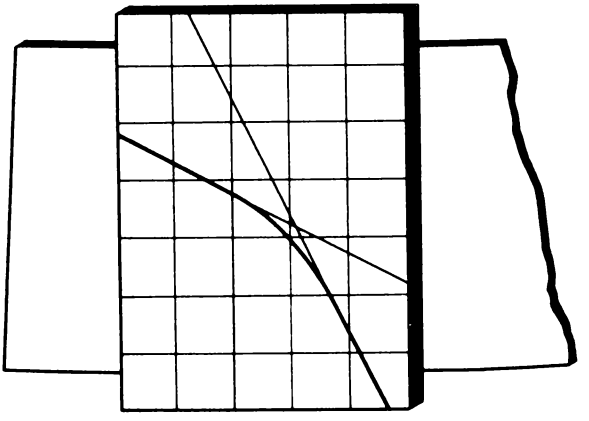
PROCEEDINGS

of the

NORTH DAKOTA ACADEMY OF SCIENCE

ABSTRACTS



Joint Minndak Bicentennial Meeting

(44th Annual Meeting, Minnesota Academy)
(68th Annual Meeting, North Dakota Academy)

APRIL 30 and MAY 1, 1976

Concordia College, Moorhead, Minnesota
Moorhead State University, Moorhead, Minnesota
North Dakota State University, Fargo, North Dakota

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of the
NORTH DAKOTA
ACADEMY OF SCIENCE

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Volume 30, Part I April 1976

NORTH DAKOTA ACADEMY OF SCIENCE

(Official State Academy; founded December, 1908)

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OFFICERS AND OTHER MEMBERS OF EXECUTIVE COMMITTEE

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EDITOR'S NOTE

The abstracts are arranged alphabetically by author or first author if more than one author is involved. An author index to all authors is on pages 53 and 54.

INTERSTATE MIGRATION TRENDS AND STATE BARRIERS, R.B. Adams, Dept. of Geography, Univ. of Minnesota, Mpls., Minn. 55455.

Secular trends of high-level residential mobility are continuing into the 1970's in the U.S., but emergent forces presage a deceleration of long-distance movement and an incipient stabilization of interstate migration patterns: 1) the Westward Movement remains strong with the exception of a marked decline to California since the mid-1960's; 2) Peripheralization has increased the share of population living in coastal states; 3) Metropolitanization is decelerating as non-rural, non-metropolitan areas are now growing at faster rates; 4) a Southward Movement has emerged, as indicated by high growth rates in the southern third of the nation ('Sun Belt'), led by Florida, Texas and Arizona; 5) the relative growth of contiguous migration (to neighboring states) implies a contraction of future patterns. Barrier indices are calculated for interstate boundaries to measure the degree of resistance to contiguous movement; the index is based upon relative length of common boundary and a linkage index of relative interaction. Boundaries are found to be "open" in most of the West and across very short boundaries, but quite restrictive between states in the East, Midwest and Southeast. The barrier index is offered as an analytical tool to reduce estimation errors from conventional gravity models of exchange.

IDENTIFICATION OF ETIOLOGIC AGENTS OF AMOEBIC MENINGOENCEPHALITIS: SEM as a diagnostic aid. D. J. Allen. Department of Anatomy, Medical College of Ohio, Toledo, Ohio 43614

With the aim of better depicting its surface contours, specimens of Acanthamoeba culbertsonii were fixed in Karnovsky solution, dehydrated in an ethanol series, Critical Point dried using a modified dry bomb technique, coated with gold and viewed in an ETEC Autoscan scanning electron microscope. An axenic, concentrated suspension of these unicellular organisms was obtained from the American Type Culture Collection. Cells taken from log-phase cultures were injected into the spinal subarachnoid space and retrieved 98 hours later by a second cisternal puncture. A comparison of the culture cells and those retrieved in CSF revealed only slight surface morphological differences. SEM of both control (cultured) and experimental specimen demonstrated a variety of surface specializations heretofore unreported. These included long and short microvillous, filiform and bleblike microappendages. The latter of these were more numerous on cells observed both in CSF and on the connective tissue linings of the subarachnoid space. These morphological differences appear to be due to the organism's response to the differences in ionic concentration and osmolarity of the CSF and the fixative.

(Supported by MCO General Research Grant)

HYDROGEOLOGY OF A SANITARY LANDFILL AT LANGDON, NORTH DAKOTA. B. Michael Arndt. North Dakota Geological Survey, Grand Forks, ND 58202

A two-year study to evaluate the effects of solid waste disposal on local groundwater supplies was recently completed at a sanitary landfill at Langdon, North Dakota. The landfill is located in an abandoned gravel pit on the east flank of a 5-mile-long northwest-trending esker. The 15-acre landfill site is underlain by 2 to 35 feet of shaly gravel, which is underlain by 5 to 15 feet of till, which is underlain by shale of the Pierre Formation.

Ten 1-inch and eleven 4-inch test wells were installed at the landfill site. Periodic water-level measurements were made on each well. Water analyses from the large-diameter wells included determinations of Ca, Na, Mg, K, NH_3, SO_4, Cl, PO_4, NO_3, specific electrical conductance, pH, temperature, and bacterial content.

Groundwater flow at the site is controlled principally by the topography. The major flow component is northeastward, with recharge occurring mainly along the crest of the esker and discharge occurring at the base of the esker outside the landfill. The gradient on the water table through the site is nearly flat, ranging between 0.004 and 0.0007. Most of the groundwater flows through the shaly gravel, which has a hydraulic conductivity between about 5 and 20 feet per day. Groundwater velocity through the landfill site is between about 0.25 and 0.01 feet per day.

Water-quality analyses indicate no significant contamination as a result of refuse disposal. The water chemistry indicates that nitrate, phosphate, and ammonia are entering the groundwater system from outside the landfill. There is an indication that some phosphate in the groundwater may be contributed by the refuse.

This study was funded in part by OWRRI Grant No. A-038NDAK.

SOME EFFECTS OF PRESCRIBED FIRE ON THE DISTRIBUTION DENSITY AND HEIGHT OF AMERICAN HAZEL (Corylus american,Walt.) ON THE CEDAR CREEK NATURAL HISTORY AREA IN MINNESOTA. A.N. Axelrod and F.D. Irving Wis. Dept. of Nat. Res. and College of Forestry, University of Minnesota, St. Paul, Mn. 55108.

On four oak savanna restoration compartments with a total area of 109 areas, annual burns (1965-1972) reduced the per cent of milacre plots stocked with hazel to 39 compared to 65 on unburned areas. Four growing seasons after one and three fires the hazel distribution was not significantly different from the control. Annual burns increased the density of hazel stems in clones to 19.5 per .0001 acre compared to 11.0 on controls. Stem density four years after 1 and 3 burns averaged 10.0 and 8.0 per .0001 acre. The o.d. weight of live hazel stems per .0001 on annual burn areas was 16 per cent of that on controls. Four years after 1 or 3 fires stem weight was not significantly different from the control. Stem height on annual burn areas averaged 17 inches compared to 33 inches on the controls. Maximum stem heights on annual burns averaged 24 inches compared to 42 inches on controls. Four growing seasons after 1 or 3 fires average and maximum stem heights were not significantly different from controls

Supported by AES, University of Minnesota

METHODS OF GENTAMICIN ANALYSIS. J. B. Axtmann, E. D. Renner and K. J. McMahon. Dept. of Bacteriology, North Dakota State Univ. and Fargo Clinic, Fargo, N. Dak. 58102.

Gentamicin assay is necessary to provide adequate bactericidal concentrations of the antibiotic and to prevent accumulation at toxic levels. Two commercial methods may be employed to assay gentamicin: a radioimmunoassay which yields a tritiated product and Serassay Garamycin, a Bacillus subtilis bioassay. These were compared to a biological assay utilizing a multiple-antibiotic-resistant strain of Klebsiella pneumoniae. When penicillins or cephalosporins were administered concommitantly with gentamicin, treatment with B-lactamase allowed accurate measurement of gentamicin levels when using the B. subtilis assay procedure. This step is unnecessary for the radioimmunoassay and only rarely necessary for the Klebsiella bioassay. According to statistical analysis by the randomized complete block design, the results obtained by all three methods were comparable. The biological assays are less sensitive than the radioimmunoassay and require antibiotic inactivation (Serassay). The Schering Serassay method is of questionable value because of interference by other antibiotics. To be economically feasible, the radioimmunoassay method would require greater than 25 gentamicin assays per day. The Klebsiella method was preferred because it did not require inactivation, and gave acceptable results.

A COMPARATIVE STUDY OF ENVIRONMENTAL RELATIONS OF BLACK SPRUCE AND TAMARACK COMMUNITIES IN NORTHWESTERN MINNESOTA. *R.H. Bares and M.K. Wali.* Dept. Biol., Univ. N. Dak., Grand Forks, N.D. 58202.

An intensive ecological investigation of minerotrophic black spruce and tamarack communities was conducted during 1974 and 1975 in Roseau County, Minnesota. Parameters included phytosociological analysis, tree mensuration data, and chemical (major and trace ions) analysis of water, peat at different depths, and litter. Litterfall data were obtained intra-seasonally during 1974 and in the late fall of 1975. While the total dry weight litterfall values in the two community types were not statistically significant, differences in woody and non woody components were significant. A multivariate analysis revealed significant differences between the two community types as follows: in water for pH, electrical conductivity, Ca, Mg, Na, Fe, NO_3, CO_3, HCO_3; in peat for several anions, major ions and trace elements in total, replaceable and water soluble forms; and in litter for Ca, Mg, K, P, Cu, Mn, Fe, Al and Pb.

UTERINE VASCULAR ADAPTATIONS PROVIDING FOR EMBRYONIC NUTRITION DURING IMPLANTATION IN THE RAT. Christopher A. Bates. Dept. of Anat., Univ. N. Dak., Sch. of Med., Grand Forks, N. Dak. 58202

Increased vascular permeability at the implantation site has been established. This study was undertaken to explore the morphological adaptations involved.

6 days after fertilization, female rats received intravenous injections of Niagara Blue, an intravital dye, and ferritin, a macromolecular tracer. After circulation of the two substances the uterus was fixed in glutaraldehyde, and implantation sites, as marked by dye, were dissected free. These specimens were prepared for electron microscopy. Endometrial tissue from various non-pregnant states were treated similarly for controls.

Implantation endometrial capillaries had areas of attenuation and also fenestrations. The latter were several hundred Å across and appeared to be closed by a diaphragm. Ferritin was observed on both sides of the fenestrations and pinocytotic vesicles were seen to contain ferritin in various stages of transport. Evidence indicated extravascular ferritin to be higher opposite the fenestrations. Search of control tissue (multiparous and nulliparous endometria, and interimplantation regions of pregnant uterus) has not revealed fenestrations. These structures may serve as unique transport mechanisms for nutrients prior to the establishment of a more direct materno - fetal blood relationship.

BIOLOGY AND ECOLOGY OF SULEIMA HELIANTHANA (RILEY) (LEPIDOPTERA: OLETHREUTIDAE) IN NORTH DAKOTA. D. W. Brassard and J. T. Schulz. Dept. of Entomology, N. Dak. State Univ., Fargo, N. Dak. 58102

A study was conducted in 1974-1975 to define the bionomics of Suleima helianthana (Riley), a pest of cultivated sunflowers in the Red River Valley. Previous studies by Ehart (1974 MS thesis, N. D. State Univ.) defined the biology and economic importance of S. helianthana. Several host preference studies were conducted to determine the importance of alternate hosts as a reservoir for S. helianthana. Bioassay of suspected alternate hosts revealed that common ragweed, Ambrosia artemisifolia L.; prairie sunflower, Helianthus maximiliani Schrad.; sand sunflower, H. petiolaris Nutt.; and wild sunflower, H. annuus L., were capable of supporting infestations of S. helianthana. Experiments designed to test ovipositional preference showed that H. annuus and H. maximiliani are preferred hosts for oviposition and that moths will oviposit on A. artemisifolia. Examination of suspected alternate hosts in the field revealed relatively low (approx. 2%) infestation levels on H. annuus with moderate (approx. 9.5%) infestation levels on H. maximiliani. No infestations were found on A. artemisifolia. Three species of parasitic wasps belonging to the families of Braconidae and Ichneumonidae were found attacking S. helianthana. Supported by N. D. Agr. Exp. Sta. and USDA Coop. Agreement 12-14-3001-209.

SOME EFFECTS OF ZINC-DEFICIENCY ON THE DEVELOPMENT OF THE HIPPOCAMPUS AND CEREBELLUM IN THE SUCKLING RAT. S. Buell, G.J. Fosmire and H.H. Sandstead Dept. of Anatomy, Univ. of North Dakota and U.S. Dept. of Agriculture, Agriculture Research Service, Human Nutrition Laboratory, Grand Forks, N. Dak. 58201

Lactating dams (ZD) were fed a zinc-deficient diet ad libitum and given demineralized drinking water. There were two zinc-supplemented (25 ppm zinc in drinking water) control groups. Dams of one control group were individually pair-fed (PF) to ZD. The second control group was fed ad libitum (AL). At 21 days of age pups from litters maintained at 7 or 8 pups were either decapitated for biochemical analysis or formalin-perfused for histological preparation. Cerebellar and hippocampal weights of the ZD pups were less than those of the PF pups which were less than those of the AL pups. The same was true for total amounts of DNA, RNA, and protein in these tissues. Histological data indicated significant retardation of development with respect to size and differentiation of the cerebellar vermis. These findings are consistent with a decrease in size and total cellularity of the cerebella and hippocampi of rat pups exposed to zinc-deficiency throughout the suckling period. Effects of undernutrition with adequate zinc are less severe than those of zinc-deficiency per se.

GLACIAL STRATIGRAPHY OF SOUTHEASTERN NORTH DAKOTA. M. Camara and S.R. Moran. Dept. of Geology, Univ. of N. Dak., Grand Forks, N. Dak. 58202.

Seven lithostratigraphic units are recognized in glacial sediment (till) of southeastern North Dakota. The units are differentiated and correlated using field characteristics, grain-size distribution (texture), and lithologic composition of the very-coarse-sand fraction of the till.

The lower-most unit, Lisbon-Fort Ransom 60, is tentatively correlated to an unnamed unit of Hobbs(1975) in northeastern North Dakota. Units 50, 40, 30, and 10 are tentatively correlated to the Tiber, Vang, Gardar, Dahlen, and Hansboro Formations (Hobbs, 1975), respectively. A stratigraphic unit correlative with Carrington-Grand Rapids 1 has not been found outside the study area.

The presence of high areas on the bedrock surface of Ransom County is reflected by increased shale down-ice from the outcrop in six of the units. On the basis of these indicator fans, units Lisbon-Fort Ransom 60 and 50 were deposited by ice flowing southward; Lisbon-Fort Ransom 40 was deposited by a glacier flowing south-southwestward; units Lisbon-Fort Ransom 30, 20, and 10 were deposited by ice flowing southeastward. Washboard moraine indicates that Carrington-Grand Rapids 1 was deposited by a glacier flowing south-southeastward.

SAMPLE SIZE FOR ESTIMATING YIELDS IN SUGARBEET PLOTS. D. R. Carey and R. D. Frye. Dept. of Entomology, N. Dak. State Univ., Fargo, N. Dak. 58102

An investigation to determine adequate yield samples from sugarbeet plots was conducted in 1973, 1974 and 1975. Sample sizes tested ranged from 5 to 100 foot lengths of beet row. 1 and 2 row samples were also tested. The samples were taken with a 1 row mechanical harvester. Results indicated that the smallest reliable sample for estimating sugarbeet yields in test plots is 15 linear feet of beets from a single row. Estimated yields from larger samples, and from 1 and 2 row samples, were not significantly different statistically. Trends indicated that larger samples may be desirable in plots with small beets and/or a poor beet stand. In view of greatly increasing logistical costs, the smallest reliable sample size should be considered for estimating sugarbeet yields in experimental plots. Supported by N. Dak. State Univ. and U.S.D.A.

INTERACTIVE STATISTICAL COMPUTING FOR UNDERGRADUATE LIBERAL ARTS EDUCATION. William L. Carlson, Ralph Bjork and Becky Lindquist, Dept. of Economics, Academic Computer Center, Dept. of Economics. St. Olaf College, Northfield, Minnesota 55057.

St. Olaf College has developed an Interactive Statistical Analysis System for classroom and research usage. SODAS (St. Olaf Data Analysis System) operates on a Minicomputer Time Sharing System (DEC PDP/1140 has 15 terminals, 64K of core, and 3 disks). SODAS is used extensively by students for study of statistics, course projects, and research. In addition, it is used for faculty research. This system has increased student interest by involving them in realistic problems. In addition, student sophistication in problem solving has increased.

The paper indicated the system design, the philosophy of interactive computing, and the pedagogical applications in an undergraduate curriculum.

BOVINE HYDROCEPHALUS IN NORTH DAKOTA. L.A.Christoferson, G.Hazen, and R.W.Leech. TNI and Dept. of Neuroscience, School of Med., Univ. North Dakota, Grand Forks, N.D. 58202

As a part of a three-part study of hydrocephalus in calves in North Dakota, including shunting and clinical evaluation of effected calves, and breeding of hydrocephalic producing cows, a survey of sporadically occurring hydrocephalus was carried out to delineated possible morphologic varieties. 22 calves, including several breeds, were received from all areas of the state. 5 were excluded as normal or having other disease. Of the remaining 17 cases, aqueductal atresia accounted for 9 cases. There was no evidence of forking or aqueductal gliosis. One case demonstrated an aqueductal membrane, and there were 4 cases of hydranencephaly, 1 Dandy-Walker malformation, 1 porencephalic cyst and 2 cases with multiple CNS anomalies. Dilatation of the fourth ventricle in the hydranencephaly cases suggested a communicating hydrocephalus component. Certain possible autosomal recessive hydrocephalus syndromes in calves were not identified nor were other causes such as chondrodysplasia and meningitis. The causes of hydrocephalus are many and even a brief survey such as this one indicates that the variety of possibilities are very similar to that seen in humans. Recognition of either possible viral causes or genetically based syndromes may alleviate the breeders' loss, or provide a better working model for the human disease.

A PARTIAL REVIEW OF PLANT ECOLOGICAL RESEARCH IN NORTH DAKOTA AND MINNESOTA. G. K. Clambey. Department of Botany, North Dakota State University, Fargo, North Dakota. 58102

To assess the development of plant ecology in North Dakota and Minnesota, 302 pertinent publications have been inventoried. Prior to 1920 there were few publications, but these included several significant contributions to the infant science of plant ecology. Research accelerated from 1920 to 1940, but the following decade, marked by the disruption of World War II, witnessed a decline in publications. Rapid expansion has characterized the post-1950 era. The publications, divided in a ratio of two to one between Minnesota and North Dakota, are distributed almost equally between four main vegetation types: deciduous forest, grassland, mixed coniferour-deciduous forest, and wetland. However, geographically, plant ecological research has been notably heterogeneous. Several regions and specific sites have been extensively studied, while other regions have been neglected. Certain topics, e.g., primary productivity, nutrient transfer, paleoecology, and the role of fire in natural plant communities, have received considerable attention, however, in the first two cases, a synthesis of currently available data is needed.

FOREST VEGETATION EFFECTS ON NUTRIENT CONTENT OF THROUGHFALL IN NORTHERN MINNESOTA. N. B. Comerford and E. H. White. DNR, Olympia, Wash., Univ. Mn., St. Paul, Mn.

Gross precipitation and throughfall in the open and under paper birch and red pine stands were monitored for concentrations of N, P, K, Ca and Mg by storms during the 1975 growing season. Data from the study indicate that hazel understories as well as paper birch and red pine canopies are of considerable importance in modifying nutrient cycling by throughfall within a forest ecosystem. The importance of the hazel layer did depend upon the extent of areal coverage. The hazel canopy was of greatest importance in the total nutrient cycling of K and Mg. Differences in nutrient input by throughfall to the two sites was related to the tree species and to significantly different interception losses between paper birch and red pine. Inputs of N, P, K, Ca and Mg to the forest ecosystem by gross precipitation are reported and discussed in relation to maintaining site productivity that may be adversely affected by full-tree harvesting techniques. Total amounts of nutrients added by gross precipitation during the 1975 growing season in lbs/acre were: Ca - 5.39; N - 2.55; K - 1.74; Mg - 0.74 and P - 0.12.

PHOSPHORUS UPTAKE AND ALKALINE PHOSPHATASE ACTIVITY IN THE GREEN ALGA, SCENEDESMUS TRAINORII (MEYEN) SHUBERT. Cecilia M. Conway and L. Elliot Shubert. Dept. Biol., Univ. N. Dak., Grand Forks, N.D. 58202.

Scenedesmus trainorii, a polymorphic species consisting of both colonies and unicells was studied to determine the cellular mechanism for control of form. Axenic cultures were grown in defined inorganic media under controlled environmental conditions and transferred daily. This method maintained complete populations of colonies (3.07 medium) or unicells (modified Bristol's medium). Elevated levels of phosphorus induce the transformation from colonies to unicells. Phosphorus (Ascorbic Acid method) and alkaline phosphatase (Fluorometric method) analyses of colonies grown in low phosphorus medium had 1.05 mg P/g; 9.55×10^{-4} µg a.p./ml respectively, whereas unicells grown in high phosphorus medium had 6.3 mg P/g; 9.35×10^{-4} µg a.p./ml respectively. This confirmed the relationship that low alkaline phosphatase in cells is equivalent to elevated levels of phosphorus in the cells. The transformation of colonies to unicells in the presence of high P was completely blocked by the inhibitor DNP (2.7×10^{-6}M). Thus oxidative phosphorylation, ATP and mitochondria are involved in the transformation process. Supported in part by the U.N.D. NSF Faculty Research Fund and the U.N.D. Biology Dept.

PHYSICAL PARAMETERS FOR WHEAT ON A ROMANIAN STATE AGRICULTURAL ENTERPRISE. William A. Dando, Department of Geography, University of North Dakota, Grand Forks, North Dakota 58202

This study evaluates the environmental ramifications of the Romanian Communist Party's attempts to extensively utilize and intensively modify the physical environment for wheat using data compiled on Dragalina State Agricultural Enterprise during the 1972 agricultural year. Drought and winterkill are the two basic physical factors which retard stable yields. Irrigation of wheat, providing a high degree of control through the regulation of water, has made possible the use of high-yielding winter-hardy wheat varieties and the application of modern farming technology. However, irrigation and monocultural practices have modified other physical parameters for wheat and have led to seasonal flooding, shifts in disease and insect significance, and the number of weeds.

COMPARATIVE ANALYSIS OF HOSPITAL UTILIZATION IN URBAN AND RURAL COUNTIES OF MINNESOTA. James Dingels. College of St Thomas, St. Paul, MN 55105

It was hypothesized that rural counties relative to their urban counterparts underutilize their hospital facilities due to differences in population characteristics, hospital resources, financial assistance, and degree of urbanization. An affirmation of this hypothesis would allow more efficient health care delivery to be developed, estimates of this increased efficiency being revealed by the signs and magnitudes of regression coefficients of "policy" independent variables.

Regression analysis was applied to 1973 data from 81 Minnesota counties to determine hospital utilization factors. Results revealed that education, income, age, physicians per population, accessibility, welfare, insurance, and population density all had insignificant effects on hospital utilization rates. After excluding observations from 6 counties due to data aberrations, physicians per population became significant at the 95% level while all other variables remained insignificant.

Initial conclusions drawn are that factors other than socioeconomic and locational variables explain differential county hospital utilization. In addition, further refined factors to compensate for inter-county flows of patients appeared essential to obtaining more satisfactory results.

THE PHOTOSYSTEM AND ULTRASTRUCTURAL MODIFICATIONS IN WHEAT CHLOROPLASTS THAT DEVELOPED UNDER SLIGHT WATER STRESS. M. E. Duysen and T. P. Freeman. Dept. of Botany, N. Dak. State Univ., Fargo, N.D. 58102

The growth and development of plastids in 8 day-old wheat leaves were altered significantly by slight water deficits between -7 and -10 bars. Chloroplast development and Chl accumulation in photosystem II were altered when etiolated wheat seedling leaves were mildly stressed in the dark by polyethylene glycol (PEG) treatment having a set water potential and were then exposed to light for 20 hr. Plastid development was also observed in leaves that had been treated either with abscisic acid (ABA) or -7 bar PEG and the growth stimulating hormones, benzyladenine and gibberellic acid. The mild stress reduced plastid size, number of plastids per section, number of grana per plastid, number of thylakoids per plastids, and the Chl of PSII. ABA reduced only the chloroplast number per section. Growth stimulating hormones applied to stressed leaves increased the number of thylakoids per granum and the accumulation of Chl PSII but did not restore the stress induced thylakoid dilation nor the other stress mediated alterations in morphology. Growth stimulating hormones were unable to restore the Chl accumulation of PSI and PSII of severely stressed leaves.

DISSIMILAR GLOBULIN PATTERNS FROM SEED OF NINE BARLEY CULTIVARS. M. A. El-Meleigi and R. L. Kiesling, Plant Pathology Department, North Dakota State University, Fargo, N. D. 58102

Seed of nine barley-covered-smut differential cultivars (Hannchen, Nepal, Lion, Odessa, Trebi, Jet, Excelsior, Himalaya, and Pannier) differed in types and amount of globulin. Globulins, extracted from finely ground kernels of each cultivar with 10 percent aqueous sodium chloride, were purified and separated using polyacrylamide disc electrophoresis. Globulins separated into nine bands in the gels. Densitometer scans of the gels were used for comparisons among cultivars. While each cultivar had a unique globulin pattern, three groups of barley cultivars with similar globulin patterns were detected: 1) Nepal and Odessa, 2) Excelsior and Himalaya, and 3) Lion, Hannchen and Trebi. The patterns of Jet and Pannier were distinct. The globulin patterns of each variety were consistent through five replications. This study indicates that globulin patterns may be used in identifying barley cultivars.

THE NUTRITIONAL AFFECTS OF RANGE FERTILIZATION

D.O. Erickson, W.T. Barker, and C.N. Haugse
Dept. of Animal Science, NDSU, Fargo, ND 58102

A native upland site in the Sheyenne National Grasslands was selected to study the effects of fertilizer additions on some nutritional parameters of the grasses produced. Fertility treatments used in pounds per acre were: 0, 33N, 48P, 33N + 48P, 67N, 67N + 48P and 100N. Samples of the forage were taken bi-weekly from early June to late Sept. Phosphorus additions increased the phosphorus in the forages from .167% (no P) to .203% (48P) (P>.01) but had no affect on the protein levels or in vitro digestibility (IVDMD). The progressive nitrogen additions decreased forage phosphorus levels from .202% to .154% (P>.01). Forage protein (N x 6.25) increased with each level of nitrogen added, ranging from 10% to 14% average during the season (P>.01). The IVDMD was improved (P>.01) from 56% to 58%. Protein, phosphorus and digestibility all decrease significantly as the season progresses. It was previously reported from these same experiments that the composite grasses of the upland sites maintain a higher nutritional level through the season as compared to those in the mid and lowland areas. Even on the upland grasses phosphorus falls below required levels for gestating cows especially in the latter part of the season and for replacement heifers and bulls from July and on. Fertilizing increased dry matter produced per acre from 2258 to 3128 for check and 67N + 48P respectively.

OBSERVATIONS ON THE CALIFORNIA BIGHORN SHEEP (*OVIS CANADENSIS*) IN WESTERN NORTH DAKOTA. *Steven D. Fairaizl.* Dept. Biol., Univ. N. Dak., Grand Forks, N.D. 58202.

In 1956, 18 California bighorn sheep were transplanted into the badlands of western North Dakota. During 1975, a research project was initiated to provide data on population ecology and habitat usage. Aerial and ground surveys revealed the locations of four population centers within an area from Hanley's Plateau to Beicegel Creek. A post-dawn population census resulted in the observation of 81 rams, 72 ewes and 11 lambs, indicating a sex ratio of approximately 100:100. Observations indicated the preferred areas were high plateaus with associated precipitous cliffs. Throughout the summer and fall the diet was composed of approximately 50% grasses and 50% sagebrush, with limited use of forbs, yucca and prickly pear cactus. During the fall of 1975, North Dakota held its first bighorn sheep hunting season. The twelve rams harvested ranged from a 3 1/2 year-old, half curl, ram to a 11 1/2 year-old, full-curl, ram. Samples of blood, hair, hoof, liver, heart, kidney, muscle and rumen content collected from each ram together with vegetation and soils are being investigated for major and trace element composition. (Supported jointly by N.D. Game & Fish Depart and Project Reclamation, UND)

SUBSTITUENT EFFECTS IN CHROMIC ACID OXIDATION OF ALCOHOLS. Bruce W. Farnum. Minot State College, Minot, ND 58701 and William A. Mosher. University of Delaware, Newark, DE 19711

Rates of oxidation of p-substituted phenyl t-butyl carbinols by di-t-butyl chromate in benzene were measured at six temperatures. Linear Arrhenius plots and linear plot of $\Delta H^{\ddagger}$ VERSUS $\Delta S^{\ddagger}$ were obtained. An isokinetic temperature of 57° was obtained, bracketed by the experimental data. Modified Hammett rho^{+} values were positive below the isokinetic temperature and negative above it, thus establishing the validity of mechanistic conclusions based on substituent effects. The data supported a mechanism in which the rate determining decomposition of a mixed secondary-tertiary chromate ester was preceded by a rapid ester interchange. An induction period preceded the establishment of a steady state concentration of mixed ester. Rate of oxidation was inversely proportional to added t-butyl alcohol, which also caused a corresponding lengthening of the induction period.

DATING OF ANTIQUE BRASS OBJECTS BY FLAME PHOTOMETRIC ANALYSIS. Sylvia A. Farnum. Minot State College, Minot, ND 58701.

A simple inexpensive method for authentication of the age of antique brass objects using very small samples was devised. Brass objects from the collection of the Henry Francis duPont Winterthur Museum, Winterthur, Delaware which had been dated by other methods as dating from 1600 to 1950 were analyzed by a combination of flame photometry and gravimetric procedures. Clear cut differences in trace metal analysis made it possible to differentiate clearly between older valuable items and new restorations of the same general physical appearance. The method is simple enough for use by museums, curators, and collectors to validate items presently in collections as well as those being acquired.

ESTABLISHMENT OF WESTERN WHEATGRASS ON SURFACE MINED COAL SPOILS UNDER CONTROLLED ENVIRONMENTAL CONDITIONS. *E.J. Finck and M.K. Wali.* Project Reclamation, Univ. N. Dak., Grand Forks, N.D. 58202.

Growth chamber and laboratory experiments were conducted to study the effects of 10 and 20% addition of each slack and leonardite (coal products in different oxidation states) and 100 lbs/acre 0-36-9 NKP on the establishment of western wheatgrass on Glenharold coal mine spoil material (characterised by high clay, sodicity, saturation percentage, and low infiltration) and the resultant physicochemical properties of the latter. Fertilizer and amendment materials were applied to upper 6" layer of spoil in 5 gallon pails. Test crop was harvested after 80 days. Biomass increased significantly with fertilizer application. Effects of slack and/or leonardite were nonsignificant under both fertilizer and nonfertilized conditions, but biomass was slightly higher in pails receiving slack+fertilizer. Slack and leonardite increased E.C. of spoil material but slack reduced SAR by increasing Ca by 150%. Saturation percentage of spoil was reduced by 7% with leonardite and 18% with slack. Slack increased Mn, Li and Sr in spoil but leonardite decreased the first two. Since germination studies show different species response to the application of leonardite, long-term effects are being investigated. *(Supported by Grant No. G0264001, Bureau of Mines, USDI)*

EGG LAYING RHYTHM IN DROSOPHILA MELANOGASTER. Walter Fluegel. Dept. of Biol., Univ. Mn., Duluth, Mn. 55812

Pairs of D. melanogaster are housed in individual 4 mm dia. x 10 cm long tubes. One end is open to food pressed into narrow channels cut into a plastic tray. The tubes are stationary. A conveyor belt moves the tray 70 cm in 24 hrs. Lights are 12 hrs. on 12 hrs. off. Trays are changed at random times and egg position is recorded. Maximum oviposition occurs in early afternoon (1300-1600) with individual variation. Individual and pooled populations show a double peak or depression in the main peak.

A mealtiming experiment limited food to 0700-1100 hrs. and 1500-1900 hrs. Under this mealtiming stress the innate rhythm peaks at early afternoon for morning-fed flies. Afternoon-fed flies shift their peak toward noon and have a second peak at dusk. Conclusion: Afternoon-fed flies are more efficient users of limited resourses.

ANATOMICAL EVIDENCE ASSOCIATED WITH THE DDT-INDUCED EGGSHELL THINNING SYNDROME OF THE DUCK. D. J. Friedenbach and K. L. Davison. USDA, ARS, Metabolism and Radiation Research Laboratory, and Zoology Department, North Dakota State University, Fargo, ND 58102

DDT has been reported to cause eggshell thinning in a variety of avian species. The mallard duck (Anas platyrhynchos) is susceptible to DDT-induced eggshell thinning but the domestic chicken (Gallus domesticus) is not. A variety of mechanisms have been proposed to explain this phenomenon. It was felt that anatomical changes within the shell-calcifying organ would provide a basis for further biochemical and physiological investigations. This work reports surface morphological variations of the shell gland of ducks and chickens following oral treatment with p,p'-DDT. Birds were biopsied before and after treatment with 40 ppm of dietary DDT, thus providing internal controls. Biopsied and non-biopsied untreated birds provided external controls. Examination was made with scanning and transmission electron microscopes. Control cilia exhibited an irregular surface morphology suggestive of secretory activity. DDT treatment abolished this structural modification. These changes may be related to biochemical (Federation Proc., 34: 811, 1975) and histochemical (unpublished) data regarding ATPase inhibition by DDT.

DISPERSING BACILLUS THURINGIENSIS FOR CANKERWORM CONTROL. R. D. Frye, T. L. Elichuk and J. T. Stein. Dept. of Entomology, N. Dak. State Univ., Fargo, N. Dak. 58102.

We evaluated the effectiveness of ground-based fogging equipment for dispersing the entomogenous bacterium, Bacillus thuringiensis (in Thuricide 16B), for cankerworm control in Siberian elm shelterbelts in 1975. The bacterium was also tested in combination with Pyrocide (pyrethrum) and Dimilin (an insect growth regulator). Pyrocide plus Dimilin and B. thuringiensis plus Pyrocide applied by hydraulic sprayer reduced cankerworm populations the most. Using a hydraulic sprayer to apply B. t. plus Pyrocide, or B. t. plus Dimilin, gave the best coverage of foliage with B. t. spores. The hydraulic sprayer and cold fogger both provided good dispersal of the bacterium when applied alone, and effectively controlled cankerworms. When logistics are considered (amount of water needed, ease of calibration and ease of handling), the cold fogger would be a good choice for applying the bacterium. Supported by N. Dak. State Univ. and U. S. Forest Service.

GLACIAL GEOLOGY OF McKENZIE COUNTY, NORTH DAKOTA. C.S. Fulton. Dept. of Geology, Univ. of N. Dak., Grand Forks, N. Dak. 58201.

The glacial geology of McKenzie County, North Dakota was mapped using airphotos and soil maps. Identified lithologic units were checked in the field. Textural analysis of glacial sediments (till) were conducted using a hydrometer technique for the clay content and dry sieving for coarser sediments. The lithology of the coarse sand fraction (1mm to 2mm) was determined using a binocular microscope.

Four separate glacial advances are identified in McKenzie County. The ages of the glaciations are uncertain but they are thought to range from early to late Wisconsin. Tentative correlations have been established with Napolean and Lostwood drifts in Dunn and Mountrail Counties.

The drainage in McKenzie County was considerably modified by these glaciations. The earliest advance caused the diversion of the Little Missouri River from a northward drainage to an eastward drainage along its present channel through Roosevelt National Park. Temporary diversions of the Yellowstone and Missouri Rivers also occurred during the glaciations and at least two temporary lakes were created by glacial damming along them.

TRANSPORT OVERSHOOT OBSERVED DURING REPRESSION AND ACTIVATION OF BIOTIN UPTAKE IN LACTOBACILLUS PLANTARUM. D.A. Gabrielson and J.R. Waller. Dept. of Micro., Univ. N.Dak., Grand Forks,ND 58202

Non-proliferating cells of Lactobacillus plantarum, ATCC 8014, can accumulate, per mg cells, dry wt, about 50 ng of biotin by an active transport process, and about 2 ng of biotin by a mediated, non-active system. Cells grown with 0.7 ng of biotin/ml exhibited maximum transport activity. The transport system of cells grown in 15 ng of biotin/ml was repressed by 90 to 95 percent. Repression of transport was studied by placing maximally active cells in a medium containing 15 ng of biotin/ml and determining transport activity at hourly intervals. Activation was studied by placing repressed cells in biotin-free medium and determining activity at hourly intervals. During the first 5-15 minutes of each transport activity determination, there was a rapid initial uptake followed by a rapid exit of a significant portion of the biotin from the cells. This occurance has been referred to previously as overshoot. The overshoot phenomenon observed during these studies was found to diminish as time spent in the growth medium increased. The data suggests that two phenomena, overshoot and envelope biotin receptor synthesis, occur during regulation of biotin transport.

EFFECTS OF METHAQUALONE (MTQ) AND METHAQUALONE-METABOLITES (MTM) ON DRUG METABOLIZING ENZYME SYSTEMS (DMES). D.L.Gildersleeve, V. Kishore, S.S.Parmar and T.K.Auyong, Dept. Physiol. Pharmacol., Univ. N. Dak.,Sch. of Med.,Grand Forks, N. Dak. 58202.

Selective inhibition of NAD-dependent oxidations reported as a molecular basis of CNS activity of MTQ (Can.J.Biochem. 43:1179 1965) prompted studies on effects of MTQ and MTM on rat liver DMES. MTQ and MTM (1 mM) inhibited DMES in vitro. Inhibition was 92%,89% and 83% by 2-methyl-3-o-toyl-6-hydroxy-4-quinazolone and 74%,84% and 72% by 2-methyl-3-(2-methyl-4-hydroxy phenyl)-6-hydroxy-4-quinazolone, compared to 69%,80% and 80% by MTQ, during N-dealkyation of cocaine, morphine and amidopyrine respectively. Thus, introduction of an additional hydroxyl group on the o-toyl moiety slightly decreased inhibition of DMES. Repeated administration of MTQ caused selective induction of DMES. These studies indicated that selective effects on DMES might be a biochemical basis for physical dependence and tolerance of MTQ abuse. (Supported by USPHS Grants 1-R01-DA00996-01 and 5-T01-HL-05939.)

HILL ACTIVITY OF ISOLATED WHEAT CHLOROPLASTS AS AFFECTED BY WATER STRESS. K. Graham and M. Duysen. Dept. of Botany, N. Dak. State University, Fargo, N.D. 58102

Six day-old etiolated wheat seedlings were water stressed by application of polyethylene glycol, 14 hours prior to exposure to continuous illumination for 24 hours. Chloroplasts isolated from wheat leaf tissue, of both control and water stressed plants showed the highest Hill activity (assessed on a per unit total chlorophyll basis) when isolated at 3025 x $\bar{g}$. Chloroplasts isolated from water stressed tissue showed an elevated Chl a/b ratio as compared to control plastids. Both the chlorophyll/carotenoid ratio and the chlorophyll/unit dry weight of chloroplasts were unchanged by water stress. Hill activity was determined at four different light intensities and was calculated on the basis of total chlorophyll, photosystem II chlorophyll, and chloroplast dry weight. Regardless of how Hill activity was calculated, water stress plants (at each light intensity) showed lower oxygen evolution rates than non-stressed plants. Chloroplasts isolated from water stressed tissue also reached light saturation at higher light intensity values as compared to non-stress plastids.

EFFECTS OF VARYING ZINC INTAKES ON GESTATION IN THE RAT. S. Greeley, G.J. Fosmire, and H.H. Sandstead. Dept. of Biochem., Univ. of North Dakota and U.S. Dept. of Agriculture, Agricultural Research Service, Human Nutrition Laboratory, Grand Forks, ND

Some effects of inadequate zinc intakes during gestation were investigated in dam and offspring. The rats were fed a 20% sprayed egg-white diet supplemented with biotin, containing less than 1 ppm zinc by analysis and were provided with either 1, 2, 3, 5, 11, or 25 ppm zinc in drinking water. The groups given insufficient zinc displayed signs of inanition; anorexia was most severe at the lowest levels of zinc intake. The decreased food consumption resulted in caloric deprivation and at lower levels of zinc intake, in protein insufficiency. The amounts of total weight gain as well as the rates of weight deposition were both a function of the level of zinc intake. The lowest levels of zinc intake resulted in the most severe growth depression and greatest lack of zinc deposition in the offspring. The pups experienced a graded response in these parameters to increasing levels of maternal zinc supplementation. At the lower levels of zinc, the pup weight was spared at the expense of the dam weight gain. At an intermediate zinc intake, the dam weight was comparable to the control value but an associated depression in pup growth was observed. Anorexia resulting in decreased calorie and protein intakes was presumably an important factor in the findings.

THE NATURE AND SIGNIFICANCE OF DOLPHIN INTELLIGENCE. M. Greenwood, POB 324, Moorhead, MN. 56560. A theoretical position paper based on work conducted by the CIA and USN over a 14 yr. period to use tursiops truncatus as open ocean weapons platforms. The learning capacities of tt in the open ocean are qualitatively and quantitatively superior to those noted for the self-same animal in the captive pool. Insight learning becomes commonplace, and is frequently noted on the first or second learning trial. The metaprogram controlling the orchestration of the animal's brain functioning appears to change dramatically. Behavior bearing the clear hallmark of ESP is frequent. The contention is supported that the size of the tt's brain (20% larger than mans) appears to mean exactly what we suspicion but have nervously shied away from due to lack of research opportunity with the animal, or on the basis of weak scientific rationalizations. The tt's apparent intelligence as supported by these studies poses challenging questions to evolutionary theory and the many psychological concepts whose well-springs reside in such theory. The tt has enjoyed its current degree of encephalization for 15 million yrs, man for 3 million.

EVALUATION OF BARLEY FOLIAR DISEASE BY MULTISPECTRAL SENSORS.
Neil C. Gudmestad and V. D Pederson, Plant Pathology Department, North Dakota State University, Fargo, North Dakota 58102

Foliar diseases of barley (Hordeum vulgare) were evaluated by measuring reflected solar radiation with a multispectral sensor on 3 x 4 m field plots during the summer of 1975. The sensor was equipped with 9 photocells each covered by a 3-cavity interference filter of approximately 10 Å band width. These filters included the wave lengths of 500-900 nanometers at 50 nm intervals. Resistance values (Kilo-ohms) of each of the photocells were obtained as the sensor was positioned 2 m above the respective plots. Treatments consisted of plots sprayed with 2 applications of Dithane M-45 and unsprayed plots of the cultivars Larker (susceptible) and Dickson (resistant). Significant differences between treatments and between resistant and susceptible cultivars were detected using sensors in the 750-900 nm range. Significant positive correlations existed between visual disease ratings and sensor resistance readings. Negative but non-significant correlations were obtained between yield and sensor readings and between yield and disease ratings.

CHOLESTEROL METABOLISM IN THE COCKROACH, BLABERUS GIGANTEUS.
P. Harber, M. E. Dempsey, and F. Ungar. Dept. of Biology, Moorhead State University, Moorhead, MN 56560

Injections of radioactive cholesterol were used to determine if cholesterol was converted to 7-dehydrocholesterol in cockroaches. Blaberus giganteus were injected with 8 µl of 4-C^{14} cholesterol (0.12 µg/µl) with a specific activity of 2.1 x 10^5 cpm/µg and a radio-chemical purity of 97%. Insect tissues hydrolyzed in 15% KOH and extracted with ether were run on silicic acid, $AgNO_3$, Super-Cel columns along with unlabeled cholesterol and unlabeled 7-dehydrocholesterol. Fractions were collected for counting and for colorimetric readings via the Liebermann Burchard reaction, absorbance at 620 nm. Analyses indicated radioactive fractions corresponding to cholesterol and to 7-dehydrocholesterol. Ultraviolet absorption spectral measurements of the labeled material having the chromatographic behavior of 7-dehydrocholesterol revealed maxima at 271, 281, and 293 nm, typical of 7-dehydrocholesterol. The UV absorption spectra and chromatographic behavior indicate conversion of cholesterol to 7-dehydrocholesterol. Supported by NIH grants (AM-05629 and HL 8634).

DIFFUSION AND ADSORPTION OF PHOSPHORUS IN SURFACE MINED MATERIALS IN WESTERN NORTH DAKOTA. *J.W. Harrell, Jr. and M.S. Arain.* Project Reclamation, Univ. N. Dak., Grand Forks, N.D. 58202.

Using P^{32} as a tracer, phosphorus self-diffusion coefficients have been measured in topsoil and in subsoil samples from Center, N.D. with 10% leonardite and with no leonardite. The self-diffusion coefficients have been determined for five different values of added phosphorus at one-half water saturation and been found to vary linearly with added phosphorus. The diffusion in the subsoil was greater than in the topsoil, and for both topsoil and subsoil the effect of leonardite was to reduce the diffusion coefficients. Phosphorus adsorption was measured as a function of time in spoil material from Glenharold, N.D. and in leonardite. Adsorption was greater and more rapid in the leonardite than in the Glenharold spoil. Phosphorus adsorption was measured as a function of phosphorus remaining in solution for Glenharold spoil, leonardite, Glenharold spoil plus 10% leonardite, and for slack coal. Using the Langmuir equation, adsorption maxima were obtained for each sample. The relative size of the phosphorus adsorption was as follows: leonardite > Glenharold spoil+10% leonardite > Glenharold spoil > slack coal. The long-term effects of leonardite on phosphorus mobility are being investigated. *(Supported by Grant No. G0264001, Bureau of Mines, USDI)*

Nutritional Effects on in vivo Drug Metabolism:Lysine Deficiency. J.J. Hjelle and A. Poklis. Dept. Pharmacol. Toxicol., Coll. of Pharm., N. Dak. State Univ., Fargo, N. Dak. 58102

The effect of lysine deficiency on the metabolism of hexobarbital in phenobarbital induced rats was evaluated. Four week old hooded rats of both sexes were divided into four groups. For the following five weeks two of the groups were maintained on a diet of less than 0.3% lysine while the remaining two groups received a normal diet. Two groups from each diet were treated with 37 mg/kg. i.p. phenobarbital twice daily for three days. The control groups were treated following the same injection schedule with normal saline i.p. On the day following the last pretreatment both male and female animals were slept with 125 mg/kg and 100 mg/kg i.p. hexobarbital respectively. Under conditions of protein deficiency or starvation the rate of hydroxylation of hexobarbital increases in females and decreases in males. Once induced with phenobarbital, both sexes of lysine deficient rats were statistically indistinguishable in sleep times, liver to body weight ratios and hexobarbital blood levels from respective controls. This indicates that lysine deficient rats are equally as capable of phenobarbital induction as those on a normal diet.

SORPTIVITY OF EPOXY RESIN FOR $(CH_3)_2CO$, H_2O VAPORS AND H⇄D EXCHANGE VIA INTERACTION WITH D_2O VAPOR. W. S. Hnojewyj, A. E. Rheineck, and O. W. Hnojewyj. College of Science and Mathematics, N. Dak. State Univ., Fargo, N. Dak. 58102

Data are presented for adsorption of acetone vapor at 30°, which demonstrate a weak physical bond in the range of one mole per mole of epoxy resin. Further adsorption causes formation of some stronger bond, causing desolving or solution-breaking of the solid, which is started if approximately 5 moles of acetone per mole of resin adsorbed. The desorption isotherm shows that about 2 moles of acetone per mole of epoxy resin is strongly or chemically bound. The adsorption isotherms for water vapor on epoxy resin at 25 and 30° are presented which illustrate several slopes and show approximately one mole of H_2O bonded per mole of resin in the monolayer region. Furthermore, an interaction of lyophilized epoxy resins with H_2O or D_2O vapors causes a reversible change in the original weights due to the effects of H⇄D exchanges. The H⇄D effects, which involved above 3 H-atoms per molecule of resin, are discussed in relation to the functional groups containing the labile hydrogens in the molecular structures of polymeric epoxy resins.

FURTHER STUDY OF H⇄D EXCHANGE IN SOLID POLY-L-GLUTAMIC ACID DUE TO INTERACTIONS WITH D_2O-VAPOR AND H_2-GAS. W. S. Hnojewyj and S. P. Sharma. Dept. of Physics, No. Dak. State Univ., Fargo, N. Dak. 58102

A series of successive adsorptions followed by complete desorptions of D_2O-vapor on Poly-l-glutamic acid (PGA) have been demonstrated an exchange of all two-labile hydrogens, present per unit of molecule, with deuterium atoms. Process is reversible if the H_2O-vapor is used on the deuterited PGA. Also, the successive adsorptions followed by complete desorptions of H_2-gas on a previously deuterited PGA is showing the reverse exchange. This occurred, however, in two stages indicating the different activities of labile H- or D-atoms due to their peptide- or acetic-origin in PGA molecule.

PHOSPHATIDYL ETHANOLAMINE METHYLTRANSFERASE ACTIVITIES IN LIVER MICROSOMES, Dennis R. Hoffman and W.E. Cornatzer, University of North Dakota Medical School, Grand Forks, N.D. 58202

Phosphatidyl ethanolamine methyltransferase (PEMT) is located in the microsomal fraction of the cell and catalyzes the methylation of phosphatidyl ethanolamine (PE) to form phosphatidyl choline (PC). The rate limiting step of total C^{14}-methyl methionine incorporation into PC is measured by a modified PEMT assay. The labeled reaction products from assays giving the highest activities have been identified by two-dimensional TLC. PEMT activity is enhanced by additions of exogenous egg or rat liver PE, deoxycholate or PC. The pH optimum of PEMT activity is 9.8. S-adenosylmethionine (SAM) donates the methyl groups for PEMT activity and S-adenosylhomocysteine (SAH) is the reaction product. The Km of PEMT for SAM is 14.5 μM, the Vmax is 0.297 nmoles PC formed/mg Ms protein/min and the Ki for the inhibitor, SAH, is 2.5 μM. Increased activity of PEMT is observed in animals with dietary choline deficiency, methionine deficiency or fed a liquid diet containing 5% alcohol. This inhibition of PEMT by SAH is of physiological significance and may participate in the cellular regulation of this enzyme.

AN INTERDISCIPLINARY APPROACH TO THE DEVELOPMENT AND USE OF AN OUTDOOR CLASSROOM IN THE PUBLIC SCHOOL. Tom K. Hove and Richard Debertin. Berthold Public School, Berthold, North Dakota 58718

Interdisciplinary cooperation in the small school provides for efficient use of available facilities and resources. In the Berthold Public School, an Arboretum and Environmental Study Area have been established and maintained by a cooperative effort involving the Science and Vocational Agriculture Departments. The Arboretum, begun in 1973, covers 2½ acres on which are planted 110 varieties of trees and shrubs. Other plantings include forage crops, grain varieties, and native and introduced grasses. Additional plantings are scheduled for May 1976. Curriculum suitable for use in outdoor classrooms (grades 1-12) is being developed. Additional activities involve the development of a guide suitable for use in establishing similar areas in public and private schools in North Dakota.

Supported in part by Title III E.S.E.A., North Dakota Department of Public Instruction.

MORPHOLOGY OF CARTILAGE CANALS IN CHICK EPIPHYSEAL PLATE: A LIGHT AND ELECTRON MICROSCOPIC STUDY. C.D. Hunt, D.A. Ollerich, and F. H. Nielsen. Dept. of Anatomy, School of Med., Univ. of N. Dak., and U.S.D.A., A.R.S. Human Nutrition Laboratory, Grand Forks, N. Dak. 58201.

The perforating cartilage canals in the proximal tibial epiphyseal plate of 28-day old chicks were studied using standard light and electron microscopic techniques. The arteriole (CA) within the perforating canal (PC) is located centrally after entering the proliferative zone of cartilage (PZ) and undergoes a characteristic enlargement near the bottom of the canal. Near its termination, the CA gives off a short branch (CV) by which it communicates with the lower portion of a venous vessel found at the periphery of the canal. From the point of junction with the CV, the venous vessel apparently ascends (AV) and descends. The descending branch anastomoses directly with the AV or communicates with them through a small sinus found at the bottom of the canal. All of the AV are located near the periphery of the PC and thus form a glomerulus around the CA. In the proximal portion of the PZ only two large venules are present and just before leaving this zone they fuse to become one large eccentrically placed venule. TEM reveals that the venular endothelium is extremely attenuated, possesses fenestrations, and lacks a consistant basement membrane.

INTESTINAL ABSORPTION OF LEUCINE FROM AMINO ACID MIXTURES IN THE RAT. F.A. Jacobs and Carol Overvold. Dept. of Biochem., Sch. of Med., Univ. of N. Dak., Grand Forks, ND 58202.

We have reported recently (Federation Proc., 35: 463, 1976) the effect of systemic ethanol upon the absorption of leucine as a single amino acid in rats ranging from 1-20 months of age. This report is concerned with the absorption of leucine from a mixture of 16 amino acids, each at concentrations comparable to the levels found in the intestinal lumen upon eating a commercial pelleted diet. Young male Long-Evans rats (74-105g) anesthetized with sodium pentobarbital (50 mg/kg I.P.) were used in these studies. The amino acid mixture containing 4 mM L-leucine-^{14}C and inulin-^{3}H were perfused by recirculation through a jejunal segment *in vivo*. Radioactivity was monitored automatically to measure the rate of absorption; ethanol (20%) was infused into the gut distal to the perfused segment. Water balance was assessed by measurement of inulin-^{3}H at preselected intervals. These animals absorbed leucine from the mixture at about the same rate as did animals of the same age and size from single amino acid preparations. Leucine absorption from the mixture was markedly inhibited by systemic ethanol, even though water balance was maintained. (Supported in part by USPH NIH Research Grant MH 19235 ALC, Institutional Grant No. 5 S01 RR 05407 for General Research Support, and by the United Good Neighbor Fund).

ESTABLISHMENT OF NATIVE PRAIRIE VEGETATION ON MINED LAND SPOIL MATERIALS. Dennis R. Jenkins. Dept. of Botany, N. Dak. State Univ., Fargo, N.D. 58102

In October of 1973 experimental plots were established on four strip mine sites in western North Dakota. Treatments included no topsoil, 5 cm of topsoil and 30 cm of topsoil over leveled spoil material. The plots were disked and fertilized with phosphorus; common weed seeds were then sown and the plots were again disked. In October of 1974 mature prairie hay serving as a seed source for native prairie species was spread into the weed mulch of the first year's growth. The establishment of native species during the summer of 1975 was measured using density counts and growth measurements within randomly placed quadrats of 0.092 m^2. Plant densities, with the exception of one site, were higher on the 5 cm and 30 cm topsoil plots. Plant heights were generally greatest on the 30 cm topsoil plots and least on the raw spoil plots. Of the 48 different species occurring on the plots, 8 grass species and 12 forb species are commonly found in native grassland. Koeleria cristata, with a relative density ranging from 5 to 52 percent, was the major dominant native species. Other abundant species included Agropyron trachycaulum, A. smithii, Stipa comata, S. viridula, Bouteloua gracilis, Ratibida columnifera, Plantago patagonica, Achillea lanulosa, Lactuca serriola, and Hedeoma hispida.

SPIN-LATTICE RELAXATION IN HYDRAZINE OXALATE, $2N_2H_4 \cdot H_2C_2O_4$, R.A. Jensen, Dept. of Physics, Univ. of N. Dak., Grand Forks, N. Dak. 58201

Proton spin-lattice relaxation times T_1 and $T_{1\rho}$ in polycrystalline hydrazine oxalate, $2N_2H_4 \cdot H_2C_2O_4$, have been measured at 23.9 MHz from 209°K to 383°K; $T_{1\rho}$ measurements were done at 4.2 G and 8.4 G. T_1 goes through a minimum of 18 ms at 334°K and $T_{1\rho}$ a minimum of 0.12 ms at 236°K. This motion is attributed to an NH_3 reorientation with an activation energy of 0.36 eV. A decrease in $T_{1\rho}$ above 325°K is interpreted as an NH_2 reorientation with an activation energy of 0.39 eV. To extract the most representative parameters of the data, a computer program is developed and presented. An average proton-proton separation is calculated for an NH_3 group in the lattice, and other structural and dynamical aspects resulting from the data are discussed and compared with other hydrazines. Supported in part by a Research Corporation Grant to J. W. Harrell, Jr.

EFFECTS OF GRASSLAND BURNING ON BREEDING BIRDS -- PRELIMINARY REPORT. Douglas H. Johnson. Northern Prairie Wildlife Research Center, Jamestown, N. Dak. 58401.

Populations of breeding birds were studied on six grassland tracts on the Woodworth Study Area in east-central North Dakota. The tracts, mostly 15 acres in size, were in areas subjected to various regimens of prescribed burning. Bird populations were determined by plotting individual territories after making repeated surveys in the peak period of nesting activity.

We examined the densities of common species and the species diversity in each tract, as related to the number of growing seasons after a burn. Analysis was confounded by annual variation in bird populations, often associated with the amount of precipitation, and by differences in plots irrespective of treatment effects. Fire, as a tool to alter the structure of the vegetation, will also alter the bird communities associated with the vegetation.

AN EVALUATION OF LAND USE CHANGE ASSOCIATED WITH COAL GASIFICATION: AN INTERPRETATION UTILIZING REMOTE SENSING TECHNIQUES. G. E. Johnson. Dept. of Geog., Univ. of N. Dak., Grand Forks, N. Dak. 58202.

This study (1) interpreted baseline land use in a 228 square mile area in north central Mercer County, North Dakota and (2) identified the current use of land in the vicinity of the first proposed coal gasification plant and its associated mine sites in the study area. Black and white panchromatic aerial photography, supplemented by color infrared aerial photography at a scale of 1:24,000, was collected in May and June of 1975 and interpreted for land use in the study area. Criterion for the classification of land use were adapted from the Minnesota Land Management Information System Study. Land use was mapped on the basis of the dominant use of land in each forty acre parcel in the study area. In addition to preparation of the map, which depicted the spatial relationship of land use categories, a quantitative evaluation of land use was conducted. The quantitative portion of the study enumerated land use by acreage and percentage area for (1) the entire study area and (2) the proposed coal gasification plant and mine sites. The map and statistical summation provide a baseline geographical and quantitative land use inventory of the study area prior to impact associated with proposed resource development.

STRIP MINE MORPHOLOGY INTERPRETED FROM COLOR INFRARED PHOTOGRAPHY. G. E. Johnson and M. L. Heinrich. Dept. of Geog., Univ. of N. Dak., Grand Forks, N. Dak. 58202.

This study examined the utility of color infrared aerial photography, a specific form of remotely sensed data, as an information source for the identification and subsequent measurement of morphologic units contained in strip coal mining operations typical of western North Dakota. Color infrared aerial photographic transparencies, in a 9 by 9 inch format and at a scale of 1:24,000, were interpreted. A skilled photo interpreter, familiar with the strip mining process and cognizant of applicable reclamation laws which influence mining morphology, performed the interpretation. Eleven distinct morphologic units were identified in the Indianhead Mine study area. The categories included pasture and open land, cultivated cropland, water, exposed subsoil, exposed coal seams, reclamation test sites, stockpiled topsoil, and four categories of spoil material: ungraded with vegetation, ungraded without vegetation, graded with vegetation and graded without vegetation. The morphologic units were mapped to depict their spatial association. The map was quantitatively evaluated as to acreage and percentage area of each morphologic unit present in the study area. The map and statistical data provide a baseline inventory of the mine site as of June 12, 1975.

AVAILABILITY OF IRON IN INFANT FORMULAS AND CEREAL PRODUCTS. P.E. Johnson and G.W. Evans, USDA, ARS, Human Nutrition Laboratory Grand Forks, ND 58201

The Recommended Daily Allowance (RDA) for iron is based on the assumption that 10% of the iron in food is absorbed; thus, the RDA is ten times the average daily requirement for iron. We have measured absorption of iron by rats from infant formulas and cereal products using a ^{59}Fe label. Foods tested were labeled with ^{59}Fe one hour before being fed to fasted rats. The ^{59}Fe and the intrinsic iron in the food enter the non-heme iron pool in the stomach; absorption of intrinsic and extrinsic iron is equal. Two hours after feeding, rats were decapitated, and the ^{59}Fe absorption determined with a whole-body scintillation counter. Absorption of iron ranges from less than 2% in wheat germ and cooked cereals to as much as 75% in a presweetened cereal. Absorption from unsweetened dry cereals was from 5 to 15%; absorption from pre-sweetened cereals was from 30 to 75%.

Approximately 20% of the iron in infant formulas was absorbed; there was no significant difference in absorption from milk-based and soy-based formulas. It seems clear that nutrition-labeling of foods based on the RDA does not give reliable information concerning the value of a food as an iron source.

GLUCOSE UPTAKE AND PRODUCTION BY PERFUSED LIVERS AND ISOLATED HEPATOCYTES FROM NORMAL AND DIABETIC RATS. R.A. Jorgenson, F.L. Alvares, and R.C. Nordlie. Dept. of Biochem., Sch. of Med., Univ. of N. Dak., Grand Forks, ND 58202.

Recent studies in this laboratory have suggested a physiological role for a synthetic activity of multifunctional glucose-6-phosphatase, viz. carbamyl-P:glucose phosphotransferase (GPT). In experiments described here, net uptake of nonlabeled glucose (glc) from extrahepatic media by isolated perfused rat livers or isolated rat hepatocytes was measured. In order to more accurately quantitate net uptake rates, especially under conditions of accelerated gluconeogenesis such as is seen in diabetes, de novo glc synthesis from endogenous substrates was minimized by the addition of 3-mercaptopicolinate, an inhibitor of the key gluconeogenic enzyme, P-enolpyruvate carboxykinase. Glc uptake by hepatic tissue from diabetic or normal rats under such conditions was shown to be a non-linear function of glc concentration. Furthermore, rates of phosphorylation based on experimentally measured glc uptake rates corrected for glc-6-P phosphohydrolase activity were in excess of those predicted on the basis of combined intracellular activities of glucokinase and hexokinase. However, when total phosphorylative capacity included a GPT term, much closer agreement was observed between predicted and observed rates of phosphorylation.

A NEW METHOD FOR PRESERVATION OF STOCK CULTURES OF BACTERIA. K. D. Kallander and K. J. McMahon. Dept. of Bacteriology, North Dakota State Univ., Fargo, N. Dak. 58102.

The survival of 12 species of bacteria after incorporation into tung oil polymer pellets and storage at 4 C was determined. Growth from an agar plate culture of each of the bacteria was added to tung oil containing tri-n-octylaluminum. After mixing, drops of the oil were placed on talc powder to form spherical pellets, 2 to 3 mm in diameter. Pellets were stored for 3 days at room temperature in a desiccator containing $CaSO_4$ and then placed in screw-cap vials and stored at 4 C. Monthly viable counts were obtained by grinding pellets individually in 0.1% tryptone in a Sorvall Omni-Mixer (Ivan Sorvall, Inc., Norwalk, Conn.) and plating appropriate dilutions in replicate on five standard-medium plates. Three pellets were used to determine each viable count, and recorded counts were averages of the replicate counts. After 7 months of storage, all cultures were viable. Pellets are easily stored, handled and maintained. This technique provides a simple and convenient method for preservation of stock cultures of bacteria.

RELATIONSHIP BETWEEN INHIBITORY EFFECTIVENESS OF METHAQUALONE AND METHAQUALONE-METABOLITES (MTM) ON CELLULAR RESPIRATORY ACTIVITY. V.Kishore, D.L.Gildersleeve, S.S. Parmar and T.K.Auyong, Dept. Physiol. Pharmacol., Univ. N. Dak. Sch. of Med., Grand Forks, N. Dak. 58202.

Six possible MTM were synthesized, characterized by NMR spectra, and evaluated for anticonvulsant activity and effects on respiratory activity of rat brain homogenates. All MTM (100 mg/kg, ip) possessed anticonvulsant activity and the degree of protection against convulsions by pentylenetetrazol (90 mg/kg, sc) in mice ranged from 10-70%. These results indicated a trend of more protection from convulsions with 24-hr pentylenetetrazol mortality. Like methaqualone, MTM (2 mM) selectively inhibited NAD-dependent oxidation of pyruvate (20-44%) and α-ketoglutarate (11-51%) and NADH (43-79%), while NAD-independent oxidation of succinate remained unaltered. These results suggested a relationship between anticonvulsant activity and selective inhibition of respiratory activity, which may possibly account for the biochemical basis of anticonvulsant activity of MTM. (Supported by USPHS Grants 1-R01-DA00996-01 and 5-T01-HL-05939.

SYNTHESIS OF NEW TRIAZOLES AS POSSIBLE ANTIINFLAMMATORY AGENTS. P.J. Kothari and V. I. Stenberg, Department of Chemistry, University of North Dakota, Grand Forks, North Dakota 58202

Various 5-(α-naphthylmethyl)-1-substituted-s-triazole-2-thiols and 5-(α-naphthylmethyl)-1-substituted-s-triazole 2-ylmercapatoacetic acids with substitution at the 1-position were synthesized in order to provide materials for medicinal property testing. A total of 24 compounds were synthesized. The syntheses were accomplished by the variation of a set sequence of four steps: an isothiocyanate formation, a thiosemicarbazide formation, a cyclization and a SN_2 displacement. The compounds were further characterized by sharp melting points and their nmr and ir spectra. Certain of the compounds synthesized show promise as antiinflammatory agents by means of their demonstrated antiproteolytic activity. Supported in part by USPHS, NIH (Grant 5 R01-GM 21590-02 and Career Development Award 1-K4-GM-09888).

SYNTHESIS OF NEW TRIAZOLES AS POSSIBLE ANTIINFLAMMATORY AGENTS. P. J. Kothari, S. S. Parmar, V. I. Stenberg, Department of Chemistry, University of North Dakota, Grand Forks, North Dakota 58202

Various 5-(Naphth-1-ylmethyl)-4-substituted-1,2,4-s-triazole-3-thiols and 5-(Naphth-1-ylmethyl)-4-substituted-1,2,4-s-triazole-3 ylthioglycolic acids with substitution at the 4-position were synthesized, and their antiinflammatory activities were evalucated. A total of 24 compounds were synthesized. The synthesis were accomplished by the variation of a set sequence of four steps: An isothiocyanate formation, thiosemicarbazide formation, a cyclization and a SN_2 displacement. The compounds were further characterized by sharp melting points and their ir and nmr spectra. The antiinflammatory properties of these compounds were demonstrated by their ability to inhibit *in vitro* trypsin-induced hydrolysis of bovine serum albumin (BSA). The I_{50} values of all compounds were determined. The thiol I_{50}'s ranged from 0.92×10^{-4} to 7.2×10^{-4}M In general, most compounds possessed better antiproteolytic activity than the reference compound, sodium salicylate. The activity of the substituted thioglycolic acids was found to be greater than that of the substituted thiols. Supported in part by USPHS, NIH (Grant 5-R01-GM21590-02 and Career Development Award 1-K4-GM-09888).

DIRECT LIQUID PHASE FLUORINATION OF BOSCAN AND WILMINGTON CRUDE OILS. N. Kowanko, Dept. of Chem., Moorhead State Univ., Moorhead, Mn., 56560, J. M. Sugihara and J. F. Branthaver, Dept. of Chem., N. Dak. State Univ., Fargo, N. Dak., 58102.

Liquid phase fluorination at ambient temperatures of two crude oils and their petrolenes and asphaltenes proceeds controllably. Large amounts of F (nearly 50% of the wt. of the crude) were needed to effect significant changes in properties of the crudes. Boscan crude dissolved in Freon 11 and slurried with K_2CO_3 was treated with F_2 over an extended period of time led to little F incorporation into the crude, though all F was retained by the reaction mixture. Heteroatom content of the crude was not reduced. Fifty percent of introduced F may be expected to be lost as HF, and less than half of the remaining F introduced into the reaction mixture was retained by the crude. The rest was probably lost as volatile products. The behavior of F is different from that of Cl, which is incorporated into the crude to a greater extent and which readily attacks petroporphyrins. Fluorination of model compounds such as dodecylbenzene shows an order of preference of F attack: benzylic H$\rangle$ aromatic ring addition$\rangle$ non-benzylic side-chain substitution.

INCIDENCE AND PATHOLOGY OF THE LUNGWORM, ANGIOSTRONGYLUS, IN DEER MICE AND RED-BACKED VOLES. Omer R. Larson. Dept. of Biology, Univ. N. Dak., Grand Forks, ND 58202

During March-July 1974, 49 of 149 (32.9%) deer mice (Peromyscus maniculatus) and 4 of 28 (14.3%) red-backed voles (Clethrionomys gapperi) were found to harbor a new species of Angiostrongylus. Hosts were live trapped in a moist gallery forest along the Red River in eastern North Dakota. Worm counts from 50 infected animals ranged from 1 to 10 (average 2.1) per host. Male and female worms averaged 13.9 and 23.6 mm in length, respectively. Such nematodes, resembling red and white barber poles, were often seen sliding back and forth in the pulmonary arteries. Paraffin sections confirmed that the worms extended from the right ventricle into the branches of the pulmonary arteries deep within the lungs. Arteries housing adult worms commonly possessed asymmetrically thickened fibrous walls. In extreme cases the arterial lumina were nearly blocked. Embryonating eggs and hatched larvae were present in clusters in the lungs, usually within nodules of fibrous connective tissue. Some heavily infected lobes of the lung appeared to be about one half nodular tissue. Free first-stage larvae were found in bronchial lumina and in the host's fecal pellets.

DULUTH AS A GRAIN TRANSPORTATION HUB. Gordon L. Levine. Dept. of Geog., Univ. of Minnesota-Duluth, Duluth, Mn. 55812

The Twin Ports of Duluth, Minnesota and Superior, Wisconsin function as a major grain elevator terminal for the four state region of Minn., N.D., S.D., and Mont. Duluth-Superior compete with the Twin Cities of Minneapolis-St. Paul for the nation's major supply of hard spring wheat, durum, barley, rye, and flaxseed. Of 1.4 billion bushels of grain produced in the four state region in 1974, the Twin Ports captured 16% and the Twin Cities 27%. The Twin Cities were found to receive most of the oats, corn, and soybean trade of the southern part of the four state region, while the remaining shipments went more to the Twin Ports. Analysis of grain shipments from the nine Crop Reporting Districts of North Dakota detailed Duluth's dominance in all areas for durum, hard spring wheat, and rye and the Twin Cities' in barley and flaxseed. Modal split of grain arrivals at Duluth demonstrated the rapid increase in truck shipments starting in 1956 and culminating in 1971 after which rail rates were cut. In shipping grain from Duluth-Superior the increasing importance of rail was evidence of a desire for more uniform year round shipping operations. An analysis of 1948 and 1974 data provided a clear picture of the shift away from domestic ports as destinations, e.g. Buffalo, to direct shipments to foreign ports or to lower St. Lawrence River Canadian ports for re-export.

THE EFFECTS OF VARIOUS TONICITIES OF CHICK RINGERS SOLUTION ON THE VENTRAL SURFACE OF EARLY CHICK EMBRYOS AS OBSERVED BY SEM AND TEM. L. L. Litke. Dept. of Anatomy, School of Medicine, University of North Dakota, Grand Forks, N. Dak., 58202

Fresh pullet eggs were incubated from 19-26 hours, the blastoderms were removed, immersed in various experimental solutions (various concentrations of buffered chick ringers solution, glucose, and distilled water) for 5 minutes, fixed in isotonic Tyrodes fluid (249-252 mOsm) containing 1.0% glutaraldehyde, post-fixed in 2% OsO_4. Tissues were then routinely prepared for scanning and transmission electron microscopy. Controls (fixed in ovo) were relatively flat with the cells bordered by micro-appendages (microvilli blebs, ruffles and microplicae) and a centrally located cilium. TEM revealed many microtubules and microfilaments. Many extend into microappendages. A hypotonic effect caused by ringers solution (50 mOsm), distilled water, and 3% glucose causes round bulging cells with signs of intracellular fluid uptake and occasionally cell rupture and separation exposing the underlying mesollast cells. A hypertonic effect is caused by ringers solution (1500 mOsm), and 30% glucose which causes cell shrinkage, elongate microappendages, and multiple blebs. The cells have increased density internally with a massive accumulation of glycogen - like granules in the 30% glucose treated specimens. Supported by USPHS Grant NS 09363 and NS 12106.

INTERPRETATIONS OF HOLOCENE WATER LEVEL FLUCTUATIONS IN A CLOSED BASIN LAKE, S. W. MINNESOTA. K. L. Malmquist and J. B. Van Alstine, Dept. of Geology, Univ. of Minn. Morris, Minn. 56267.

Lake Wilson, a closed basin lake (with no definite inlet or outlet) in southwestern Minnesota was studied to determine the reasons for repeated water level fluctuations within recorded history of the area. There has been a continuous decline in the water level, emphasized by periods of total dryness. Precipitation is probably the most important factor controlling the drastic changes in water level; however, a constant reduction in water shed through roadbuilding and tiling, as well as a very high sedimentation rate in the basin appear to be the long range controlling factors. The average grain size of the sediment in the lake is silt-clay (less than .0625 mm) and muck (finely divided plant material). This sediment may very well form a seal in the lake, which would be punctured by a dredging operation. The only feasible way to increase the water level of the lake would be to bring in water from the outside to replace runoff lost through watershed reduction.

ENDOCRINE SECRETIONS OF THE BOVINE PLACENTA. Donald L. Matthies, Dept. of Anatomy, School of Medicine, Univ. of N. Dak., Grand Forks, N. Dak. 58201.

Placental endocrine secretions have been described for a number of different animal forms including human, horse, rodent, goat and ewe. Detection of a bovine placental gonadotrophin (BPL) was announced in 1967. Lactogenic hormones are known to be secreted by the placenta of the human, ewe and rodent. We wish to announce the detection of lactogenic activity in extracts of the placenta of the cow also.

Our bioassay animal was the immature male rat injected locally over the fourth right mammary gland for four days with the supernatant from homogenized placental tissue. The lactogenic synergist, prednisolone, (by itself inactive) was suspended in the test solution in the amount of 20 micrograms per dose. After fixing, staining, and clearing whole mounts of the treated gland as well as the contralateral untreated control gland from each animal, it was possible to demonstrate the mammary alveolar distention characteristic of the secretory state of this tissue.

Serum titre of the postulated bovine placental lactogen (BPL) was too low for detection by bioassay. It does cross-react with antiserum to human placental lactogen (HPL) however, and could be detected by the precipitin reaction in agar plates.

ACTIVATED SUBARACHNOID MACROPHAGES: AN ELECTRON MICROSCOPIC STUDY. R. E. Merchant. Dept. of Anatomy., Sch. of Med., Univ. of N. Dak., Grand Forks, N. Dak. 58202.

Mongrel dogs were anesthetized with an intraperitoneal injection of pentobarbitol. One ml of cerebrospinal fluid was drawn through a 19-gauge needle inserted into the cisterna magna and mixed with one ml (4 to 9 million living organisms) of freeze-dried bacillus Calmette - Guerin (BCG, Glaxo Lab Ltd.). The mixture was then injected into cisterna magna. At one and twelve days postinjection, experimental animals were perfused with buffered aldehydes and samples of their leptomeninges removed. Tissues were post-mixed with 2 percent osmium tetroxide for one hour and routinely prepared for either scanning or transmission electron microscopy. Leptomeninges of untreated, control animals were prepared in a similar manner.

Living BCG in the subarachnoid space produces a three-fold increase in the free cell population in 24 hours and a ten-fold increase in 12 days. These cells tend to form associations varying from loose aggregates to tight clusters. Approximately 80 per cent of these free cells express a morphology corresponding to that of the macrophage. The remaining free cell population is made up of at least two other members of the leukocyte series, polymorphonuclear granulocytes and non-vacuolated agranulocytes.

Supported by U.S.P.H.S. Grant NS 09363.

A PRECEDENT FOR KANT'S CRITICAL PROGRAMME. Theodore Messenger
Dept. of Philosophy, University of North Dakota, Grand Forks, ND

Since antiquity, philosophers have displayed a concern for the "unity" of science--a concern, i.e., to show that the various intellectual disciplines are all parts of the same endeavor. Not only this goal but the means of achieving it have acquired a certain conventionality. At the end of the 18th century, Immanuel Kant proposed a classification of the sciences which, he said, corresponded with that of the ancient Greeks. Kant's classification does, in fact, parallel that of Zeno the Stoic (early 3rd century B.C.). However, as the present paper demonstrates, it more closely resembles the classification proposed by John Locke in the 17th century. The paper also summarizes and defends a methodology for treating these matters.

ASTRONOMICAL COMPACT OBJECTS. F. H. Meyer. Dept. of Physics, Univ. of Wis.-Superior, WI 54880. As a general physical theory, the Reciprocal System of D. B. Larson covers all physical fields, including astronomy, and inasmuch as all the conclusions reached in the theoretical development are derived entirely by deduction from the basic postulates of the system, these conclusions provide an important new source of astronomical information, that is completely independent of observation. A typical result concerns astronomical compact objects, characterized by ultra-high density, such as white dwarfs, pulsars and quasars. The compactness of each occurs mainly because of its formation from explosive motion FASTER than the speed of light, unit speed in the Reciprocal System. Such motion can NOT occur in more space; all motion in space must occur at less than unit speed. Motion at greater than unit speed can and does occur, for no theory can prohibit the physical universe from doing what it does. The only restriction on motion FASTER than unit speed is that it must be motion in time. According to theory, the reason that motion in time causes quasars, pulsars, white dwarfs, etc. to be the compact objects that they are is simply that expansion of the constituting particles in more time is equivalent to lesser spatial separation of these particles. Aided by a grant from the Learn. Resources and Res. Comm., UW-S.

ATOMIC NUMBERS REVALUED. F. H. Meyer. Dept. of Physics, Univ. of Wis.-Superior, WI 54880

As a general physical theory, the Reciprocal System of D. B. Larson covers all physical fields, including atomic physics, and inasmuch as all of the conclusions reached in the theoretical development are derived entirely by deduction from the basic postulates of the system, these conclusions provide important new information that is completely independent of observation. The theoretical development indicates that the Moseley atomic number mathematical formula is quite right, and the Rutherford-Bohr-Moseley nuclear atom physical interpretation of atomic number is badly wrong. The discrete units constituting atoms evidently are not neutrons and electrically charged particles. Nor are atoms made up of parts, a nucleus, electron orbitals, etc. From the Rutherford experiment it can be inferred that the size of an atom is about 10^{-13} cm. instead of 10^{-8} cm. and that all, not merely most of, its mass is in the region with the smaller dimension. Nobody has found the unknown nuclear force assumed to attract alleged protons in spite of the known repulsion between them. Work aided by a grant from the Learning Resources and Research Committee, UW-S.

GEOLOGY AND GROUNDWATER HYDROLOGY OF THE PROPOSED COAL GASIFICATION PLANT AT DUNN CENTER, NORTH DAKOTA PRESENT AND FUTURE. Stephen R. Moran, John A. Cherry, James H. Ulmer, Wm. M. Peterson, and Margery Hulbert, Engineering Experiment Station, Univ. of N. Dak., Grand Forks, N.D. 58202

The Dunn Center area occupies approximately 175 square miles in central Dunn County. It is underlain by 300 to 550 feet of semi-lithified silt, clay, sand, and lignite of the Sentinel Butte Formation (Paleocene). The overlying Golden Valley Formation (Paleocene-Eocene) caps buttes in the southern part of the area and the crest of the ridge at the northern edge of the area. The Coleharbor Group (Quaternary) occurs as a thin discontinuous veneer of glacial sediment in the northern part of the area and as a narrow 120- to 150-foot-thick fill in a series of generally NW-SE trending glacial meltwater channels. Ten widespread continuous lignite beds and less extensive sand beds in the Sentinel Butte Formation and the permeable fills in the glacial meltwater valleys are the principal aquifers. The Fox Hills Formation provides an important aquifer under the entire region that is only very slightly used at present. Throughout most of the area groundwater flow is vertically downward through the silt and clay beds and horizontally toward the nearest outcrop of the permeable lignite and sand beds. Groundwater flow rates are very slow. Hundreds to thousands of years are required for groundwater to flow from upland recharge areas to intermediate groundwater discharge areas in the valleys of Spring Creek, Knife River, and the Little Missouri River. Water in aquifers that do not outcrop in the area or the Little Missouri River valley flows toward the east. Excavation of the mine will result in a drawdown of water levels in wells around the mine. Glacial meltwater valleys that border the north, west, and east edges of the mine area will limit the drawdown in those directions. To the south, significant drawdown will probably not occur more than 2 miles from the highwall. The chemical quality of groundwater in the reclaimed mine area is very difficult to assess, but even if the quality is degraded relative to the pre-mining condition, replacement water supply will be available from aquifers beneath the Dunn Center Bed.

EVIDENCE FOR CHARGE TRANSFER IN COCAINE PHOTOCHEMISTRY. N. K. Narain, S. P. Singh and V. I. Stenberg, Department of Chemistry, University of North Dakota, Grand Forks, North Dakota 58202

Spectroscopic evidence for a charge transfer in cocaine spectra has been found. Compared to methyl benzoate, the absorption spectrum of cocaine in a variety of solvents, e.g., cyclohexane, acetonitrile, methanol, water and water/HCl, provides no evidence that direct excitation to a charge transfer singlet state occurs nor is one evident from its fluorescent spectra in the same solvents. The phosphoresence spectrum in methanol clearly demonstrates the presence of a triplet charge transfer state different than the triplet state of methyl benzoate. Supported in part by USPHS, NIH (Grant 5 ROl GM 21590-02 and Career Development Award 1-K4-GM-09888).

AOA: A PERSONAL APPROACH TO ENVIRONMENTAL EDUCATION. Michael J. Naylon, Executive Director, Minnesota Environmental Sciences Foundation, Inc., Minneapolis, Minnesota 55422

MESFI is field testing materials for a community-based environmental education course of study. Program emphasis includes values clarification, cooperative problem solving and an examination of logistics necessary to the maintenance of communities in order that they might meet societal needs. Its approach is referenced to the individual and provides a means of studying the impact of one's lifestyle on the environment. Much emphasis is placed upon the development of case studies, small group discussion and cooperative problem solving. Use of graphics as a form of summary is stressed. The Area of Affect (AOA) is a method of mapping participant activity, range or environmental impact within the community. Modifications of Johari window and paired comparison techniques are used to map data and infer alternatives.

ADENOHYPOPHYSEAL DELTA CELL SIZE IN RELATION TO PHOTOPERIOD AND ANTLER GROWTH OF MULE DEER ODOCOILEUS HEMIONUS HEMIONUS (CERVIDAE). Ken E. Nicolls Dept. of Anatomy, Sch. of Med., Univ. of N. Dak., Grand Forks, N. Dak.

Male deer were collected throughout the year in north central Colorado. Pituitary glands were prepared for light microscopy using standard histological technique. Sections were stained by the combined aldehyde fuchsin-acetic alum hematoxylin-trichrome method. Slides to be stained, sections to be studied, and fields to be evaluated were selected systematically. Nuclear and cytoplasmic area of large delta cells were measured by a glass micrometer net installed in the ocular lens. Each intersection on the net had a value of $2.76\mu^2$ at the 1000X of oil immersion. Nuclear and cytoplasmic areas were greatest in the Spring and Summer photoperiod seasons, respectively. Nuclear and cytoplasmic areas were greatest in the Antler Hardening portion of the annual antler growth cycle. Shedding of boney antlers, growth of velvet antlers and increase in nuclear and cytoplasmic areas of large delta cells in the adenohypophysis occur when the photoperiod is increasing. Construction and retention of hard antlers, maximal nuclear and cytoplasmic area, and decreasing photoperiod occur simultaneously.

SLOW LEAF RUSTING OF DURUM WHEAT. John T. Nordgaard and Glen D. Statler, Plant Pathology Department, North Dakota State University, Fargo, North Dakota 58102

Durum wheats (Triticum durum Desf.) characteristically display the quality of slow rusting in response to leaf rust (Puccinia recondita f. sp. tritici) infection. Field trials demonstrated that a susceptible durum (D6618) was not infected until later in the growing season than a susceptible hard red spring wheat (Thatcher). The rate of rust development was more rapid on Thatcher than on D6618. Slow rusting durums Botno and Rolette when sprayed with Dithane M-45 or Indar, had a nonsignificant yield reduction as compared to a no-chemical (control) treatment. In contrast, unsprayed Thatcher had losses of 31.2% for yield, 2.9 for test weight, and 9.4% for 1000 kernal weight when compared to sprayed Thatcher. Many greenhouse studies were conducted to investigate the slow rusting phenomena. It was found that leaf rust uredia break the leaf epidermis of Botno and Rolette as much as 24 hours later than on Thatcher. Size of leaf rust uredia on durum, depending on environmental conditions and varietal differences, are never larger and are generally smaller than uredia on hard red spring wheats.

CHLOROFLUOROCARBON EFFECTS ON CARDIAC, PULMONARY AND RESPIRATORY FUNCTION. M. E. Olson. Dept. of Phys. Med. and Rehab. Med. Sch. U. of Minn., Minneapolis, MN 55455

Research results from studies on the physiological effects of aerosol propellants on animals and people are summarized. The papers selected for this summary were published between 1968 and 1975. Effects of the 15 chlorofluorocarbons used as propellants have been recorded on the cardiac, pulmonary and respiratory functions of a number of animal species as well as man. The 15 propellants have been classified into four groups on the basis of the degree of their toxicity. Fluorocarbon 11, the most frequently used propellant, is in group 1, the most toxic. The relative toxicity of each of the 14 other propellants compared with FC 11 is reported. On the basis of the results of these studies, it is suggested that the two problems created by chlorofluorocarbon propellants, potential ozone depletion and adverse effects on cardiac, pulmonary and respiratory functions be considered simultaneously since limiting the exposure of human beings to the compounds would decrease the risk to the ozone layer as well as the risk to people.

Thin-layer Chromatographic Determination of Flurazepam and its Major Metabolite in Human Urine. S.F. Palermo and A. Poklis. State Toxicology Lab. Fargo, N. Dak. 58102

Four thin-layer chromatographic methods for the detection of flurazepam and its primary urinary metabolite N-1-hydroxyethyl flurazepam were evaluated. Urines spiked with 1.0 ug/ml flurazepam and 1.0 ug/ml metabolite and urine samples obtained from hospital patients on oral flurazepam therapy were analyzed by each method. The drugs were extracted, chromatographed and detected by combinations of ultraviolet or visible light and spray reagents according to each method. Flurazepam and its hydroxyethyl metabolite were detected in the spiked urines by all four methods. However, only the method of J.A.F. de Silva et al (1971) involving hydrolysis of flurazepam to a benzophenone derivative was found consistent in detecting the drug in hospital urines. The method of C.S. Frings, et al (1974) detected the metabolite but recoveries were not consistent. The methods of E.G.C.Clarke (1969) and P.R.Sedgwick (1975) were found unreliable.Supported in part by Vet. Admin. (Project MR1S-5709-01).

SOME CHRONOSEQUENCES OF VEGETATION IN THE SURFACE MINED AREAS OF WESTERN NORTH DAKOTA. *R.H. Pemble*, Dept. Biol., Moorhead State Univ., Moorhead, MN. 56560, and *M.K. Wali*, Dept. Biol., Univ. N. Dak., Grand Forks, N.D. 58202.

During the summer of 1975 a study was conducted to determine the relationship between vegetation pattern and local site conditions on mined and unmined areas in southeastern Ward County, N.D. A total of 204 stands of vegetation from a range of topographic positions on both unmined sites and spoils material belonging to five different age classes (1, 7, 17, 30, and 45 years of age) were examined. Target diagrams were constructed to show the distribution of each vascular plant species encountered by topographic position along a time gradient, which demonstrate a pronounced change in vegetative species composition with time following disturbance. Species variety increases from 23 species on one year old spoils to 114 species on unmined sites; only 5 of the 152 species were present throughout the sere. The pattern of replacement is complex. Whereas 13 species occurred only on the one year old spoils, 66 were restricted to unmined sites. The ecological success of each species in relation to soil characteristics and topography should indicate the specific types of environmental modifications necessary to successfully reestablish each of these plant species. *(Supported by Grant No. G0264001, Bureau of Mines, USDI)*

FERRIC CHLORIDE PHOTOCHEMICAL OXIDATION OF TETRAHYDROFURAN. Phred Petersen, G. Hendrickson and V. I. Stenberg, Department of Chemistry, University of North Dakota, Grand Forks, North Dakota 58202

The photolysis of a degassed tetrahydrofuran solution of iron (III) chloride was done using a medium-pressure mercury arc lamp with a Pyrex filter. Gas-liquid chromatography was used to analyze and separate the components of the mixture. The decolorization of the yellow solution occurred most readily in the presence of added water in a 4:1; water: iron(III) chloride molar ratio. Iron(III) cloride hexahydrate in dry, purified tetrahydrofuran also gave excellent results. In more anydrous solutions, a white, crystalline complex consisting of $FeCl_2 \cdot 2\ C_4H_8O$ formed in the reaction mixture. An alcohol, 3-butene-1-ol, was isolated from the reaction solution by gas phase chromatography and identified by nmr, ir and mass spectral analyses. Supported in part by USPHS, NIH (Grant 5 RO1-GM 21590-02 and Career Development Award 1-K4-GM-09888).

Sexual Asphyxia and Aerosol Abuse A. Poklis and D. H. Lawrence. State Toxicology Lab. and Fargo Community Health Dept. Fargo, N. Dak. 58201

A fatal case of sexual asphyxia is reported. The deceased was deliberately inhaling the vapors of an aerosol shoe cleaner while engaging in sexual self-stimulation. The cause of death in this case may be related to the cardiotoxicity of aerosol propellants. Persons practicing sexual asphyxia place themselves in a life threatening situation. The deliberate inhalation of aerosol products during the ritual sexual activity displayed in such cases increases the danger of a fatal accident.

CONSTRUCTION AND SENSITIVITY OF LARGE AUTOMATIC NON-WEIGHING LYSIMETERS, G. A. Reichman, E. J. Doering, L. C. Benz, and R. F. Follett. USDA, Agricultural Research Service, Mandan, N. D.

Twelve 2.44 m x 4.88 m non-weighing lysimeters from 1.22 m to 2.44 m deep were built into a sandy field near Oakes, N. Dak. They were filled with soil from the field, returning the 0- to 0.30-m layer, the 0.30 to 0.61-m layer, and the subsoil layer in their original order. Each lysimeter was hydraulically connected to a standing well located in a low instrument shelter. The stilling wells duplicated the water level in the lysimeters and provided an access to add or remove water needed for water-table control. The water level is automatically measured and adjusted every 30 minutes. The water level may be set at any depth within the limit of the lysimeters; during 1974 and 1975 the water tables were 0.45, 1.00, 1.55 and 2.10 m deep. The control system is described in detail and has operated continuously and successfully since August 1, 1974. The system has the design capacity to add water at a rate of 2.02 cm/day and remove water at a rate of 4.21 cm/day. Hence, water uses as small as 0.42 mm/day can be measured. Additions of water during the test period was highly correlated with both time and available atmospheric heat units. After a 10-cm rain, the 0.45 and the 2.10 m water-table levels were reestablished in 15 to 95 hours, respectively.

SOIL ALGAE FROM SURFACE MINED AREAS OF WESTERN NORTH DAKOTA. *L. Elliot Shubert.* Dept. Biol., Univ. N. Dak., Grand Forks, N.D. 58202.

A study was initiated to determine the species diversity of algae inhabiting topsoil and spoil materials collected aseptically from 4 mine sites in western N.D. during 1975. Using the enrichment culture-controlled environment technique algae from the divisions Chlorophyta (*Chlorococcum* sp., *Chlorosarcinopsis psuedominor*), Chrysophyta (*Nitzschia* sp., *Navicula* sp.); and Cyanophyta (*Nostoc commune, Oscillatoria* sp., *Phormidium* sp., *Lyngbya* sp.) were identified. The Center and South Beulah topsoils showed the greatest diversity with 5 and 8 species respectively. Spoil materials from nearby locations and from Glenharold and North Beulah spoil materials had low species diversity (2-5). Chemical analysis of the soils revealed that high SAR's (22-39), pH (8.4) and E.C. values (2.8-4.6 Mmhos/cm) at the Glenharold and North Beulah sites (Mercer County) probably were the factors inhibiting growth and reproduction of algae in these soils. The Center sites (Oliver County) had lower SAR's (4), pH (7.9) and E.C. (0.7-2.4 Mmhos/cm). The presence of 4 genera of blue-green algae, capable of fixing N, suggests the possibility of nutrient amelioration through algae in conjunction with various amendments for reclaiming surface mined land. *(Supported by Grant No. G0264001, Bureau of Mines, USDI)*

PLANT GROWTH COMMUNITY ANALYSIS IN THE VICINITY OF STANTION, NORTH DAKOTA. S. J. Rothenberger, G. E. Larson, W. T. Barker, D. S. Galitz. Botany Dept., N.D.S.U., Fargo, N.D. 58102

To assess possible effects of coal development on native vegetation, plant communities near the Missouri River in Oliver and Mercer Counties were analyzed during the summers of 1974 and 1975. The twelve sites sampled included five sites in the mixed-grass prairie and seven sites in or near the Missouri River bottomland forests. Twelve species of graminoid plants and 67 species of forbs were reported at the prairie sites. Graminoid species were sampled systematically by the point-frame method. Forbs were sampled using 25 randomly placed square foot quadrats. Bouteloua gracilis, Carex filifolia, and Stipa comata were the dominant graminoid species. The mixed-grass prairie in this area is of the Grama-Needlegrass-Sedge Type as recognized by Hanson and Whitman in 1938. Trees and shrubs at the woodland sites were sampled by use of a modified belt transect method. Randomly placed square meter quadrats were used to sample understory vascular plants. The three forest types observed were: floodplain forest on the valley floor dominated by Populus deltoides, wooded slopes of the lower terrace with codominants Populous deltoides and Fraxinus pensylvanica, and wooded draws of the upper terraces dominated by Fraxinus pensylvanica. Eight species of trees, 13 species of shrubs, and 134 species of understory vascular plants were reported.

THE ALGAL GROWTH POTENTIAL OF DEVILS LAKE, NORTH DAKOTA.
L. Elliot Shubert. Dept. Biol., Univ. N. Dak., Grand Forks, N.D. 58202.

Devils Lake can be characterized as a saline, alkaline, eutrophic, shallow, closed body of water. The purpose of this field and laboratory study was to document chemical, physical and biological changes in Devils Lake and to determine the algal productivity and limiting factors of growth by the bioassay method. A rise in the lake level to a 70 year high in 1975 (1424.8 ft) has resulted in a decrease in TDS (2600 mg/l). The concentrations of cations, anions and trace elements have decreased, except phosphorus. Ambient levels of P have remained quite high (0.5 mg/l). This has resulted in massive blue-green algal blooms (*Microcystis aeruginosa & Aphanizomenon flos-aquae*) during July & August. The algal growth potential of Devils Lake is very high (2 dbls of cells/48 hr). Nutrient addition experiments revealed that no nutrient (singly or in combination) was limiting during the months of July & August, 1975. Using the Vollenweider loading formula for N & P, it was calculated that the annual N loading was within permissible limits whereas the annual P loading was above the dangerous level. The major contributions of N & P are from agricultural runoff and effluent from a sewage lagoon. Water management practices were suggested. *Supported by USDI, Bureau of Reclamation. (#14-06-600-959A)*

PHOTOCHEMISTRY OF COCAINE ANALOGS. S. P. Singh, N. K. Narain, and V. I. Stenberg. Department of Chemistry, University of North Dakota, Grand Forks, North Dakota 58202

In our continuing efforts to understand the photochemistry of cocaine, three cocaine analogs have been synthesized and investigated. Irradiation of p-toluoyl-ℓ-ecgonine methyl ester and p-anisoyl-ℓ-ecgonine ester in methanol was carried out in the Rayonet photochemical reactor fitted with the 300-nm lamps and a Corex filter. On the other hand, a methanolic solution of phenylacetyl-ℓ-ecgonine methyl ester was irradiated in the same reactor with the 253.7 nm lamps without the Corex filter. The first two compounds undergo photochemical decomposition and give demethylated products while the latter one, which has different chromophoric group, does not undergo photochemical decomposition. This stability of phenylacetyl-ℓ-ecgonine methyl ester at 253.7 nm reveals that the benzoyl chromophore is essential for demethylation in cocaine and its derivatives. The yield of the demethylated product for the first two compounds was lower than for norcocaine under similar experimental conditions. This indicates that the methyl and methoxy electron donating groups cause less charge transfer from tertiary nitrogen atom to the excited benzoyl group. Supported in part by USPHS, NIH (grant GM 21590 and Career Development Award 1-K4-GM-09888).

CONTRIBUTIONS OF EARLY AMERICAN WOMEN TO SCIENCE. Beatrice A. Smith[1] and Elizabeth W. Reed[2]. St. Paul, Minn.

Early American women (before 1876) whose contributions to science are found in the form of papers in scientific journals, magazine articles, textbooks, and other occasional writings include the pre-Revolutionary War botanist Jane Colden; the educator Emma Willard; the writer of science textbooks Almira Lincoln Phelps; the astronomer Maria Mitchell; the entomologist Margaretta Hare Morris; the chemist and doctor Rachel Bodley; and several others. A study of 19th and 20th century biographical compilations, of the proceedings and journals of scientific societies, and of specialized scientific bibliographies has generated a list of 22 American women who made important contributions to various aspects of science in the period before 1876. Research still in progress indicates that many more women, at present largely unknown and unrecognized, were constructively involved in many branches of science at this time in America.

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SYNTHESIS OF NEWER SUBSTITUTED QUINAZOLONES AS CNS DEPRESSANTS. N. G. Srivastava, V. I. Stenberg, and S. S. Parmar, Department of Chemistry, University of North Dakota, Grand Forks, North Dakota 58202.

Twenty four naphthylquinazolones, synthesized by a two-step general procedure and characterized by their sharp melting points and spectral analyses, were evaluated for anticonvulsant and antihemolytic properties. Most quinazolones (100 mg/kg, ip) provided 10-60% protection against convulsions induced by pentylenetetrazol (90 mg/kg, sc) in mice, where β-naphthyl compounds showed greater activity than α-naphthylquinazolones. Maximum activity was observed with 6-iodo compounds. *In vitro* protection of hypoosmotic hemolysis of rat red blood cells by quinazolones (0.05 mM) ranged from 17-60%. Such membrane stabilizing effects were unrelated with anticonvulsant activity. The nature of the substituents at 6, 7 or 8 position altered anticonvulsant and antihemolytic properties. These results have indicated that antihemolytic property cannot account for the biochemical basis for anticonvulsant activity of naphthylquinazolones. Supported by USPHS NIH Grant 5 RO1-GM-21590-02 and Career Development Award (1-K4-GM-09888).

CYTOCHALASIN B: EFFECTS ON FINE STRUCTURE OF EARLY CHICK EMBRYOS AS REVEALED BY SCANNING AND TRANSMISSION ELECTRON MICROSCOPY. P.A. Stagno. Dept. of Anat., Sch. of Med., Univ. N. Dak., 58202.

This study was undertaken to observe the effects of cytochalasin B (CB) on organized tissue. Eggs were incubated from 36-48 hours. The blastoderms were exposed to CB (10 or 49µg/ml) by immersion in chick Ringer's containing CB, in dimethylsulfoxide (DMSO), for 5 minutes. Fixation took place in isotonic Tyrode's solution containing 1.6% glutaraldehyde. Preparation for scanning and transmission electron microscopy was routine. Controls were fixed *in ovo* or after 5 minutes exposure to 1% DMSO. Controls fixed *in ovo* possess flat cells with bulges due to previous phagocytosis of yolk. Numerous microappendages are present (microvilli, blebs, ruffles, microplicae) especially at cell margins. DMSO controls present a similar cell surface except that small blebs are more prominent. The surfaces of the entodermal cells possess numerous large blebs (2-10µm), small blebs (0.5µm) and microvilli. Areas of cell dissociation are common. Dissociated cells possess large holes in the plasmalemma, possibly representative of burst blebs. TEM of large blebs reveals no cellular material except for membranous vesicles. Cellular fine structure is otherwise normal. No relationship between plasmalemmal blebs and cytological components was noted. Supported by USPHS Grants NS 09363 and NS 12106.

PRODUCTION AND ECONOMIC CONSIDERATIONS WHEN MACHINING GLASS CERAMIC (K_2O-MgF_2-MgO-SiO_2). J. Stanislao. Prof. and Dean of Engr. and Arch., N. Dak. State Univ., Fargo, N. Dak. 58102

Glass Ceramic (K_2O-MgF_2-MgO-SiO_2) was found to have relatively good machinability capabilities but is restricted within a very limited range of machine settings. The microstructure of glass ceramic has significant influence on machinability parameters. Tool geometry, tool composition, and the machining environment will influence cutting forces, workpiece surface quality and tool life. To determine production conditions an economic model was developed using Taylor's equations. A machining parameter was ultimately established with a minimum cost per unit while achieving a maximum production rate. Some of the significant findings were chip formation correlated with surface quality, tool life was influenced by machining parameters and a cost could be achieved.

THE ULTRASTRUCTURE OF UNICELL FORMATION IN THE GREEN ALGA, *SCENEDESMUS TRAINORII* (MEYEN) SHUBERT. *Thomas L. Starks and L. Elliot Shubert.* Dept. Biol., Univ. N. Dak., Grand Forks, N.D. 58202.

Scenedesmus trainorii, a species possessing both a colonial and a unicellular form, was studied to determine ultrastructural differences in daughter cell formation in synchronous, axenic cultures grown in defined media under controlled environmental conditions. Cultures of colonies and unicells, from the first through the seventh hour of the dark period, were prepared in the standard method and examined with a TEM. Evidence was found to suggest that cell cement was produced by rough endoplasmic reticulum (ER). ER was observed migrating toward adhesive sites during colony formation, but not during unicell formation. No adhesive sites were observed in unicell formation. ER was also involved in cleavage furrow and cell wall formation. Mitochondria reappeared earlier and were more numerous in unicells, supporting the theory that unicell transformation has a greater energy requirement than colony formation. A Trilaminar Sheath (TLS) completely enclosed each unicell and was identical to the layer that enclosed each colony. Spines, props, openings and the remnants of bristles were observed for the first time on newly formed unicellular and colonial daughter cells still within the mother cell, and on vegetative unicells and colonies. Supported in part by the U.N.D. NSF Faculty Research Fund.

CYTOGENETIC ANALYSIS OF SOME PATIENTS AT THE GRAFTON STATE SCHOOL FOR THE MENTALLY RETARDED. Peggy J. Stupca and S.M. Jalal. Dept. of Biology, Univ. of N. Dak., Grand Forks, N.Dak. 58202.

Seventy patients were analyzed initially for determination of X-chromosome abnormality. The patients were examined for typical physical traits. In all cases the features were within expected ranges for Down's syndrome. IQ in Down's syndrome rarely exceeds 100. All of the individuals in the study were well within this range.

Chromosome 21 trisomy increases in frequency with an increase in the mother's age. There is about a seven fold increase for mothers 35-45 years compared to 15-20 age group. There was a similar rate of increase at the same age range in this study. In addition a seven fold increase occurred among mothers in the 20-25 year range. This apparently reflects institutionalized individuals. In this group one finds a much higher proportion of mentally retarded children from unwed mothers and young couples.

Sixteen of these patients were karyotyped by the whole blood culture techniques. Fifteen patients had 21 trisomy and the other individual appeared to be a mosiac with a predominance of the 47, 21+ cell line. Giemsa banding technique of Seabright's was used to demonstrate that chromosome 21 was involved in the trisomy.

PREPARATION AND PROPERTIES OF METALLO-DERIVATIVES OF MESO-HALOGENATED PORPHYRINS. J. M. Sugihara and J. F. Branthaver, Dept. of Chem., NDSU, Fargo, N. Dak., 58102.

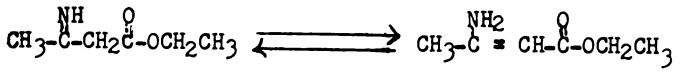
Chlorine readily reacts at low temperatures with the VO- and Ni-porphyrins in crude oils, resulting in much porphyrin destruction and demetalation. Chlorine reacts with VO- and Ni-octaethylporphine (OEP) less rapidly than with the petroporphyrins. Reactions are light-catalyzed and of a radical nature. Ni OEP treated with an excess of chlorine or sulfuryl chloride yields Ni meso-tetrachloro-OEP, starting material, and decomposition products. VO OEP treated with sulfuryl chloride yields VO meso-dichloro-OEP, starting material, and decomposition products. Attack of chlorine thus tends to occur at a meso-position, and chlorinated products are more susceptible to further chlorination than the parent metalloporphyrins. No metal-free porphyrin intermediates were isolated. Cu and Ni complexes of mono-, di-, and tetrachloro-OEP were prepared, as well as the VO complexes of mono- and dichloro-OEP.

REACTION OF LONG-CHAIN MERCAPTANS WITH NICKEL CHELATES J. M. Sugihara and J. F. Branthaver, Dept. of Chem., NDSU, Fargo, N. Dak., 58102.

Mercaptans react with many Ni β-diketonate complexes to yield polymeric Ni mercaptides and β-diketones. The order of reactivity with n-decyl mercaptan in toluene at room temperature is: Ni dipivaloylmethanate $>$ Ni acetylacetonate $>$ Ni-trifluoroacetylacetonate. Ni hexafluoroacetylacetonate required heating for reaction to occur. Soluble, stable hexameric Ni n-decyl mercaptide was prepared by heating n-decyl mercaptan with Ni CO_3 in a mixture of toluene and ethanol on a steam cone. Ni n-decyl mercaptide prepared in other ways eventually polymerized, suggesting that acids catalyze this transformation. NMR peaks of the hexameric Ni n-decyl mercaptide were slightly upfield of those of n-decyl mercaptan. Long alkyl side-chains on a Ni mercaptide do not inhibit polymerization, and the method of preparation is more important in this regard.

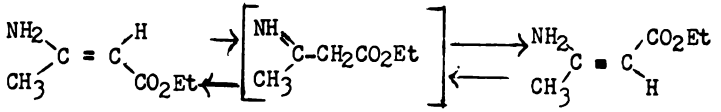
A STUDY OF THE STEROCHEMISTRY OF β-AMINO CROTONATES. W. Kevin Sundal and Arne N. Langsjoen, Gustavus Adolphus College.

Ethyl β-amino crotonate has been isolated in two isomeric forms. Early literature identified the isomers as amino-imino tautomers:



A. (mp = 34° C.) (mp = 20° C.)

Subsequent literature suggests rather that the isomers are cis-trans forms of the free amino form:



B. (mp = 34°C.) C. (mp = 20°C.)

Both isomers of this system have been isolated and studied. Our evidence strongly suggests that the isomer melting at 20° C. is (C.) and its stereomer melting at 34° C. is (B.) No spectral evidence for an imino form (A.) was found though it is assumed that such would be a necessary intermediate in the ready observed interconversion between (B.) and (C.).

A METHOD FOR THE COLLECTION OF BOVINE EMBRYOS USING PROSTAGLANDINS J.E. Tilton, L.E. Christoferson, R. Leech and M.L. Buchanan. Dept. of Animal Science, NDSU and TNI, Fargo, ND 58102

The collection of bovine embryos was attempted for utilization in cytological studies of hydrocephalus. The sequence of treatments involved a 45 mg I.M. injection of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) followed by either insertion of Laminaria tent, suture of the vulva or insertion of menstrual cups. Every four hours after insertion these devices were evaluated for purposes of maximal collection success of aborted conceptus. Using a regime of $PGF_{2\alpha}$ followed 24-30 hours later by menstrual cup insertion resulted in the successful recovery of 5 of 7 aborted embryos and one intact placenta minus the embryo in another case. The $PGF_{2\alpha}$ was effective in eliminating the cervical plug at 44-48 hours with the uterine contents expelled between 49.5 and 96 hours post-injection. The time of expulsion was related somewhat to length of gestation with greater dilation of the cervix required for longer term fetuses. The menstrual cup was very effective in retaining the early term embryos within the vaginal cavity after movement from the uterus. The combination of procedures using $PGF_{2\alpha}$ and the menstrual cup were very simple, effective and repeatable with respect to time. These techniques were found to provide viable biological materials for cytological analysis and fertility of the donor females was not affected by treatment.

NUTRITION AND PHYSIOLOGY OF THE LICHEN PHYCOBIONT *TREBOUXIA*. *Paul H. Tomasek and L. Elliot Shubert.* Dept. of Biol., Univ. N. Dak., Grand Forks, N.D. 58202.

The green alga *Trebouxia* was isolated into axenic culture from the lichen *Cladonia mitis* and cultured under controlled environmental conditions. A dilute, defined, inorganic medium 3.07 (pH 6.8) was supplemented with various nutrients to determine their effect on the growth of *Trebouxia*. Cultures were transferred daily using sterile techniques. Sheath formation by the cells in culture resulted in extensive sticking of cells to the glassware, thus optical density, cell counts and fluorometric readings were not satisfactory methods for measuring growth. The ^{14}C method proved to be the most effective and sensitive measurement of growth. The cultures were pulsed with a NaH $^{14}CO_3$ solution during the light period and terminated after 6 h. The cells were membrane filtered and analyzed for ^{14}C activity with a liquid scintillation counter. ^{14}C uptake was greatest in the 3.07 medium supplemented with $NaNO_3$ (4.1 mg N/l) and was statistically different from the control (0.3 mg N/l). A new dilute defined inorganic medium 26.07 effective as a base medium for growth studies of *Trebouxia* was developed. Supported in part by the Sigma Xi, Grants-in-aid-of-research program and the UND Biology Dept.

THE EFFECTS OF LONG-TERM CAFFEINE ADMINISTRATION ON PLASMA GLUCOSE LEVELS IN A GENETICALLY STANDARDIZED STRAIN OF MICE. R.K. Tweten, Dept. Biol., Moorhead St. Univ., Moorhead, Mn. 56560

Low levels of caffeine (0.05-0.10 mg/24 hrs.) were shown to elevate plasma glucose in male C57BL/6J mice. The mice were caged individually; food (Purina Laboratory Chow) and sterilized tap water were provided ad libitum. Blood samples were obtained via orbital sinus puncture and assayed by an ultra-micro method utilizing Hycel's Direct Glucose Reagent. All mean glucose levels are reported as mg/100 ml. Previous to caffeine administration mean plasma glucose levels in the test and control groups were, respectively, 149±4.6 (n=17) and 142±5.1 (n=16). These means were not significantly different. Caffeine was then placed in the test group's water and after 21 days the mean was 162±4.7 (n=17); the control mean was 144±7.9 (n=17). Although the test group's level increased it was not significantly higher than the control mean. After another 21 days the mean levels were 173±5.5 (n=16) and 152 ±6.2 (n=15), respectively. This difference of 21 mg/100 ml was significant ($p<0.05$). The caffeine was then removed and 21 days later the mean level in the test group dropped to 148±4.4 (n=17); the control mean was 146±5.8 (n=14). The difference in means was not significant. The return of the test group's mean level to that of the control supports the conclusion that caffeine was the factor causing the elevation in plasma glucose levels.

EFFECT OF DIETARY FACTORS ON CHOLINE PHOSPHOTRANSFERASE (CPT) AND PHOSPHATIDYL ETHANOLAMINE METHYLTRANSFERASE (PEMT) ACTIVITY IN LIVER MICROSOMES, Eric O. Uthus and W.E. Cornatzer, University of North Dakota Medical School, Grand Forks, N. D. 58202

Female rats were fed a liquid diet containing amino acids, minerals, vitamins, and choline. The assay of CPT which catalyzed CDP-choline and α,β-diglyceride and PEMT which catalyzes the methylation of phosphatidyl ethanolamine to form phosphatidyl choline has been determined in liver microsomes and expressed as specific activity (nmoles phosphatidyl choline/min/mg protein). In the total assay there was a significant drop in the specific activity of the CPT when animals were fed the diet with the omission of choline and methionine for 1,2,7 and 14 days. In rats fed the diet with the omission of choline, methionine, B_{12} and folic acid the specific activity and total liver microsomal CPT was significantly decreased in the total assay. The addition to the diet for 7 days a methyl group acceptor, guanidoacetic acid and a methylation inhibitor, 2-amino-2-methyl-1-propanol lower significantly the specific activities of CPT. Animals fed a B_{12}-folic acid deficient diet for 83 days had a significant decrease in specific activity and total liver microsomal activity of PEMT. It is apparent from the data that dietary choline and methionine effect the activity of CPT. The omission from the diet of methionine actually raise the specific activity of PEMT.

EFFECTS OF NUTRITIONAL DEFICIENCY ON HERPES SIMPLEX VIRUS INFECTION IN MICE. M. Van Eeckhout, J. Varani, R. Pekarek and J.J. Kelleher. University of North Dakota and USDA Human Nutrition Laboratory, Grand Forks, ND.

Three groups of nutritionally controlled mice were compared as to their resistance to infection with Herpes simplex virus type 1. Prior to infection with the virus, one group of mice was maintained on a diet lacking zinc. These animals were compared to an ad libidum control group with a fully supplemented diet and a pair-fed group which received a fully supplemented diet but only in a quantity equal to that consumed by the zinc deficient group. Periodically, animals were killed and serum samples were taken for zinc assay. Serum zinc levels of the zinc deficient group dropped rapidly and remained low for the duration of the experiment. Serum zinc levels of the ad libidum and pair-fed groups remained at normal or slightly higher than normal levels. After four weeks on the diets, all groups were injected intravenously with Herpes simplex virus. A significantly higher death rate was observed in the zinc deficient group (59%) as compared to the ad libidum group (12%). The mortality rate of the pair-fed group (43%) was intermediate between these groups.

SPECIFIC AND NONSPECIFIC RESISTANCE IN MICE TO HERPES SIMPLEX VIRUS. J. Varani, D. Gabrielson and J. J. Kelleher. University of North Dakota, Grand Forks, N. Dak. 58201

Mice were specifically immunized to herpes simplex virus (HSV) by 3 injections of 0.1 LD_{50} of HSV or nonspecifically immunized by a single injection of a killed Corynebacterium granulosum preparation. The mice specifically immunized to HSV demonstrated a high degree of resistance to a subsequent challenge with a lethal dose of virus. Spleen cells obtained from these animals protected syngeneic recipients when injected 24 hours before the challenge virus and inhibited the growth of HSV in rabbit kidney cells when added to the culture medium 4 hours after the cells were infected with virus. The non-specifically-immunized mice also demonstrated a high degree of resistance to subsequent challenge with HSV. However, spleen cells taken from these animals did not protect recipients against challenge with virus and did not limit the growth of virus in cell cultures.

BIOLOGICAL CONTROL AND ECONOMIC DAMAGE LEVEL OF THE EUROPEAN CORN BORER. J. Vera-Graziano and R. D. Frye. Dept. of Entomology, N. Dak. State Univ., Fargo, N. Dak. 58102

Quantification of natural biological control of the European corn borer and the density of borer populations that cause economic damage in sweetcorn were investigated. Field experiments were conducted to determine the degree of woodpecker predation and arthropod control, and the economic damage level of the borer. Twelve plots were randomly selected in a corn field. In each plot a number of plants were artificially infested with borer eggs. Six of those plots were confined under cages in order to prevent the access of the enemies to the borer larvae. At the end of the season, comparisons involving predator and borer activity were made between caged and uncaged plants. A randomized complete-block design was used to determine the economic damage level. Two varieties of sweet corn at two different periods of plant maturity (beginning of tassel formation and at completion of male flower formation) were treated with seven different levels of borer eggs per plant. 57% of the pest population was controlled by parasites and predators, and 15% was controlled by birds. 41 or more eggs per plant caused significant loss in ear weight and plant weight. Plants treated at tassel formation yielded less than plants treated later. Supported by NDSU and USDA.

BREEDING BIRD COMMUNITIES IN DUNN COUNTY, NORTH DAKOTA--1975. L. Voorhees, G. Baumann, M. Carlisle, F. Cassel, R. Crooke, J. Gulke and D. Jacobson. Zoology Dept., NDSU, Fargo, ND 58102.

Between May 31 and July 1, 1975, the bird communities in central Dunn Co. were assessed by three methods: intensive studies of territorial males on 18 limited sized plots (≤25A), extensive surveys of 23 random quarter sections and roadside counts. The Chestnut-collared Longspur was the most frequent species in range and cropland accounting for 23% or more of the birds on most areas of these types. The Horned Lark and Lark Bunting were next most frequent and abundant. These three species comprised 62% of the 45 species encountered during extensive surveys and 69% of 29 species during the intensive. The Western Meadowlark was most frequent on the roadside counts. Longspurs are not readily observed by this technique. Rangeland had the highest density and diversity (462 prs/mi^2 - 35 sp.), mixed the lowest density (304 - 29) and cropland the lowest diversity (351 - 20). Support through contract with NDSU experiment Station by Natural Gas Pipeline Co.

HISTONE METHYL TRANSFERASE FROM RAT BRAIN. J.C. Wallwork and J.A. Duerre, Dept. of Micro., Sch. of Med., Univ. N. Dak. 58202.

The enzyme or enzymes which catalyze the transfer of methyl groups to the arginine rich histones, F_3 and F_{2a1}, is associated with chromatin. We have used several procedures to extract the enzyme from rat brain chromatin, prepared from 12-14 day-old rats. Sequential extraction of the chromatin with 1.5 M NaCl yielded the best results. The enzyme was partially purified by ethanol precipitation, DEAE-cellulose and Sepharose 6B-100 chromatography. The partially purified enzyme had the capacity to transfer methyl groups from S-adenosyl-methionine to histones both free and in association with DNA. When histones are associated with DNA only histones F_3 and F_{2a1} are methylated. This is in agreement with previously published *in vivo* data. Results of heat inactivation studies and purification procedures have failed to show more than one enzyme. The K_m for S-adenosyl-L-methionine in the presence of 1.0 mg total soluble histone per ml is 3.8 µM. The K_is are 0.9 µM and 7.2 µM for the L and D isomers of S-adenosylhomocysteine respectively, inhibition being competative. With Tris buffer enzyme activity remains constant over a pH range 7.2 - 8.5 and the enzyme is relatively stable at pH 7.6 in phosphate buffer, losing 50% activity in 2 months at -40°.

THE EFFECTS OF SNOWMOBILE TRAFFIC ON THE SURVIVAL AND VITALITY OF SELECTED NATIVE AND CULTIVATED PLANTS. W. J. Wanek. Biol. Dept., Bemidji State Univ., Bemidji, Minn. 56601

Soil temperatures monitored during five winters were found to be significantly lower where snowmobiles compact the snow. The colder soil environment retarded spring growth of forest herbs and alfalfa as much as two weeks and substantially reduced the reproductive success of native plants. Species sustaining 40% or greater mortality included Arisaema triphyllum, Aralia nudicaulis, Aster cordifolius, A. laevis, Clintonia borealis, Helianthus tuberosus, and Lysimachia ciliata. Alfalfa productivity was lowered 22-74% due to winterkill which generally varied directly with the intensity of snowmobile traffic. Tissue preparations of subterranean organs exhibited cytolysis caused by intracellular ice crystals and disruptions due to extracellular ice masses in parenchyma of the pith, vascular rays, cortex and phloem. Supported in part by the Minn. Dept. of Nat. Res.

TERRESTRIAL HEAT FLOW MEASUREMENTS AT FOUR SHALLOW WELLS IN SOUTHWESTERN NORTH DAKOTA. K.V.Watson,R.Scattolini, and F.L. Howell.Univ. No. Dak.,Grand Forks,No. Dak. 58201

As part of an effort to determine surface heat flow through out the state of No. Dak. measurements have been completed at four sites in the south western part of the state. Borehole temperatures were obtained from the surface to depths greater than 250 m employing a resistance (thermistor) thermometer. Average temperature gradients were calculated from these measurements. The values of the gradients range from a low of 23°C/km at the eastern most site to a high of 43°C/km at the western most site. Thermal conductivities of drill cuttings from the wells were measured using a divided bar method. The samples consisted primarily of unconsolidated sand clay mixtures. Thermal conductivity values ranged from 3.7 ± 0.4 to 8.2 ± 0.8 m cal/ cm sec°C. Using the thermal conductivities of samples obtained at depths between 200 and 300 m and the corresponding thermal gradients, heat flows were calculated. The uncorrected values were found to be 2.4 ± 0.4, 1.7 ± 0.2, 1.8 ± 0.2, and 1.5 ± 0.1 μ cal/cm^{2}sec. for the sites located in Bowman, Hettinger, Mercer, and Oliver counties respectively. Supported in part by NSF (DES 74-22277) and the North Dakota Geological Survey.

BIOLOGICAL AND ENVIRONMENTAL FACTORS AFFECTING TELIUM FORMATION IN MELAMPSORA LINI. Glenn Wehtje and G. D. Statler, Plant Pathology Department, North Dakota State University, Fargo, North Dakota 58102

The morphology and development of telia of Melampsora lini varied with the host cultivar, host area attacked, race of pathogen and air temperature during formation. The morphology and development of telia were studied using standard histological techniques. Races 218 and 191, grown on the cultivar Bison, caused extensive hypertrophy of host tissue and deeper than normal penetration of hyphae, resulting in a distorted tetial mat. Temperatures higher (25C) or lower (16C) than the optimum (22C) reduced the spread of the telial mat. In all races tested mature telial cells produced at 16C were on an average smaller and more difficult to germinate than those produced at 22C. Telial of race 7 grown at 16C were on an average 10μ shorter than those grown at 22C. Telia were tested for germinability. Telia grown at 22C on a fully susceptible plant in excellent health were most likely to germinate.

FOG - A VEHICLE FOR DISPERSAL OF A MICROBIAL INSECTICIDE. R. Weinzierl, R. D. Frye and K. J. McMahon. Dept. of Entomology, N. Dak. State Univ., Fargo, N. Dak. 58102

An investigation to determine the effectiveness of ground fogging equipment for dispersal of the entomogenous bacterium, Bacillus thuringiensis (in Thuricide 16B), in shelterbelts was initiated in 1975. A cold fogger and a thermal fogger were compared to a conventional hydraulic sprayer. Results indicate that fogging equipment is promising for dispersal of the bacterium. Although they did not improve on the hydraulic sprayer regarding spore coverage on foliage, and spore survival over extended periods of time in all cases, they do have other advantages. Less water is required with foggers (3 quarts total spray/acre with the foggers vs. 5 gallons with the hydraulic sprayer), and they were easy to handle when in use. The foggers required less directing of the spray than did the hydraulic sprayer. However, considerable difficulty was encountered in starting and maintaining operation of the thermal fogger. Heat generated by the thermal fogger burned substances in the B. thuringiensis preparation. The burned materials had to be cleaned from various orifices frequently. The fog produced by the cold fogger was affected less by air currents than was the fog produced by the thermal fogger. Of the 3 types of equipment, the cold fogger was easiest to calibrate. Supported by NDSU and US Forest Service.

A CURRICULUM FOR A COLLEGE COURSE IN INDUSTRIAL CHEMISTRY, Dr. Harold Wittcoff, University of Minnesota, Dept. of Chemistry, Minneapolis, Mn. 55455

Chemistry students frequently have difficulty relating chemical theory to the real world of industrial chemistry. Much of the chemistry basic to the industrial enterprise is not in textbooks and students have little knowledge of the associated technology. The student may also be unaware of the economics of the chemical industry, the principles of laboratory organization and the various technically-based areas in the chemical industry which include -- in addition to research, applications and development -- technical service, market research, market development and liaison functions. The student is certainly frequently unaware of the interfaces (e.g., between the chemist and the engineer) which must be penetrated if success is to be achieved. Many of today's students are concerned about the moral obligations of industry particularly relative to ecology, raw material depletion and profit motivation.

In a 4-hr., 2-quarter course, an attempt has been made to provide understandings in the above areas. About 60% of the course is devoted to the chemistry associated with petroleum, petrochemicals, polymers, pharmaceuticals and specialty chemicals. The other 40% is devoted to the economics of the industry, its literature, the philosophy of industrial research, project evaluation, laboratory organization and administration and management theory.

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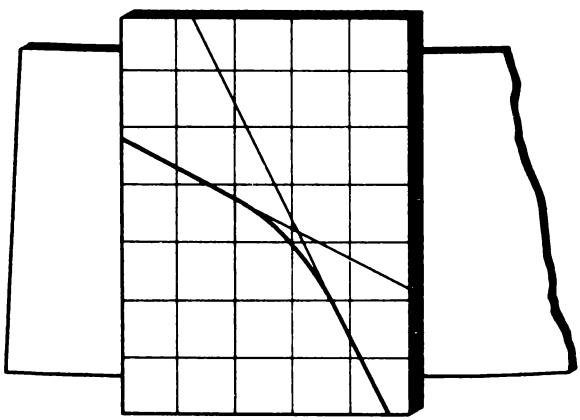

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PHYSICAL PARAMETERS FOR WHEAT ON A ROMANIAN STATE AGRICULTURAL ENTERPRISE

William A. Dando
Department of Geography
University of North Dakota
Grand Forks, North Dakota 58202

ABSTRACT

The continued cultural development and economic growth of any society hinges on the availability of an adequate and stable supply of food. There is a marked difference in the intensity and efficiency of world crop production practices. Selection of appropriate methods for increasing the production of high quality food for society will depend upon political decisions, cultural preferences and current technological levels. This study evaluates the environmental ramifications of the Romanian Communist Party's attempts to extensively utilize and intensively modify the physical environment for wheat, using data compiled on Dragalina State Agricultural Enterprise during the 1972 agricultural year. Drought and winterkill are the two basic physical factors which retard stable yields. Irrigation of wheat, providing a high degree of control through the regulation of water, has made possible the use of high-yielding winter-hardy wheat varieties and the application of modern farming technology. However, irrigation and monocultural practices have modified other physical parameters for wheat and have led to seasonal flooding, shifts in disease and insect significance, and the number of weeds.

INTRODUCTION

Intreprinderea Agricola de Stat "Dragalina" is located about 100 km due east of Bucuresti in the dry southwestern quadrant of the Baragan Plain, a subdivision of the great Romanian Plain, between the cities of Slobozia and Calarasi. Composed of seven farms, the 7,306 hectare enterprise is supervised by a Director, a Party Chief, an Engineer Chief, an Engineer Chief Mechanic and a Bookkeeper Chief. Dragalina employs approximately 250 full-time permanent workers and 400 or more seasonal or part-time workers. Only the Engineer Chief and less than 10 percent of the permanent workers live on the enterprise in facilities provided by the state; the others commute. Wheat is the single most important crop sown on Dragalina; it comprised 31 percent of the sown area in 1972, or 2,055 hectares out of a total 6,715 under cultivation. The state supplied Dragalina with approximately 30 large, tractor-drawn combines, 14 self-propelled combines, in addition to 90 tractors and an adequate pool of necessary ubiquitous implements.

CLIMATE

As noted in Figure 1, the climate is classified according to Koeppen as a Dfax; a cold winter, hot summer microthermal climate. Precipitation, winds and temperatures are similar to a continental arid steppe and differentiated by extremes and precipitation effectiveness. Average annual precipitation is 449 mm, but this figure varies markedly each year. Normally, there is a short rainy period in spring

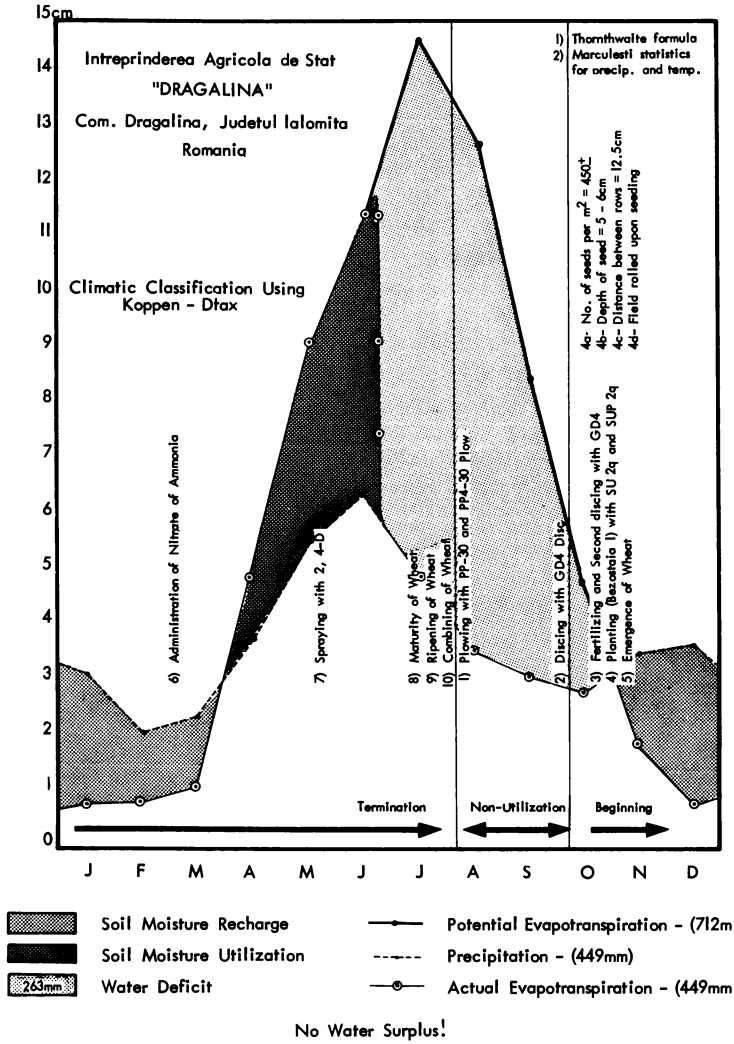

FIGURE 1. Generalized diagram of wheat - climatic relations on Dragalina I.A.S.

and at the beginning of summer (late April to June), followed by a drought period (July to October). Precipitation increases slightly in late fall and early winter (November to January), but another dry period usually occurs in late winter and early spring (February to early April). Temperatures also vary greatly; maximum temperatures in summer normally reach 40°C, while minimum winter tem-

peratures may drop to −34°C. July is the hottest month with an average temperature of 22.2°C and January with a −2.0°C average is the coldest. The first frost in the fall is expected by mid-October and the last frost in spring generally occurs in the first week of May. Temperatures below freezing are recorded at least 105 days a year. Snow accumulations vary from 30 to 40 mm and snow is expected from mid-November until the beginning of March. Wind speeds average 20-22 meters per second and may approach 40 meters per second; 70 to 77 days with strong winds are recorded each year (Marculesti Agricultural Experiment Station, 1964, pp. 4-6). As a result of high summer temperatures and strong winds, actual evapotranspiration in an average year equals precipitation and potential evapotranspiration is almost doubled.

SOILS

Within the present boundaries of the farm, at an elevation of 40 to 44 meters above sea level, there are a series of north-south undulations. These undulations, with grades of 2 to 4 percent and numerous microdepressions, have influenced soil development but have had no appreciable influence upon mechanized, irrigated agricultural activity. Variations in micro-relief have restricted runoff and, through time, have led to modifications in natural vegetation and in the general chernozem soil type. On the crests of ridges and flat plains chestnut chernozems have developed, on slight grades or slopes chocolate chernozems are formed, and in depressions slightly leached and leached chernozem soils. All of the soils here were formed on loess. Roughly 46 percent of the enterprise soils are identified as *chestnut chernozems*. The "A" horizon varies in depth from 46 to over 100 cm, and is chestnut-brown in color. Dust strata can be observed in the upper half of the horizon and agglomerated nodules in the lower; texture is clayey and is crossed by numerous crotovines. A very compact, almost impervious, 6 to 15 cm thick hardpan with pseudochist structure is found just below plow level. The "C" horizon appears at a depth of 120 to 150 cm; it is yellow in color, loessal in structure and sandy-clayey in texture. Chestnut chernozems here are slightly alkaline (pH of 7.4) and humus content varies from 3.4 percent to 4.9 percent. Although *chocolate chernozems* occupy about 34 percent of the enterprise, they are widely distributed in small undulations that vary less than half a meter from the plain. The "A" horizon extends from 50 to 150 cm below the surface; its color is blackish-brown when moist and chocolate brown when dry; the structure is fluffy and agglomerated, and its texture is clayey. A hardpan is found at depths ranging from 9 to 24 cm. The "C" horizon is yellowish-white in color, its structure is loessal, porous and it is very rich in $CaCo_3$. Chocolate chernozem soils have a pH of 6.8 to 7.2, an their humus content varies from 2.9 to 4.9 percent. Both slightly leached chernozems and leached chernozems are found in uneven depressions, known on the Baragan Plain as "crovui".

Slightly leached chernozems occupy only 4 percent of the enterprise; their "A" horizon is thick, extending from 47 to more than 130 cm below the surface. It is blackish-brown when wet and greyish-brown when dry; the structure is

agglomerated and coarse-grained and the texture is clayey. In general, slightly leached chernozems have a pH of 8.2 and a humus content of 2.9 to 4.8 percent. *Leached chernozems*, which occupy 16 percent of the surface, are found in depressions. They have a combined "A/B" horizon which extends 120 to 130 cm in depth, are blackish-brown in color, agglomerated in structure and clayey in texture. Leached chernozems have a pH of 6.5 to 6.8, and the humus content varies between 4.45 and 4.65 percent. Prior to massive irrigation, the water table was found at a depth of 25 to 30 meters; with irrigation, however, the water table rises to within 3 meters of the surface at times (Ministerul Agriculturii, 1965, pp. 1-9; IAS Dragalina, 1970, map). There is no erosional problem in Dragalina, but there is always the possibility of temporary flooding in late spring and early winter. Soils on Dragalina are fertile, medium textured, and friable; they work well under normal soil moisture conditions and are considered excellent for wheat culture.

PLANT DISEASES

Along with relief, climate and soils, three other significant physical factors — wheat diseases, insects and weeds — influence wheat yields on Dragalina I.A.S. More than one hundred diseases and insects have been observed and recorded in the wheat fields of Dragalina, but most of these seem to be of minor economic importance. However, seven diseases and ten insect pests cause an estimated 6 to 13 percent direct loss of production and warrant special consideration. Growing a large amount of wheat year after year on the same enterprise has created an ideal situation for the development of wheat diseases and insect multiplication and specialization. The most important rusts observed on Dragalina were: *Puccinia recondita tritici* or "leaf rust" which causes a distinct loss in yield and weakens a plant, making it susceptible to winterkilling, and *Puccinia striiformis* or "stripe rust" which reduces the overall size of a plant and affects yields by reducing the number of heads and the number of grains and weight per head. Conspicuous during the flowering stage was *Ustilago tritici* or "loose smut". As infected spikes emerged, the characteristic spore mass was exposed and eventually dispersed by the wind, laying the rachis bare.

Unlike rusts and smuts which infect generally from air-borne spores, blights, root, and foot rot diseases are caused by pathogens that persist in crop residue or stubble. *Erysiphe graminis* or "powdery mildew", easily recognized by a powdery growth on the surface of leaves, increases water losses of the plant while retarding photosynthesis, causing a reduction in the number of grains per head and a loss of grain weight. A blight which infects the head of wheat and also reduces both yield and grain weight was *Fusarium graminearum* or "scab" (Fusarium head blight). The most serious wheat diseases on Dragalina, however, were those which attacked the basal stems and roots. *Ophiobolus graminis* or "take-all" causes considerable damage by invading the roots and lower stems of the wheat plants, stunting their growth or inducing premature death and creation of white heads, empty of grain; and *Cercosporella herpotrichoides* or "eye-spot

root rot", which produces an elliptical eye-spot brown area on the outer leaf sheaths of the culm, weakening the stems and inducing helter-skelter lodging, killing tillers and causing premature lodging plus shriveled grains or even dead white heads (Radulescu, 1957, pp. 5 & 11-16). Shifts in disease and insect significance have been noted by various engineers on Dragalina, and they claim these shifts are a result of variations in annual weather patterns, planting of new varieties of wheat or experimentation, agro-techniques practiced on each farm (in particular, crop rotation pattern, sowing dates, amount of fertilizer applied and date of plowing) and the introduction of irrigation facilities.

INSECTS

Of the vast number of insects catalogued in the various wheat fields, only ten were significant in the reduction of wheat production on Dragalina. These insects were found to not only cause direct damage to plants by feeding, but they were also found to be vectors of wheat diseases. The insect which caused the greatest damage was a species of stem boring sawfly, called *Cephus pygmaeus* or "wheat stem sawfly". The adult wasp-like wheat stem sawfly lays its eggs in the stem and the larvae tunnel the stem, eventually girdling it near the soil surface and causing the stem to break off. Unless a combine is equipped with special attachments, most of the heads on fallen stems are lost. Almost as destructive as the wheat stem sawfly is the sap-sucking *Meyetiola destructor* or "Hessian fly". Infestation by the Hessian fly in the fall kills young plants and reduces the stand; maggots of the spring brood produce a weakened culm and, in many cases, result in lodging of the plant after the head has developed. While infestations of the wheat stem sawfly and the Hessian fly are spotty, the *Macrosiphum avenae* or grain "aphid" is almost ubiquitous. Aphids feed first on the leaves and stems but, in early June, move to the heads and feed on the developing grain.

A rather odd looking small insect, *Haplothrips tritici Kurdjumov* or "thrips" cause marked visible injury and deformation to the wheat head, upon which both the adults and nymphs feed. *Eurygaster austriaca* or the "stink bug" attacks the developing heads and sucks sap from the grains; the grains fail to fill out and wheat is lost. Several chewing insects cause injury to the heads of wheat; among the most important are *Anisophia austriaca* and *Zabrus tenebrioides Goeze*. Both cause extensive damage to wheat in late spring by gnawing into the spikelets containing the developing grains. The *Hadena basilinea* or "rustic moth" at the caterpillar stage chews the stems in spring and hollows out wheat grains in June. Although found in limited numbers, the *Contarinia tritici Kerby* or "wheat blossom midge" causes considerable damage; the larvae feed on the developing ovary, thus preventing the development of grain. Finally, *Tetranychus urticae* or "red spider mites" damage the grain by feeding along the veins of the leaves (which lead to leaf death) and the head; infected fields stand out from other fields for they have a yellowish-bronze hue (Radulescu and Negru, 197?, pp. 97-117). Diseases and insects cause a sizable loss in wheat yields but the exact percentage is

difficult to compute. They cause a definite reduction in wheat yields, however, variously estimated to range from 6 to 13 percent.

WEEDS

Also of great significance in the cultivation of wheat is the number and the density of weeds per square meter. Weeds are competitors for space, sunlight, water, and soil nutrients; furthermore, they are better adapted to the environment than is wheat. The number of weeds counted in 17 experimental plots in 1972 ranged from 74 to 261 per square meter. Weeds were more prevalent in fields where wheat followed another small grain than where wheat followed corn or other clear cropped cultures, and the types of weeds were different. In fields where wheat followed another small grain, there were at least 34 different weeds, and in fields where wheat followed corn or sunflowers there were only 24 different weeds. Weeds have been controlled to a large degree by good farming practices, including summer plowing and disking before planting, application of fertilizers to enhance plant health and enable plants to crowd out weeds, planting weed-free seed at the recommended density and by elimination of weeds by manual or chemical means.

THE INESCAPABLE COMPLEXITY OF INSEPARABLE COMPONENTS IN A WHEAT CROPPING SYSTEM

The Engineer Chief of Dragalina, in consultation with state planners and his seven Farm Chiefs, is responsible for critical long-term and short-term decisions concerning the winter wheat crop. His production plan for the enterprise must be approved by the Director and the state a year in advance. It takes into consideration the requirements of the state and the established capabilities of the farm. The plan divides the farm's wheat cropping system into sowing, growing, and harvesting segments, and integrates it into a 4-to-6 year crop rotation scheme.

Wheat fields are plowed to a depth of 18 to 22 cm. A mixed chemical fertilizer containing nitrogen is applied during seedbed preparation, along with 40 tons of barn manure per hectare every 4 years. Fall sowing is delayed by the Engineer Chief until he is certain that the adult Hessian flies have disappeared, the soil has cooled enough to reduce the possibility of root-rot, and the air temperature ranges between 12° and 17°C. He begins the sowing process on a date that will assure the availability of 450° to 500°C of heat prior to permanent freezing. Bezostaia 1 is sown in October at a density of 450 seeds per square meter, in rows 12.5 cm apart, and at depths of 5 to 6 cm. Short but warm fall days and cool, long nights provide adequate quantities of heat and soil moisture for normal sprouting and tillering before the beginning of the dormant period. Soil moisture normally is not a limiting factor for seed germination or plant growth in the fall; if necessary, however, the newly planted wheat is spray-irrigated. After rooting is completed, plant development is slowed and stem nodes form low in consequence of short days with limited sunlight. Plants with high stem nodes suffer more from frost heave and from low winter temperatures than plants with low stem nodes.

Plant management in the spring includes aerial fertilization, periodic irrigation and chemical control of disease, insect pests and weeds. Although chemical fertilizers are applied to the soil in the fall, additional nitrogen is applied in February or March. Supplemental irrigation, when needed, tempers the yield-reducing effects of the normal dry period in late winter and early spring. While the elimination of all plant diseases, all insect pests and all weeds is impossible, sound plant management and control measures have already reduced insect pests, plant disease and weed problems on Dragalina to a minimum.

Meticulous advanced planning, proper preliminary agro-techniques, careful seed selection and cleaning, as well as highly monitored sowing procedures, lowered infestation of Hessian flies to a modest 4 percent, root-rot to a low 18 percent and the loss of winter wheat plants to bitter, low, late-winter temperatures to 6 percent during the 1971-1972 agricultural year.

The only real measure of a successful wheat crop is the amount of grain harvested and delivered to the storage silos. Harvest planning on Dragalina begins in early spring, and by early June, each combine has been placed in running order and tested. Five or six weeks before the anticipated beginning of harvest, a work schedule listing all personnel who are to participate in the harvest is posted. A normal harvest period lasts one month, beginning in late June and ending in late July. Harvesting is carefully supervised by the Engineer Chief, who determines when fields are to be harvested, measures the moisture content of the grain, and restricts the time each day when harvesting can take place. The 1972 winter wheat harvest began on June 26, concluded on July 21 and the average yield was 3,600 kg/ha.

ACKNOWLEDGEMENTS

The author received assistance from the Committee on International Exchange of Persons (Senior Fulbright-Hays Program), which enabled him to live and work on a Romanian state agricultural enterprise. Cartographic aid was provided by Patricia Ellen Fox.

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ADENOHYPOPHYSEAL DELTA CELL SIZE IN RELATION TO PHOTOPERIOD AND ANTLER GROWTH OF MULE DEER, *ODOCOILEUS HEMIONUS HEMIONUS* (CERVIDAE)

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ABSTRACT

The objectives of this study were: (1) to ascertain the amount of association between photoperiod, an environmental regulator of pituitary activity, and delta cell function implied from morphological changes; and (2) to ascertain the amount of association between changes in delta cell function and the deer antler growth cycle thought to come under this cell's influence via the testes. Male mule deer were collected throughout the year in north central Colorado. Pituitary glands were prepared for light microscopy using standard histological techniques. Sections were stained by the combined aldehyde fuchsin-acetic alum hematoxylin-trichrome method. A systematic sampling technique was used to obtain slides to be stained, sections to be studied, and fields to be evaluated. Nuclear and cytoplasmic areas of large delta cells were measured by a glass micrometer net installed in the ocular lens. Each intersection on the net had a value of 2.76μ^2 at the 1000X of oil immersion. Nuclear and cytoplasmic areas were greatest in the spring and summer photoperiod seasons, respec tively. Nuclear and cytoplasmic areas were greatest in the Antler Hardening portion of the annual antler growth cycle. Shedding of boney antlers, growth of velvet antlers and increase in nuclear and cytoplasmic areas of large delta cells in the adenohypophysis occurs when the photoperiod is in creasing. Construction and retention of hard antlers, maximal nuclear and cytoplasmic area, and decreasing photoperiod occur simultaneously.

INTRODUCTION

Freund (1955) identified acidophilic and basophilic cell types in the hypophysis of the red deer (*Cervus elaphus*) and correlated their relative numbers with the annual sexual and antler cycles. Stosic and Pantic (1966) identified acidophilic cells as a general tinctorial cell type while two basophilic cell types were successfully identified as to their thyrotrophic and gonadotrophic function in male red deer. Using stains very similar to those applied in the study reported here, Jubb and McEntee (1955) were able to distinguish beta cells (β-cells) which are thyrotrophic basophils and delta cells (Δ-cells) which are a broad class of gonadotrophic basophils in the bovine pars distalis.

Stosic and Pantic (1966) observed that gonadotrophic cells in the hypophysis of mature male red deer reached their maximum size in July, about 10 weeks before the rut. Concurring with this, Bruggeman *et al.* (1965) found concentrations of interstitial cell stimulating hormone (ICSH) in the pituitary gland of adult and young male red and roe deer (*Capreolus capreolus*) to be greatest 10 weeks before the rut and to decline as mating progressed. This peak ICSH level was followed during the mating period by the peak Leydig cell nuclear volume in the testes. Bubenik (1971) correlated these observations for roe deer with those of

Short and Mann (1966) on testosterone levels in this species and found that maximum values for the latter variable coincided with the largest Leydig cell nuclear volume. Markwald *et al.* (1971) found that the highest Leydig cell nuclear volumes for Colorado mule deer corresponded with the mating period in this species. Whitehead and McEwan (1973) found maximum plasma testosterone levels in reindeer (*Rangifer rangifer*) and caribou (*Raniger tarandus*) to occur during the mating period when antlers were hard.

Benoit and Assenmacher (1959) concluded that visible radiations stimulate gonadotrophic function of the anterior lobe of the hypophysis of the domestic duck through the oculohypothalamic path and by direct action on the hypothalamus through the orbital tissues. Farner *et al.* (1967) pointed out that photoperiodic stimulation increases the synthesis and release of pituitary gonadotrophins in birds. According to Thibault *et al.* (1966), gonadotrophin content of the mammalian hypophysis varies greatly under the influence of photoperiod. They showed that FSH and ICSH levels in the pituitary of Ile-de-France rams were maximal in June when photoperiods were longest but only ICSH levels were minimal in February when photoperiods were still quite short. Implicit in the study of seasonal variations of nuclear size of hypothalamic cells in the roe-buck by Bubenik (1972) is a higher order of control of the reproductive and antler growth cycles.

The objectives of this study were: (1) to ascertain the amount of association between photoperiod, an environmental regulator of pituitary activity, and delta cell function implied from morphological changes; and (2) to ascertain the amount of association between changes in delta cell function and the deer antler growth cycle thought to come under this cell's influence via the testes.

METHODS AND MATERIALS

Mule deer were shot bimonthly (1961-1965) within the Cache La Poudre River drainage of north central Colorado. Hypophyses were fixed in a mixture of ethanol, formalin, and glacial acetic acid and subsequently stored in ethanol (Anderson, 1962). Specimens from males were secondarily fixed in Zenker's fluid (Thompson, 1966) before processing through standard histological techniques. Sections of 4μ were cut from the middle one-third of the sagittally bisected organ and stained with the combined aldehyde fuchsin-acetic alum hematoxylin-trichrome stain (ALF-AAH-TC) (Thompson, 1966).

The adult male specimens were classified by age, and month and season of collection. Ages were 1 year 2 months to 10 years 1 month as estimated by the method of Erickson and Seliger (1969). Based on the antler phenology of Anderson and Medin (1971), two events and five periods of the antler cycle are correlated with the classical seasons in Table 1.

Systematic sampling by the method of Rasmussen (1929) was used to obtain the five slides stained, the one stained slide studied, the single section investigated, and the microscope fields where cells were measured. A glass micrometer net, with a value of 2.76μ^2 per intersection at the 1000X of oil immersion was installed in the ocular lens to obtain cytological areas (μ^2). Thus, 432

TABLE 1. Photoperiod seasons defined and correlated with the periods and events of the antler cycle for adult male Colorado mule deer.

<table>
<tr><th>Photoperiod Seasons</th><th colspan="3">Periods of The Antler Cycle</th></tr>
<tr><td>Day length less than 12 hours
and increasing
WINTER
3/20</td><td colspan="3">Antlers Recently Shed (ARS)</td></tr>
<tr><td>3/21
Day length greater than 12 hours
and increasing
SPRING
6/20</td><td colspan="3">Initial Antler Growth (IAG)</td></tr>
<tr><td rowspan="3">6/21
Day length greater than 12 hours
and decreasing
SUMMER
9/20</td><td rowspan="3">Velvet</td><td>Growth of Velvet
Antler Form (GVAF)</td></tr>
<tr><td>Antlers Hardening
(AH)</td></tr>
<tr><td colspan="2">Velvet Shedding (VS)</td></tr>
<tr><td>9/21
Day length less than 12 hours
and decreasing
FALL
12/20</td><td rowspan="2">Bone</td><td>Rutting Season (RS)</td></tr>
<tr><td>12/21
Day length less than 12 hours
and increasing
WINTER</td><td>Preparation for
Shedding (PFS)</td></tr>
</table>

Δ-cells were considered in 675 fields within the 26 sections representing as many animals. Means and variance of the cross-sectional areas of nucleus and cytoplasm were analyzed by the one-way analysis of variance and Student's "t" - test (Bailey, 1959). Individual comparisons of ranked means were made by Duncan's Multiple Range Test (LeClerg, 1957) when the analysis of variance was significant (p=0.05) (Pearson and Hartley, 1966).

RESULTS

The basophilic delta cells in this study are of greater size but less abundant than are the acidophilic alpha cells of the mule deer pars distalis reported by Nicolls (1971). As observed by Jubb and McEntee (1955) in the bovine pars distalis, basophilic cells of the mule deer dominate in a central "medullary" region while acidophilic cells are dominant in a peripheral "cortical" region. Delta cells occurred in clusters and singly. Extreme examples of the latter are three sections in which there occurred only one "giant" Δ-cell of greater than average whole cell area ($132\mu^2$, $132\mu^2$, $193\mu^2$). The abundant cytoplasm in Δ-cells contained comparatively small granules and stained green, grey-green, or blue-green with the ALF-AAH-TC stain (Thompson, 1966).

Analysis of variance disclosed highly significant (p=0.01) seasonal differences among the means of cytoplasmic area (Figure 1) and no significant difference among the means of nuclear area (Figure 2). Individual comparisons of cytoplasmic area means (LeClerg, 1957) showed the winter mean to be significantly smaller than summer and spring means but not the fall means.

Means representing each cytological parameter (nuclear area and cytoplasmic area) under change in day length (increasing and decreasing) and duration of photoperiod (greater than and less than, 12 hours) were compared with the aid of the unpaired, unequal −N, "t" - test. For the shorter photoperiods (<12 hours) of fall and winter there were 14 animals with a total sample of 182 cells having mean nuclear and cytoplasmic areas of 27.74 and $48.58\mu^2$, respectively. For the longer photoperiods (>12 hours) of spring and summer there were 12 animals with a total sample of 250 cells having mean nuclear and cytoplasmic areas of 28.89 and $57.78\mu^2$, respectively. There was no significant difference between the two nuclear means but there was a highly significant difference between the two cytoplasmic means. The increasing photoperiod of spring and winter involved 14 animals with a total of 314 cells having mean nuclear and cytoplasmic sizes of 28.44 and $52.46\mu^2$, respectively. The decreasing photoperiod of summer and fall involved 12 animals with a total of 118 cells having mean nuclear and cytoplasmic areas of 28.49 and $57.74\mu^2$, respectively. There was no significant difference between the two nuclear means. However, there was a significant difference between the two cytoplasmic means.

Analysis of variance indicates the presence of highly significant differences among the means of nuclear and cytoplasmic area for the two events and five periods of the antler cycle shown in Figures 3 and 4, respectively. Individual comparisons of these means (LeClerg, 1957) showed the mean nuclear area of Δ-cells

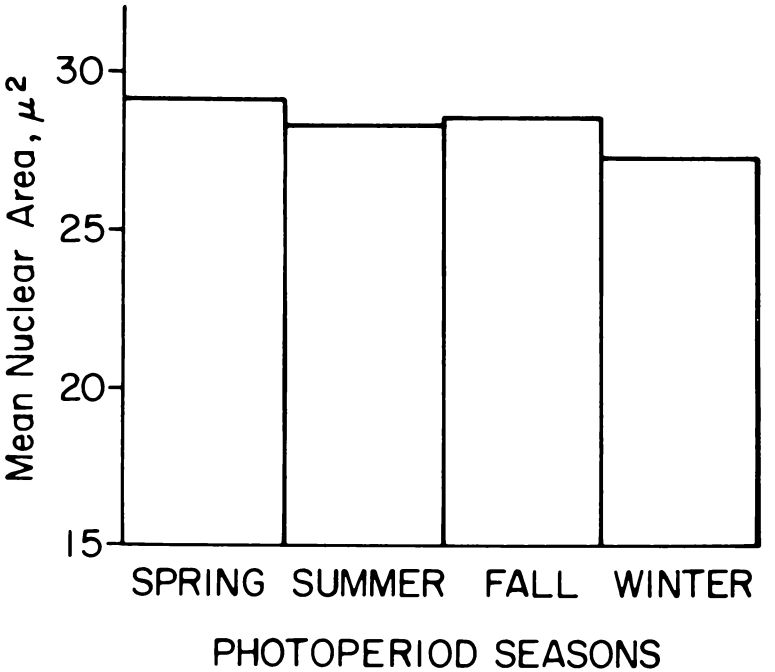

FIGURE 1. Mean area of the cytoplasm for large delta cells in the pars distalis of adult male Colorado mule deer during four photoperiod seasons.

during AH to be highly significantly larger than during ARS and PFS. This technique showed the mean cytoplasmic area of Δ-cells during AH and VS to be highly significantly larger than during IAG.

DISCUSSION

Observations of cytoplasmic area for Δ-cells in the mule deer hypophysis during the four classical seasons concur with those of Stosic and Pantic (1966) who observed relative numbers of gonadotrophic cells in the European red deer pituitary gland during the same time periods. Minimal values were noted during the winter and maximal values during the summer. In addition, these investigators noted that the maximum size (probably diameter) of gonadotrophs occurred during the summer season. These authors observed during the spring season "... single basophilic gigantic cells, whose nucleus and nucleolus were hypertrophic, ..." Because of their staining affinity and overall configuration, cells of this type were classified as Δ-cells in this study. There were only three occurrences in which a single Δ-cell of "giant" (>120μ^2 total area) size was the only representative of Δ-cells in the section. Two of these were during the summer and one during the fall. However, "giant" Δ-cells were among multiple represen-

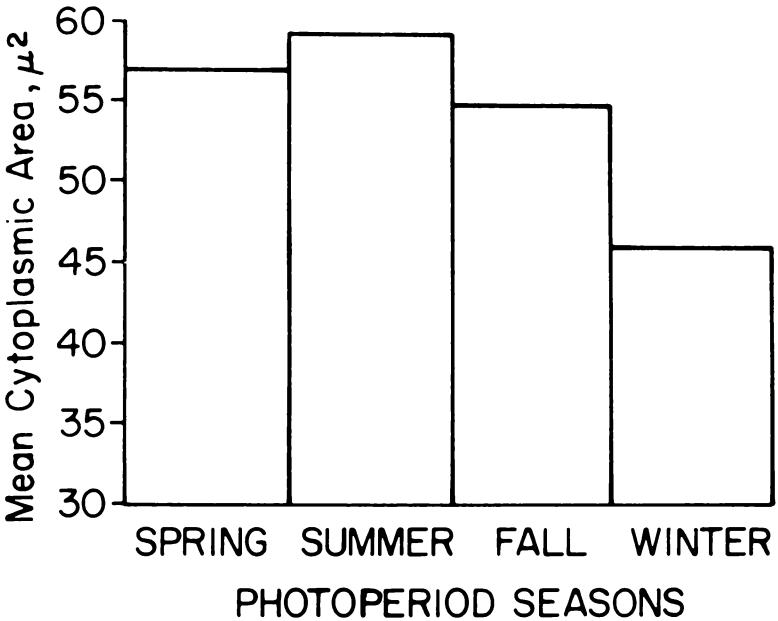

FIGURE 2. Mean area of the nucleus for large delta cells in the pars distalis of adult male Colorado mule deer during four photoperiod seasons.

tatives of Δ-cells in tissue sections during all seasons except winter. The proportion which "giant" Δ-cells was of all Δ-cells and their average total area (μ^2) for each season are: (1) Spring, 8% and 157μ^2; (2) Summer, 10% and 159μ^2; (3) Fall, 6% and 139μ^2; (4) Winter, 0%.

Findings for cytoplasmic area of Δ-cells in mule deer during the four seasons concur with those of Bruggeman *et al.* (1965) for ICSH levels in the hypophysis of red deer except during winter and spring. These investigators observed lowest ICSH levels during spring instead of winter, which is also in disagreement with the cytological observations of Stosic and Pantic (1966) for the red deer in Yugoslavia. The observed discrepancies may arise because Bruggeman *et al.* (1965) had only two animals representing the spring season and, for reasons to be discussed in a subsequent paragraph, these two happened to have low levels of ICSH.

Findings for Δ-cell cytoplasmic area on a seasonal basis are corroborated by the ICSH levels Thibault *et al.* (1966) found in Ile-de-France domestic sheep rams which have a reproductive cycle much like that of the male Colorado mule deer. These scientists found maximal and minimal ICSH levels in summer and winter, respectively.

The tissue levels of gonadotrophins in the pituitary gland of red deer (Bruggeman *et al.* 1965 and Lincoln *et al.* 1970) and roe deer (Bruggeman *et al.*

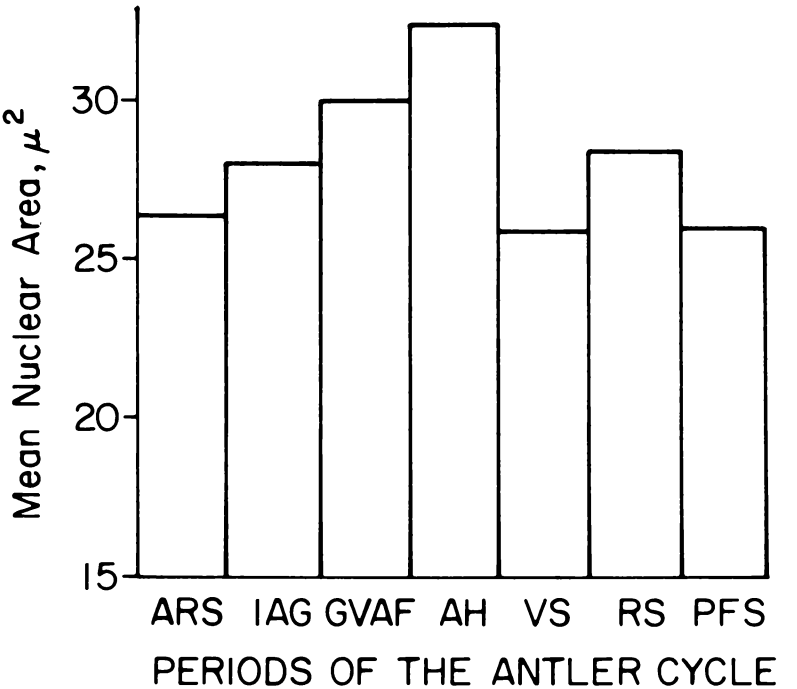

FIGURE 3. Mean area of the nucleus for large delta cells in the pars distalis of adult male Colorado mule deer during two events (ARS and IAG) and five periods (GVAF, AH, VS, RS, PFS) of the annual antler cycle. Events and periods are correlated with the classical seasons in Table 1.

1965 and Short and Mann, 1966) are inversely related to the gondal and blood levels of testosterone. Findings of this study were correlated with those of Markwald *et al.* (1971) on the testes and accessory sex organs of the same species and some of the same animals. It was found that the summer maximum cytoplasmic area values for Δ-cells were followed by fall maximum Leydig cell nuclear volumes, indicating maximum testosterone levels in the testis (and perhaps systemically).

In Figure 2 there is a general decline in Δ-cell nuclear area from a maximum during spring to a minimum during winter. However, the value for fall lies slightly above this line. This may be due to negative feedback of gonadotrophins and/or positive feedback of testosterone to the supraoptic and arcuate hypothalamic nuclei, stimulating them to a second peak of activity (Bubenik, 1972). The secretory substances from these hypothalmic nuclei may bring about a second minor elevation of synthetic activity in the nuclei of the gonadotrophic Δ-cells.

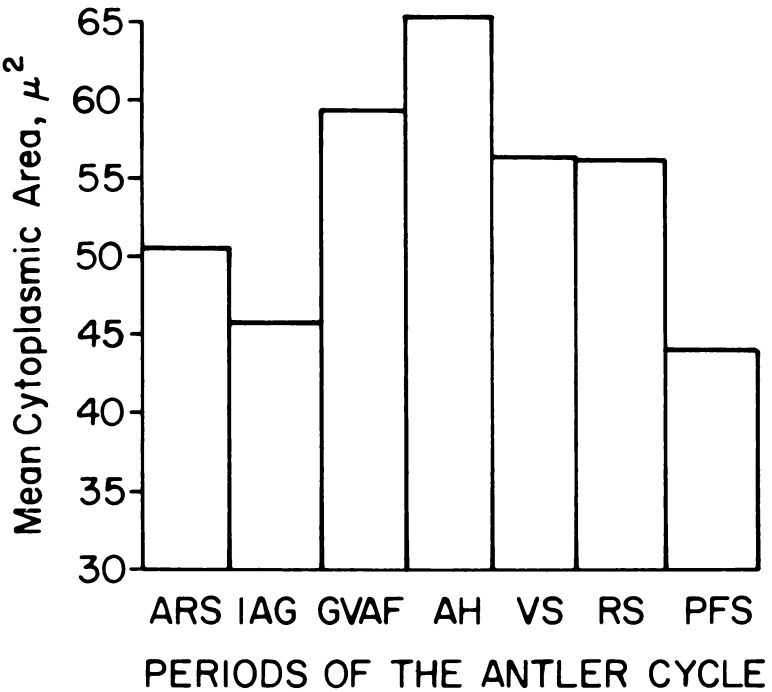

FIGURE 4. Mean area of the cytoplasm for large delta cells in the pars distalis of adult male Colorado mule deer during two events (ARS and IAG) and five periods (GVAF, AH, VS, RS, PFS) of the annual antler cycle. Events and periods are correlated with the classical seasons in Table 1.

Prior to the work of Markwald *et al.* (1971) on the mule deer most of the available evidence derived from histological studies of the testes and accessory sex organs of several species of temperate zone deer indicated that the testes were inactive during the entire proliferative phase of the antler cycle. These investigators observed Leydig cell and spermatogenic activity closely accompanying the appearance of antler buds (IAG) and this suggested to them a possible rise in secretion of gonadotrophins concurrent with antler formation. The evidence presented in Figure 4 above substantiates that belief when it is noted that Δ-cell cytoplasmic size becomes smaller during IAG, indicating increased release of gonadotrophins. Increased release of gonadotrophins from the adenohypophysis during IAG in red deer porbably accounts for the low ICSH values recorded for the spring season by Bruggeman *et al.* (1965). Goss (1969) proposed, but did not substantiate, that gonadotrophins might act directly on antlers at the time of IAG. This is probably true because Short and Mann (1966) found testosterone levels in roe deer were not elevated at the time of IAG but rose sharply some 4-6 weeks later. Examination of graphical and tabular data presented by Bruggeman *et al.*

(1965) for the red deer shows that low ICSH levels in the pituitary gland at the time of IAG are followed 4-6 weeks later by elevated Leydig cell nuclear volume, indicating a concomitant rise in testosterone production. Because testosterone has been found to completely inhibit antler regeneration when given exogenously a few days after the old antlers of Sika deer (*Cervus nippon*) were shed (Goss, 1968) it probably does not participate in IAG at high titers. Nicolls (1971) found that acidophilic cells of the male mule deer pars distalis also demonstrated increased secretory activity during IAG. Thus, it can be concluded that one or both of the gonadotrophic hormones (FSH; ICSH) and one or both of the acidophil cell hormones (STH; LTH) probably participate significantly in IAG processes. The growth promoting hormones (STH and LTH) from the acidophil cells are known to promote resorption and mobilization of bone salts from the skeleton. Nicolls (1971) noted increased secretory activity by acidophil cells during IAG, and Banks *et al.* (1968 a and b) also observed a short cyclic rise in bone resorption from the rib compacta of mule deer. Testosterone is known to promote absorption of bone salts from the blood and increased secretory activity by the gonadotrophic Δ-cells at the time of IAG (Figure 4) was associated with a short cyclic resurgence of Leydig cell metabolic activity (Markwald *et al.* 1971) indicative of concomitant, but low level, resurgence in testosterone titers. The importance of these low titers of testosterone during IAG and GVAF have been well documented by the work of Belanger *et al.* (1967) who found the growing antlers of castrate reindeer were less calcified, more cancellous, of lower density, and less active in bone remodeling than the growing antlers of normal reindeer.

As shown in Figure 6 of Nicolls (1971) and Figure 4 of this study, release of secretory products from the acidophil cells and from the gonadotrophic Δ-cells during the GVAF period is minimal. This concurs with Banks *et al.* (1968a and b), who found decreased resorption from compact rib bone, and with Markwald *et al.* (1971) who found a regression in Leydig cell nuclear volume indicative of a concomitant decrease in testosterone production.

Comparison of Nicolls' (1971) Figure 6 with Figure 4 of this study reveals that the secretory activity of the acidophil cells and of the gonadotrophic Δ-cells are inversely related to each other during the AH and VS periods of the antler cycle. This concurs with the observation of Banks *et al.* (1968 a and b) that resorption of compact rib bone is maximal and with the observation of Markwald *et al.* (1971) that Leydig cell nuclear area is increasing during this time after the depression observed in the GVAF period. These relative degrees of secretory activity are also in agreement with the findings of Bubenik *et al.* (1974) that the most intense immunohistological reaction for testosterone is in the prochondral blastema layer and in the growing hair follicle of the velvet at the beginning of the period of accelerated calcification (AH). This may indicate that testosterone participated primarily in bone matrix synthesis during most of the AH period and only at the end of the period is very active in the mineralization process which finally results in VS. During VS, acidophil cells have a low degree of secretory activity and the Δ-cells have an elevated degree of secretory activity. This concurs

with the observation of Banks *et al.* (1968 a and b) that resorption of compact rib bone is decreased and with the observation of Markwald *et al.* (1971) that Leydig cell activity is further elevated during this period.

During the RS period there is a marked increase in the secretory activity of the acidophil cells which corresponds to the brief cyclic resurgence of compact bone resorption and linear growth in the antler as noted by Banks *et al.* (1968 a and b). This may be the effect of the feedback mechanisms alluded to above during the discussion of the interplay of photoperiod and pars distalis secretory activity. The continued increase in gonadotrophic secretory activity during the RS (Figure 4) is congruent with the maximal Leydig cell activity noted by Markwald *et al.* (1971).

Conclusions to be drawn from this study and those cited in the foregoing discussion are:

(1) Photoperiod does regulate the morphophysiology of the deer hypophysis cerebri, especially the acidophil cells which produce growth promoting hormones (STH and LTH) and the gonadotrophic basophil cells (Δ-cells) which produce gonad stimulating hormones (FSH and ICSH). Increasing photoperiods of winter and especially spring are associated with accretion of these hormones within the cytoplasm during the ARS period followed by the IAG event about the time of the vernal equinox when photoperiods change from less than 12 hours duration to greater than 12 hours duration.

(2) After their release both classes of hormones have dual functions. First, both groups act directly on the frontal bone pedicle and the associated dermis to initiate antler growth (IAG). Secondly, acidophil trophins are probably responsible for resorption and mobilization of bone salts from the skeleton while gonadotrophins bring a brief resurgence of Leydig cell activity which elevates circulating testosterone to low level titers sufficient to stimulate absorption of bone salts from the blood into the growing velvet antler form (GVAF) without inhibiting growth as does testosterone at high titers.

(3) During GVAF it appears as though the hypophyseal-gonadal-antler association is part of a free running system. Growth and gonadal trophins accumulate in the hypophysis but are probably secreted in sufficient amounts to continue stimulating the physiological processes alluded to above with exception of marked resorption of bone salts from the skeleton. Because the environment in terms of photoperiod, temperature, and nutrition is favorable to a very high rate of biological activity the organic salts necessary for production of the modest amount of bone in the velvet antler form are probably derived more directly from the diet.

(4) During the period of antler hardening (AH) which finally results in the loss of the velvet (VS) growth trophins are again required to bring about resorption of large amounts of bone salts from the skeleton in order to produce the fully ossified antler. Gonadal trophins gradually increase their stimulation of the Leydig cells which yield proportionately larger amounts of testosterone to aid in absorption of bone salts into the antler. This process of rapid calcification begins about the time photoperiods change from the increasing limb of the cycle to the decreasing limb of the cycle at the summer solstice.

ACKNOWLEDGMENTS

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DEEP GULLYING IN EASTERN NORTH DAKOTA, A CATASTROPHIC EVENT

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ABSTRACT

A gully system 1500 m long, as wide as 46 m and up to 7 m deep, was eroded into low-relief cropland near Leonard, Cass County. Headward erosion continued for 36 hours during which an estimated 383,516 metric tons of silt and fine sand were transported distances of up to 1.6 km.

High rainfall triggered the erosion, but with adequate drainage and different agricultural use of the slope, the results may not have been so severe. The similarity of the gully system to natural streams in the area is the basis for speculating that they too may have originated from catastrophic rather than gradual processes.

INTRODUCTION

During the last two weeks of June 1975, southeastern North Dakota and adjacent Minnesota were traversed by several storms. Heavy rainfall produced widespread flooding on the Red River and its tributaries. On shallow slopes run-off initiated erosion. The gullying which resulted deserves attention as it has the appearance of erosion normally associated with poorly vegetated slopes in arid regions. Locally the landscape was significantly modified by this erosion, which was certainly the most severe within the last hundred years.

In the sand hills of southern Cass and northern Richland counties several gullies developed on low-relief farmland. The subject of this paper is the most impressive of these, located in the NE ¼, Sec. 30, and the W ½, Sec. 16, T. 137N., R. 52W., 2.4 km north and 1.6 km west of Leonard in southern Cass County. Here, the northeastern slope of the Sheyenne Delta deposits border the flat-lying Lake Agassiz sediments. The slope is a composite structure shaped by Lake Agassiz as it stood at successively lower water levels. Wavecut features can be traced along the escarpment; the most prominent of these features is the Campbell Strand near the top of the slope. Although the escarpment is a prominent local relief feature rising 23 m to 30 m above the lake plain, slope angles never exceed 2°. The deltaic sediments in this area consist of unconsolidated, finely laminated silt and fine sand.

DESCRIPTION OF THE GULLY SYSTEM AND ORIGIN

The main gully is L-shaped (Fig. 1), with the longest section of 1 km trending in an east-west direction (Fig. 2). At the eastern end, where the trench turns abruptly northward, are the widest and deepest sections, 46 m and 7 m respectively. Several tributary trenches enter from the south side. The largest of these is 330 m long, and has an average width and depth of 27 m and 4.5 m respectively.

Widening of the main trench and tributaries is still occurring as a result of marginal slumping. The amount of sediment transported during the gullying is estimated to be approximately 191,142 m^3, weighing about 383,516 metric tons. Deposition was controlled by slope gradient and 3 fans (Fig. 3) formed on the shallower reaches of the escarpment. Sediment depths of up to 1.3 m were measured in the lowermost fan.

The main trench was cut below water table and seepage furthered the erosional process. Flow will cease as the water table subsides but it can be expected to return every spring and early summer when the water table is high. In this respect the newly formed drainage system is similar to the dozens of naturally occurring, intermittent streams which dissect the escarpment in the general area.

Several people who claim to have witnessed at least a part of the downcutting were interviewed. Because of impending legal actions, it was impossible to sort fact from rumor and hearsay. The gully was examined from the ground and the air and the following account is based largely on this study, supplemented with eyewitness observations that do not seem to be in dispute.

In the week preceding the downcutting, high rainfall had saturated the deltaic sediments, and run-off led to water ponding in low spots and behind section roads. Ponding occurred in the NW ¼ of Sec. 20 until it overflowed the section road at this point. The ditches to the north along the maximum slope were already full, forcing the excess water to flow eastward along the shallow ditch on the north margin of Sec. 20. Here it was joined by other run-off streams flowing from standing water in the S ½ of Sec. 20. Ponding of this eastward-flowing water then occurred in the NE ¼ of Sec. 20, because there was no culvert to transport the water further east and the north-south culvert was small and probably plugged. Finally it overflowed the section corner and ran down the natural slope to the north. The drop of a few meters at this point resulted in a waterfall and headward erosion commenced. Other nick points probably formed on the steeper sections of the slope and each of these contributed to the erosion. As the main trench was eroded, the streams flowing north across Sec. 20 were left hanging and headward erosion proceeded along each. Groundwater discharge must also have played a significant role in the erosion. Once cuts had been opened by overland flow, groundwater release resulted in sediment collapse behind the nick point facilitating its removal. It also added to the flow in the channel thus increasing carrying capacity. The most surprising feature of the erosion was its rapidity; the entire process occurring within a 36 hour period.

DISCUSSION

Causes.— In the past the unconsolidated sediments of the escarpment have had a history of minor erosion during heavy rainstorms, and undoubtedly the severity of the present erosion was triggered by exceptionally high rainfall. There is no official recording station at Leonard, but at Enderlin, 22.4 km west, 300 mm (11.80 in.) of rainfall was recorded in the main storm period from June 27 to July 2. In the same period, Kindred, 16 km east, recorded 230 mm (9.07 in.)

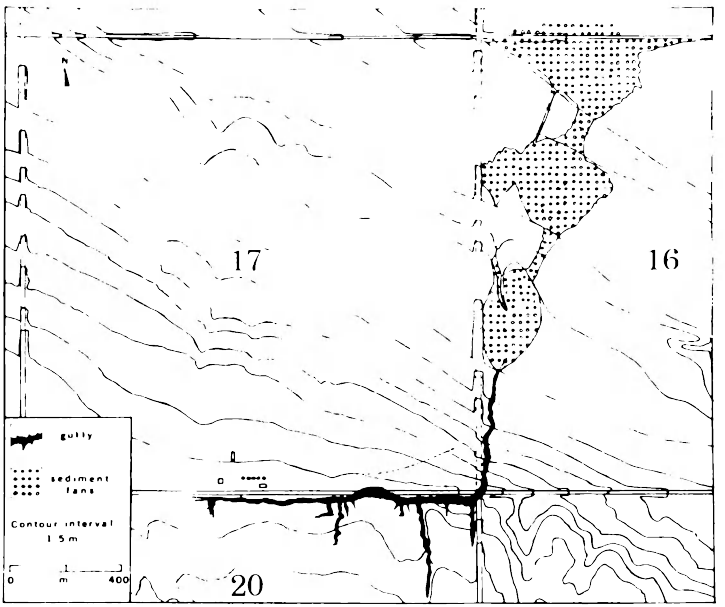

FIGURE 1. The gully system and sediment fans. (Aerial photographs plied by R.G. Spomer, USDA-ARS, Council Bluffs, Iowa were used to plo position of the fans.)

FIGURE 2. The western part of the main trench viewed from the east.

FIGURE 3. Oblique aerial view of the fans viewed from the south.

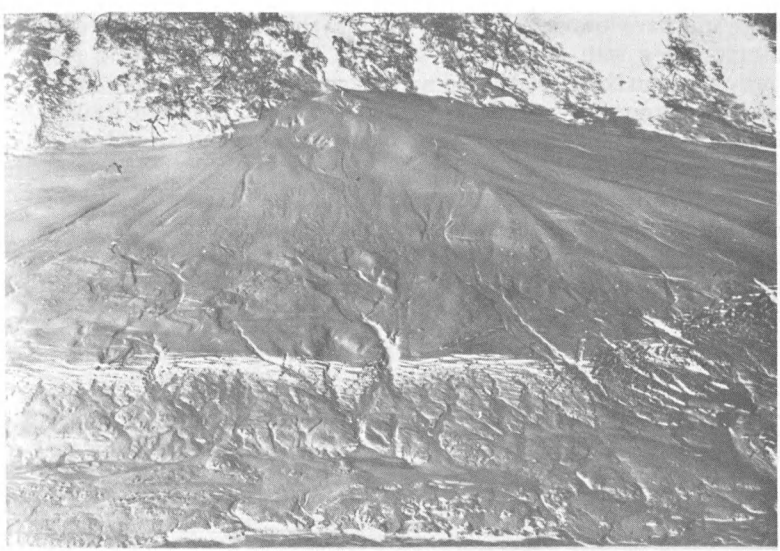

FIGURE 4. A seepage fan in the main trench with gully systems developed on the leading edge. Scale: 1 cm represents 40 cm.

(personal communication, Mr. E.V. Hendrikson, National Weather Service, Fargo). In an attempt to obtain a better idea of the amount of rain that fell in the Leonard area, several people who maintain gauges were also contacted. In nearly all cases records were partial or not available because gauges had overflowed. The exception was Mr. Lee Burkhart of Leonard who supplied the following figures; June 22-25, 50.8 mm; June 26, 50.8 mm; June 27, 38.1 mm; June 28-29, 317.5 mm; June 30, 101.6 mm. The 558.8 mm (22 in.) he recorded is considerably higher than from neighboring communities, but there is little reason to suspect that this figure is greatly inaccurate.

Usually June is the wettest month of the year in this area, with an average rainfall of between 75 and 100 mm. Rainfall at the time of the erosion was the highest in the region since records were started at Abercrombie in 1860.

Given the slope, the unconsolidated sediments and the rainfall, it was inevitable that some erosion would result. Even so, it is unlikely that erosion would have been so severe if it had not been for other factors. The first of these was the failure to provide adequate drainage paths for run-off waters. Water ponded in critical positions because culverts were not in place or were too small or clogged. The second factor concerns the agricultural usage of the slope. Maximum downcutting occurred on land that had been ploughed and planted with corn. The fact that the grassed ditch which paralleled the section road and along which water initially flowed remained largely intact after gullying suggests that if the slope had been left in pasture the erosion would not have been so severe.

Geological Significance. — The escarpment to the southeast of Leonard is dissected by numerous small intermittent streams. Under normal flow conditions these streams have low carrying capacity and yet each stream is entrenched in a significant valley with a mappable sediment fan at the break in slope. The similarity between these established water courses and the recently formed gully system is striking and permits speculation that they may also have resulted from a single catastrophic event rather than a gradual process. The natural vegetation of the deltaic deposits is prairie grasses, which once established, retard erosion greatly. The time at which the escarpment would have been particularly prone to erosion would be the period immediately after Lake Agassiz receded and before stabilization by vegetation. A naturally-occurring model of this system is shown in Figure 4, where channeled run-off water has eroded several miniature gullies on the leading edge of a seepage fan developed in the walls of the main trench.

GEOLOGY AND GROUNDWATER HYDROLOGY OF A PROPOSED COAL GASIFICATION PROJECT NEAR DUNN CENTER, NORTH DAKOTA

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ABSTRACT

The Dunn Center project area, which occupies approximately 450 square kilometers in central Dunn County, North Dakota, is underlain by 90 to 170 metres of semi-lithified silt, clay, sand, and lignite of the Sentinel Butte Formation (Paleocene). The Coleharbor Group (Quaternary) occurs as a thin discontinuous veneer of glacial sediment in the northern part of the area and as a narrow 35- to 15-metre-thick fill in a series of generally northwest-southeast trending glacial meltwater channels. The 5- to 6-metre-thick Dunn Center Bed is the lowest of the 4 lignite beds that are proposed for mining.

Ten widespread, nearly continuous lignite beds and less extensive sand beds in the Sentinel Butte Formation, as well as the permeable fills in the glacial meltwater valleys, are the principal aquifers. Throughout most of the area groundwater flow is vertically downward through the silt and clay beds and horizontally toward the nearest outcrop of the permeable lignite and sand beds. Hundreds of years are required for groundwater to flow from upland recharge areas to intermediate groundwater-discharge areas in the valleys of Spring Creek and the Knife River. Thousands of years are required to reach more regional discharge areas such as the Little Missouri valley. Water in aquifers that do not crop out in the area or in the Little Missouri River valley flows toward the east.

Surface mining will result in drawdown of water levels in wells around the mine. Significant drawdown will probably not occur more than 3 kilometres from the highwall. The potential chemical quality of groundwater in the reclaimed mine area is very difficult to predict. Replacement water supply will be available from aquifers beneath the Dunn Center Bed.

INTRODUCTION

The Natural Gas Pipeline Company of America (Natural) has proposed the development of a coal-gasification plant near Dunn Center, North Dakota. The University of North Dakota Engineering Experiment Station (EES) was sponsored by Natural to conduct a baseline environmental study to support an Environmental Assessment Report for this site. This report is a summary of the geological and hydrological findings of this study. The detailed findings of this study are reported elsewhere by Moran and others (1976, 1978).

The Dunn Center Project area, which is roughly rectangular, approximately 27 kilometres (NS) by 16 kilometres (EW), is located between Dunn Center and Halliday in Dunn County, North Dakota (Fig. 1). The proposed AMAX Dunn Center No. 1 Mine, which will supply the gasification plant, consists of about 39 square kilometres in the south-central part of the project area (Fig. 1).

The EES study was conducted during the summer and fall of 1975. About 8000 metres of test drilling was completed. About 180 potentiometric observation wells were installed and have provided data on hydraulic conductivity, water level, major and minor ion chemistry, and stable and radioactive isotope composition of the water.

GEOLOGY

Stratigraphy. — The Dunn Center area is underlain by semi-lithified silt, clay, sand, and lignite of the Sentinel Butte Formation (Paleocene). The Golden Valley Formation (Paleocene-Eocene) caps butte tops in the southern part of the area and underlies the ridge along the northern edge of the project area. Sediment of the Coleharbor Group (Quaternary) occurs as a veneer, with a maximum thickness of about 3 metres, over the Sentinel Butte and Golden Valley Formations in the northern part of the area and as a narrow 35- to 45-metre-thick fill in a series of north-south or northwest-southeast trending meltwater trenches. The Tongue River Formation (Paleocene) underlies the entire area at depths that range from about 90 to about 105 metres.

Ten informally named lignite beds in the Sentinel Butte Formation were traced throughout the Dunn Center area. The Dunn Center Bed, which is the lowest bed proposed for mining, is about 60 to 75 metres below the top of the formation. It ranges in thickness from about 3 to about 6 metres. It is overlain, in ascending order, by the A-, B-, and C-lignites, which are proposed for mining in some places. The A-lignite is present throughout most of the project area; the B-lignite has a more restricted distribution; and the C-lignite has a very limited distribution. All three of these lignite beds are replaced laterally by sand in places. The Dunn Center Bed is present everywhere in the area, except where it has been eroded along the meltwater trenches and Spring Creek. In the northern and western parts of the area, it is split into as many as three separate beds by intertonguing silt wedges that are as much as 9 to 12 metres thick. Beneath the Dunn Center Bed, the Sentinel Butte Formation contains six major lignite beds,

the E-, F-, G-, H-, I-, and J-lignites, as well as numerous unnamed lignites 0.3 metres or less thick.

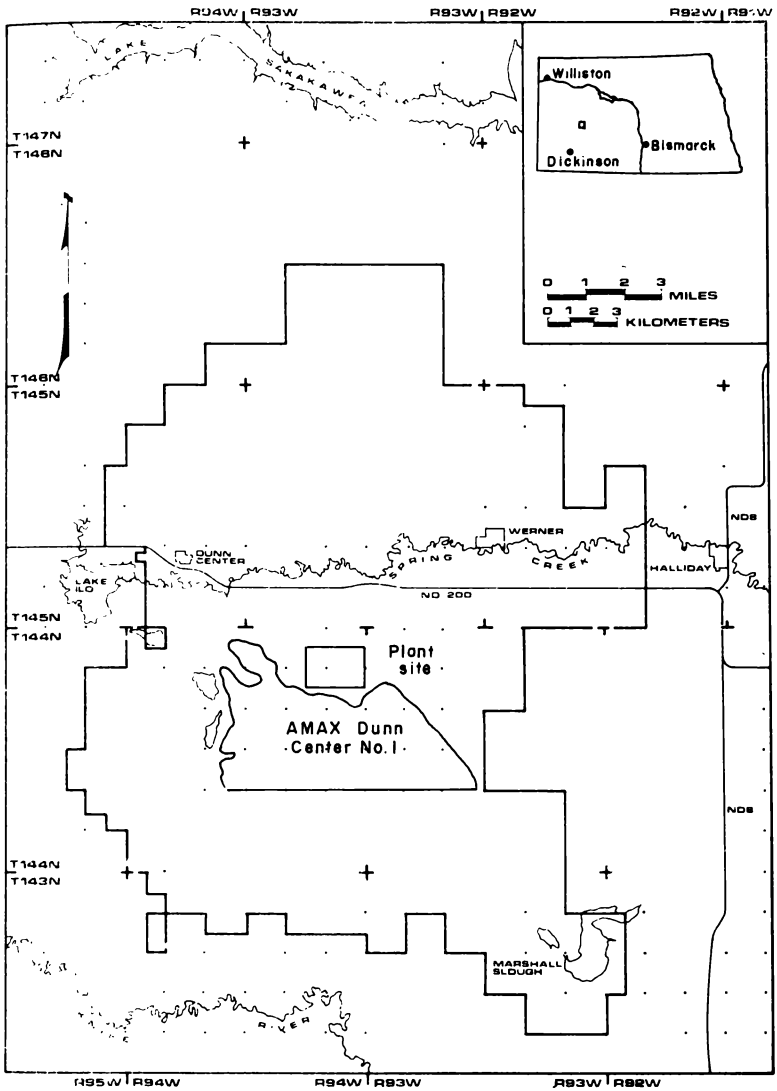

FIGURE 1. Map showing location of the Dunn Center project area, the proposed location of the gasification plant and AMAX Dunn Center No. 1 Mine. Inset map shows location of the project area in North Dakota.

Although each of the lignite beds beneath the Dunn Center Bed is as much as 3 metres thick in small areas, none of them is extensive enough to make them of economic interest. Their principal importance is as aquifers. In the interval between the E- and F-lignites, a 1.5- to 9-metre-thick unit of white, highly calcareous silt is correlated with the "lower yellow bed" that is exposed in the badlands along the Little Missouri River north of the area.

Other Mineral Resources. — Although the lower member of the Golden Valley Formation contains ceramic clay near Hebron, south of the project area, no clay with acceptable properties for ceramic use was seen in the project area. Gravel of variable quality occurs in patchy deposits along the meltwater trenches and in beds as much as 10 metres thick in the fill in the trenches. Baked silt and clay or "scoria" occurs throughout the area where combustion of lignite along the line of outcrop has resulted in melting and vitrification of the overlying material. The scoria is used as a road surfacing material throughout the region.

Geologic Hazards. — The project area is seismically stable. Only ten earthquakes have been felt in North Dakota in historic times and no damage has occurred. Slopes greater than 30 percent, especially damp, north-facing slopes, are generally subject to slumping and earth flows. Drier south-facing slopes remain stable at slightly steeper inclinations. Under present climatic conditions, erosion occurs only during periods of very high runoff, either during snow melt or during local, extremely heavy rain storms. Surface subsidence poses a potential hazard in small areas along Spring Creek about 2 to 5 kilometres east of Dunn Center where the Dunn Center Bed has been removed in underground mines.

Geology and Reclamation. — In the area of proposed mining, clayey and silty materials in the overburden are generally sodic. This is especially pronounced in low lying groundwater discharge areas where these materials are also saline. In upland groundwater recharge areas, the fine-grained materials near the surface are weathered and leached and generally less sodic. Silty sand and sand in upland groundwater recharge areas is generally suitable plant growth material, even to considerable depth. In lowland, groundwater discharge areas, these coarser-grained materials tend to be saline and sodic but generally are less affected than the finer-grained material.

GROUNDWATER HYDROLOGY

Aquifers and Aquitards. — The principal aquifers in the project area include sand and gravel in the valley fill deposits and lignite and sand in the Sentinel Butte Formation. The Fox Hills Formation is a significant but little-used aquifer beneath the entire project area.

The hydraulic conductivity of the aquifer material in the valley fill of the Coleharbor Group has a measured range from 2.3×10^{-4} to 3.0×10^{-2} cm/sec. (0.65 to 85 ft/day). Values as high as 3.0×10^{-1} cm/sec (850 ft/day) probably occur in some places in the fill. In parts of the area, the valley fill contains two aquifers separated by silt, clay, and pebble-loam.

The hydraulic conductivity of the lignite aquifers decreases systematically with depth. In the Dunn Center Bed and above, the hydraulic conductivity of lignite beds ranges from 1.5 x 10^{-5} to 1.8 x 10^{-2} cm/sec (4.25 x 10^{-2} to 51 ft/day). Long-term pumping tests gave results that are generally about one order of magnitude greater than these values, which were determined by single-well response tests. In the E-, F-, G-, H-, and I-lignites, values generally ranged from 4.5 x 10^{-3} to just less than 1.0 x 10^{-5} cm/sec (13 to 2.83 x 10^{-2} ft/day). A single value in the H-lignite was as high as 3.4 x 10^{-2} cm/sec (100 ft/day). On the basis of long-term pumping tests the storage coefficient of the shallow lignite aquifers ranges from about 1.5 x 10^{-2} to 5.0 x 10^{-5}. The permeability of the lignite is believed to result from a fracture porosity of about 10^{-2} to 10^{-4}.

The hydraulic conductivity of sand aquifers in the Sentinel Butte Formation ranges from 1.2 x 10^{-2} to 9.8 x 10^{-6} cm/sec (34 to 2.78 x 10^{-2} ft/day). The hydraulic conductivity of each interval generally varies 2 to 2.5 orders of magnitude. As with lignite aquifers, the hydraulic conductivity of sand aquifers decreases with depth.

The silt and clay beds that constitute the aquitards in the Sentinel Butte Formation have hydraulic conductivity values that range from 4 x 10^{-6} to 1 x 10^{-8} cm/sec (1.13 x 10^{-2} to 2.83 x 10^{-5} ft/day). Most values are 10^{-7} cm/sec or less.

Groundwater-Flow System. — Because of the two- to six-order-of-magnitude difference between the hydraulic conductivity of the aquifers and aquitards, groundwater flow in the aquifers is nearly horizontal and in the aquitards is vertical.

The hydraulic head data indicate that nearly everywhere in the Dunn Center area groundwater flow is downward. Only in some low lying areas around Lake Ilo and along the Spring Creek valley is this trend reversed. The upward gradient is generally associated with narrow, linear, channel sand bodies that transmit high heads toward the east where the potentiometric head is generally lower. Lignite beds and sand beds that crop out in valley sides are characterized by flow toward the valley. In beds that do not crop out, flow is toward the east or northeast.

The pattern of decreasing hydraulic head with depth is reversed below the Cannonball Formation. In the Hell Creek and Fox Hills Formations, the hydraulic gradient is upward.

Calculations of groundwater flow rates indicate that hundreds of years are required to move water from upland recharge areas to adjacent discharge areas such as Spring Creek; thousands of years are required to reach intermediate discharge areas such as the Little Missouri River. Data from stable and radioactive isotopes confirm that the present groundwater-flow system is very sluggish. Tritium occurs in only a few places in groundwater in the Dunn Center area. Even in clearly defined upland recharge areas tritiated water is limited to the very shallow part of the flow system. This is a clear indication that groundwater recharge is very slow. The ^{14}C data also suggest that groundwater flow is very slow. Water, even shallow in the system, has ^{14}C ages of several thousands of years. Although some workers have raised questions about the use of ^{14}C dating of

water in lignite terrains, the ^{14}C data in the Dunn Center area are internally consistent and are supported by the conclusions of other lines of evidence.

General Chemical Characteristics of the Groundwater. — With the exception of shallow groundwater that has recharged either from evaporating surface water bodies, and is correspondingly highly saline, or through pothole sloughs situated on sandy bedrock, and is very fresh, the groundwater in the Dunn Center project area is generally moderately saline, Na (HCO_3, SO_4) type water. Electrical conductivity values are generally 2500 micromhos/cm and typically range from about 1500 to about 3500. Calcium, magnesium, and sulfate content of water is higher in the valley-fill sediment of the Coleharbor Group and in the upper part of the Sentinel Butte Formation. Beneath the Dunn Center Bed, sodium is everywhere the dominant cation. With increasing depth the ratio of bicarbonate to sulfate is increasingly large.

Groundwater-Surface Water Interactions. — Three significant surface water bodies occur in the Dunn Center area: Lake Ilo, Marshall Slough, and Spring Creek.

Lake Ilo is in a groundwater recharge area. The presence of tritiated water that has heavy ^{18}O values in wells as much as 30 metres deep indicates deep intrusion of lake-derived water into the groundwater reservoir. The lake overlies a gravel valley fill, which transfers the water downward.

The hydraulic head data around Marshall Slough suggest that there, too, water from the slough recharges the groundwater reservoir.

During non-snowmelt periods, the flow of Spring Creek appears to be largely supplied by groundwater discharge from the Dunn Center Bed and the E-lignite. Tributaries of Spring Creek are fed by springs and seeps that occur at the outcrop of lignite beds ranging from the C-lignite to the E-lignite. On the basis of sample calculations, as much as 25 percent of the total discharge in Spring Creek at Halliday from mid-July to October 1975 can be accounted for by direct seepage into the creek and one of its tributaries from the Dunn Center Bed, E-lignite, and A-lignite. A groundwater recharge of 1.25 cm/year over the entire area of the Dunn Center Bed that feeds Spring Creek is adequate to produce this flow.

Places where lignite beds crop out in side-hill positions are generally groundwater discharge area; upland and valley floor sites are generally groundwater recharge areas.

IMPACTS OF THE PROPOSED DUNN CENTER PROJECT ON THE GEOLOGIC AND GEOHYDROLOGIC ENVIRONMENT

Effects on Water Levels in Wells. — Throughout most of the area of the proposed AMAX Dunn Center No. 1 Mine, the Dunn Center Bed and A-lignite are beneath the regional water table. In small areas, the B-lignite is also saturated. The process of mining will cause groundwater to flow through the lignite beds toward the mine where it will discharge into the excavation as springs and seeps. This will result in a decline in the potentiometric surface in the lignite beds, which in turn will produce an increase in downward seepage from the confining

beds. This will ultimately result in a decline in the regional water table adjacent to the mined area. The effect of these declines in potentiometric surface will be to cause a decline in water level in wells that are completed in lignite beds that crop out in the walls of the excavation. The water level in lignite beds beneath the Dunn Center Bed is not expected to be affected by mining.

The area of the proposed AMAX Dunn Center No. 1 Mine is bounded on the west, north, and east by deeply eroded, partly filled glacial meltwater valleys. These valleys effectively limit the decline in water level out from the mine. On the west and north, the Dunn Center Bed crops out above the floor of the valley so all effects on water levels will end at the valley wall. On the east, the Dunn Center Bed is bounded by saturated, highly permeable material in the valley fill. On the basis of our study, it appears that the valley fill sediment can supply all the water that will seep into the mine without experiencing a significant decline in head.

The deeply eroded glacial meltwater valleys that bound the mine area on the south are more distant from the mine, and water levels in wells between the mine and these valleys, several kilometres to the south, will decline. The magnitude of water-level decline in a well is a function of the distance from the mine, the time since mining began, the amount of water level decline at the edge of the mine, the storage coefficient and transmissivity of the lignite, and the hydraulic conductivity of the overburden on the lignite. On the basis of the values of these variables that we have determined or estimated in the Dunn Center area, we believe that water level decline in wells will probably be less than 2 metres at a distance of 3 kilometres from the mine. In most places, drawdown will probably be 0.3 metres or less at a distance of 3 kilometres. In most places, drawdown of 3 metres or more will probably be restricted to a distance of about 0.75 kilometre.

Following reclamation, the water level in areas that have been mined will begin to rise (Moran and others, 1976). Once mining stops, the water level in wells south of the mine will also begin to return toward their former level.

Effects on Surface Water Regime. — The proposed project should have no impact on either Lake Ilo or Marshall Slough. Both lakes are located in groundwater-recharge areas and neither is fed by significant amounts of groundwater. In addition, Lake Ilo is situated such that it would not receive seepage from the mine area.

Spring Creek receives groundwater discharge that passes through the Dunn Center Bed in the area of the proposed AMAX Dunn Center No. 1 Mine. The mine would prevent this water from reaching Spring Creek. It is estimated that this would represent a decrease of about 4160 cubic metres/day (1.7 cfs) in the flow of Spring Creek, about 10 percent of the groundwater discharge that reaches Spring Creek from within the Dunn Center project area.

Effects on Groundwater Chemistry. — The estimation of chemical quality of groundwater in the cast overburden following reclamation is extremely difficult. The chemical system is very complex and contains numerous variables, many of which can only be estimated with the available data. On the basis of the data available, the worst case seems to be that the chemical quality of the groundwater

in the cast overburden will be similar to the lower-quality water that occurs in the overburden at present.

The same uncertainty exists with respect to the chemical quality of groundwater in cast overburden in which gasifier ash has been disposed. The data available suggest that the chemical quality may be as low or lower than the lower quality water in the overburden at present. Although chemical analysis of ash indicates very high concentrations of cations, especially sodium, it is not at all certain whether these cations are in a soluble form.

Effects on Post-Mining Water Supply. — If the water in the cast overburden is of low chemical quality, adequate groundwater supplies can be developed in the mined area to permit the reestablishment of an agricultural economy. Aquifers beneath the Dunn Center Bed should generally be shielded from the cast overburden by a significant thickness of aquitard material and will probably be unaffected by the mining. These aquifers are generally less permeable than the shallower lignite and sand aquifers, and therefore it may be necessary to drill more wells to produce the same amount of water as at present.

ACKNOWLEDGMENTS

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INTERSTATE MIGRATION TRENDS AND STATE BOUNDARIES

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ABSTRACT

The high level of interstate migration is continuing in the 1970's, but recent trends indicate a deceleration of long-distance migration, especially to the West Coast, accompanied by increased flows to the Southeast and to contiguous states. However, specific interstate linkages of high volumes persist and patterns of interchange have not dramatically changed since the 1950's. Movement to contiguous states reveals differential rates by selected age-race groups. The effects of boundaries upon flow rates between adjacent states is quantified by an index which indicates wide variation by region and between individual state pairs.

MAJOR SECULAR TRENDS

Three main spatial components have characterized the history of United States internal migration. The most enduring has been the *Westward Movement*, which resulted in a net migration of +2,854,000 persons to the Mountain and Pacific Coast states between 1960 and 1970, three-quarters of them to California. Since 1970 movement to California has sharply declined to less than 100,000 net in-migrants annually, although the state still registered the second largest absolute population gain of 1,214,000 in five years.[1] All the Mountain states had estimated population gains of more than 12 percent during the 1970-75 period, approximately half of which were from positive migration balances. Arizona led all states in population growth rate with an increase of 500,000 or 25%, in the half-decade. This westerly growth component is further reflected in the steady march of the national population centroid, which is now about thirty miles south of St. Louis.

Figure 1 shows 1970-75 state population changes and their percentage differences from the 1965-70 period. All of the 24 states west of the Mississippi, including Hawaii and Alaska, reported population gains and only eight of them decelerated in growth rate between the two quinquennia.[2] Quite unexpected was the turnaround from loss to gain, or a diminution of loss rates, in all of the Northern Great Plains states and Iowa. North Dakota, for example, is estimated to have gained 17,000 persons in the last half of the 1965-75 period, compared to a loss of 7,000 in the first half. Thus, the West as a whole is retaining its historic role as an attractive region of residence.

A second and less-recognized component is *peripheralization*, which has characterized American internal migration since 1910, following culmination of the colonization process. The share of United States population living in coastal states continues to increase, despite slow-growth in New York and most of New

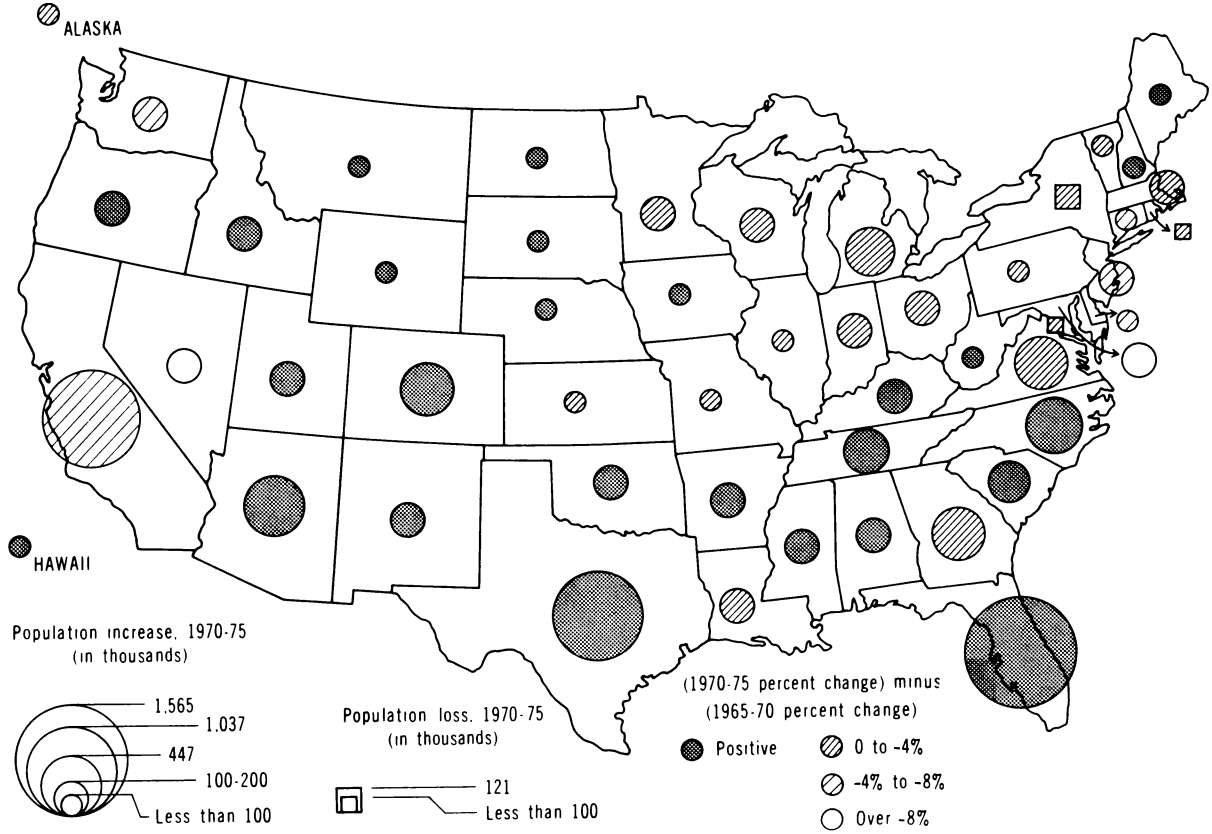

FIGURE 1. 1970-75 population change and comparison with 1965-70 change.

England. Until 1970 California was responsible for much of this drift from the Interior, while recently the Southeastern states and Texas have maintained the upward trend in coastal state population. Today, approximately 55 percent of the nation's residents live within fifty miles of oceanic shoreline or the Great Lakes, as compared to 49 percent in 1950.

The third major long term aspect is *metropolitanization*. The Standard Metropolitan Statistical Areas are capturing more of the national population, in part because of definitional criteria, but a percentage asymptote appears to be in sight. The 1975 metropolitan proportion is estimated at 70.9% with the inclusion of several new SMSA's since 1970 when the figure was 68.6%. The higher rate of non-rural, non-Metropolitan growth (4.2% vs. 2.9% since 1970)[3] is occurring in resort and retirement areas and around the fringes of metropoli in many parts of the country.

RECENT TRENDS AND SHIFTS

Although spatial patterns of migration manifest past momentum, a number of emerging changes can be identified at the interstate level. The most striking of them is rapid growth in the mid-1970's across the entire southern third of the nation, i.e., the 'Sun Belt' (Figure 1). This process was underway, but not conspicuous, in the early 1960's.[4] Every state southward and westward from Virginia and Kentucky, as well as those two, have grown at above-average rates since 1970. Also, their 1970-75 growth rates — with the exception of Virginia, Georgia, Louisiana, and California — are higher than those of the 1965-70 period. The massive movement to Florida has made it the nation's major migration destination and fastest-growing state in absolute terms. From a net inflow of roughly one million persons, Florida's population increased to 8.4 million residents, a gain of 23 percent, between 1970 and 1975. The other South Atlantic states also grew at rates of 6.8% or more, well above the estimated national average of 4.8%. In this bloc, North Carolina registered the greatest absolute gain, while South Carolina had the largest percentage gain of 8.8%. Also, as a surprise to demographers, has been the growth of the South Central states which reversed their long-term record of sub-normal growth rate. All eight states in the region, with the exception of Louisiana, are now above the national average. In absolute terms Texas added more than one million residents in five years, while in relative terms Arkansas recorded an exceptional gain of 10%.

Within these regional patterns are selective migration streams which have been tentatively identified from school movement data, auto registrations, and income tax records. An emergent growth component in the South is the net inmigration of Blacks, following a century of outflow which peaked in the late 1950's. Most of this shift is related to the greatly reduced out-migration of Blacks from the Atlantic Coastal Plain and Lower Mississippi Valley, as well as countermigration from the North, in particular to the Border states, Texas, Florida, and Georgia (notably into Atlanta).[3]

Age selectivity is another differential aspect in recent migration. Younger migrants are no longer so dominant in the interstate flow as in the past, especially to the 'Sun Belt'. It is estimated that over 40% of the net inflow to Florida and about 25% to Texas is by persons over 60 years of age.[5] Areal specificity is also evident in regions of weak population growth or decline. The Northeast has continued into the mid-1970's to lose migrants. New York and Rhode Island have had small absolute losses since 1970, but New Hampshire and Maine are now realizing net migration gain and higher growth rates than in the late 1960's. A marked slowdown has taken place in New Jersey, Delaware, and Maryland, despite the continued inflow to these states from adjacent metropoli. An opposite case is West Virginia where migration losses have been pared to nearly zero for the first time since World War I; the explanatory factor here has undoubtedly been prosperity from a revival of coal mining and new industrial investments which have arrested the chronic outflow of young people. Lastly, the Midwest constitutes a fairly homogeneous region of slow recent growth. No states in this bloc are up to the national rate, although net migration losses from Minnesota and Wisconsin have declined. The sharpest change has been in Illinois which is now experiencing substantial migration loss from both net outflow and a decline of Black in-migration.

LINKAGE PERSISTENCE AND CHANGE

Despite these significant changes in population growth and movement, the interstate flow pattern is not dramatically different from that of the 1940's or even earlier. The 50 x 50 interchange matrix is still complete — i.e., each state has migrational exchange with all others over a five-year period — and the rank order of migration partners for most states correlates highly for at least two decades. For example, among the top ten destinations of North Dakota out-migrants in 1965-70, nine of them were on the list in 1955-60 (Arizona displaced Iowa in tenth place); and the same correlation among all 49 states is very high ($r = -.82$). The persistence of migration links is a function of accessibility and relative opportunities, either real or perceived, which change slowly over time.

Nevertheless, change of considerable magnitude has occurred among the high-volume flows, which account for about 15 percent of all interstate migration; this is given in Table 1 which ranks the interstate volumes and compares them to their 1955-60 values. Most of the streams increased because of the enlarged population base but some of them expanded greatly in per capita rates, while others actually decreased. The largest increases were the California outflows to Washington, Oregon, and Texas, followed by substantial growth in the New Jersey-to Pennsylvania and Louisiana-to-Texas flows. The two strongest streams, New York-to-New Jersey and New York-to-Florida, also expanded over the decade. Most of the cases of slow growth or decline involved either California as a destination or special cases of metropolitan sprawl across state lines in the East. There is now much less migration from Washington, Oregon, and Midwestern states to California, and the District of Columbia-to-Maryland suburban

movement appears to be peaking-out. Several anomalies beg explanation: a decline in the Ohio-to-Florida flow and a reversal of net flow between New Jersey and Pennsylvania.

An analysis of the matrix of 2,550 interstate flows (51x50) reveals several generalizations:

1. The correlations of migration volumes between 1955-60 and 1965-70 by individual states are all above +.50; thus, spatial flow patterns are generally stable;

2. Most interstate flows (approximately 65%) have expanded at lower rates than has the population in the state pairs; thus, *mass* may be declining in importance relative to distance.

3. The total interstate migrant-miles is probably declining because of weaker flows to California and from the Southeast to the North.

TABLE 1. Leading interstate migration flows (flows of over 75,000, 1965-70).

RANKS 1955-60	RANKS 1965-70		1965-70 volume (1000's)	change, 1955-60 to 1965-70 number (1000's)	change, 1955-60 to 1965-70 percentage
1	1	New York-to-New Jersey	216	+35	+19.3%
2	2	New York-to-Florida	189	+33	+21.1
3	3	Texas-to-California	136	−14	− 9.4
5	4	New York-to-California	128	− 2	− 1.5
23	5	California-to-Washington	120	+61	+103.4
4	6	Illinois-to-California	115	−17	−12.9
6	7	Pennsylvania-to-New Jersey	113	− 2	− 1.7
19	8	California-to-Texas	113	+46	+68.7
27	9	California-to-Oregon	104	+51	+96.2
11	10	New Jersey-to-New York	86	+12	+16.2
22	11	Arizona-to-California	84	+23	+37.7
9	12	Ohio-to-Florida	83	− 8	− 8.8
30	13	New Jersey-to-Pennsylvania	82	+24	+41.3
14	14	District of Columbia-to-Maryland	79	+ 2	+ 2.6
7	15	Washington-to-California	77	−24	−23.8
13	16	Oklahoma-to-Texas	77	+ 2	+ 2.7
25	17	Louisiana-to-Texas	75	+21	+38.9
15	18	Pennsylvania-to-New York	75	+ 1	+ 1.3

Computed from: *Mobility for States and State Economic Areas,* (Table 16), Department of Commerce, Bureau of the Census, Washington, 1963; and *Mobility for States and the Nation,* (Table 44), Department of Commerce, Bureau of the Census, Washington, 1973.

CONTRACTION AND CONTIGUITY

There is reasonably strong evidence to conclude that interstate migration is weakening in the 1970's and that migrants are finding closer destinations. These are nascent, as judged by comparison of the 1955-60 and 1965-70 trends. The volume of interstate flow during the latter period was nearly 17 million persons, or 51.6% of all internal migration, herein defined as change in county of residence; this compares with nearly 15 million interstate migrants during the 1955-60 period, or 50.7% of the total. However, the growth rate of interstate migration per se was 12.2%, compared to a population growth rate of 13.3% during the 1960's. Relatively fewer Americans are moving between states although total mobility is not declining; in short, a spatial contraction of flow appears to be underway.

As an indicator of the effect of distance, and perhaps perceived opportunities, *contiguity* is liberally defined to include all cases of states with any length of common boundary (but not a point). The volume of *contiguous* migration increased 17.6% in ten years, which is appreciably more than overall mobility or the population growth rate. Contiguity as a migration stimulus in the recent period is characteristic of the Western states, including the Pacific Coast, most of the Southern states, and particular areas of high-density along state borders in the East. Contiguity also differentiates by age and race groups, as seen in Table 2.

Contiguous migration has become almost one-third of all interstate migration. White females are the most likely to move to an adjacent state, but they are showing an increasing proclivity toward longer moves. Black males are the most likely to move to non-contiguous states. These relative propensities are evident in the migration patterns of states with high or low proportions of particular age-race subgroups. More significantly, the trends are quite consistent for all of the subgroups, excepting white females, toward more contiguous state movement; this represents a reversal from the trend of the 1950's toward longer distance migration.

TABLE 2. Percentage of interstate migration to contiguous states.

	1965-70	1955-60
Total Population	32.6%	31.5%
Male	31.3	30.9
Female	33.9	34.0
White male, 23 years	27.6	27.2
White female, 23 years	34.0	34.6
Black male, 21 years	22.3	21.7
Black female, 22 years	24.6	24.4

Contiguous migration is typically high volume; the leading migration partners are contiguous states for 63 of the 96 two-way flows of coterminous states in 1965-70. Contiguity may account for as little as 8% (Maine) or as much as 60% (Kentucky) of an interstate total, and as high as 43% with a single partner — namely, California's contribution to Nevada's in-migration. Figure 2 shows the distribution of leading percentage flows for all the states. The highest interaction levels for most states is less than 15% of the total with a median value of 8.2%; but in 1955-60, the median value was 6.5%, which indicates a lower intensity of adjacent flows in the earlier period.

BOUNDARY EFFECTS

Although the United States is an open system for residential change, there are numerous restraints upon interstate flow which may affect contiguous migration. The objective here is to present a measure of the strength or weakness of state boundaries as barriers to migration across them, independent of social and economic forces. Two sets of measurements are therefore included in the following *Barrier Index* (BI).

$$BI_{ij} = \frac{C_i + C_j}{LI_i + LI_j} \quad ,$$

where $C_{i,j}$ = the length of common boundary relative to the total internal perimeter of the state;

and, $LI_{i,j}$ = a *linkage* index,[6] which has been previously developed for all state pairs, as a measure of the drawing power of one area (state) upon another, namely, the relative migration between i and j, considering the competition of population throughout the system.

C_{ij} is simply a measure of opportunity to migrate to a bordering state on the assumption that a longer relative boundary will induce more flow. The Barrier Index for Minnesota and North Dakota is:

$$BI = \frac{32 + 21}{13.4 + 15.2} = 1.78 \quad ,$$

from estimation that the common boundary is 32% of North Dakota's internal perimeter and 21% of Minnesota's (the Canadian border and Lake Superior ignored); and the LI's (as calculated on 1965-70 data) are among the highest linkage indexes for all state pairs.[7] The distribution of BI's range from 1.46 to over 10.0; they are used for the classification and map in Figure 3. This display of "State Boundaries as Migration Barriers" suggests the degree of "openness" or resistance for migration flows between contiguous states.[8] Barriers are weak in most of the Mountain and Great Plains states, with the exception of Kansas

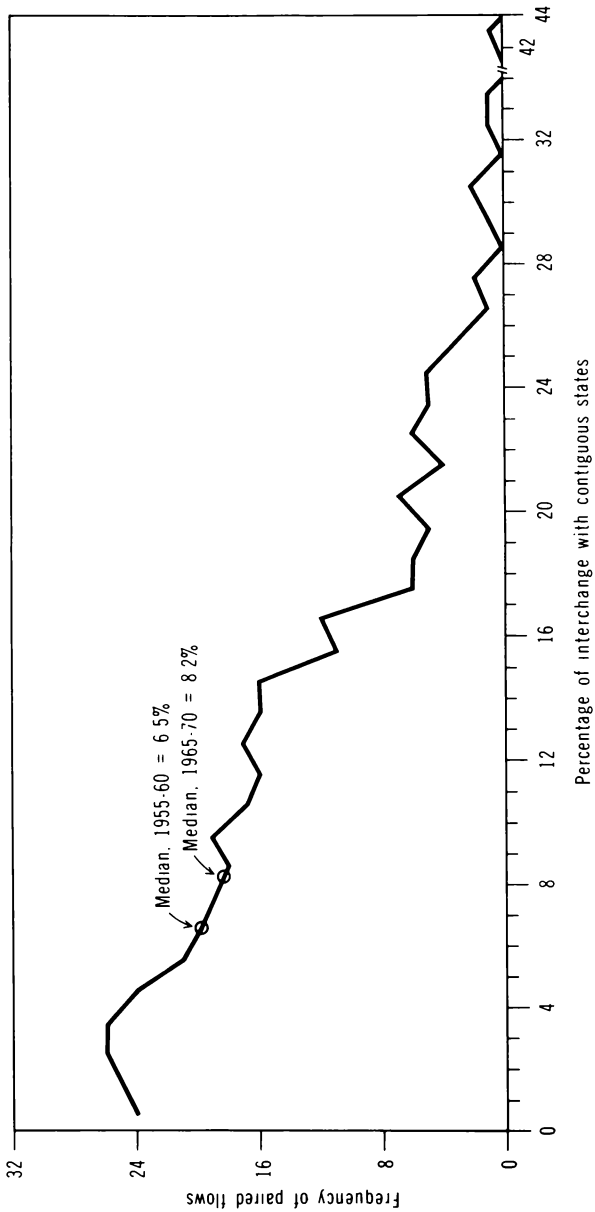

FIGURE 2. Contiguity and relative interchange, 1965-70.

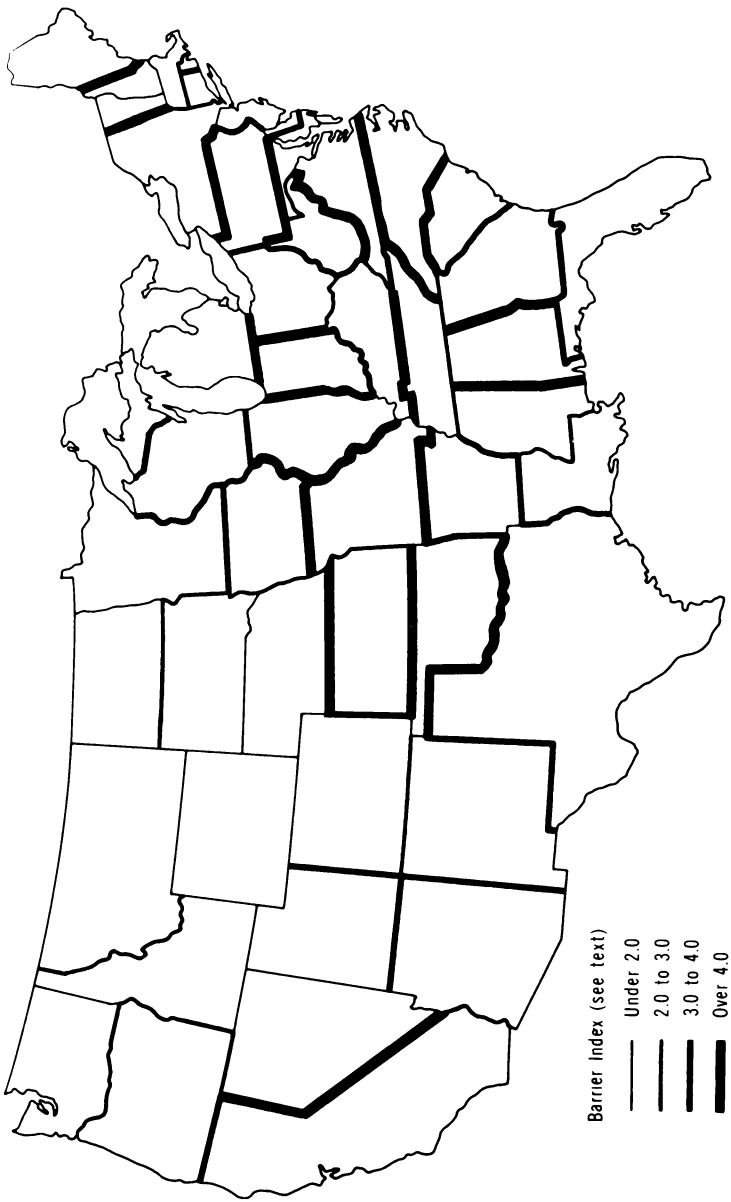

FIGURE 3. State boundaries as migration barriers.

which has a low level of interaction with its neighbors (relative to boundary), excepting for Missouri. North Dakota is more open east-to-west than with South Dakota; on the other hand, Minnesota's eastern and southern boundaries are not highly "permeable." The strongest barriers are found in Eastern States, such as the Pennsylvania-New York and Maine-New Hampshire boundaries. These state pairs have much less migration between them than would be expected with respect to their boundary conditions. It is not implied that boundaries are in any sense a physical barrier, but it does appear that migration flow across them varies according to historical linkages, as well as the present set of relative opportunities, an important element of which is population distribution within the states.

State boundaries can be seen as barriers, or filters, with greater precision at the local level where conditions are similar on either side of the line. It is found, for example, that Fargo attracted rural migrants from North Dakota to a much greater extent than did any Minnesota center from 1955 to 1960; similarly, Moorhead, which is 40% of Fargo's size, drew more rural migrants from its three adjacent Minnesota counties than did Fargo. A similar result was found for the relative pulling power of Grand Forks and East Grand Forks upon migrants in their respective states. Without field knowledge, one might infer that state loyalty and local information fields are effective builders of boundaries at the micro-geographic level.

IMPLICATIONS

Explanation of the migration process and modelling for forecasting has conventionally assumed the isotropic surface or at best intervening opportunities and directional bias. Residential choice may be strongly conditioned by barriers, as has been demonstrated in many studies of intraurban movement, particularly where social and economic barriers suppress mobility. The analogy is offered that state boundaries may play a similar role. The liklihood of augmented interstate migration between contiguous states suggests that the variable strength of boundaries will affect the number of migrants taking up residence in neighboring states.

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[1]The 1970-75 data are from *Population Estimates and Projections*, "Estimates of the Population of States," (July 1974-1975), p. 25, no. 615, November 1975, U.S. Bureau of the Census.

[2]Minnesota, Missouri, Louisiana, Kansas, Nevada, California, Washington and Alaska.

[3]*Intercom*, v. 3, no. 8, Aug.-Sept. 1975, Population Reference Bureau, Washington, D.C.

[4]A number of reasons for the southerly movement have been advanced: 'climatic', retirement, economic opportunity, flight from Northern ghettos, cost of living, lower taxes, energy costs, etc.

[5]"Go South, old man," may be a forthcoming frontier maxim.

[6]R.B. Adams. 1969. "Migration Geography: A Methodological Inquiry and United States Case Study," Ph.D. dissertation, University of Minnesota, Part I-b, p. 133.

[7]In this example the value of $LI_i = 13.4$ is the ratio of Minnesota's contribution to North Dakota's total in-migration (interstate) divided by Minnesota's percentage of the U.S. population (excluding North Dakota); thus Minnesotans migrated to North Dakota at 13.4 times the national rate, relative to population.

[8]R. Yuill has classified boundaries in Discussion Paper No. 5, Michigan Inter-University Community of Mathematical Geographers, April 1965, "A Simulation Study of Barrier Effects in Spatial Diffusion Problems."

SIMULATION AND EVALUATION OF ALTERNATIVE GRADING METHODS IN POTATO PACKAGING OPERATIONS

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ABSTRACT

A computer simulation model to assist the detailed studies of potato packing house operations was developed earlier. The model simulates relationships between individual tuber characteristics, machine functions, and workers activities to provide a logical description of potato packing house operations. A study to enhance the predictive capabilities of the model is described. The results of laboratory experiments to develop a basis for incorporating alternative methods of grading potatoes is reported. The principle conclusions drawn from the experimental results are that inspection errors are primarily ones of detection rather than ones of misclassification and that simultaneous scanning methods are more accurate than sequential scanning methods when the incidence of items requiring inspector action is low.

INTRODUCTION

Fruit and vegetable packing operations are being handled increasingly by fewer and larger, highly commercialized firms. With the large-scale operations that are involved in packing fruits and vegetables for the fresh produce market, the relationships between time, material, labor, equipment, and costs have become quite complex. Although these factors and their interactions are extremely important to good management, they are difficult to analyze. A research tool has been needed with which both the individual operations and the total system of operations in packinghouses can be analyzed simultaneously. The effectiveness of system simulation models in agricultural processing systems has been well documented. [See Link and Splinter (1968), Peart (1967), Casler and Morris (1967), Price, *et al.* (1971) and Corcoran (1971).]

We have developed an operative model of packinghouse operations that completes an important first step in expanding our analytic capabilities for conducting economic, engineering, and managerial research studies of (1) packinghouse equipment performance under abnormal or unusual operating conditions, (2) the determination of attainable quality levels under various raw product input conditions, (3) the evaluation of alternative plant operating policies, and (4) the allocation of raw material and packaging costs under various combinations of packinghouse operations.

The simulation model is programmed in the IBM General Purpose System Simulation (GPSS) language (1967) where individual potatoes (tubers) comprise the basic unit of flow in the model. The individual tubers, which are represented in terms of their physical and biological characteristics such as size, smoothness, and disease incidence, flow through the receiving, presizing, pregrading, washing/drying, grading, sprout inhibition/transfer, sizing, and packaging operations in the same sequence that occurs in the packinghouse. Machine functions and worker activities are simulated in terms of responses to the individual tuber characteristics and these responses in turn effect changes in the parameters used to represent the characteristics of the individual tubers. A more detailed description of the model and its interactions is given in Orr and Ebeling (1974) and Orr, *et al.* (1975). The model has been tested under typical packinghouse operating conditions and has passed known validation tests for reasonableness of output by researchers who are familiar with potato packinghouse operations.

The second step in the logical development of our analytic capabilities for conducting system performance studies involves enhancing the predictive qualities of the model, particularly as it relates to human elements that are most significant in the grading operations. This paper provides a brief overview of the present status of the grading elements in the model and proceeds with a description of our efforts to enhance the model's capability to predict grading performance under various raw product input conditions.

GRADING OPERATIONS

Inspectors work at roller type grading tables at two stations in the process. The first station, known as pregrading, involves the removal of obvious cull tubers from the main product flow immediately after the mechanical pre-sizing operation. After pregrading, the remaining tubers are washed before being further graded into a four-way classification of product. The program logic which simulates inspectors working at two side-by-side roller type grading tables employs conditional operators which algebraically compare the values of the tuber's parameters with a series of quality specifications derived from established product grade standards. The product grades used in this simulation, in decending order of quality, are Premium, Number 1, Number 2, and Cull. After determining the individual tuber's quality, the tuber flows through a routine that determines the inspectors availability to observe the tuber, to decide which of the four grading classifications this tuber satisfies, and to remove the tuber from the grading table should such action be necessary on the basis of the inspector's grading decision. In making the grading decision, a cumulative probability distribution function is used to reflect the fact that inspector grading errors are more likely to occur with tubers that are closer to the border line between any two grades. In otherwords, errors in grading of the tubers which pass through an inspector's viewing area can occur as a result of the inspector's limited capacity to observe all the tubers, the inspector errors in judgment, and errors resulting from the inspector's limited capacity to physically effect the quality separations. The output of the model

provides a means of evaluating the collective effectiveness of the inspectors assigned to the grading table, the utilization of the inspectors, and the unit oeprating costs of the grading table under various quality levels of incoming product and various rates of product flow across the grading table.

EVALUATION OF ALTERNATE SCANNING METHODS IN GRADING

Enhancement of the model's capability to predict grading performance under various raw product input conditions implies that one has at least a detailed knowledge of the most significant factors involved as well as a general insight into the nature of the relationship between those factors. Much of the current research into inspector performance has been concentrated on the identification of factors that influence grading accuracy. Such research has apparently been motivated by earlier studies in which it was found that accuracy in grading of products was surprisingly low. Wallack and Adams (1969) indicated that grading accuracy may range from 56 to 83%, but seldom is it greater than 80%. Of the factors that influence grading accuracy identified by Harris and Chaney (1969), the scanning method used by the inspector was discovered to be an important one which we had overlooked in the absence of any quantitative studies of potato grading operations. Since all of our modeling was based on the concept of each inspector simultaneously scanning for all grades, and excluded the possibility of each inspector scanning for only one grade in sequential order, a laboratory experiment was conducted in which the two scanning methods were compared and the relationship between scanning method and grading accuracty was evaluated. Each of six inspectors was given three opportunities, with each scanning method, to grade a set of items having three incoming levels of quality. The items were passed in front of the inspector from his left to his right, at a speed of one-half foot per second. Each inspector was assigned one of six sequences of grading three quality levels of items. The sequences were 123, 132, 213, 231, 312, and 321 where level 1 denotes the set with the highest incidence of premium grades. Additionally, each inspector was assigned a sequence of grading method. At the conclusion of each pass, data were recorded concerning the number of correct and incorrect gradings.

The data were analyzed in several stages. First, they were checked for wild points, or wildly scattered values. Next, the grading accuracies obtained with the two scanning methods were compared on the basis of the total number of grading errors committed. Then, grading errors were further categorized and enumerated as either type I (nonremoval of an item that should have been removed — a detection error) or type II (removal of an item that should not have been removed — a misclassification error). Finally, regression analysis was performed to determine the influence of the number of items to be removed on the total number of items removed by each inspector. The results of the analysis were as follows:

Wild Points - None were found.

Comparison of grading accuracy with the two scanning methods Simultaneous scanning provided a higher average percentage of correct classifications for each quality level.

Comparison of errors by type - Most of the errors (95%) were type II (removal of an item that should not have been removed), as shown in Table 1.

Simultaneous scanning was superior to sequential scanning in the prevention of type II errors, and sequential scanning was slightly superior in the prevention of type I errors (nonremoval of a defective item that should have been removed.)

Regression analysis - Exponential equations provided the best fit according to stepwise regression analysis. The exponential equations were as follows:

(1) *Simultaneous method*

$$Z = -1.42 + 101.32\,(1.0 - e^{-.0088X})$$

STD ERROR = 5.04

(2) *Sequential method*

$$Z = 44.35 - 0.10Y + 81.63\,(1.0 - e^{-.01626X})$$

STD ERROR = 2.70

where

Z = Total number of items removed
X = Total number of items to be removed
Y = Total number of items presented

The exponential equations passed the F test for goodness of fit at the 5% level of significance and also provided the smallest standard error. Examination of the above equations indicates that the two methods of scanning were different in both the magnitude of the coefficients and the variables that entered the equations. Further examination of the equations indicates that the sequential scanning method is superior to the simultaneous method for lower quality levels (X), as shown in Figure 1.

DISCUSSION

As previously indicated, the grading task in this experiment was a laboratory approximation of an industrial grading task in which untrained inspectors performed a simplified simulation of actual industrial grading for a short time. Thus, the results of this study are only an indication of the results one might obtain in an industrial situation.

As a further check of the experimental results, a test run was made utilizing three inspectors working together at the table to sort the items once by the sequential scanning method and once by the simultaneous scanning method. This preliminary look at the methods being applied with several inspectors working at once supported the conclusions that the best scanning method depends on the

TABLE 1. Comparison of Product Grading Errors by Type*

Level of Quality	Inspector No.		Simultaneous Scanning Type 1 No. of Errors	Simultaneous Scanning Type II No. of errors	Sequential Scanning Type I No. of errors	Sequential Scanning Type II No. of errors
1	1		1	0	0	19
1	2		2	2	0	23
1	3		2	6	1	20
1	4		0	9	0	22
1	5		1	19	0	21
1	6		0	11	1	21
		Total	6	47	2	126
2	1		0	3	1	15
2	2		1	2	0	7
2	3		0	2	0	9
2	4		1	7	0	12
2	5		0	8	0	12
2	6		1	6	0	6
		Total	3	28	1	61
3	1		0	0	0	2
3	2		0	1	1	1
3	3		0	1	0	2
3	4		2	0	0	4
3	5		0	1	0	3
3	6		0	0	0	5
		Total	2	3	1	17
		Grand Total	11	78	4	204

*Type I errors — Failure to remove product item that should have been removed.

level of defectives, and that sequential scanning is best at the lower levels while simultaneous inspection is best at the higher levels.

The fact that a crossover point exists for the two methods (Fig. 1) suggests a need for further research. Specifically, one might investigate how the division of inspector tasks influences the location of this cross-over point. Additionally one might evaluate a grading task design that combines the two methods.

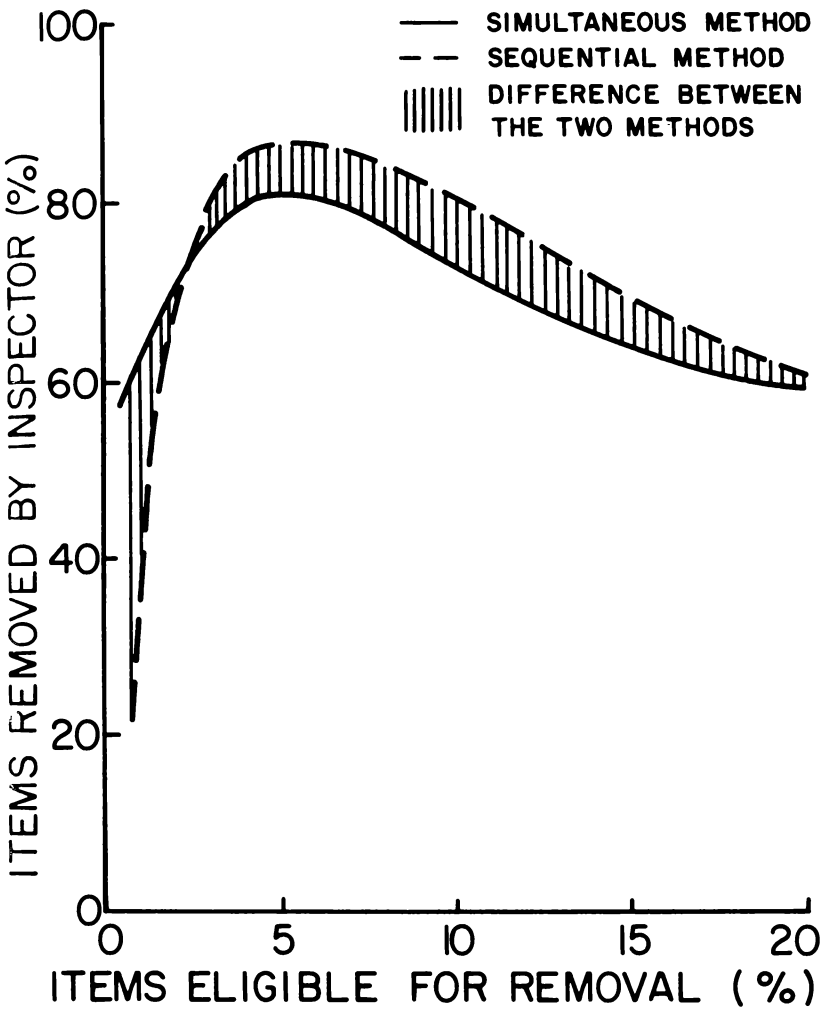

FIGURE 1. Grading accuracy of simultaneous and sequential scanning methods.

ACKNOWLEDGMENTS

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EVALUATION OF FLOTATION AND SEDIMENTATION IN TREATING OIL REFINERY WASTES

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ABSTRACT

A pilot plant study was conducted to evaluate both the coagulation-sedimentation and the air floatation methods in removing oil and suspended solids from oil refinery wastes. Factors affecting oil and suspended solid removals, such as overflow rates, rise rates, recirculation ratios, and chemical dosages, were investigated. Experimental results on waste from API separator indicate that under the condition of optimum overflow rate, rise rate and chemical dosages, an oil removal efficiency of 90-95% is attainable by either the coagulation-sedimentation or the air flotation process. For the coagulation-sedimentation process, the required operating conditions are: 1) an overflow rate of 390 gpd/sq ft (15,890 l/day/sq m); and 2) chemical dosages of 2 mg/l polyelectrolyte, 100 mg/l $CaCO_3$, and 50 mg/l $Ca(OH)_2$. For the air flotation process, the required operating conditions are: 1) a rise rate of 1.9 gpm/sq ft (77.4 l/min/sq m); 2) a recycle rate of 25%; 3) chemical dosages of 2 mg/l polyelectrolyte and 50 mg/l Ca $(OH)_2$. The selection of the process, whether the coagulation-sedimentation or the air flotation process, should be based on a cost comparison.

INTRODUCTION

Both air-flotation and coagulation-sedimentation processes have been used extensively as methods for the primary treatment of oil refinery wastes. The objectives of the primary treatment are: 1) the clarification of wastewaters by the removal of suspended matter, both oil and solids; and 2) the enhancement of the secondary treatment or biological waste treatment by reducing suspended solids and oil content to a permissible level. For the air flotation process, air is first dissolved in the wastewater under pressure and is then released into atmospheric pressure in a tank or basin. The released air forms tiny bubbles which adhere to the suspended matter, giving it enough buoyancy to float to the surface of the water where it may then be removed by skimming. The API Manual on "Disposal of Refinery Wastes" (American Petroleum Institute, 1969) gives a detailed discussion on the theory and application of the process. The use of the air flotation process for oil-refinery wastes has been described by several investigators (Roth, Helwig, and Hull, 1960; Campbell and Scoullar, 1964; Simonsen, 1962; Prather, 1961; Rohlich, 1954; D'Arcy, 1951). Prather (1961) discussed the effect of operating variables such as pH, air rate, and chemical dosage rate.

For the coagulation-sedimentation process, chemical coagulants are added to the wastewater, then mixed and flocculated to form a gelatinous porous floc in which the suspended solids and oil are enmeshed. The floc is agglomerated until it reaches a settleable size and then is removed by gravity settling. The API Manual (1969) contains a description and discussion of the process. The use of the

coagulation-sedimentation process for oil-refinery wastes is reported by several investigators (Phillips, 1954; Weston and Merman, 1954; Schindler, 1951).

Although the information on the treatment of oil-refinery wastes by either the air flotation or the coagulation-sedimentation process is available in the literature, a direct comparison of two processes in treating the oil-refinery wastes from the same refinery plant has not been reported in the literature. This study was undertaken to evaluate both the air flotation and the coagulation-sedimentation methods in removing suspended solids and oil from oil-refinery wastes and to determine factors affecting oil and suspended solids removal.

MATERIALS AND METHODS

The pilot plant unit consisted of an equilization basin, an air flotation unit, a coagulation-sedimentation unit, a centrifuge unit, a sludge storage tank, a chemical feed system with necessary pumps, and flow metering devices. The capacity of the equalization basin was 7,500 gallons (28,387 liters), which provided an equalization time of 2.7 to 6.9 hours. The Link-Belt coagulation-sedimentation unit included a flash mix chamber, a flocculation chamber and a settling tank with sludge scrapers. The sludge scrapers were operated at a constant speed of 1.1 ft/min (0.34 m/min). The two sludge hoppers were relatively small, six inches square and one foot deep. The Rex Chain Belt air-flotation unit was preceded by a flash mix chamber consisting of a 55-gallon (208-liter) drum and a mixer. The air-flotation unit consisted of a flocculation chamber and a flotation tank. The float scrapers were operated at variable speeds of 3.4 to 11 ft/min (1 to 3.4 m/min). Figure 1 depicts the pilot plant layout.

The purpose of the three-month pilot plant operation was to establish the optimum operating conditions and chemical dosages for the air flotation or the coagulation-sedimentation process for treating wastewaters from a petroleum refinery which converts crude oil into salable products such as gasoline, kerosine, fuel oils, and asphalts. The wastewaters were first discharged into API (American Petroleum Institute) separators for the removal of free oil. Effluent from API separators was pumped to an equalization basin. A 200-gpm (757 l/min) centrifugal pump was used to provide the recirculation of the basin contents and to pump the equalization basin effluent to the air flotation unit and the coagulation-sedimentation unit. The coagulation-sedimentation unit was operated at three flow rates and various coagulant dosages. Influent flow rate varied from 2 to 6 gpm (7.6 to 22.7 l/min) with the corresponding overflow rate of 200 to 540 gpd/sq ft (22,000 l/day/sq m), and settling time between 30 to 75 minutes for the settling tank. Coagulants used include polyelectrolyte (Nalco 603), hydrated lime and calcium carbonate. Calcium carbonate served as a weighting agent to improve the settling characteristics of the chemical flocs. The air flotation unit was also operated at three flow rates, two recycle rates and various chemical dosages. Chemicals used include polyelectrolyte (Nalco 603) and hydrated lime. The influent flow rate varied from 16 to 40 gpm (60.6 to 151.5 l/min), the rise rate ranged from 1.2 to 2.4 gpm/sq ft (48.9 to 97.8 l/min/sq m) and the flotation

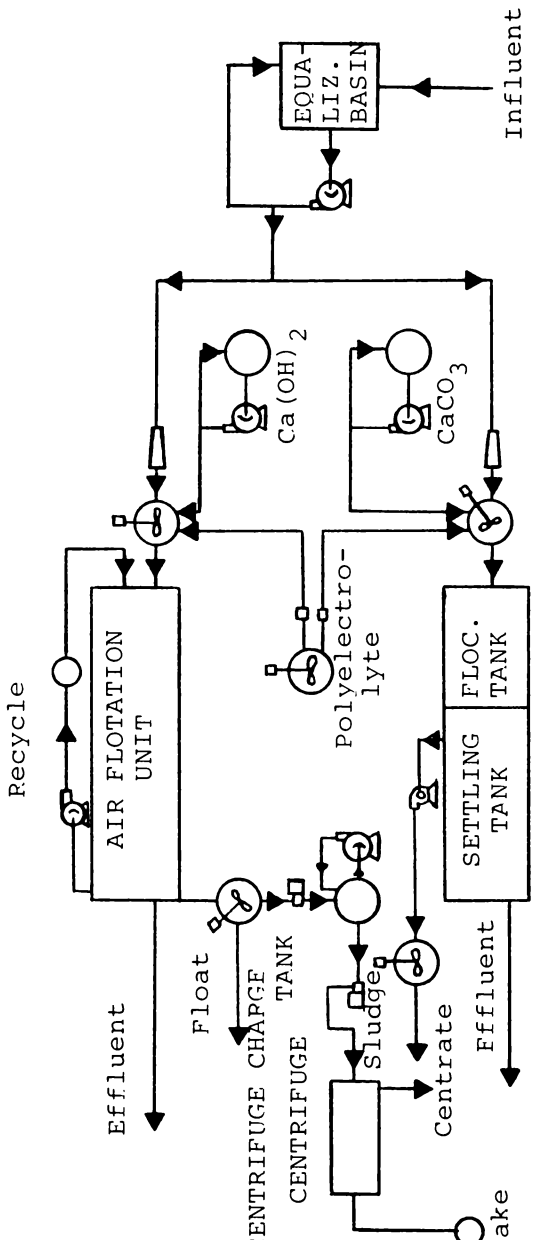

FIGURE 1. Pilot plant layout.

time varied from 7.5 to 19 minutes for the flotation tank. The 24-hour composite samples were taken daily from influent and effluent of both units for analysis of oil, suspended solids (SS), chemical oxygen demand (COD), 5-day biochemical oxygen demand (BOD_5) and total oxygen demand (TOD) to determine the optimum operating conditions which gave the best effluent quality in terms of oil and SS concentration. The laboratory analysis was in accordance with "Standard Method" (APHA, 1971).

RESULTS AND DISCUSSION

The refinery waste used as influent to the pilot plant system was the effluent from an API separator. A statistical variation of the most important waste parameters was established for the equalization basin effluent as listed in Table 1.

The results indicate that the influent to both the coagulation-sedimentation and the air flotation units contained high concentration of emulsified oil, SS, and not readily biodegradable organic material since COD and TOC values are much higher than BOD_5. Results of the coagulation-sedimentation unit and the air flotation unit operations are summarized in Tables 2 and 3.

Coagulation-Sedimentation Unit. — For the range of different operating variables experimented with during the study, the percent removal was 34 to 99% for oil, 11 to 97% for SS and 13 to 93% for COD. From the results listed in Table 2, the flow rates, the overflow rates and the settling times over the range tested during the study did not have significant effect on the removal efficiency of oil, SS and COD. The overflow rate of 200 to 540 gpd/sq ft (8,148 to 22,000 l/day/sq m) was well below 600 to 900 gpd/sq ft (24,445 to 36,668 l/day/sq m) usually employed in the full scale unit. But the retention time of 30 to 75 minutes is shorter than 1.5 to 2 hours employed in the full scale unit. The overflow rate and the retention time of the pilot unit was out of proportion compared to those of the full scale unit because of the shallower water depth of 1.5 ft (0.46 m) for the pilot plant settling tank compared to a depth of 7 to 10 ft (2.1 to 3 m) for the full scale unit. Types and dosages of chemical additive appeared to have an important effect on the removal of oil and SS. With lime, calcium carbonate and no polyelectrolyte addition, the removal efficiency of oil and SS was poor. The percent

Table 1. Refinery Waste Characteristics.

	Equalization basin effluent (mg/l)	
PARAMETER	50% Probability	90% Probability
Oil	270	680
SS	250	470
BOD_5	310	600
COD	1,300	2,450
TOD	1,600	4,200

removal for oil and SS was 36% and 16%, respectively. When the addition of polyelectrolyte and lime was employed with no addition to calcium carbonate, a high removal efficiency of oil and SS could be achieved by a high dosage of lime of 500 mg/l but not by a high dosage of polyelectrolyte of 25 mg/l. The addition of calcium carbonate as a weighting agent appears to be essential in the good settling characteristics of the chemical flocs. The addition of calcium carbonate together with polyelectrolyte and lime appears to be the proper combination of chemical addition to achieve an effective coagulation-sedimentation operation. For a 90% oil and SS removal efficiency, the optimum chemical dosages are 2 mg/l polyelectrolyte, 100 mg/l calcium carbonate and 50 mg/l lime. An overflow rate of 390 gpd/sq ft (15,890 l/day/sq m), corresponding to a flow rate of 4 gpm (15.1 l/min) to the pilot plant coagulation-sedimentation unit, was found to be a suitable design parameter in order to obtain a good settling performance. Figures 2 and 3 depict the percent removal of oil and SS versus the influent oil and SS respectively for an influent flow rate of 4 gpm (15.1 l/min) to the coagulation-sedimentation unit.

Air Flotation Unit. — During the pilot plant study, the removal efficiency was 22 to 98% for oil, 7 to 97% for SS, and 7 to 92% for COD. The results of the air flotation unit operation are summarized in Table 3. The pilot plant air flotation unit retention time and the rise rate were somewhat out of proportion when compared to the usual 15 to 20 minutes retention time and 3 gpm/sq ft (122 l/min/sq m) rise rate usually employed in the full scale unit, as evidenced in Table 4.

The two recycle rates employed during the study were 25 and 50%. Under the same flow rate and the same chemical dosage condition, the 50% recycle rate tends to produce a better quality in terms of oil and SS removal than the 25% recycle rate. For the range of rise rate of 1.2 to 2.4 gpm/sq ft (48.9 to 97.8 l/min/sq m) employed in this study, which is less than the 3 gpm/sq ft (122 l/min/sq m) usually used in the full scale air flotation unit, the rise rate has little effect on the removal efficiency of oil and SS. On the other hand, the flotation time plays an important role in the removal of oil and SS. The best removal efficiency of oil and SS was obtained with the longest flotation time of 19 minutes. The addition of polyelectrolyte and lime was effective in removing oil and SS. Addition of calcium carbonate together with polyelectrolyte and lime was not beneficial, since calcium carbonate as a weighting agent tends to increase the density of chemical flocs and to interfere with the air flotation process. The optimum chemical dosages are 2 mg/l polyelectrolyte and 50 mg/l lime. Also the recommended rise rate is 1.9 gpm/sq ft (77.4 l/min/sq m) and the recycle rate is 25%. Figures 4 and 5 illustrate the percent removal of oil and SS versus the influent oil and SS, respectively.

Both the coagulation-sedimentation and the air flotation processes achieved about 90% removal of oil and SS from refinery wastes under the optimum operating conditions. The oil removal efficiency obtained in this study was far better than the 20 to 64% removal efficiency reported by Rohlich (1954). Chemical dosages of 2 mg/l of polyelectrolyte and 50 mg/l of lime are recommended for the

TABLE 2. Summary of results of coagulation-sedimentation unit.

Flow Rate gpm	Chemical* Dosage	Overflow Rate gpd/ft^2	Settl. Detn. Time Min.	Period of run Day	Oil			SS			COD		
					Infl. Avg. mg/l	Effl. Avg. mg/l	% red. Avg.	Inf. Avg. mg/l	Effl. Avg. mg/l	% Red. Avg.	Infl. Avg. mg/l	Effl. Avg. mg/l	% Red Avg.
2	0-100-50	200	75	1	286	182	36	268	224	16	960	832	13
2	6-200-0	200	75	2	697**	201	71	251	173	30	2,120	1,130	47
					655-738***	184-217	67-75	227-274	154-192	15-44	2,080-2,160	1,100-1,160	44-49
2	6-400-0	200	75	1	441	108	76	494	268	46	1,080	769	29
2	20-300-0	200	75	2	268	42	84	366	118	68	1,720	577	65
					205-331	41-42	83-88	320-412	96-139	66-70	1,440-2,000	480-673	53-76
2	20-500-0	200	75	1	378	46	88	194	112	43	1,230	741	38
2	50-300-100	200	75	1	389	185	53	408	264	35	1,280	781	39
4	2-50-50	390	40	2	429	22	95	150	6	95	1,685	335	80
					359-498	5-38	90-99	50-250	4-8	92-97	1,370-2,000	310-360	78-82
4	2-50-150	390	40	1	117	6	95	370	84	77	1,440	560	61
4	2-100-50	390	40	1	612	38	94	210	40	81	2,820	200	93
4	2-100-100	390	40	7	371	32	92	262	35	88	1,772	325	78
					227-501	10-72	83-97	134-496	6-84	83-96	704-3,600	188-640	63-92
4	2-100-150	390	40	2	150	27	82	278	100	66	1,480	640	58
					112-187	20-34	82	264-292	24-176	40-91	1,160-1,800	440-840	54-62
4	2-100-200	390	40	2	158	24	85	108	22	80	1,480	640	56
4	2-100-300	390	40	1	189	61	68	208	8	96	920	440	52
4	2-150-150	390	40	1	453	39	92	240	40	84	680	240	65
4	2-200-150	390	40	2	338	41	99	332	46	86	1,340	400	70
					271-405	22-59	86-92	320-344	44-48	86	1,000-1,680	320-480	68-72

Table 2 (Continued)

Flow Rate gpm	Chemical* Dosage	Overflow Rate gpd/ft^2	Settl. Detn. Time Min.	Period of run Day	Oil			SS			COD		
					Infl. Avg. mg/l	Effl. Avg. mg/l	% Red. Avg.	Inf. Avg. mg/l	Effl. Avg. mg/l	% Red. Avg.	Infl. Avg. mg/l	Effl. Avg. mg/l	% Red Avg.
4	2-400-100	390	40	1	109	15	86	360	24	94	840	480	43
4	2-700-150	390	40	1	531	30	95	560	88	85	1,240	920	26
4	6-150-50	390	40	1	496	328	34	440	308	30	1,520	1,120	26
4	6-300-0	390	40	3	400	107	73	445	204	54	2,173	881	58
					164-552	43-160	67-79	308-548	128-340	29-74	1,880-2,400	600-1,242	34-74
4	6-500-0	390	40	1	172	21	88	384	56	86	1,440	640	56
4	25-150-0	390	40	1	105	43	59	222	38	83	1,520	920	40
6	2-150-0	540	30	1	126	52	59	129	98	25	1,460	360	75
6	2-200-0	540	30	1	306	153	50	292	192	34	1,220	700	43
6	2-300-0	540	30	1	154	49	68	212	143	32	940	700	26
6	5-200-0	540	30	2	199	91	53	148	108	25	1,170	530	51
					145-253	75-107	48-58	130-165	101-115	11-39	880-1,460	500-560	36-66
6	10-300-0	540	30	1	129	85	34	190	142	25	2,440	700	71
6	20-200-75	540	30	1	276	86	69	273	58	79	600	400	33

* NALCO 603, $CaCO_3$, and $Ca(OH)_2$
** Average value
*** Range of Value

TABLE 3. Summary of results of air flotation unit.

Flow Rate gpm	% Re-cycle	Chemical* Dosage mg/l	Rise Rate gpm/ft^2	Flota. Detn. Time Min.	Period of run (days)	Oil			SS			COD		
						Infl. Avg. mg/l	Effl. Avg. mg/l	% Red. Avg.	Infl. Avg. mg/l	Effl. Avg. mg/l	% Red. Avg.	Infl. Avg. mg/l	Effl. Avg. mg/l	% Red Avg.
16	25	0-75	1.9	19	1	712	171	76	114	92	19	1,900	950	50
16	25	2-50	1.9	19	7	408**	23	94	221	31	84	1,613	477	50
						227-612***	10-48	86-97	50-496	8-64	71-95	760-2,820	260-680	42-85
16	25	2-75	1.9	19	6	329	51	87	291	36	88	2,104	594	66
						117-501	3-137	72-98	108-480	6-88	80-97	704-3,600	240-960	45-92
16	25	2-100	1.9	19	1	249	76	70	206	20	90	1,440	320	78
16	50	0-50	1.2	16	1	552	98	82	548	116	79	1,880	1,360	28
16	50	0-75	1.2	16	1	164	52	68	308	112	64	2,240	520	77
16	50	2-75	1.2	16	2	313	25	92	312	43	87	1,060	390	62
						172-453	18-31	90-93	240-384	30-56	86-88	680-1,440	300-480	56-67
16	50	2-100	1.2	16	5	317	27	91	339	43	85	1,328	592	55
						187-531	13-60	85-97	208-560	28-60	77-94	920-1,800	320-800	44-68
25	25	0-0	1.4	12	1	389	222	43	408	264	35	1,280	1,160	9
25	25	0-25	1.4	12	1	105	59	44	222	96	57	1,520	720	53
25	25	0-100	1.4	12	1	276	120	57	273	124	55	600	480	20
25	50	0-25	1.8	10	1	496	302	39	440	196	56	1,520	920	40
25	50	2-100	1.8	10	1	145	29	80	165	34	80	880	560	36
40	25	0-0	2.4	7.5	1	348	273	22	416	324	22	560	520	7

Table 3 (Continued)

Flow Rate gpm	% Re-cycle	Chemical* Dosage mg/l	Rise Rate gpm/ft^2	Flota. Detn. Time Min	Period of run (days)	Oil			SS			COD		
						Infl. Avg. mg/l	Effl. Avg. mg/l	% Red. Avg.	Infl. Avg. mg/l	Effl. Avg. mg/l	% Red. Avg.	Infl. Avg. mg/l	Effl. Avg. mg/l	% Red. Avg.
40	25	0-50	2.4	7.5	4	382	144	64	324	203	36	1,385	960	27
						268-488	77-249	44-77	178-494	102-396	7-72	1,080-2,000	880-1,000	11-50
40	25	0-75	2.4	7.5	6	408	105	66	165	107	36	1,247	573	48
						126-925	70-173	40-85	125-227	56-166	20-57	640-2,080	380-780	17-72
40	25	0-100	2.4	7.5	2	281	49	83	362	94	75	1,180	540	52
						205-357	33-64	82-84	320-404	88-100	73-76	920-1,440	520-560	39-64
40	25	2-50	2.4	7.5	1	129	55	57	190	84	56	2,440	720	71

* NALCO 603 and $Ca(OH)_2$

** Average Value

*** Range of Value

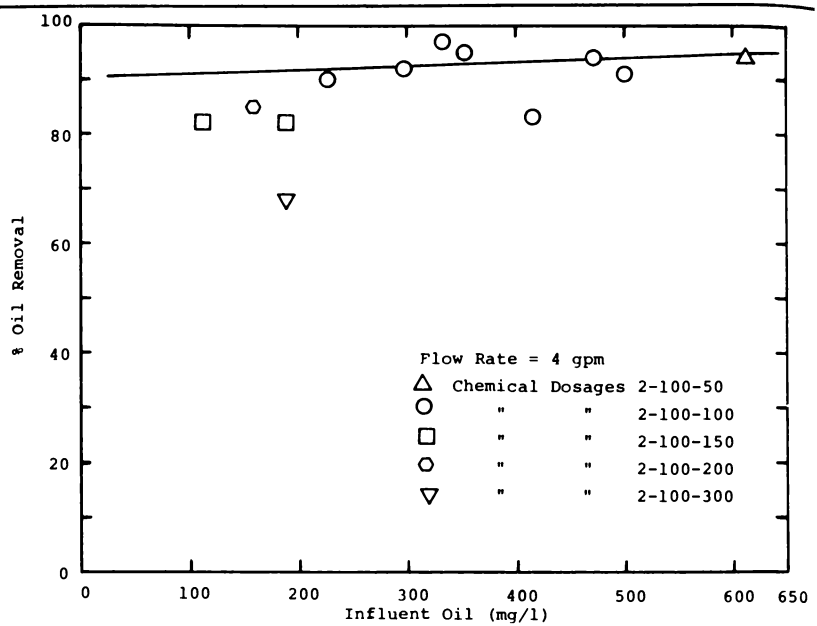

FIGURE 2. % oil removal vs. influent oil — coagulation-sedimentation unit.

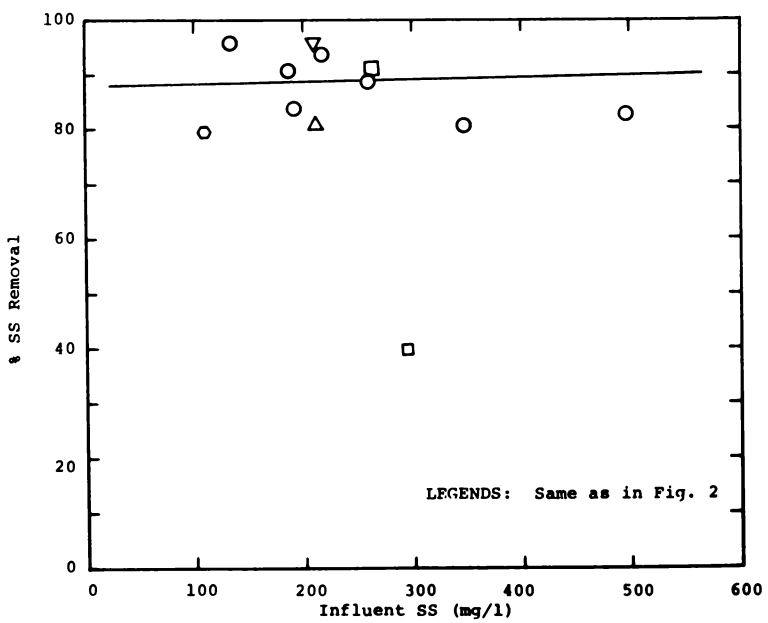

FIGURE 3. % SS removal vs. influent SS — coagulation-sedimentation unit.

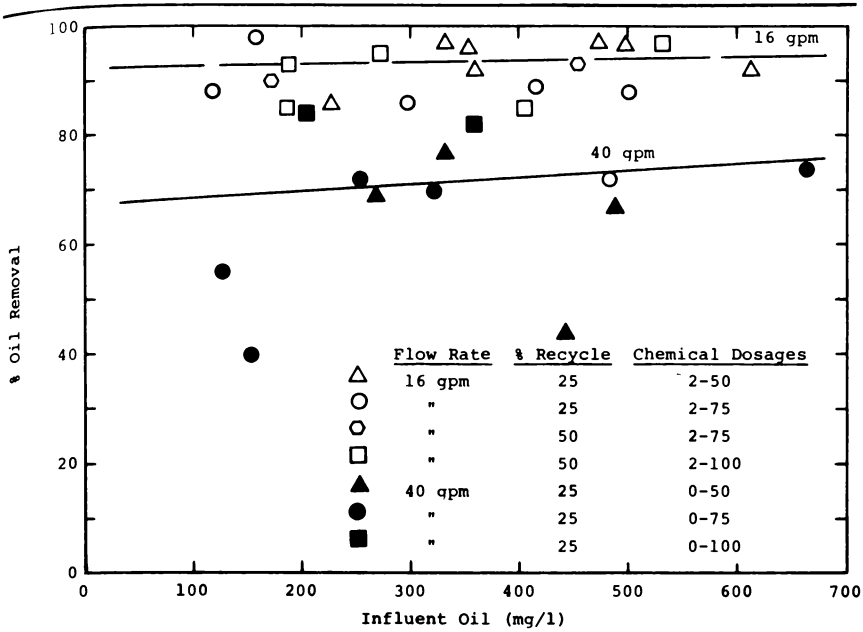

FIGURE 4. % oil removal vs. influent oil — air flotation unit.

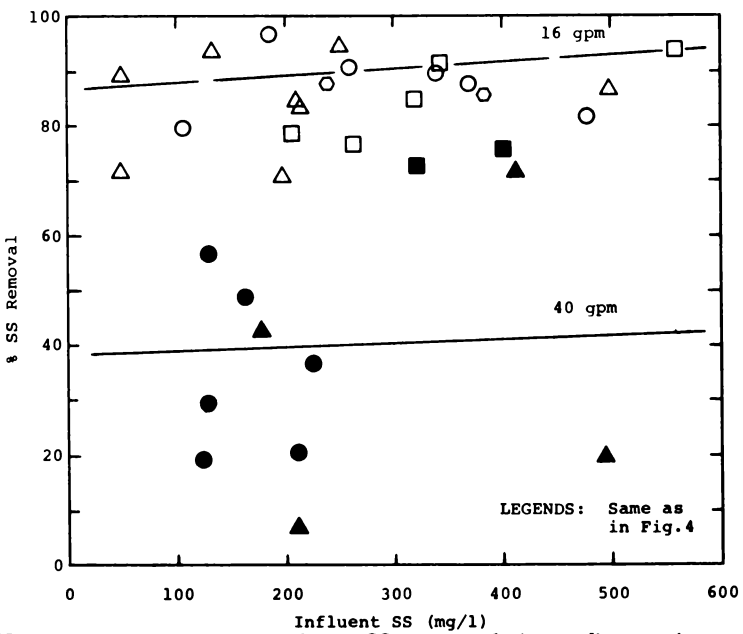

FIGURE 5. % SS removal vs. influent SS — coagulation-sedimentation unit.

TABLE 4. Operating parameters for full-scale air-flotation unit.

Flow gpm	Recycle %	Detention time min	Rise rate gpm/sq ft
16	50	16	1.2
25	50	10	1.8
40	25	7.5	2.4

air flotation process. For the coagulation-sedimentation process, the same chemicals and dosages are required in addition to 100 mg/l calcium carbonate used as a weighting agent to improve the settling characteristic of chemical flocs by increasing floc density. In the case of the air flotation process, pressurized air is employed to cause the chemical flocs to float to the water surface for skimming. The selection of the process to be used should depend upon a cost comparison of operating a pressurized recycle unit for the air flotation process and the additional chemical cost of calcium carbonate for the coagulation-sedimentation process.

CONCLUSIONS

1. In this study an oil-refinery waste influent to the primary treatment unit was found to contain a higher concentration of oil, 270 mg/l, and SS, 250 mg/l, compared to an oil concentration range of 131 to 260 mg/l reported in the literature (Rohlich, 1954). Most of the organic contaminants in the refinery waste were not readily biodegradable material as evidenced by the higher values of TOC and COD than BOD_5 values for the wastewaters.

2. For the coagulation-sedimentation process, the overflow rates and the settling times over the range employed in this study had little effect on the removal efficiency of oil and SS. Types and dosages of chemical addition played an important role in the oil and SS removal.

3. For the air flotation process, the rise rate over the range employed in this study had little effect on the removal efficiency of oil and SS, whereas the recycle rate, the flotation time, and the chemical dosages had an important effect on the oil and SS removal.

4. The optimum operating conditions for the coagulation-sedimentation process are an overflow rate of 390 gpd/sq ft (15,890 l/day/sq m) and chemical dosages of 2 mg/l polyelectrolyte, 100 mg/l calcium carbonate and 50 mg/l lime.

5. The optimum operating conditions for the air flotation process are a rise rate of 1.9 gpm/sq ft (77.4 l/min/sq m), a recycle rate of 25%, and chemical dosages of 2 mg/l polyelectrolyte and 50 mg/l lime.

6. The selection of which process to use should be based on a cost comparison.

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AN EXPERIMENT WITH COMPUTER-AIDED INSTRUCTION IN ECONOMIC PRINCIPLES

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ABSTRACT

The Teaching Information Processing System (TIPS) is a computer aid which supplements instruction in social science classes adaptable to the use of a multiple choice testing procedure. TIPS was employed in the teaching of Economic Principles at the University of North Dakota during the 1975 academic year at which time research data concerning its impact on student learning and attitude were collected.

Data analyses indicate that TIPS did not significantly enhance student performance on Economic Principles within generally acceptable confidence intervals. Student perceptions of TIPS, on the other hand, showed a high regard for the TIPS system and its impact on their learning habits. A subjective evaluation by the authors suggests that TIPS can be a valuable supplement to instruction, particularly for large classes.

INTRODUCTION

During the past decade or so, numerous research efforts have been directed toward the beginning courses in economics. Some of these have led to the development of various teaching techniques and aids, all of which are oriented toward improving student learning and attitudes toward economics. One such innovation, developed by Allen Kelley (1968), is called the Teaching Information Processing System (TIPS). TIPS is computer-aided instruction which is designed primarily to assist instruction in large classes. Although having its inception in economics, its use has been extended to the physical sciences, the humanities, as well as the social sciences.

It is recognized by all instructors of large classes of Principles of Economics that their teaching efforts must be geared toward the rather imaginary "average" student, often times at the expense of boredom for the above average student and frustration for the below average student. This situation is less than desirable in any event; however, the availability of a system of communication which would allow some degree of individualization of instruction could be of considerable value to the instructor of such courses. This is the primary objective of TIPS.

Under our TIPS System a 10-15 multiple choice question survey is administered to students about once per week. The results of the surveys are processed by the computer which evaluates them against a set of decision rules previously prepared by the instructor. Based upon the prespecified learning prescriptions broken down by concept areas, the computer program generates a report to the professor, his assistant, and each student.

The student report contains a summary of student response to each question, the correct answers, and the number correct. On the basis of this information

various assignments in the text, workbook or additional readings are identified for the individual student. The information is then stored and used with subsequent information to keep the students informed with respect to their performance, where to obtain help, and optional assignments for high achievers. The message that any student receives will vary according to the performance criteria the professor establishes for each concept area.

Class comprehension of different concepts as measured by the TIPS surveys allows regular feedback to the instructor and teaching assistant. The information on these reports includes percentage correct by question, by concept, actual responses, messages that were sent to each student, relative class standing, etc. Thus, the teaching assistant and professor receive reports which contain information to help them appraise the performance of each student on a week-to-week basis.

Some studies (Kelley, 1968, 1972) have demonstrated several potential benefits from the use of TIPS. One benefit is a significant increase in student achievement as measured by course examination scores. Furthermore, the distribution of benefits has been shown by Kelley to be such that low achievers (based on ACT-SAT percentile rank) gained more than average or high achievers. The gain in average test scores was invariant to type of exam question (multiple choice, short answer or essay). Moreover, this positive impact of TIPS on achievement was retained over time. Still, even if all the costs of TIPS are known, it is not always possible to make a rational statement concerning the economic efficiency of TIPS without making a normative statement concerning the value of the benefits (measured as increased test scores) to each student classified by some criteria, e.g., ACT-SAT score (Hansen, 1970).

TIPS, as employed in the authors' classes over the last three years, was voluntary with respect to the student's decision on how to use the system. That is, each student was entered into the TIPS data file but was not required to take any of the TIPS surveys. Each student received a TIPS Student Report for each survey given. If a student did not take the survey, he was given a report indicating various optional assignments that could be done to help ensure a good grasp of the concepts covered during the previous week's instruction. Students who actually took the surveys received assignments that corresponded to their level of performance on a given survey. Completion of assignments was encouraged to the extent that a record was kept of the assignments successfully completed by each student and students were rewarded for regular completion of TIPS surveys. The maximum point reward for completing all assignments was about 5% of the total number of points available for the course. In addition, the top 5% of the class on a composite score for groups of three surveys were given the option of participating in a class debate and earning an "A" for that section of the course rather than taking an exam. The debate option and borderline grade breaks were the only explicit rewards available to students for taking advantage of the information TIPS provides. There was no direct-related penalty for not taking the TIPS surveys or completing the assignments.

RESULTS

To evaluate the usefulness of TIPS, three sections of Principles of Economics were selected for testing during the first semester of the 1975-76 school year. One section (Section 2) had an initial enrollment of 200 students while the remaining sections enrolled 110 students each (Sections 1 and 3). TIPS was designated for use in Section 1 and Section 2. Section 3 was designated as the control group. The experimental group consisted of two sections with different instructors to compensate for any significant instructor differences which might influence the final results.

The classes in the experimental group were conducted in roughly the same way with both instructors following a common syllabus. Each instructor made similar usage of the TIPS surveys and subsequent assignments. The evaluation process consisted of the administration of pre- and post-tests of The Test on Understanding College Economics (TUCE)-Form B-Macro. These were administered on the first and last day of classes and were not used for grading. In addition, a prequestionnaire gained pertinent information on student characteristics while a postquestionnaire attempted to measure student reactions to TIPS. The results were tabulated and tested using multiple linear regression and Kendall's Tau. Although test results on all students were collected, difficulty in obtaining ACT scores limited the final sample to 186 students which is slightly less than 50% of total enrollment.

Table 1 contains pre- and post-test results showing that both the experimental and control groups began on approximately equal footing. Students' prior knowledge of economics (pre TUCE scores) was slightly below national norms, although the overall gain is consistent with the norming data with the experimental section showing the greater improvement.

Analysis of these data were performed by fitting the data and test results to a multiple linear regression model. The equation for the model takes the familiar form wherein:

$$Y = A + B_1X_1 + B_2X_2 + B_3X_3 \ldots\ldots B_{10}X_{10} + E$$

Post TUCE, the dependent variable, was assumed to be linearly related to the following independent predictor variables chosen from Table 2.

X_2 Pre TUCE — A measure of prior knowledge in Economics

X_3 ACT — A measure of student ability.

X_4 Section 2 (TIPS) — A binary variable designed to account for variations in the class environment.

X_5 Section 1 (TIPS) — A binary variable designed to account for variations in class environment.

X_6 TIPS — All students participating in TIPS (experimental group) were designated as 1; other students were designated as 0.

X_7 Post Attitude — This score was obtained by completing an attitude test at the completion of the course.

TABLE 1. Test results for student population.

	Experimental	Control
Pre TUCE	12.3	12.8
Post TUCE	18.8	18.0
Gain	6.5	5.2

Examination Instrument:
Test on Understanding College Economics
Form B (Range 0 to 35)

Table 3 contains regression results using Post TUCE as a dependent variable. The presence of pre TUCE together with post TUCE means that all the coefficients of Table 2 can be interpreted as changes in TUCE scores (Post TUCE with pre TUCE present and held constant).

At the 5 percent confidence interval variables X_2 (pre TUCE) and X_3 (ACT) and X_7 (Post Attitude) turn out to be significantly associated with student performance. The significance of X_2 and X_3 is expected and is confirmed by similar research on this subject (Lumsden, 1967; Paden, 1969, 1971).

The positive association between student attitude and post TUCE has also been shown in previous research (Ramsett, 1973; Sloane, 1970). This helps to substantiate the close association between the cognitive and attitudinal dimensions of learning. Variables X_5 (Section 1 - TIPS) and X_4 (Section 2 - TIPS) indicate possible differences in class environment (as against Section 3 - which was the base of comparison) that are associated with student performance.

The influence of TIPS on student performance is not as strong as was expected. The TIPS variable (X_6) explained enough variation in post TUCE to be significant at the 10 percent confidence level but not the 5 percent level.

TABLE 2. Data results: Total group (n = 186)

Variable	Mean	S.D.
X_1 Post TUCE	18.44	4.47
X_2 Pre TUCE	12.08	5.25
X_3 ACT (Composite)	22.22	4.51
X_4 Section 2	.48	.50
X_5 Section 1	.22	.41
X_6 TIPS	.71	.45
X_7 Post Attitude	37.21	6.80

TABLE 3. Factors influencing student performance: regression results

Independent Variables	Dependent Variable: Post TUCE (n = 186)
X_2 Pre TUCE	.20*
	(3.85)
X_3 ACT (Composite)	.49*
	(8.04)
X_4 Section 2	-5.75
	(-1.57)
X_5 Section 1	-6.47
	(-1.75)
X_6 TIPS	6.18
	(1.68)
X_7 Post Attitude	.11*
	(2.74)
Constant — 0.65	
R^2 (Adjusted) — .33*	
F Statistic — 16.10	

* Significant at .05 level.

STUDENT REACTIONS TO TIPS

Another criterion used by the authors to discern the impact of TIPS was an analysis of several student response variables designed to gain information about student reactions to the TIPS surveys. Student reactions to TIPS were gauged from a series of questions on a special questionnaire administered during the final class meeting. These questions attempted to measure the usefulness of TIPS to the student as he/she perceived it. They also were designed to measure the degree to which students took advantage of the information TIPS gave them concerning their areas of strengths and weaknesses. Some evidence concerning the extent to which optional TIPS assignments were completed is shown in Table 4.

According to Table 4, about four out of five students completed at least some of the optional TIPS assignments. The benefits provided by TIPS *as perceived by students* are summarized in Table 5.

As is easily observed, most students attributed "some" or "a great deal" of contribution toward learning because of TIPS. In order to investigate these data further, several of the above variables were cross-tabulated to test the significance

TABLE 4. TIPS assignments completed by students

Student Response (Category)	Frequency	Percent
None	32	16.1
Some	43	21.6
Most	67	33.7
Always	51	25.6
Missing	6	3.0
TOTALS	199	100.0

of the relationships between student responses to TIPS. The chi-square test for independence was used. Each student in our sample was classified according to two criteria for each of the chi-square tests for independence. Given an r X c contingency table, the null hypothesis is that the event "an observation is in row i" is independent of the event "that an observation is in column j," for all i and j. For example, the responses to questions concerning "asignments done" and "did TIPS help you understand economic concepts" were revealed to have a significant association by a chi-square of 17.07, which is significant at $\alpha = .009$ (Table 6).

In addition, the positive direction of association may be inferred from the contingency table and from Kendall's Tau value of 0.207 which is significant at $\alpha = .0002$. Thus, it may be inferred that "more TIPS assignments completed" was associated with a "more favorable perception by students of the help they received from TIPS" in understanding economic concepts.

TABLE 5. Student perceptions of the benefits of TIPS

	Did TIPS help identify problem areas for you?		Did TIPS help you keep current with course material?		Did TIPS help your understanding of Economic Concepts?		DID TIPS reinforce your understanding of Economic Concepts?		Did TIPS help stimulate your interest in Economics?	
Category	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Not at all	18	9.0	14	7.0	21	10.6	18	9.0	47	23.6
Some	95	47.7	90	45.2	116	58.3	125	62.8	118	59.3
A great deal	80	40.2	89	44.7	56	28.1	48	24.1	28	14.1
Missing	6	3.1	6	3.0	6	3.0	8	4.0	6	3.0
TOTAL	199	100.0	199	100.0	199	100.0	199	100.0	199	100.0

TABLE 6. Results of cross-tabulations of assignments done and instructor rating for TIPS-related "how" questions

Questions Cross-tabulated	Chi-square	Sig.	Tau C	Sig.
1. Help Understand Concepts; Assignments Done	17.07	.009	.21	.0002
Help Understand Concepts; Instructor Rating	32.04	.00001	.25	.00001
2. Identify Problem Areas; Assignments Done	2.56	.86	.02	.37
Identify Problem Areas; Instructor Rating	13.65	.03	.19	.001
3. Help Keep Current; Assignments Done	8.48	.20	.17	.003
Help Keep Current; Instructor Rating	12.12	.06	.15	.006
4. Reinforce Understanding; Assignments Done	11.40	.08	.14	.01
Reinforce Understanding; Instructor Rating	31.69	.00001	.25	.00001
5. Stimulate Interest; Assignments Done	7.50	.28	.16	.004
Stimulate Interest; Instructor Rating	24.78	.0004	.23	.0001

Subsequently, instructor rating and student perceptions of the help TIPS gave them in understanding economic concepts were cross-tabulated. The instructor question asked the students to rate the instructor relative to other instructors at the university. These results are shown in Table 6. The chi-square of 32.04 is significant at $\alpha = .00001$ as is Kendall's Tau C of .254 which indicates a positive association between the higher "instructor rating" and higher student rating of the "help TIPS gave them in understanding economic concepts."

In a similar fashion, each of the other TIPS-related "how" questions mentioned above were cross-tabulated with assignments done and instructor rating. These results are also listed in Table 6.

It is worthwhile to note that student perceptions of the help that was given them in all areas by TIPS were positively associated with increased use of the system. In addition, their assessments of help provided by TIPS were positively associated with instructor ratings. Thus, both the use of TIPS and instructor ratings (as perceived by students) were associated with the overall value of the TIPS system. This seems to imply that TIPS was not a substitute for instruction but instead was a valuable aid to the instruction process. In fact, TIPS together with the instructor may bring about a synergistic effect on learning economic principles.

Previous research indicates that the use of TIPS led to substantial increases in the number of Economics majors. In recent years our experience with majors has been somewhat similar except that we have no evidence that this occurrence is associated with TIPS. Although the number of majors is up by more than 100 percent over three years, the authors are inclined to attribute this to various causal phenomena, one of which may be TIPS.

Regarding the impact of TIPS on student achievement (as measured by grades) the evidence is mixed. Generally, the class grade point averages for all classes using TIPS have been higher than those not using TIPS, based on

historical comparisons with the same instructors. There are a number of reasons why this is logical but the main influence is believed to be the point incentive system which the authors tied to the use of TIPS. In a recent semester approximately 7 percent of the students were able to raise their grade simply because they completed the surveys and did the assignments. Additionally, the average grade point for students that used TIPS "more than 50 percent of the time," was consistently between one-half and one full grade level above the class average. This has been the case over four semesters of continuous use.

It is also important to note, however, that there is typically a sizable group of students who choose not to use TIPS (usually better than 25 percent). These same students seem to do poorly in the course. Although data for all classes have not been examined, a sample of two large sections revealed that students who did not use TIPS achieved an average GPA which was considerably below 2.00. In this sample, more than two times as many students received D's and F's as opposed to A's and B's, although most students not using TIPS earned a C.

DISCUSSION

Based on an analysis of data collected for the 1975-76 academic year, as well as a continual subjective evaluation over a four semester period, it is the opinion of the authors that the benefits associated with TIPS are significant, especially for colleges and universities that are "stuck" with large introductory classes in economics.

First of all, TIPS is not expensive to buy or to use so long as the initiator is willing to commit the desired quantity of time to its preparation and implementation. Installation and experimentation costs run about $1,500 unless there are some unusual problems (which there may be). Assuming the university computer center bears all computer costs, the department outlay of variable costs is limited to some GTA time (about 10 hours per week), secretarial help and paper costs. Costs per student for large lecture classes (150-200) prove to be quite manageable and will normally not be a major deterrent to usage. In fact, the major cost of TIPS is probably other foregone faculty activities which may also enhance student comprehension of course subject matter.

TIPS contains a good feedback mechanism for both faculty and students and as such provides the instructor with information on student progress prior to the completion of unit exams. TIPS is neatly tied to a program of instruction which permits a significant individualization of instruction. Students in large classes are thereby given some kind of identity, even though this is accomplished through a computer message. Most students appreciate this effort.

TIPS also is very flexible; it does not necessarily need to be tied to the traditional format of economic principles. It is true that TIPS surveys are given to students based on a pre-specification of concept areas but the instructor can arrange the instructional format to fit the student's preferences. In fact, TIPS forces the instructor to decide *a priori* the subject matter to be covered by concept areas. TIPS also allows instructors the option of using a class debate format for

those students who excel in the class. This is particularly effective for smaller sections where interactions between students are comfortable.

There are several reasons, however, which suggest that TIPS is less than perfect as a teaching aid. Somewhat bothersome, in theory at least, is whether or not the most significant benefits accruing to students are associated with the completion of the surveys as opposed to the completion of the assignments which are given based on survey performance. For example, students often make comments to the effect that "if nothing else TIPS helps me keep up." Conceivably, the mere administration and grading of surveys may account for the vast majority of benefits associated with the TIPS system. The individualization of assignments, which is the unique contribution of TIPS, may be the least valuable of its components. Our suspicions here are evidenced somewhat by a decision to develop an incentive system to assure more extensive completion of the student assignments made by TIPS. At this point, however, these matters are mere speculation.

Research findings by the authors confirm that TIPS is not a panacea for all the problems associated with poor or mediocre instruction, but it can be of significant assistance to the instructor who wants to create a system of communication with large numbers of students. The point is that many instructors, no matter how talented, are physically overwhelmed by classes ranging from 100-300 students. In these circumstances TIPS can help. By no means, though, should the availability of TIPS constitute a rationalization to combine, for example, four (or more) sections of 40 students in a mass lecture. TIPS currently is being used in courses ranging from chemistry to philosophy in several academic institutions; as such, one could envisage TIPS becoming the administrator's dream; that is, cutting instructor costs by extensive utilization of mass lectures for survey type courses while using computer-assisted instruction to make up the difference. Despite the variety of teaching gimmicks which are currently available, there is, in our view, still no substitute for a good instructor in a classroom setting which permits interaction with students on other than a pure lecture basis.

By way of summary, TIPS is, in our opinion, a useful addition to the "bag of tricks" available to educators to improve both the cognitive and the attitudinal dimensions of learning. The decision to use it requires a commitment of time and resources but most instructors will find the effort worthwhile.

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A PRECEDENT FOR KANT'S CRITICAL PROGRAMME

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ABSTRACT

From antiquity onwards, philosophers have made repeated attempts to fit all departments of human knowledge into a common scheme; and earlier efforts to do this seem to have influenced later ones. By "Kant's critical programme" we may understand his endeavor to canvass all areas of human concern (science, morality, taste) and to isolate their *a priori* elements. In the present paper, after the methodological significance of the term "precedent" has been explained, a passage from Kant's *Grundlegung zur Metaphysik der Sitten* (1785) is compared with the concluding chapter of Locke's *An Essay Concerning Human Understanding* (1690), and the latter is claimed to be a precedent for the former.

INTRODUCTION

In this paper, I wish to comment on Kant's point of departure in the *Grundlegung zur Metaphysik der Sitten*.[1] But first, some account of the approach here to be taken seems in order. In a recent study,[2] part of a methodology for establishing the literary genealogy for a particular piece of writing was outlined. Briefly, if, for our object of study, we can find some passage from an earlier work which is morphologically similar to that object, we call the passage a *precedent* for it. The precedent is regarded as a *sufficient* condition for the object of study, and, as the portion of the work for which the passage is taken to be a precedent approaches the whole work, the passage approaches the status of a *necessary* condition. In the paper just referred to, a feature of Anselm's ontological argument is taken as a precedent for one step in Kant's transcendental deduction of the categories in the *Critique of Pure Reason*. The claim is made, in other words, that the given feature of Anselm's argument is "where Kant got his idea for" his move in the transcendental deduction.

In order to illustrate the kinds of difficulty this approach entails, consider at least one objection. Citing precedents for a particular piece of writing might seem to detract from its author's originality. This is a valid inference about the approach sketched above, but not a fatal objection to it. In particular, the suggestion that anyone employs precedents can only be their slave is rejected. To describe some earlier passage as a sufficient condition for part of an author's work is to imply that the author in question regarded it as a sufficient condition for that part of his work. His contribution to the solution of his own problem will have been the insight that the precedent can be treated as a sufficient condition for some aspect or element of that solution. Pointing out this kind of connection does not so much detract from an author's originality as give us a much more precise estimate of that originality.

There is a difference between *citing* a precedent and *using* one; and it will be helpful to enumerate the logical possibilities in this connection. There are four cases: a) An author cites a precedent for what he claims to be doing and also uses it — that is, actually follows the precedent. b) He fails to cite a precedent for what he is doing, but (demonstrably) uses one. c) He claims to be using a precedent but (demonstrably) is not. d) He neither cites a precedent nor uses one. Of these possibilities, *d* may be dropped from further consideration, because, by hypothesis, no precedent is involved. As for *c*, it no doubt might happen that an author, though claiming to give a consistent account of reality, nevertheless contradicted himself by saying he was going to use (or had used) a certain precedent, even though there was no evidence of such use in his work. Such inconsistency on his part would either be deliberate (a rhetorical device) or accidental (a blunder). Which of these was the more plausible explanation would vary from one instance to the next. Hence, no further generalization about such situations seems appropriate. In the present study it is cases *a* and *b* which are of special interest. An example of *b* has already been mentioned: In his transcendental deduction Kant no where mentions Anselm's ontological argument. The example to which this presentation turns falls under case *a*. As shall be seen, however, its accurate classification will necessitate complicating the above four-fold scheme.

DISCUSSION

At the very beginning of the *Grundlegung*, Kant writes: "Ancient Greek philosophy was divided into three sciences: physics, ethics, and logic. This division conforms perfectly to the nature of the subject . . ." (386f). Kant does not tell us with whom, precisely, he is aligning his thought. Such a division is suggested in Aristotle's *Topica*, i. 14 (105 B 19),[3] and is reported of Zeno the Stoic in Diogenes Laertius vii. 39.[4] The latter passage ought to have appealed to Kant, inasmuch as Diogenes goes on to mention various subsequent complications of Zeno's trichotomy. Though endorsing the division, Kant opines that, "one can improve on it perhaps only by supplying its principle in order both to insure its exhaustiveness and to define correctly the necessary subdivisions" (387). He then assigns physics and ethics to the "material" part of rational knowledge, and logic to its "formal" part. Physics and ethics deal with definite objects and the laws to which they are subject. The laws of physics — "laws of nature" — are those according to which everything happens. The laws of ethics — "of freedom" — are laws according to which everything *should* happen (387f). But Kant also divides rational knowledge — now called "philosophy" (388) — into "empirical" knowledge, derived from experience, and "pure" knowledge, derived from *a priori* principles. Pure, formal knowledge is logic. Pure, material knowledge is metaphysics, and, depending upon its objects, will be either the metaphysics of nature or of morals. The upshot is that Kant divides physics into a pure and an empirical part, and makes a like division of ethics. Logic, he maintains, can have no empirical part. However, as he makes clear presently (390), he has not abandoned the distinction he made in the first *Critique*

(A 55-57) between "general" logic and "transcendental" logic (here "transcendental philosophy"). In point of fact, therefore, Kant divides each of the ancient parts of science into two sub-parts.

Here, as noted, Kant's appeal is to an *ancient* precedent. But, as it happens, there exists a precedent for just this sort of apportionment in an author almost contemporary with Kant. In the final chapter of his *Essay*[5] (IV, xxi, 1-5), John Locke divides "the intellectual world" into three "domains," φυσικη, πρακτικη, and σημειωτικη of which physics ("natural philosophy"), ethics, and logic are respective subdivisions. Like natural philosophy, φυσικη treats of "matter and body," but also studies "spirits" (§2). While ethics seeks out "the rules and . . . actions which lead to happiness and the means to practice them," πρακτικη is "the skill of right applying our powers and actions, for the attainment of things good and useful" in general (§3). Similarly, logic would appear to be a consideration of words as signs employed by the mind in communication; whereas σημειωτικη deals with ideas as well as words (§4). Φυσικη, Locke says, investigates "things as they are in themselves, their relations and their manner of operation" (§1), Its end is "whatever can afford the mind bare speculative truth" (§2). The end of πρακτικη is "right and a conduct suitable to it" (§3). As for σημειωτικη, Locke explains that, "since the things the mind contemplates are none of them, besides itself, present to the understanding, it is necessary that something else, a sign or representation of the things it considers, should be present to it: and these are *ideas*" (§4). He continues: "The consideration, then, of *ideas* and words as the great instruments of knowledge makes no despicable part of their contemplation who would take a view of human knowledge in the whole extent of it. And perhaps if they were distinctly weighed and duly considered, they would afford us another sort of logic and critique than what we have hitherto been acquainted with" (§4).

The *Grundlegung zur Metaphysik der Sitten* appeared in 1785. It had been preceded in 1781 by the *Kritik der reinen Vernunft*, and was followed in 1788 by the *Kritik der praktischen Vernunft*. Whereas Kant's aim in the first *Critique* had been "to isolate and give a systematic account of the *a priori* elements in scientific knowledge,"[6] his aim in the *Grundlegung* and the second *Critique* was to do the same for the *a priori* elements in morality. Anyone familiar with these works will find several of their most characteristic features anticipated in Locke's final chapter. These would include: 1) the peculiar trichotomy of the branches of knowledge; 2) the setting aside of a branch of knowledge to investigate "things . . . in themselves" (cf. Kant's "*Dinge-an-sich*."); 3) the suggested distinction among different kinds of *practical* rules (cf. Kant's "Rules of Skill, Councels of Prudence, and Laws of Morality."); 4) the designation of ideas as "representations" (cf. Kant's "*Vorstellungen*."); and 5) the suggestion that, if the instruments of knowledge were distinctly weighed and duly considered, they might yield a new sort of "critique." In view of these points of connection, the possibility certainly suggests itself that Kant not only read the chapter from Locke but used it as a kind of blue-print for his own philosophizing.

Previous scholarship has neglected this apparent link between Kant and Locke. Kemp Smith, for instance, traces Kant's use of *Kritik* to Henry Home's *Elements of Criticism* (1762).[7] One reason for this neglect might be the following: In his final chapter, Locke is using a precedent but not citing it — essentially the same precedent ("ancient Greek philosophy") which Kant in the *Grundlegung* cites and uses. Anyone conversant with the history of philosophy, turning from Kant to Locke, would be reminded of the ancient precedent which they both use, and might tend to focus attention on it rather than on the peculiar use Locke makes of it. Be this as it may, we can at least say that, if the passage from Locke actually did influence Kant, then the opening paragraphs of the *Grundlegung* present us with a passage in which an author cites and uses one precedent and simultaneously fails to cite but also uses another.

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THE CONCEPTION OF SOCIAL AND POLITICAL DEVELOPMENT IN THOMAS PAINE'S *RIGHTS OF MAN*

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ABSTRACT

Past research has identified the general features of Thomas Paine's theory of historical development in *The Rights of Man*, but a detailed and coherent account has not been previously produced. This paper is intended to provide such a detailed account by textual analysis of *The Rights of Man*. Paine considered history to be man's search for his place in nature's structure. Each stage is a social experiment to determine man's place. Passion motivates man in his search and reason provides an intuitive idea of nature's possible structure. The level of technology identified by reason is the fundamental determinant of the structure of society at each stage. Government is necessary for order in those stages when man has not found his place in nature. When technology is developed to a level at which all human wants can be secured, man will have found his place in nature and government will be unnecessary.

INTRODUCTION

Thomas Paine's theory of social and political development in *The Rights of Man* is a topic which has been infrequently discussed in scholarly literature until recently.[1] The research which has been done on this aspect of Paine's thought and related topics has indicated that Paine was an exponent of a progressive theory of human historical development founded on a belief in human secular perfectability. This belief was distinguished by a faith in the inherent developmental character of science and technology which would produce greater moral awareness among men and improvement in the human condition. The sources in which Paine's theory of historical development have been discussed have dealt with the general characteristics of this aspect of Paine's thought, but have not provided a philosophically detailed and coherent analysis. This paper is intended to supplement previous research by providing such a more detailed analysis.

I

Paine appears to have considered man to fill a particular place or role in a universal scheme. He said, "... she [nature] fitted him [man] for the station she intended."[2] This "station" is reflected in the laws of nature, and man, being "fitted" for his station, has the ability to behave in conformity with his natural place.

Paine can be understood as having viewed *The Rights of Man* as a scientific study of the laws of human nature. Unlike the necessary (deterministic) laws of physical nature, the laws of human nature are dispositional and probabilistic. This

dispositional quality of the laws of human behavior is indicated, for example, by Paine's assertion of the ability of government to interfere with the functioning of the laws of human nature.[3] The probabilistic nature of the laws of human nature is a product of human freedom. Man unlike matter is free — that is, self-determined rather than other-determined. Being "fitted" to his natural station, however, man inherently strives to fulfill his place in the scheme of nature.

The basis of human behavior is the possession of infinite wants. Paine made this clear when he said, "When man ceases to be, his power and *his wants* cease with him . . ."[4] By satisfying these inherent wants, man realizes his station in the scheme of nature. These wants appear naturally to man. In order to satisfy them, intelligence or reason is necessary. Intelligence, however, will occur only if stimulated or caused by wants or emotion. Paine indicated this when he asserted "There is existing in man a mass of sense lying in a dormant state, and which, unless something excites to action, will descend with him, in that condition, to the grave."[5] Thus, in contrast to the prevalent view of ancient Greek and Medieval philosophers, Paine viewed intelligence as the servant of passion and not passion as the servant or enemy of reason. Paine also would appear to have been a metaphysical idealist. The world for man was as man conceived it, not as man perceived it. He said in this respect that, "Monarchy, Aristocracy, and Democracy, are but creatures of imagination; and a thousand such may be contrived as well as three."[6] There would appear no reason to doubt that Paine considered all human institutions to be "creatures of imagination" just as the forms of government, and that all institutions could be "contrived" in a multitude of ways.

Human imagination would occur in response to the inefficiences of existing institutions[7] among those who would not benefit from the inefficiencies. Paine did not make clear in the *Rights of Man* the means by which new transcedent ideas would occur. They would, however, appear to, ". . . bolt into the mind of their own accord," as indicated in *The Age of Reason*.[8] They would presumably issue forth from the "mass of sense" lying within each individual. Such an exposition would appear consistent with the other aspects of the epistomological theory developed in the *Rights of Man*. New ideas could not be produced by a process of formal reasoning. Formal reasoning could only derive the implications of existing conceptions; it could not transcend these conceptions and derive new conceptions.[9]

The standards of validity for all concepts were indicated in the following passage:

> In contemplating the French Constitution, we see in it a rational order of things. The principles harmonize with the forms, and both with their origin.[10]

What appears indicated by the comment that, "the principles harmonize with the forms. . . ," is that the validity of a concept would be a function of its internal consistency. There could be no contradiction among the inferences entailed by a concept. Validity, however, would also be a function of the harmony of the principles and forms of a concept with "their origin." The origin of a concept would be an intrinsically valuable end which would give purpose to the concept. A concept

would have purpose only insofar as it served as a means to such an end, and would be justified to the extent that it secured this end. The end by which government and presumably all institutions are to be judged is general happiness.[11] The meaning of "general happiness," however, was never made clear by Paine.

Paine asserted that the validity of a concept would be known directly upon consideration of the concept. Presumably because the criteria of validity would be logical, the validity of a concept could be known directly and *a priori*. *A posteriori* empirical verification would be unnecessary. The moral qualities of each alternative conception will be intuitively identified and weighed. As Paine noted, the mind will consider the merits of all ideas that appear to it.[12] The method of consideration will be a weighing of moral qualities.[13] When the most moral alternative is determined, it will be implemented. Given the alternatives considered and the knowledge available, that alternative which is most moral will benefit men to the greatest extent.[14]

The assumption that what is most moral will benefit man to the greatest extent can only be explained if it is assumed Paine accepted the eighteenth century notion of the economy of nature. The universe in this concept is considered what in contemporary terms could be spoken of as a balanced ecological system in which each part plays a necessary functional role. The maintenance of the universal system is the greatest good and man's intuitive moral sense is the means by which he understands the structure of the universal system. Each part of the universe, including man, is naturally constituted to strive to fulfill its function. This natural or inherent striving appears in man in the form of his wants. Happiness is the satisfaction of his wants and the consequent realization of his universal functional role. If each part of the universe fulfills its role, the universe will be efficient and produce the resources necessary for the continued functional production of each part. If each part does not fulfill its role, the universe will be inefficient and not produce the resources necessary for the continued functional production of each part. In effect, Paine conceived of the universe as a gigantic self-sufficient division of labor in which the productive function of each constituent was necessary to produce the resources needed by each part to continue its productive role at an optimal level. Thus, man will benefit and be happy only if he behaves in conformity with his sense of morality.

Man's failure to fulfill his universal function can only be a product of ignorance.[15] Ignorance itself is a function of two things: first, the failure to produce the ideas necessary to discovering the means to satisfy an individual's wants;[16] and second, ignorance of facts. Ignorance of facts will lead an individual to conclude that a state of affairs is the case when in fact it is not the case. Such a misunderstanding will cause an individual to do what would be moral in the state of affairs he believes is the case, but is not moral in the existing state of affairs.

II

Having asserted that inherent and infinite wants are the basis of human behavior, Paine summarized the nature of these wants in the following passage:

> In all cases [nature] made [man's] natural wants greater than his individual powers. No one man is capable, without the aid of society, of supplying his own wants; and those wants acting upon every individual, impel the whole of them into society, as naturally as gravitation acts to a centre.
>
> But she has gone further. She has not only forced man into society by a diversity of wants which the reciprocal aid of each other can supply, but she has implanted in him a system of social effections, which, though not necessary to his existance, are essential to his happiness.[17]

Paine appears to have recognized two categories of human wants, the first necessary for life and the second necessary for happiness or the good life. Man seems self-sufficient in his ability to satisfy the wants necessary for life since the social affections are, ". . . not necessary to [his] existence." Man, however, is not self-sufficient in his ability to satisfy the wants necesssary to the good life or happiness. As Paine noted, "In all cases [nature] made [man's] natural wants greater than his powers. No one man is capable, without the aid of society, of supplying his own wants . . ." An implication of Paine's categorization of human wants appears to be that the earth is abundant in the resources necessary for life but scarce in the resources necessary for the good life. This seems indicated by Paine's assumption of man's self-sufficiency in securing his existence, but lack of self-sufficiency in securing his happiness. In order to secure the goods necessary for happiness from the scarce resources of the earth, the productive efficiency of an economic division of labor is necessary. This division of labor is manifested in society. Society is nothing more than an economic system which appears in response to the need to produce the goods necessary to satisfy the human wants for happiness or the good life. It is a structure of labor in which each member fulfills the productive role for which he is best fitted by nature in order to secure for a group of men maximal efficiency in the production of the goods necessary to each member's happiness. Thus, society is a natural product of man's nature.

Society seems to appear almost simultaneously with man. It can be assumed that man cannot be expected to seek after the good life until life is assured. The apparent ease, then, in securing the goods necessary to life seems to indicate that society appears almost simultaneously with man. This view is supported by Paine's comment, "There is no period in life when this love for society ceases to act. It begins and ends with our being."[18]

III

Paine's account of the structuring of society was expressed in the following passage:

> Whether the forms and maxims of Governments which are still in practice were adapted to the condition of the world at the period they were established is not in this case the question. The older they are the less correspondence can they have with the present state of things.
>
> Time, and change of circumstances and opinions, have the same progressive effect in rendering modes of Government obsolete as they have upon customs and manners. Agriculture, commerce, manufactures, and the tranquil arts, by which the prosperity of Nations is best promoted, require a different system of Government, and a different

species of knowledge to direct its operations, than what might have been required in the former condition of the world.[19]

What Paine said of government in this passage can be considered his view of all social institutions ("customs and manners"). Therefore, the basis of all social development is technology — *i.e.* "agriculture, commerce, manufactures, and the tranquil arts." Technology sets limits to the extent to which a community can satisfy its wants. The members of a community will create those institutional structures which will provide for the maximal possible gratification of their wants given the level of technological development of the community. Assuming a stable technological capacity, the appearance of the most efficient social structure will occur over time. As wants appear to the members of society, they will experiment with the available technology, identifying from the alternatives available the most efficient method of production. Having identified what is considered the most efficient method of production, each will make others aware of it. The various alternatives introduced will be rationally considered and debated by the members of the community, and over time the most efficient practicable means mutually recognized.[20] As the members of a community accept a means of production as best, each member will implement it in his behavior, participating in the construction of an institution. After implementation of an institution, alternative methods of production will still be considered, and if a more efficient method of satisfying a want is identified, it will replace the existing institutional structure.

Although Paine did not make it explicit, he seems to have believed that what is recognized by the members of a community as the most efficient means of production would be implemented because every individual affected by it would find himself better off.[21] Distinctions beyond the minimal condition of mutual benefit may occur among those affected by an institution. They would, however, "... be founded only on public utility."[22] Any other structural alternative considered will not be accepted by the members of a community because it will be less efficient and benefit them to a lesser extent.

A change in the level of technology will render existing modes of production obsolete. More efficient modes of production will be identified and implemented. Expansion in society will also make it possible to satisfy wants which previously could not be satisfied. In this way the number of institutions in society will increase, providing for the greater happiness of man. Thus, society will experience a radical change in its structure. The change, however, will occur slowly as the new technology is experimented with, and institution is built upon institution as each want of the members of the society is considered individually.

A basic principle in this conception of social development is the value of freedom.[23] Social development advances in proportion to the extent of human freedom. Freedom makes possible the introduction of all identified means of production, the greatest possible consideration of alternatives, and speedy implementation of the most efficient method of production. This effectiveness of freedom as a means of producing the institutions providing for human happiness

will only be possible if human freedom is a part of the scheme of nature and man's station in it. As such, it is an inherent or natural right of man and intuitively recognizable by all.

IV

Government for Paine was an institution of society which appeared comparatively late in social development.[24] As a social institution, government comes into being in order to improve the productive efficiency of society.[25] It is, as is every social institution, an economic institution.

Crime is a product of ignorance, which causes error in moral judgments. As such, it can never be wholly eliminated, although it presumably can be reduced by reformative education. Crime reduces a victim's ability to gratify the wants of others to the greatest possible extent. Crime is the reduction of individual productive potential through death or maiming or the reduction of the ability to utilize individual productive potential through theft. Whether individual potential is reduced, or the ability to utilize individual potential is reduced, production will be lessened and the members of society "cheated" of a level of happiness they would otherwise have.

Society by itself is capable of controlling crime, but less perfectly than is government.[26] Each individual has a natural right to punish those who violate the rights of others, but this right can only be exercised imperfectly without government.[27] Paine may have been assuming here, as did Locke, that because punishment exercised in an *ad hoc* and personal manner will ordinarily be administered by those injured or persons close to them, it will tend to be affected by emotion. Passion will blind moral judgment and lead to excessive punishment or punishment for imagined offenses. Additionally, since some are stronger than others, the weaker will be unable to punish the stronger.[28]

Government can alleviate the injustices of personal punishment by acting as an unbiased third party in disputes and by having the strength to punish any offender. Paine made it clear, however, that as society progresses it will develop institutional methods of punishment more efficient than government, making government ultimately unnecessary.[29] Thus, government will presumably "wither" away and be replaced by a more effective anarchy.

V

In order to understand how government comes into being, it is necessary to distinguish between the alienable and inalienable rights of man. The wants of an individual can only be gratified by the exercise of his natural rights. Because no man is self-sufficient, no individual can perfectly exercise all of his natural rights by himself. To be secured in his wants, the individual must alienate or give up those rights he can exercise only imperfectly to those who can exercise them more perfectly.

The rights an individual can exercise perfectly are inalienable. There would be no advantage in alienating such rights. If rights of this sort were alienated, they

might be exercised less perfectly or not at all, leaving the individual worse off. Paine said "Man did not enter into society to become *worse* than he was before, not to have fewer rights than he had before, but to have those rights better secured."[30] As Rousseau indicated,

> To say that a man gives himself gratuitously, is to say what is absurd and inconceivable; such an act is null and illegitimate, from the mere fact that he who does it is out of his mind. To say the same of a whole people is to suppose a people of mad men; and madness creates no right.[31]

Society comes into being when a group of individuals mutually consent to alienate or give up those natural rights which they can exercise only imperfectly to those who are mutually accepted as being able to more efficiently exercise them for the benefit of all. This is what Paine apparently meant when he spoke of an individual joining society by "depositing" or "throwing" those rights he could exercise only imperfectly into "the common stock of rights of society."[32] The rights which an individual receives in exchange for his natural rights by such an act of mutual consent are civil rights. No individual is obliged to accept any distribution of civil rights unless he consents to it because the right to judge what is in one's best interest is inalienable.[33] Social development occurs when the members of a community exercising their inalienable right to determine what is in their best interest mutually consent to redistribute their civil rights in a way which will benefit them all to a greater extent.

Government appears as an institution of society in the process of social development. A logical precondition of government is the mutual agreement of a group of individuals to establish it.[34] Agreeing to establish government, the members of the group must create a constitution.[35] If there is no constitution, government can not exist. It will be impossible to know the authority of any individual because there will be no objective standard as a basis for appeal. Such a constitution must also be written to exist. If it is not, then it will be subjective and interpretation will be relative to individual judgment.

Acceptance of a constitution alienates the right of punishment. Each member of society consents with every other to give up his right of punishment to some other or others.[36] Consent cannot be with government because government cannot exist (be constituted) until the right to punish is alienated to it by public acceptance of a constitution. As with Locke, Paine maintained that government holds political authority as a fiduciary trust for the members of the community.

The right to punish is alienated because it can only be exercised imperfectly by each individual and each will be better off if it is exercised by government.[37] The authority of government is limited to the rights alienated to it by the act of consent. If members of government act outside of this authority they are committing assault — *i.e.* tyranny — and are not acting as governmental officials. In this circumstance, there is no obligation to obey them.

Paine considered the responsibility for judging the exercise of punishment to be inalienable. The individual retains this responsibility and can disobey when deemed justified. There are limits to justified disobediance, however. Presumably,

since government is composed of men, it can be expected to periodically commit injustices because of errors of ignorance, although its general conduct may be just. In such instances, "... it is better to obey a bad law, making use at the same time of every argument to show its errors and procure its repeal, than forcibly to violate it; because the precedent of breaking a bad law might weaken the force, and lead to a discretionary violation of those which are good."[38]

If government rules without consent or is disposed to act outside the authority granted to it by consent, it rules by force and is tyrannous. Political change or revolution will be justified in this instance, however, only if it will produce great national benefit.[39] If revolution is justified, then it should be pursued by reason and discussion and force should be appealed to only if these means are repressed.[40] The great danger is the use of force when public attitude is incensed. Justified change will tend to be accompanied by unjustified violence motivated by a sense of revenge. Such revolution, however, will not lead to the destruction of society. Contrary to Hobbes, Paine assumed that when men, "... have habituated themselves to social and civilized life, ... it is almost impossible to put [them] out of it."[41]

VI

Paine's history of political development began with the assumption that primitive man, striving to establish the most efficient social institutions for gratifying his wants, created a system of direct democracy as his form of government.[42] In order to do what was in the best interests of a community, direct democracy provides the opportunity for each individual to make all others aware of his wants. In monarchy and aristocracy one or a few determine the wants of all others. Assuming that in general no one can know an individual's interests or wants better than himself, monarchy and aristocracy, drawing on a more inadequate source of knowledge, will tend to be more ignorant of these factors than direct democracy. Additionally, in order to determine the best means for securing the public interest in a circumstance, it will be necessary to determine the effects of alternative actions in similar past circumstances. The greater the number of such past circumstances considered, the better able one will be to determine what action in the present circumstance will be most likely to secure the public interest. No proportion of the members of a community less than all the members of a community could have as much knowledge of past circumstances as all the members of a community. Thus, a democracy in which all knowledge is shared will always be more knowledgeable than a monarchy or aristocracy drawing on the knowledge of one or a few. Monarchy and aristocracy can only become as knowledgeable as direct democracy if they encompass all members of the community into an advisory staff, which they are not disposed to do. Being more knowledgeable, direct democracy will be more likely than monarchy and aristocracy to do what is in the best interest of a community.[43]

Additionally, although the ideas necessary for producing the most efficient method of satisfying the wants of the members of a community will always appear

within society when needed, the individuals who will originate these ideas can never be predicted.[44] Democracy duplicates the method of development which occurs in society. It provides a forum in which the ideas of each member of the community can be freely interchanged and shared with every other member. The ideas are openly debated allowing each to gain the knowledge and insight of every other. With this knowledge democracy is able to determine the most efficient means of satisfying the wants of the members of society. In monarchy and aristocracy the government will tend to only be aware of the ideas of the one or few forming the government. Since these ideas are not likely to be the best, the actions of monarchy and aristocracy cannot be expected to be in the best interests of society. Monarchy and aristocracy will perpetually place man, "... in contradiction with himself."[45] By less adequately satisfying the wants of man, they restrain man from fulfilling his proper place in the universal scheme of nature.

As the level of technology develops, the number of individuals necessary to utilize it efficiently increases. Society naturally becomes larger, making direct democracy inefficient as a method of government. A form of democracy which can function efficiently with a large population is not devised for lack of ideas.[46] The most efficient forms of government which can be devised to deal with the increase in population are monarchy and aristocracy.

Monarchy and aristocracy, however, are inherently corrupt. Inbreeding among the members of an aristocratic community fosters genetic deterioration. The nobility, "... becomes in time the opposite of what is noble in man."[47] Additionally, monarchy and aristocracy alienate man from himself. Man's function in the scheme of nature is to act as a free — *i.e.* self-determining — and moral being. These characteristics are what identify man as a species. The failure to exhibit the characteristics of freedom and morality cause man to descend "below the stature of mental manhood."[48]

Unlike later developmental theorists such as Hegel, Emerson, and Marx, Paine considered man always capable of behaving freely and morally. The failure to exhibit these properties at any time is a product of ignorance. It is ignorance which produces monarchy and aristocracy; the inability of men to imagine a form of democracy which can function efficiently with a large population. In democracy the ruled are also the rulers. They are free because they rule themselves. They will also tend to behave morally because the wisdom of democracy allows them to determine what they ought to do. In monarchy and aristocracy, one or a few rule the many. The many must unquestioningly obey others. Thus, their behavior will be determined by others and they will be unfree. Men will also behave immorally because of the inherent ignorance of monarchy and aristocracy. Monarchy and aristocracy, therefore, "... turn the progress of the human faculties upside down."[49]

The American and French revolutions devised in representative democracy a form of democracy which could function efficiently with a large population. In representative democracy, assuming the representatives act as conduits for the interests and ideas of their constituents and not as representatives of their own in-

terests and ideas, the public interest can be determined as effectively as in direct democracy.[50] The representatives ideally will compose a unicameral body containing all legislative and executive authority in itself.[51] A multi-cameral body will allow a majority of one house, which at the same time is a minority of the whole legislature, to defeat legislation. Since no number less than the whole of the community can be as wise as the whole, such a system cannot be justified. It will create rule by an aristocracy. The representatives of the people must also control all functions of government. A separation of powers such as in a system of checks and balances will again allow a less knowledgeable one or few to rule the many. (Note the similarity of the structure of Paine's conception of representative government to the Articles of Confederation and most of the contemporary forms of local government in the United States.)

In such a system of representative democracy the people will rule themselves. They will be free and moral because their representatives will do only what the people desire.[52] The appearance of this form of government stimulated its recognition among all men, in Paine's view, ". . . and no sooner did the American Governments display themselves to the world than despotism felt a shock and man began to contemplate redress."[53]

CONCLUSION

In summary, Paine considered man a part of a universal order. The place of man in this universal order is fulfilled in a developmental process. The universal order can not be directly known. There is no inherent universal order from the perspective of man. The structure perceived will be determined by human definition. Human history is the struggle to determine the fundamental order of the universe and man's place within it. Passion is the driving force of change. It is inherent in human nature and incessant. Passion is the product of the fundamental structure of the universe and expression of man's desire for what will fulfill his place in this structure. Reason redefines the universal structure in order to provide for greater human happiness. The validity of such a redefinition is a function of the extent to which human happiness will be secured. Paine in this respect presaged the pragmatic definition of truth.

Because no man is self-sufficient, society appears in response to human desires as a necessary means for providing the division of labor needed to gratify the wants of man. Government occurs comparatively late in the process of social development as a means of controlling crime and its economic inefficiencies. Technology is the central factor affecting human development. It sets the limit to the extent to which man can satisfy his wants. Striving to satisfy his wants to the greatest possible extent, man develops in whatever way will allow for maximal gratification of his wants given existing technology. When, in the evolution of technology, a level is achieved such that the means necessary for man to fulfill his place in the fundamental structure of the universe can be produced, government will become unnecessary. There will be no scarcity relative to needs. Presumably, as Rousseau indicated, man will have no need to compete and each will express empathy for the condition of all sentient beings.[54]

FOOTNOTES

[1]See P.F. Nursey-Bray, "Thomas Paine and the Concept of Alienation," *Political Studies*, 16 (June 1968), pp. 223-242; Eric Foner, *Tom Paine and Revolutionary America*, (Oxford Press: New York, 1976), especially p. 91; Daniel Boorstin, *The Lost World of Thomas Jefferson*, (Henry Holt and Company: New York, 1948), especially pp. 176-177; Henry F. May, *The Enlightenment in America*, (Oxford University Press: New York, 1976), part III, chap. 1; Ernest Lee Tuveson, *Redeemer Nation*, (The University of Chicago Press: Chicago, 1968), pp. 66-67; John Passmore, *The Perfectibility of Man*, (Charles Scribner's Sons: New York, 1970), pp. 158-159, 195-196, and 200-201; Stow Persons, "The Cyclical Theory of History in Eighteenth Century America," *American Quarterly*, 6 (1954), pp. 158-163.

[2]Thomas Paine, *The Rights of Man*, (Dutton: New York, 1966), p. 157.

[3]"[Monarchy and presumably aristocracy as well] turns the progress of the human faculties upside down." *Ibid.*, p. 179.

[4]*Ibid.*, p. 13, italics mine.

[5]*Ibid.*, p. 172.

[6]*Ibid.*, p. 133.

[7]"The enormous expense of Governments has provoked people to think by making them feel. . ." *Ibid.*, p. 104.

[8]Daniel Edwin Wheeler, ed., *Life and Writings of Thomas Paine*, vol. I, (Vincent Parke and Company: New York, 1908), p. 68.

[9]*Ibid.*, p. 68; *Rights of Man*, p. 103.

[10]*Rights of Man*, p. 73.

[11]*Ibid.*, pp. 153 and 212.

[12]*Ibid.*, p. 104.

[13]*Ibid.*, p. 103.

[14]"The rights of men in Government are their advantages; . . ." *Ibid.*, p. 103. See also, "All the great laws of society are laws of nature . . . They are followed and obeyed, because it is the interest of the parties so to do . . ." *Ibid.*, p. 160.

[15]*Ibid.*, p. 148.

[16]*Ibid.*, p. 173.

[17]*Ibid.*, pp. 157-158.

[18]*Ibid.*, p. 158.

[19]*Ibid.*, p. 137.

[20]"When men unite in agreeing that a thing is good, could it be obtained . . . the object is more than half accomplished. What they approve as the end they will promote in the means." *Ibid.*, pp. 279-280.

[21]"[The laws] of trade and commerce, whether with respect to the intercourse of individuals or nations, are laws of mutual and reciprocal interests. They are followed and obeyed, because it is in the interest of the parties so to do . . ." *Ibid.*, p. 160, italics mine.

[22]*Ibid.*, p. 125.

[23]See for example *Ibid.*, p. 12.
[24]*Ibid.*, pp. 159-160.
[25]"Government is nothing more than a national association; and the object of this association is the good of all, as well individually as collectively. Every man wishes to pursue his occupation, and to enjoy the fruits of his labours and the produce of his property in peace and safety, and with the least possible expence. When these things are accomplished, all the objects for which Government ought to be established are answered." *Ibid.*, p. 198.
[26]*Ibid.*, p. 158.
[27]*Ibid.*, p. 45.
[28]John Locke, *The Second Treatise of Government*, (The Bobbs-Merrill Company, Inc.: Indianapolis, Indiana, 1952), p. 71.
[29]*The Rights of Man*, p. 159.
[30]*Ibid.*, p. 44.
[31]Jean Jacques Rousseau, *The Social Contract and Discourses,* translated by G.D.H. Cole, (E.P. Dutton and Company, Inc.: New York, 1950), p. 8.
[32]*The Rights of Man*, pp. 44-45.
[33]*Ibid.*, p. 45.
[34]*Ibid.*, p. 47.
[35]*Ibid.*, p. 48.
[36]*Ibid.*, p. 47.
[37]*Ibid.*, p. 45.
[38]*Ibid.*, p. 146.
[39]*Ibid.*, p. 149.
[40]*Ibid.*, p. 279.
[41]*Ibid.*, p. 159.
[42]*Ibid.*, p. 173.
[43]*Ibid.*, pp. 134-135, 171, and 175-176.
[44]*Ibid.*, p. 171.
[45]*Ibid.*, p. 172.
[46]*Ibid.*, p. 173.
[47]*Ibid.*, p. 172.
[48]*Ibid.*, p. 172.
[49]*Ibid.*, p. 179.
[50]*Ibid.*, p. 176.
[51]*Ibid.*, pp. 198-201.
[52]*Ibid.*, p. 130.
[53]*Ibid.*, p. 151.
[54]Rousseau, p. 223.

LOCKE, LIBERALISM AND THE DECLARATION OF INDEPENDENCE

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ABSTRACT

The history of American political thought has evolved under a general consensus that John Locke was chief architect of the American political tradition. Americans have readily assumed that it was Locke who provided their early political spokesmen with a text ready made for use in justifying a revolution and in patterning a subsequent, viable form of government. However, research in colonial newspapers and pamphlets finds no basis to assume his influence to be any greater than any number of other English or colonial thinkers. Locke was cited selectively from a "radical Whig" — Commonwealthmen — strain of liberal thought. This strain of thought has not been identified well within the liberal tradition which, in fact, comprises a psychological and bourgeois strain. The result is that scholars have poorly interpreted Locke's role in the American political tradition and, more broadly, poorly understood and interpreted the liberal tradition in America.

INTRODUCTION

On the eve of America's bicentennial it is commonplace to resort to our past, to retrace the fountain sources of America's tradition and to pay homage to the principles and political theories cast in the wake. So let it be with John Locke. The history of American political thought has evolved under a general consensus that John Locke was chief architect of the American political tradition. His is the influence commonly assumed to have transformed thirteen British colonies into a group of independent states united freely within a unique federal system of government.

Locke wrote in the *Second Treatise* that in the beginning all the world was America, for the America of his time appeared to be ample evidence for his political philosophy. If Locke felt that early colonial America fit appropriately into his theory of government, Americans since have been just as willing to assume that it was Locke who provided their early political spokesmen with a text ready made for use in justifying a revolution and in patterning a subsequent, viable form of government.

The assumptions of John Locke's role and impact on America have been common, near universal, assumptions — taken for granted and allowed to stand for too long a period of time. It is striking that claims of Locke's significance in American thought have gone virtually unchallenged — a general willingness to accept his influence without really questioning if the debt is truly owed. The general claim to Locke's influence was representatively summarized by a classic text on American political thought:

> The patriots were familiar with this philosophy of their English predecessors and they followed it closely. They referred to these writers, quoted from them, and adopted the

substance of their argument, and in some cases the form as well. Locke, in particular, was the authority to whom the patriots paid greatest deference.[1]

Similarly, Vernon Parrington wrote in his *Main Currents in American Thought*:

> The argument of Locke went home with such convincing force to the colonial liberal because it embodied conclusions toward which America had long been moving. It was an eloquent confirmation of native experience, a sober justification of the psychology of individualism.[2]

If Parrington drew the conclusion more on circumstance than on America's direct debt to Locke, his response was none the less enthusiastic.

One of the earliest commentators of Locke's influence was Archibald Coolidge who, while preceding Parrington by nearly half a century, was none the less confident in assessing Locke's place in America. In asserting Locke's influence as "hardly less in America than in England," he concluded, "Locke's theories fit perfectly with the argument of the colonies during the dispute with the Mother Country."[3]

John C. Miller, a recognized authority on this period of America's history, offered the impression that most typically represented the feeling toward Locke:

> At every turn, Locke's principles stood Americans in good stead and confounded imperialists. It is not remarkable that Americans enthusiastically adopted Locke as their guide and prophet.[4]

Numerous authors attempted to illustrate exactly what in Locke influenced the revolutionary patriots. The most frequent examples not surprisingly referred to natural rights, revolution and the second paragraph of the Declaration of Independence.

> It is well known that the second paragraph of the Declaration of Independence, that in which the general theory of government, and in particular the right of revolution against an unjust government, are set forth, is a paraphrase of certain of Locke's statements.[5]

Lest the Declaration be considered a paraphrase of some Puritan documents that antedated Locke, Carl Becker specifically noted: "Most Americans had absorbed Locke's works as a kind of political gospel; and the Declaration in its form, in its phraseology, follows closely certain sentences in Locke's *Second Treatise on Government*."[6] Elsewhere A. C. Coolidge has commented that "it seems more than probable that the Declaration of Independence was inspired by Locke's Treatise on Civil Government."[7] And finally, Miller concluded:

> The Declaration of Independence, as drawn up by Thomas Jefferson, was the final proof — if Englishmen needed any further proof — that the doctrine of John Locke could be made to serve the prophets of revolution everywhere.[8]

However, recent scholarship on the subject of Locke's influence on American political tradition has exploded this myth of intellectual history. First there was the caution of one of America's most noted historians, Clinton Rossiter:

> It is difficult to estimate the debt owed to Locke by patriot thinkers, yet the unmistakable impression one gets from roaming through the entire range of

> revolutionary literature is that he was definitely not so important a figure as we have hitherto assumed. There is no evidence that his treatise sold any better than half a dozen other books that said pretty much the same thing, and until 1774, his name was mentioned only rarely in the columns of even the most radical newspapers.[9]

Then John Dunn's timely piece "The Politics of Locke in England and America in the Eighteenth Century"[10] confirmed what Rossiter had suspected. Writing under the tutelage of Peter Laslett at Cambridge University, Professor Dunn debunked the notion that Locke's *Two Treatises* enjoyed a pre-eminence in European or American circles. Rather the *Two Treatises* appeared as only one work within a much larger cross section which articulated a Whig science of politics. Dunn carefully documented the circumstances in which Locke's political works appeared, noting it caused no great stir. Dunn has also noted that many of Locke's theories were rejected in England and Europe. With respect to America, the *Two Treatises* appeared to have had no greater impact; American intellectual and political circles were no warmer to Locke than European audiences. Dunn concluded Locke was viewed by Americans as neither particularly original nor correct.

DISCUSSION

My own research on Locke's impact in America has discovered that while references to Locke can be found in colonial newspapers and pamphlets, his works being offered for sale in the colonies, there is no basis to assume his influence to be any greater than any number of other English or colonial thinkers. Never were there more than a half dozen references to him in any one gazette and never more than two or three in a year. References came not one upon another, but appeared only occasionally and with some irregularity. Further there is no evidence to suggest that references to Locke indicated any effort to single him out as having been studied more or digested more thoroughly than references to other English or Continental sources.[11]

Theorists and historians have invented considerable history in order to justify a position whose relevence to intellectual history is now being seriously questioned. The quest for meaningful history has led us to badly understand the political philosophy of John Locke in America. My thesis is that we have poorly interpreted Locke's role in the American political tradition. Implicit in this statement is a larger effort now becoming clear — that we have poorly understood and interpreted the liberal tradition in America.

Robert Cumming's recent reinterpretation of liberalism[12] offers major insight into the problem. We are confronted by two different ways of identifying liberalism.

> We have (already) run into two different ways of identifying liberalism which involve in turn two different ways of interpreting its process of development. Laski's (*The Rise of European Liberalism*) identification is socio-historical. Liberalism is something that rises. To identify it, reference has to be made to a particular social class and to a particular period of history, on the grounds that no form of political thought can transcend the limiting conditions of its origin, and that it is "The

> meaning of this limitation which is the key to the understanding of the liberal idea." Trilling (*The Liberal Imagination*) instead identifies liberalism with a particular tendency of the human mind, manifest in the form of theories and principles regarding the nature of the human mind. Liberalism is something which should be more imaginative, but which tends to develop theories and principles that are too rationalistic.[13]

In an attempt not to circumvent the distinction of the two traditions, but in order to recognize the methodological problem of handling the distinction, Professor Cumming turns to the political thought of John Stuart Mill in hopes of identifying the liberal tradition. This launches Cumming into a full, detailed study of the enterprise of political philosophy through the pivitol works of John Stuart Mill.

In identifying the two traditions within liberalism, Cumming notes that liberalism is in the throes of crisis. Psychological liberalism seeks to "justify its organization of the elements of life in a rational way by adopting too limited a view of the human mind. But liberalism also becomes in Trilling himself the attempt to overcome these psychological and moral limitations by fostering The Liberal Imagination."[14] Whereas socio-historical liberalism is identified with a specific and limited period of social history, it seeks to "overcome the socio-historical limitations of liberalism by restating its doctrines in a form which will meet the requirements of the present period in social history."[15]

John Locke has been identified with both sides in the continuing debate over liberalism. The problem is not a simple one; John Locke's political philosophy defies simple categorization. Writing in 1660, Locke argued from the approach:

> . it being sufficient to my purpose that the supreme magistrate of every nation what way soever created, must necessarily have an absolute and arbitrary power over all the indifferent actions of his people.[16]

Although this was unfamiliar writing of Locke, the more familiar *Second Treatise* reflected a changed tone. These earlier, unpublished tracts of 1660 represented Locke's first works on politics. Throughout, he firmly announced the necessity of obedience to authority for on all matters concerning things indifferent the power of the magistrate need be absolute, the nature of society required it. Here Locke appeared conservative and authoritarian, using language paralleling that of Hobbes. It is not until the *Two Treatises* that we get a complete and original political philosophy from John Locke.

If there is a difficulty in reconciling the earlier Locke with the *Two Treatises* the mature Locke presents no less a problem. Locke's other major works, *An Essay Concerning Human Understanding* and *Letters Concerning Toleration*, confound any consistent approach one might wish to attribute to Locke. Much of the problem rests with the *Second Treatise* itself. Several interpretations have been put forth offering explanations of what Locke may truly have meant. The range of views has extended from calling Locke an outright Hobbesian making an attempt to conceal his real meaning behind a facade of "traditional phrases, ambiguities and designedly confused statements, and pious denials,"[17] to the more common, traditional view that Locke represented the liberal tradition of individualism, limited government and natural rights.[18]

In dealing with the ambiguities and seeming inconsistencies in Locke's thought, interpretations have polarized into extremes. On the one hand there are the psychological interpretations stressing Locke's *Essay* and principles of natural rights. On the other side of the ledger are the bourgeois interpretations placing Locke as the defender of property rights within the historical period of the Glorious Revolution.

The earlier studies on Locke were concerned with his ambiguities and contradictions. They asserted his individualist philosophy, although sometimes qualified, and attempted to reconcile his political philosophy as expressed in the *Two Treatises* with the psychological foundations laid in his *Essay*. J. W. Gough stated:

> I think Locke can still be called an individualist; but he was not a thorough-going nor a strictly consistent one . . . we should all agree that Locke has no place in his system for an absolute sovereign such as that of Hobbes.[19]

Yet, deeply troubled by the seeming inconsistencies in Locke, Leo Strauss set to work on a major reinterpretation of natural law,[20] wherein he sought to "correct" this view of Locke by associating Locke's psychology with that of Thomas Hobbes'. The result was a major distinction in the traditions of classical natural law and modern natural right, and through the medium of modern natural rights Hobbes and Locke were linked in a common fulcrum of reason and nature that ends in a life which is a "joyless quest for joy."

Finally, present accounts of Locke are struck by the close association between Locke's religious and political thought and the parallel development of Locke from an authoritarian philosopher to that of a libertarian.[21] Abrams traces the development from Locke's earlier works, *Two Tracts on Government* (1660), that reveal that unfamiliar authoritarian Locke whereas John Dunn attempts to logically tie Locke's rational action to his commitment to the strenuous discharge of a series of duties to God.

The bourgeois interpretation of Locke's political philosophy was most forceably argued by C. B. MacPherson's controversial *The Political Theory of Possessive Individualism*.[22] Starting from the class assumptions of 17th Century England, MacPherson read back into Locke those assumptions and distinctions peculiar to the time, notably the individual as proprietor and class differentials in rights and rationality. Locke, MacPherson argued, reduced individualism to a series of market relations and natural law to market morality, thereby providing a sufficient basis for political obligation as understood by the reason of 17th Century man.

The same position was presented by Reinhold Niebuhr in his classic vindication of democracy, *The Children of Light and the Children of Darkness*.[23] Liberalism, for Niebuhr, was inextricably aligned with the bourgeois revolt against feudalism, awakening new vitalities in the social order. The right to property was one of those new vitalities. Enter John Locke. For Niebuhr, Locke was one of the misguided Children of Light who exaggerated the individual freedom of middle class existence. In fact, Niebuhr argued, in Locke's own day, economic

life had already become too complex to permit the labor theory of value to function in splendid isolation.

Yet, it was in America that Locke felt his state of nature and labor theory of value most freely operated.[24] "That in many parts of America, there was no government at all." The liberal tradition in America rested largely on the assumptions of natural law, individual liberty and limited government. Just as Cumming has noted two strains of liberal thought — psychological and socio-historical — the literature of John Locke's political philosophy clusters toward the extremes of the two strains — the psychological and bourgeois. Consequently, if one intends to build a liberal society in America, founded upon John Locke, then it seems incumbent to delineate adequately the factors at work in that tradition and to place Locke properly within that tradition.

The position Locke occupies in the American political tradition has received very singular treatment and until very recently this singularity of treatment was the result of a failure to preceive two divergent strains running through liberal thought.

The psychological strain of liberalism, a tradition more commonly noted than that of the bourgeois strain, speaks for economic and political concessions — individualism, as it were — but always within the framework of spiritual and natural values. It is a doctrine of the absolute worth of the individual; and it looks to new vitalities. Bourgeois liberalism is no less important, but it is often neglected as a theme forceful in itself and in its oppostion to psychological liberalism. It raises property to an end in itself from which other values flow. The only moral life is comprised of a vitality based upon the sanctity of property; and men and governments are judged as they add or detract from the accumulation of private wealth. It is precisely this nascent strain of liberalism that has not been recognized or given due consideration, particularly with respect to John Locke's influence on American political thought. There has generally been a widespread failure only now being corrected to identify the elements of this tradition when it has come to examining the consequence or contributions of the political thought of liberalism. This in fact has resulted in a single-minded treatment of American liberal thought.

The liberal tradition in America was felt to rest largely on the assumptions of natural law, individual liberty and limited government. To this frequently was associated the name of John Locke. That was Daniel Boorstin's opinion, presently expanded into his multiple volume *The Americans*, that the liberal tradition in America had a certain "giveness" to it.[25]

Boorstin argued that America's values were somehow automatically defined: "given by certain facts of geography or history peculiar to us." With both the past and the present, America's unique circumstance made an articulated political theory superfluous. Working parallel to Boorstin on both time and thought, Louis Hartz expanded on Boorstin with respect to Locke's importance to America's liberal tradition. The American tradition Hartz attested, rests on irrational Lockeanism.[26] "A Nationalist articulation of Locke which usually does

not know that Locke himself is involved.''[27] Hartz built a liberal tradition for America on the premise that it lacked a real revolutionary tradition — the lack of an *ancien regime*. Therefore the colonists could import John Locke's ideas, build upon his individualism, and untangle men from ''the myriad associations of class, church, guild and place in terms of which feudal society defined their lives.'' Hence the implicit acceptance of the state as the only legitimate coercive force in society. This, then, was to become for America only a set of preliminary remarks leading to the nation's final interpretation of Locke's view: limited government. The end result, or master assumption of American political thought: the reality of atomistic social freedom.

The liberal tradition pre-supposed a psychological unity within the American people, to an idea or reality of the idea which transcends to the level of a liberalized conception of life whether expressed by the mobility of social freedom or the agricultural roots of the availability of land and westward expansion. It assumed a new way of viewing the world, rendering intelligible to the mind new vitalities. The Declaration of Independence was but the highest expression of the American Enlightenment.

It is useful to look at the Declaration of Independence as a representative document symbolizing the liberal tradition in America. More than anywhere else assertions of Locke's influence on the intellectual milieu of ideas in general, and Jefferson's draft in particular, are to be found. Carl Becker has noted, ''nothing could have been more futile than an attempt to justify a revolution on principles which no one had ever heard of before.''[28] John Adams wrote of the Declaration, ''there is not an idea in it, but what had been hackneyed in Congress two years before.'' And then Jefferson himself:

> Pickering's observations, and Mr. Adams' in addition, that it contained no new ideas, that it is a commonplace compilation, its sentiments hackneyed in Congress for two years before . . . may all be true. Of that I am not to be the judge. Richard Henry Lee charged it as copied from Locke's *Treatise on Government* . . . I know, only, that I turned to neither book nor pamphlet while writing it. I did not consider it as any part of my charge to invent new ideas altogether and to offer no sentiment which had ever been expressed before.[29]

Later again, in 1825, Jefferson was to reiterate his position that the Declaration was part of the intellectual milieu of ideas.

> Not to find out new principles, or new arguments, never before thought of, not merely to say things which had never been said before; but to place before mankind the common sense of the subject, in terms so plain and firm as to command their assent. . . . Neither aiming at originality of principles or sentiments, nor yet copied from any particular or previous writing, it was intended to be an expression of the American mind . . . all of its authority rests then on a harmonizing sentiment of the day, whether expressed in conversation, in letters, printed essays, or the elementary books of public right.[30]

The Declaration follows Locke in phrase and style. However, it is wrong to assume that the Declaration was a Lockean document. The Americans were fond of quoting authority in defense of their colonial positions. But the transmission of

Locke to America was as Caroline Robbins has dramatically pointed out in her book, *The 18th Century Commonwealthman*, part of a dissenting Whig tradition. Robbins has noted a strain of Whigs from the 17th to the 18th Century — whom she labeled commonwealthman — whose thought received little support or encouragement from Whigs in office, but who "served to maintain a revolutionary tradition and to link the histories of English struggles against tyranny in one century with those of American efforts for independence in another."[31] There were three generations of Commonwealthmen, the last being brought up in the age of the American revolution. Locke was representative of the first generation of dissenting Whigs, appearing around the Revolution of 1689. This important contribution of Caroline Robbins made apparent that Locke was a part of a tradition of Commonwelathmen which influenced American thought but which also gave us reason to be cautious regarding the overriding importance of Locke's works in America.

The Declaration of Independence, as it embodied the sentiments of the day, was clearly borrowed from English and continental sources. It had hardly occurred to the colonists that they were seeing those sources and heritage differently from other Englishmen. They spoke the language of the 18th Century, read and cited the sources of the 18th Century, but it is only now becoming clear, largely through the pioneering effort of Caroline Robbins, just how selective the colonists were in their use of British literature as it focused on what she has termed an opposition view of English politics. Clearly, the opposition criticism invariably tended Whiggish and liberal, but in the final analysis this led to a rather peculiar reading and application of John Locke. These opposition Whigs of the 18th Century, or Commonwealthmen, took their character from the unwillingness to accept the developments of the 18th Century British Empire. They were reacting to the bureaucratization of government and the maturation of the empire, and they offered their fellow Englishman a strident and impassioned critique of their society and politics. And if this criticism never matured or dominated English thought, it found its most receptive audience across the Atlantic. And in the ideas of the state of nature, the social contract, natural rights and the right of resistence, we found the commonwealthman's ideas most freely embraced by a Whig science of politics in America. Bernard Bailyn noted:

> The political culture of colonial America — the assumptions, expectations, patterns of responses, and clusters of information relevant to the conduct of public affairs — was thus British, but British with a peculiar emphasis. It was not simply a miscellaneous amalgam of ideas and beliefs current in 18th Century England, nor, most emphatically, was it simply a distillation of the thoughts of a few great minds, particularly Locke's. It was rather a pattern of ideas, assumptions, attitudes, and beliefs given distinctive shape by the opposition elements in English politics, those elements whose attack on "influence" and ministerial corruption was the one idealistic feature of early 18th Century (English) politics, the only political programme which could appeal to men with a sense of moral purpose. It was primarily this opposition frame of mind through which the colonists saw the world and in terms of which they themselves became participants in politics.[32]

This same view is adopted from Robbins by Gordon Wood in his masterly *The Creation of the American Republic, 1776-1787*. Focusing upon the opposition view of English politics, American spokesmen turned to Whig and Tory alike to express in a particularly meaningful way the anxieties Americans felt.

> While this opposition thinking can be broadly conceived, ranging from Bolingbroke to Burke, the expressions of it the Americans found most attractive, most relevant to their situation and needs, were precisely those with the least respectibility and force in England — those expressions of radical intellectuals writing to the left of the official Whig line. The radicalism of the Real Whigs, as the most self-conscious of these early eighteenth-century writers called themselves, or commonwealthmen, as they have recently been called, came not from the concrete proposals they offered for the reformation of English politics. For most of these proposals — prohibitions on placement in the House of Commons, attacks on the increasing debt and the representational system, and recommendations for shorter Parliaments and the right of constituents to instruct their representatives — were the stock reforms of Opposition politicians during the eighteenth century.[33]

The Declaration of Independence paralleled the thinking of Locke inasmuch as the *Second Treatise* was a part of the dissenting Whig tradition of Commonwealthmen and made use of the commonwealth symbols — natural rights, social contract, limited and representative government, and the right of resistance. Again, Bailyn noted:

> The skeleton of their political thought was Lockean — concerned with inalienable rights and the contract theory of government — but only the skeleton. The flesh, the substance, the major preoccupations and the underlying motivations and mood were quite different, as was, of course, the level of discourse.[34]

When Locke declared men naturally to be in a state of perfect freedom, to order their actions and dispose of their possessions and persons as they thought fit, the Whig knew he had a theory to make 1688 a Glorious Revolution. But the social contract was not new. Plato knew of it in antiquity, and the Medieval world recognized and used the social contract to limit authority of Pope and King alike. America, too, had made use of it, the most famous use being the Puritan theological covenant wherein God convenanted with Churchmen and civil rulers for the establishment of a holy commonwealth.

But by the Eighteenth Century God was withdrawing from the contract and more and more Nature was becoming the mediator between men. Newton had removed mystery from nature. In his hands, philosophy came to be reducable to techniques of observation and mathematics, capable of rational inquiry and human understanding. Whereupon in revolutionary thought, an agreement of free and equal men, not to enter society, but to institute government on mutually satisfactory terms, could specify the structure, functions, powers, and most importantly, the limits to government.

The social contract became the substance and symbol of the American solution to the problem of political obligation, that most unsettling of all questions of political philosophy. And in the social contract, the revolutionary colonists found this one word answer to the issue of obligation — consent.

An examination of the Declaration shows the clear use of these 18th Century symbols. First, there was self government through the legislative process. Acknowledging of King George, the Declaration stated:

> He has refused his assent to laws the most wholesome and necessary for the public good.
>
> He has refused to pass other laws for the accommodation of large districts of people, unless the people would relinquish the right of representation in the legislature — a right inestimable to them and formidable to tyrants only.
>
> He had dissolved representative houses repeatedly for opposing with manly firmness his invasions on the rights of the people.

A second category of grievances revolved around the basic symbolization of differentiation in the separation of powers of government.

> He has obstructed the administration of Justice by refusing his assent to laws for establishing judiciary powers.
>
> He has made judges dependent on his will alone for the tenure of their offices and the amount and payment of their salaries.
>
> He has kept among us in times of peace standing armies without the consent of our legislatures.
>
> He has affected to render the military independent of and superior to the civil power.

And a final category of particulars from the Declaration involved the commontime understanding of tyranny, wherein the King had acted wantonly, outraged sensibilities and morals of virtuous people. To wit:

> He has plundered our seas, ravaged our coasts, burnt our towns and destroyed the lives of our people.
>
> He has constrained our fellow citizens taken captives on the high seas to bear arms against their country, to become the executioners of their friends and brothers or to fall themselves by their hands.
>
> He has excited domestic insurrections against us and has endeavored to bring on the inhabitants of our frontiers, the merciless Indian savages, whose known rule of warfare is an undistinguished destruction of all ages, sexes and conditions.

And so the colonists constructed their Whig science of politics to meet the challenge of obligation for political resistance.

What had happened in America is that the self-referent symbols of the 17th Century — natural rights, social contract, popular sovereignty and right of resistance — were extrapolated from a people in an English society to become the political behavior of another people in another century. Americans had, in their own revolutionary way, revolutionized the traditional conception of politics. The result to our understanding of liberalism in America is the failure to disentangle what the American colonists could not hope to disentangle: a Whig science of politics based upon the play of social forces within English society and the operational ideals of liberal democracy which were straining the limits and, at the same time, transforming that Whig science of politics.

The debate over the American revolution and the Declaration of Independence will continue. But its intellectual history will not be the same. Fresh attention must be directed to this bourgeois interpretation of the opposition

politics of dissenting Whigs within the intellectual history of the liberal climate in America. America had perceived a political mission to fulfill, for herself and before the eyes of the world: to prove that natural rights, consent and self government were fruits of a genuine vine. The details of an American life had not been clearly deciphered. The origins of the values of individualism and natural rights must be traced to their source. Men had acted upon their beliefs, how they would sustain them fills out the meaning of liberalism in America.

At the risk of venturing afield, this overview allows me to suggest some directions for future inquiries into the liberal tradition in America. At the least there should be attention paid to disentangling the two strains in liberal thought, documenting where the psychological and the bourgeois elements have prevailed. More importantly, effort should be made to see where the two strains met and what change in thinking was produced as a result. At a deeper level, historians must cease striving for a meaningful history. It is time to move away from the sterile debate in intellectual and historical circles between the ideologues and social and economic historians. There is ample opportunity for someone to return to the sources, and quantitatively correlate those sources with their intellectual and social milieu. Finally I hold a wishful expectation that someone with an intellectual breath will rescue liberalism from the polarity emerging over liberalism and integrate the ideological with the socio-economic so perhaps a new, more accurate picture of the revolutionary origin of liberalism can take its place.

FOOTNOTES

[1]Charles E. Merriam, *A History of American Political Theories* (New York: The Macmillan Co., 1920), pp. 89-90.

[2]Vernon L. Parrington, *Main Currents in American Thought* (New York: Harcourt, Brace & Co., 1939), p. 189.

[3]Archibald C. Coolidge, *Theoretical and Foreign Elements in the Formation of the American Constitution* (Freiburg, I.B.: Chr. Lehmann, 1892), p. 19.

[4]John C. Miller, *Origins of the American Revolution* (Boston: Little, Brown & Co., 1943), p. 171.

[5]Benjamin F. Wright, *American Interpretations of Natural Law* (Cambridge Mass.: Harvard University Press, 1931), p. 11.

[6]Carl L. Becker, *The Declaration of Independence* (New York: Alfred A. Knopf, Inc., 1942), p. 27.

[7]Coolidge, op. cit., pp. 20-21.

[8]Miller, op. cit., p. 491.

[9]Clinton Rossiter, *The Seedtime of the Republic* (New York: Harcourt, Brace and World, Inc., 1955), p. 358.

[10]John Dunn, "The Politics of Locke in England and America in the Eighteenth Century," ed., John Yolton, *John Locke: Problems and Perspectives* (Cambridge, Cambridge University Press, 1969).

[11]See Pynn "The Influence of John Locke's Political Philosophy on American Political Tradition," *North Dakota Quarterly*, Vol. 42 (Summer, 1974). pp. 48-56.

[12]Robert Cumming, *Human Nature and History: A Study of the Development of Liberal Political Thought* (Chicago: University of Chicago Press, 1962), 2 Vols.

[13]*Ibid.*, pp. 2-3.

[14]*Ibid.*, p. 5.

[15]*Ibid.*

[16]John Locke, *Two Tracts on Government*, ed., Philip Abrams (Cambridge: Cambridge University Press, 1967), pp. 122-23.

[17]Richard Cox, *Locke on War and Peace* (Oxford: at the Clarendon Press, 1960).

[18]See J. W. Gough, *John Locke's Political Philosophy* (Oxford: Clarendon Press, 1956) and Sterling Lamprecht, *The Moral and Political Philosophy of John Locke* (New York: Russell and Russell, 1962).

[19]J. W. Gough, op. cit., p. 36.

[20]Leo Strauss. *Natural Right and History* (Chicago: University of Chicago Press, 1953).

[21]Philip Abrams. *Locke: Two Tracts on Government* (London: Cambridge University Press, 1967) and John Dunn *The Political Thought of John Locke* (Cambridge: at the University Press, 1969).

[22]C.B. MacPherson. *The Political Theory of Possessive Individualism* (Oxford: Clarendon Press, 1962).

[23]Reinhold Niebuhr. *The Children of Light and the Children of Darkness* (New York: Charles Scribner's Sons, 1960).

[24]Whether Locke took seriously this 17th Century symbolic device is subject to debate. For a further discussion of the point see Richard Ashcraft, "Locke's State of Nature: Historical Fact or Moral Fiction?" *American Political Science Review*, 62 (1968) and William G. Batz, "The Historical Anthropology of John Locke," *Journal of the History of Ideas*, 35 (Oct-Dec, 1974).

[25]Daniel Boorstin, *The Genius of American Politics* (Chicago: The University of Chicago Press, 1953).

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[27]*Ibid.*, p. 11.

[28]Carl Becker, op. cit., pp. 24-26.

[29]Thomas Jefferson, *The Writings of Thomas Jefferson,* Vol. XV, ed., Albert A. Bergh (20 Vols.; Washington, D.C.: Thomas Jefferson Memorial Association, 1904), pp. 461-462.

[30]Thomas Jefferson, *Works*, Vol. XII, ed., Paul L. Ford (Federal Edition: New York, 1904), p. 404.

[31]Caroline Robbins, *The Eighteenth Century Commonwealthman* (Cambridge, Mass.: Harvard University Press, 1959), pp. 3-4.

[32]Bernard Bailyn, *The Origins of American Politics* (New York: Random House, 1967), p. 57.

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PRODUCTION AND ECONOMIC CONSIDERATIONS WHEN MACHINING GLASS CERAMIC (K_2O-MgF_2-MgO-SiO_2)

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ABSTRACT

Glass Ceramic (K_2O-MgF_2-MgO-SiO_2) was found to have relatively good machinability capabilities but is restricted within a very limited range of machine settings. The microstructure of glass ceramic has significant influence on machinability parameters. Tool geometry, tool composition, and the machining environment influence cutting forces, workpiece surface quality, and tool life. To determine production conditions an economic model was developed using Taylor's equations. A machining parameter was ultimately established with a minimum cost per unit while achieving a maximum production rate.

INTRODUCTION

In general, the machining of glass ceramic is not like machining of ductile metals because of the brittle nature of the glass ceramic. In machining of metals, there are varying degrees of plastic deformation which will generally generate a continuous chip formation. When machining glass ceramic material, the chip particles are either fractured or plucked out of the work piece during the machining process which indicates that there is a lack of plastic deformation causing a discontinuous chip formation.

Because of the unique microstructure of glass ceramic, it is extremely difficult for a crack to propagate through the material. Because of the unique microstructure, machining of glass ceramic is now possible on a standard machine tool lathe. It is even possible to use other standard machinery equipment such as mills, drills, etc. Little or no machinability research has been conducted on the tool-workpiece behavior for this important material. Energy or cutting force requirements, and speed and feed rate requirements have not been rigorously established. Tool life, tool material, and tool geometry have not been correlated with surface quality. The mode of material removal has not been adequately established experimentally and mathematically. Because of this lack of understanding the machining process, production standards and cost requirements could not be developed.

The goal of this research was to further establish the mechanism of material removal rate to determine what tool material and geometry would yield the best tool life and workpiece surface quality, and to establish some production requirements necessary for processing glass ceramic when using a standard turning operation.

The main thrust of this study was to determine the machinability of glass ceramic when machining with conventional lathes, and to establish production and economic limits.

EXPERIMENTAL PROCEDURE

The Experimental Procedure was to collect data for characterizing the mode of stock removal when using a standard lathe in a turning operation and to determine the optimal machine settings when machining glass ceramic. There were four major areas of experimental concern:

1. Evaluating the speed settings for the turning operation.
2. Determining the cutting forces for each combination of machine settings when no tool wear was introduced.
3. Determining the tool life of a carbide tool when machining in a dry and wet environment.
4. Determining the surface roughness for each of these machine settings.

In order to make these evaluations, specific instrumentation was necessary. A lathe to conduct the machining, a dynamometer to measure the cutting forces, a microscope to measure the wear, and a profilometer to measure the surface roughness were all used in this research. The instrumentation was somewhat modified in order to measure the various parameters of the machining operation.

Lathe. — A standard Monarch lathe was used in this experiment. A small manual tachometer was used in conjection with the RPM meter provided on the lathe to accurately determine peripheral speed of the workpiece. The lathe was provided with sufficient power to withstand the cutting loads without any loss of velocity or speed setting. The Monarch lathe was selected because it provided an infinite variable speed setting which lent itself effectively to the experimental requirements.

Dynamometer. — A specifically designed dynamometer was used to measure the cutting force (F_c,F_t). The tangential force (F_c) and transverse force (F_t) are shown in Figure 2. Because of limited workpiece material, the sequence of cutting was very important. The cutting forces were measured at very short time intervals with a new cutting edge carbide tool in order to assure that no wear would be introduced in the removal process (It is believed that the cutting forces will increase substantially when wear is introduced in the machining process). Since the dynamometer is basically a cantilever beam, with strain gages to measure its deflection, it was important that this beam be so designed to register only the cutting forces and not to introduce any vibrations which would affect the machine surface and introduct instant wear. The dynamometer design and tool-workpiece relationship are shown in Figure 1.

Microscope. — A standard microscope was redesigned to measure tool wear along the flank and nose of the carbide tool. This method of observing tool wear is shown in Figure 1. A very critical consideration in redesigning the microscope was the limited range and length of time to introduce measurable wear imposed by the material available for this experiment. A standard depth micrometer gage was mounted on the stage of the microscope so that numerical readings could be observed when observing tool wear.

MATERIALS

Workpiece. — Glass ceramics, more specifically known as Tetrasilicicmica glass ceramics, are manufactured from glass based on the K_2O-MgF_2-MgO-SiO_2 quaternary system. Although a wide range of products can be obtained by sub-

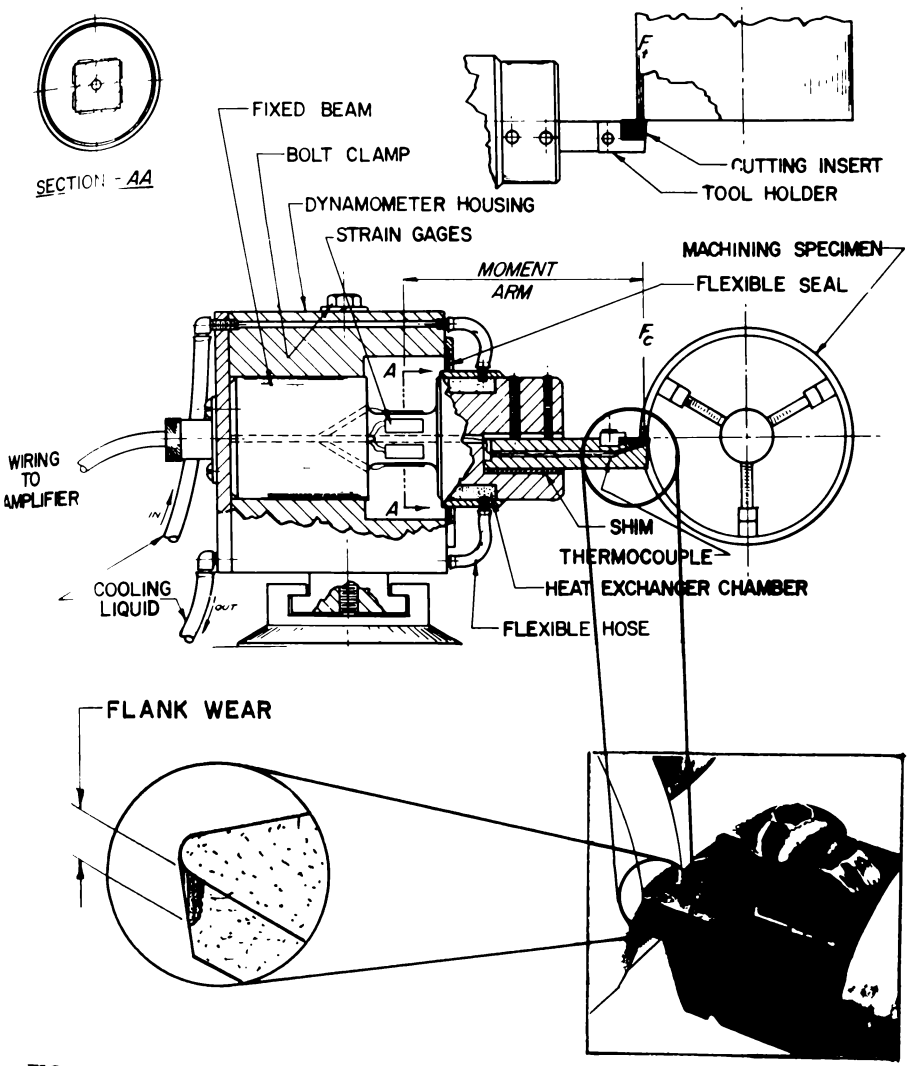

FIGURE 1. Experimental set-up illustrating method of measuring cutting forces and tool wear.

stituting potassium ions for divalent ions, the present work has been limited to K-Mg fluorosilicate systems.

Such glasses are fluid but, because of their extreme viscosity, they are formed in predetermiend geometrical shapes by rolling and casting. Forming operations

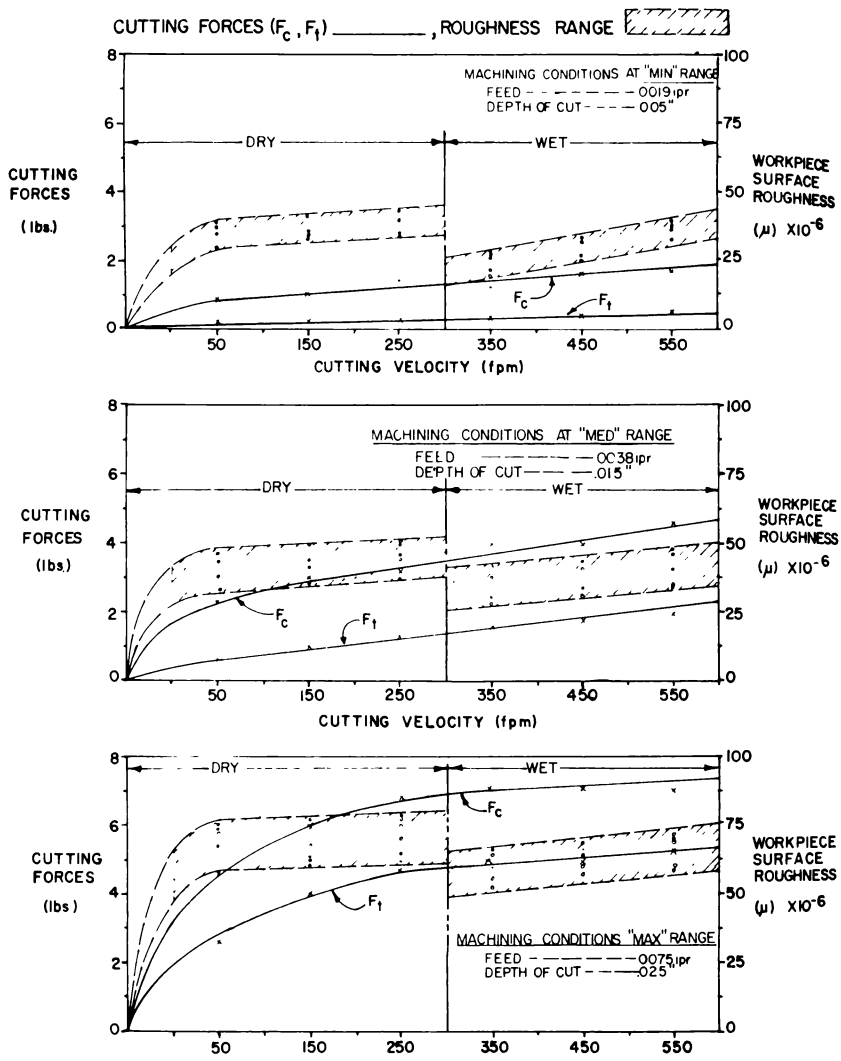

FIGURE 2. Cutting forces and surface roughness vs. cutting velocity for both a dry and wet environment without introducing any tool wear.

are followed by heat treatment operations at temperatures to 1100°C thereby producing a uniform dispersion of randomly oriented two-dimensional tetrasilicic-mica crystals. Mechanical properties depend on the microstructure of the mica-containing glass ceramic and especially on range of physical and mechanical properties can be tailored by minute changes in thermal processing conditions.

Two mechanically and physically characterized workpieces were initially selected for the machinability tests in this study. These samples are illustrated in Table 1.

Cutting Tool. — The carbide tool which was ultimately used in this machinability research had high resistance to wear and the following properties:

Chemical Composition (by wt.)	
Tungsten carbide (WC)	94.0%
Cobalt (Co)	6.0%
Hardness (R_cA)	91.7-92.2
Density	15.0 gm/cm²
Transverse Rupture Strength	290,000 psi
Ultimate Compressive Strength	790,000 psi
Ultimate Tensile Strength	210,000 psi
Modulus of Elasticity	94x10⁷ psi
Proportional Limit	280,000 psi
Ductility (% elongation)	0.2%
Impact Resistance (Charpy)	12.0 in-lbs
Abrasion Resistance (1/Vol. Loss)	35
Electrical Conductivity (% Cu. @ 25°C)	10.2%
Electrical Resistivity	17.0 Microhm-cm

The tool geometry which was selected to be used for the entire experiment was a mechanical holder to accommodate a triangular insert (Figure 1). The tool geometry had a back rake of 0°, side rake of 5°, end relief of 5°, and a side relief of 5°.

RESULTS AND DISCUSSION

Both workpiece samples I and II, as described in Table 1, were characterized by the lack of appreciable plastic deformation during dynamic testing conditions. Therefore, it can be assumed that the test material underwent brittle failure during machining operations because of the brittle property of the workpiece material.

It has been reported by Grossman (1) that the aspect ratio and volume percent of the mica crystals are the two important variables which affect directly the degree of interlocking, thus modifying the failure under external stress. The effect of microstructure on mechanical properties of mica glass ceramics has also been extensively studied by Chyung *et. al.* (2).

The crack formation and crack propagation probably were the key factors in determining the machinability of glass ceramic. Random crack propagation in the

TABLE 1. Characteristics of glass ceramic (K_2O-MgF_2-MgO-SiO_2)

	Compression Strength (psi)	Mica Flake Size (μ)	Mica Flake Diameter (mμ)	Elastic Modulus (10 psi)
Sample I	15,000	8.0	0.5	9.4
Sample II	4,500	220.0	15.0	8.1

glass phase was believed to be influenced by the geometry, orientation, and population distribution of tetrasilicic-mica crystals. Sample I was characterized by excessively long and random crack propagation independent of tool geometry and machining conditions. Such cracks lead to excessively large chips and mass failure of material with erratic surface quality. Size of mica crystals did not seem to affect the random crack propagation process when subjected to standard mechanical testing. Therefore, Sample I was not used in this machinability test. Test results are shown in Figures 2 and 3.

Sample II responded to tool geometry and machining conditions. Microscopic studies revealed that the individual chips were characterized by the presence of cleavage planes on the generated surface, thus indicating that large flake sizes and diameters of mica crystals were responsible for arresting fractures by blunting cracks and causing diversions.

The machinability trends of glass ceramic follow brittle metal machining trends. These glass ceramic machining trends show clearly that the minimum volume of material removed (.0057 in ^{3}/min) will yield a much better surface and tool life than the maximum volume removed (1.237 in^3/min). This trend would be expected but not with this order of magnitude. As shown in Figure 2, the tool life is probably affected primarily by the abrasive properties of the glass ceramic work piece material, implying that a very narrow range of speed feeds and depth of cut can be used when machining this material as compared to other materials when utilizing a standard turning operation. However, even with this small range of machine settings, an optimal removal rate could be obtained experimentally, and this is also shown in Figures 2 and 3. A medium volume of material was removed using a depth of cut of .015 in. and a feed rate of .0038 in. per revolution, and appears to yield relatively low cutting force and good tool life with relatively good surface quality for both the dry and wet environments at all speed ranges of 50-550 feet per minute (fpm) when no tool wear is introduced.

In order to achieve cutting speeds higher than 250 fpm, a wet environment was necessary. The wet environment consisted of a mist spray having approximately 20 pounds of pressure and consisting of 90% air and 10% water by volume. The experimental data has shown that speeds lower than 250 fpm do not require a wet environment. In lower cutting speeds of 50-250 fpm, the cutting forces increased with increased volume of material removed. In a wet environment, the cutting forces tended to increase for both the minimum and

maximum volume of material removed; however, the magnitude of force levels and surface quality were significantly lower in the range where the volume of material removed was a minimum. The application of the wet environment at speeds of 350 fpm showed an immediate improvement of surface quality; however, as the speed was increased to a maximum of 550 fpm, the surface

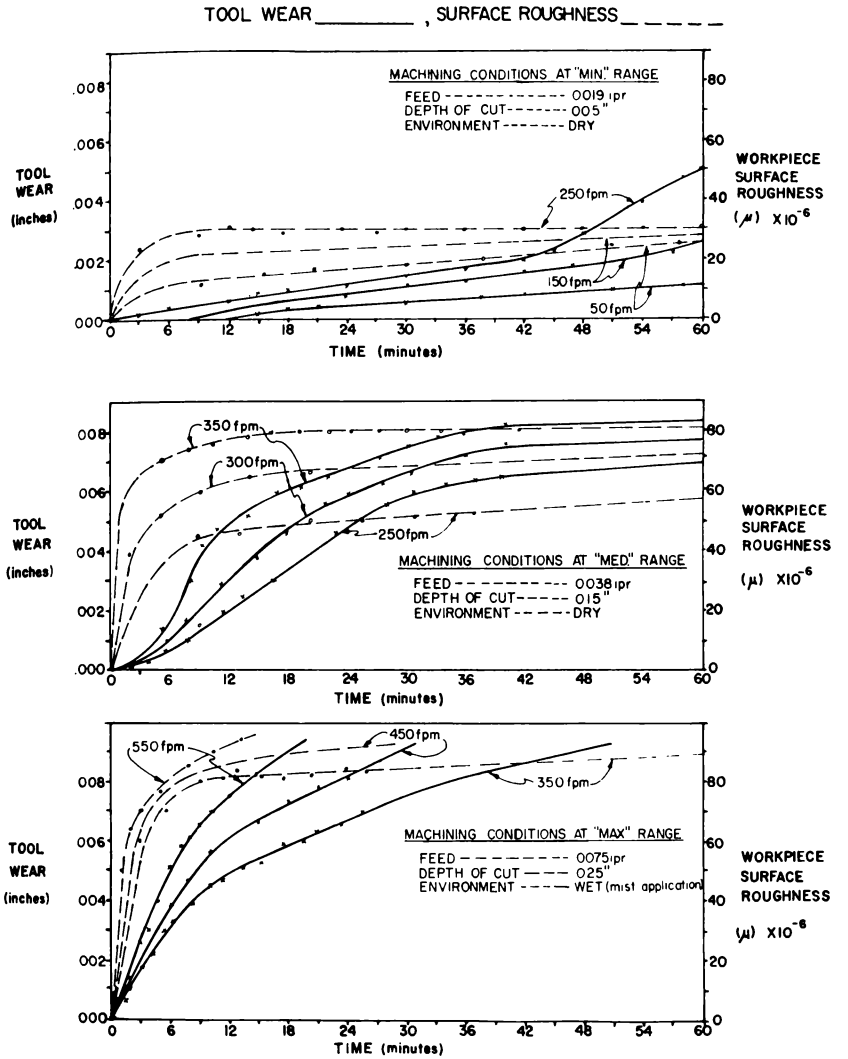

FIGURE 3. Tool wear and surface roughness vs. cutting time for various speeds for minimum, medium and maximum volume of materials removed.

quality began to approximate that obtained with the dry environment. This trend appeared in minimum, medium and maximum material removal ranges as is depicted in Figures 2 and 3. All of these cutting force measurements were conducted with no tool wear so that the cutting measurements were under ideal cutting tool geometry. The data indicates that more than twice the cutting forces and surface roughness were achieved when using higher cutting speed and machining with a larger volume of material removal.

Because of the brittle failure of the workpiece, no continuous contact on the microscopic level could be achieved at the tool-workpiece interface. High frequency intermitting impact loads on the tool face ultimately lead to the failure of tools with low modulus of elasticity. The abrasive nature and the irregular geometry of the tool-workpiece material at the interface requires that a tool material have a high abrasive resistance attribute.

Wet cutting produced more uniform chip size distribution thus generating better surface finish with respect to dry machining under the same operating conditions.

Observations indicated that surface quality (roughness) was also closely related to depth of cut. See Figures 2 and 3. Lower depth of cuts producing smaller chips generated better surface finish, while surface finish was not affected appreciably by the changes in machining conditions at constant depths.

MACHINING CONCLUSIONS

The following conclusions can be arrived at from the machinability study:

1. The machinability behavior of ceramic glass chip formation and surface quality are directly related to the configuration and distribution of mica-crystals within the glass matrix.
2. a. Tool life is increased when machining at low volume removal rate.
   b. The tool life is greatly reduced by fatigue failure because of the high frequency of micro dynamic loads during the machining process at high volume removal rate.
3. Whenever large tool forces (F_c,F_t) existed which were beyond the normal level in conducting the machining processes, tool wear was the contributing factor to increase tool cutting forces.
4. With a maximum volume of material removed, the surface quality or roughness was significantly poorer, producing higher cutting forces with excessive flank wear, than when machining at lower speeds, feeds and depth of cuts.
5. When machining ceramic glass, a carbide tool is necessary (WC 94%, Co 6%) and the range of speeds, feeds, and depth of cut is much less when compared to machining ranges of known standard brittle metallic materials.
6. With increased machining speeds, a wet environment is necessary to maintain a reasonable tool life and compete with surface quality obtainable at lower machining speeds in a dry environment.

ECONOMIC CONSIDERATION

Since the turn of the century when F. W. Taylor (3) introduced his article "On the Art of Metal Cutting," many theories have been proposed which have added to the knowledge of the fundamentals of the mechanics of metal cutting. Taylor discussed the production and economic implications when analyzing a total machining system. The true economic optimum for any one machining operation must take into account all processes to be performed on the component. The situation is further complicated by the fact that, in general, most manufacturing tools are used for more than one type of component, and this may give different economic returns. The problem of full optimization may be approached by using dynamic programming, but the solution is rather complex.

Work conditions were selected for a single-point turning operation to arrive at a specific optimization level. Two widely accepted criteria used in the optimization of the machining of glass ceramic operation were minimum cost per component and maximum production rate. Maximum profit rate for the operation was not utilized because of the difficulty of obtaining meaningful marketing data. The physical properties and machining behavior of the glass ceramic under investigation put a rather severe restriction on the selection of final cutting conditions. It was experimentally observed that surface finish restrictions of the machined product allowed a maximum feed at a minimum speed. Given the above restrictions, suboptimal velocity, feed, and depth of cut for two criteria were determined.

The variables affecting the economics of a machining operation are numerous and include tool material, machine-tool capacity and cutting conditions. Figure 4 illustrates the functional relationship between various cost factors, production factors and cutting velocity. This classical model further illustrates how production costs may be reduced by increasing the cutting speed until tool expense begins to rise.

The total cost per component and total time per component are given by the following equations respectively:

$$C = x T_l + x T_c + x T_d T_{ac}/T + y T_{ac}/T \quad \ldots\ldots (1)$$

and

$$T_t = T_l + T_c + T_d T_{ac}/T \quad \ldots\ldots (2)$$

Machine time, T_c, is generally approximately equal to cutting time, T_{ac}. Thus,

$$T_c = \left[\frac{\ell}{\lambda V f}\right] T_{ac} \quad \ldots\ldots (3)$$

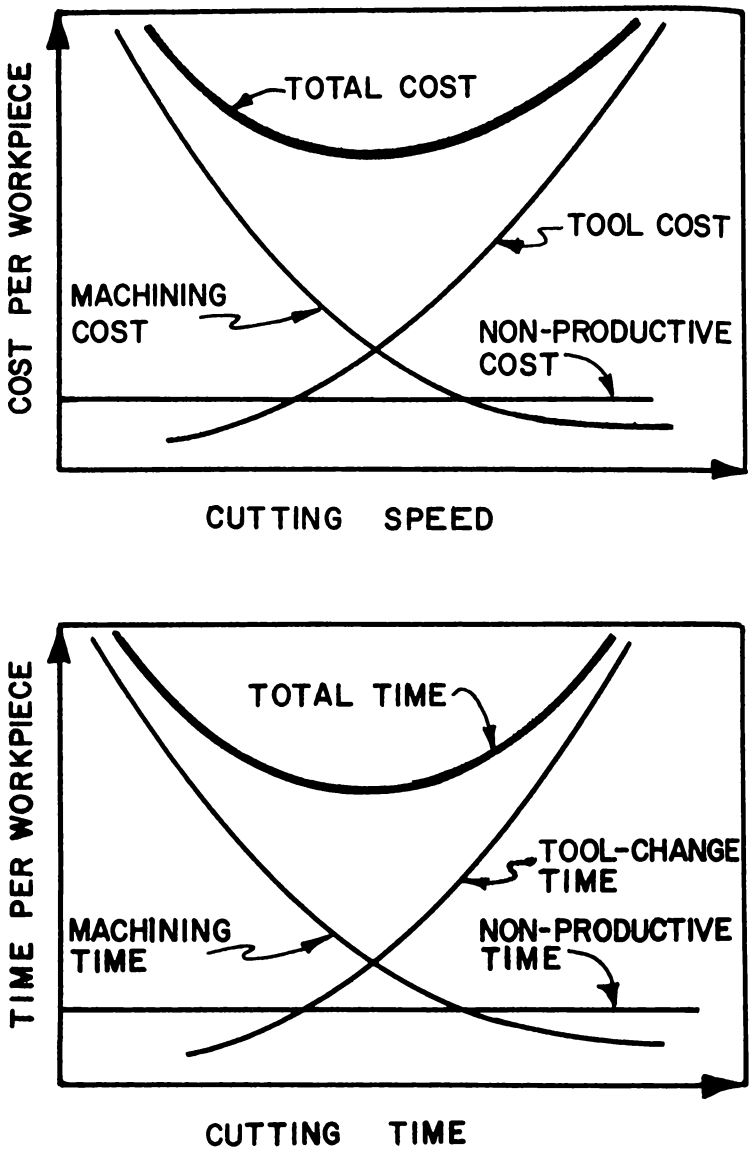

FIGURE 4. Cutting speed versus time and cost per workpiece.

The tool life equation for a turning operation is represented by:

$$T = \frac{K}{V^{1/n} f^{1/n_1} d^{1/n_2}} = \frac{A}{V^{1/n} f^{1/n_1}} \quad \ldots\ldots\ldots (4)$$

Equations 1 and 4 will permit evaluation of the cutting conditions for minimum cost and maximum production.

The cutting conditions for minimum cost per component are:

$$\frac{\partial C}{\partial V} = 0 \qquad \frac{\partial C}{\partial f} = 0$$

Because $1/n = 1/n_1$, the above equation cannot be simultaneously satisfied and a unique minimum does not occur. Therefore, it is necessary to determine a method of selecting the feed or speed which will give the permissible minimum cost. The surface finish restrictions in the actual cutting operation set the limiting maximum value of feed to 0.025, thus permitting the calculation of V, for $\frac{\partial C}{\partial V} = 0$.

$$\left[\frac{\partial C}{\partial V}\right]_{f = 0.025} = 0$$

$$1 = \left[\frac{1}{n} - 1\right]\left[\frac{V^{1/n} f^{1/n_1}}{A}\right]\left[x T_d + \frac{y}{x}\right]$$

tool life for minimum cost: $$T_{co} = \left[\frac{1}{n} - 1\right]\left[x T_d + \frac{y}{x}\right] \quad \ldots\ldots (7)$$

Similarly, maximum production:

$$\left[\frac{\partial T_t}{\partial V}\right]_{f=.025} = 0 \qquad 1 = \left[\frac{1}{n} - 1\right]\left[\frac{V^{1/n} f^{1/n_1}}{A}\right]\left[T_d\right]$$

Tool life for maximum production:

$$T_{po} = \left[\frac{1}{n} - 1\right]\left[T_d\right] \quad \ldots\ldots\ldots\ldots (8)$$

It is interesting to note that the tool life for minimum cost and maximum production is affected only by the slope or exponent (n), cost of labor and overhead, tool cost per cutting edge and tool change time. If the cost is not a deciding factor and the rate of production is the important factor, the higher rates of production can be obtained by increasing the cutting speed and decreasing the tool life.

To make this analysis, two parameters were used — tool life, which was obtained experimentally, and cutting speed. For all cutting conditions, only one grade of carbide tool with a fixed tool geometry was used. In order to show some production and economic application when machining glass ceramic material, the production model was based on classical concepts of the tool life model.

A minimum cost cutting time (Tco) and maximum production tool life (Tpo), were calculated for a given grade of carbide tool in order to predict a cutting velocity range for two categories of stock removal. The tool life curves devised experimentally are shown in Figure 5, which is plotted as an exponential function. There are three curves illustrating the minimum, medium and maximum stock removal with a .004'' of flank wear total tool life in all three categories of stock removal was reached.

Each tool life curve was later plotted on the log-log coordinates to show this linear relationship. Since the cutting velocity and the cutting time were derived experimentally, the remaining parameters could then be claculated. This was accomplished as follows:

$$T = \frac{K}{V^{1/n} f^{1/n_1} d^{1/n_2}} = \frac{B}{V^{1/n}} \quad \ldots\ldots\ldots (9)$$

Where:

$$B = \frac{K}{f^{1/n_1} d^{1/n_2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Experimental tool life in minutes, plotted vs. cutting velocity in feed per minute, on a log-log scale (Figure 6) permits the determination of n and B at constant feed, depth of cut and wear as shown in Table 2.

It is obvious that at low speeds, small depth of cut and fine feed rates, such as experienced in the minimum stock removal machine settings, practically no wear was experienced by the carbide tool. However, machining at these small removal rates makes the machining process uneconomical, and this process is not competitive with other forming operations.

Minimum cost and maximum production criteria were computer by using equations 7 and 8, assuming:

Labor and Overhead Cost	$0.80/hr.
Tool Cost Per Cutting Edge	$0.80
Tool Change to Recondition Time =	5 min.

Results are listed in Table 2.

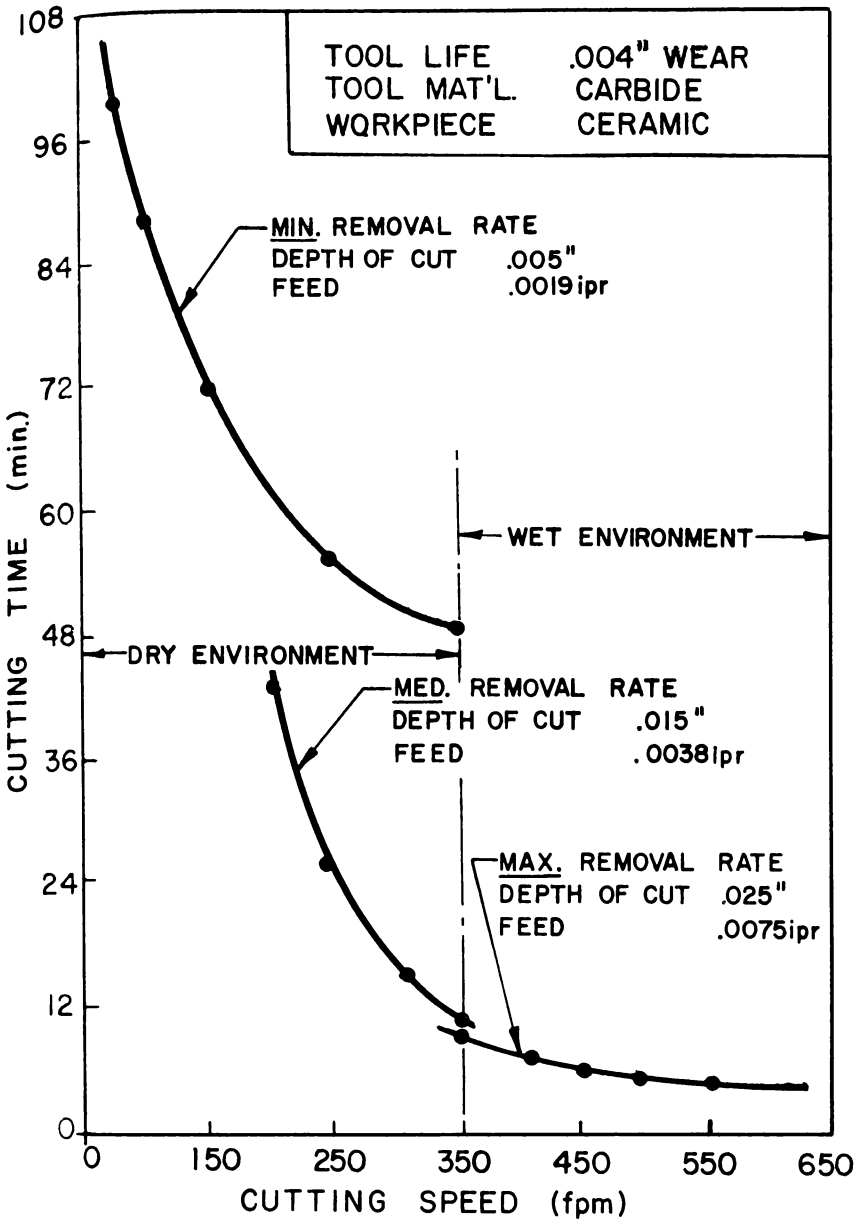

FIGURE 5. Cutting speed versus cutting time for three removal rate settings plotted on rectangular coordinates.

Figure 7 indicates the range of speed at which material removal must occur for economical operations. It is often suggested that the cutting conditions should be selected between the minimum cost per component and the maximum production rate, which is a valid argument provided the income per component is sufficiently high to produce an acceptable rate of return.

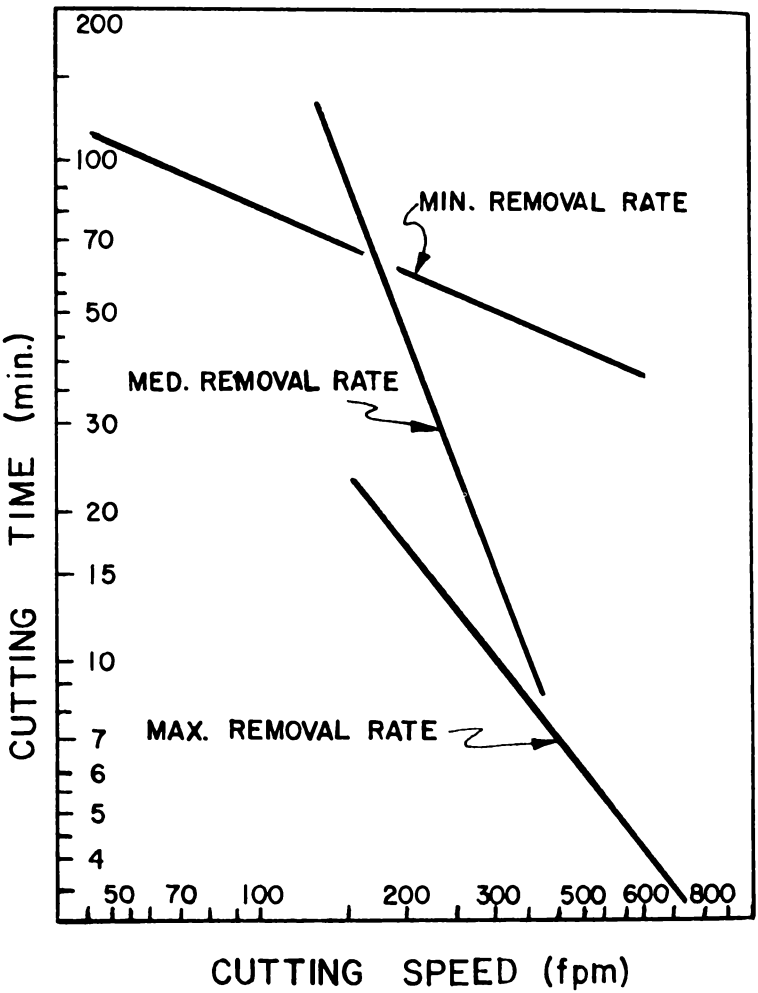

FIGURE 6. Cutting speed versus cutting time for three removal rates plotted on log-log coordinates.

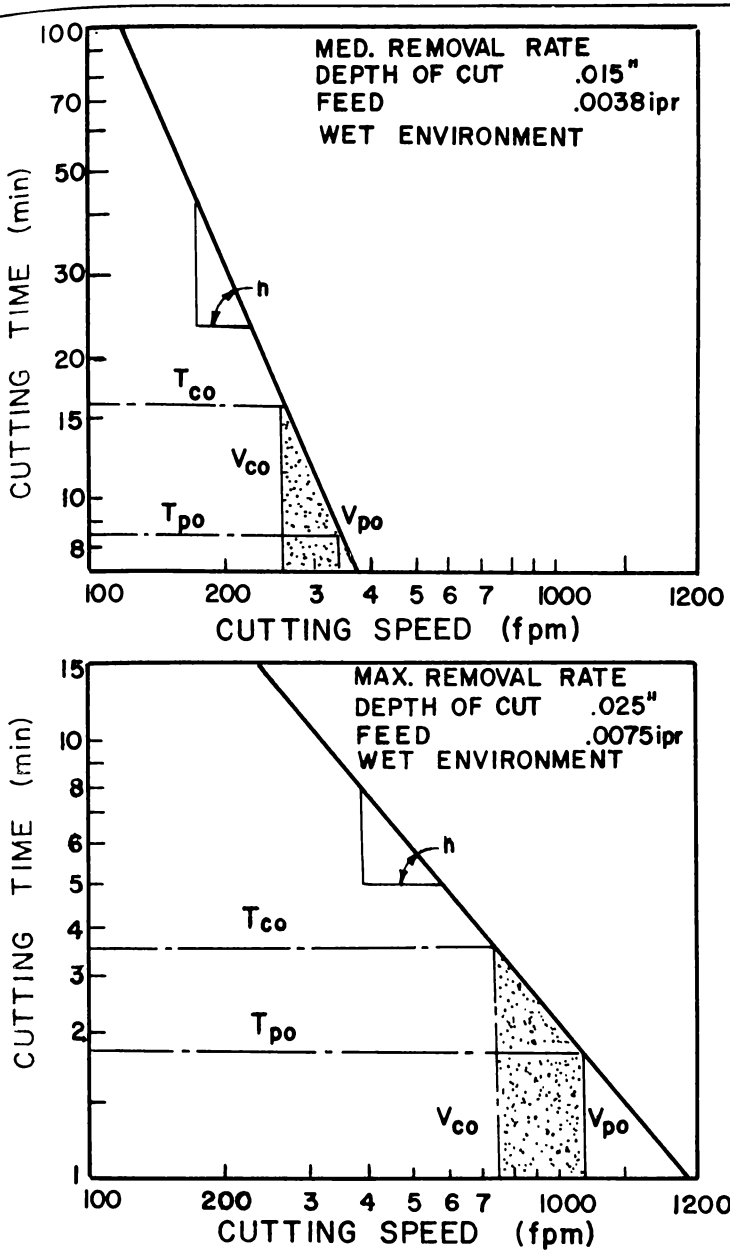

FIGURE 7. Cutting speed versus cutting time for medium and maximum removal rates showing optimal machining speed and time range.

TABLE 2. Machinability data

	Machinability Index (B)	Tool-Life Slope (n)	Cutting Time		Cutting Speeds	
			T_{co}	T_{po}	V_{co}	V_{po}
Minimum Stock Removed	237,000	2.280	—	—	—	—
Medium Stock Removed	756	.369	16.5	8.5	270	340
Maximum Stock Removed	1,680	.726	3.7	1.9	750	1050

SYMBOLS

C = total cost per component
x = labor and overhead cost rate
y = tool cost per cutting edge
T_1 = non productive time in minutes
T_c = machining time per component in minutes
T_d = time required to replace cutting edge or tool in minutes
T_{ac}= actual cutting time in minutes
T = tool life in minutes
T_t = total time per component
$\lambda = 12/\pi D$
D = diameter of workpiece in inches
ℓ = length of cut in inches
T = tool life in minutes
n = slope of tool life curve
V = cutting speed in feet per minute (fpm)
f = feed in inches per second (in/sec.)
d = depth of cut in inches
K = is system constant
$1/n, 1/n_1, 1/n_2$ = exponents of speed, feed and depth of cut
$A = Kd^{-1/n_2}$
μ = microns
$m\mu$ = millimicrons
∂ = partial differential function
T_{co} = minimum cutting time cost
T_{po} = maximum production tool life time
V_{co} = minimum cutting velocity
V_{po} = maximum cutting velocity

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