of the Academy, and an index of presenters and paper authors.

## IN APPRECIATION

The Academy wishes to acknowledge current and emeritus members of the Academy who have supported the mission of the North Dakota Academy of Science Research Foundation through their special gifts. A listing of these supporters is found on page 77 of these Proceedings. The Academy also wishes to express its thanks to the presenters of papers at the Annual meeting, the session chairs, as well as all who have helped in organizing spaces and places, reviewing manuscripts, and assisting in the editing of this year's communications. The President of the Academy also wishes to sincerely thank our special guest, Dr. Donald Schwert, for speaking at this year's awards banquet.

Jon A. Jackson
Secretary-Treasurer
*Proceedings* Editor

Jody H. Rada
President

# BUILDING ENTHUSIASM FOR SCIENCE THROUGH HANDS-ON EDUCATION

**Fred Orth Lecture Bowl**

Thursday 9:00 a.m.

*Moderator*: *Joseph Hartman,* University of North Dakota

## INTRODUCTION

**Overview of water-related hands-on science education in the Red River watershed**

Joseph H. Hartman*, Wayne R. Goeken, Charlene R. Crocker, and Daniel J. Daly

## ONGOING PROGRAMS

**Red River geoscience education – A three-school pilot program in northeastern North Dakota**
Daniel J. Daly*, Charlene R. Crocker, and Joseph H. Hartman

**Hands-on water related education through water quality monitoring**
Christine C. Holland*· Wayne R. Goeken, and Daniel J. Daly

## STUDENT INVOLVEMENT

**Science – Where the Park River, the laboratory, and students meet**
Kristin M. Thorfinnson*, Miranda J. Gudmundson*, Jill A. Kertz*, Kayla M. Kertz*, Muriel A. Kingery*, and JoAnn L. Ohma*

**The importance of hands-on learning experiences for science-bound youth**
Alaina J. Seymour*, Red River High School

## DISCUSSION AND OTHER TOPICS

**Controversial issues in the science classroom – Evolution as a courtroom experience in shaping the experience of preservice teachers to deal with controversy and due process**
Lars Helgeson*, University of North Dakota Department of Teaching and Learning, Box 7189, Grand Forks (lars_helgeson@und.nodak.edu)

**Promoting geoscience education through digital imagery – Using GeoDIL in the classroom**
Joseph H. Hartman* and Dexter Perkins

**Building an international perspective on the K–12 education and student leadership in science in the Red River Basin, North Dakta, Minnesota, and Manitoba**
Joseph Courneya*, Center for Watershed Education, 219 Family Life Center, Box 5016, Fargo (jcourney@ndsuext.nodak.edu)

**Student involvement in the Red River Riparian Project – An opportunity for growth and learning in the sciences**
David Rush*, Red River Regional Council, 516 Cooper Avenue, Suite 101, Grafton, ND 58237 (riparianproject@yahoo.com)

**Student field studies and chemistry of Turtle River, North Dakota**
Roger Palmer*, Red River High School, 2211 17th Avenue South, Grand Forks, ND 58201 (redrog@aol.com)

# OVERVIEW OF WATER-RELATED HANDS-ON SCIENCE EDUCATION IN THE RED RIVER WATERSHED

Joseph H. Hartman*[1,3], Wayne R. Goeken[2], Charlene R. Crocker[3], and Daniel J. Daly[3]
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[3]Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND 58202

## INTRODUCTION

### About the Symposium

The mission of this symposium is to provide a forum for the many people interested in science education in the watershed of the Red River of the North. The focus of the meeting is to bring people together to have a chance to learn about each other and their science-based activities, with the hope of stimulating new partnerships, and to give high school students an opportunity to interact with the science community.

In the year 2000, a proposal was submitted by the Energy and Environmental Research Center (EERC) to the National Science Foundation under Element 1 (NSF00-38), which was an NSF initiative to develop ways to expand geoscience education to younger students. After the grant was awarded, we were at least partially surprised to learn that many other educators and resource managers were interested in using water-quality issues as a way of promoting science and the scientific method in the classroom. This symposium is an outgrowth of some of the collaborations that have developed over the last 18 months. We believe that getting students involved early in practical (beyond book learning) application of methods and practices will instill a long-term interest in science. The presentations by students at this, the 94th North Dakota of Academy of Science, annual meeting will, I understand, be the first at which high school students will speak.

## WHAT PEOPLE ARE DOING

The watershed of the Red River of the North is the major natural feature of northeastern North Dakota and northwestern-most Minnesota. Over the past decade, hands-on water-related education has grown dramatically using the Red River and its tributaries as a field laboratory to promote science inquiry in students of all ages. Currently, more than 500 students in more than 30 school districts in the Red River watershed are involved in one of the following outreach activities: Red River Geoscience Education, Red River Basin River Watch, FM River, and Minnesota State University at Moorhead (Red River Center for Watershed Education). In addition, 700 students are served by the Eco-Ed camps (Table 1). This paper provides an overview of the distribution and activities of these programs through the following maps and tables.

## ACKNOWLEDGMENTS

This activity was funded by grants to the EERC from the National Science Foundation (to Joseph Hartman, NSF EAR00-85583) and the U.S. Environmental Protection Agency (to Dan Daly and Charlene Crocker, EPA NE 998221-01). We also wish to thank Wes Peck for his help with Figures 1 and 2 of this paper.

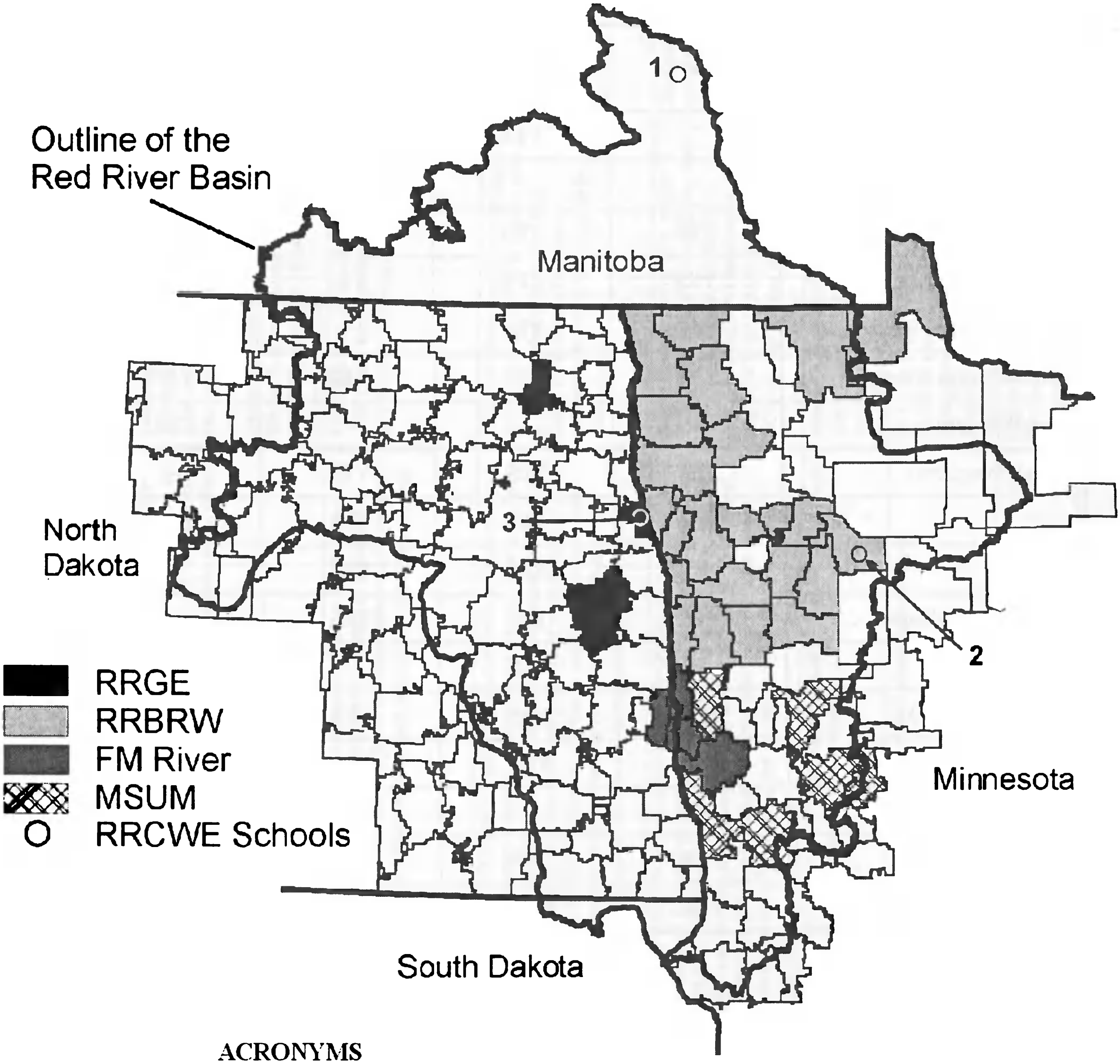
Table 1
**Selected Regional Water-Related Educational Programs in the Watershed of the Red River of the North**

| Program | School and Area | Description | Group/Funding Source/Duration | Contact |
|---|---|---|---|---|
| Red River Basin River Watch (RRBRW) | 24 schools in northwestern MN | Extracurricular activity with a group of 10 students per school; monthly sampling of tributary or Red River mainstem under ice-free conditions; in-school analysis for four parameters; data reduction; up to 7 years of data available depending on school; annual regional water forums where schools present and compare findings; high school focus. | Past grants from MN Board of Water and Soil Resources and financial support from the Red River Watershed Management Board (RRWMB); currently funded from Flood Damage Reduction Funds (MN Department of Natural Resources) administered by RRWMB, subject to annual budget review and renewal. | Wayne Goeken<br>RRBRW<br>(218) 574-2622<br>wrg@gvtel.com |
| Red River Geoscience Education (RRGE) Pilot Project | 3 schools in northeastern ND | Pilot project to initiate ND water education; modeled on RRBRW, but with geoscience context and GIS activities; goal of monthly sampling and in-school analysis of tributary or Red River mainstem waters during ice-free months; high school focus; full class and summer school field camp groups | EERC/National Science Foundation (NSF); NSF funding 8/00 to 8/02; out-year funding in development. | Dan Daly, Charlene Crocker, and<br>Joseph Hartman<br>EERC<br>(70) 777-5000<br>ddaly@undeerc.org<br>ccrocker@undeerc.org |
| North Dakota River Watch Laboratory Field Experience (LFE) | 3 schools in northeastern ND | Pilot project to initiate program providing students with 1-day sessions in a professional laboratory setting (e.g., laboratories at local universities, water treatment facilities, industries, research facilities) performing water analysis and critical thinking activities under the guidance of professionals; high school focus; full-class groups; stand-alone or supplement to other water education programs; students learn about Red River watershed natural setting, range of water types over the watershed, and treatment needs for use options. | EERC/Environmental Protection Agency (EPA), Region VIII; EPA funding 6/00 to 11/01; verbal commitment from Grand Forks Water Treatment Laboratory to host future sessions for local schools. | Dan Daly and Charlene Crocker<br>EERC<br>(701) 777-5000<br>ddaly@undeerc.org<br>ccrocker@undeerc.org |
| FM River | School program in development in the Fargo (Cass County, ND) and Moorhead (Clay County, MN) area | EPA EMPACT (Environmental Monitoring for Public Access and Community Tracking) project; goal of semimonthly sampling of 3 sites on Red River mainstem by school and community groups supplemented by other data sources; data management by the EERC; data and data context available to community through Web site, television, and other venues; high school focus for sampling and in-class analysis activities; annual water forum. | Project management by EPA Region VIII; partnership of municipalities, state agencies, the EERC, Prairie Public Television, and FM RiverKeepers; EPA, Region VIII (EMPACT) funding 6/01--6/03; out-year funding in development | Christine Holland<br>River Keepers<br>(701) 235-2895<br>riverkeepers@i29.net |
| Water Education/ MSUM Regional Science Center (RSC) | 10 schools in Fargo–Moorhead metropolitan area, ND–MN | Annual 1-day class sessions featuring water sampling and school laboratory analysis of water samples from local tributary or Red River mainstem; middle school focus. | Minnesota State University Regional Science Center (MSUM/RSC) Environmental Education Center/Mix of long-term funding and grants.. | George Davis<br>MSUM/RSC<br>(218) 236-2904<br>davisg@mnstate.edu |
| Red River Center for Watershed Education (RRCWE) | NA | Watershedwide facilitation of water-related education curriculum development. | Tri Colleges (MSUM, North Dakota State University, Concordia College)/Bremer Foundation (BF); BF grant 2001--2003; out-year funding in development | Joe Courneya<br>Center for Watershed Education<br>(701) 231-6184<br>jcourney@ndsuext.nodak.edu |
| Eco-Ed Camps | 7 middle schools in Grand Forks School District | Combination of 2- and 1-day camps held annually in September at Turtle River State Park featuring a variety of units, including soils, wetlands, and water quality, facilitated by professionals; 9 camps held in 2001 for 700 students. | Eastern Grand Forks County Soil Conservation District; district resources and grants; annual application and renewal | Nedra Hoberg<br>Education Coordinator<br>(701)746-7934<br>nedra.hoberg@nd.usda.gov |

Table 2
**Types of Data Being Collected by Water Education Programs**

| Parameter | Red River Basin River Watch | Red River Geoscience Education Program | FM River | Red River Valley Water Quality Testing Network |
|---|---|---|---|---|
| Ammonia | – | YES | – | – |
| BOD | – | – | – | YES |
| Dissolved Oxygen | YES | YES | YES | YES |
| Electrical Conductivity | YES | YES | YES | – |
| Fecal Coliform Bacteria | YES | YES | – | – |
| Nitrate/Nitrite Nitrogen | YES | YES | YES | YES |
| Total Phosphates | – | – | – | YES |
| Total Phosphorus | YES | YES | YES | – |
| pH | YES | YES | YES | YES |
| Salinity | – | YES | YES | – |
| Stream Depth/Stage | YES | YES | YES | – |
| Stream Flow | – | YES | – | – |
| Temperature (air) | YES | YES | YES | – |
| Temperature (water) | YES | YES | YES | YES |
| Total Solids | – | – | – | YES |
| Transparency | YES | YES | YES | – |
| Turbidity | YES | YES | YES | YES |

Figure 1
**Map of the Red River Drainage Basin Showing the School Districts Involved in Water-Qualilty-Based School Studies**




ACRONYMS

RRGE – Red River Geoscience Education
RRBRW – Red River Basin River Watch
FM River – Districts shown are planned activities
MSUM – Minnesota State University at Moorhead (in collaboration with FM River districts)
RRCWE – Red River Center for Watershed Education

**Figure 2**
**FM River Sampling Location in the Fargo–Moorhead Area**

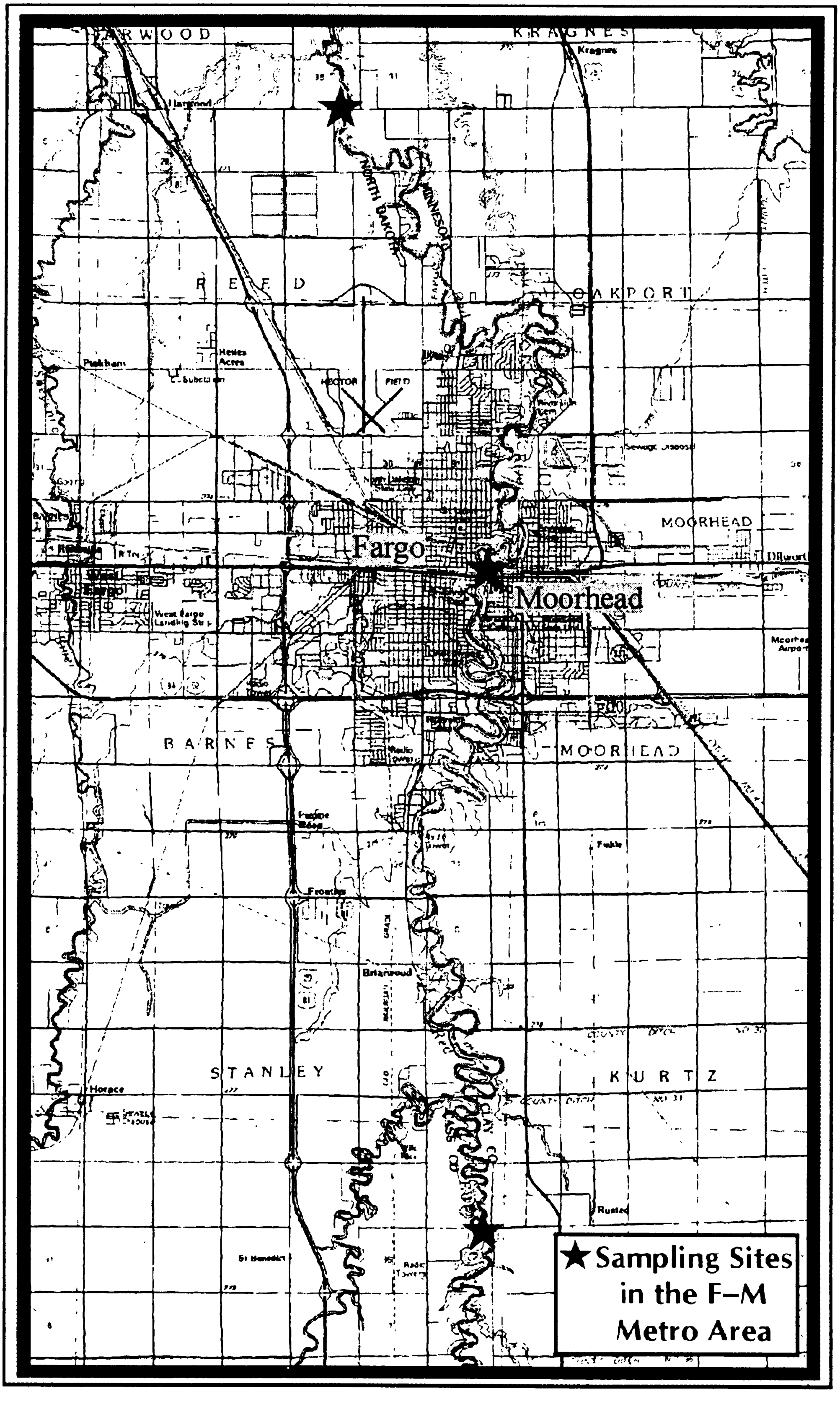


Table 3
**Schools, Sampling Sites, and Related Water-Based Educational Programs**

| School/Community | Watershed/Subwatershed | Monitoring Initiated | Organization |
|---|---|---|---|
| Ada, MN | Wild Rice River, Felton Ditch, Dalen Ditch | 2000 | RRBRW |
| Barnsville, MN | Red and Buffalo Rivers | 2001 | FM River |
| Breckenridge, MN | Bois de Sioux, Otter Tail, and Red Rivers | 1992 | MSUM |
| Clearbrook–Gonvick, MN | Clearwater River | 1998 | RRBRW |
| Climax, MN | Sand Hill and Red Rivers | 1995 | RRBRW |
| Crookston, MN | Red Lake River, Burnham Creek | 1999 | RRBRW |
| Detroit Lakes, MN | Buffalo River, Otter Tail River | 1992 | MSUM |
| Dillworth–Glyndon–Felton, MN | Buffalo River | 1992 | MSUM |
| East Grand Forks Public, MN | Red Lake and Red Rivers, Grand Marais Creek | 1999 | RRBRW |
| East Grand Forks Sacred Heart, MN | Red Lake River, Red River | 2000 | RRBRW |
| Edinburg, ND | Park River | 2000 | RRGE |
| Fargo North, ND | Red River | 1992 | MSUM |
| Fargo Shanley, ND | Red River | 1992 | MSUM |
| Fargo South, ND | Red River | 1992 | MSUM |
| Fargo Woodrow Wilson, ND | Red, Sheyenne, and Wild Rice Rivers | 1993 | MSUM |
| Fergus Falls, MN | Otter Tail River | 1993 | MSUM |
| Fertile–Beltrami, MN | Sand Hill River | 1995 | RRBRW |
| Fisher, MN | Red Lake River, Burnham Creek, Grand Marais Creek | 2001 | RRBRW |
| Fosston, MN | Sand Hill and Poplar Rivers | 1995 | RRBRW |
| Grand Forks Red River, ND | English Coulee, Red River | 2000 | RRGE |
| Hallock, MN | Two Rivers | 1999 | RRBRW |
| Karlstad, MN | Two and Tamarac Rivers | 2000 | RRBRW |
| Lancaster, MN | Two Rivers | 1999 | RRBRW |
| Mahnomen, MN | March Creek, Spring Creek, White Ditch | 2000 | RRBRW |
| MayPort CG, ND | Goose River, Mayville city pond | 2000 | RRGE |
| Moorhead, MN | Buffalo River | 1992 | MSUM |
| New York Mills, MN | Otter Tail River | 1994 | MSUM |
| Newfolden, MN | Middle River | 1999 | RRBRW |
| Norman County East, MN | Coon, Mash, and Moccasin Creeks | 2000 | RRBRW |
| Norman County West, MN | Marsh and Wild Rice Rivers, Spring Creek | 1995 | RRBRW |
| Oklee, MN | Clearwater River, Hill River, Lost River | 1998 | RRBRW |
| Perham, MN | Otter Tail and Toad Rivers | 1993 | MSUM |
| Plummer, MN | Clearwater, Hill River, and Lost Rivers | 1998 | RRBRW |
| Red Lake Falls, MN | Red Lake, Clearwater, and Black Rivers | 1998 | RRBRW |
| Roseau, MN | Roseau River, Hay Creek | 2000 | RRBRW |
| Stephen–Argyle, MN | Tamarac River | 1999 | RRBRW |
| Warren–Alvarado–Oslo, MN | Snake River | 1999 | RRBRW |
| Warroad, MN | Warroad River, Swift Ditch | 2000 | RRBRW |
| West Fargo, ND | Sheyenne River | 1992 | MSUM |
| Win-E-Mac, MN | Sand Hill River, County Ditch 16, Poplar River, Oak Lake | 1995 | RRBRW |

# RED RIVER GEOSCIENCE EDUCATION – A THREE-SCHOOL PILOT PROGRAM IN NORTHEASTERN NORTH DAKOTA

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## INTRODUCTION

The Red River of the North (Red River) watershed, part of the Hudson drainage system, encompasses northeastern South Dakota, eastern North Dakota, northwestern Minnesota, and the southern portion of the Canadian Province of Manitoba. The north-flowing Red River mainstem and tributary system developed in the wake of the northward retreat of Wisconsinan glaciers forming Glacial Lake Agassiz at the close of the Pleistocene. The upper and middle reaches of tributaries occur in glacial till and beach deposits, while lower reaches of the tributaries and the Red River mainstem flow through the prime agricultural land characterized by a very-low-relief setting composed of the silty clay deposits of the Agassiz lake bottom.

Over the last century, agricultural crops have replaced the native tall grass prairie ecosystem of the region, and the increased population has resulted in increased demands on the water resources of the region and subsequent changes to the drainage system. The Red River watershed is currently central to public dialogue that addresses the need to ensure adequate water for human use, mitigate flooding, and ensure the health of the natural ecosystems for the economic health of the region. Sound input into these discussions requires knowledge of the evolution of the natural landscape and system ecology with regard to the distribution of geological materials and processes. In response to this need, the Energy & Environmental Research Center (EERC), with funding from the U.S. Environmental Protection Agency (EPA) and the National Science Foundation (NSF) and in collaboration with the Red River Basin River Watch (RRBRW), developed and tested a Red River Geoscience Education (RRGE) pilot program in three high schools in northeastern North Dakota. This paper describes the goals and components of the RRGE pilot program, summarizes activities to date, and provides a view for future activities.

## RRGE OVERVIEW

Building on the RRBRW tributary-monitoring activities initiated in the Minnesota portion of the watershed, the RRGE pilot project is providing a collaborative approach to science teacher development and student education using the Red River watershed. The hands-on approach features locally relevant, firsthand geoscience content, with field, laboratory, and instrument technology training in themes relating to riparian habitats, hydrology, and human impact on water quality. RRGE objectives include the following:

- Provide area high school students with the opportunity to gain real-world experience in scientific research and to prepare them for university classes and possible science careers.

- Develop students' critical-thinking and problem-solving skills as they participate in data collection and assessment procedures in local watershed studies.

- Provide area educators with readily available and useful geoscience activities, focused on water issues to be used in the field and in the classroom.

- Develop water quality baseline data that are acceptable to natural resource managers and regulatory personnel.

- Strengthen cooperation among the variety of science education stakeholders divided among various political, institutional, and economic interests.

Schools from three North Dakota districts (Grand Forks; the consolidated district comprising Mayville, Portland, Clifford, and Galesburg; and Edinburg) are taking part in the RRGE program. The students use physical, chemical, and biological monitoring of local waters as a basis for critical thinking and problem solving. Under the tutelage of science professionals and using established protocols, students performed 1) water quality monitoring, 2) physical characterization of field sites, 3) analysis of selected parameters in the laboratory, and 4) activities that relate the resulting data and observations to the local geology and environmental geochemistry. Participating teachers are offered 1) training in field sampling and laboratory analytical techniques; 2) technical training in the use of geographic information systems (GIS); and 3) technical support in the field, laboratory, and classroom activities. Teachers also receive local area background information for activities, lesson plans, and sample lessons.

The scientific integrity, utility, implementation, and sustainability of the program are ensured through partnerships with schools, existing water-related educational programs, and sources of facilitators and technical expertise. These groups include the University of North Dakota (UND), Red River Basin River Watch (RRBRW), the Red River Riparian Project (RRRP), City of Grand Forks Water Treatment Plant (GFWTP), Upper Midwest Aerospace Consortium (UMAC), North Dakota State University (NDSU), Project WET staff at the North Dakota State Water Commission (NDSWC), and Turtle River State Park (TRSP). Periodic evaluation is an important component of the program. Project scientists meet regularly with participating teachers to discuss implementation methods and make changes as needed. All teachers and project partners participate in an annual project debriefing in June to review the previous year and make recommendations for the following. The program is also subject to external review by an education professor from Northland College, Ashland, Wisconsin.

RRGE PROGRAM COMPONENTS

RRGE components include educator training and materials, monitoring activities, laboratory activities, and an annual field session.

**Educator Training**

The RRGE program provides orientation and training workshops and GIS training to participating teachers. A 2-day training session focuses on orientation to the program and to Red River Basin geology, field and laboratory training including a practice monitoring event, and a 6-hour Project WET teacher workshop introducing the Project WET K–12 Curriculum and Activity Guide. Teachers receive a copy of the RRGE source book, which includes several publications on Red River Basin ecology, water resource issues, and monitoring guides (e.g., Volunteer Stream Monitoring: a Methods Manual [1]). GIS workshops introduce teachers to the concept of GIS and ArcView GIS software and then the application of GIS to the analysis and presentation of water quality-monitoring data. The teachers also receive training on handheld Global Positioning System (GPS) units.

**Monitoring Activities**

Water quality monitoring involves field collection of site data and water samples for analysis in the classroom. Students travel to the monitoring sites (e.g., see Figure 1 in Hartman et al., this symposium) by bus or van, record field data, photograph the site, and collect and preserve water for transport to the school. Field data include dissolved oxygen; conductivity; salinity; air and water temperature; stream depth and flow; transparency; weather, phenological, and physical observations; and annual stream cross sections. On the return to school, students follow established protocols to complete several analyses: total phosphorus, nitrate/nitrite nitrogen, ammonia, fecal coliforms, turbidity, pH, and dissolved oxygen by titration. Quality assurance and quality control (QA/QC) elements written into the protocols assist students in the evaluation of their data. They record their results in a spreadsheet in preparation for uploading to a monitoring data Web site or GIS software for presentation.

Sampling is being conducted at the following locations. Edinburg High School is sampling at two sites on the Park River located upstream of bridge on ND Hwy 32 and downstream of the Red River Riparian Program restoration site in the Park River Bible Camp. MayPort CG High School is sampling at three sites in Mayville–Portland located on the Goose River upstream of the dam in Mayville, on the Goose River downstream of the dam in Mayville, and at the Oxbow Pond in the city park. Red River High School is sampling at three sites in the Grand Forks area located on English Coulee at the bridge on County Road 5 (southwest of Grand Forks), upstream on English Coulee upstream at the bridge on ND Hwy 81 (north of Grand Forks), and on the mainstem of the Red River on the upstream side of the Sorlie Bridge in downtown Grand Forks.

**Laboratory Activity**

During this activity, dubbed Laboratory Field Experience (LFE), students bring samples of local surface water and groundwater to an EPA-certified laboratory where they characterize the water and use this information in subsequent problem-solving activities. They learn about the natural (geologic) and human influences on water occurrence and quality in the Red River watershed, analyzed several water samples using commercial equipment under the tutelage of analytical chemists, and identify mystery water samples using deductive reasoning and the knowledge gained through the LFE activity. Students also tour a water treatment plant and learn about physical and chemical water treatment. Experimental parameters vary by venue. At the EERC Analytical Research Laboratory (ARL), parameters: calcium, iron, magnesium, potassium, sodium, chloride, nitrate, phosphate, sulfate, alkalinity, electrical conductivity, pH, total dissolved solids, total suspended solids, transparency, and dissolved oxygen. At the Grand Forks Water Treatment Plant (GFWTP), students determine calcium and magnesium as hardness, total hardness, iron, chloride, nitrate, phosphate, sulfate, alkalinity, ammonia, electrical conductivity, pH, total dissolved solids, total suspended solids, turbidity, and dissolved oxygen. Other parameters such as fecal coliform bacteria are presented to them based on previous analyses or estimates of likely concentration. The mystery samples included waters from tributaries, the Red River mainstem, wells, bogs, agricultural processing, precipitation, saline slough water, and municipal wastewater and are intended to provide an overview of the variability of waters in the region.

### Summer Field Camp

A 5-day Red River High School (RRHS) Summer Field Camp is a collaborative effort by RRHS faculty, the EERC, Grand Forks Water Treatment Plant, and Turtle River State Park. Students participate in hands-on field and classroom activities focused on the Turtle River subwatershed. Orientation includes a crash course in geoscience, water quality, GIS, and handling digital still and moving camera editing software. Geoscience activities include nine exercises comprising a combination of geologic mapping, geomorphologic assessment, geology in fluvial analysis, stream bed materials and bedforms, geology and water quality, regional geologic analysis, geology and ecology, geoscience and environmental assessment applications of GIS, changes in geologic setting from the headwaters of the Turtle River to its confluence with the Red River, and geologic variables in runoff and stage prediction. Water quality concepts take center stage as students investigate five sites along the Turtle River from mouth to headwaters. Field data and water collection take place as described above in the monitoring activities. Students take collected water to the GFWTP and analyze parameters listed above in the LFE section with direction from GFWTP chemists. Students use ArcView GIS and digital video technology to document their work and present their results.

## RESULTS, DISSEMINATION, AND FUTURE ACTIVITIES

To date RRGE has involved five teachers, 166 students, and twelve facilitators. The facilitators include six chemists, Jenny Sun (EERC), Carolyn Nyberg (EERC), Charlene Crocker, (EERC), Craig Locher (GFWTP), Steve Kolar (GFWTP), and Andy Job (GFWTP); three geologists, Joseph Hartman (EERC and UND Department of Geology and Geological Engineering [GGE]), Alan Schlag (UND GGE), and Dan Daly (EERC); an environmental scientist, Dave Rush (Red River Regional Council, formerly of the EERC); and two student interns, Stacie Laducer (EERC) and Lindsay Beard (EERC). Activities during the period August 2000 to March 2002 are summarized in Table 1.

Dissemination of the RRGE-related materials has occurred through presentation, packet distribution, Internet publication, and interaction with other regional water-related programs. The concept has already been presented at two educator workshops and water festivals (MAEE Conference, August 8, 2001; and Manitoba STA Workshop, October 19, 2001 ). The instructional packet will be distributed to educators and preservice teachers as the occasion arises, as well as to the Red River Center for Watershed Education (RRCWE), which is working to build curricula for water-education in the Red River Basin and serve as a regional clearinghouse for water-related educational programs. Internet publication of the materials on the EERC Web site will occur in the Spring of 2002 and will be available through links to several key Web sites in the region, including the FM River Web site hosted by Prairie Public Television as part of the EPA-sponsored FM River EMPACT project. The Red River Basin River Watch Director has expressed a desire to implement geoscience components of RRGE with students in the Minnesota portion of the Red River Basin in 2002, and the GFWTP's agreement to participate enables the LFE component to be marketed to schools in the 24 school districts within a 60-mile radius of Grand Forks.

A RRGE packet describing the program and educational materials is in preparation. Plans are to continue to collect river-monitoring data at the existing sites and expand the program to include more schools in the basin through a collaboration with RRBRW, River Keepers (in the Fargo–Moorhead metropolitan area), and the Red River Center for Watershed Education. The project team is looking for avenues of support for sustaining RRGE activities beyond the pilot project.

The impact of this project's activities are greater science literacy in the communities participating in the program and a successful model for bringing the "hands on—minds on" approach to geoscience education to the high schools of the Red River watershed. Because the pilot includes both rural and urban school districts, the unique problems associated with both groups can be explored and addressed, yielding a program exportable throughout the Red River watershed and beyond.

## REFERENCES

1. U.S. Environmental Protection Agency, 1997, Volunteer Stream Monitoring: A Methods Manual: EPA Publication 841-B-97-003 (Nov. 1997), 211 p.

## ACKNOWLEDGMENTS

This activity was funded by grants to the EERC from the National Science Foundation (to Joseph Hartman, NSF EAR00-85583) and the U.S. Environmental Protection Agency (to Dan Daly and Charlene Crocker, EPA NE 998221-01).

Table 1
**RRGE Monitoring, Laboratory, and Training Activities.**

| Date | Activity | Location | School | Students | Scientists |
|---|---|---|---|---|---|
| 8/22/00 to 8/23/00 | Workshop | EERC ARL | All schools | 4 science teachers | 2 EERC geologists, 1 EERC environmental scientist, 1 EERC chemist; 1 RRBRW trainer, 1 Project WET facilitator |
| 10/19/00 | Monitoring | Red River | Grand Forks Red River | 9 field biology and geology students | 1 EERC environmental scientist, 1 EERC chemist; 2 UND students |
| 10/19/00 | GIS Workshop | Red River High School | All schools | 3 teachers | 1 UMAC GIS trainer |
| 3/13/01 | LFE | EERC ARL | Grand Forks Red River | 11 field biology or geology students | 1 EERC geologist, 3 EERC chemists |
| 4/10/01 | LFE | EERC ARL | May-Port CG | 18 chemistry students | 1 EERC geologist, 3 EERC chemists |
| 4/17/01 | LFE | EERC ARL | May-Port CG | 18 chemistry students | 1 EERC geologist, 3 EERC chemists |
| 4/18/01 | Monitoring | Park River | Edinburg | 9 chemistry students | 1 EERC geologist, 1 EERC chemist, 1 RRRC environmental scientist |
| 4/24/01 | Monitoring | English Coulee Red River | Grand Forks Red River | 20 geology students | 1 UND geologist, 1 EERC chemist |
| 5/1/01 | Monitoring | Goose River | May-Port CG | 40 chemistry students | 2 UND geologist, 1 EERC chemist |
| 5/3/01 | Monitoring | Park River | Edinburg | 13 chemistry students | 1 EERC geologist, 1 EERC chemist, 1 RRRC environmental scientist |
| 5/11/01 | Monitoring | English Coulee Red River | Grand Forks Red River | 14 geology students | 1 UND geologist, 1 EERC chemist |
| 5/15/01 | Monitoring | Goose River | May-Port CG | 40 chemistry students | 2 UND geologist, 1 EERC chemist |
| 5/17/01 | Monitoring | English Coulee Red River | Grand Forks Red River | 18 geology students | 1 UND geologist, 1 EERC chemist |
| 6/4/01 to 6/8/01 | Field Camp | Turtle River, Red River High School | Grand Forks Red River, Bismarck Shiloh | 6 high school students | 1 EERC geologist, 1 EERC chemist, 3 WTP chemists |
| 6/11/01 | Annual Review | EERC | All schools | 3 teachers | 2 EERC geologists and 1 chemist, 1 RRRC environmental scientist, 1 NDSU education professor |
| 9/26/01 | LFE | GF WTP | May-Port CG | 18 chemistry students | 1 EERC geologist, 1 EERC chemist, 2 WTP chemists |
| 9/28/01 | LFE | GF WTP | May-Port CG | 18 chemistry students | 1 EERC geologist, 1 EERC chemist, 2 WTP chemists |
| 10/1/01 | LFE | EERC ARL | Edinburg | 15 physics students | 1 EERC geologist, 1 UND geologist, 2 EERC chemists |
| 10/9/01 | Monitoring | Park River | Edinburg | 15 physics students | 1 UND geologist, 1 EERC chemist, 1 RRRC environmental scientist |

EERC ARL = Energy & Environmental Research Center, RRBRW = Red River Basin River Watch, UND = University of North Dakota, UMAC = Upper Midwest Aerospace Consortium, RRRC = Red River Regional Council, GF WTP = Grand Forks Water Treatment Plant.

# HANDS-ON WATER RELATED EDUCATION THROUGH WATER QUALITY MONITORING

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## INTRODUCTION

The Red River Basin River Watch and FM River are collaborating to provide opportunities for middle and high school students and volunteers to gain first hand science experience through water monitoring and analytical activities. These programs are profiled in Table 1, their geographic distribution is shown in Figure 1 of Hartman et al. (this volume), and the parameters and methods for the chemical and physical characterization of the water samples are outlined in Table 2. program in the North Dakota and Manitoba portions of the watershed in conjunction with the efforts of the Energy & Environmental Research Center's Red River Geoscience Education program and the schools working with the Red River Center for Watershed Education at North Dakota State University.

School teams of 8-12 students gather water samples at three to five sites monthly during ice-free conditions, including summer months. School teams are led by full time RRBRW personnel with additional help from local Soil and Water Conservation District and Watershed District personnel. The full-day monthly monitoring sessions include glasswear preparation and water sample collection in the morning followed by in-class analysis and data recording and storage. Data are managed via Microsoft Excel spreadsheets. An interactive Web site is being developed for data sharing, and annual regional youth forums involving clusters of schools allow students to share results. A sample of data presentation is shown in Figure 1.

**Table 1.**
**Selected water-related educational programs in the southern and eastern portion of the Red River of the North Watershed**

**Red River Basin River Watch (RRBRW)** – 24 schools; northwestern MN Extracurricular activity with group of 10 students per school; monthly sampling of tributary or Red River mainstem under ice-free conditions; in-school analysis for six parameters; data reduction; up to 7 years of data available depending on school; annual regional water forums where schools present and compare findings; high school focus.

Past grants from MN Board of Water and Soil Resources and financial support from the Red River Watershed Management Board (RRWMB); currently funding from Flood Damage Reduction Funds (MN Department of Natural Resources) administered by RRWMB, subject to annual budget review and renewal.

***Contact:*** Wayne Goeken, **RRBRW (218) 574-2622 wrg@gvtel.com**

**FM River** – Schools in FM area (Fargo, ND – Moorhead, MN; Cass County, ND, and Clay County, MN); EPA EMPACT (Environmental Monitoring for Public Access and Community Tracking) project; goal of semimonthly sampling of 3 sites on Red River mainstem by school and community groups supplemented by other data sources; data management by the EERC; data and data context available to community through Web site, television and other venues; high school focus for sampling and in-class analysis activities; annual water forum.

Project management by EPA Region VIII; partnership of municipalities, state agencies, the EERC, Prairie Public Television, and FM River Keepers. EPA funding 6/01–6/03; outyear funding in development.

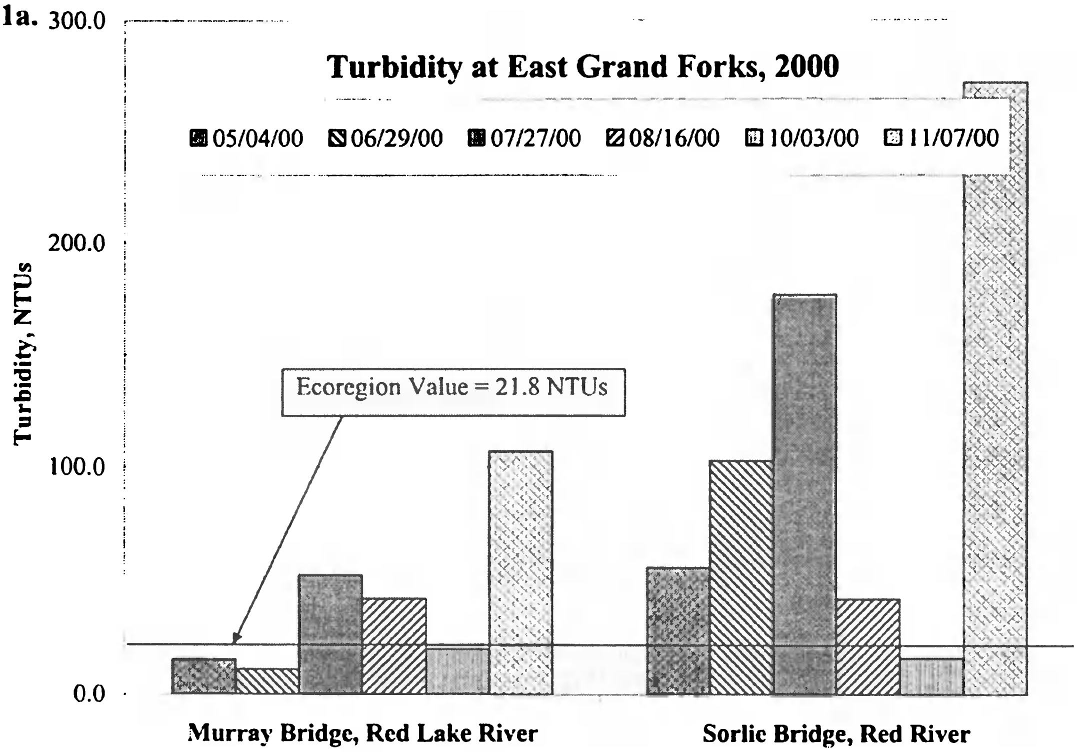
***Contact:*** Christine Holland, **River Keepers (701) 235-2895 riverkeepers@i29.net**

## RED RIVER BASIN RIVERWATCH

Red River Basin River Watch (RRBRW), supported by the Red River Water Management Board (RRWMB) Flood Damage Reduction funding, offers the opportunity for students to use standardized methods to produce scientifically credible baseline water quality information and to develop an understanding of the environment through hands on science focused on local water quality. The program involves approximately 200 students in 24 schools in the Minnesota portion of the basin. These schools monitor 88 sites on 18 rivers and 13 creeks and ditches. Interest is growing to use the

Figure 1
**Examples of Data Summaries Presented at the Lower Red Lake River Cluster River Watch outh Water Forum**

1a.




1b.

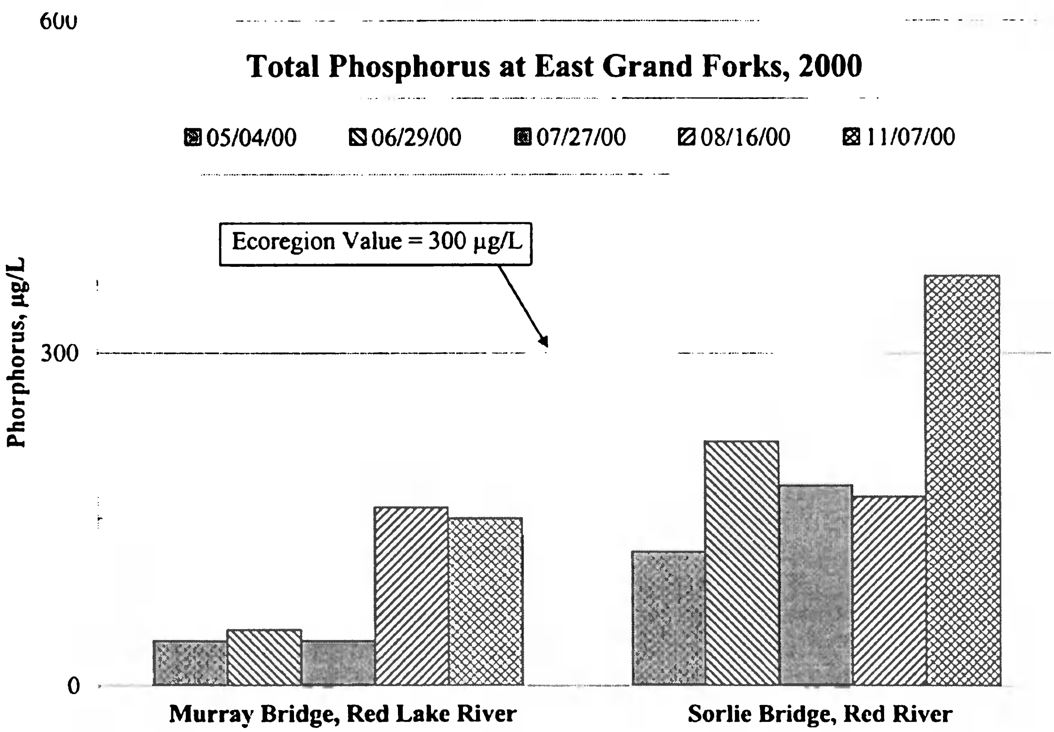


Table 2
**Parameters and Methods**

| Parameter | Method |
|---|---|
| Conditions (Air and Water Temperature, turbidity) | Armored thermometers and/or DO meter for air and water temperature. Hach 2100P Turbiditometer and/or transparency tube for turbidity and transparency |
| Dissolved Oxygen, Conductivity, | YSI DO meter and/or digital titrator for DO. |
| Temperature, Salinity | YSI or Hach meters for conductivity, temperature, and salinity |
| Water Sample Collection for Laboratory Analysis | Van Dorn sampler and/or wading for field grab sampling |
| Nitrate Nitrogen | Hach Spectrophotometer DR 2010 |
| Total Phosphorus | Hach Spectrophotometer DR 2010 |
| *p*H | Hach Sension *p*H meter |

**FM RIVER**

As described on Table 1, the FM River project is designed to provide the citizens of the Fargo—Moorhead metro area with accurate, time-relevant information on the quality of the Red River, the main source of drinking water for the community. The FM River project also provides information on basic measures citizens can take to protect water quality, promote the health of the river system, and promote appropriate recreational use of the river. The program includes regular water quality monitoring by Energy & Environmental Research Center (EERC) personnel as well as monitoring by citizen volunteers and students under the direction of River Keepers. The FM River information system combines these data with data from municipal, state, and federal agencies, to provide a capability to assess the physical, chemical, and biological data necessary to characterize and track the health of the Red River. River-monitoring activities occur at three locations along an approximately 20-mile segment of the Red River in the Fargo—Moorhead area shown in Figure 2 in Hartman et al. (this volume). The monitoring activities include physical and chemical water quality parameters and biological monitoring of macroinvertebrate communities. Relevant community water quality issues include total maximum daily load (TMDL) projects, source water protection, and Phase II storm water permit issues. River Keepers is collaborating with RRBRW in the Fargo—Moorhead area to promote and implement monitoring activities. Results from the FM River activities can be accessed at the FM River Web site at www.fmriver.org.

**Physical and Chemical Monitoring**

Since August of 2001, grab samples have been collected semimonthly from the Red River monitoring sites for water quality analysis using EPA-approved methods by EERC personnel. Beginning in the spring of 2002, students and community volunteers working through River Keepers and under the guidance of water quality specialists from the EERC will aid in sample collection and receive a split of the sample for analysis. The EERC sample split is analyzed by the EPA-certified laboratory at the Fargo Water Treatment Plant (FWTP), while the student/citizen split will be analyzed separately by the volunteers themselves under the supervision of River Keepers. EERC sampling is semimonthly while citizen/student volunteer sampling may not be held on a regular basis, depending on availability of volunteers and time constraints. Table 2 shows the parameters to be monitored.

**Macroinvertebrate Monitoring**

Macroinvertebrates, animals without backbones that live at least part of their life cycles in or on the bottom of a body of water, include aquatic insects such as mayflies, stoneflies, caddisflies, midges, and beetles as well as crayfish, worms, clams and snails. The monitoring of macroinvertebrates provide an indication of the overall health of the fluvial environment and reflects the effects of both short- and long-term perturbations in that system.

Because existing EPA-approved protocols for biomonitoring apply to swift, sand- or rocky-bottomed streams, studies are currently underway through groups such as the Biological Monitoring Working Group, to establish new protocols to support biological monitoring for low-gradient, mud-bottomed streams, like the mainstem Red and the lower reaches of its tributaries. One step in this process is the development of an appropriate biotic index that weighs the relative abundance of each taxon in terms of their pollution tolerance to produce a community score that can be used to rate the river=s health. The index will require calibration over several sampling periods and include existing data from several sources. These include the headwaters of a tributary to the Red River at Fargo–Moorhead (Buffalo River in Minnesota), results from the U.S. Geological Survey S National Water Quality Assessment Program Study, North Dakota Department of Health data from the Sheyenne River and the Red River near Wahpeton, North Dakota. Data from several reaches of the basin are required in developing an Index of Biotic Integrity (IBI) for the Red River Basin.

Through FM River, citizens and students are involved in the biomonitoring research activities planned for the Fargo–Moorhead area. Beginning in the fall of 2001, macroinvertebrates data are being collected each fall and spring at the same three locations for FM River chemical monitoring. At each sampling site, artificial substrates, mimicking the submergent vegetation and woody debris native to the river, are placed in the water. Retrieval occurs following a minimum 30-day colonization period. Dr. Bryan Bishop of Concordia College, Moorhead, Minnesota, is the technical supervisor for the activities.

The Fall 2001 sampling featured three types of artificial substrates – hester-dendy samplers, cottonwood slabs, and rock baskets. The substrates were tied together as indicated in Figure 2 and deployed as shown in Figure 3. Ekman grab samples of the river bottom were obtained adjacent to the artificial substrates. Citizen and Concordia College student volunteers help set and retrieve the substrates.

Because Fall 2001 was the initial biomonitoring event, a variety of processes were used to set and retrieve the substrates, including a pontoon, canoe, and small fishing boat. The pontoon worked well at 1st Avenue North because it was readily available, big and stable. The canoe worked well for sites that were too far from boat ramps to get to quickly, but not much equipment could be kept in the canoe at a time. When a boat ramp could not be used, it was sometimes difficult to get a canoe or small fishing boat in the river because of the muddy riverbank.

Barnesville (MN) High School students from Sheila Carlson's biology class identified and counted a portion of the macroinvertebrate sample using the River Watch Network Benthic Macroinvertebrate Monitoring Manual (Figure 4). Concordia College students checked preliminary identifications and have carried the identification of the material to the genus level.

A volunteer day is scheduled for April 6, 2002, to finish identifying the macroinvertebrates from the fall 2001 sampling event. Discussions with teachers suggest that the opportunity exists to involve entire classes throughout the process, not just the sampling and initial identification and counts. After the spring 2002 floodwaters subside, a schedule will be set for the spring substrate deployment, retrieval, and macroinvertebrate identification and counting.

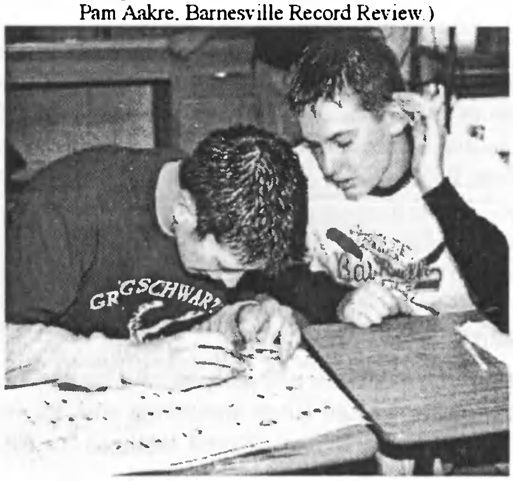

**ACKNOWLEDGMENTS**

Red River Basin River Watch activities have been funded by grants from the Minnesota Board of Water and Soil Resources and the Minnesota Department of Natural Resources flood damage reduction initiatives through the Red River Watershed Management Board. Local support to schools has been provided by county Soil and Water Conservation Districts and Watershed Districts in the Red River Basin. This activity was also funded in part by a grant to the EERC from the National Science Foundation (to Joseph Hartman, NSF EAR00-85583) and grants to the EERC from the U.S. Environmental Protection Agency (to Dan Daly and Charlene Crocker, EPA NE 998221-01) and to the FM River Project (EPA X988394-01).


**Figure 2.** River Keepers volunteers display three artificial substrate types: from left to right a rock basket, Hester-Dendy substrate, and cottonwood slab.

**Figure 3**. River Keepers volunteers mark deployed artificial substrates for macroinvertebrate monitoring with empty milk jugs at monitoring Site 1-RR

**Figure 4.** Barnsville High School biology student Dan Kava inspects the collected critters while his partner, Mason Askegaard, looks on. (Photo credit and content to Pam Aakre, Barnesville Record Review.)



# SCIENCE – WHERE THE PARK RIVER, THE LABORATORY, AND STUDENTS MEET

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## INTRODUCTION

Science education is not merely book learning. Our school encourages students to discover the possibilities for wonder in our own backyard, a great river site about five miles down the road. Edinburg High School (EHS) did not have the skilled personnel, equipment, or supplies to gather and analyze data collected from the Park River. The Red River Geoscience Education (RRGE) pilot project provided the "missing piece" in the science curriculum at EHS.

For three years, the 7th and 10th grade biology students went to the Park River Bible Camp area to assess the river's quality by interpreting the macroinvertebrate fauna. By collecting, counting, and identifying the macroinvertebrates, we knew the water quality was quite high because we found pollution intolerant species each time. However, we lacked quantitative evidence about the chemical content of the water and physical features of the stream. Through the RRGE, EHS 11th and 12th graders had a meaningful field and lab experience that met all the goals for the curriculum that the school alone could not provide.

### Project Goals

Provide a hands-on experience to answer a question about a real issue that impacts the students' lives.
Use technology appropriately to collect and analyze meaningful data in the field and the laboratory.
Give the students the opportunity to job shadow scientists and have a working experience.
Apply all steps of the scientific method.
Create enthusiasm for science.

### Study Area

All of the river studies were conducted on the South Branch of the Park River (Figure 1). We chose two sites near the Bible Camp. Site 1 are on the west side of the Bible Camp bridge on Hwy 32, which is 6 mi south of Edinburg. The most complete data are from this site and are the only data used in this report. Site 2 is downstream to the east of Site 1. It is north of the Bible Camp at the reshaped riverbank area (changed in the spring of 2000). All the laboratory testing was done in the EHS science laboratory.

## METHODS

### Background

We completed field sampling and laboratory analyses on the same day. The first times, we used five periods out of a seven-period school day. We subsequently extended the class time frame to a full day (morning for field experience, afternoon for laboratory study). Project dates in 2001 and class participation are as follows: 1) April 18, nine students from 12th grade Chemistry Class; 2) May 3, 12 students from 11th grade Chemistry Class; and 3) October 9, 15 students from 11th and 12th grade Physics Class. We depended on the following resource people to accomplish our task: Dave Rush (Red River Regional Coucil [RRRC]), Allen Schlag (University of North Dakota [UND] Department of Geology and Geological Engineering), Charlene Crocker and Wesley Peck (Energy & Environmental Research Center [EERC]), and Loretta Monson (EHS). Funding was provided by a National Science Foundation grant (to Joseph Hartman of the EERC), the RRRC, and Edinburg High School.

### Field Procedures

Physical Description of the Stream. To measure the cross section of the stream, we used a measuring rod, telescopic instrument, and a weighted tape measure. The depth of the river was taken at approximately 2-ft horizontal intervals. Water temperature was measured by using an Orion pH meter and electrode in freely flowing water.

The surface stream flow was measured using an orange and a stopwatch. As the orange traveled down the river, it was timed between two fixed points. We then measured the distance between the points and calculated the speed. The mean stream flow was measured using a Pigmy flowmeter.

**Water Collection.** The water collection was done in a very meticulous manner. A person holding the water collection bottle inverted it at least three times into the water before taking the actual sample. The person stood downstream so as to not contaminate the sample. The cover was placed on the bottle under the water to prevent additional oxygen from entering the sample. Five samples were taken; one was to be tested for dissolved oxygen, two for phosphates and nitrate, and two for fecal coliforms. Chemicals (manganous sulfate, alkaline iodine azide, and sulfuric acid) were used to preserve the water for the dissolved oxygen tests.

To collect water for fecal coliforms testing, a 180-mL Whirl-Pak bag was opened just before immersing it in the water. Pull-tabs were used to allow the water flowing from upstream into the bag. While still submerged, the tabs were used to close the bag. After removal from the water, the tab was folded over and the bag was swirled three times. The sample was collected above river bottom sufficient to avoid substrate-based fecal coliform bacteria contamination. The samples were placed on ice. Analysis was done as quickly as possible to minimize changes in the bacterial population.

**Laboratory Procedures**

**Nitrate Testing.** Prior to starting the nitrate-nitrogen analysis, all glassware was appropriately cleaned. Standard concentrations of nitrate–water solutions were prepared starting with the intermediate standard. Using a micropipette dispenser with a clean tip, 5000 μl of the stock standard was mixed with enough water to make 100 mL of solution. The intermediate standard was used to prepare the low and high standards and spike sample.

To prepare the low standard, a new clean pipette tip was used to transfer 400 μl of the intermediate standard into enough deionized water to make 25 mL of solution. This was appropriately mixed and covered. To mix the high standard, 4000 μl of intermediate standard was mixed with enough deionized water to a volume of 25 mL. This solution was also mixed and covered. To make the spike sample, a cylinder was first rinsed with water from the sample to be spiked. Second, 400 μl of the intermediate standard were then added with enough sample water to equal 25 mL of solution. We measured 25-mL additional samples including the reagent blank (deionized water only), field blank (sample only), and duplicate (sample water again). Each sample was poured into its own flask and labeled.

A Hach DR 2010 spectrophotometer was used to analyze each sample. The spectrophotometer was calibrated for the desired wavelength. The contents of one NitraVer 5 nitrate reagent powder pillow were added to each flask. After sealing, flasks were shaken with a uniform vigor for 1 minute. The flasks were then left to react and settle.

The reagent blank and a sample were placed into separate clean cuvettes, avoiding the transfer of cadmium residue. The reagent blank was used to zero in the spectrophotometer, initially and between each sample's analysis. The machine compared light transmission through known concentrations of nitrate solutions to the light transmission through each sample.

**Phosphorus Testing**. Standards of known concentrations were prepared first by transferring 0.4 mL of the stock standard into enough deionized water to make 100 mL of solution. Twenty-five mL of this solution became the low standard and was set aside. The high standard was prepared in the same way, except 2.4 mL of the stock standard was added to the required amount of water to make 100 mL of solution. Again, 25 mL of this solution was set aside and labeled appropriately.

To prepare the spike sample, we rinsed a flask with water from the sample to be used for the spike. Then 0.4 mL of the stock standard was mixed with enough stream water to make 100 mL of solution. Twenty-five mL of this solution was measured.

The reagent blank was an uncontaminated sample of deionized water. Two-25 mL samples of stream water were placed into bottles, one labeled field blank and the other, duplicate. The contents of one potassium persulfate powder pillow were added to each sample and swirled. We added 2.0 mL of sulfuric acid solution to each flask using a micro-pipette dispenser. The flasks were placed on a hot plate and simmered for 30 minutes. The volume of 20 mL per sample was maintained during simmering by adding small amounts of deionized water. The flasks were then removed from the hot plate and cooled to room temperature. 2.0 mL of sodium hydroxide solution was added to each flask and swirled. The contents of each flask were poured into a 25 mL graduated cylinder, and deionized water was added until the volume reached 25 mL.

The samples were tested on the spectrophotometer after it was set to the meter to the correct wavelength. The contents of one PhosVer 3 phosphate powder pillow were added to each flask; 10 minutes were allowed for the contents to react. We poured 25 mL of the sample to be tested into an acid-washed cuvette and wiped dry with a Kim-wipe before placing into the spectrophotometer. This procedure was repeated until all standards and samples were tested and recorded.

***p*H Testing.** The *p*H content was measured using an Orion Model 250A pH meter. After the meter had been calibrated we collected a sample of water in a clean beaker (triple rinsed with deionized water and the sample water). The probe was rinsed with deionized water and placed in the sample. The measure key was pressed on the meter to receive the results. This procedure was repeated until the meter produced the same number three times.

**Fecal Coliform Testing**. The fecal coliform bacteria test was performed using membrane filtration. First, a water bath was prepared with distilled water. The temperature was stabilized at 35°C. The filter apparatus was set up with a vacuum flask funnel adapter and filter funnel. Next, a petri dish was prepared. Contents of the m-ColiBlue 24 were poured evenly over the absorbent pad. A cover was placed on the petri dish. Then, 20–30 mL of buffered dilution solution were added to a new filtered funnel. Ten mL of the sample were placed into the filter funnel using a sterile pipette. The vacuum was applied along with the filter sample. After the vacuum was turned off, the filter funnel was removed. Using sterilized forceps, the filter membrane was removed from the pad and transferred to the previously prepared petri dish. The filter was placed grid side up on the absorbent pad. The lid was placed on the petri dish and the petri dish was inverted. This process was repeated for each sample. After all the petri dishes had been prepared, they were stacked and wrapped tightly in Parafilm. The petri dishes were put into a resealable bag removing as much air as possible. They were placed in another resealable bag. Finally, the petri dishes were placed into the water bath using weights to hold the inverted petri dishes completely under water. Samples were incubated at 35° C for 24 hr. The petri dishes were then removed and the membranes were examined for colony growth.

**Dissolved Oxygen Testing**. The dissolved oxygen in the water was analyzed using the Winkler titration method. Materials used were 30 mL of 0.2 N $Na_2S_2O_3$ for each sample, one 50-mL burette, one 100-mL graduated cylinder, two 250-mL Erlenmeyer flasks, Parafilm, a starch indicator, a transfer pipette, and a dissolved oxygen laboratory data collection sheet.

The 50-mL burette was set up with the 0.2 N $Na_2S_2O_3$ solution. A sample volume corresponding to the expected dissolved oxygen concentration was selected. The expected dissolved oxygen range was >10 mg/l dissolved oxygen, so 50 mL of sample were transferred to a flask. This flask was placed under the burette. The burette tip was sealed to the flask using Parafilm.

The starting volume of the 0.2 N $Na_2S_2O_3$ (titrant) in the burette was recorded on the laboratory data sheet. Slowly, we started dripping 0.2 N $Na_2S_2O_3$ into the flask. The flask was swirled constantly while the titrant was added. We continued titrating the sample in the flask until it turned pale yellow in color. Once it had turned pale yellow in color, 1 mL (1.0 mg/L) of starch indicator solution was added to the flask and swirled to mix. A dark blue color developed. Titrating was then continued until the sample solution became clear. Great care was taken approaching the end point of the titration because change rapidly occurs. Once the sample had turned completely clear, the volume of titrant left in the burette was recorded on the lab data sheet.

Trials were repeated three times per sample and the average titrant used was calculated. This number was then multiplied by the digit multiplier (in this case 0.2400) to determine the dissolved oxygen level. Dissolved oxygen percent saturation was calculated by dividing the average dissolved oxygen value for each sample in mg/L by the maximum dissolved oxygen possible for water to contain at the field temperature of the sample being measured.

## RESULTS

**Physical Description of the Stream**. On April 18, 2001, the conditions at the sites were clear and cold. Water flowed freely at 3.65 ft/s and the river was bankfull. The river was teeming with life. The rocks were covered with moss and algae, and minnows swam uninhibited. Foam was observed floating on the water. On May 3, 2001, the water was clear and odorless. The conditions were like those on April 18. On October 5, 2001, the conditions were similar. The sky was clear, and there was a slight breeze blowing from the southwest. It was sunny but cool. The water was clear, emitting no odor. Rocks were present due to the dam upstream. Moss grew on the rocks, along with some algae. Many signs of life were again noted. Frogs, minnows, and water bugs were prevalent.

**Analytical Studies**. The following tables and comments summarize our water sample analyses.

**Table 1**

**Nitrate–Nitrogen Results**

| | Site 1 | | | Site 2 | | |
|---|---|---|---|---|---|---|
| **Date** | 4/18 | 5/3 | 10/9 | 4/18 | 5/3 | 10/9 |
| **Field Blank** | 0.02 | 0.02 | _ | _ | _ | _ |
| **Low Standard** | 0.3 | 0.5 | 0.7 | 0.3 | 0.5 | 0.7 |
| **Spike Sample** | 2.3 | 1.2 | 0.6 | 2.2 | 1.2 | 0.6 |
| **Sample** | 2.0 | 0.8 | _ | 1.9 | 0.5 | 0.2 |
| **Duplicate** | _ | _ | 0.3 | 1.8 | 0.8 | _ |

Our Site 2 results for the nitrate–nitrogen tests are more consistent. This could be explained by students having more experience in methods and procedures for taking and testing samples. The natural level of nitrate is typically less than 1 mg/L. Higher values can be associated with spring runoff (1).

**Table 2**

| **Phosphorus Results** | Date | |
|---|---|---|
| (mg/L P) | 5/3 | 10/9 |
| **High Standard** | 0.37 | 0.38 |
| **Low Standard** | 0.02 | 0.07 |
| **Field Blank** | 0.00 | 0.00 |
| **Spike Sample** | **0.23** | **0.11** |
| **TOTAL PHOSPHORUS** | **0.20** | **0.08** |

Phosphorus rates were often higher than U.S. Environmental Protection Agency (EPA) criteria (2). Our measurements showed elevated levels in May, associated with spring runoff carrying fertilizer components and livestock waste.

**Table 3**
***p*H Results**

| Date | pH |
|---|---|
| April 18 | 8.15 |
| May 3 | 7.00 |
| October 9 | 7.96 |

The value of our May pH readings are in doubt. North Dakota surface waters show higher pH levels. Possible problems include use of a defective electrode, poor meter calibration, or residual acid in sample bottles.

**Table 4**
**Fecal Coliform Results***

| | Date | | | |
|---|---|---|---|---|
| | April 8 | | May 3 | |
| sample | 1 | 2 | 1 | 2 |
| Volume Filtered (mL) | 1 | 5 | 1 | 5 |
| Fecal Colonies per 100 mL sample | 2500 | 1900 | 1100 | 840 |
| *E. coli* Colonies per 100 mL sample | 500 | 160 | 300 | 80 |

* All samples were incubated for 24 hr at 35°C.

North Dakota standard for fecal coliforms in water used for recreation is 200 colonies/100mL (3). Our concerns include doubtful accuracy (collection of data may be problematic, with a high dilution rate skewing statistics). Further investigations should 1) look for possible pollution sources upstream, 2) collect data again at same time frame, and 3) include attaining more experience in colony counting and recording.

Table 5
**Dissolved Oxygen Results**

| Date | Average Dissolved Oxygen (mg/L) |
|---|---|
| April 18 | 11.17 |
| May 3 | 10.15 |
| October 9 | 11.14 |

Dissolved oxygen greater than 5 mg/l is good (1). All three measurements at Site 1 are well above this value.

## DISCUSSION

### Value of Experience

The ecosystem of the Park River was great for this study because it is an integral part of our community. The upper branch of the watershed is an important agricultural area, and we think that our results show that the farming practices used in the Park River watershed have an impact on the environment that needs to be further studied. Our findings show that the Park River nitrate content is quite low, while the phosphate content is a little high and the dissolved oxygen content is quite high. The fecal coliform content is exceedingly high, but we doubt the validity of this result and suggest additional analysis.

All of the students involved in this study now understand the process of science as represented in water quality work. We learned how to eliminate variables and how to use the cross-checks that have been built into these experiments to prevent errors. We learned how to use standards to prepare an instrument and not necessarily trust the results without due consideration. While trying to analyze our data, we have realized that a complete data set with quality values is exceptionally important. These are important learning achievements for our students.

In doing this study, we worked our way through every step of the scientific method. We hypothesized, experimented, collected data, and analyzed our data. We repeated our experiments on three different occasions. This paper marks the last step of the process, communicating results. It has been a great experience for us to write this paper, because for the first time, we are sharing our results with someone other than our classmates and teacher. Deciding what is relevant and reasonable has been a challenge.

The careful measurements and tests that were done have helped us develop a sense of the precision and accuracy required in research science. It has also been a great experience to work hand in hand with trained scientists to generate actual results that we used to analyze our local watershed. We feel that we have vastly increased our understanding of the methods necessary to do this type of study.

### Problems

In writing this paper, we have discovered that in the beginning we did not see the big picture. We did not realize how much data need to be recorded in an orderly fashion. This lack of understanding led to incomplete data recordings and less than ideal concentration. Our results would have been more meaningful had we some way to make a comparison (EPA standards, for example) while we were doing the testing. At the time, our results were simply a number with little meaning. Our class visit to the EERC provided an opportunity to compare water from various sources, but this occurred after our field and lab experiences at home.

When we began this study, all the students lacked the understanding and experience in experimentation and taking measurements. This is what led to accidental contamination, inaccurate measurements, and sloppy process at times, which led to inconsistent data. We noticed these problems dissipating as students gained experience.

**Successes**

All of the goals we set prior to this study have been met. We learned how to use cutting-edge instrumentation to collect data concerning an issue that has a real impact on our lives. We also had an excellent job-shadowing experience with our scientists, because we were encouraged to do the actual work while they mentored us. We were not standing around watching them do the experiments. We have decided that while all of the students are more enthusiastic about science, we would have been more focused and accountable had we known that we would eventually be writing this paper.

**Future Goals**

It is our hope that our school's science classes will continue to collect and analyze data and publish their results. We have done some research, and discovered that there is insufficient water quality data on the Park River. This project gives students the opportunity to learn field and lab processes and gathers needed data. In order to continue in this study, we need support from the RRGE Program and the EERC, both with technological equipment and also the people with the technical expertise to use it. We also hope to get other schools involved, and perhaps have them work on the other branches of the Park River, so that we can collaborate to publish results on the entire Park River watershed.

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3. EPA, 2002, Coliform: WWW.epa.gov/OST/beaches/local/sum2/html.

# THE IMPORTANCE OF HANDS-ON LEARNING EXPERIENCES FOR SCIENCE-BOUND YOUTH

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## INTRODUCTION

Last spring, the geology classes at Red River High School conducted an experiment to gain a total chemical and physical view of the Red River of the North. With the help of Charlene Crocker and Dan Daly of the Energy & Environmental Research Center (EERC) (1), we were able to learn technique and instrumentation from professional scientists. This experience was critical in our gaining a greater understanding of water quality in relation to urban development as well as gaining experience in what it means to conduct scientific research. Students were provided a chance to obtain an enthusiasm for science and an interest in a geological career. Hands-on learning experiences provided students with five main opportunities: 1) the ability to interact with professionals in specific fields of study; 2) to view the kinds of studies that professionals perform in their career; 3) use of high-tech equipment that many high schools lack; 4) to develop their own unique learning style in an enhanced way; and 5) an experience in a field of study that motivates and excites them about their future. Our experiment last spring satisfied all of these objectives. The three geology classes, taught by Mr. Scott Berge at Red River High School, were able to meet and interact with Ms. Crocker, Mr. Daly, and Mr. Alan Schlag (University of North Dakota Department of Geology and Geological Engineering). By working with these scientists, we were able to see what a career in the science field entails. We were given a wonderful array of equipment to use, both in the field and in the laboratory. The experience was exciting for us all and was motivational as well. I know of two students who participated in the project last spring who now plan on pursuing a career in geology in the future. As far as learning methods are concerned, hands-on learning is effective because it utilizes more than one technique. Thus the information provided has a better chance of being remembered (2). This means that hands-on learning is not only effective for kinesthetic learners, but for all students.

## METHODS

Three water-sampling sites were chosen on the basis of their location relative to the city of Grand Forks. Site 1 is downriver and located on the north side of 11th Avenue North at the English Coulee (see Table 1). Site 2 is upriver and located near the junction of Grand Forks County Road 5 and 32nd Avenue South. Site 3 is located upriver from the influent of the English Coulee at the Sorlie Bridge crossing the Red River of the North. Water was sampled on April 24, 2001, May 11, 2001, and May 17, 2001. We were split up into groups of three or four to collect the samples and the respective data in the field and laboratory.

With the help of Ms. Crocker and Mr. Daly, we were able to utilize several high-precision EERC instruments. We used the YSI 85 dissolved oxygen (DO) meter to collect data on dissolved oxygen, temperature, electrical conductivity, specific conductance, and salinity of the water. We recorded air and water temperatures using a thermometer and turbidity using a transparency tube. A global positioning system receiver (GPS) was used to locate the sampling site by latitude and longitude. In the lab, we measured dissolved oxygen using titration methods. The nitrate, phosphate, and total phosphorus were found using colorimetric analysis on a Hach 2010. We used an Orion pH meter and electrode to measure pH levels and a La Motte 2008 turbidimeter to measure turbidity levels.

## RESULTS

The tables below show the data retrieved on each of three collection days.

(see Tables 1 to 3 on the following pages)

Table 1
**April 24, 2001**

| Test | Units | Method | Site 1 | Site 2 | Site 3 |
|---|---|---|---|---|---|
| Temperature | °Celsius | YSI 85 DO Meter | 7.3 | 6.0 | 6.7 |
| Dissolved $O_2$ (field) | % Saturation | YSI 85 DO Meter | 102.9 | 93.0 | 80.3 |
| Dissolved $O_2$ (field) | mgm/L | YSI 85 DO Meter | N/A | N/A | N/A |
| Electrical Conductivity | mS/cm | YSI 85 DO Meter | N/A | 102.2 | N/A |
| Specific Conductance | mS/cm | YSI 85 DO Meter | N/A | 16.4 | N/A |
| Salinity | ppt | YSI 85 DO Meter | N/A | 0.8 | 0.2 |
| Air Temperature | °Celsius | Thermometer | 9.0 | 10.0 | 13.0 |
| Water Temperature | °Celsius | Thermometer | 8.0 | 8.0 | 7.0 |
| Turbidity | cm | Transparency Tube | 45.2 | 12.3 | 16.2 |
| Waypoint | Latitude | GPS | 47° 54.885' | 47° 53.284' | 47° 55.648' |
| Waypoint | Longitude | GPS | 97° 04.400' | 97° 10.477' | 97° 01.624' |
| Stream Depth | ft | N/A | 6.2 | 2.3 | 41.9 |
| Stream Width | ft/in. | N/A | N/A | N/A | N/A |
| Surface Stream Flow | ft/sec | Grapefruit and Stop Watch | 0.0 | 0.9 | 4.1 |
| Dissolved $O_2$ (lab) | % Saturation | DO Titration | 133.0 | 76.0 | 91.0 |
| Dissolved $O_2$ (lab) | mgm/L | DO Titration | 15.8 | 9.0 | 11.0 |
| $NO_3$ | mgm/L | Colorimetric | 0.3 | 0.3 | 1.9 |
| pH | pH | pH Meter | 7.34 | 7.13 | 7.82 |
| Phosphate | mgm/L | Colorimetric | 0.24 | 0.18 | 1.1 |
| Total Phosphorus | mgm/L | Colorimetric | 0.08 | 0.06 | 0.37 |
| Turbidity | NTU | Turbidimeter | 9.2 | 6.8 | 137.6 |

Table 2
**May 11, 2001**

| Test | Units | Method | Site 1 | Site 2 | Site 3 |
|---|---|---|---|---|---|
| Temperature | °Celsius | YSI 85 DO Meter | 12.6 | 13.9 | 14.1 |
| Dissolved Oxygen (field) | % Saturation | YSI 85 DO Meter | 95.3 | 95.4 | 94.8 |
| Dissolved Oxygen (field) | mgm/L | YSI 85 DO Meter | 10.1 | 9.61 | 9.7 |
| Electrical Conductivity | µS/cm | YSI 85 DO Meter | 1227 | 1350 | 484 |
| Specific Conductance | µS/cm | YSI 85 DO Meter | 1609 | 1715 | 570 |
| Salinity | ppt | YSI 85 DO Meter | 0.8 | 0.9 | 0.3 |
| Air Temperature | °Celsius | Thermometer | 40.0 | 55.0 | 65.0 |
| Water Temperature | °Celsius | Thermometer | 13.0 | 15.0 | 17.0 |
| Turbidity | cm | Transparency Tube | 60.0 | 27.0 | 5.0 |
| Way Point | Latitude | GPS | N/A | N/A | N/A |
| Way Point | Longitude | GPS | N/A | N/A | N/A |
| Stream Depth | ft | N/A | 2.03 | N/A | N/A |
| Stream Width | ft | N/A | 26.0 | N/A | 328.0 |
| Surface Stream Flow | ft/sec | Grapefruit and Stop Watch | 1.4 | 1.4 | 3.6 |
| Dissolved Oxygen (lab) | % Saturation | DO Titration | 90.0 | 98.0 | 76.0 |
| Dissolved Oxygen (lab) | mgm/L | DO Titration | 9.6 | 9.16 | 7.82 |
| $NO_3$ | mgm/L | Colorimetric | 0.2 | 0.6 | 0.9 |
| pH | pH | pH Meter | 8.01 | 8.22 | 8.6 |
| Phosphate | mgm/L | Colorimetric | N/A | N/A | N/A |
| Total Phosphorus | mgm/L | Colorimetric | 0.0 | 0.10 | 0.18 |
| Turbidity | NTU | Turbidimeter | 1.3 | 14.8 | 86.9 |

Table 3
**May 17, 2001**

| Test | Units | Method | Site 1 | Site 2 | Site 3 |
|---|---|---|---|---|---|
| Temperature | °Celsius | YSI 85 DO Meter | 16.7 | 18.5 | 18.6 |
| Dissolved Oxygen (field) | % Saturation | YSI 85 DO Meter | 73.5 | 97.0 | 96.5 |
| Dissolved Oxygen (field) | mgm/L | YSI 85 DO Meter | 7.19 | 9.10 | 9.00 |
| Electrical Conductivity | µS/cm | YSI 85 DO Meter | 1469 | 1646 | 692 |
| Specific Conductance | µS/cm | YSI 85 DO Meter | 1745 | 1882 | 795 |
| Salinity | ppt | YSI 85 DO Meter | 0.9 | 1.0 | 0.04 |
| Air Temperature | °Celsius | Thermometer | 17.0 | 20.0 | 17.0 |
| Water Temperature | °Celsius | Thermometer | 15.0 | 18.0 | 20.0 |
| Turbidity | cm | Transparency Tube | 60.0 | 21.2 | 8.0 |
| Way Point | Latitude | GPS | N/A | N/A | N/A |
| Way Point | Longitude | GPS | N/A | N/A | N/A |
| Stream Depth | ft | N/A | 2.0 | 2.1 | N/A |
| Stream Width | ft | N/A | 18.3 | 26.17 | N/A |
| Surface Stream Flow | ft/sec | Grapefruit and Stop Watch | 0.86 | 1.8 | 4.0 |
| Dissolved Oxygen (lab) | % Saturation | DO Titration | 64.0 | 53.0 | 45.0 |
| Dissolved Oxygen (lab) | mgm/L | DO Titration | 6.4 | 8.12 | 6.9 |
| $NO_3$ | mgm/L | Colorimetric | 0.2 | 0.5 | 0.9 |
| pH | pH | pH Meter | 6.46 | 6.79 | 8.83 |
| Phosphate | mgm/L | Colorimetric | N/A | N/A | N/A |
| Total Phosphorus | mgm/L | Colorimetric | 0.09 | 0.16 | 0.22 |
| Turbidity | NTU | Turbidimeter | 1.2 | 11.3 | 56.5 |

## CONCLUSION

This experience was an introduction to gathering data and conducting scientific experiments for many students at Red River High School. The sampling and analyses sparked our critical thinking skills and motivated us to want to learn more about research methods. As students, we were exposed to the level of evaluative thinking of professional scientists and gained familiarity with high-tech equipment. The experience was valuable for all learners, as an understanding of quality research methods is needed in just about every field of study and inquiry.

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2. Haury, D.L., and Rillero,P., 1994, Perspectives of Hands-On Science Teaching: Columbus, Ohio, ERIC Clearinghouse for Science, Mathematics, and Envionmental Education.
3. Data collected by students of Scott Berge, Geology teacher, Red River High School, Grand Forks, North Dakota

# PROMOTING GEOSCIENCE EDUCATION THROUGH DIGITAL IMAGERY – USING GeoDIL IN THE CLASSROOM

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## INTRODUCTION

The geosciences provide stimulating fields of research, but somehow, few nongeologists associate mountains, earthquakes, flooding, fossils, or volcanoes with the exciting work done by geologists or geoscientists. Sure, some people know this is what geologists do, but why do so few people take Earth science classes in college and why do so many governmental agencies lack Earth scientists on their payrolls? Why did my (Hartman) parents and their brothers and sisters invest in a gas well many years back and not even think to ask their geologist son what he thought of the idea? Besides the obvious possible parent–son communication problems, we think there is some sort of misconception about what geologists do or accomplish, even with famous actors playing volcanologists or paleontologists in recent movies.

This communication is an overview of a new Web-based image database called GeoDIL, a geoscience digital image library that we think can eventually play an important role in communicating what geoscientists do and how they interpret their data. For the present, GeoDIL is a sophisticated search and browse engine tied to an image collection of around 3000 high-resolution photos, along with capabilities of virtual carousel construction and electronic classroom projection. We envisage GeoDIL to be much more as we, and other teachers, design study plans around the imagery. The result, we hope, will be that GeoDIL will be more than pretty pictures, but an integrated resource of educationally stimulating, well-documented images that bring home the message of the importance of Earth studies to all citizens and, hence, their elected public officials.

## ABOUT GeoDIL

GeoDIL was conceived as a visual learning environment that provides an opportunity for excitement concerning the features and processes of the geosciences. With this idea in mind, we proposed a digital image library project to the National Science Foundation (NSF). We believed that the proposal was funded because we intended to document images included in the database in a way that would separate our GeoDIL Web site (1) from quality images available elsewhere on the Web. Thus images are searchable or browseable on a number of geographic and geological parameters to make finding a desired image possible.

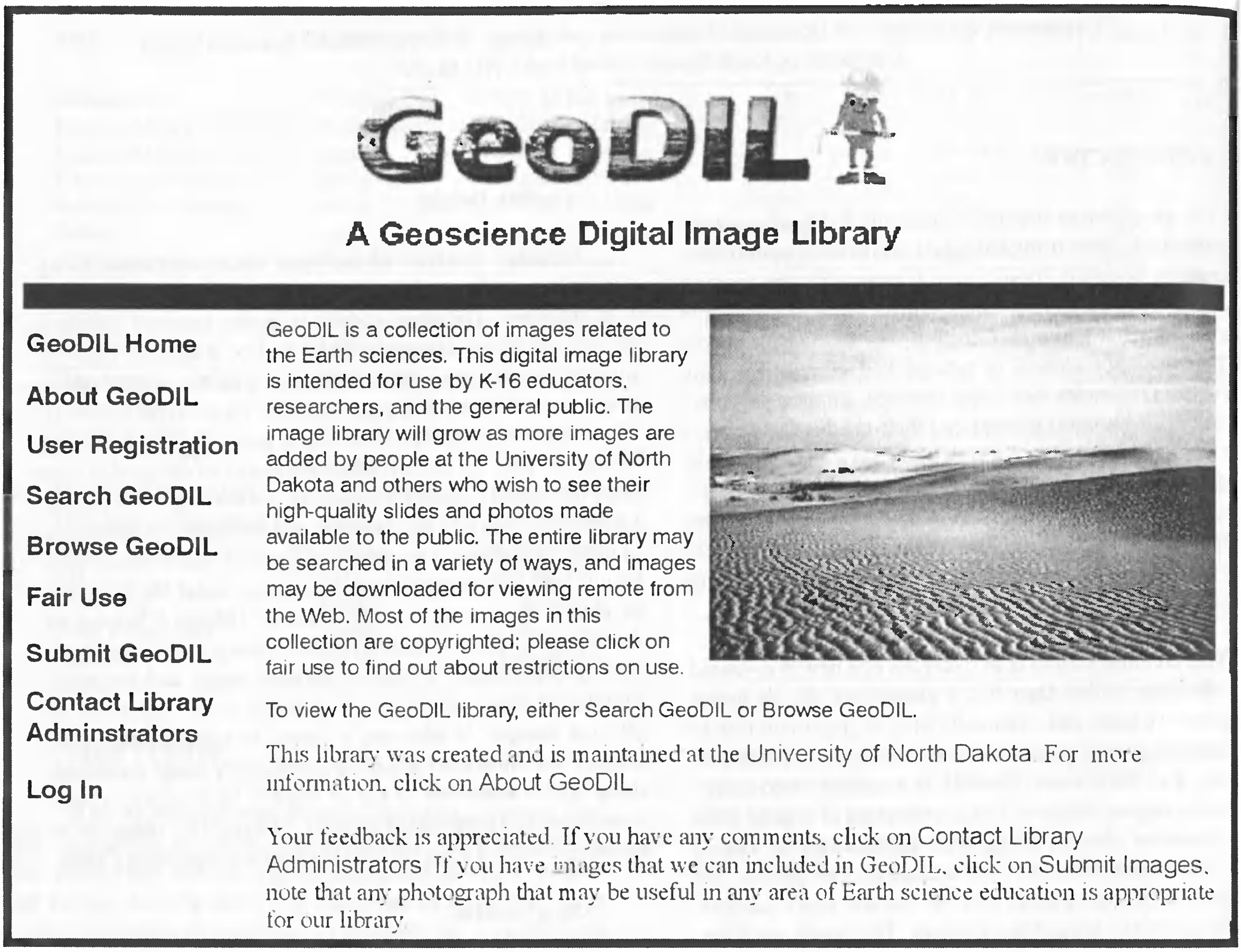
### GeoDIL Details

GeoDIL consists of an open database connectivity (ODBC)–compliant relational database with a custom-designed user interface. Database coding is in the industry standard structured query language (SQL). The database itself is invisible to all users, with interactions with the system taking place via a standard Web page interface (www.GeoDIL.com). The administrative side of GeoDIL is password-protected and accessible only to GeoDIL administrators and designated data entry personnel (GeoDIL librarians), not to the general public. Library staff can edit the database and facilitate the uploading of images for others. Our design of GeoDIL was implemented by our lead programmer Joseph Stevens, under the direction of Henry Borysewicz in the John D. Odegard School of Aerospace Sciences. GeoDIL includes integrated search-and-browse capabilities, a general-purpose image and metadata submission form, and a means to make virtual carousels of selected images. In addition, a means to communicate with GeoDIL administrators is available with every image presented, along with a statement of use of images for educational and noneducational purposes (Figure 1). The GeoDIL computer is secure and backed up in the UND Scientific Computing Center.

### Using GeoDIL

The public side of GeoDIL is where students, instructors, and anyone else interested in Earth sciences will go to find images. The public Web pages allow users to search the GeoDIL database for images that are of interest to them. Searches can be as simple as typing in a short text string and clicking "Search" (Figure 2). GeoDIL will search all database fields for the text string and return thumbnail images and a brief title of all images. Searches can be as complicated as entering information in any number of database fields (e.g., key words, location, photographer), which will restrict the possible selected images. All searches in any given session are saved and can be retrieved for subsequent use. A user may also browse GeoDIL (Figure 3). A number of hierarchical categories have been established (and more are created as needed) that permit the user to move through topics of interest. For example, if a person is interested in minerals, the mineral browse category includes choices for silicates, native elements, carbonates, and other mineral types. Clicking on silicates loads 10 of 132 silicate thumbnail images. Likewise, clicking on "Geologic Time" brings up all of the typical

Figure 1
GeoDIL Homepage – www.GeoDIL.com




geologic time intervals (e.g., Triassic, Cretaceous) that can be clicked on to load images of strata, fossils, or other features related to this time interval. In addition to these features, GeoDIL has an "Intimate Relationship" between images of closely related content. This feature permits GeoDIL librarians or the contributor to associate images that are intimately related. Upon retrieval of such an image, a note and direct link to other related images are provided.

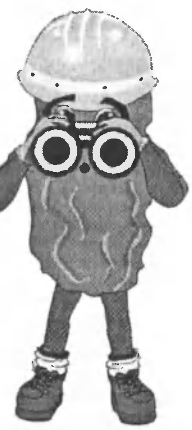
Users can view images at several different resolutions. Thumbnail resolution provides a quick way of viewing a large number of images (searches can return any number of requested thumbnails). Standard view provides the first retrieved size for a single image. On most monitors this image will be about 6 x 10 cm (2.5 to 4 in.). This image can be expanded to basically four times a standard 17-in. monitor. Thus considerable detail is available for viewing and potential study. Other projection sizes are available for classroom use.

Figure 2
Search GeoDIL

A quality feature of GeoDIL is the high print quality of its images. Unlike many other Web sites, we wish the image selected to be used by the viewer (see Fair Use below). This subsequent study or projection use requires initial input of digital images scanned or originally photographed at resolutions creating TIFF format files between 4 to 6 Mb. Once a thumbnail is selected, the original large-format file is converted to a JPEG format for quicker uploading.

Besides these display features, users have direct access to information about the image (supporting metadata). The supporting data are the most essential and ultimately unique part of our database. The combination of digital images and associated metadata allows the database to be effectively searched beyond the initial interests of the photographer. Standard information fields displayed currently include titles, key words, image collection (e.g., Hartman photograph C4277), photographer, date of the photograph, contributor of the images, copyright information, and information about the original image format. Boxes can be clicked to note whether the image is of a vista, outcrop, hand specimen, or thin section. Detailed location information can be provided along with stratigraphic and geologic time information. With the appropriate fields entered, a contributor can click on a number of boxes that help define the information content of the image. These boxes are directly linked to the browse fields available to subsequent users (as noted above).

Figure 3
Browse GeoDIL



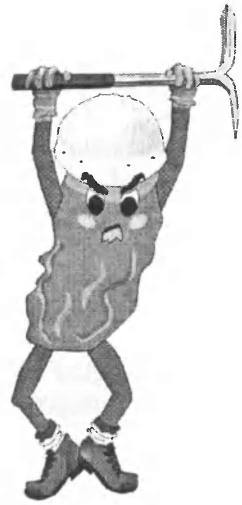
**Public Submission of Images**

The professional community and public are invited and, indeed, solicited to provide images to GeoDIL (Figure 4). Interested users can submit their own images for inclusion in the GeoDIL library. We are counting on submissions to help the library grow and make its selections all the more useful to a greater audience of users. We feel that GeoDIL is a community-based library that will grow as more images are added by people at the University of North Dakota (UND) and others who wish to see their high-quality slides and prints or digital photos made available to the public. As personal examples, the authors have many thousands of slides and prints that ultimately will see limited use beyond their research interests. We think that there are many other geoscientists who have amassed similar well-documented image collections who may appreciate the ability to share their photographic data worldwide while safely archiving the originals. Conversely, conversion to electronic format can also be considered archival, as images do not deteriorate, a fact not lost on the UND faculty member who had over 6000 photographs, slides, and negatives, destroyed in the 1997 Grand Forks flood.

Figure 4
Submit Images to GeoDIL

Anyone can contribute to GeoDIL. After a no-cost registration (for bookkeeping purposes only), a person can upload a file from a computer, fill in the blanks and click on some boxes and upload an image to the GeoDIL computer. The user can specify the copyright holder of the image (presumed otherwise to be the photographer). The uploaded image is categorized as a "recent submission." We, as GeoDIL administrators, are notified of such submissions and can evaluate the contribution for final submission. The only requirements are that the image be of Earth science interest (in its most encompassing sense and including paleontology and modern floral or faunal analogs), be in good taste, be of sufficient resolution, and provide appropriate documentation. Note that pretty pictures without provenance or description are just that, artifacts for calendar use, a worthy use, but will have no place in the GeoDIL collection. During the review period, contributors have the opportunity to edit their image and data, but after a contribution becomes public, only library administrators can make such changes. With the image made public, it is available to the contributor for classroom or other use or to any other user. We have a specific hope that students will find GeoDIL a resource to both submit and show off their images. Quality images uploaded at one location can easily be seen by informed associates and friends as well as by the unknown user.

Figure 5
Fair Use in GeoDIL



**Fair Use**

The images in GeoDIL are the property of those who submitted them to the library (Figure 5). A user may copy them as much as they like for noncommercial, personal, educational, or classroom use (see further explanation below), but redistribution in any way requires the permission of the person who owns the copyright. GeoDIL administrators or staff cannot grant the right to copy or redistribute any of the images in the library, but, where possible, will facilitate communication between interested commercial users and the copyright holder.

The U.S. Constitution and the Federal Copyright Act give photo owners exclusive rights to make copies, prepare other photos based on the original, distribute copies, and publicly display the photos. The same rights can be assumed to apply to digital images, although some complicated legal issues have not been completely resolved. However, there are generally two limitations to the author's rights: fair use and educational exemption. "Fair use" permits the use of work for criticism, comment, news reporting, teaching, scholarship, or research. "Fair Use" means incidental use. The owner's rights and interest remain protected. "Educational exemption" provides the educational community considerable freedom in using copyrighted material. Loading images from GeoDIL into virtual carousels or other image-viewing programs falls under the educational exemption category, provided 1) the organization using the material is a nonprofit educational institution, 2) the use is part of the regular curriculum of a class, 3) the material is in a classroom, 4) the material has been legally obtained, and 5) the material will not be copied or duplicated. Submission of an image to GeoDIL means to us that the submitter has allowed the image to be used for noncommercial, specifically, educational purposes. We interpret "educational" in a broad sense, meaning both classroom and nonclassroom use. If any questions arise from this usage, we should be contacted for clarification.

## GeoDIL AND EDUCATION

### In General

GeoDIL images are intended for students of all ages and all kinds, but we specifically hope that K–20 educators and the general public will use the library to make worthy value out of the tens of -thousands of images taken by geoscientists and others. Our aim was to create a digital resource that will ". . . serve educators and students of all types, at all grade levels, and in all locations . . . " (2).

To be successful to any one user, our library must contain a large number of useful and exciting photos. As the collection grows, those with an Earth science interest will find satisfaction in being able to select the appropriate image from a number of choices. Educators and researchers around the globe will have the opportunity to submit images on the local geological phenomena that would make for great examples for others living in different geological terrains and climates. We anticipate having as many as 10,000 images in the library within the next few years.

With the broad number of topics available in the geosciences, categorizing images for topics of interest they may represent is an ongoing activity. Teachers and other users are invited to comment on images and the interpretations that may be possible beyond what is already reported in GeoDIL. As contributors and users ourselves, we recognize that the reason we took a picture or what value we might see in the picture may be different than someone preparing a teaching lesson, a lecture, or a book report. By e-mailing us (GeoDIL@und.nodak.edu) or clicking on the "provide comments" button next to an image, the user can inform us as to which additional subject categories to make or text to include with a specific image. Recent category additions have concerned cultural features, such as petroglyphs (GeoDIL 312)and Earth materials in construction activities (GeoDIL 2424).

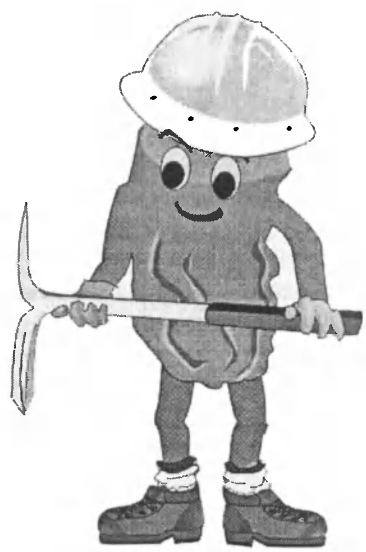
### Lesson Activities

GeoDIL can be used as a resource for imagery and information – a well-captioned photo book, as it were. By arranging selected images in virtual carousels, a lesson plan or storyboard can be constructed for classroom use. In a UND Earth Through Time class, I (Hartman) wished to show some examples of fossilization and methods of preservation. The images used were technically unrelated and used as necessary in class. The carousel consisted of images of chert nodules and chalk from the White Cliffs of Dover, England, a decomposing deer in leaf litter, shell accumulations along a North Carolina shoreline, and shells in drawers as part of a university collection. As no immediate cost (outside of having a scanner and computer and Internet link) is required to scan the image and upload it to GeoDIL, the images were uploaded before class and available for immediate use.

Carousels in GeoDIL are generally considered public. The organizing of images into a carousel and providing a carousel title means that image sets are available to any user. Although individual users are likely to have their own ideas of what they want to do, existing carousels (like one on the Grand Canyon) may help some users with new ideas or speed along the process of carousel construction.

One of early GeoDIL librarians, Tywla Baker-Demaray, has recognized the potential use of GeoDIL as a teaching resource at tribal colleges. Her presentations on GeoDIL have included lesson plans on the use of GeoDIL and the development of lesson plans. As individuals like Ms. Baker-Demaray access and implement GeoDIL for such purposes, models for the use of GeoDIL will become available to others, and educational goals of GeoDIL can be expanded to include suggestions by teachers.

Figure 6
Mr. GeoDIL



## IN SUMMARY

GeoDIL is a work in progress (Figure 6). We hope for feedback by contributors and users to make GeoDIL an obvious resource for images and geoscience information. Down the road, we wish to incorporate a geospatial component where images can be searched by map view. The addition of searchable map views, in addition to the current location searches, will make possible a wide variety of choices to the user in selecting images and constructing carousels.

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## ACKNOWLEDGMENTS

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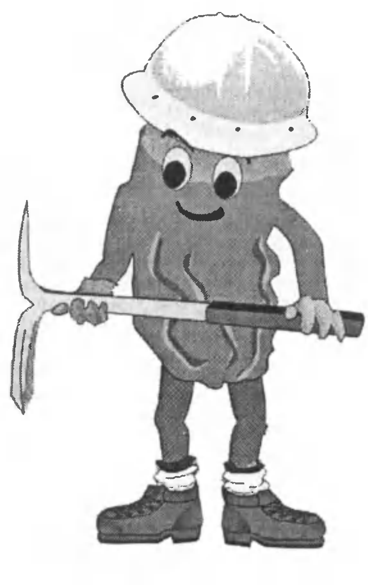
**Figure 6**
**Mr. GeoDIL**



# COMMUNICATIONS

## UNDERGRADUATE

**A. Rodger Denison Competition – Undergraduate Division**
**River Valley Room - Memorial Union**

**Moderator:** **Dr. Ron Jyring, Bismarck State College**

**Judges:** **Ms. Melissa Kennedy, University of North Dakota**
**Dr. Margaret Nordlie, University of Mary**

**1:15** Welcome Dr. Jyring

**1:20** "*Ectypodus lovei* from the Medicine Pole Hills local fauna (Chadronian, latest Eocene), Bowman County, ND, " Karew Schumaker* and Allen J. Kihm, Department of Geosciences, Minot State University.

**1:40** "Heavy mineral analysis of sandstone using an XRD-Rietveld Method." Roy P. Kight*, Christopher A. Cool, John R. Webster, and Ryan S. Winburn, Minot State University.

**2:00** "Comparison of population characteristics and morphological features of painted turtles from two sloughs in western Minnesota," Joanna M. Schmit*, Candice J. Zemlicka, Deanna M. Thompson, and Donna M. Bruns Stockrahm, Department of Biology, Minnesota State University-Moorhead.

**2:20** "Auxin induced leaf growth inhibition in *Phaseolus vulgaris*." Traci Tranby* and Christopher P. Keller, Minot State University.

**2:40** "Effects of light, growth history and temperature on larval life history parameters of *Ambystomatid* salamanders,"Lori S. Ihli* and Christopher K. Beachy, Department of Biology, Minot State University.

**3:00** BREAK

**3:20** "Correlation between variation in flight speeds and wing morphology of North American dabbling ducks (*Anus*)," William E. Langer*, Department of Biology, Minot State University.

**3:40** "The role of nitric oxide and oxidative stress in cardiac ventricular myocyte excitation-contraction coupling dysfunction under simulated diabetes," Lucy Esberg* and Jun Ren, Department of Pharmacology, Physiology, and Therapuetics, University of North Dakota.

**4:00** "Thermal desorption of mercury from coal fly ash," Amy L. Gieske,* Linnea M. Schluessler, and David J. Hassett, Energy & Environmental Research Center, University of North Dakota.

**4:20** "Dietary copper but not dietary zinc decreases protein kinase Cα expression and dimethylhydrazine-induced aberrant crypt foci formation in the rat colon," Erin Fox*, Cindy D. Davis, and W. Thomas Johnson, USDA-ARS Human Nutrition Center, Grand Forks.

**4:40** "The ontogeny of tibial spurs in *Eurycea* salamanders," Jessica Edgell*, Heidi Richter, and Christopher K. Beachy, Department of Biology, Minot State University.

# *ECTYPODUS LOVEI* FROM THE MEDICINE POLE HILLS LOCAL FAUNA (Chadronian, latest Eocene), BOWMAN COUNTY, N.D.

Karew K. Schumaker*, Allen J. Kihm
Department of Geosciences, Minot State University, Minot

**INTRODUCTION** The study of the Multituberculate, *Ectypodus lovei*, is part of a larger analysis of the small mammal fauna from the Medicine Pole Hills Local Fauna. The marsupials (1, 2) and the small artiodactyl, *Leptomeryx* (3), are the only portions of the fauna which have been studied in detail. The deposits of the Medicine Pole Hills are interpreted to be early Chadronian in age (3) and are currently being studied by Kight, Webster and Winburn (this volume). The Multituberculates are an extinct lineage of mammal, which had their first appearance in the Jurassic, are common in the early Tertiary and become extinct in the middle Chadronian (4).

**REFERRED SPECIMENS** (all PRTM) PU 4984; LP4 4932, 4934; RP4 2068, 4932, 4935; LM1 2029, 4840, 4842, 4925, 4928; RM1 1962, 2060; RM2 4937; Rp4 1328, 4938; Lp4 4927, 4933; Lm1 4841, 4930, 4936; Rm1 4931, 5481.

**DESCRIPTION** **p4** The one complete p4 (PTRM 1328) has 8 serrations (and one pseudoserration). The crown is high and arched in profile view. There is a well defined posterobuccal ledge which descends from the most posterior serration. **m1** The cusp formula is 7:4-5. The two rows of cusps meet on the anterior margin of the tooth. **m2** The sample contains no m2's. **PU** PTRM 4948 appears to represent an anterior premolar. It has a larger anterior-posterior dimension than lingual-buccal dimension. There is one dominant cusp which is on the buccal margin of the tooth and elongate in the anterior-posterior dimension. There are two accessory cusps, one is on the anterior margin of the tooth and the second cusp on the internal margin. **P4** **The** P4 is gently arched in profile view. The anterior slope is straight and the posterior slope is straight to slightly concave. The lingual margin of the tooth is concave. The cusp formula is 2-3:5:0. The penultimate cusp is the tallest on the internal row. **M1** The M1 is nearly rectangular in outline. In profile, the tooth is concave dorsally. The cusp formula is 6-8:8-9:4-6 and is highly variable. All cusps increase in size posteriorly. **M2** The M2 is triangular in outline. The buccal and lingual margins are virtually straight although obliquely oriented. The cusp formula is 1:2:3.

**DISCUSSION** All of the identifiable multituberculates that have been reported from post-Bridgerian rocks have been assigned to *Ectypodus* and nothing in our sample suggests a different genus. Sloan's (5) original diagnosis of *Parectypodus lovei* is primarily based on partial P/p4's, although he does gives a description of the molars. Krishtalka and Black (6) transferred the species from *Parectypodus* to *Ectypodus*, based on the morphology of a nearly complete p4, which showed a straight anterior slope, characteristic of *Ectypodus*, rather than a convex anterior slope, which is characteristic of *Parectypodus*. The complete p4 (PTRM 1328) in our sample has a straight anterior slope, supporting their conclusion. The Medicine Pole Hills has a nearly complete dental arcade, with the first complete p4, the first complete P4 and the first possible anterior premolar, lacking only the m2 among the cheek teeth. The morphology and the size range of the teeth in the Medicine Pole Hills sample match that of *Ectypodus lovei* as described by Storer (7). The only differences are in the M1 which shows a slightly different cusp formula, with fewer cusps in the external row. The fact that there are more complete M1's from the Medicine Pole Hills which do not differ greatly in their morphology from *E. lovei* from the Badwater Local Fauna, Raben Ranch Local Fauna or Lac Pelletier Lower Fauna samples, strongly suggests that they all represent the same species. The variation in the rest of the dentition falls within the range of variation seen in these samples. These differences do not suggest the presence of a second species of *Ectypodus*, but rather variation within a variable population.

**BIOCHRONOLOGY** The identification of *E. lovei* from the Medicine Pole Hills Local Fauna does not support or contradict the existing age interpretation of the Medicine Pole Hills deposits (3) because *E. lovei* has been reported from the late Uintan (5) to the middle Chadronian (8).

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# HEAVY MINERAL ANALYSIS OF SANDSTONE USING AN XRD-RIETVELD METHOD

Roy P. Kight[1]*, Christopher A. Cool[2], John R. Webster[1], and Ryan S. Winburn[2]
[1]Department of Geosciences, [2]Department of Chemistry, Minot State University, Minot, ND.

## INTRODUCTION

The major constituents of sandstones are quartz and feldspar grains, and in some cases lithic (rock) fragments. The nature and relative abundances of these grains reflect the source area and the transportation history. Sandstones also contain minor abundances of heavy mineral grains (densities > 2.85 g/cm$^3$). These heavy minerals also reflect the source area because different rock types contain different assemblages of these minerals. Heavy minerals can be very useful for determination of the source (provenance) and for correlation of sandstones, especially when interpretation of major constituent grains is ambiguous. The typical procedure for heavy mineral analysis involves: (1) sieving sand grains to obtain a particular size range within the fine to medium sand range, (2) density separation of heavy minerals using a heavy liquid, and (3) mounting the heavy mineral grains and counting the number of grains of each mineral using transmitted light microscopy. One problem with this method is that identification of the minerals by transmitted-light microscopy can be very difficult, and it is not useful for opaque grains. Also, despite the fact that a restricted sand size range is characterized, counting the number of grains of a particular mineral may not correlate well with its modal percentage.

This study focuses on development of a methodology for quantifying heavy minerals using X-ray diffraction (XRD) and the Rietveld method. Rietveld refinement of XRD data involves a least-squares method of matching the observed XRD pattern with calculated patterns of the minerals present. As long as the number of minerals involved is not too large, the Rietveld method should yield accurate mineral percentages. Also, compositional information can be obtained on solid solution minerals because the Rietveld refinement incorporates site occupancy. Thus, the Rietveld method yields more detailed information about the source rock(s) and should allow more detailed correlation (or differentiation) of sandstones.

## METHODS

The Rietveld heavy mineral method is being tested using an Eocene sandstone from the Medicine Pole Hills (MPH) south of Rhame, North Dakota. Heavy minerals were separated from a 0.18-0.30 mm size fraction using a lithium heteropolytungstate solution with a density of 2.85 g/cm$^3$. Some of the heavy mineral grains were mounted on glass slides, partially ground, polished, and coated with carbon for microanalysis using a scanning electron microscope equipped with an energy dispersive X-ray analysis system (SEM/EDX). Most of the heavy mineral grains were powdered and 0.9000 g were mixed with 0.1000 g of a powdered rutile internal standard for XRD analysis. The Rietveld method is evaluated by comparing refinement results with weight percentages based on volume percentages (number and size of grains) determined from optical microscopy and densities calculated based on SEM/EDX microanalyses.

## RESULTS

The combined optical and SEM/EDX work shows that the heavy minerals in the MPH sandstone consist of (by weight) diopside (59%), calcic amphibole (25%), almandine-rich garnet (5%), and a few less abundant phases including augite, talc-minnesotaite, grossular-rich garnet, and Fe-Ti oxide. The phases and their compositions suggest a dominantly metamorphic source for the MPH sandstone. Some quartz and feldspar are also found in the heavy mineral fraction because of less than perfect separation and/or their presence in composite grains with heavy minerals. In addition, the XRD results show several minor phases, such as hematite and goethite, which likely occur as inclusions within the heavy mineral grains or as weathering products. Results of Rietveld refinements will be compared with SEM/EDX results to evaluate the success of the Rietveld method

# COMPARISON OF POPULATION CHARACTERISTICS AND MORPHOLOGICAL FEATURES OF PAINTED TURTLES FROM TWO SLOUGHS IN WESTERN MINNESOTA

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## INTRODUCTION

In recent years, turtles have received renewed interest partly because of concerns pertaining to commercial harvest for food and the pet trade. The painted turtle (*Chrysemys picta*) is the most widely distributed North American turtle (1). It ranges from southern Canada to northern Mexico and from the Pacific Northwest to much of the Atlantic coastline. Due to the abundance of the painted turtle, many aspects of its morphology, habitat requirements, reproduction, and movements are available for study. However, many studies have taken place in habitats in the more southern parts of its range. Due to limited information on turtles in western Minnesota, the Minnesota Department of Natural Resources (DNR) is interested in our findings. Painted turtles display some sexual dimorphism, with the females being larger than the males. This size difference is seen in shell measurements, tail length, foreclaw length, and overall body size (1). The purpose of the study we present here is to compare population characteristics and morphological features of painted turtles from two different kinds of sloughs in Clay County, Minnesota.

## METHODS

Turtles were live-trapped during the summer and early fall of 2001 in two sloughs in Clay County, Minnesota. Both sloughs have undergone rapid expansion in the past several years. The larger slough has been in existence for over 30 years, whereas in 1997 the smaller slough was very shallow and less than 10 m in diameter. For each captured turtle, scutes along the outer edge of the carapace were notched in a unique pattern for individual identification. Turtles were also weighed, sexed, and measured for length and width of carapace, then released.

## RESULTS

Data for 250 turtles were analyzed, with 43 males and 28 females (1.54:1) from the smaller slough and 95 males and 84 females (1.13:1) from the larger slough. Turtles of both sexes were larger in the larger slough for all measurements, with the differences being more pronounced in females. A larger proportion of smaller females occurred at the smaller slough, with 53.6% (15/28) being below 400 g compared with only 10.7% (9/84) below 400 g at the larger slough. Because males are smaller than females in this species for all age groups, the size differences were not as pronounced in males. A canonical discrimination analysis using the variables weight, length, and width showed significant separation ($P < 0.0001$) between the males and females within the same slough for both sloughs. The same test showed significant separation when comparing females ($P < 0.0001$) between sloughs and when comparing males ($P < 0.0019$) between sloughs.

## DISCUSSION

The population of turtles in the smaller slough was morphologically smaller and presumably younger than the population in the larger slough. The smaller slough has not been in existence as long as the larger slough, and this might have contributed to the size differences noted. The females had greater size variation than the males, which can be expected due to their larger overall size. Rowe (2) studied growth rate, body size, sexual dimorphism, and morphometric variation in painted turtles from Nebraska. He found that sexual dimorphism was greatest in populations with relatively slow individual growth rates, but he goes on to say that this finding was inconsistent with the findings for other local populations of turtles. Our future research plans include monitoring growth rates, long-term survival rates, population dynamics, and nesting habitat use.

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# AUXIN-INDUCED LEAF GROWTH INHIBITION IN *PHASEOLUS VULGARIS* (THE COMMON BEAN)

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Division of Biology, Minot State University, Minot, North Dakota

## INTRODUCTION

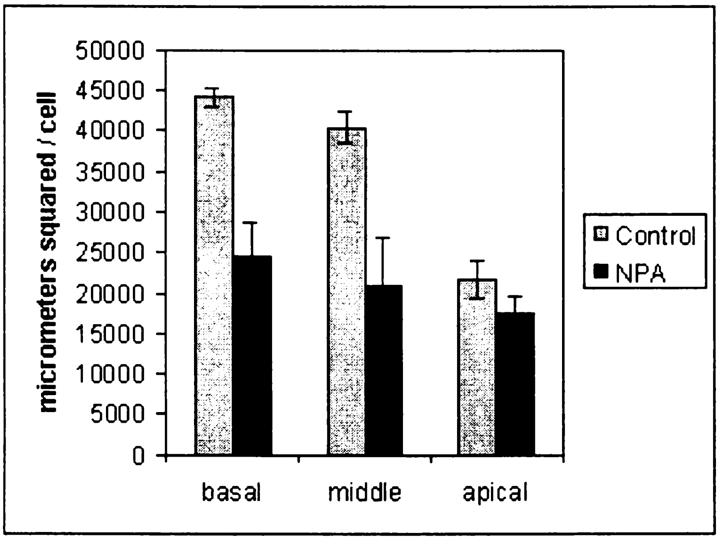
Auxin (indole acetic acid), a plant growth hormone, has long been thought to only control vein elongation in leaf growth (1). However, it is now known to be essential for leaf vein patterning in *Arabidopsis* (2) and the initiation of new leaves in tomato (3). Also, excised leaf strips of inter-veinal tissue from tobacco respond to auxin treatment with epinastic growth (4).

In bean leaves (*Phaseolus vulgaris*) auxin appears to have inhibitory effects both on midrib elongation and overall leaf area. This may be due to decreased cell division, decreased cell elongation/enlargement, or both. This project attempts to distinguish between these possibilities.

## METHODS

*Phaseolus vulgaris* var. contender were grown in moist vermiculite under greenhouse conditions. After 10-12 days, plants with similar sized monofoliate leaves (either 30mm or 45mm) were selected for experimentation. Auxin transport was experimentally blocked by placing a 3mm band of lanolin containing NPA (a non-competitive auxin inhibitor that has no auxin activity) to one petiole of a bean plant. This treatment inhibits leaf growth presumably by increasing endogenous levels of auxin in the leaf (5). As a control, lanolin was placed on the opposite petiole. Measurements of the midrib length were taken daily, starting on the first day, for seven days. On the seventh day clear fingernail polish was painted on inter-veinal regions of the leaves. Upon drying, sections were peeled off and digitized images prepared. Average cell areas for the basal, middle, and apical regions for the treated and untreated leaf of each plant were measured.

## RESULTS AND DISCUSSION




The figure shown indicates that the mechanism for leaf growth inhibition is, at least primarily, decreased cell enlargement. Basal and middle NPA treated cells are significantly smaller. Subsequent experiments are being conducted to see if decreased cell division is also a factor. Preliminary results suggest a similar pattern exists in leaves initially 45mm long.

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# EFFECTS OF LIGHT, GROWTH HISTORY AND TEMPERATURE ON LARVAL LIFE HISTORY PARAMETERS OF AMBYSTOMATID SALAMANDERS

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## INTRODUCTION

In salamanders, two developmental pathways can be followed to attain sexual maturity. An animal can metamorphose prior to maturation, or it can become paedomorphic, thus reaching sexual maturity without (or at least, prior to) undergoing metamorphosis. *Ambystoma tigrinum* is a facultative paedomorph, meaning it can exhibit either the metamorphic or paedomorphic state upon maturity. We hypothesize that paedomorphosis can be induced in *A. tigrinum*, given the appropriate conditions (e.g. food, temperature and light).

Supporting literature suggests:

- The effect of thyroxine, a metamorphose-inducing hormone, is reduced in absence of light (1).
- Gonad development is increased in absence of light, due to the repression on thyroxine (2).
- Cave-dwelling salamanders are obligate paedomorphs (3), but are known to metamorphose when exposed to lighted laboratory conditions (4).

Further, we hypothesize that metamorphic timing, metamorphic size, and growth rate are affected by light, food availability, and temperature in both *A. tigrinum* and *A. maculatum*.

## METHODS

Identical treatment groups consisting of light & dark, high & low temperature, high & low food and all combinations thereof were developed for each species in order to contrast the effects in both an obligate metamorph and a facultative paedomorph. 150 eggs per species were obtained and allowed to hatch "naturally" in the lab. Hatching began February 14, 2001. Upon hatching, each individual was randomly assigned to a group, and placed in its own 11 X 5.5 X 3.5 in. polyethylene container, along with 950mL of reverse-osmosis water. Water was changed and animals were fed on a daily basis. Each animal was blotted dry and weighed every 30 days. Temperature differences of 3 degrees C were maintained through placement in environmental chambers. Twice as much food was made available to high food treatment groups as was to low food treatment groups. Darkness was simulated by covering the exterior of each individual's container with foil. Positional effects were negated by rotating the animals daily. Animals were weighed, then sacrificed upon metamorphosis (to be defined as the complete absorption of the gills) with a solution of 2% MS – 222. Sacrificed animals were then preserved in solution of 10% formalin, tagged with pertinent identifying information and later moved to ethanol. The experiment was terminated July 15, 2001. All remaining animals were sacrificed and preserved as previously described.

In order to assay paedomorphosis, fat bodies and gonad tissue of *A. tigrinum* were removed, scored and weighed to determine allocation of caloric intake toward sexual development. Snout-vent length (defined as the tip of the snout to the most posterior opening of the cloacal slit) was measured with calipers for both species. MANCOVA statistical tests were run on all available data.

## RESULTS

Low temperatures resulted in increased metamorphic size, and extended larval periods in both species as expected. (Low temperature slows down metabolism, and allows for allocation toward growth.) Reduced food led to increased larval periods in both species. (A certain amount of storage must be reached before an animal can undergo metamorphosis, as starvation without reserves is imminent.) Increases in food led to increased gonad development. (Evolutionary-wise it is beneficial to reproduce earlier.) The results of light treatments varied between species, but did not have a significant role in SVL or metamorphic mass. Light deprived *A. maculatum* metamorphosed later (thyroxine effects reduced), whereas light only affected metamorphic timing of *A. tigrinum* in certain contexts, e.g., in low food or low temperature conditions. Analysis of allocation to storage, gonad and metamorphic development supports the notion that facultative paedomorphosis is contingent upon environment, and that light is an important additional factor to consider.

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# CORRELATION BETWEEN VARIATION IN FLIGHT SPEEDS AND WING MORPHOLOGY OF NORTH AMERICAN DABBLING DUCKS (ANUS).

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## INTRODUCTION

In observations of ducks in flight there is an apparent difference in flight speed between species. This study was designed to verify if flight speeds are varied between species of dabbling ducks and if difference in wing morphology could be attributed to these differences. Species of dabbling duck native to north central North Dakota that were sampled included Mallard, Pintail, Green wing Teal, Blue wing Teal, Gadwall, American Widgeon, and North American Shoveler. Flight speed data was obtained for 6 of the 7 species listed with a total of 69 individuals harvested.

## METHODS

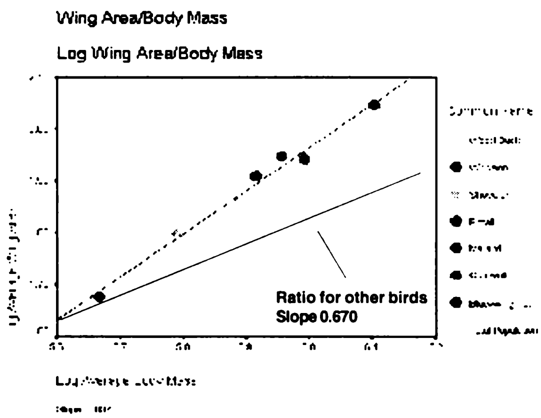
Flight speeds were measured using a hand held Stalker Pro radar unit set on "Ball" mode designed to pick up small fast moving objects. Flight modes measured were level flight (LF), take-off/escape (TO), and landing (LD). The most repeatable measurements were obtained by the TO method: that is scaring ducks into flight from small prairie potholes after species identification had been made. Speeds were measured from take-off to the maximum range of the radar unit to reduce measurement variance and were recorded in kilometers/hour (kph).

Body measurements were taken from harvested ducks and included body mass (g), wingspan (m) and photographs of the wings. Photographs were later used in calculating wing morphology using Image computer software to determine total wing area (S), area of the arm wing ($S_{aw}$), wing cord length ($l_c$), total wing length (l), root box length ($l_{rb}$), and arm wing length ($l_{aw}$). These data were used to determine information needed for wing morphology studies as listed in Norberg and Rayner (1987).

## RESULTS AND DISCUSSION

Casual observation leads us to believe that the smaller species of ducks fly at much higher speeds than larger species. Kortright (1967) states that Blue-winged teal were clocked with automobile at speeds ranging over 45 miles per hour with only the Green-winged teal being the faster flier. Air speed measurements from TO data show no significant difference between species (P=0.874) for this mode of flight. The data contradict the widely held belief that the smaller species fly faster and suggests that this is simply an optical illusion produced by small body size.

Wing morphology tends to be similar in many respects between species, but variation exists. Data showed that larger species of ducks have larger wings than expected from isometry: linear regression of wing area on body mass produces a slope of 0.837 $R^2$ = 0.994 (isometric slope = 0.670). That is wings of the larger species of puddle ducks, such as Mallards, have larger wings than you would expected to find in comparison to the smaller species. This may be necessary to allow for the explosive style of take-off that is used by dabbling ducks. Wing Loading is the weight (mass x gravity constant) divided by wing area (S) and is proportional to fight speed. While the wings of dabbling ducks scale larger than predicted from isometry, area still does not increase as fast as body mass (slope 0.837). Thus the wing loading of large ducks is higher than small ducks as predicted by aerodynamic theory.




Reliable flight speed data collection and the complicated relationships between the many variables included in wing morphology still leave many questions unanswered. Further data needs to be collected and analyzed for the various flight modes of dabbling duck species. The question of the proportionally larger wings of the larger species may be attributable to the need for extra lift and acceleration to perform the explosive take-off method used by the dabbling ducks. With the idea that actual flight speeds for the different moods of flight still need to be refined as the TO speeds analyzed possible represent a flight mode of balancing speed with altitude gain to escape danger.

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# THE ROLE OF NITRIC OXIDE AND OXIDATIVE STRESS IN CARDIAC VENTRICULAR MYOCYTE EXCITATION-CONTRACTION COUPLING DYSFUNCTION UNDER SIMULATED DIABETES

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We have shown that ventricular myocytes maintained in a high glucose (HG) culture medium exhibit abnormalities in excitation-contraction coupling (ECC) simulating *in vivo* diabetes. Nitric oxide (NO), an important regulator of cardiac function, is believed to play a role in the pathogenesis of diabetes. NO may react with superoxide anions to form peroxy nitrite ($ONOO^-$), which can nitrosylate membrane proteins and oxidize lipids. This study was to examine the role of NO and $ONOO^-$ in HG-induced cardiac ECC dysfunction at the cellular level. Isolated adult rat ventricular myocytes were cultured for 24 hours in a serum-free medium containing either normal (5 mM) or high (25 mM) glucose, in the presence or absence of NO synthase (NOS) inhibitor Nω-nitro-L-arginine methyl ester (L-NAME, 100 µM), superoxide scavenger superoxide dismutase (SOD, 500U/ml) or peroxy nitrite ($ONOO^-$) scavenger manganese (III) tetrakis (4-benzoic acid) porphyrin (MnTABP, 100 µM). Mechanical properties were evaluated using a video-edge detection system. NOS activity was evaluated by $^3$H-arginine to $^3$H-citruline conversion assay. Oxidative stress was assessed by measurement of glutathione (GSH) and glutathione disulfide (GSSG) levels. Peak shortening was unchanged whereas time-to-90% relengthening ($TR_{90}$) was significantly prolonged in myocytes cultured in HG. HG increased the NOS activity and reduced GSH/GSSG ratio, indicating enhanced oxidative stress. Co-culturing with SOD and MnTBAP prevented the HG-induced abnormalities in relaxation. Incubation with L-NAME did not prevent slower intracellular $Ca^{2+}$ clearing induced by HG. This data demonstrates that scavengers of superoxide and $ONOO^-$ may provide cardioprotection against HG-induced abnormalities in myocyte relaxation, perhaps through preventing the reaction of NO with superoxide to form $ONOO^-$ and induce free radical damage.

Ventricular myocytes maintained in a high glucose (HG) environment exhibit abnormal excitation-contraction (E-C) coupling simulating *in vivo* diabetes. However, the mechanisms of action underling the altered E-C coupling has not been defined. Local overproduction of nitric oxide (NO) has been reported in early stages of diabetes, and may react with superoxide ($O_2^-$) to form peroxynitrite ($ONOO^-$), contributing to cardiac damage. This study was to examine the impact of scavengers for NO, $O_2^-$, and $ONOO^-$ on the HG-induced cardiac contractile dysfunction.

Adult rat ventricular myocytes were cultured for 24 hr in a serum-free medium containing either normal (NG, 5.5 mM) or high (25.5 mM) glucose, in the absence or presence of the NO scavenger PTIO (100 µM), the NOS inhibitor L-NMMA (100 µM), superoxide dismutase (SOD, 500U/ml) or the $ONOO^-$ scavenger MnTABP (100 µM). Mechanical and intracellular $Ca^{2+}$ properties were evaluated using an IonOptix MyoCam system.

HG myocytes displayed reduced peak shortening (PS), decreased maximal velocity of shortening/relengthening (± dL/dt), prolonged time-to-relengthening ($TR_{90}$) and normal time-to-PS (TPS) associated with reduced intracellular $Ca^{2+}$ rise and clearing compared to NG myocytes. The HG-induced abnormalities in E-C coupling were abolished by MnTBAP and L-NMMA, partially attenuated by SOD and hardly affected by PTIO. Neither MnTBAP nor SOD altered the cell mechanics in NG myocytes. L-NMMA significantly reduced the PS whereas PTIO depressed ± dL/dt and prolonged TPS in NG myocytes.

These results suggested that NO and $ONOO^-$ may play a role in the glucose-induced impaired E-C coupling and the pathogenesis of diabetic cardiomyopathy.

(Supported by McNair Program and American Diabetes Association).

# THERMAL DESORPTION OF MERCURY FROM COAL FLY ASH

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In 1998, there were nearly 63 million tons of coal combustion fly ash produced in the United States. Approximately 21.1 million tons was utilized, and the rest (41.9 million tons) was disposed generally in large monofills or in ash ponds (1). The ash itself, except for a few isolated cases, does not seem to be presenting an environmental problem; however, awareness of the potential for hazard posed by mercury in the environment has caught the attention of environmental groups and regulatory agencies. It is estimated that the fly ash produced each year in the United States contains between 16 to 25 tons of mercury, based on an assumption of a mean concentration of between 0.25 and 0.4 micrograms per gram. Most of the mercury released during coal combustion is currently being emitted to the atmosphere, but pending regulations will likely require coal-burning electric power plants to begin controlling mercury emissions. When this happens, the use of sorbents for mercury capture may increase the ash concentration of mercury significantly. It is known that little mercury is leachable from most coal combustion by-products (CCBs); however, little is known about the volatility of sorbed mercury from CCBs.

Experiments are ongoing to determine thermal desorption profiles on CCBs with relatively high mercury concentrations (>100 ng/g of mercury). An apparatus for the thermal desorption of mercury was assembled and is shown schematically in Figure 1. The thermal desorption apparatus consists of a small tube furnace and temperature controller for heating the CCBs. A heated detection cell run at 800°C was used to thermally decompose mercury compounds for detection by atomic absorption (AA) spectroscopy. Nitrogen gas flow through the apparatus was generally held at a target rate of 20 mL/min, and the temperature was ramped from ambient to 600°C at 25° per minute. A more complete description of the apparatus and experiments can be found elsewhere (2). The apparatus is attached to a Varian 1475 AA spectrophotometer for the detection of mercury.

Thermal desorption curves consisted of between one and five distinct peaks. Each thermal desorption peak was evidence of a separate occurrence of mercury release but may not be indicative of different mercury compounds. Summaries of thermal desorption runs on several ash samples are shown in Table 1. Table 1 presents a listing of CCB identities, a listing of the temperatures of maximum absorbance ($T_a$ Max), and a listing of the relative area percent under each peak. The percentage listed which add up to 100 are not meant to be representative of the percentage of total sorbed mercury but are rather representative of the percentage of total mercury desorbed. Analyses of thermally desorbed CCB samples have shown that between 45% and 80% of the total mercury was desorbed at temperatures up to 600°C.

In addition to the thermal desorption experiments described above, research is under way to determine the potential for mercury vapor release at ambient and near ambient (37°C) temperatures. Research on the effect of biota on mercury release from ash is also under way.

**Figure 1. Schematic of the thermal desorption apparatus**

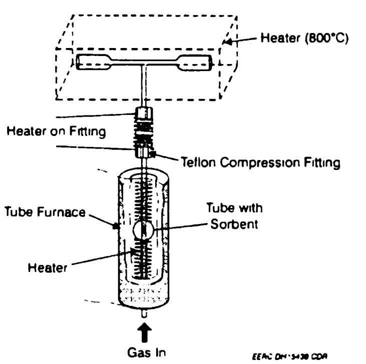


**Table 1. Thermal Desorption Results**

| Sample Type | $T_a$ Max | % of Total |
|---|---|---|
| Illinois No. 6 | 544 | 100 |
| Flue Gas | 250 | 75 |
| Desulfurization | 357 | 9 |
| Residue | 429 | 12 |
| | 454 | 3 |

1. American Coal Ash Association (1998) Coal Combustion Product Production and Use Document.
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# DIETARY COPPER BUT NOT DIETARY ZINC DECREASES PROTEIN KINASE Cα EXPRESSION AND DIMETHYLHYDRAZINE-INDUCED ABERRANT CRYPT FOCI FORMATION IN THE RAT COLON

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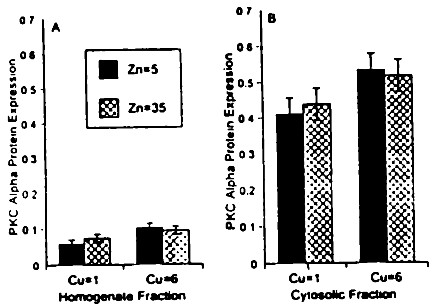
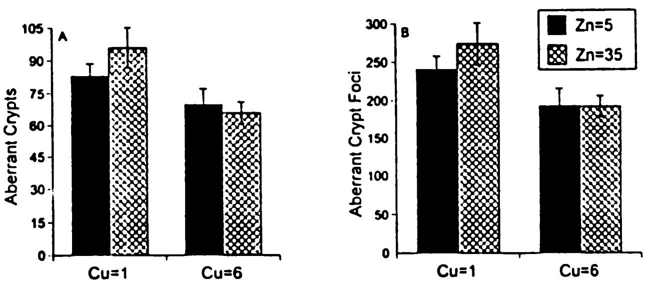
Worldwide, colon cancer is the fourth greatest cause of cancer death. In the United States, it is the second leading cause of cancer mortality. It is believed that diet is the single largest factor to bring about colon cancer and may account for 35-45% of the disease (1). It has been shown that Cu deficiency increases the incidence of chemically-induced colon cancer in rats (2, 3). A recent study has also shown that changes in protein kinase C (PKC) isoform protein concentration may correlate with the increased susceptibility of Cu-deficient rats to colon cancer (4). However, the effect of dietary zinc on colon cancer susceptibility and PKC expression is unknown even though PKC is a zinc containing protein.

The purpose of this study was to determine what if any affect dietary zinc has on colon cancer susceptibility and PKC expression. One hundred eight weanling, male Fischer-344 rats were fed diets containing 1 mg Cu/g or 6mg Cu/g diet and 5 mg Zn/g diet or 35 mg Zn/g diet in an AIN-93 based diet. The experimental diets continued for 24 days after which 21 rats/diet were injected with dimethylhydrazine (DMH) (25 mg/kg body weight) dissolved in saline with 1 mmol/L EDTA, adjusted to pH 7.4 with NaOH. They were given an additional similar dose 7 days later. Six other rats/diet received a comparable injection of saline with 1 mmol/L EDTA only. Two weeks after the last carcinogen dose the rats used for PKC analysis (6 carcinogen and 6 control per diet) were sacrificed. Six weeks later the remaining 15 animals per diet were sacrificed for aberrant crypt analysis. Samples from rats used for PKC analysis were obtained by removing the colon and rectum and flushing with cold saline. The colonic mucosa was scraped and processed. PKC was determined by immunoblotting. Crypt analysis was done by fixing the entire colon and rectum between a paper towel in 70% ethanol. The samples were stained with 1 g/L methylene blue in 0.1mol/L sodium phosphate buffer (pH 7.4). The total number of aberrant crypts (AC) and aberrant crypt foci (ACF) were evaluated by means of a dissecting microscope to visualize the ACF and AC.




This study lends support to previous studies showing that rats fed Cu-deficient diets have decreased PKC a protein expression and increased DMH-induced aberrant crypt formation. The Western Blots indicate that dietary copper deficiency significantly reduced PKC a protein expression in both the homogenate ($p<0.009$) and cytosolic ($p<0.04$) fractions; however, the varying levels of dietary zinc did not affect PKC a protein expression. The rats fed the Cu-deficient diet had 30% more total abberant crypts ($p<0.003$) and 22% more aberrant crypt foci ($p<0.003$) than did animals fed the Cu-adequate diet. Therefore, while dietary copper did appear to affect the rat susceptibility to colon cancer, dietary zinc did not appear to have an effect. Zinc is needed for normal growth. Therefore, the lack of an effect of dietary zinc may affect normal development, but not the abnormal development of cancer. Within this study, the rats fed the zinc deficient diet weighed less than the rats fed the zinc adequate diet.

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# THE ONTOGENY OF TIBIAL SPURS IN *EURYCEA* SALAMANDERS

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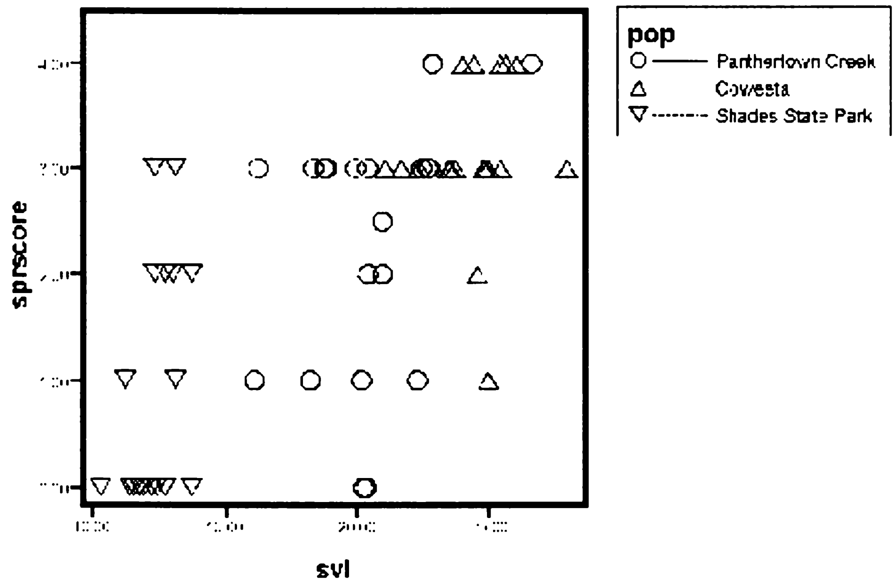
## INTRODUCTION

While tibial spurs are found in most families of salamanders, the function of this feature is still unknown. Possibly a sesamoid bone, the spur could function as muscle or ligament attachment site, or possibly for increased movements as limb length increases. Whether this is a genetic feature or an acquired one is also a mystery.

## METHODS

We examined samples of *Eurycea wilderae* from two different populations in North Carolina and one sample of *E. cirrigera* from Shades State Park in Indiana for the presence of tibial spurs. We expected to see variety in presence and size of tibial spurs in all of our population samples. To examine their skeletal elements, we cleared and stained 20 salamanders from each of the three populations. We also measured snout-vent-length (SVL) for comparison, as it is a good indication of age for this genus. We then cut off and labeled their hind legs and placed a slide over each to observe the tibial spurs under a dissecting microscope. We rated the spurs by size, from 0 (no spur) to 4 (the spur reached up into the cartilage of the tibia).




## RESULTS AND DISCUSSION

ANCOVA indicated that there was no significant difference between the populations and spur size. However, we found that there is a strong correlation between the covariant SVL and the presence and size of the spur, suggesting that tibial spur length increases in relation to the tibia as *Eurycea* salamanders grow.

1. Jockusch, E.L., Yanev, K.P., and Wake, D.B. (2001) *Herpetol. Monogr.* 15: 54—99
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# PETROLOGY OF THE TOT MOUNTAIN LAVAS, MOUNT BACHELOR, CENTRAL OREGON HIGH CASCADES: INTERPRETATION BASED ON DETAILED GEOCHEMICAL AND PETROGRAPHIC ANALYSIS

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## INTRODUCTION

The Cascade mountain range in the Pacific Northwest is an area which has been volcanically active for about 40 Ma. Mount Bachelor is a shield volcano that formed between 18,000 and 11,000 years ago. It is located in the High Cascade range of central Oregon (approximately 50 km southwest of Bend), as a part of the Mount Bachelor Volcanic Chain (MBVC). Tot Mountain is a small vent on the southern flank of Mount Bachelor that has erupted a series of well-exposed, laterally extensive lavas. The purpose of this study is to combine information from previous studies of the area with new data to delineate the different episodes of activity of Tot Mountain.

## METHODS

Work for this project began with an eleven-day round trip to Oregon with four days spent in the field collecting twenty samples from the Tot Mountain lavas. In the laboratory, rock samples were cut into slabs, trimmed, then mounted to make thin sections for petrographic analysis. Other portions of the samples were crushed, powdered, and put into solution for inductively coupled plasma atomic emission spectrometer (ICP-AES) whole rock chemical analysis.

## RESULTS AND DISCUSSION

Tot Mountain unit lavas fall into four compositional groups which also signify different eruptive events. The new samples from this study supported the four sample groups (lavas) found in previous research and allowed for a significantly refined interpretation of the distribution of each flow. These groups became more felsic with time when looking at them together as a whole and on an individual basis. The oldest lava was basalt and the youngest was low-silica andesite. The compositional changes parallel temporal trends of other Mount Bachelor eruptive units. Chemical and petrographic evidence from this study suggests that only two distinct lavas erupted from Tot Mountain; these two are the younger, more felsic lavas of the four previously established. Samples from the two more mafic units originally suggested as being from Tot Mountain seem to represent exposures of older Mount Bachelor lavas.

# COMMUNICATIONS

GRADUATE

**A. Rodger Denison Competition – Graduate Division**
**River Valley Room - Memorial Union**

Moderator: **Dr. Margaret Nordlie, University of Mary, Bismarck**

Judges: **Dr. James Swain, USDA/ARS Human Nutrition Research Center, Grand Forks**
**Dr. Ronald K. Jyring, Bismarck State College**
**Dr. Christopher Keller, Minot State University**

9:30 Welcome and Overview

9:40 "Brownian dynamics of rabbit glyceraldehyde-3-phosphate dehydrogenase (GAPDH) mutants binding rabbit F-actin." Victor F. Waingeh, Stephen L. Lowe, and Kathryn A. Thomasson, Department of Chemistry, University of North Dakota.

10:00 "Gap junctional protein connexin expression in cumulus oocyte complex of ewes treated with follicle stimulating hormone," Disha Pant*, Lawrence P. Reynolds, Flavia Lopes, Kimberley D. Petry, Jerzy J. Bilski, Robert M. Weigl, Dale A. Redmer and Anna T. Grazul-Bilska, Department of Animal and Range Sciences, North Dakota State University.

10:20 "Influence of phosphorylation on the half-life of the regulatory subunit of Type I cAMP-dependent protein kinase," Clay Comstock* and John Shabb, Department of Biochemistry and Molecular Biology, University of North Dakota.

10:40 COFFEE BREAK

11:00 "Conception rate to timed artificial insemination protocols in lactating dairy cows," C. Navanukraw*, L.P. Reynolds, A.T. Grazul-Bilska, D.A. Redmer, and P. M. Fricke, Department of Animal and Range Sciences, North Dakota State University and Department of Dairy Science, University of Wisconsin, Madison, WI.

11:20 "Extracellular matrix changes in parturition," Rhonda Schafer* and Jody Rada, Department of Anatomy and Cell Biology, University of North Dakota.

11:40 "Effects of hormonal treatment on follicular development and oocyte quality in anestrous ewes treated with follicle stimulating hormone," J.S. Luther*, D.A. Redmer, L.P. Reynolds, J.T. Choi, C. Navanukraw, D.R. Arnold, A. Schaeffer, J.D. Kirsch, R. Weigl, K.C. Kraft, and A.T. Grazul-Bilska, Department of Animal and Range Science, North Dakota State University.

# BROWNIAN DYNAMICS OF RABBIT GLYCERALDEHYDE-3-PHOSPHATE DEHYDROGENASE (GAPDH) MUTANTS BINDING RABBIT F-ACTIN

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Department of Chemistry, University of North Dakota, Grand Forks, ND 58202

## Introduction

F-actin, the polymerized form of actin, can play a significant role in cellular metabolism by enhancing specificity of reactions in various metabolic pathways. F-actin has been shown to bind glycolytic enzymes like fructose-1,6-biphosphate aldolase (aldolase) and glyceraldehyde-3-phosphate dehydrogenase (GAPDH). These interactions between F-actin and glycolytic enzymes have been suggested to be electrostatic in nature (**1**) Previous studies involving GAPDH and F-actin (**2**) identified four residues on the GAPDH structure to be important for the binding of the enzyme to F-actin. These residues, lysines 24, 69, 110 and 114 are positively charged and present the source of strong attraction for negative sites on F-actin. Herein, the interactions between computational mutants of GAPDH (one or more of these lysines are replaced with alanine) and F-actin are examined by Brownian dynamics.

## Methods

Brownian Dynamics (BD) has been used to study the binding of GAPDH mutants to F-actin. The model of F-actin was built by the method of Holmes *et al* (**3**). The tertiary structure of rabbit GAPDH was built by homology modeling using Insight II (Accelyrs, San Diego, CA). Mutants of GAPDH were made using the MacroDox package (**4**) by replacing charged residues with alanine. The MacroDox Charge set was used to calculate and assign charges to titratable amino acids and determine the electrostatic fields around the proteins. BD simulations determined the potential of mean force and average electrostatic potential of GAPDH mutants in the F-actin electric field as function of the reaction coordinate $R_c$ (distance of GAPDH center of mass from the F-actin axis). Calculations were done at pH = 7.0, ionic strength I = 0.05 M, temperature = 298 K.

## Results

Table 1 shows the charges and interaction free energies for wild and mutant GAPDHs. The total charge of wild GAPDH was +17.8 e. Single mutations of the four lysine residues on GAPDH reduced the net charge by about 4 e. This resulted in a decrease in binding; i.e., free energy increased from –0.81 to about –0.4 kcal/mol for the single mutants. Net charge and binding decreased even more for the double mutants. No binding was noticed with the triple and quadruple mutants, indicating that by the time the GAPDH charge reaches +7 e binding is eliminated. These results confirm that the interactions of F-actin with GAPDH are indeed electrostatic. The decrease in binding with decrease in charge was, however, not linear indicating that charge alone is not sufficient to explain the binding. The most exposed residues are most important for binding; the most important residue for binding was lysine 69.

**Table 1: Calculated Charges and Free Energies of GAPDH mutants Binding F-actin.** $R_{Cmin}$ is the location along the reaction coordinate where the minimum in the free energy occurs; i.e., where the GAPDH/actin interaction is greatest. Only the weakest and strongest binding results are shown.

| GAPDH | | Charge (e) | Binding Free Energy (kcal/mol) | $R_{Cmin}$ (Å) |
|---|---|---|---|---|
| Wild-type | | 17.8 | -0.81 | 82 |
| Single mutants | K69A | 14.2 | -0.35 | 87 |
| | K110A | 13.7 | -0.49 | 81 |
| Double mutants | K110_114A | 10.0 | -0.28 | 80 |
| | K114_69A | 10.4 | -0.07 | 86 |

Support for this project was provided by NIH/NIGMS 2R15 GM55929-02.

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3. Holmes KC., Popp D., Gebhard W., Kabsch W. (1990) *Nature*, *347*, 44-49.
4. Northrup SH., Laughner T., Stevenson G. (1997) MacroDox Macromolecular Simulation Program. Tennessee Technological University, Department of Chemistry, Cookeville, TN 38505.

# GAP JUNCTIONAL PROTIEN CONNEXIN (Cx) 43 EXPRESSION IN CUMULUS OOCYTE COMPLEX (COC) OF EWES TREATED WITH FOLLICLE STIMULATING HORMONE (FSH)

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Department of Animal and Range Sciences, and Cell Biology Center, North Dakota State University, Fargo, ND 58105

**INTRODUCTION.** Somatic cell-oocyte interactions via gap junctions are essential for oocyte growth, provision of substrate for metabolism, cytoplasmic maturation of the oocyte, inhibition of transcription of maternal genes and maintenance of meiotic arrest (1). Although several different gap junctional proteins are found in different species, Cx43 is a dominant gap junctional protein found in the cumulus oocyte complex and in granulosa cells during folliculogenesis in several species including sheep (2). The objective of this study was to evaluate the Cx43 expression in FSH treated ewes on days 15 and 16 of the estrous cycle.

**METHODS.** Non-pregnant ewes were randomized into control (n=13) and FSH treated (n=14) groups. The latter were treated with FSH for two to three days beginning day 13 of the estrous cycle and ewes were slaughtered on days 15 or 16. COC were collected from all visible small (≤3 mm) and large (>3 mm) ovarian follicles. Immediately after collection on day 16, COC were embedded in agarose gel and fixed in Carnoy's solution. However, after collection on day 15, a portion of COC was embedded and fixed as for day 16, but the other portion of COC were incubated in maturation medium (TCM-199 containing 10% FBS, FSH, LH, and estradiol; 3) for 24 h before embedding and fixing. Cx43 was immunolocalized in histological sections (6 μm) of each COC, followed by nuclear fast red to stain cumulus cell nuclei. The area of positive staining for Cx43 and the number of nuclei were determined for each COC using computerized image analysis. Cx43 data are expressed as area of positive staining per cumulus cell ($\mu m^2$/cell).

**RESULTS**

**Table 1: Cx43 expression in COC in ewes non treated and treated with FSH for 2 days**

| Treatment | Cx43 expression |
|---|---|
| Control | $0.16\pm0.03^a$ |
| 2 day FSH | $0.27\pm0.03^b$ |

**Table 2: Cx43 expression in COC in ewes non treated and treated for 3 days**

| Treatment | Cx43 expression |
|---|---|
| Control | $0.71\pm0.09^a$ |
| 3 day FSH | $0.25\pm0.05^b$ |

**Table 3: Cx43 expression in COC on day 15 and 16 of estrous cycle in FSH treated ewes**

| Stage of estrous cycle | Cx43 expression |
|---|---|
| Day 15 | $0.22\pm0.02^a$ |
| Day 16 | $0.60\pm0.09^b$ |

**Table 4: Cx43 expression in mature and non-mature COC**

| Maturity Status | Cx43 expression |
|---|---|
| Non-mature | $0.36\pm0.06^A$ |
| Mature | $0.31\pm0.03^B$ |

**$^{a,b}$ P<0.01, P<0.1; $^{A,B}$ means ±SEM differ within a table and a column**

**DISCUSSION.** Gap junctions are essential for communication between the cumulus cells and oocytes and gap junctions are involved in the regulation of oocyte maturation (1). Expression of Cx43 was enhanced by FSH treatment for 2 days but decreased by FSH treatment for 3 days. This indicates that prolonged FSH treatment maybe detrimental to communication between oocyte and cumulus complex. The expression of Cx43 in COC increased with the progression of the estrous cycle. In the present study, non-mature COC had a greater Cx43 expression than mature COC. These results indicate that the expression of Cx43 in ovine COC depends on the day of estrous cycle, stage of maturation and duration of exposure to FSH in vivo.

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# INFLUENCE OF PHOSPHORYLATION ON THE HALF-LIFE OF THE REGULATORY SUBUNIT OF TYPE I cAMP-DEPENDENT PROTEIN KINASE

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## INTRODUCTION

Previous work by this lab has identified an *in vivo* phosphorylation at Ser-81 of the type I regulatory subunit (RIα) of cAMP-dependent Protein Kinase (PKA) by mass spectrometry (1). Sequence analysis suggests that Ser-81 is located in a putative PEST region, which is a hydrophilic stretch of ten or more amino acids enriched in Pro, Glu/Asp, and Ser/Thr residues flanked by positively charged residues (2). Ubiquitin-mediated degradation of PEST containing proteins can be modulated by phosphorylation (3). It is our hypothesis that phosphorylation at Ser-81 may influence the half-life of the regulatory subunit of PKA.

## METHODS

Amino terminal six histidine tagged RIα ($H_6RI$) and a Ser-81 to Ala mutant ($H_6RI_{S81A}$) were generated by standard Polymerase Chain Reaction (PCR) protocols. Stable human embryonic kidney cell lines (EcR-HEK 293) expressing the $H_6RI\alpha$ or $H_6RI\alpha_{S81A}$ proteins, under the control of ecdysone, were generated using the Ecdysone Inducible System (Invitrogen). Proteins were induced 24hours with 10μM Ponasterone A, an ecdysone analog, washed then chased in regular media for the indicated times. Lysates for the indicaded times were western blotted with 1μg/ml mouse monoclonal anti-6X histidine antibody (R&D Systems) and analyzed using a Lumi-imager (Boehringer). The half-life of endogenous RIα protein was determined by standard [$^{35}$S]-methionine pulse-chase.

## RESULTS

To assess the role of phosphorylation on the half-life or the regulatory subunit (RIα) an epitope tagged RIα and a Ser-81 to Ala mutant needed to be generated to distinguish it from the endogenously expressed RIα. An amino terminal six histidine tag was utilized for its small size and ease of purification by nickel affinity chromatography. An affinity purified $H_6RI\alpha$ from *E.coli* had similar *in vitro* characteristics when compared to the literature values for wild type RIα. Further characterization was performed using exogenously expressed $H_6RI\alpha$ or $H_6RI\alpha_{S81A}$ protein from the EcR-HEK 293 stable cell lines (see Methods). Western blot analysis determined that both proteins are expressed to similar levels with the ecdysone analog, Ponasterone A. Moreover, it was determined using a polyclonal anti-phosphoSer81 specific antibody, generated in this laboratory, that the $H_6RI\alpha$ protein was phosphorylated *in vivo* whereas the $H_6RI\alpha_{S81A}$ protein was not. Half-life measurements for the $H_6RI\alpha$ and $H_6RI\alpha_{S81A}$ proteins were performed using western blot (see Methods). Based on western analysis the $H_6RI\alpha$ protein has a half-life of 3.3 hours (n=4) and the $H_6RI\alpha_{S81A}$ protein has a half-life of 3.8 hours (n=4). The endogenous RIα has a half-life of 6.2 hours (n=1) based on standard [$^{35}$S]-methionine pulse-chase.

## CONCLUSIONS

The half-lives of the $H_6RI\alpha$ (3.3hours) and $H_6RI\alpha_{S81A}$ (3.8hours) proteins do not appear to be different, suggesting that phosphorylation is not influencing the half-life of RIα. However, if the half-life of the endogenous RIα (6.2hours) is correct this suggests that the histidine tag maybe influencing the degradation of RIα in this experimental model.

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# CONCEPTION RATE TO TIMED ARTIFICIAL INSEMINATION PROTOCOLS IN LACTATING DAIRY COWS

C. Navanukraw*, L.P. Reynolds, A.T. Grazul-Bilska, D.A. Redmer, and P. M. Fricke[1]
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[1]Department of Dairy Science, University of Wisconsin-Madison, Madison, WI 53706.

**INTRODUCTION.** Synchronization of ovulation using a combination of prostaglandin F $_2\alpha$ (PGF) and gonadotropin releasing hormone (GnRH) (termed "Ovsynch") is an effective timed artificial insemination (TAI) protocol for increasing heat detection rate and conception rate (2, 3). However, the Ovsynch protocol is initiated in all open cows without regard to stage of the cycle at initiation. Recent data indicated that stage of the estrous cycle at which the Ovsynch protocol is initiated affects subsequent conception rate (4). Therefore, to target the optimal stage of the estrous cycle at which the Ovsynch protocol should be initiated, it is necessary to presynchronize estrus before initiation of the Ovsynch protocol. Thus, the objectives of this experiment were: 1) to compare conception rate of cows that initiate the TAI protocol at random stages of the cycle (Ovsynch) to cows that initiate the TAI protocol at a targeted stage of the estrous cycle (Presynch) and; 2) to determine the effect of physiological status, i.e. parity, days in milk (DIM) and body condition score (BCS) on conception rate to TAI protocols.

**METHODS.** This experiment was conducted as a multi-year study. Briefly, for Year 1, 98 lactating dairy cows at 60-350 d postpartum were blocked by parity and DIM and were randomly assigned within block to one of two protocols (Ovsynch vs Presynch). For Year 2, 94 lactating dairy cows, 60-350 d postpartum, were used and assigned to one of two protocols (Ovsynch vs Presynch) similar to Year 1. For Year 3, 77 lactating dairy cows, 60-400 d postpartum, were used and assigned to one of two protocols (Ovsynch vs Presynch) similar to Year 1 and 2. All cows received intramuscular injection of PGF and GnRH as previously described (1) and were subjected to AI at 16-18 hr after the 2$^{nd}$ injection of GnRH. After treatment, we used transrectal ultrasonography to determine conception rate.

**RESULTS.**
Table 1. Effects of TAI protocols on synchronized ovulation and conception rates ($^{a,b}$, P<0.05 for Overall).

| Protocol | Synchronized ovulation rate (%) | Conception rate (%) |
|---|---|---|
| Year 1 (n=98) | | |
| Ovsynch (n=49) | 71.4 | 42.9 |
| Presynch (n=49) | 79.6 | 53.1 |
| Year 2 (n=94) | | |
| Ovsynch (n=46) | - | 37.0 |
| Presynch (n=48) | - | 50.0 |
| Year 3 (n=77) | | |
| Ovsynch (n=39) | - | 28.2 |
| Presynch (n=38) | - | 44.7 |
| Overall (n=269) | | |
| Ovsynch (n=134) | - | 37.3$^a$ |
| Presynch (n=135) | - | 49.6$^b$ |

**DISCUSSION.** Although the synchronized ovulation rate and conception rate did not differ between treatments within each year, the Presynch protocol in which two injections of PGF administered 14 d apart preceded initiation of Ovsynch by 14 d increased (P<0.05) the overall conception rate by 12.3%. Parity, DIM, or BCS at TAI did not affect conception rate. Therefore, these data support the use of the Presynch protocol to increase conception rate of lactating dairy cows receiving TAI.
*Supported in part by Hatch projects ND01705 to DAR and LPR and WIS04222 to PMF.*

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# EXTRACELLULAR MATRIX CHANGES IN PARTURITION

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**BACKGROUND** Cervical ripening during parturition is a dramatic process of tissue remodeling that produces drastic changes in the biomechanical properties of the tissue. Proper timing of these biomechanical and biochemical changes, combined with uterine contraction, leads to uncomplicated delivery. We sought to compare the temporal changes in extracellular matrix activities such as proteoglycan synthesis, glycosaminoglycan accumulation, and gelatinase activity that occur in the cervix before, during, and after delivery, so as to precisely define the biochemical events orchestrating the matrix remodeling. By characterizing the cervical extracellular matrix changes associated with parturition, we hope to identify specific rate-limiting cellular events that could serve as potential targets for therapies aimed at slowing or inducing the cervical ripening process.

Proteoglycan synthesis was measured in cervices isolated from non-pregnant or pregnant Sprague-Dawley rats at day 11, 17, term and 4 days post partum. The resected cervices were radiolabeled in organ culture with $^{35}SO_4$ (200 µCi/ml in DMEM containing 15% FBS) for 2 hours and frozen at –80°C. When the time course was complete, cervixes were thawed, dissected and either digested in protease K at 60°C (for proteoglycan synthesis rates) or extracted in 4 M guanidine-HCl (to characterize newly synthesized proteoglycans). Latent and active forms of gelatinase A were characterized from guanidine HCl extracts of rat cervixes from non-pregnant rats, and pregnant rats at day 11, 17, term and 4 days post partum using gel zymography and/or western blot analyses (1, 2). Cultures of human cervical fibroblasts were established by explant culture of tissue obtained after surgery, using a method developed for the culture of human scleral fibroblasts (3).

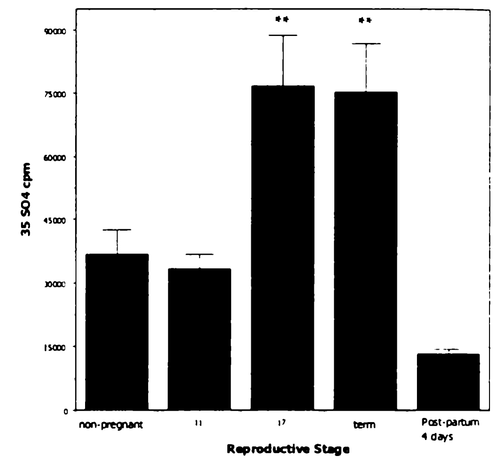


Figure 1. Proteoglycan synthesis was measured as the amount of $^{35}SO_4$ in CPC-precipitable material following protease K digestion of radiolabeled rat cervix from organ culture. ** $p < 0.001$, as compared with non-pregnant, day 11, and postpartum samples (n = 3 cervices in each group [ANOVA]).

**RESULTS** Incorporation of [$^{35}$S] sulfate into newly-synthesized proteoglycans in rat cervices isolated from pregnant rats at several stages was significantly increased in late pregnancy and at term (Figure 1). This incorporation diminished by four days post-partum, suggestive of an active down-regulation of proteoglycan synthesis immediately post-partum. In contrast, total glycosaminoglycan content in the same rat cervices increased slightly at day 17, and remained elevated through the four-day post-partum period (data not shown). Western blot results indicated that both latent and active forms of gelatinase A accumulate in the cervix during pregnancy and are maximal at term (Figure 2).

**CONCLUSIONS** Our data suggest that proteoglycan synthesis in cervical fibroblasts is actively regulated before, during, and after parturition. We suspect that the increased rate of proteoglycan synthesis results in increased glycosaminoglycan accumulation in the cervix that does not return to normal levels as rapidly as observed for the rate of proteoglycan synthesis. Due to the parallel changes in proteoglycan synthesis and levels of gelatinase A activity, we believe that changes in gelatinase A levels in the uterine cervix play a role in proteoglycan turnover and remodeling in the cervix during parturition.

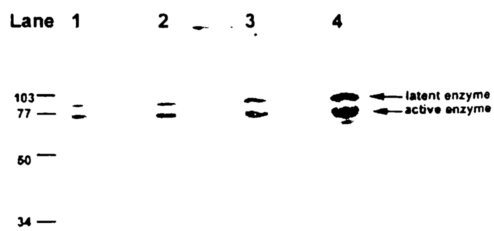


Figure 2.
**Western blot of gelatinase A isoforms.**
Lanes 1 & 2, non-pregnant; Lane 3, E17;
Lane 4, term

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# EFFECTS OF HORMONAL TREATMENT ON FOLLICULAR DEVELOPMENT AND OOCYTE QUALITY IN ANESTROUS EWES TREATED WITH FOLLICLE STIMULATING HORMONE (FSH)

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## INTRODUCTION

The number of developing follicles, oocytes and embryos obtained from animals must be optimized to maintain high efficiency of assisted reproductive technologies. Numerous studies have focused on developing hormonal treatments to improve follicular development and induce a fertile estrous response in seasonally anestrous ewes (3). However, limited amounts of data are available concerning the effects of exogenous hormones, such as melatonin (MEL) and progesterone ($P_4$), on oocyte quality for in vitro production (IVP) of embryos during seasonal anestrus. The aim of this study was to evaluate the effects of MEL and controlled internal drug release (CIDR) device on follicular development and oocyte quality in FSH-treated ewes. In the current study oocyte quality was measured by the rate of maturation, fertilization, and morula and blastocyst formation following *in vitro* fertilization procedures.

## METHODS

Seasonally anestrous, crossbred (Rambioullet x Targhee) Western range ewes (n=25) were randomly assigned to four treatments in a 2 x 2 factorial design (-/+MEL and -/+CIDR) from the months of March to May. Ewes in the MEL and MEL/CIDR treatment groups (n=14) received a Melovine® (18 mg melatonin) implant for 42 d before slaughter. Ewes in the CIDR and MEL/CIDR treatment groups (n=11) were vaginally implanted with CIDR (Type G intravaginal pessaries containing 0.3 g of $P_4$) for five days before slaughter. Two days before slaughter all ewes received injections of FSH-P (FSH with 10% luteinizing hormone; Sioux Biochemical, Sioux Center, IA) twice daily. At slaughter, ovaries were removed and oocytes were collected from all visible follicles, matured and fertilized *in vitro*. Culture medium was changed every other day and embryonic development was evaluated until day 8-9 of culture or until embryonic arrested (2). The nuclear status of non-fertilized oocytes was evaluated by epifluorescence microscopy and the maturational stage was determined (1).

## RESULTS

The average number of follicles per ewe was greater (P<0.08) for MEL/CIDR treated ewes than Control ewes (37.3±5.5 vs. 22.6±5.5), but was not different from MEL (31.3±5.5) or CIDR (25.8±5.5) treated ewes. The percentage of oocytes recovered from follicles and the rate of oocyte maturation was similar (P>0.10) across treatment groups (overall 89.9±7.1% and 78.6±11.0%, respectively). Oocytes collected from CIDR-treated ewes (CIDR and MEL/CIDR treatment groups) had reduced (P<0.02) fertilization rates (10.3±2.0 and 10.1±2.0%) compared with ewes not treated with CIDR (MEL and Control; 18.5±2.0 and 20.0±2.0%, respectively).

## DISCUSSION

Administration of exogenous FSH, melatonin and progestagens has been shown to promote ovarian activity and follicular development in the seasonally anestrous ewe (3). In the current study, administration of melatonin and CIDR devices in conjunction with FSH increased the number of developing follicles. However, prolonged $P_4$-treatment seems to be detrimental to oocyte quality. Although MEL/CIDR ewes had more developing follicles, MEL did not affect fertilization rates and subsequent IVP of ovine embryos. Therefore, melatonin does not appear to affect oocyte quality. During anestrous the rates of IVF (10-30%) are much lower than during the normal reproductive season (70-80%; 2). Establishment of more optimal hormonal treatments for seasonally anestrous ewes to mimic the hormonal environment of sheep during the breeding season is still desirable. Further research involving the use of hormonal treatments is needed to improve in vitro production of embryos in the anestrous ewe.

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# COMMUNICATIONS

## PROFESSIONAL

## NDAS SENIOR ACADEMY PROGRAM
**Sioux Room - Memorial Union**

**Thursday, April 25**

**Moderators: Fariba Roughead, USDA/ARS-Grand Forks Human Nutrition Research Center**
**Douglas Munski, University of North Dakota**

1:15 Welcome Fariba Roughhead

1:20 "Inadequate copper intake reduces serum insulin-like growth factor-1 concentration and bone strength in growing rats." Fariba Roughhead* and H.C. Lukaski, USDA/ARS Human Nutrition Research Center, Grand Forks.

1:40 "Carbonyl iron is a more effective hemoglobin repletion agent than electrolytic or reduced iron powder in rats," James Swain* and Janet Hunt, USDA/ARS Human Nutrition Research Center, Grand Forks.

2:00 "A European map assessment as a UND Bush Scholarship of Teaching Activity," Douglas C. Munski*, Department of Geography, University of North Dakota.

2:20 "Cognitive dissonance theory and judges scores at a springboard diving championship," William A. Siders*, Grand Forks, ND

2:40 SPECIAL REPORT: "Lignite - Fuel or Feedstock?" Paul Pansegrau, Dakota Gasification Company, Beulah, ND.

3:00 COFFEE BREAK

3:20 "Regional and whole body composition and bioelectrical impedance analysis (BIA)," William A. Siders* and Henry C. Lukaski, USDA/ARS Human Nutrition Research Center, Grand Forks.

3:40 "Effect of exogenous auxins on leaf expansion in the common bean (*Phaseolus vulgaris*)."Chris Keller*, Department of Biology, Minot State University.

4:00 "A comparison of ultimate pullout strength of four bioabsorbable tacks," Susan H.N. Jeno*, B. Bleess, L.M. Haugen, R.L. Mabey, and P.Q. Johnson, Department of Physical Therapy, University of North Dakota.

4:20 "Progress report on the UND Bush Project on map reading and interpretation," Douglas C. Munski*, Department of Geography, University of North Dakota.

4:40 "Lorenzo's Oil and the blood brain barrier: ramifications for the treatment of x-linked Adrenoleukodystrophy," Eric J. Murphy*, Department of Pharmacology, Physiology, and Therapeutics, University of North Dakota.

## INADEQUATE COPPER INTAKE REDUCES SERUM INSULIN-LIKE GROWTH FACTOR-1 (IGF-1) CONCENTRATION AND BONE STRENGTH IN GROWING RATS

Z.K. Roughead*, H.C. Lukaski. USDA/ARS Human Nutrition Research Center, Grand Forks, ND, 58202.

BACKGROUND: Decreased serum concentrations of IGF-1are reported to be strongly associated with an increased risk of osteoporotic fractures (1). It is generally believed that serum concentration of IGF-1 is controlled by food intake, however, the effects of specific nutrients on serum IGF-1 have not been sufficiently studied. OBJECTIVE: This study was designed to determine whether the interaction between graded intakes of zinc (Zn) and copper (Cu) affected serum IGF-1concentration and bone quality in growing rats. METHODS: In a 3x3 factorial design, weanling male Sprague Dawley rats (n = 84) were randomly assigned to 12 groups and were fed one of 9 modified AIN-93G basal diets with varying amounts of Cu (0.3, 3, and 10 mg/kg, designated as LC, MC, and HC, respectively) and Zn (5, 15, 45 mg/kg, designated as LZ, MZ, and HZ, respectively) for 6 weeks. A group of rats was pair-fed to each LZ group. RESULTS: No statistical differences were found between the LZ groups and the pair-fed groups in the variables reported. Body weights were determined primarily by dietary Zn and were the highest in the HZ groups ($p=0.02$). Although dietary Zn had a tendency to influence serum IGF-1 concentrations ($p=0.09$), dietary Cu was the main determinant of this variable ($p<0.0001$) with no detectable interactions between Cu and Zn (see Table). Lumbar vertebral density (L4), as determined by Archimedes' Principle, was influenced by dietary Zn, Cu, and interaction of Zn and Cu ($p<0.05$). Variabilities in femur density and breaking strength, as measured by a 3-point breaking test, were determined mainly by dietary Cu ($p<0.05$, Table). Compared to the HC groups, serum IGF-1, vertebral and femur densities and femur breaking strength were the lowest in the LC groups (by 27%, 2%, 3% and 14%, respectively, $p<0.05$, Table). Also, femur calcium-to-nitrogen ratio, as an indirect measure of degree of mineralization of the organic matrix, was the lowest in the LC groups ($p=0.05$). Tibia osteocalcin was significantly affected by Cu and Cu x Zn interaction ($p<0.01$) and was the lowest in the HCHZ group. In multiple linear regressions, serum IGF-1 was positively correlated with both femur density and breaking strength even after accounting for body weight (semi-partial $R^2=0.17$ and 0.15, respectively, $p<0.001$).

| Diet | Serum IGF-1 (ng/ml)[&] | Tibia Osteocalcin (ug/mg)[1&] | Femur Ca:N[&] | Vertebrae (L4) Density (g/ml)[1'&] | Femur Strength (N)[&] |
|---|---|---|---|---|---|
| LCLZ | 718.4 | 1.05 | 6.00 | 1.30 | 81.4 |
| LCMZ | 733.2 | 1.18 | 5.97 | 1.30 | 83.4 |
| LCHZ | 662.0 | 1.17 | 5.73 | 1.28 | 74.5 |
| MCLZ | 780.0 | 1.25 | 6.26 | 1.34 | 87.3 |
| MCMZ | 942.5 | 1.26 | 5.96 | 1.31 | 95.1 |
| MCHZ | 869.3 | 1.24 | 6.34 | 1.29 | 89.2 |
| HCLZ | 839.2 | 1.09 | 5.94 | 1.30 | 85.3 |
| HCMZ | 982.1 | 1.04 | 6.35 | 1.34 | 90.2 |
| HCHZ | 1050.1 | 0.90 | 6.23 | 1.33 | 98.1 |
| *Pooled SD* | *140.2* | *0.10* | *0.54* | *0.04* | *10.8* |

[1]**Significant Cu x Zn interaction ($p<0.01$). [']Significant Zn effect ($p<0.02$). [&] Significant Cu effect ($p \leq 0.05$).**

CONCLUSION: Low Cu intake caused a dramatic decline, by almost one-third, in serum IGF-1 concentration. Also, compared to dietary Zn, dietary Cu had a stronger influence on indicators of bone quality in growing rats. The poor quality of spinal and long bones associated with inadequate Cu intake may be explained, in part, by the decreased serum IGF-1and alterations in the composition of the organic and inorganic matrix of these bones.

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# CARBONYL IRON IS A MORE EFFECTIVE HEMOGLOBIN REPLETION AGENT THAN ELECTROLYTIC OR REDUCED IRON POWDER IN RATS

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## INTRODUCTION

Fortification of food with elemental iron (Fe) powder is designed to reduce Fe deficiency anemia, but little or no verification exists as to the efficacy of elemental Fe powders used widely as food fortificants today. Our objective was to determine the bioavailability of six different commercially-produced (~2001) elemental Fe powders, collected by SUSTAIN (1).

## METHODS

The relative biological value (RBV) of the Fe powders was determined (2) using the AOAC hemoglobin repletion/slope ratio method (3) in 220 weanling, male Sprague-Dawley rats. After dietary Fe depletion (24 d; ~1.5 mg Fe/kg AIN93G diet), rats consumed a repletion diet (14 d; AIN93G diet) fortified with one of six elemental Fe powders (each ~12, 24, and 36 mg Fe/kg), ferrous sulfate ($FeSO_4 \cdot H_2O$; ~6, 12, 18, and 24 mg Fe/kg), or no added Fe (~1.5 mg Fe/kg); n=9-10/diet. Solubility measurements were done by placing 20 mg of the iron powder in 250 mL dilute (0.02 M) hydrochloric acid at 37°C with constant shaking (150 rpm). Solubility data were analyzed using one way analysis of variance with differences among the means tested using Tukey's multiple comparison test.

## RESULTS AND DISCUSSION

Although Fe intake and bioavailability influenced both food intake and weight gain, relative bioavailability was similar whether based on dietary Fe concentration (mg/kg) or absolute Fe intake (µg/d). Fe bioavailability of these powders was significantly different ($p<0.05$) from $FeSO_4$, ranging from 20-66% (see table). Fe bioavailability between some powders also differed significantly. Carbonyl Fe powder was approximately two to three times more bioavailable than the H-reduced, Reduced (ATOMET 95SP), and CO-reduced Fe powders, similar to earlier findings (4). Furthermore, at 150 min, carbonyl Fe powder was most soluble.

| Type of Fe, Product Name or Grade (Country Produced) | RBV[1] diet Fe (mg/kg) | RBV[1] Fe intake (µg/d) | Solubility[2] |
|---|---|---|---|
| Carbonyl, Ferronyl™ (U.S.) | 64 (62 – 67)[a] | 66 (61 – 71)[a] | 97.3 ± 1.0[a] |
| Electrolytic, A-131 (U.S.) | 54 (50 – 58)[b] | 55 (50 – 60)[b] | 85.7 ± 4.7[ab] |
| Electrolytic, Electrolytic Fe (India) | 46 (43 – 50)[bc] | 50 (45 – 54)[bc] | 65.3 ± 9.2[abc] |
| H-Reduced, AC-325 (U.S.) | 42 (37 – 46)[c] | 43 (37 – 48)[c] | 60.8 ± 6.0[bc] |
| Reduced, ATOMET 95SP (Canada) | 24 (20 – 28)[d] | 24 (19 – 28)[d] | 50.6 ± 2.8[c] |
| CO-Reduced, RSI-325 (Sweden) | 21 (17 – 25)[d] | 20 (15 – 25)[d] | 71.6 ± 12.9[abc] |

[1]Bioavailability (RBV; 95% C.I.) relative to $FeSO_4 \cdot H_2O$(=100); values in a column with the same letters are not different ($p<0.05$). [2]Values are mean ± SEM of 3 replicated assays of each sample (at 150 min).

## CONCLUSIONS

Findings illustrate that of the elemental iron powders tested, carbonyl Fe powder more effectively repletes hemoglobin in rats. Additionally, solubility was not a good predictor of bioavailability, nor would it likely be an acceptable substitute for this current AOAC bioassay in estimating comparative bioavailabilities of iron powders. Because current guidelines (1) for Fe fortification of foods do not consider the differences in Fe bioavailability from current, commercially-produced Fe powders, the present findings, together with results in humans, can assist in the development of quantitative recommendations for fortification of foods with specific forms of Fe.

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*U.S. Department of Agriculture, Agricultural Research Service, Northern Plains Area is an equal opportunity/affirmative action employer and all agency services are available without discrimination.*

# A EUROPEAN MAP ASSESSMENT AS A UND BUSH SCHOLARSHIP OF TEACHING ACTIVITY

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Department of Geography, University of North Dakota, Grand Forks, ND 58202

Teacher trainees in social studies, earth science, and geography are expected to be able to not only have good map reading and interpretation abilities but be able to teach those skills as appropriate to the students in their chosen K-12 classrooms (1,2). These geographic skills have been taught principally at the University of North Dakota in the past in GEOG 319 (Geography for Teachers), a two-credit course for elementary school, middle school, and high school pre-service educators, but since 2000, a three-credit course, GEOG 419 (Methods and Materials of Geographic Education) has been available which focuses upon secondary education. Students in GEOG 419 in the Spring of 2002 were research subjects in a variety of map reading and interpretation activities in a project under the auspices of a University of North Dakota Office of Instructional Development Bush Scholarship of Teaching Grant. One mini-study in which these juniors and seniors participated was a demonstration of how shape, orientation, size, and distinctive borders play major roles in promoting recognition of individual nation-states on maps.

The activity was designed to do two things. First, it was to discover whether or not upper-classmen in a methods and materials of geographic education course had an understanding of place recognition for selected nation-states; and 2) determine if these juniors and seniors could decipher later the cartographic clues for learning place recognition for those nation-states using an atlas if they did not already know the places on the map test. The premise was that if these pre-service educators initially could not perform the expected tasks involving a particular world region, they would have to learn the skills necessary if they were going to be able to teach those same map reading and interpretation skills to students in a typical grade nine global studies class.

The enrollment in GEOG 419 is limited to maximize one-on-one learning, so the pool of participants was only one dozen undergraduates. Because many of these pre-service educators would be student teachers in a ninth grade global education course, the world region selected for the map test was Europe, one of the four areas generally taught in that class. Their assignment was to identify the outlines of as many nation-states of Europe as possible that had been drawn as individual places and fixed in a matrix of five squares by five squares on a standard size of notebook paper. They had to realize that the scale had been altered for each of the 25 European countries so that using relative size as a factor in map reading and interpretation had to be adjusted. Also, some nation-states were rotated or reversed in orientation to force them to look for key clues of elongations, proruptions, and other distinctive elements. They also had only 20 minutes to complete the task to simulate a typical ninth grade class, i.e., a teacher breaks the class activities into a series of 15-20 minute blocks. As an added test of their mental mapping abilities and historical geography knowledge, they only were told that the outlines included Europe's pre-1991 boundaries, i.e., the idea was for them to acknowledge that nation-states do change in size and shape through time.

Results of the activity revealed that the undergraduates only partly comprehended place recognition for European nation-states but could, once allowed the use of an atlas, decipher the cartographic clues for learning the places they had either not identified or misidentified on the map test. Distinctive shapes were readily noted, e.g., Italy, as were those nation-states with unique proruptions, e.g., Iceland. Futhermore, the eastern European places were less successfully identified at first than western or northern European places, a possible indicator of lower place awareness because of the greater attention given in American schools to nation-states such as France and the United Kingdom than to Bulgaria and Romania. Their historical geography understanding was mixed with most students successfully identifying the former U.S.S.R. but not being able to identify what was West Germany or East Germany. Greece and Denmark were not always identified correctly with the students often interchanging them because they did not at first grasp that the outlines of each had been rotated significantly.

Based upon this exercise, the undergraduates gained a greater appreciation for the reason that geographers focus upon shape, size, orientation, and distinctive borders when teaching simple place name vocabulary. Yet, building a place name vocabulary is but one facet of basic map reading and interpretation, so other mini-studies have been emphasizing integrating this skill into map construction and areal analysis of specific regions so that these pre-service educators will be better able to work with their own students when dealing with maps.

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# COGNITIVE DISSONANCE THEORY AND JUDGES' SCORES AT A SPRINGBOARD DIVING CHAMPIONSHIP

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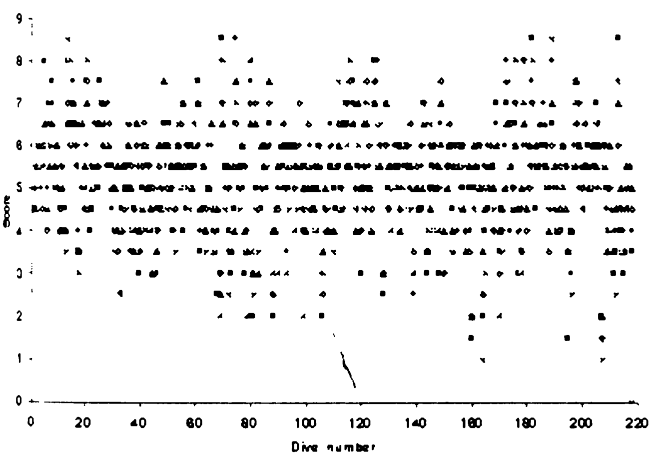
Cognitive dissonance theory (1) postulates that when individuals receive information contrary to their beliefs they may try to relieve the dissonance by decreasing their number of inconsistent behaviors (balance theory) or increasing their number of consistent behaviors (consistency theory). In competitive springboard diving, dives are scored by judges on a scale from 0 to 10 in 0.5 unit increments. Diving rules (2) provide guidelines for scoring dives and each judge awards points, somewhat subjectively, independent of the other judges. Each judge declares their score and then all scores are announced. Thus judging competitive diving may provide a unique paradigm for studying the effects of immediate and public feedback to an individual judge on how their belief (score) compares to beliefs (scores) of other judges. It was hypothesized that, over a large number of dives, the variability among the judges' scores would decrease (balance theory) but that high scoring judges would still score high and low, low (consistency theory).

At the 2001, N.D. High School Girls Springboard Diving Championships, contestants, who had previously qualified for that meet, performed 218 dives in 11 rounds over two days (rounds 1-5, n=22; rounds 6-8, n=20; rounds 9-11, n=16). Dives performed were selected by the contestants to conform to championship guidelines (2). Five judges and a supervising referee were selected to serve at that competition by the N.D. High School Activities Association. The round of diving, dive number, description, position, and degree of difficulty, and judges' scores were recorded, in order and as publicly announced.

What spectators "saw" is depicted in Figure 1 – a plot of scores by dive number with each judge represented by an unique symbol. While the five dive groups were nearly equally represented in the total number of dives, 57% of forward dives were performed in rounds 1-4, 42% of back dives in rounds 1 and 2, 47% of reverse dives in rounds 7-9, 58% of inward dives in rounds 3, 4, 6 and 7, and 44% of twisting dives were performed in rounds 9-11 ($c^2$=77, df=40, $p<0.01$). Most dives were in the tuck position (45%), 14% of the dives were in the straight position, and the pike and free positions were about equally represented ($c^2$=225, df=30, $p<0.01$). The dives in rounds 5 and 11 had the highest mean degree of difficulty (2.2) and rounds 1 and 6 the lowest (1.7 and 1.6, respectively) ($F$=5.8, df=10,15, $p<0.01$).




Scores were analyzed with a three-way analysis of variance (ANOVA) and dives performed in the straight and pike positions received the highest mean scores (6.0 and 5.8, respectively) while dives in the tuck and free positions received the lowest (5.1 and 4.8, respectively) ($F$=3.04, df=3,12, $p<0.05$). The main effects of dive group (the mean score ranged from 5.7 for inward dives to 4.8 for twisting dives) and round were not statistically significant. Rounds 1, 6 and 9 had the highest mean scores (5.9, 5.8, and 5.7 respectively) and rounds 8 and 11 the lowest (4.8 and 4.7, respectively).

The Pearson correlation coefficient for scores and dive number ($r$=-0.065, n=1090, p<0.05) indicated a decrease in scores over dive number. But the correlation of the absolute value of the difference of each score from the mean (ADM) and dive number ($r$=0.023) was positive and not statistically significant. When the ADM was regressed against dive number for all judges together, the slope (0.00013) was not significantly different than zero. When the same regression was calculated for each judge, the slopes ranged from -0.0003 (negative for two judges) to 0.0006 and none were significantly different than zero. Scores were analyzed with a two-way ANOVA and there was a significant main effect of judge ($F$=17.05, df=4,40, $p<0.01$) but not round. The mean scores, by round, were higher from three judges (5.3,5.3,5.2) than the other two (5.0,4.9). ADMs were analyzed with a two-way ANOVA and the main effects of round and judge were not statistically significant.

In spite of apparent periodic decreases in the variability among the judges' scores, regression analysis and ANOVA of the ADMs did not support the hypothesis of decreased variability over time. But the two-way ANOVA of scores supported the hypothesis that the judges would be consistent in their different scoring. At least in this setting, officials judging competitive springboard diving, consistency theory seems to be the method of choice for reducing cognitive dissonance.

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**REPORT**

LIGNITE: FUEL OR FEEDSTOCK?

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The exploitation of fossil fuel resources within North Dakota contributes ~12% annually to the State's economy. A portion of this revenue arises from the operation of the Great Plains Synfuels Plant by Dakota Gasification Company, a subsidiary of Basin Electric Power Cooperative.

By the daily gasification of 18,000 tons of lignite, the Great Plains Synfuels Plant is able to produce, on average, the fuel equivalent of 150 million standard cubic feet of Substitute Natural Gas (SNG). The Plant is also able to produce phenol, cresylic acid, naphtha and methanol, which are sold as commodity chemicals. Also, the Plant produces anhydrous ammonia and ammonium sulfate for sale in regional and national agricultural fertilizer markets.

Potentially available for future production are catechol, 3-methylcatechol and 4-methylcatechol. These chemicals differ from chemicals currently produced at the Plant in that they are not categorized as commodity chemicals, but rather as fine chemicals. Further, the catechols serve as excellent feedstocks for the synthesis of other value-added fine chemicals.

The isolation and purification of the catechols will be touched upon. Major discussion will focus on the development of synthetic methods that may be adapted to large-scale production of fine chemicals derived from 3- and 4-methylcatechol. The presentation will focus on technology by which the methyl group of 3- and 4-methylcatechol is transformed to either an aldehyde, or subsequently a phenol group, thus providing access to fine chemicals currently traded in U.S. and International markets. Examples of lab-scale produced fine chemicals, derived from North Dakota Lignite, and which are utilized in the agrochemical and pharmaceutical industries, will be provided.

# REGIONAL AND WHOLE BODY COMPOSITION AND BIOELECTRICAL IMPEDANCE ANALYSIS (BIA)

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The use of BIA to reliably estimate whole body composition requires standardized methodology (1). The usual tetrapolar method uses electrode placement on the right hand and foot; another approach uses the left hand and foot. Recently marketed devices measure from either both feet or both hands. This study determined the symmetry of regional body composition and then related any dissymmetry to differences in bioelectrical impedance (*Z*).

Seventy-three volunteers (45 women, 28 men) were measured for whole body *Z* at 50 kHz (RJL Systems Quantum X) and body composition by pencil beam dual x-ray absorptiometry (Hologic, Inc. QDR 2000). *Z* was measured with electrodes placed on the right hand and foot (right side), the left hand and foot, on both hands (upper body), and on both feet. Right and left body were defined by a midsagital plane. Upper and lower body were differentiated with a transverse plane just superior to the crests of the ileum. When repeated measures analysis of variance (ANOVA) was performed and results were significant, means were analyzed with Tukey studentized range tests.

**Table 1. Regional Body Composition as a Percent of Whole Body (mean, CV)**

| | Right half: whole | Lower half: whole Female | Lower half: whole Male |
|---|---|---|---|
| Total, kg | 50.0, 2.4 | 49.9, 2.8 | 50.1, 1.6 |
| BMC, g | 50.5, 8.9 | 50.2, 10.1 | 52.6, 5.1 |
| Fat, kg | 50.1, 3.1 | 58.9, 12.5 | 51.5, 12.2 |
| FFBF, kg | 50.0, 2.0 | 51.2, 4.7 | 49.3, 2.9 |

The volunteers ranged in age from 22 - 72 yr, body mass index from 18.6 - 35.5 kg/m$^2$, and percent body fat from 6.7 - 54.5%. The right and left regions of the body in both sexes were nearly equal (Table 1) for bone mineral content (BMC) and total, fat, and fat-free, bone-free weights (FFBF). Upper and lower regions were similar in males, but the fat in the lower body was apparently greater, than the upper, in females.

A two-way (sex and measurement side) ANOVA of *Z* (Table 2) revealed a significant interaction ($F$=26.27,df=3,73,$p$<0.01) and the mean *Z*s were lower in males than females and lower in both when measurements were from the feet. The highest mean *Z* was from upper body measurements in females. A two-way (sex and body region) ANOVA on percent fat-free mass (%FFM), Table 3, showed a significant interaction ($F$=15.03, df=4,71, $p$<0.01). Males had a higher mean %FFM than females and, among females, the highest mean %FFM was in the upper body and the lowest in the lower body. *Z* was highly correlated with the whole body and with presenting body region %FFM (Table 4). When measures were made from the feet, the absolute value of *r* was higher for *Z* and lower body than for *Z* and whole body - the opposite was true when measures were from the hands.

**Table 2. *Z* by Sex and Measurement Side (mean, CV)**

| | Right side | Left side | Upper side | Lower side |
|---|---|---|---|---|
| Female | 592,11.0$^B$ | 595,12.1$^B$ | 615,10.8$^A$ | 520,14.8$^C$ |
| Male | 484,11.1$^D$ | 485,11.2$^D$ | 472,11.7$^E$ | 449,12.3$^F$ |

$^{A,B,C,D,E,F}$ Indicate statistically different means ($p$<0.05).

**Table 3. %FFM by Sex and Body Region (mean, CV)**

| | Whole | Right half | Left half | Upper half | Lower half |
|---|---|---|---|---|---|
| Female | 60.8,15.5$^C$ | 60.8,15.4$^C$ | 60.9,15.7$^C$ | 64.4,18.6$^B$ | 57.8,13.8$^D$ |
| Male | 76.8,10.0$^A$ | 76.7,10.1$^A$ | 76.8,10.0$^A$ | 77.2,12.1$^A$ | 76.4,8.4$^A$ |

$^{A,B,C,D}$ Indicate statistically different means ($p$ <0.01).

**Table 4. Correlation Coefficients (*r*) for *Z* with Measurement Side Body Region %FFM**

| | Left side | Right side | Lower body | Upper body |
|---|---|---|---|---|
| Whole | - 0.461 | - 0.456 | - 0.355 | - 0.519 |
| Half | - 0.462 | - 0.455 | - 0.438 | - 0.381 |

Note: All *r* are statistically significant at $p$ <0.01, n=73.

The left and right regions of the body were similar in percent of body composition components and similar *Z* values seemed to reflect that symmetry. In both sexes the lowest *Z* was from foot-to-foot measurement and the highest %FFM was in the upper body, but the highest *Z* was from hand-to-hand measurement only in females. These findings indicate that the use of right and left hand-foot electrode placements are superior to upper or lower body placement for determining body composition with BIA.

[1]Lukaski HC (1996) Am J Clin Nutr, 64, 397S-404S.

# EFFECT OF EXOGENOUS AUXINS ON LEAF EXPANSION IN THE COMMON BEAN (*PHASEOLUS VULGARIS*)

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## INTRODUCTION

Plant growth and development is orchestrated by several classes of morphogens. Chief among these are the auxins (from the Greek for "to grow"). The principle naturally occuring auxin is indole acetic acid (IAA). IAA is synthesized in leaves with the greatest production occurring in the very youngest. Besides IAA, other naturally occurring auxins exist and a number of similar but non-naturally occurring compounds, the "synthetic auxins," have been identified. Transported basipetally (i.e. downward) from young leaves, auxin has a controlling role in diverse aspects of plant development including apical dominance, stem elongation, tropisms, and root development.

In leaf growth, however, the role of IAA was long thought limited to the control of vein elongation (Went, 1951). I found, however, that excised leaf strips from tobacco (*Nicotiana tabacum* L.) have a substantial growth response to auxins (Keller and Van Volkenburgh, 1997, 1998). Others have since shown that this auxin growth response by isolated tobacco leaf tissues is mediated by a specific auxin hormone receptor, auxin binding protein 1 (ABP1) (Jones et al., 1998, Shimomura et al., 1999: Chen et al., 2001).

Recent work in my lab has asked the question whether auxin plays a role in the expansion of leaves in the *intact* plant. In preliminary experiments described last year (Keller, 2001), single applications of the synthetic auxin NAA in concentrated solutions was reported to significantly *inhibit* rather than stimulate leaf blade elongation. This current report describes a more detailed investigation of both the long and short term effects of auxin application to the growth of intact leaves.

## METHODS

*Phaseolus vulgaris* var. Contender were grown in moist vermiculite under greenhouse conditions. After 10 to 14 days, plants with monofoliate leaf blades measuring between 45 to 55 mm in length in most experiments were selected for experimentation. IAA and the synthetic auxins NAA ($\alpha$-naphthalene acetic acid), and 2-NAA ($\beta$-naphthalene acetic acid) were applied in solution at various concentrations directly to leaves. Blade length was measured regularly for 6 or more days. In other experiments high resolution measurements of leaf growth were achieved by attaching leaves to a linear displacement transducer for 30 hour periods. The effect of exogenous auxin on the growth of excised leaf strips was also tested in petri dish assays similar to those described previously (Keller and Van Volkenburgh, 1997).

## RESULTS AND DISCUSSION

Growth-inhibition was specific for active auxins. NAA significantly inhibited long term leaf growth applied at 0.1 and 1.0 mM, the weak auxin 2-NAA was effective at 1.0 mM, but a weak acid control benzoic acid was ineffective. IAA (1 μM, 10 μM, 0.1 mM, and 1 mM) required daily application to be effective. Auxin-induced leaf growth inhibition appeared not to be mediated by auxin-induced ethylene synthesis as growth inhibition was not rescued by treatment with the ethylene synthesis inhibitor AVG.

High resolution measurements of leaf growth found that auxin-induced growth inhibition is preceded by an initial auxin-induced growth surge, generally complete in 6 hours. Excised bean leaf strips, incubated 48 hours in 10 μM NAA, experience only the initial auxin-induced growth phase.

These data suggest a model in which basipetal auxin transport from a leaf either blocks movement of a growth-stimulatory signal (possibly cytokinin in nature) or initiates a movement of a growth inhibitory signal into the leaf from lower plant organs.

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2. Keller CP and Van Volkenburgh E (1997) Plant Physiol 113, 603.
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5. Shimomura S, Watanabe S, Ickikawa H (1999) Planta 209: 118-125.
6. Chen J-G et al. (2001) Plant J. 28(6): 607-617.
7. Keller CP (2001) N. D. Acad. Sci. 55: 60.

# A COMPARISON OF UTLIMATE PULLOUT STRENGTH OF FOUR BIOABSORBABLE TACKS

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## PURPOSE

Bioabsorbable tacks historically have been used to fixate non-contractile tissue such as the glenoid labrum but are currently being used during the repair of contractile tissue such as the supraspinatus tendon. Research has not yet determined the effectiveness of these devices for this purpose. An uninjured supraspinatus tendon in an unloaded arm at 30° shoulder abduction can actively generate approximately 300 N of force. At a minimum, fixation devices must be able to withstand that level of force. The purpose of this study was to evaluate pullout strength; both parallel and perpendicular to the tack shaft; of four different bioabsorbable tacks utilized during supraspinatus repair surgeries.

## METHODS

A total of 46 tacks of four different tack styles were obtained from two separate manufacturers. Each tack was implanted according to manufacturer's direction into a 30# density foam board used to simulate cortical bone of the human humeral head. Each tack was then pulled parallel or perpendicular to the shaft of the tack until the point of failure at the tack-foam interface. Force measurements were recorded via a load cell and computer. *Data analysis:* Data was analyzed via one-way ANOVA and Scheffe's post hoc analysis. Significance was set at the $p = 0.05$ level.

## RESULTS

A significant difference in force tolerance existed between tack styles under both parallel ($F(3,21)=33.30$, $p<.001$) and perpendicular ($F(3,17)=19.44$ $p<.001$) pull out forces. Post hoc analysis indicated the Bionx B tacks withstood significantly greater parallel and perpendicular mean ultimate pullout forces than the other 3 tack styles with failure at $292.04 \pm 18.31$ N and $468.47 \pm 4.21$ N, respectively.

## CONCLUSIONS

Bioabsorbable tacks have qualities similar to other surgical fixation devices. The forces measured in these four tack types were not sufficient to indicate that any of these tacks, if used alone, could reliably withstand the force generated by an active contraction of supraspinatus tendon, without possible disruption of the repair site during the early phases of healing.

## RELEVANCE

The results indicate therapists must be familiar with surgical procedures and the possible impact different fixation devices pose to rehabilitation. Further research needs to be conducted on surgical devices such as the bioabsorbable tacks, in vivo, to determine the efficacy of early or accelerated rehabilitation.

# PROGRESS REPORT ON THE UND BUSH GRANT MAP READING AND INTERPRETATION PROJECT

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Map reading and interpretation is a form of communication that has lifelong learning implications which is why it is an important concern of more than academic geographers (1,2). While it is not soley confined within the teaching of geography, map reading and interpretation is most likely to be associated with geography courses. The general premise of many university 100-level geography courses is these skills have been learned by the entering undergraduates while in pre-college social studies and earth science courses. Consequently, little attention often is paid to helping undergraduates improve their learning strategies to deal with maps and other cartographic representation in such 100-level courses in favor of the academic geographer introducing new geographical concepts and related course content.. However, based upon increasingly negative anecdotal evidence at the University of North Dakota in the late 1990s in the basic human geography course (GEOG 151), there became a need to reconsider whether or not some, if not most, students require remedial education in map reading and interpretation plus, if so, how best to help those undergraduates learn basic map reading and interpretation most successfully.

A five-year longitudinal study of the map reading and interpretation abilities of students in GEOG 151 (Human Geography) began in 2001 with the first year funded through the University of North Dakota's Office of Instructional Development's Bush Scholarship of Teaching Grant. Answers are being sought in this study to four interconnected questions concerning how can undergraduates best master and understand:

- What is the basic vocabulary of cartography as a basis for communicating using maps;
- How to interpret simple maps that are I the choropleth, circle, dot, and isoline formats;
- How to create a readable map using simple computer software; and
- What is the notion that maps are an important means of communication outside GEOG 151 and will be a crucial medium to use in an increasingly interdependent, global economy?

In order to answer this project's set of questions, several different methods of inquiry have been utilized over the summer and past two semesters and have begun to generate preliminary results. These include an on-going survey of the literature, particularly the psychology of learning and of geographic education, especially related to cartography, that is resulting in a useful bibliography. There also is a data base being developed and modified using the International Geographical Union's World Basic Place Vocabulary Test among other instruments: initial analysis of this material indicates major weaknesses in student knowledge of non-American and non-European places. Qualitative interviews are being undertaken with an appropriate sample of GEOG 151 students in conjunction with the collection of data on student usage of a commercially packaged CD-ROM and textbook (3).

Current research attention is upon student usage of the packaged CD-ROM and textbook because there appear to be both advantages and disadvantages to using an electronic medium to teach map reading and interpretation. Based upon data analyzed thus far, the advantages of using the computer software are that students: 1) do not find it so tedious to try to construct various types of maps such as choropleth or circle or dot or isoline maps; 2) are able to focus more upon interpreting the maps produced because of having been able to spend less time on map-making than when using traditional pen-and-ink cartography; and 3) have a sense of being "professional geographers" as they master the technology of the simple GIS (geographic information system) of this particular CD-ROM. The disadvantages discovered using this CD-ROM thus far in the research are that the students with limited computer skills become frustrated with the technology and lose focus of the map reading and interpretation while students with advanced computer skills are still not grasping some of the basic principles, e.g., the difference between equal frequency and equal interval. The next phase of the study is to continue to collect baseline data and to begin conducting a new and more focused series of pre-test and post-test exercises using what has been discovered about student map reading and interpretation skills in this first year of the five-year research project.

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# LORENZO'S OIL AND THE BLOOD BRAIN BARRIER: RAMIFICATIONS FOR THE TREATMENT OF X-LINKED ADRENOLEUKODYSTROPHY

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Adrenoleukodystrophy is a rapid, progressive demyelinating disease affecting the CNS that is characterized by large increases in plasma and tissue very long saturated fatty acids (VLCFA). Lorenzo's oil (LO), consisting of erucic (22:1 n-9) and oleic (18:1 n-9) acid in a triglyceride form, is a dietary therapy effective in reducing plasma and tissue VLCFA levels. Despite the decrease in VLCFA, clinical studies have indicated that LO failed to stop the progressive demyelination, suggesting that erucic acid, the active component of LO, did not cross the blood brain barrier (BBB).

We addressed this question by infusing [14-$^{14}$C]22:1 n-9 (170 µCi/kg) into male rats using two different infusion paradigms. The radiotracer was infused (i.v.) into awake, adult male rats over a 10 min period or infused (i.c.v.) directly into the brain's fourth ventricle over a 7 day period using an osmotic mini-pump. Brains were removed from the cranium, frozen in liquid nitrogen, pulverized at liquid nitrogen temperatures, lipids extracted and separated using standard techniques. For a positive control, [1-$^{14}$C]20:4 n-6 was infused (i.v.) into a separate cohort of awake, adult male rats. Following i.v. infusion, 0.011% of the erucic acid was taken up by the brain compared to 0.055% of the arachidonic acid. About 60% of the brain erucic acid was found in the aqueous fraction compared to 30% for arachidonic acid. This is indicative of greater use of erucic acid for β-oxidation in the brain relative to arachidonic acid. Further, erucic acid was targeted for esterification into cholesteryl ester and triglyceride pools, whereas arachidonic acid was targeted for esterification into phospholipid pools.

In i.c.v. infused rats, 0.078% of the infused dose was taken up by the brain and about 60% of this erucic acid was targeted for esterification into phospholipid pools. A minor amount of i.c.v. infused erucic acid was found incorporated into heart and liver lipid pools suggesting that a portion of the dose left the brain compartment intact. Prolonged exposure of the brain to erucic acid by i.c.v. infusion resulted in a shift in the lipid pools to which the erucic acid was targeted compared to i.v. infusion. These results clearly demonstrate that erucic acid crosses the BBB, similar to arachidonic acid, and is incorporated into specific lipid pools. Hence, these data suggest that prolonged exposure to LO should result in an increase in brain erucic acid content and may be an important consideration when considering the use of LO as a therapeutic agent.

## CONSTITUTION of the NORTH DAKOTA ACADEMY OF SCIENCE

*Founded 1908, Official State Academy 1958*

### ARTICLE I - *Name and Purpose*

Section 1. This association shall be called the NORTH DAKOTA ACADEMY OF SCIENCE.

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

### ARTICLE II - *Membership*

Membership in the Academy shall be composed of persons who share the stated purpose of the Academy and who are active or interested in some field of scientific endeavor.

### ARTICLE III - *Council*

The officers of the Academy shall be a President, a President-Elect, and a Secretary-Treasurer. The Council, consisting of the officers, the retiring President, and three elected Councilors, shall be responsible for the fulfillment of the scientific and business obligations of the Academy.

### ARTICLE V - *Dissolution and Limits of Action*

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

Section 2. No substantial part of the activities of the Academy 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.

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

### ARTICLE VI - *Amendments*

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

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

## BYLAWS

### BYLAW 1. *Meetings*

Section 1. *Scientific Meetings.* The Academy shall hold at least one annual scientific meeting each year at a time and place determined by the Council. Other scientific meetings, regional, state, or local, may be held at times and places determined by the Council. The Council shall establish regulations governing the presentation of papers at Academy sessions. Such regulations shall be made available to members at least three months before any meeting at which they are to apply.

Section 2. *Business Meetings.* A Business Meeting of the membership shall be scheduled at the regular, annual scientific meeting of the Academy. Ten percent of the active members shall constitute a quorum at the annual business meeting.

Section 3. *Special Meetings.* Special meetings shall be called by the President upon the request of ten percent of the active members and require twenty percent of the active members for a quorum. Notice of the time and place of such meetings shall be sent to all members of the Academy at least four weeks in advance of the meeting. Only matters specified in the call can be transacted at a special meeting.

Section 4. *Procedure.* Parliamentary procedures to be followed in all business meetings shall be those specified in "Standard Code of Parliamentary Procedure" by Alice F. Sturgis.

BYLAW 2. *Financial*

Section 1. *Dues and Assessments.* The annual dues and assessments may be changed from time to time by the Council, subject to approval by a two-thirds vote of the members at an annual Business Meeting. The student member dues shall be one-third (to nearest dollar) of the regular member dues. These dues are payable 1 December of each year.

Section 2. *Supporting Members.* Council shall maintain a program to encourage members to voluntarily contribute funds over and above the regular dues and assessments for the support of activities of the Society.

Section 3. *Sustaining Members.* Any association, corporation, institution, or individual desiring to support the Society with funds or services valued at $50 or greater may be invited by the President or designee to become a Sustaining Associate.

Section 4. *Audit and Reports.* The Nominating Committee shall appoint on a yearly basis one member who is not a member of Council to conduct at least one internal audit per year. The Secretary-Treasurer shall report on the financial affairs of the Society, including the results of an annual audit, as may be requested by the Council.

BYLAW 3. *Membership*

Section 1. *Membership Categories.* Classes of membership shall include the following: (a) Regular, (b) Student, (c) Emeritus, (d) Honorary, (e) Supporting, (f) Sustaining, and (g) Lifetime Members.

Section 2. *Eligibility and Procedure for Membership.* Candidates for membership, except Sustaining Member, may be proposed by any regular or emeritus member of the Academy by submitting the candidate's name to the chairman of the Membership Committee.

(a) *Regular Members.* Any person who is active or interested in some field of scientific endeavor shall be eligible for regular membership. A majority vote of Council shall elect to regular membership.

(b) *Student Members.* Any student who is an undergraduate or graduate student in some field of science shall be eligible for student membership. A majority vote of Council shall elect to regular membership.

(c) *Emeritus Members.* Any member in good standing upon formal retirement is eligible for emeritus membership. A majority vote of Council shall elect to emeritus membership.

(d) *Honorary Members.* 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 Academy to honor in this fashion. A two-thirds vote of members attending the annual business meeting shall elect to honorary membership.

(e) *Supporting Members.* Regular or student members may voluntarily contribute funds over and above the regular dues and assessments for the support of activities of the Society.

(f) *Sustaining Associates.* Any association, corporation, institution, or individual desiring to support the Society with funds or services valued at $50 or greater may be invited by the President or designee to become a Sustaining Associate.

(g) *Lifetime Members.* Any regular member in current good standing for at least one year may become a Lifetime Member by paying an assessment equal to 18 times the current annual dues in one lump sum or in two equal payments over the current and following year.

Section 3. *Privileges of Membership.*

(a) Voting at the annual business meeting is permitted of regular and emeritus members.

(b) Members of all categories may attend business meetings of the Academy.

(c) The Secretary-Treasurer and members of Council must be regular members in good standing.

(d) Regular, student, and emeritus members may submit abstracts or communications for scientific meetings of the Academy.

(e) Emeritus and Honorary Members shall be exempt from payment of dues.

(f) A Sustaining Member is provided a display area at the annual scientific meeting of five linear feet per $50 donation up to a maximum of 20 linear feet.

(g) Every member in good standing shall receive a printed copy or an electronic copy (if available and of equal or lesser cost than the printed copy) of the annual *Proceedings of the North Dakota Academy of Science*, the form to be determined by the member.

(h) Special offices such as Historian may be created by the unanimous vote of the regular members at the annual Business Meeting.

(i) All student research participants shall receive a properly inscribed certificate.

Section 4. *Forfeiture of Membership.*

(a) *Nonpayment of dues.* Members shall be dropped from the active list on 31 November following the nonpayment of dues during the membership year commencing the previous 1 December. A member may return to the active list by paying the current year dues.

(b) *Expulsion for Cause.* Membership may be terminated for conduct injurious to the Academy or contrary to the best interests of the Academy. The accused member shall be given an opportunity for a hearing before the Council. If a majority of the Council votes to expel the member, the action must be ratified by at least two-thirds of the members present at the next annual business meeting of the Academy. An expelled member shall forfeit all paid dues and assessments.

BYLAW 4. *Duties and Responsibilities of the Council and Council Members*

Section 1. *Council.* The Council shall meet, at the call of the President, at least twice a year. The Council shall:

(a) be the governing board of the Academy, responsible only to the membership.

(b) arrange for programs, approve committee appointments, be responsible for the fiscal affairs of the Academy, an transact such business as necessary and desirable for function and growth of the Academy.

(c) determine the location of the annual meeting three years in advance.

(d) 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.

(e) shall appoint and may compensate a Secretary-Treasurer.

(f) shall appoint and may compensate an Editor of the PROCEEDINGS and other publications.

(g) shall be empowered to charge a publication fee of authors on a per page basis.

(h) shall control all activities of the Academy including grant applications.

Section 2. *President.* The President shall preside at meetings of the Council and over the annual business meeting of the Academy at the close of the regular term of office. The President shall vote only to break a tie. Unless otherwise specified, the President shall, with the approval of the Council, appoint members to serve on Standing Committees and *ad hoc* Committees, designate the chair of each Committee, and appoint representatives to other organizations. The President serves as Coordinator of the Local Arrangements Committee for the annual meeting that occurs at the end of the President's term.

Section 3. *President-Elect.* The President-elect shall be considered a vice president and shall serve as such in the absence of the President.

Section 4. *Past-President.* The retiring President shall serve as Past-President and chair of the Nominating Committee. The Past President shall serve ex officio on those committees designated by the President and shall serve in the absence of the President and President-elect.

Section 5. *Secretary-Treasurer.* The Secretary-Treasurer shall:

(1) Assist Council in carrying on the functions of the Academy including the receipt and disbursement of funds under the direction of Council.

(2) Manage the Academy Offices under Council's general supervision.

(3) Serve as Managing Editor of the *Proceedings of the North Dakota Academy of Science.*

(4) Prepare a summary of the most recent audit and a report of the Academy's current financial status. This information shall be shared with the membership at the annual business meeting and published in the PROCEEDINGS following the business meeting.

(5) Perform all other duties of the Secretary-Treasurer listed in the Bylaws.

(6) Serve as archivist and be responsible for all official records, archives, and historic material which shall be in reposit with the Secretary-Treasurer.

BYLAW 5. *Appointment, Nomination and Election of Members of Council*

Section 1. *Eligibility for Office.* All candidates for election or appointment to the Council must be regular members in good standing. Nominees for President-elect must be members who reside within easy commuting distance of the site of the annual meeting selected by the Council that occurs when the President-elect serves as President.

Section 2. *Nomination Procedures.* The Nominating Committee shall be responsible for all nominations to elective office, shall determine the eligibility of nominees, shall ascertain that nominees are willing to stand for office, and shall be required to advance to the Secretary-Treasurer at least two names for each open position as needed. Academy members shall have been encouraged to suggest nominees to the committee prior to the Committee submitting its report.

Section 3. *Election Procedures.* Election shall be by secret mail ballot. The Secretary-Treasurer shall prepare a printed ballot that bears all names submitted by the Nominating Committee, that contains a brief biography of each candidate, and that has space for write-in candidates for each office. This ballot is to be mailed to all members no later than 1 November. Each member wishing to vote must return the marked ballot in a sealed signed envelope to the Secretary-Treasurer postmarked not more than thirty days after the ballots were mailed out to members. The President shall appoint tellers who shall count the ballots which have been received by the Secretary-Treasurer and the tellers shall present the results in writing to the President. A plurality of the votes cast shall be necessary to elect and in the case of a tie vote, the President shall cast the deciding vote. The results of the election shall be announced at the annual Business Meeting.

Section 4. *Term of Office.* A President-Elect shall be elected annually by the membership and the following years shall succeed automatically to President and Past President to constitute a three year nonrenewable term. Three Councilors shall be elected by the membership to three-year, non-renewable terms on a rotating basis. All elected Council members shall take office at the end of the next annual Business Meeting following election and shall continue until relieved by their successors. Council is empowered to appoint and compensate a Secretary-Treasurer to successive three-year terms that commence with the beginning of the fiscal year.

Section 5. *Removal from office or position* If for any reason any elected member of Council is unable to fulfill his/her duties, the Council member may be removed from office by two-thirds vote of Council. If for any reason the Secretary-Treasurer is unable to fulfill his/her duties, the Secretary-Treasurer may be relieved of all duties by a majority vote of Council.

Section 6. *Interim vacancies.* Should a vacancy occur in the Presidency, the Council by a majority vote shall appoint a member of the Academy able to coordinate the next annual meeting to fill the unexpired term. A retiring interim President shall succeed automatically to Past President. Should a vacancy occur in the Presidency-elect, the Council shall reassess and change the location of the coinciding annual meeting as necessary and then call for a special election by mail ballot. An interim vacancy in the Past-Presidency shall be filled by the most recently retired Past-President able to fill the duties of the Past-President. Persons appointed to fill the unexpired term of Secretary-Treasurer are expected to remain in the position for a minimum of three years. A vacancy in the office of Councilor shall be filled by a majority vote of Council until the following election at which time the interim Councilor may stand for a full three year nonrenewable term.

## BYLAW 6. *Committees*

Section 1. Standing Committees. Standing committees shall include but not be limited to, the following: Editorial, Education, Denison Award, Necrology, Nominating, Resolution, Membership, and Audit Committees. The President shall appoint members of committees other than the Nominating and Audit Committees.

Section 2. *Editorial Committee.* The Editorial Committee shall consist of three regular members appointed to three year terms. The duties are explained in BYLAW 7 (Publications).

Section 3. *Education Committee.* The Education Committee shall consist of five regular members and two high school teachers appointed to five year terms. 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.

Section 4. *Denison Awards Committee.* The Denison Awards Committee shall consist of six regular members appointed to three year terms. 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.

Section 5. *Necrology Committee.* The Necrology Committee shall consist of three regular members appointed to three year terms. The Necrology Committee shall report to the annual meeting on those deceased during the preceding year. Obituaries may be included in the minutes of the annual meeting and/or published in the Proceedings.

Section 6. *Nominating Committee.* The Nominating Committee shall consist of the five most recent past-presidents. The major duties of the Nominating Committee are listed in BYLAW 5 (*Appointment, Nomination and Election of Members of Council*). The Nominating Committee will also administer the selection process, develop a separate funding source for a monetary award, and develop, for Executive Committee approval, the criteria for the North Dakota Academy of Science Achievement Award.

Section 7. *Resolution Committee.* The Resolution Committee shall consist of three regular members appointed to three year terms. The Resolution Committee 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.

Section 8. *Membership Committee.* The Membership Committee shall consist of unlimited numbers of regular members appointed annually.

Section 9. *Audit Committee.* The Nominating Committee shall appoint on a yearly basis one member who is not a member of Council to conduct at least one internal audit per year.

Section 10. *State Science Advisory Committee.* The State Science Advisory Committee (SSAC) shall consist of five regular or emeritus members appointed to four year terms. The SSAC shall serve to direct questions of a scientific nature to the appropriate expert as requested, shall inform regional granting agencies and state and national science policymakers of its expertise and availability and shall counsel those agencies and persons upon their request. The SSAC shall adhere in particular to the guidelines described in Article V, Section 2 of the Constitution.

Section 11. *Ad hoc Committees.* The President may appoint such additional committees as may be needed to carry out the functions of the Academy. Ad hoc committees serve only during the tenure of the president who appointed them. Reports of ad hoc committees shall be presented to Council or to the annual meeting.

BYLAW 7. *Publications*

Section 1. *Editorial Committee.* Three regular members are appointed to the Editorial Committee for renewable three year terms. The Editorial Committee shall develop and recommend the Academy publication program and policies to the Council. It will assist the Editors of each official publication in reviewing manuscripts for those publications that include the *Proceedings* . Chairs of symposia will review manuscripts written for relevant symposia.

Section 2. *Managing Editor.* The Secretary-Treasurer shall serve as the Managing Editor of all Academy publications and as such shall oversee each Editor.

Section 3. *Editor.* Editors shall serve three year terms. The Editors shall edit all official publications of the Academy including the *Proceedings.*

BYLAW 8. *Memorial Fund*

The Council of the Academy shall establish a J. Donald Henderson Memorial Fund and administer this fund so that the proceeds will be used to promote science in North Dakota.

BYLAW 9. *Fiscal Year*

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

BYLAW 10. *Achievement Award*

The Academy establishes the North Dakota Academy of Science Achievement Award to be given periodically to an Academy member in recognition of excellence in one or more of the following:

a. Nationally recognized scientific research.

b. Science education.

c. Service to the Academy 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 Council approval, the criteria for the award.

BYLAW 11. *Research Foundation*

The **North Dakota Science Research Foundation** is established as an operating arm of the Academy. 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 Academy and shall be separately accounted for annually.

The Foundation Board of Directors shall be comprised of five members of the Academy , representing different disciplines. Members shall be appointed by the President of 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 report to the membership of the Academy at each annual meeting, and the Secretary-Treasurer shall present an accompanying financial report.

BYLAW 12. *Affiliations*

The Academy may affiliate itself with other organizations which have purposes consistent with the purposes of the Academy. Such affiliations must be approved by the Council and by a majority of those attending a regularly scheduled business meeting of the membership.

BYLAW 13. *Indemnification*

Section 1. Every member of the Council or employee of the North Dakota Academy of Science shall be indemnified by the Academy against all expenses and liabilities, including counsel fees, reasonably incurred or imposed upon him/her in connection with any proceedings to which he or she may be made part, or in which he or she may become involved, by reason of being or having been a member of the Council, or employee at the time such expenses are incurred, except in such cases wherein the member of the Council or employee is adjudged guilty of willful misfeasance or malfeasance in the performance of his or her duties. Provide, however, that in the event of a settlement of the indemnification herein shall apply only when the Council approves such settlement and reimbursement as being for the best interests of the Academy.

The foregoing right of indemnification shall be in addition to and not exclusive of all other rights to which such members of the Council or employee may be entitled.

# ACADEMY OFFICERS AND COMMITTEES

**Executive Committee**
Membership:
- Past-President
- President
- President-Elect
- Secretary-Treasurer
- Councilors (three-year terms)

**President**
Jody A. Rada
Dept. of Anatomy & Cell Biology
University of North Dakota
PO Box 9037
Grand Forks, ND 58202
(701)777-2101
jarada@medicine.nodak.edu

**Past-President**
Ronald K. Jyring
Bismarck State College
1500 Edwards Avenue
Bismarck, ND 58501
(701)224-5400
jyring@gwmail.nodak.edu

**President-Elect**
see ballot

**Secretary-Treasurer**
Jon A. Jackson
Dept. of Anatomy & Cell Biology
University of North Dakota
Grand Forks, ND 58202
(701)777-4911
jackson@medicine.nodak.edu

**Councilor**
Joseph H. Hartman (2000-2003)#
Department of Geology
University of North Dakota
Grand Forks, ND 58202
interim - serving the portion of the term of Carl Fox

Richard Barkosky (1999-2002)
Department of Biology
Minot State University
Minot, ND 58701
barkosky@warp6.cs.misu.nodak.edu

Larry Heilmann (2001-2004)
3535 - 31st St SW
Fargo, ND 58102
lheilmann@worldnet.att.net

**Executive Committee***

** Leaving - needs a replacement

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**Committees of the North Dakota Academy of Science**

**Editorial Committee***

**Education Committee***

**Denison Awards Committee***

**Necrology Committee***

**Nominating Committee**

**Resolution Committee***

**Membership Committee***

**North Dakota Research Foundation Board of Directors***

*** indicates available openings**

## PAST PRESIDENTS AND LOCATIONS OF THE ANNUAL MEETING

## 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 | Bismarck |
| 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 | Bismarck |
| 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 |
| 1995 | Carolyn Godfread | Bismarck |
| 1996 | Eileen Starr | Valley City |
| 1997 | Curtiss Hunt | Grand Forks |
| 1998 | Allen Kihm | Minot |
| 1999 | Joseph Hartman | Grand Forks |
| 2000 | Mark Sheridan | Moorhead, MN |
| 2001 | Ron Jyring | Bismarck |
| 2002 | Jody Rada | Grand Forks |
| 2003 | | Minot |

## Contributors to the North Dakota Academy of Science Research Foundation

Brant Bigger (Lincoln, NE)
Virgil Carmichael (Bismarck)
Clay Comstock (Grand Forks)
Daniel Daly (Grand Forks)
J. Mark Erickson (Canton, NY)
W. Thomas Johnson (Grand Forks)
Glenn Lykken (Grand Forks)
Douglas Munski (Grand Forks)
William Siders (Grand Forks)
Glenn Smith (Fargo)
John Steiner (Bismarck)
Katherine Sukalski (Grand Forks)

## Life Memberships

Ron Jyring (Bismarck)
J. Mark Erickson (Canton, NY)
Douglas Munski (Grand Forks)

## FINANCIAL STATEMENT
### Summary of Accounts as of:

| | 2000 | 2001 | 2002 |
|---|---|---|---|
| ASSETS | | | |
| Operating Accounts | | | |
| Checking | 5753.04 | 4883.60 | 3448.11 |
| | | | |
| Trust Accounts | | | |
| Scholarship | 20193.80 | 23092.90 | 28729.64 |
| Research Foundation | 13780.17 | 13813.80 | 13843.65 |
| | | | |
| Total | $39,727.01 | $41,790.30 | $46,021.40 |
| | | | |
| LIABILITIES | | | |
| | | | |
| Advanced Dues Payments | 540.00 | | |
| Restricted Purpose Funds | | | |
| Scholarship Principal | 20193.80 | 23092.90 | 28729.64 |
| Research Foundation | 13780.17 | 13813.80 | 13843.65 |
| | | | |
| Total | $34,513.97 | $36,906.70 | $42,573.29 |
| | | | |
| Accumulated Surplus | $5,213.04 | $4,883.60 | $3,448.11 |
| Change in Surplus | ** | (329.44) | (1,435.49) |
| | | | |
| DUES | | | |
| Reinstatements | | | |
| Current year | 3084.36 | 2232.00 | 1910.79 |
| Future years | | | |
| Sponsor/Patron | | | |
| Total | $3084.36 | $2332.00 | $1910.79 |
| | | | |
| INSTITUTIONAL SUPPORT | | | |
| NDUS TOTAL | $0.00 | $0.00 | $0.00 |
| | | | |
| ANNUAL MEETING | | | |
| Registration fees | 301.50 | 1684.00 | 1911.00 |
| Total | $301.50 | $1,684.00 | $1,911.00 |
| | | | |
| AWARDS PROGRAM | | | |
| Scholarship Dividends | 493.49 | 789.76 | 575.26 |
| NDAS Research Foundation | 0.00 | 0.00 | 0.00 |
| Total | $493.49 | $789.76 | $575.26 |

| | 2000 | 2001 | 2002 |
|---|---|---|---|
| PUBLICATION SALES | $64.00 | $50.00 | $0.00 |
| MISCELLANEOUS INCOME | | | |
| Donations | 0.00 | 0.00 | 0.00 |
| Dividend Income | 0.00 | 975.00 | 0.00 |
| Total | $0 | $975.00 | $0.00 |
| TOTAL INCOME | $3,943.35 | $5,730.76 | $4,397.05 |
| MEMBERSHIP | | | |
| Emeritus | 48 | 44 | 46 |
| Students | 40 | 45 | 59 |
| Professional | 140 | 140 | 140 |
| Delinquent | 18 | 14 | 10 |
| Dropped | 10 | 10 | 10 |
| Other | 7 | 7 | 7 |
| Total Member Count | 253 | 250 | 262 |
| ANNUAL MEETING | | | |
| Speakers Expenses | 0 | 0 | 0 |
| Meals/Refreshments | 600.00 | 1074.39 | 1760.75 |
| Printing | 200.00 | 200.00 | 183.83 |
| General Expenses | | | 800.86 |
| Registration refund | (12.50) | (22.50) | |
| Total | $787.50 | $1,251.89 | $2,745.44 |
| AWARD PROGRAMS | | | |
| ND Science/Engineering Fair | 50.00 | 50.00 | 50.00 |
| Denison | 400.00 | 400.00 | 400.00 |
| ND Junior Academy | 350.00 | 350.00 | 402.00 |
| Research Foundation Grant | 500.00 | 0 | 460.00 |
| Total | $1,300.00 | $800.00 | $1,312.00 |
| PUBLICATION | | | |
| Proceedings | 438.00 | 136.00 | 0.00 |
| Supplement | | | |
| Total | $438.00 | $136.00* | $0.00* |

* listed under duplicating in 2000-2001

| | 2000 | 2001 | 2002 |
|---|---|---|---|
| OFFICE EXPENSES | | | |
| Postage | 153.79 | 194.44 | 153.79 |
| Post Office Box Rental | 39.00 | 39.00 | 39.00 |
| Duplication | 76.64 | 515.99 | 76.64 |
| Supplies | 579.00 | 579.86 | 524.00 |
| Clerical Assistance | | 105.10 | 635.65 |
| Phone | | | |
| Other | 14.09 | 14.09 | 14.09 |
| Bank Fees | 28.30 | 28.30 | 28.30 |
| Total | $890.82 | $1,476.78 | $1,471.47 |
| | | | |
| MISCELLANEOUS | | | |
| Fidelity Bond | 75.00 | 75.00 | 75.00 |
| NAAS Dues | 70.00 | 70.00 | 70.00 |
| Other | 10.00 | 10.00 | 10.00 |
| Research Foundation Loan interest | | | |
| Total | $155.00 | $155.00 | $155.00 |
| | | | |
| Total Disbursements | $3,571.32 | $3,819.67 | $5,683.91 |
| | | | |
| SCIENCE RESEARCH FOUNDATION | | | |
| | | | |
| CASH INCOME | | | |
| Donations from Members | 315.00 | 0.00 | 287.00 |
| Allocations from Dues | 20.00 | 0.00 | 112.00 |
| Interest Accrued | 36.54 | 68.14 | 36.54 |
| Sponsors/Patrons | | | |
| Total | $371.54 | $68.14 | $435.54 |
| | | | |
| CASH EXPENSE | | | |
| Grants | 500.00 | 500.00 | 0.00 |
| Interest Compounding | 0.00 | 0.00 | 0.00 |
| Other Disbursements | | | |
| Bank Fees | 3.30 | 6.70 | 6.70 |
| Total | $503.30 | $506.70 | $6.70 |
| | | | |
| Net Change | ($131.76) | ($438.56) | $428.84 |
| | | | |
| ASSETS | | | |
| Pass Book Savings, 31 Dec | 3780.17 | 3813.80 | 3843.64 |
| T-Note, book value | 0.00 | 0.00 | 0.00 |
| CD - note value | 10000.00 | 10000.00 | 10000.00 |
| | | | |
| Investment Total | $13,780.17 | $13,813.80 | $13,843.65 |
| Change from previous year | $39.54 | $33.63 | $29.85 |

| | 2000 | 2001 | 2002 |
|---|---|---|---|
| SCHOLARSHIP FUND | | | |
| CASH INCOME | | | |
| Sempra Energy | 283.25 | 352.00 | 137.50 |
| Alliant Energy | 210.24 | 437.76 | 437.76 |
| Total | $493.49 | $789.76 | $575.26 |
| CASH EXPENSE | | | |
| Denison Awards | 400.00 | 400.00 | 400.00 |
| Junior Academy Awards | 350.00 | 350.00 | 350.00 |
| ND Science and Engineering Fair | 50.00 | 50.00 | 50.00 |
| Other Expenses | | | |
| TOTAL | $800.00 | $800.00 | $800.00 |
| Net Change | ($306.51) | ($10.24) | ($224.74) |
| ASSETS | | | |
| Sempra Energy (purchased as ENOVA 1983, 250 shares) | | | |
| | 821.32 | 850.94 | 873.94 |
| Price 18.50 | 17.13 | 18.94 | 25.27 |
| Value 4625.00 | 14065.16 | 16115.01 | 22084.44 |
| IEC/Alliant Energy | | | |
| (purchased as IES Industries 1990, 120 shares) | | | |
| | 218.88 | 218.88 | 218.88 |
| Price 31.63 | 28.00 | 31.88 | 30.36 |
| Value 3795.60 | 6128.64 | 6977.89 | 6645.20 |
| Total Investment Value | $20,193.80 | $23,092.90 | $28,729.64 |
| Change from previous year | – | $2,899.11 | $5,636.73 |

Respectfully submitted

Jon Jackson
Secretary-Treasurer,
NDAS

3/31/02

## A

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