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**TELECOMMUTING BY INDUSTRY: AN EMPIRICAL ANALYSIS**

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In recent years, while the number of persons who report doing work at home has not increased dramatically, there has been a sharp increase in the number of persons who were *paid* for working at home. These workers are part of a growing phenomenon called telecommuting. The purpose of this study is to determine which industry characteristics influence an employer's decision to use telecommuting as an alternative work arrangement. This study first identifies characteristics affecting labor supply when time constraints, monetary costs, and employer mandated hours are relaxed. The study also examines how telecommuting can influence an employer's labor demand decisions by allowing them to draw resources from a broader labor market when labor markets are tight, insufficient skills are found within the local labor market, or when mobility constraints become an obstacle. Telecommuting can also be an alternative to expansion when physical plant resources are limited. Since telecommuting numbers by detailed industry are unavailable, this study uses the number of workers who use a computer to perform their work at home for pay as the dependent variable. Due to this variable's high correlation with the statistic for telecommuting, it does not appear to detract from the study's overall purpose. Using this dependent variable, the independent variables: industry growth, current technology use, occupational breakdown, gender composition, and industry flexibility are used as a proxy for the factors discussed above. With the exception of occupational breakdown, we would expect each of the factors to be positively correlated with the telecommuting decision.

 **$\alpha$  1-ADRENERGIC ACTIVATION PATHWAY OF THE SODIUM/HYDROGEN ION EXCHANGER IN CCL-39 CELLS**

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Maintenance of intracellular pH (pHi) and cell volume regulation is a function of the sodium/hydrogen ion exchanger (NHE). NHE1 is the only isoform of the exchanger expressed in Chinese hamster lung fibroblasts (CCL-39). Therefore CCL39 cells are a good system to study NHE1 regulation. NHE1 is activated by a wide variety of agonists. One of the most studied is the growth factor  $\rightarrow$  Ras  $\rightarrow$  MAPK pathway. In cardiac cells, G-protein coupled  $\alpha$  1-adrenergic receptor leads to the activation of NHE-1, however its mechanism is not clear. The present study elucidates the relationship between G-proteins, MAPK, and NHE-1 in CCL39 cells. Phenylephrine (PE), an  $\alpha$ 1-adrenergic specific agonist, has been shown for the first time to stimulate both NHE-1 and MAPK in CCL-39. Activation of MAPK occurs in a dose dependent manner. Optimal MAPK activation was observed at ten minutes and displayed a maximum stimulation at 50  $\mu$ M PK.  $\alpha$ 1-adrenergic stimulation also lead to a rise in steady-state pHi. PE activation of MAPK was inhibited by pre-treatment with either staurosporine or the specific PKC inhibitor Ro-31-8220. Addition of 100 mM PMA greatly increased the activity of both NHE-1 and MAPK. To determine the Ras dependent activation of MAPK and NHE-1, a dominant negative Ras construct was transfected into the CCL-39 cells. The transfection process has been optimized using Fugene-6 as a transfection agent. These studies indicate a direct involvement of PKC on MAPK in the  $\alpha$ 1-adrenergic activation of NHE-1.

**DETERMINING THE MECHANISMS OF ALLOSTERIC REGULATION FOR GLUTAMATE DEHYDROGENASE**

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The binding of regulatory ligands that lead to structural and functional alterations of an enzyme is termed allosteric regulation. This short-term enzymatic regulation allows exquisite control of substrate and product levels in response

to cellular needs. Studying the mechanisms of such allosteric regulation is a key to understanding the dynamic activity of certain important metabolic enzymes. The overall goal of this investigation is to characterize the allosteric regulation of the metabolic enzyme glutamate dehydrogenase (GDH).

For many oligomeric enzymes like GDH, subunit to subunit interactions transfer and amplify allosteric regulation. Specifically this study is aimed at determining structural features involved in transferring the effects of regulatory ligand binding from one subunit of GDH to the next. Using x-ray crystal data potential allosteric regulatory sites have been determined whose function will be explored via site-directed mutagenesis. The work done thus far has focused on obtaining a cDNA clone of both the bovine and human GDH genes. Starting with primers designed from the published human sequence, reverse transcriptase and polymerase chain reaction (PCR) techniques were utilized to produce a clone representing half of the amino acid coding region of human GDH. Sequencing data shows that the cDNA fragment produced corresponds with the expected PCR product for the primers used. This data suggests that altered priming techniques will produce a clone of the entire coding region that can be used for mutagenesis studies. Future kinetics and structural determinations of mutated enzyme will help elucidate the mechanisms of allosteric regulation in GDH.

**RAP1A BASAL LEVEL IMPORTANCE AND REGULATION IN MULTIPLE CELL TYPES**

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Rap1A is a 21 kD protein that belongs to the GTP-binding superfamily of Ras-related proteins. Rap1A has been the subject of extensive research in an attempt to characterize its participation in cell growth regulation. Although it clearly has the potential to act as an inhibitor of cell proliferation, published studies disagree on both the nature and the importance of its role. Previously, our lab has shown Rap IA expression to be down regulated prior to DNA synthesis in regenerating rat liver. Subsequent experiments with various cell types have now shown similar results with primary cultures of rat hepatocytes and with a non-immortalized human cell line. Using Northern analysis, we have shown that immortalized cell lines vary dramatically in their regulation of Rap1A expression. This finding raises questions about previous conclusions drawn from studies using immortalized cell lines. In six different cell types, we have found that cells that have significant resting levels of Rap1A mRNA show more down-regulation of Rap1A when given a signal to proliferate. Cells with a lower resting level of Rap1A seem to be unable to regulate their Rap1A to any appreciable extent. These results suggest that basal levels of Rap1A mRNA may determine its importance in cell cycle regulation, and that careful selection of cell types is necessary for further Rap1A studies.

**MITOCHONDRIAL NITROSATED PROTEINS**

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Mitochondria are a source of nitric oxide (NO) via the enzymatic conversion of L-arginine to L-citrulline. NO has many diverse effects such as modulating O<sub>2</sub> consumption, neurotransmission, and immune response. One result of NO production has been the formation of nitrosated proteins. Since nitrosation is known to occur on the tyrosine residue of many proteins, it may regulate the activity of target proteins in a manner similar to phosphorylation. In order to identify nitrosated mitochondrial proteins, rat liver mitochondria were purified and subfractioned into the outer membrane, inner membrane, contact sites, intermembrane space, and matrix. These fractions were then separated on SDS-PAGE and analyzed by western blot, probing with an anti-nitrotyrosine antibody. The ratios of nitrosated protein to total protein were highest in the outer membrane and intermembrane space, however, the matrix contained the most nitrosated proteins.

Two-dimensional SDS-PAGE was performed on these same mitochondrial fractions followed by western blot analysis. Numerous proteins were detected, some of which have been potentially identified using molecular weight and pI of the protein. The  $\beta$  and  $\lambda$  subunits of the  $F_1F_0$  ATP synthase, cytochrome oxidase subunit II, NADPH:adrenodoxin oxidoreductase, carbamoyl phosphate synthase I, and citrate synthase are some heavily nitrosated proteins. The  $\beta$  subunit of the  $F_1F_0$  ATP synthase has been unequivocally identified using antibodies specific to this subunit. Future studies will explore nitrosation of the  $\beta$  subunit effects on  $F_1F_0$  ATP synthase activity, as well as identify and characterize other nitrosated proteins.

#### DEGRADATION PATHWAYS OF GSNO

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Nitric oxide (NO) is a physiologically important free radical whose brief physiological half-life, due to high reactivity with other free radicals, limits its diffusion to its target sites. NO may need a transport/storage system. Thiols bond reversibly with NO. Thiol containing proteins such as BSA are suspected agents of NO storage and transport. Glutathione (a thiol containing molecule found *in vivo*), is capable of reversibly bonding with NO to form S-nitrosoglutathione (GSNO). The objective of this project was to study the degradation kinetics of this potentially significant biological molecule.

Degradation of GSNO was followed with a spectrophotometer (at 337nm) and HPLC (at 215nm) which allowed for concentration determination and identification and measurement of rates of individual degradation products. With the help of mass spectroscopy (MS), the products were identified as glutathionyl sulfonic acid ( $GSO_3H$ ), glutathionyl ether (GSOSG),  $GSO_2SG$ , and oxidized glutathione (GSSG). GSNO degradation was found to be pH dependent, rates being 16 to 20 times faster at basic pH's. Degradation was slowed in the presence of a chelator (catechol or deferoxamine) and absence of oxygen. Conversely, it was increased in presence of light as seen with the difference in rates given by HPLC and spectrophotometer. Results point to two degradation pathways: a light dependent homolytic cleavage of GSNO to GS and NO and heterolytic metal catalysis of GSNO to GS and NO.

The implications of this study include possible metal induced NO release mechanism *in vivo*. Further studies will include the investigation of copper and iron metals on GSNO degradation.

#### PATTERNS OF RESOURCE ALLOCATION TO FLORAL STRUCTURES IN THE RANUNCULACEAE FAMILY

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Evolutionary theory predicts that organisms will adapt to maximize reproductive success. Because resources are finite, natural selection will favor the most efficient method of resource allocation for this purpose. Plants, specifically hermaphroditic angiosperms, show a variety of reproductive strategies involving resource allocation to male and female reproductive structures (stamens and carpels respectively) as well as attractive structures (sepals and petals). This study examined the phenotypic variation in resource allocation to floral structures as well as the degree of developmental variation (i.e. resource allocation as a function of blooming rank) in four species of buttercups (Ranunculaceae); rue anemone *Anemone thalictroides*, columbine *Aquilegia canadensis*, Canada anemone *Anemone canadensis*, and prairie larkspur *Delphinium virescens*. Resource allocation was determined by the number of stamens (male reproductive structures), the number of carpels and the number of ovules per carpel (female reproductive structures), as well as the size of the flower, or the length and number of petals and sepals (structures for attracting pollinators). Our results revealed significant variation from plant to plant in most structures in each species as well as significant decreases in the size or number of each structure as the blooming season progressed. This variation may be due to environmental or genetic factors,

a question we plan to address in further studies. The reproductive consequences of these patterns will also need to be determined to understand the evolutionary pressures on floral structures. We are currently developing microsatellite DNA markers that will enable us to measure male reproductive success.

#### THE EFFECTS OF SPATIAL CONDITIONS ON THE PRAIRIE PLANT DIVERSITY AND SPECIES RICHNESS OF SUCCESSIONAL OLD FIELDS AROUND CEDAR CREEK NATURAL HISTORY AREA

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Mac Arthur and Wilson's theory of island biogeography states that the number of species on an island exists as an equilibrium between colonization by species from an outside species pool and extinction of present species. Large islands, or other isolated areas, can support larger populations of different species with greater genetic diversity, which can decrease the probability of extinction in the event of a disturbance. An abandoned agricultural field can be thought of as an island that has undergone disturbance in the form of cultivation; it is returning to equilibrium through secondary succession. This study explores the effect the area of each field has on its prairie plant species diversity and species richness. To determine species-area relationships, 16 agricultural fields that were abandoned between 1950 and 1957 in Cedar Creek Natural History Area, Minnesota, were surveyed for species composition over a three-week period in July of 1999. In the middle of each field, four 30m transects were spaced every 10m along a base line, and a 1x1 1/2m quadrant was placed every 3m along each transect. Species composition was documented inside each quadrant. The effects on species diversity and composition by the position of the field on a north-south topographical gradient and the type of the perimeter habitat surrounding each field were also considered. The results show that species diversity and richness do not increase with field area, although the field position and perimeter type do have an effect on the species composition of the field.

#### INFLUENCE OF BODY FLUIDS ON VIRUCIDAL EFFECT OF UV RADIATION

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The effect of organic matter on the survival of pathogens in the environment remains to be thoroughly studied. The hypothesis that body fluids decrease the anti-microbial effect of UV radiation was tested using equine herpesvirus type-1 (EHV-1) and milk and serum of bovine origin as the test samples. A preliminary neutralization test confirmed the absence of virus inhibiting factors in the milk and serum used. Serum or milk was added to the virus and the mixture was exposed to UV radiation; EHV-1 in phosphate-buffered saline (PBS) was included as control. After UV exposure for a designated amount of time (5, 10, 20, 40, and 60 min), an aliquot of each mixture was assayed for residual virus using the  $TCD_{50}$  endpoint method of Reed and Muench. The respective decreases in virus  $TCID_{50}$  titer (log 10) in milk, serum and PBS were 0, 0.7, and 2.9 after 5 minutes of UV irradiation, and 0.9, 2.4 and 6.0 after 60 minutes of UV irradiation. These results indicate that milk and serum protect EHV-1 against the virucidal effect of UV radiation, and that milk offers a higher degree of protection than serum.

#### POSITIONAL ORIENTATION IN THE DAMSELFLY *ISCHNURA RAMBURII*

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Damselflies, when perched, must choose which direction they will face. This orientation may be used to their advantage, most likely as a means of thermoregulation, since by altering orientation, an individual alters the amount of body surface exposed to the sun or wind, and therefore, their internal temperature. To discover if *I. ramburii* shows any orientation

preferences, I recorded the orientation of individuals in the field at various times of the day. *I. ramburii* showed a preference for facing into the incoming wind, as well as orienting perpendicular to the sun's incoming rays during much of the day. *I. ramburii* may have been attempting to perch in the most aerodynamically efficient way possible, or was attempting to raise its temperature. Whether orienting perpendicular to the sun or facing into the wind is more important to them remains unclear.

#### EFFECTIVENESS OF TRITERPENOID COMPOUNDS AND POLYETHYLENEIMINE DERIVATIVES OF BETULIN AGAINST HUMAN PATHOGENIC *CANDIDA* SPECIES.

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*Candida*, a genus of yeast like fungi are often part of the normal microbial flora of the mucus membranes of the mouth, vagina, and intestinal tract. *Candida* species may cause kidney, urinary tract, lung, and soft tissue infections. The infections are more common in immunocompromised, cancer and AIDS patients. In this study the activity of different triterpenoid compounds including betulin and its polyethyleneimine derivatives were determined against *Candida albicans* and *Candida guilliermoundii* by agar disk diffusion method. The *Candida* cultures were streaked on Sabouraud's Dextrose Agar plates and sterile filter paper disks were placed on the surface of the agar. Different concentrations of the test compounds and antifungal antibiotics were placed on the paper disks. The plates were incubated at 37°C for 18-24 hours. After 24 hours of incubation, zone size was measured. A significant anti-*Candida* activity of polyethyleneimine and its betulin analogs were observed against *C. albicans* and *C. guilliermoundii*. Allobetulin succinate was found to inhibit *C. albicans* resulting in the 9.0 mm zone of inhibition. Different ratios of Betulin-3,28-dioxalate and polyethyleneimine resulted in zone of inhibition from 09-18 mm against *C. albicans* and *C. guilliermoundii*, while the zone of inhibition of Nystatin was found to be 9.0 mm and 10 mm for *C. albicans* and *C. guilliermoundii* respectively. Polyethyleneimine, known to increase the permeability of cell membranes was also found to show some anti-fungal activity. Further study is in progress to evaluate the effectiveness of above compounds against other pathogenic *Candida* species.

#### RITANSERIN ALLEVIATES TICS IN A TRANSGENIC MODEL OF TS+OCD

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Tourette's syndrome (TS) and its comorbid condition obsessive-compulsive disorder (OCD) may involve abnormal hyperactivity of cortical and limbic neurons. In humans, TS responds both to D2 dopamine receptor antagonists (traditional neuroleptics) and to mixed D2 dopamine and 5HT2 serotonin antagonists (atypical neuroleptics), but the efficacy of pure 5HT2 antagonists is unknown. We have previously characterized mice with comorbid TS+OCD-like behaviors generated by the expression of a neuropotentiating cholera toxin (CT) transgene in cortical-limbic D1 receptor-expressing (D1+) neurons. These hyperactivated excitatory neurons reside within the same areas of the brain that show hyperactivity in PET scans of patients with TS and OCD. The abnormal behaviors induced in these mice are distinct from drug-induced stereotypies and limbic seizures, but closely resemble the tics and abnormal perseverance of all behaviors exhibited by persons with comorbid TS+OCD. In this study, we have addressed the question of whether a pure 5HT2 receptor antagonist, ritanserin (1mg/kg), alleviates the tic-like behavior of this TS+OCD model. Ritanserin completely normalized tic-like behavior in these mice to the level seen in control (non-transgenic) mice. These data suggest that ritanserin and possibly related 5HT2 receptor antagonists will be useful in the alleviation of human TS and OCD.

#### EFFECTS OF UNIONIZATION ON RURAL COUNTY OUTCOMES

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Existing empirical results on labor unions focus mainly on internal effects at the firm level. The objective of this proposal is to determine if the union status of a rural firm affects the county in which it is located in terms of productivity, wages, and various other externalities. The Occupational Safety and Health Administration (OSHA) website contains inspection data used to determine the union status of a firm.

The paper mill and meat packing industries were chosen for this study. These industries produce a relatively homogeneous product, are heavily unionized, and are located in predominantly rural settings. A rural setting is defined in this proposal as having a population less than 70,000 and being at least 10 miles outside of a Rurally Metro Area. Data from the Census Bureau is available on the county level for all counties that meet the criteria.

Manufacturing output per capita and value added by manufacturing will capture any productivity effects of unionization. Wage effects will be measured by per capita money income, per capita personal income, and the wage spread between manufacturing and retail wages. The crime rate, poverty rate, unemployment rate, and state and local government employment are the other externalities that will be considered

These dependent variables will be functions of such variables as population, manufacturing employment, total earnings, farming population and, of course, union status. Regression analysis will determine if the union status of a rural firm has an effect on the selected dependent variables.

#### RESOURCE AVAILABILITY AND THE INVASIBILITY OF PLANT COMMUNITIES

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The conditions required for the establishment of introduced non-native species has for a long time puzzled ecologists. Recently, questions regarding invasive non-native species have become more urgent as homogenization of plant communities has increased. The purpose of this study was to determine the role of resource availability, competition, and the interaction of these two factors in the success of introduced native plants. The study was conducted in summer 1999 in an abandoned farm field dominated by non-native grass species at Cedar Creek Natural History Area in Bethel, Minnesota. The effects of competition and water availability on the invasion success of 5 native plant species were studied with an experimental design consisting of 8 replicates of 4 treatments, which included wet weeded, wet non-weeded, dry weeded, and dry non-weeded. Invasion success of species hand seeded into plots was measured by percent cover and success of transplants by survival. Resource availability, including soil nitrogen, soil water, and light, was also recorded in the plots. Results showed that introduced plants in the wet had greater success than in the dry treatment. In the wet treatment, competition was not a significant factor in introduced plant success. In contrast, competition was a significant factor in the dry treatment. Success in the weeded dry treatment was greater than in the non-weeded dry treatment. Overall, the results showed that community invasibility was strongly correlated with water availability. Successfully determining the characteristics of communities that are particularly susceptible to invasion is vital to predicting and preventing the further spread of non-native species.

#### EVALUATING GIANT FOXTAIL (*SETARIA FABERI*) FOR HERBICIDE RESISTANCE

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Repeated application of a herbicide in agricultural fields may select for weed populations that are resistant to the herbicide. A rapid and reliable seedling bioassay was used to

determine resistance in giant foxtail seeds to sethoxydim. Known susceptible and resistance giant foxtail seedlings were exposed to a dilution series of sethoxydim and were measured for root and shoot growth at 3 and 6 days after application. Results were used to develop a specific bioassay for determination of resistance in giant foxtail seeds. Using a bioassay concentration of 10mg/L sethoxydim, seeds collected from 12 herbicide resistant management trials were tested and scored for resistance. Eight trials had the same herbicide treatment applied annually for four years. The herbicides used were atrazine + metolachlor and sethoxydim + dicamba DGA at half and full label rates. Four trials had alternating years of atrazine + metolachlor and sethoxydim + dicamba DGA. Half of 12 herbicide resistant trials received annual row cultivation practices. The proportion of resistant seeds allowed for the determination of the relative success of each of the management treatments. Susceptibility of giant foxtail to sethoxydim ranged from 6% to 86%. Treatments that were sprayed with sethoxydim + dicamba DGA showed a greater percentage of resistant giant foxtail seeds than those sprayed with atrazine + metolachlor.

#### COMPARATIVE VAGAL LOBE ORGANIZATION IN THE BRAINS OF CATOSTOMID FISHES

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The vagal lobe is an enlargement of the dorsal surface of the hindbrain of fishes that have a well-developed sense of taste. The cellular organization within the lobe of some of these fishes is laminar, with different layers consisting of sensory nerve fibers entering the lobe, interneurons connecting different layers with each other or with different regions of the brain, and motor neurons with fibers that innervate musculature involved in feeding behaviors. Several species of catostomids were used in this study, including species with habitats varying from large rivers and lakes to small mountain streams. Several brains from each species were sectioned in paraffin and were stained either for cell bodies (Nissl protocols) or for neuronal processes (Bodian silver-staining), and were compared microscopically.

There was very little variation in the laminar organization of the vagal lobe between species. However, the size of the VL in each sucker was proportionate to the amount of gustatory epithelium in the pharynx. The river carsucker (*Carpodes carpio*) and the smallmouth buffalo (*Ictiobus bubalus*) – species with complex palatal organs lined with gustatory receptors – had the largest VLs, whereas the northern hogsucker (*Hypentelium nigricans*) and the shorthead redhorse (*Moxostoma macrolepidotum*) – species with the smallest palatal organs – had the smallest VLs. The elongated vagal lobe in some species allows the resolution of taste stimuli to remain high in suckers with extraordinarily large numbers of taste receptors. These species generally inhabit larger, slower-moving bodies of water than those species with smaller vagal lobes.

#### BISON (*BISON BISON*) HABITAT USE AND BEHAVIOR DURING THE BREEDING SEASON IN THEODORE ROOSEVELT NATIONAL PARK IN THE NORTH DAKOTA BADLANDS.

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Herd composition, calf production, habitat use, and reproductive behavior of bison (*Bison bison*) were studied in the South Unit of Theodore Roosevelt National Park during July and August of 1999 to address concerns that bison bulls might be too numerous in the herd for its long-term health. Bull behaviors towards lactating cows versus nonlactating cows were compared. If bulls greatly outnumbered cows, lactating cows might be tended more frequently even though such cows are less likely to ovulate that year than nonlactating cows. Highest bison counts for any single day were approximately 350. Although the herd was often split into

various-sized bands and counts varied daily, averages of our best counts indicated the herd composition was roughly: 18% adult bulls, 33% adult cows, 5% subadult males, 4% subadult females, 4% subadult unknowns, 21% calves, and 15% unknowns. Calf production was fairly high at approximately 0.6 calves/cow. Bison used black-tailed prairie dog (*Cynomys ludovicianus*) towns extensively for their rut activities. Bulls tended mainly nonlactating cows until later in the rut, when the percentage of lactating cows being tended increased slightly. No calves were seen with cows being mounted. However, towards the end of the rut several lactating cows were seen with fresh wounds on their backs, presumably from being mounted. Although bull-to-bull aggression levels were sometimes fairly high, good calf production and normal breeding behaviors suggested that the current number of bulls is not detrimental to the herd. However, we suggest further monitoring as subadult males reach reproductive age.

#### UNCOVERING THE *IN SITU* PROPERTIES OF C<sub>4</sub> PYRUVATE, ORTHOPHOSPHATE DIKINASE REGULATORY PROTEIN, RP, A MOST UNUSUAL DUAL REGULATORY PROTEIN KINASE/PHOSPHATASE

Erin Watkin and Adam Vossen, Department of Biology, Moorhead State University, Moorhead, MN 56560

Pyruvate, orthophosphate dikinase (PPDK) is a cardinal enzyme of the C<sub>4</sub> photosynthetic pathway. It catalyzes the regeneration of the primary CO<sub>2</sub> acceptor molecule, phosphoenolpyruvate (PEP), from pyruvate and ATP/Pi. Evidence is mounting that PPDK is perhaps the most rate limiting enzyme of the pathway. Thus, its regulation is of paramount importance with respect to how the overall pathway operates and responds to a wide array of environmental cues. In C<sub>4</sub> plants, PPDK regulation is mediated by reversible phosphorylation of a specific active-site Thr residue (THR-456 in maize). A single bifunctional protein kinase/phosphatase, PPDK Regulatory Protein (RP), catalyzes this regulatory phosphorylation and dephosphorylation. To explore how RP is regulated in maize leaves, we have developed antibodies specific for the inactivated (phospho-Thr-456) form of C<sub>4</sub> PPDK. These polyclonal antibodies were generated against a synthetic phosphopeptide composed of 20 residues flanking the Thr-456 region of the maize C<sub>4</sub> polypeptide. We have employed these antibodies as a new tool for assessing *in situ* RP activity via immunoblotting of the PPDK activation state. Among the studies to be presented using this approach will be (i) a kinetic analysis of RP mediated PPDK light activation and dark inactivation, and (ii) RP modulation of PPDK activity in response to changes in light intensity.

#### AN EXPLORATION IN SYMBOLIC DYNAMICS: THE GOLDEN MEAN SHIFT AND THE SILVER MEAN SHIFT SIDE BY SIDE

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Symbolic Dynamics is a tool to study general dynamical systems and is a rapidly growing field in mathematics. To investigate a dynamical system, symbolic dynamics employs infinite sequence of symbols that represent a space. These sequences of symbols, or shifts, the building blocks of symbolic dynamics. One of the well-studied shifts is the shift of finite type. The Golden Mean Shift is a famous example of this shift. Interestingly, this shift is embedded with connections to the well-known Fibonacci sequence, i.e. a sequence of integers 1,1,2,3,5,8,13,... in which  $F_n = F_{n-1} + F_{n-2}$ . Its cousin, the Silver Mean Shift, is constructed similarly with connections to the less-known Padovan sequence, a sequence of integers 1,1,1,2,2,3,4,5,7,9... where  $P_n = P_{n-2} + P_{n-3}$  discovered by Richard Padovan. We will explore in depth the dynamical differences between the two shifts and how their names reflect their properties.