NSERC grants at Laurentian University
Subventions du CRSNG à l’Université Laurentienne

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A message from the President
Un message de la rectrice

Judith Woodsworth, Ph.D.
President of Laurentian University
Rectrice de l’Université Laurentienne

For the third time, Dr. Patrice Sawyer, Dean of the Faculty of Science and Engineering, has taken the initiative of preparing a compilation of NSERC funded research at Laurentian University.

This booklet is one of the many ways we have of profiling and celebrating the work of our faculty – more specifically those who have received funding from the Natural Sciences and Engineering Research Council of Canada.

Laurentian University is the #1 Canadian University in research income growth for 2006. According to RE$EARCH Infosource, which ranks Canada’s Top 50 Research Universities each year, research funding at Laurentian grew by 133 per cent from 2005 to 2006. In dollar terms, Laurentian received $38.6 million in sponsored research funding in 2006; in 2005, it had received $16.6 million. We have clearly benefited from the presence of our first-ever Associate Vice-President, Research, Dr. Liette Vasseur, and from the increased research activities of our seasoned faculty, as well as the highly competent junior faculty who have recently joined our ranks.

Laurentian University has remained true to its mission as a northern university, with research and teaching grounded in the North. At the same time, while meeting some of the immediate needs of the
community – in areas such as mineral exploration, environmental restoration and northern and rural health, for example – research at the University has grown and flourished to match that conducted at any mature institution of higher learning, and is now attracting national and international attention.

The impact of the projects described here is profound. The dollars attracted to the University are spent on goods and services here in the city, contributing to the local economy. Wages are paid to students and, in particular, these students are given an invaluable opportunity to work alongside faculty. In many cases, even undergraduate students get a chance to do this kind of work, which is not the case at most larger universities. This gives them a taste for research and provides them with the experience required to go on to graduate studies.

The results of some research projects will be immediate and concrete. Others have an impact that will be felt in the longer term. All are valuable in themselves as contributions to knowledge. Finally, and perhaps most important, researchers bring their insights from the laboratory to the classroom and thereby enrich the educational experience of all students.

I would like to express my appreciation, once again, to Dr. Patrice Sawyer for his work in producing the 2008 edition of the NSERC Booklet and to congratulate all the researchers whose work is highlighted here.

***

Pour la troisième fois, M. Patrice Sawyer, doyen de la Faculté des sciences et de génie, a pris l’initiative de compiler les recherches menées à l’Université Laurentienne et financées par le CRSNG. Celles-ci ont été rassemblées dans une brochure qui fait partie des nombreux moyens dont nous disposons pour exposer et souligner les travaux des membres de notre corps professoral, surtout les personnes ayant reçu des fonds du Conseil de recherches en sciences naturelles et en génie.

L’Université Laurentienne a vu croître le financement de ses recherches plus que toutes les autres universités canadiennes en 2006. Selon RE$EARCH Infosource Inc., qui classe annuellement les 50 meilleures universités au Canada, le financement de recherche à l’UL s’est accru
de 133 % entre 2005 et 2006. En d’autres mots, l’UL a reçu, en 2006, 38 600 000 $ en fonds destinés à la recherche subventionnée comparativement à 16 600 000 $ en 2005. Nous avons grandement bénéficié de la présence de notre première vice-rectrice associée à la recherche, Mme Liette Vasseur, et de l’augmentation des activités de recherche de nos professeurs chevronnés mais aussi de nos jeunes professeurs fort compétents qui sont entrés récemment dans nos rangs.

L’Université Laurentienne est demeurée fidèle à sa mission d’université du Nord dont l’enseignement et la recherche sont ancrés dans le Nord. En même temps, tout en répondant à certains besoins immédiats de la collectivité (par exemple, dans des domaines comme l’exploration minière, la restauration environnementale et la santé dans le nord et les régions rurales), la recherche a pris de l’expansion et prospéré au point de se trouver sur un pied d’égalité avec celle de n’importe quel établissement d’enseignement supérieur pleinement développé, et elle est devenue aujourd’hui susceptible d’attirer l’attention des centres de recherche sur les scènes nationale et internationale.

Les projets présentés ici ont de profondes retombées. Les fonds que l’Université reçoit servent à acquérir des biens et services à Sudbury et contribuent à alimenter l’économie locale. Des salaires sont versés à des membres de la population étudiante qui ont ainsi une occasion inespérée de travailler aux côtés de certains membres du corps professoral. Bien souvent, même des étudiants du premier cycle ont la chance d’accomplir ce genre de travail, ce qui n’est pas le cas dans la plupart des grandes universités. Ils ont ainsi l’occasion de s’initier à la recherche et d’acquérir l’expérience requise pour effectuer des études supérieures.

Certaines recherches produisent des résultats immédiats et concrets. D’autres ont des retombées qui se manifestèrent à plus long terme. Elles sont toutes précieuses, car elles contribuent au savoir. Finalement et c’est peut-être ce qui importe le plus, les chercheurs apportent dans la salle de classe le fruit de leurs réflexions en laboratoire et enrichissent ainsi l’expérience des membres de la population étudiante.

Je tiens à remercier de nouveau M. Patrice Sawyer d’avoir produit l’édition 2005 de cette brochure sur les subventions du CRSNG et féliciter tous les chercheurs dont le travail y est mis en valeur.
Foreword
Préface

Liette Vasseur, Ph.D.
Associate Vice-President, Research
Vice-rectrice associée à la recherche
Laurentian University/Université Laurentienne

Laurentian University has grown from an undergraduate institution to a comprehensive university with a strong mandate in research. In the past years, Laurentian has effectively built on excellence and has become a prime location to bring unique opportunities in the fields of natural resources, mining, environment, health and cultural, social and economic sciences. The university maintains its commitment to support both fundamental and applied research, alone or in collaboration with other institutions and universities. The new Ph.D. programs as well as new research centers are now pushing the university into a new era of discovery and innovation.

With the creation of the Research, Development and Creativity Office, Laurentian University can now support researchers in a more efficient way and also will be able to better promote research success in the community. Fields of research in biology, chemistry, biochemistry, commerce, geography, psychology, engineering, mathematics and computer science, physics, earth sciences, and human kinetics are positively contributing to Canadian knowledge translation. The Northern Ontario School of Medicine is also a precious addition that brings collaborative
work at the northern Ontario level. Through all these programs and initiatives, highly qualified personnel (HQP) have a wonderful opportunity to learn and be trained in areas of great importance to Ontario, Canada and beyond. In addition, Laurentian has been able in the past few years to embark in the sphere of innovation leading to commercialization. With a few patents and royalty bearing licenses being signed or currently negotiated, the researchers can demonstrate the excellence of their contributions to society in many ways.

I am therefore very pleased to be associated to the presentation of this booklet outlining the amazing projects and research programs of researchers at Laurentian as well as the incredible potential they have to contribute to HQP training, knowledge translation and commercialization.

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Un établissement de premier cycle à l’origine, l’Université Laurentienne s’est transformée en une université polyvalente ayant un important mandat de recherche. Bâissant sur l’excellence au cours des dernières années, la Laurentienne est devenue une destination de premier ordre pour les recherches exceptionnelles dans les domaines des ressources naturelles, de l’exploitation minière, de l’environnement, de la santé, de la culture et des sciences sociales et économiques. L’Université appuie indéfectiblement les recherches fondamentales et appliquées, qu’elle effectue seule ou en collaboration avec d’autres établissements. En outre, les nouveaux programmes de doctorat de pair avec les nouveaux centres de recherche la dirigent vers une ère nouvelle de découvertes et d’innovations.

La création du Bureau de la recherche, du développement et de la créativité permet à l’Université Laurentienne d’appuyer plus efficacement les chercheurs et de mieux promouvoir les réussites en recherche auprès de la collectivité. Les progrès en biologie, chimie, biochimie, commerce, géographie, psychologie, génie, mathématiques, informatique, physique, sciences de la Terre et sciences de l’activité physique contribuent de manière significative à l’application de connaissances au Canada.

L’École de médecine du Nord de l’Ontario est aussi une précieuse
nouveauté qui apporte des possibilités de collaboration dans le nord de l’Ontario. Grâce à tous ces programmes et initiatives, le personnel hautement qualifié a une merveilleuse occasion d’apprentissage et de formation dans des domaines qui ont des incidences importantes sur l’Ontario, le Canada et ailleurs.

De plus, au cours des dernières années, la Laurentienne a mis l’accent sur l’innovation aux fins de commercialisation. À l’heure actuelle, nos chercheurs négocient ou concluent des ententes de brevet et des licences qui rapporteront des redevances, témoignant de l’excellence de leurs contributions diverses à la société.

C’est l’une des raisons pour laquelle je suis très fière de participer à cette brochure qui étale les superbes projets et programmes de recherche de la Laurentienne ainsi que l’immense potentiel qu’ont les chercheurs à contribuer à la formation de personnel hautement qualifié, à l’application des connaissances et à la commercialisation.
NSERC (pronounced n’serc) stands for Natural Sciences and Engineering Research Council of Canada, a federal agency whose mandate is to encourage research and discovery in the natural sciences and engineering in Canada. In its own words:

NSERC’s role is to make investments in people, discovery and innovation for the benefit of all Canadians. We invest in people by supporting some 23,000 university students and postdoctoral fellows in their advanced studies. We promote discovery by funding more than 11,000 university professors every year. And we help make innovation happen by encouraging about 1,300 Canadian companies to invest in university research and training. Over the last ten years, NSERC has invested more than $6 billion in basic research, university-industry projects, and the training of Canada’s next generation of scientists and engineers.

This booklet provides the summaries of all the research endeavours by current holders of NSERC grants at Laurentian University. These summaries were written by each researcher as part of their application to NSERC.

Laurentian University president, Dr. Woodsworth, and the associate vice-president of Research, Dr. Vasseur, have already mentioned the impact of NSERC’s funding on the university and on the region. From the viewpoint of a researcher who has benefited from NSERC’s funding for a number of years, I cannot emphasize enough what this support has meant to me. It has allowed me to meet with researchers across the world to learn of their work and to let them know about mine as well. My grant allows me to hire students. In addition to earning a
salary, this gives them an introduction to research, so it works to their benefit as well as mine.

I believe that you will find much in these pages to interest you and hope that you will share my pride in the achievements of my fellow researchers from Laurentian University.

I am thankful for the help I have had from many sources in putting this booklet together. In particular, I want to mention Ms. Mary-Catherine Taylor and Mr. Brent Wohlberg, who provided me with many of the photos you will find here. The cover was designed by Ms. Mélanie Laquerre. Several of the summaries were provided by Daniel Archambault from the Research, Development and Creativity Office.

Special thanks go to Ms. Louise Rancourt who assisted me in preparing the booklet.

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CRSNG (que certains prononcent « seringue ») est l’acronyme du Conseil de recherches en sciences naturelles et en génie du Canada, est l’agence fédérale dont le mandat est de promouvoir la recherche et la découverte dans les sciences naturelles et dans le génie.

Son rôle se définit en ces termes :

Le rôle du CRSNG est d’investir dans les gens, la découverte et l’innovation pour en faire bénéficier tous les Canadiens. Nous investissons dans les gens en accordant un appui à quelque 23 000 étudiants universitaires et stagiaires postdoctoraux. Nous faisons la promotion de la découverte en offrant un appui financier à plus de 11 000 professeurs d’université chaque année. Et nous favorisons l’innovation en incitant environ 1 300 entreprises canadiennes à investir dans la recherche et la formation universitaires. Au cours des dix dernières années, le CRSNG a investi plus de six milliards de dollars dans la recherche fondamentale, les projets universités-industrie et la formation de la prochaine génération de scientifiques et d’ingénieurs du Canada.

Cette brochure contient les résumés de tous les projets de recherche de membres du corps professoral de l’Université Laurentienne qui détiennent
une subvention du CRSNG. Ces résumés ont été composés par les chercheurs lors de leur demande de subvention au CRSNG.

La rectrice de l’Université Laurentienne, Mme Woodsworth, et la vice-rectrice associée à la recherche, Mme Vasseur, ont déjà expliqué l’impact qu’ont les fonds octroyés par le CRSNG sur l’université et la région. Du point de vue d’un chercheur qui a bénéficié de l’appui du CRSNG depuis un bon nombre d’années, je ne peux pas assez insister sur l’importance de ce soutien pour moi. Il m’a permis de rencontrer des chercheurs de partout dans le monde pour apprendre ce qu’ils font et, aussi, pour leur faire connaître mes propres projets de recherche. Ma subvention me permet d’employer des étudiants qui, en plus de gagner un salaire, ont la chance de se familiariser avec la recherche pour notre avantage mutuel.

Je crois donc que cette brochure vous intéressera et j’espère que vous partagerez ma fierté devant les accomplissements de mes collègues chercheurs de l’Université Laurentienne.

Je suis reconnaissant à toutes les personnes qui m’ont aidé à préparer ce recueil, notamment Mme Mary-Catherine Taylor et M. Brent Wohlberg qui m’ont fourni plusieurs des photos, Mme Mélanie Laquerre, qui a créé le design de la page couverture et Mme Louise Rancourt, qui m’a aidé à préparer cette publication. Plusieurs des résumés ont été fournis par Daniel Archambault du Bureau de la recherche, du développement et de la créativité.

Patrice Sawyer, Ph.D.
NSERC’s Representative at Laurentian University
Représentant du CRSNG à l’Université Laurentienne
Grants lexicon
Lexique des subventions

Discovery Grants

Discovery Grants support ongoing research programs. These grants recognize the creativity and innovation that are at the heart of all advances in research, whether made individually or in groups. Researchers are free to work in the mode most appropriate for the research area. The grants generally cover for five years.

Research Tools and Instruments (RTI) Grants

RTI Grants assist in buying or developing research equipment that costs more than $7,000.

Collaborative Research and Development (CRD) Grants

CRD grants support well-defined projects undertaken by university researchers and their private-sector partners. CRD awards cover up to half of the total eligible direct project costs, with the industrial partner(s) providing the balance in cash and in kind.

Major Facilities Access Grants

Major Facilities Access Grants support researchers’ access to major regional or national research facilities by helping these facilities remain in a state of readiness for researchers to use.

Idea to Innovation (I2I) Program

The I2I program provides funding to university researchers for research and development activities leading to technology transfer to a
new or established Canadian company. Two distinct funding phases are proposed; these phases are limited in time and the direct costs of research in the first phase will be entirely supported by NSERC while those of the second phase will be shared with a private partner.

**Strategic Network Grants**

The objective of the Strategic Network Grants program is to increase research and training in targeted areas that could strongly enhance Canada’s economy, society and/or environment within the next ten years.

**Strategic Project Grant**

A grant which addresses a priority area identified in the Government of Canada’s new science and technology strategy, “Mobilizing Science and Technology to Canada’s Advantage”.

**PromoScience**

NSERC’s PromoScience program offers financial support for organizations working with young Canadians to promote an understanding of science and engineering.

**John C. Polanyi Award**

The NSERC John C. Polanyi Award celebrates the research excellence exemplified by Dr. Polanyi during his remarkable career as well as the outstanding contributions he continues to make to science and society.

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**Subventions à la découverte**

Les subventions à la découverte soutiennent des programmes continus de recherche. Elles reconnaissent que la créativité et l’innovation sont au cœur des percées en recherche, qu’elles soient réalisées individuellement ou en groupe. Les chercheurs sont libres de choisir le mode
le plus approprié à leur domaine de recherche. Ces subventions sont généralement d’une durée de cinq ans.

Subventions d’outils et d’instruments de recherche (OIR)

Les subventions d’OIR soutiennent l’achat ou la mise au point d’appareils de recherche dont le coût dépasse 7 000 $.

Subventions de recherche et développement coopérative (RDC)

Les subventions de RDC soutiennent des projets de recherche bien définis menés conjointement par des chercheurs universitaires et leurs partenaires du secteur privé. Les subventions de RDC couvrent jusqu’à la moitié des coûts totaux admissibles du projet, le ou les partenaires industriels accordant le reste en espèces et en nature.

Subventions d’accès aux installations majeures

Les subventions d’accès aux installations majeures permettent aux chercheurs d’avoir accès à de grandes installations de recherche régionales et nationales afin d’en assurer l’état de préparation aux fins d’utilisation par les chercheurs.

Programme de l’idée à l’innovation (INNOV)

Le programme de l’idée à l’innovation (INNOV) offre des fonds à des chercheurs universitaires aux fins d’activités de recherche et développement menant à un transfert de technologie vers une entreprise canadienne établie ou nouvelle. Deux phases de financement distinctes d’une durée déterminée sont offertes. À la première phase, les coûts directs de la recherche sont totalement assumés par le CRSNG alors qu’à la seconde, ils sont partagés avec un partenaire du secteur privé.

Subventions de réseaux stratégiques

Le Programme de subventions de réseaux stratégiques vise à accroître la recherche et la formation dans des domaines ciblés propres à améliorer de façon appréciable l’économie, la société ou l’environnement du Canada au cours des dix prochaines années.
Subvention de projet stratégique

Une subvention qui s’inscrit dans un des domaines jugés prioritaires dans la nouvelle stratégie du gouvernement du Canada en matière de sciences et de technologie intitulée « Réaliser le potentiel des sciences et de la technologie au profit du Canada ».

PromoScience

Le programme PromoScience du CRSNG offre une aide financière à des organismes qui donnent l’occasion aux jeunes Canadiens d’en apprendre davantage sur les sciences et le génie.

Prix John C. Polanyi

Le Prix John C. Polanyi du CRSNG souligne l’excellence en recherche dont M. Polanyi donne l’exemple par sa remarquable carrière, ainsi que par les contributions exceptionnelles qu’il continue d’apporter à la science et à la société.
Research, Development and Creativity Office

Bureau de la recherche, du développement et de la créativité

Liette Vasseur\textsuperscript{1}

Research Capacity Development – Renforcement de la capacité de recherche

A grant of $1,500,000 for five years.
Une subvention de 1 500 000 $ pour cinq ans.

Research Capacity Development in Small Universities Pilot Program – Programme pilote de renforcement de la capacité de recherche dans les petites universités

Laurentian University has received $1.5 million from the Natural Sciences and Engineering Research Council of Canada (NSERC) for 2004–2009. This funding comes from NSERC’s Research Capacity Development in Small Universities Pilot Program. Laurentian is one of seven universities in Canada selected to participate in this program. There were 34 applicants for the awards.

This federal investment seeks to help small universities increase their research capacity. It will create new opportunities for professors and students, as well as help spread a culture of research and innovation across the country.

\textsuperscript{1}The Associate Vice-President, Research administers the grant on behalf of Laurentian University./La vice-rectrice associée à la recherche administre la subvention au nom de l’université.
The RCD Pilot Program is one of the new initiatives NSERC has launched to fill some significant gaps in Canada’s innovation system. These initiatives are designed to help Canada become a nation of discoverers and innovators.

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L’Université Laurentienne a reçu une contribution de 1,5 millions de dollars pour 2004–2009 du Conseil de recherches en sciences naturelles et en génie du Canada (CRSNG). Ces fonds sont offerts grâce au Programme pilote de renforcement de la capacité de recherche dans les petites universités (RCR) du CRSNG. La Laurentienne figure parmi les sept établissements retenus pour ce programme alors que 34 établissements avaient présenté une demande de subvention.

Le but de ce programme fédéral est d’aider les petites universités à renforcer leur capacité de recherche. Cet investissement créera de nouvelles possibilités pour les professeurs et les étudiants, et aidera à développer une culture de recherche et d’innovation dans l’ensemble du pays.

Le Programme pilote de RCR fait partie des nouvelles initiatives que le CRSNG a lancées pour combler des lacunes importantes de notre système d’innovation et pour aider le Canada à devenir un pays de découvreurs et d’innovateurs.
Department of Biology
Département de biologie

Yves Alarie

Systematics, evolution and larval morphology of world hydradephaga (coleoptera)

A grant of $22,700 per year.
Une subvention de 22 700 $ par année.

Discovery Grant – Subvention à la découverte

Understanding of all life stages of insects is of critical importance to ecological and environmental management. However, encounters with immature insects are relatively uncommon compared with adults, yet larvae undoubtedly cause more direct injury to crops and other materials valued by human than do adults. This is true because most feeding is done in the larval stage whereas adults are primarily involved in dispersal and reproduction. Our research emphasizes the study of larval morphology of aquatic beetles, because these insects are abundant, diverse and provide many challenging taxonomic problems. Although water beetles are among the most common insect inhabitants of freshwaters, knowledge of their larval morphology is scanty throughout the world. The identification of larvae is usually a regular and continuing problem for many because the literature available to accomplish this is
widely scattered, limited to certain groups, outdated, difficult to use or non-existent. This situation has been an obstacle to ecological work. Because of this, we developed a framework that facilitates comparison among species. Our system of analysis focuses on study of body sensilla (setae and pores) and we have demonstrated that the characteristics of setae and pores are useful and important both for diagnoses and study of the genealogical (= phylogenetic) relationships among taxa. Study of larval features should allow more comprehensive classifications to be constructed. Most classifications of groups of insects are based on the study of adult stages only. Subsequent to publication, these classifications are rarely tested or evaluated. A way to test these preliminary classifications is to study the larval morphology. Larvae are under differing selection pressures and therefore show quite different features. A long-term goal of our research is to produce a more rigorous and stable classification by combining characters from larvae with other data sets including adult and molecular characters.
Jennifer Cory (Algoma)

The ecology and evolution of insect pathogens

A grant of $32,900 per year.
Une subvention de 32 900 $ par année.

Discovery Grant – Subvention à la découverte

In order to be able to manage the environment effectively, either in terms of preserving biodiversity, protecting crops from pests or maintaining human health, we need to understand how different organisms interact and what mechanism underlie the patterns we observe.

One of the key components of our environment is the pathogens that cause diseases of varying severity in virtually all groups of plants and animals. This program will focus on the interactions between an insect, the western tent caterpillar, and a virus pathogen. Tent caterpillars are often seen on deciduous trees in early summer. However, when their numbers are high, they are frequently killed by a virus disease which attacks the caterpillar stage. This disease is thought to play an important role in the population fluctuations that are so evident in this insect every 8-11 years. In this program we will study several tent caterpillar populations found in the vicinity of Vancouver, BC. We are particularly interested in the evolution of this interaction: whether the resistance of the insect to the virus alters as it changes in density, and how the virus population responds to this in terms of its virulence.

We are not just interested in recording numbers: we also want to study the genetics of the interaction and the role that different levels of genetic variation play in the outcome. Our earlier research has shown that the virus populations are highly variable genetically and that this is influenced by the spatial structure of the different populations. One of the questions we want to answer is why the virus population is so variable? We suspect that infections made up of many closely related
virus strains are more pathogenic than any single strain. However, we want to be able to test this idea in a natural population and to understand why it is that more viruses are better than one.

We also want to understand how infection by the virus affects the genetics of insects, for example, are there times in the population cycle when the insects are more susceptible and what is its basis? The findings from this project will have implications, not only for the role of pathogens in wildlife populations, but also in terms of understanding the development of disease severity in human diseases and pathogens of agricultural interest.
Garry Ferroni with/avec Léo Leduc¹

Activities of A. ferrooxidans and other acidophiles in acid mine drainage and bioleaching

A grant of $33,000 per year.
Une subvention de 33 000 $ par année.

Discovery Grant – Subvention à la découverte

Acid mine drainage (AMD), the microbially-mediated generation of acid from sulfidic mine wastes, is an immense environmental problem. We have been studying the ecology, physiology, and molecular biology of Acidithiobacillus ferrooxidans and related bacteria to better understand AMD. Bioleaching, the bacterialy mediated extraction of valuable metals from sulfidic ores, has been studied primarily with the bacterium A. ferrooxidans. We have been investigating the efficiencies of different strains of this bacterium in this process. Our proposal objectives are:

1. to describe the microbial populations that make up an AMD environment;
2. to further study the genetic diversity of strains of the key bacterium A. ferrooxidans;
3. to examine the effectiveness of mixed cultures in bioleaching studies employing low-grade ores and tailings.

The scientific approach will involve the use of standard microbiological methods for the isolation of the various representatives of the microbial populations, the use of molecular techniques such as DNA fingerprinting and fluorescent probes to study strain diversity and community structure, and the measurement by atomic absorption spectroscopy of metals leached by bacterial isolates paired with A. ferrooxidans.

The expected significance of the research is increased knowledge of the microbial ecology of AMD, an evaluation of the extent of genetic

¹shown in the reverse order in the photo/dans la photo, ils apparaissent dans l’ordre inverse
dissimilarity in the key species, and improved metal bioleaching rates from sulfidic ores and waste materials.
Hoyun Lee

Determining the hamster Cdc7 and Dbf4 amino acid residues that are required for kinase activity

A grant of $25,000 per year.
Une subvention de 25 000 $ par année.

Discovery Grant – Subvention à la découverte

The cell division process in a normal cell is tightly regulated and closely coordinated with copying of its genetic material (DNA). It is thought that two proteins, called Cdc7 and Dbf4, are involved in coordinating the cell division and DNA replication processes.

These two proteins, which function as a complex, may act as a molecular switch for DNA replication. A cell has to turn on DNA replication when it needs to divide. However, if the replication machinery is turned on while the cell is not yet ready, it may die or become genetically unstable. A cell can turn off its replication machinery when it faces a crisis, caused usually by genotoxic agents such as radiation or DNA-damaging chemicals. Accumulating lines of evidence suggest that the turn on or off control mechanism is directly regulated by association or dissociation of Cdc7 with the regulatory subunit Dbf4, and indirectly by changing the location of either or both the proteins within the cell. These control mechanisms may be regulated by the modifications of certain Cdc7 and/or Dbf4 amino acid residues. To further study this biologically important control mechanism in mammalian cells, we have cloned hamster Cdc7 and Dbf4. Using a hamster model, we propose to study the following two specific areas.

First, we want to identify the hamster Cdc7 amino acid residues that are required for Cdc7 activity and the binding of Cdc7 with Dbf4, both of which are essential for the activation of DNA replication. Second, we want to determine the hamster Cdc7 and Dbf4 amino acid
residues that are crucial for subcellular localization, which is important for determining how Cdc7 activity is regulated in a living cell.

The communication between cell cycle control and DNA replication is fundamental for all living organisms. Since the Cdc7-Dbf4 complex is thought to be involved in this communication process, the success of our proposed work will shed significant new insights into how mammalian cells regulate their cell division and DNA duplication. Thus, the data from this proposed work can have significant impacts on a wide scope of research areas including basic, environmental, and biomedical sciences.
Mery Martinez Garcia

Physiological bases of hypoxia tolerance in fish: The role of phenotypic plasticity in patterns of intraspecific and interdemic variation

A grant of $23,304 per year.
Une subvention de 23 304 $ par année.

Discovery Grant – Subvention à la découverte

Periods of low dissolved oxygen, or hypoxia, are found in a great variety of aquatic environments. Due to human activities, hypoxic episodes have increased in recent years in area, duration and frequency in coastal regions, lakes and wetlands. Fish develop different strategies and mechanisms to survive hypoxia, including adjustment in behaviour, physiology and biochemistry. It is currently difficult to make generalizations on physiological responses to hypoxia because of the widely different environments that are considered and the plasticity of the response.

My research program aims to develop predictive models regarding fish adaptive mechanisms to low dissolved oxygen. More specifically, I propose to conduct a cross-species field and laboratory study from fish in Northern Ontario to determine whether different fish species living in a single environment subject to periodic hypoxia share common metabolic adaptations and what is the plasticity of this response. Second, using an African species as a model, I will determine experimentally whether differences in metabolic responses of fish exist between populations from normoxic versus hypoxic habitats, and to what degree any difference is a consequence of phenotypic plasticity versus genetic differentiation.

Finally, I propose to conduct an experiment on the effects of hypoxia at egg and larval stages of a single fish species from Northern Ontario in order to establish the degree of phenotypic plasticity of fish during early development.
This entire research will increase our understanding of hypoxia tolerance on a global level as well as the underlying physiological mechanisms. In the long term, it will also increase our understanding of the detrimental effects of hypoxia in all aquatic habitats. As a result, this research will be invaluable to aquatic biologists and environmental scientists.

Once we understand the individual responses to hypoxia, and the plasticity of these responses, we will be in a better position to assess negative impacts of hypoxia and potentially control the biological impacts of hypoxia in aquatic ecosystems.
John Gunn

**Effects of invasive fish species on lakes recovering from acidification**

A grant of $15,000 per year.
Une subvention de 15 000 $ par année.

**Discovery Grant – Subvention à la découverte**

The effect of invasive species on the biodiversity of freshwater ecosystems is one of the major environmental concerns of our time. The movement of both native and exotic fish species has resulted in extinction of many local fish populations as well as extensive “homogenization” of fish communities across regions such as the Boreal Shield region of Canada. Two other major stressors, acidification and climate change, appear to combine to make Boreal Shield lakes even more vulnerable to the impact of invaders.

Cold water species such as lake trout (Salvelinus namaycush) and brook trout (S. fontinalis) may be directly affected by the warming conditions, but the more extensive damage is likely to occur because of indirect effects, such as increased competition for food with the arrival of warm water invaders (e.g. centrarchids). The acid-damaged lakes in the Sudbury Ontario area, where I have been conducting long-term studies of recovery dynamics of salmonid and percid-dominated communities, now appear to be at the front line of a northern movement of warm water invasive species. These acid-damaged lakes, with their simplified fish communities, represent important model systems to predict the effect of invasive species in lakes of the far north where species diversity is also low, or unique morphometry exists (e.g. very shallow lake trout lakes).

My research program will assess the effects of warm-water invasive species on population structure, behaviour, habitat use, swimming activity and trophic relationships among prey and predator species in lakes
recovering from acidification. The findings will increase our understanding of the effects of multiple stressors and will have both important theoretical and practical applications.
John Gunn with/avec Bill Keller, Norman Yan & Charles Ramcharan

In partnership with/En collaboration avec Xstrata & Vale Inco

Barriers to biological recovery in historically disturbed Sudbury Lakes: Lingering toxicity or ecological bottlenecks?

A grant of $378,867 for four years. Une subvention de 378 867 $ pour quatre ans.

Collaborative Research and Development Grant – Subventions de recherche et développement coopérative

In recent decades, billions of dollars have been spent to prevent and reverse the damages caused by acid deposition in thousands of lakes and rivers around the world. This massive environmental problem reached its peak in the late 1970s and 1980s, and since then there has been widespread evidence of water quality improvements following regulated emission reductions. However, biological recovery in damaged systems has lagged far behind the chemical improvements and there are many competing hypotheses to account for the delays. The study of the factors (physical, geochemical, or biotic) that control the recovery or resilience of disturbed ecosystems is therefore of great interest to both applied and theoretical ecologists, especially at the broad landscape levels at which the acidification impacts occurred.

The area around the metal smelters in Sudbury, Ontario, represents an especially important study site in this regard because of the scale and duration of the damage (> 100M tons of S0₂ emitted, an estimated 7000 damaged lakes) and the wealth of existing synoptic and long-term monitoring data for this area. Our study addresses two hypotheses. The first, which applies particularly to the many mining regions of the world, is that atmospheric or liquid effluent inputs of persistent and non-degradable contaminants, such as metals (Cu, Ni, etc.) prevent the recolonization of sensitive organisms and also affect the functional processes (such as productivity or nutrient cycling) of acid/metal damaged systems in ways that acidifying compounds (H+, S0₄, NOx) alone do
not. The second hypothesis, critical to the field of disturbance ecology, is that food web-alterations create significant “biological resistance” that prevents recolonization or restructuring of typical communities.

We use a combination of statistical analyses of regional survey and monitoring data, mesocosm experiments, laboratory toxicity testing, and food-web modeling to address these hypotheses. The results will be critically important for mining companies to design effective amelioration techniques and to respond to new environmental regulations.
Global amphibian decline: emerging infectious diseases and local extinctions

A grant of $19,250 per year.
Une subvention de 19 250 $ par année.

Discovery Grant – Subvention à la découverte

Extinction is a common fate to any species. However, determining the causes and processes is often difficult. Increasing evidence suggests that amphibians are actually facing a global decline representing a singular opportunity to study the biology of extinction. Among other causes, emerging infectious diseases are involved in this decline. They consist of a fungal infection responsible in extinctions all around the world as well as another group of amphibian pathogens, ranaviruses, which have been shown to only cause local mortality but no known extinction.

While the physiological mechanisms of these pathogens are well understood, the ecological and genetic components of the host-pathogen relationship remain to be studied. Understanding infectious disease ecology and evolution is a key to the more general investigation of extinction. Therefore amphibians are an excellent model for studying such a process in the wild. Not only do they suffer from these emerging infectious diseases but they also face anthropogenic and ecological pressure in many of their habitats. Only by exploring the role of these diseases in broad context will we be able to both test pathogen-induced extinctions and address appropriate conservation solutions.

To this end, I will establish a long-term program in northern Ontario, where a matrix of disturbed and undisturbed habitats is present, and the diseases have been recently recorded. Using a combination of field observations and experiments, I will be able to investigate the pathogen mechanisms leading to the decline of local populations. Considering the
current knowledge and theory on population genetics and EIDs, the hypotheses that will be tested in this application are

1. host differences in susceptibility and mortality have a significant genetic component
2. EIDs are not only causing mass mortalities within populations, but also affect individual development and
3. environmental factors affect the extensive spread of the diseases and the susceptibility of infection.

In the context of the global amphibian decline, the program can be viewed as an attempt to bridge ecology and genetics to create a field that might be termed as evolutionary conservation genetics.
Jacqueline Litzgus

Geographic variation in life history and physiology of reptiles: Adaptation at the extremes

A grant of $19,500 per year.
Une subvention de 19 500 $ par année.

Discovery Grant – Subvention à la découverte

My research program examines natural phenotypic variations in the wild at three levels: within individuals over time; among individuals within a population; and among populations of the same species, particularly those that are widely distributed. Studies of animals at the extremes of their range limits (e.g., northern and southern distribution limits) can provide insight into how they may respond to global climate change. My research relies on the study of animals, particularly reptiles, in their natural environment, using radio telemetry and mark-recapture techniques.

I use field-collected data to test basic questions from life history theory and to examine the effects of environmental conditions on fitness. For example, I am interested in how variation in body size affects individual fitness, and in the environmental and behavioural factors that affect reproductive frequency and sexual size dimorphism. My work also describes seasonal activity patterns, habitat use, and home-range size for use in status assessment of reptiles being considered for listing as Species at Risk.

A future avenue of research will integrate behavioural and physiological data to examine bioenergetic adaptations (e.g., ways to save energy) at environmental extremes using spotted turtles (Clemmys guttata) at two field sites at opposite limits of the species’ distribution: Ontario and South Carolina, where I have been conducting research for several years. In sum, my research program examines how animals deal with stressful environments, including those that occur naturally and as a result of human activities.
Furthermore, the work tests key concepts and questions that will advance knowledge in the field of evolutionary ecology, in addition to providing essential data for conservation programs for Canada’s reptiles.
Jacqueline Litzgus

In partnership with/En collaboration avec Sciensational Sssnakes

Reptiles at risk on the road

A grant of $30,100 for three years.
Une subvention de 30 100 $ pour trois ans.

PromoScience Grant – Subvention PromoScience

Reptiles are the most “at-risk” class of wildlife in Canada, with 79 per cent of taxa classified as endangered, threatened or special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The objectives of our project are to introduce Canadian youth and their families to this misunderstood group of animals, to inspire them to be concerned about the animals’ conservation, to challenge them to discover solutions to the threats posed to these species, and to highlight possible career trajectories in the natural sciences.

These objectives will be achieved through the interactive, hands-on programs provided to participants in our programs. Reptiles at Risk on the Road is an interactive program that is presented at schools, libraries, parks, and other venues across Canada, with a particular focus on rural regions which support a high diversity of species at risk. The programs feature an informal discussion about the animals, their ecology and conservation issues, as well as hand-on interaction between the participants and live Canadian reptiles.
Kabwe Nkongolo

**Genome organization and physical mapping of repeated DNA sequences in black and red spruces**

A grant of $20,000 per year.
Une subvention de 20 000 $ par année.

**Discovery Grant – Subvention à la découverte**

Although the genus Picea contains economically important species in Canada that contribute to about 30% of the total Canadian forest production, genetic research in this genus has lagged behind that of other important plant species. Black spruce is a key component of the boreal forest, while red spruce is a dominant species of the Acadian forest region in Eastern Canada. These are among the most important trees for the production of wood pulp and lumber and are prime reforestation species in Canada. Genetic information in the mapping of these two spruces is limited. Conifer species such as the spruces are characterized by their large genome size, whose organization is still largely unknown.

During the first phase of our research program, we have identified highly informative molecular markers, which are useful to facilitate programs in genetics, breeding, genome mapping, tree improvement, tree forensics, conservation, and restoration. We have characterized species-diagnostic and specific molecular markers. The main goal of the present study is to develop other useful genetic markers and to physically map DNA sequences and genes of interest. This information will be used to identify individual chromosomes and will provide relevant information on spruce genome organization. The results will have implications for genome evolution and the suitability of particular genetic markers and sequences for genetic mapping and genome analysis. Most importantly, the project will contribute to the international effort to map conifer genomes. Accurate identification of each chromosome will be used to localize gene families and linkage groups and to monitor gene transfer.
The methodology developed in the present study will be applied to other spruce species and to the genus Pinus. Physical mapping data will be registered in the dendrome, a database of forest tree genome, to facilitate access by other forest tree geneticists.
Kabwe Nkongolo with/avec Peter Beckett

In partnership with/En collaboration avec Falconbridge Ltd
& International Nickel Company Ltd

Sustainable land reclamation and conservation of plant populations from contaminated and uncontaminated areas in the Sudbury Region monitored with molecular and cytological tools

A grant of $96,000 for four years.
Une subvention de 96 000 $ pour quatre ans.

Collaborative Research and Development Grant – Subventions de recherche et développement coopérative

The genetic structure of Northern Ontario forests has been seriously affected by pollution, mining, and past forest management. Data of previous chemical analysis of the soil and vegetation samples collected by previous studies has indicated that nickel, copper, sulphur, and to a lesser extent, arsenic, and selenium concentrations are elevated in Sudbury and that these concentrations decrease with distance from the smelting works. The impoverished plant communities that are currently found in the Sudbury area are not only structurally and floristically different from the plant communities found elsewhere in the region, but they appear to have a different genetic make-up and low level of genetic diversity.

To compensate for losses of forestlands in areas negatively affected by past pollution and mining activities, land reclamation programs that include afforestation with primarily conifer species have been implemented. However, seed source identity, especially in spruce is a main problem in such reforestation/afforestation programs. Moreover, preliminary data shows some genetic instability of tufted hair grasses growing in contaminated areas receiving S02 and metal particulate emissions.

The proposed study aims at establishing the linkage between genetic instability and heavy metal accumulation; developing molecular markers to monitor the identity and purity of spruce samples used for reforestation/afforestation; and determining and increasing genetic diversity in plant populations growing in contaminated areas.
The project will provide more accurate information to design a viable strategy to improve long-term site sustainability. More importantly, a genetic tool (biomarker) will be developed to accurately certify seeds and seedlings used for reforestation/afforestation. The data collected during the study will assist in establishing current baseline information for evaluating abatement procedures.
Charles Ramcharan

New directions in lake food webs

A grant of $16,000 per year.
Une subvention de 16 000 $ par année.

Discovery Grant – Subvention à la découverte

My goal is to replace some entrenched ideas about the structure and functioning of lake food webs that we have held for over three decades. Common paradigms in lake ecology are that fixed energy comes from phytoplankton, that “planktivorous” fish are major consumers of zooplankton and eat only the large ones, and that invertebrate predators eat just small zooplankton. These old models are quickly fading as we embrace a more realistic model of lake food webs.

In the new view, energy may come from many sources, many species of fish regularly depend on benthic (bottom-dwelling) prey, and fish compete with large invertebrate predators for the same sizes of zooplankton. These “macroinvertebrates”, not fish, are the major consumers of zooplankton.

I propose several projects involving enclosure experiments, food web modeling, and wide-scale lake surveys, all designed to test the paradigms above and the veracity of possible alternatives.

Ultimately, the new views of lake food webs that I espouse will help us better predict the distribution of contaminants in lake biota, the production of fishes in different lakes, the factors that may determine interannual fluctuations in fish populations, and the responses of lake ecosystems to stressors such as fishing, eutrophication, and climate change.
Peter Ryser

Ecological significance of plant biomass turnover

A grant of $25,000 per year.
Une subvention de 25 000 $ par année.

Discovery Grant – Subvention à la découverte

The distribution of plant species is largely determined by their ability to cope with the environmental conditions in different habitats, conditions such as the availability of nutrients, water and light. A plant’s ability to acquire these resources is, in this respect, an important and well-studied trait. Equally important, but less studied, is the plant’s ability to avoid losses of the once acquired resources, i.e., its turnover rate. Resource acquisition is closely related to growth rate, resource loss with lifespan of leaves and roots. There is generally a reverse relationship between growth rate and organ lifespan: plants which grow fast usually produce short-lived leaves and roots.

The aim of this project is to investigate factors underlying this tradeoff between growth and lifespan, and the consequences for species’ performance in different environments. The focus lies in leaf and root lifespan in relation to disturbance and growing season length.

Furthermore, biomass turnover characteristics of vegetation strongly influence nutrient and carbon cycling in ecosystems, an aspect that will be studied as well. The project consists of garden and field experiments. Short-term investigations of plant structure will be combined with long-term experiments about interactions between the species. An important aspect is that roots, which are often neglected in such studies, will be investigated as well.

The project concerns basic questions about ecological and evolutionary mechanisms, but it is also potentially important for understanding the consequences of changes in land use and climate.
Albrecht Schulte-Hostedde

Evolutionary and behavioural ecology of mammals: individual and genetic approaches

A grant of $22,000 per year.
Une subvention de 22 000 $ par année.

Discovery Grant – Subvention à la découverte

Individual fitness is often defined as the number of offspring produced over the course of an individual’s life, and natural selection occurs when individual differences lead to variation in individual fitness. These differences may occur with respect to morphological traits such as body size or condition, and life-history traits such as the number of offspring produced or the timing of breeding. My research program seeks to understand how and why individual variation leads to variation in fitness through the action of selection. My students and I will use the northern flying squirrel as a model to examine three areas of research. First, we are interested in why one sex is often larger than the other (sexual size dimorphism) in many animals. To study this question, we will examine the direction and magnitude of selection on body size. Second, we are interested in how the environment, especially weather, affects selection on morphological and life-history traits. Third, we are interested in why females mate with multiple males, and whether the litters that are the result of multiple matings are superior with respect to individual growth rates and survival.

To answer these questions, we will establish a long-term project in Algonquin Park using a combination of nest boxes and live-trapping. We will also use DNA profiling techniques to assign parentage of offspring and determine levels of relatedness among the adult flying squirrels. The results of this research will be used to develop the discipline of evolutionary and behavioural ecology, as well as help answer questions
of conservation interest. For example, our work on the effects of envi-
ronmental variation on individual fitness of the flying squirrels will help
predict how these animal populations may change as global warming
occurs.
Galls are atypical, organ-like growths on plants caused by specialized insects that have evolved the ability to control the growth of plants to the insect’s advantage. Only the insects gain in the association as they are surrounded by thick layers of cells that provide food and shelter. Several kinds of insects induce plant galls as part of their life history strategies, but the most common and diverse are midges and gall wasps. Most gall wasps attack oaks and wild roses and each species induces a structurally distinct gall. Wasps of the genus *Diplolepis* are restricted to inducing galls on wild roses. There are about 42 species of *Diplolepis* in the world and 13 in Canada with galls that vary in size from small pea-like structures on leaves to large swellings the size of golf balls on stems.

Studying the anatomy and development of galls provides a novel tool for understanding how plants control their own development. Galls represent discrete microhabitats that support closed communities of specialist inhabitants and the ease by which galls can be collected, their occupants observed and counted, and the interactions among them inferred, make them useful study systems in subject areas ranging from population dynamics to the evolution and zoogeography of animal communities. Studying gall communities from southern Canada to the tree line in the NWT and northern Ontario provides insight into how flora and fauna moved into Canada following glaciation. They also provide an opportunity to study how global warming is allowing both roses and the gall insects associated with them to move further northward.

Some domestic roses, such as *Rosa rugosa*, have become weeds in eastern Canada, the USA, and Europe, and two of the *Diplolepis* gallers
found in Ontario are being considered as agents for their biological control.
Molecular shape and conformational transitions in biomolecules: theory and simulations

A grant of $57,000 per year.
Une subvention de 57 000 $ par année.

Discovery Grant – Subvention à la découverte

I am engaged in basic research dealing with conceptual developments and practical applications of computational chemistry and molecular modeling. As a tool, molecular modeling acts as a complement to experiments by providing a microscopic window into molecular behaviour. As a theoretical chemist, my goal is to improve the methodologies used in computer-assisted molecular modeling. As well, I work at applying these methods to gain insights into fundamental physico-chemical phenomena. Since 1992, my NSERC-funded research program has focused on studying the properties of large flexible molecules. Examples of application include simple polymers (e.g. plastics) and biopolymers (e.g. proteins) under various environmental conditions.
With the present proposal, I will continue to make significant advances towards establishing the factors that control (and modify) the shape of a macromolecule. Among other phenomena, we will consider the compression of grafted polymers and the spontaneous folding transition for natural proteins. Understanding these transitions is important because they regulate the yield and specificity of chemical processes.

For these reasons, molecular modeling is used actively in biotechnology and pharmaceutical research. More importantly to us, these phenomena also serve as prototypes for the behaviour of more complex systems, and they can teach us much about the fundamental principles at play.

In tackling these objectives, I will continue to collaborate actively with colleagues from two research groups in Sweden involved in polymer simulation. The projects, planned over four years, will advance the field and also contribute to training students and post-doctoral fellows in this promising area of biophysical chemistry.
It is no longer necessary to mention the importance of chemical speciation when referring to environmental studies and to the assessment of toxicity and bioavailability of trace elements for aquatic organisms and humans. However, the biogeochemistry of some elements of high environmental concern is still poorly known. This is the case for elements such as antimony (Sb), thallium (Tl), selenium (Se) and mercury (Hg) for which the degree of toxicity is very often related to the chemical form or speciation.

The main objective of this research program is to determine the concentration and speciation of the above-mentioned toxic trace elements in lake waters, sediment and pore waters of the highly contaminated Sudbury area. This program is the continuation of ongoing research aimed at defining mechanisms and factors controlling the mobility and bioavailability of trace elements in the aquatic environment. Specific objectives of the present program include:

1. the development of adequate analytical procedures for the speciation of Sb, Tl, Se and Hg in pore waters and lake sediments;
2. a detailed geochemical study of the four elements in lakes; and
3. a study on the kinetics of oxidation / reduction transformations of these trace elements in presence of natural oxidizing or reducing agents.

The methodology of the project is based on in situ sampling techniques to collect pore waters, sediments and diagenetic minerals. Laboratory simulations under controlled conditions are used to study redox
modifications in solutions. Very sensitive techniques exploiting atomic fluorescence spectrometry will continue to be used/developed/modified for the analysis and speciation of the toxic trace elements. The study will also consider the context of environmental rehabilitation in which Sudbury area lakes are now evolving to eventually apply the results to other locations affected by metal pollution.

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Il n’est plus nécessaire de mentionner l’importance de la spéciation chimique quand on se réfère aux études environnementales et à l’évaluation de la toxicité et de la biodisponibilité des éléments trces pour les organismes aquatiques et les humains. Cependant, la biogéochimie de certains éléments à potentiel toxique est encore très peu connue. C’est le cas d’éléments tels que l’antimoine (Sb), le thallium (Tl), le sélénium (Se) et le mercure (Hg) dont le niveau de toxicité est très souvent relié à la forme chimique ou spéciation.

Le principal objectif de ce programme de recherche est de déterminer la concentration et la spéciation de ces éléments trces toxiques dans les eaux de lac, les sédiments et les eaux de pore dans la région hautement contaminée de Sudbury.

Ce programme continue la recherche visant à mieux connaître les facteurs qui contrôlent la mobilité et la biodisponibilité de ces éléments trces dans le milieu aquatique. Les objectifs spécifiques du programme comprennent:

1. le développement de procédures analytiques adéquates pour la spéciation de Sb, Tl, Se et Hg dans les eaux de pore et dans les sédiments de lac;
2. une étude géochimique détaillée des quatre éléments dans les lacs;
3. une étude des vitesses des transformations d’oxydation et de réduction de ces éléments trces en présence d’agents naturels à nature oxydante ou réductrice.

La méthodologie du projet repose sur des techniques d’échantillonnage in situ pour la collecte des sédiments, des eaux de pore et des minéraux formés par diagénèse. Nous utiliserons aussi des simulations en laboratoire sous conditions contrôlées pour étudier les modifications redox du
milieu. Nous continuerons d’utiliser, de développer et de modifier des techniques d’analyse très sensibles qui reposent sur la spectrométrie de fluorescence atomique pour l’analyse et la spéciation des éléments traces toxiques. Notre étude considérera le contexte de réhabilitation environnementale dans lequel se situent les lacs de la région de Sudbury dans le but d’en appliquer, si possible, les résultats à d’autres régions affectées par la pollution par les métaux.
Éric Gauthier

Molecular control of apoptosis in mammalian cells

A grant of $29,300 per year.
Une subvention de 29 300 $ par année.

Discovery Grant – Subvention à la découverte

The use of mammalian cell lines for the industrial production of biomedical or pharmaceutical products is hampered by the high cellular sensitivity to culture-related stresses. Our research program is centered on the molecular and cellular mechanisms of cell suicide (apoptosis) and on the use of cell death inhibitors in cellular engineering. This grant application will describe two main projects:

1. A detailed analysis of the effect of the anti-apoptotic protein Bcl-xL on cell culture behaviour and productivity. Bcl-xL is a protein whose role in the cell is to prevent the untimely triggering of cell suicide. Several studies have shown that Bcl-xL could be used to protect cells against apoptosis, leading to increased productivity. In this proposal, we argue that one major limitation to the use of Bcl-xL in mammalian cells of biotechnological interest is the lack of understanding of the regulation of Bcl-xL in these cells, as well as the paucity of information currently available on the effect of the over expression of Bcl-xL on cell behaviour and the cellular response to nutrients. The work proposed here will lead to a thorough characterization of the function and regulation of Bcl-xL in mammalian hybridoma cells.

2. The generation of a Hybridoma Gene Expression Profile Database. A major factor limiting the applicability of cellular engineering to improve mammalian cell culture bioprocesses is the current lack of information on the changes in gene expression occurring in cultured cell lines.
We propose to establish a Hybridoma Gene Expression Profile Database using the latest DNA-Chip technologies. This information will allow researchers to tailor their cellular engineering strategies to their favorite cell line, leading to optimal improvements in cell viability and productivity.

Altogether, this research program will provide a basis for a more systematic strategy of optimization of mammalian cell cultures, an area where Canada stands as a world leader.

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L’utilisation de cellules de mammifères dans la production de substances d’intérêt pharmaceutique ou biomédical est grandement limitée par la sensibilité des cellules aux stress inhérents aux procédés de culture cellulaire. Notre programme de recherche est concentré sur l’étude des mécanismes moléculaires et cellulaires menant au suicide cellulaire (apoptose), ainsi que sur l’utilisation d’inhibiteurs de la mort cellulaire en bioingénierie cellulaire. Cette demande de subvention de recherche décrit deux projets majeurs:

1. Une analyse détaillée de l’effet de la protéine anti-apoptotique Bcl-xL sur le comportement et la productivité des cellules de mammifères en culture. La protéine Bcl-xL fait partie des mécanismes de régulation de l’apoptose et prévient la mort inappropriée des cellules. Plusieurs études ont démontré que Bcl-xL peut protéger les cultures de cellules de mammifères contre le suicide cellulaire, ce qui contribue à augmenter la productivité de ces bioprocédés. Nous proposons que la méconnaissance de la régulation de Bcl-xL, chez les cellules d’intérêt biotechnologique, ainsi que le rôle inconnu de cette protéine dans la modulation du comportement des cellules en culture, contribue à limiter l’efficacité de cette protéine. Le projet de recherche proposé dans le cadre de cette demande mènera à une caractérisation détaillée de la fonction et de la régulation de Bcl-xL chez un type de cellules de mammifères, les hybridomes.

2. L’établissement d’une base de donnée du profil d’expression des gènes des hybridomes. Un facteur important qui limite l’utilisation de la bioingénierie cellulaire dans l’amélioration du comportement
et de la productivité des cultures de cellules de mammifères est l’absence quasi complète d’informations concernant la régulation de l’expression des gènes pendant la culture cellulaire.

Nous proposons d’utiliser les technologies de puces à ADN afin de créer une base de donnée de l’expression des gènes caractéristiques des cellules hybridomes en culture. Cette information permettra aux chercheurs d’adapter leurs stratégies de bioingénierie cellulaire à leurs cellules préférées, ce qui mènera à une optimisation de la viabilité et de la productivité cellulaire.

Ainsi, ce programme de recherche établira une base solide qui permettra l’optimisation systématique des cultures de cellules de mammifères, un domaine pour lequel le Canada est l’un des leaders mondiaux.
The applicants are involved in highly competitive research in diverse fields of study. These areas of investigation include life sciences, biotechnology, nanotechnology, and environmental science. This NSERC Research Tools and Instruments grant proposal is in response to the current need expressed by the applicants to have access to a reliable tabletop ultracentrifuge that allows the processing of small volume samples (i.e. 1-2ml).

This piece of equipment is essential for several aspects of the applicants’ research. For example, the preparation of extracts from cells, a key step in several projects spearheaded by some of the applicants, requires centrifugation at a very high speed (over 150 000$\times g$!) that is only possible with the help of an ultracentrifuge. Other applicants require an ultracentrifuge to purify small amounts of environmental samples, or to separate nanoparticles according to their size.

The instrument that the applicants are requesting is the Beckman Optima Max ultracentrifuge. This piece of equipment is small enough to be placed on a table or even on a cart. Considering the large number of expected users (this proposal involves 11 researchers), the fact that this ultracentrifuge can be relatively easily moved from one laboratory to another is a major advantage. This ultracentrifuge also allows for 10 user programs, meaning that 10 research teams will be able to save their own ultracentrifugation settings, a big advantage in a multiuser environment.

This Beckman Optima Max ultracentrifuge will have a major impact on the research programs of over 10 Laurentian University research
teams, including dozens of graduate and undergraduate students.
Joy Gray-Munro

Surface modification of novel medical implant materials

A grant of $27,000 per year.
Une subvention de 27 000 $ par année.

Discovery Grant – Subvention à la découverte

With our aging population in North America it is becoming increasingly important to develop better, less expensive implants and devices. An understanding of the chemistry that takes place at the surface of a biomaterial is essential to improving medical implants. We can use this understanding to change the surface chemistry of the material to eliminate any adverse reactions that can result when a foreign substance is introduced into the human body.

Permanent metallic implants (stainless steel or titanium) are commonly used in orthopaedics to fix broken bones or to stabilize them after surgery. In many instances these implants serve no purpose after healing has occurred. In these cases a biodegradable implant that would provide the necessary stability in the initial stages of healing and would gradually dissolve over time and be replaced by bone would be advantageous. Magnesium alloys are an excellent material for this purpose because they have mechanical properties that are similar to bone, have been shown to dissolve in biological fluids and are non-toxic.

This research program will focus on understanding the behaviour of magnesium alloys in the human body and developing ways to change their surface chemistry to improve their biocompatibility and control their dissolution rates.
Helen Joly

Preparation, characterization and study of the reactivity of high energy intermediates formed in metal atom reactions

A grant of $27,000 per year.
Une subvention de 27 000 $ par année.

Discovery Grant – Subvention à la découverte

Activated metals have had a significant impact on organic synthesis. Also, many industrially important processes use metals as catalysts. The efficiency of the processes depends on the nature of the metal, the material on which it is supported and the techniques available to introduce the metal into the support.

My research program involves studying the reactions of metal atoms with the aim of understanding the mechanisms controlling metal mediated catalysis, surface chemistry and the formation of organometallic compounds. Metal atoms will be reacted with organic compounds at -196 degrees Celsius in a high vacuum chamber called a “rotating cryostat”.

Pieces of metal wire or pellets heated in a furnace will be used to generate the metal atoms. The products generated in the metal atom reactions are special in that their instability affords them extraordinary reactivity. We will take advantage of the unusual reactivity of these compounds by treating them with appropriate reactants between -196 degrees Celsius and room temperature to provide new synthetic routes with increased reaction rates, product yield and cost efficiency. Cyclic compounds containing a metal atom, i.e., metallacycles, are important intermediates implicated in many catalytic processes. We will study how these intermediates are formed as well as their ability to react with compounds containing electron-deficient centres. In addition, to gaining a better understanding of catalytic processes, we will investigate the nature of the organometallic intermediates formed in a number of different metal atom reactions.
To do this, the intermediates will be collected and their structure determined by a spectroscopic technique known as electron paramagnetic resonance (EPR) spectroscopy. The parameters extracted from the spectra will give us information about the bonding characteristics of metal-centered radicals generated in our reactions. Some of the systems we will investigate include organomagnanese intermediates, intermediates formed in yttrium atom reactions and organometallic complexes of zerovalent copper.
Louis Mercier

Functionalized nanoporous materials: synthesis, inclusion properties and applications

A grant of $45,000 per year.
Une subvention de 45 000 $ par année.

Discovery Grant – Subvention à la découverte

Nanotechnology has now emerged as an important research branch leading to potentially major breakthroughs in many areas of economic and social benefit. The ability to make materials that can execute specific tasks is one of the main objectives in materials science research. The manipulation of matter at the “nanoscale” (length scale approaching that of molecules), is now recognized as an excellent approach to make materials (known as nanomaterials) whose reactivity can be precisely tuned. In this research, we aim to prepare highly efficient nanomaterials that can be used to improve the health of the environment, as well as to make certain industrial processes more efficient. Our general approach is to prepare “sponge-like” nanomaterials that contain numerous pore channels with nano-sized openings. Using the tools of chemistry, the surface of these pore channels will be modified to make the materials active for specific environmental and industrial tasks.

Some of our specific environmental goals include the design of nanomaterials that can remove toxic compounds such as heavy metals and pesticides from water systems, and to clean up toxic gas emissions from mine smelters. We will also design nanomaterials that can improve the efficiency of converting ores into metal products, so that these processes become less energy-intensive and less polluting.
Thomas Merritt

Genetic dissection of the NADPH metabolic network in Drosophila

A grant of $29,170 per year.
Une subvention de 29 170 $ par année.

Discovery Grant – Subvention à la découverte

All organisms, be they flies or people, have physical characteristics (phenotypes) that distinguish them from other flies, people, or that distinguish flies from people. These characteristics are, in part, the product of heritable differences (genotypes), but relatively little is known about the connection between genotype and phenotype. In many cases we can expect that a phenotype is the product of multiple genes interacting as a network. My research program investigates a network of metabolic enzymes in the fruit fly that share the cofactor, NADP, as a model system to explain genotype-phenotype connections in general. This grant application will describe two main aims that are the foundation of my long-term research program:

Aim 1) Quantify interactions between NADP(H) network members in the fruit fly D. melanogaster. I will quantify interactions between the NADP(H) enzymes using wild-caught and laboratory-engineered flies.

The project will quantify interactions within the network across fly life stages and environmental conditions combining techniques from genetics and biochemistry.

Aim 2) Determine the level of constancy of observed interactions between NADP(H) enzymes across species. I will determine the degree of similarity in the interactions between the NADP(H) enzymes, quantified in Aim 1, are across species. This will be done by comparing and contrasting associations and interactions among the enzymes between the closely related cosmopolitan fruit fly species D. melanogaster and D. simulans, and across a trio of fly species native to North America and common in Sudbury Ontario, D. affinis, D. naragansette and D.
algonquin. Results from this comparison will directly improve our understanding of the consistency of networks across species and the utility of model organisms in general.

The results from these two aims will combine to further our understanding of metabolic networks, biological networks in general, and the constancy of network interactions across species.
Thomas Merritt, with Mery Martinez Garcia

Spectrophotometric analysis system for determination of enzyme kinetics and metabolite concentrations

A grant of $60,866.
Une subvention de 60 866 $.

Research Tools and Instruments – Subvention d’outils et d’instruments de recherche

The applicants’ research programs use fruit flies and fish to address questions involving the molecular genetics of complex networks, energy metabolism and ecological physiology. Our research programs are distinct, but bridge departmental and discipline boundaries united by a central focus on enzyme function and metabolic complexity. While we ask different questions, we share a common absolute requirement for the accurate quantification of enzyme kinetics and metabolite concentration, and fundamental need to efficiently and quickly process a large number of temperature-sensitive samples.

We propose to purchase a package of equipment necessary for spectrophotometric assays of a large number of samples for a suite of enzyme activities and metabolite concentrations. This package is built around a microbalance and a microplate spectrophotometer, two pieces of equipment that are required as a package for our research. This package of equipment will be unique on the Laurentian University campus allowing research projects not otherwise possible. Further, the package will allow continuation and expansion of the research programs of both laboratories of the applicants, and allow ongoing training of undergraduate and graduate students under the supervision of the applicants and other researchers in both Chemistry and Biochemistry as well as the Biology Departments.
Sabine Montaut

Cancer chemopreventive products and antioxidants from glucosinolate-containing plants

A grant of $27,000 per year.
Une subvention de 27 000 $ par année.

Discovery Grant – Subvention à la découverte

The cancer chemopreventive activity of cruciferous vegetables (e.g. broccoli, cabbage, cauliflower, kale and Brussels sprouts) is believed to be related to sulfur-containing products (glucosinolates and isothiocyanates), flavonoids and phenolic compounds. Most of the studies involving biological activity have been limited to cruciferous vegetables from the Brassica species. Very little information concerning “non-Brassica” glucosinolate-containing plants has been collected. Therefore, it is of great importance to screen these plants with the view of determining their pharmacological value in terms of cancer chemopreventive and antioxidant activity. The phytochemical composition of wild cruciferous plants, not yet screened for potential cancer chemoprotection or antioxidant properties, will be investigated. The plants will be chosen among plant families already known to possess glucosinolates or from those used in folk medicine against cancer. Special attention will be given to particularly promising wild plants of Canada whose phytochemistry has not been investigated for production of intact glucosinolates and flavonoids. This will significantly increase the probability of finding new metabolites with interesting biological activity. The activity-guided fractionation proposed in this study will allow the rapid screening of antioxidant molecules in plants. Once the structure of the new metabolites is established, in vivo bioassays will be performed
(a) to confirm the potential of the new molecules to act as cancer chemopreventive agents; and
(b) to determine their mechanism of action.
The identification and bioassay of the enzymatic hydrolysis or thermal breakdown products of the metabolites will also be studied to determine their potential in cancer chemoprevention. By relating the cytotoxicity and free radical scavenging ability to the structure of the secondary metabolites, we expect to get a better understanding of the relative contributions of various components of these plants to cancer risk reduction. Finally, our work may show new uses for these plants as food supplements (nutraceuticals) to interested pharmaceutical and food companies.
Ravin Narain

Surface coated metal nanoparticles with carbohydrate polymers as “stealth” materials for biomedical applications

A grant of $20,000 per year.
Une subvention de 20 000 $ par année.

Discovery Grant – Subvention à la découverte

Surface coated metal nanoparticles as therapeutic delivery agents are revolutionizing biomedical technologies. Currently there are several approaches being developed for cell-specific targeting of nanoparticles from systemic administration, but the fate of these particles inside the cell/body is often not well controlled. Our research focuses on developing advanced multifunctional nano-based materials that overcome transport limitations in tissues and within cells. Our goal is to prepare surface coated metal nanoparticles with well-defined carbohydrate polymers for improved solubility and stability (less aggregation in complex mixture), more resistance to surface adsorption, prolonged circulation time in bloodstream, reduced protein and cell adherence, reduced toxicity and reduced foreign body response in tissues.
Jeffrey Shepherd

Engineering defects in SAMs of alkylthiols for improved biosensing strategies

A grant of $23,500 per year.
Une subvention de 23 500 $ par année.

Discovery Grant – Subvention à la découverte

Biosensors are a class of device engineered to recognize a target biomolecule in a given environment. They have been used in the medical community for the early detection and treatment of disease but are also desirable as methods of detecting biological warfare agents.

As such, the attributes of a sensor often include miniaturized size, high specificity, multi-functionality and the absence of false positives. With the ever changing requirements of the sensor, new methods for the creation and characterization of the sensor material are ongoing. Typically the bio-recognition event is based on molecular binding with a substrate and surface modification strategies exist to functionalize the material with specific receptor groups. To enhance possible multi-functionality, a variety of receptor groups is desirable and is made possible through surface patterning methods.

Our research focuses on the use of electrochemical techniques to uniquely design and characterize a surface coated with organic-receptor materials in a patterned geometry. We will combine our experience with surface patterning of bulk surfaces to decorate gold nanoparticles in a similar manner. Coupling the device to a spectroscopic method of Surface Plasmon Resonance Spectroscopy (SPR) will enhance our detection schemes beyond typical SPR investigations.
Jeffrey Shepherd with/avec Ravin Narain

**Electrochemical surface plasmon resonance studies of thiol decorated nanoparticles as biosensors**

A grant of $37,718 per year.
Une subvention de 37 718 $ par année.

**Research Tools and Instruments – Subvention d’outils et d’instruments de recherche**

The equipment requested in this grant is a Surface Plasmon Resonance (SPR) Spectrometer that will be used in a project supported by an NSERC Discovery Grant entitled *Engineering defects in SAMs of alkylthiols for improved biosensing strategies*. SPR is a spectroscopic tool that monitors subtle changes at a gold surface. Typically, gold is modified with ligand that will have a specific binding with an analyte material that is passed over the sensor surface. In this arrangement, the binding kinetics of various antigen antibody pairs have been quantified and SPR has proven to be a powerful sensing device for biomaterials. However, SPR is not always sensitive to low molecular weight compounds and may require modifications to the gold sensor surface. Recent studies have shown that gold nanoparticles may improve the sensitivity of SPR. We will use our experience in surface modification and electrochemistry to decorate gold nanoparticles with a variety of ligands and couple the nanoparticles with SPR spectroscopy. In this arrangement, we will also have electrochemical control over the interface thereby improving the functionality of the sensor. The creation of new and improved biosensors may lead to new detection limits and earlier diagnosis and treatment of disease thus having a positive impact on the health and well being of society.
Stefan Siemann

Role of metal ions in the catalytic mechanism of anthrax lethal factor

A grant of $22,000 per year.
Une subvention de 22 000 $ par année.

Discovery Grant – Subvention à la découverte

Zinc is an essential element because of its involvement in growth, development and the transmission of genetic information. The metal ion is an indispensable constituent of more than 300 enzymes involved in many critical cellular processes. My research program seeks to understand how zinc enzymes fulfill their cellular function. In particular, my students and I will focus on the mechanisms underlying the diverse types of reactions, which are facilitated (catalyzed) by zinc enzymes. The primary objective of our research lies in the elucidation of the role of zinc and other accessory metal ions (e.g. calcium and magnesium) in the mechanism of anthrax lethal factor (LF), one of the three (on their own, non-toxic) components that constitute the anthrax toxin. To address this aspect, we will initiate the large-scale production of LF by conventional cell culture and protein purification methods. Large quantities of LF are required to conduct our research appropriately.

Secondly, we will replace the zinc ion in LF with other metal ions, such as cobalt or copper ions, in order to be able to perform detailed spectroscopic studies on these metal-substituted protein forms. Such approach has proved useful in the past to gain insights into the active site structure and mechanism of zinc enzymes. These spectroscopic techniques (using metal-substituted LF) will also be employed to unravel the role of calcium and magnesium in LF.

Thirdly, the molecular basis for the inactivation of LF at low pH values will be investigated. In light of the general concerns regarding
anthrax toxin as an animal and human pathogen, as well as a weapon of bioterrorism, our research will further our understanding of how LF works on a molecular level. Such insights may be exploited by pharmaceutical enterprises to develop drugs that would counteract the deleterious effects associated with anthrax. Finally, insights into the mechanisms operative in LF may also prove useful in the study of other zinc containing toxins, such as botulinum neurotoxin or tetanus toxin.
Global reef expansion and collapse: radiation, evolution, mass extinction of mid Paleozoic reef and peri reef biotas

A grant of $30,000 per year.
Une subvention de 30 000 $ par année.

Discovery Grant – Subvention à la découverte

Tropical and temperate carbonate platforms have been major marine sinks for the global C/CO₂ budget since Early Proterozoic time (2.5 billion years ago): the geo-history of such platforms shows responses to global tectonic cycles (plate dispersal), climate and atmospheric change, and the evolution of life. This proposal focuses primarily on tropical carbonate platforms and specifically on the long-term record of reef and perireef ecosystems and their biotas during the Early and Middle Paleozoic (Late Ordovician through Devonian: 460-355 Ma). This 105-million-year-long greenhouse episode, when atmospheric CO₂ content was 16 to 24 times that of the Recent interglacial, is sandwiched between two major icehouse events, the Late Ordovician (O/S) and End Devonian (F/F) glaciations, featuring 2 of the 5 most severe global mass extinction episodes (MEs) of the half-billion-year-long Phanerozoic.

I document the nature of changes in major reef tracts (reef area, thickness, latitudes) on a global basis, the biodiversity of principal components of mid-Paleozoic reefs, especially the corals, calcifying sponges
(especially stromatoporoids), calcimicrobes, and shelly organisms, and their evolutionary response during major sea level high stand and low stand systems tracts, during and following mass extinctions. To complement this, we plan detailed $O_{18}$ and $C_{13}$ stable isotopic sampling (brachiopods, micrites, cements) of the Anticosti O/S extinction boundary chapter, and isotopic sampling of carbonates from the Frasnian (Late Devonian) chapter of Banks Island prior to the F/F mass extinction.
Harold Gibson

Volcanic, tectonic and magmatic processes, their control on VMS deposits and the architecture and evolution of submarine volcanoes

A grant of $44,200 per year. Une subvention de 44,200 $ par année.

Discovery Grant – Subvention à la découverte

Volcanogenic massive sulphide (VMS) ore bodies are rare and incredibly valuable economic accumulations of sulphide minerals from which important industrial and precious metals such as zinc, copper, silver and gold are produced. They form in rifted arc and back-arc geodynamic settings where hot (> 300° C), evolved, metal- and sulphur-bearing sea water, perhaps with a fluid component derived from magmas (magmatic fluid), is discharged onto the sea floor within ancient and modern volcanoes and, due to rapid cooling, deposited sulphide minerals at, and immediately below the sea floor.

The objectives of this research are to:

1. determine controls and processes, such as caldera formation, that may be responsible for the formation and location of VMS deposits by understanding the architecture, magmatic, tectonic, and volcanic evolution of ancient and modern submarine volcanoes;

2. assess the use of the platinum group elements to discriminate geodynamic environments and petrogenetic processes, and to determine the potential role of sulphur solubility in generating metal bearing, magmatic hydrothermal fluids; and

3. train highly qualified personnel to replace those in an aging exploration work force, and/or continue in research.

Results of this research will benefit those who study ancient and/or modern seafloor volcanoes, and it will impact on crustal growth models. The Canadian mining industry who explore for VMS deposits in
Canada, and globally, will be a direct beneficiary of this research and, indirectly, so will the non-urban, northern Canadian, mining communities whose survival, growth, and prosperity are linked to successful exploration and responsible mining.
Volcanogenic massive sulphide (VMS) ore bodies are economic accumulations of sulphide minerals. They form where hot (> 300° C), evolved, metal- and sulphur-bearing sea water, perhaps with a fluid component derived from molten rock (magmatic fluid) deep with the earth, discharged onto the sea floor within ancient volcanoes and, due to rapid cooling, deposited sulphide minerals at, and immediately below the surface. VMS deposits are rare and incredibly valuable. VMS deposits such as those at Flin Flon in Northern Manitoba and Saskatchewan contain more than 80 million tonnes of sulphide ore from which important industrial and precious metals such as zinc, copper, silver and gold are produced. This research will determine the volcanic, magmatic and hydrothermal evolution of a large, 1.85 Ga, subaqueous volcano that hosts VMS ore bodies at Flin Flon in order to:

1. establish controls on the formation and location of VMS deposits and translate this new knowledge into exploration criteria that will benefit mineral exploration at Flin Flon, in Canada and globally;

2. develop sophisticated models of submarine eruptive and emplacement processes that are required to interpret ancient volcanic successions;

3. train highly qualified personnel that will conduct exploration, and/or continue in research.

The direct beneficiary of this research is the Canadian mining industry. However, as the minerals and metals sector accounts for 13.3% and 3.7% of Canada’s export earning and GDP, the main beneficiary is
Canada, and the non-urban, northern Canadian, mining communities such as Creighton, Saskatchewan and Flin Flon, Manitoba, whose survival, growth, and prosperity are linked to successful exploration, and sustainable, responsible mining.
Pedro Jugo

Experimental studies on the behaviour of sulfur and precious metals in magmatic systems

A grant of $19,900 per year.
Une subvention de 19 900 $ par année.

Discovery Grant – Subvention à la découverte

Our planet is a complex and dynamic system. For example, the thin outmost portion of the solid Earth is slowly, but continuously, being recycled back into deeper parts of our planet and new material is brought up to the Earth’s surface. Erupting volcanoes are one of the most spectacular expressions of this recycling process which results in the transfer of material from the Earth’s upper mantle to the Earth’s surface. My research is related to these volcanic processes and is directed at:

(a) understanding the processes controlling magma generation deep in the Earth’s mantle, which dictates which elements are incorporated in these magmas,

(b) the processes controlling the changes in the composition of magmas as they ascend through and interact with the Earth’s crust, and

(c) the processes controlling the final products and accumulation of these magmas.

I am interested in particular in the processes leading to anomalous concentration of economic metals such as copper, nickel, gold and platinum, and in the role that sulfur plays in these processes. Because we cannot witness these processes I use high-pressure and high-temperature equipment to simulate them. This approach allows us to isolate and study multiple variables and test multiple hypotheses by comparing the products of our experiments with the products of natural processes. The results of this research will further advance our
understanding of how these anomalous concentrations are formed and will help us design better methods for the exploration of these resources.
The search for terrestrial protocrust

A grant of $34,800 per year.
Une subvention de 34 800 $ par année.

Discovery Grant – Subvention à la découverte

Unlike the Moon and Mars, where heavily cratered original (primordial) crust is preserved, there is an apparent complete absence of rocks older than 4.05 billion years on Earth. Yet minerals as old as 4.35 billion years have been discovered, testifying to the former existence of a terrestrial protocrust. The formation and destruction of this crust are the most cryptic steps of the Earth’s differentiation. There are, however, radiogenic isotope clues preserved in the oldest known rocks that were inherited, either via mantle depletion or crustal recycling, from the ancient but lost crust. Learning to read these clues will decipher the history of the primordial crust. Here I propose the first systematic study of the significance of one of these, the so called high mu (U/Pb) signature, which is expressed in the lead isotope systematics of Precambrian rocks in several shields, including Canada. Significantly, the high mu provinces (Slave, Yilgarn, Zimbabwe, SW Greenland, Wyoming, Winnipeg River Terrane) are those places on Earth where researchers also find the oldest known minerals, which in all cases significantly exceed the ages of the rocks. The rationale behind the proposed approach is two-fold. First, I propose to test whether there exists a relationship between the strength of the high mu character of a rock and the amount of ancient zircon in the rocks that carry the signature. The implication being that both were inherited from the no longer preserved protocrust. The research will employ rapid, in situ U/Pb zircon dating in a CFI-funded state-of-the-art facility on minerals selected from the highest mu late Archean gneisses and metasediments. Second, regardless of the zircon yield, the proposal also aims at studying whether there are any
chemical variations that accompany the lead isotopic fingerprint, like on the Moon (also with a high \( \mu \) crust). This will be studied along systematic transects across isotopic gradients, exposed e.g. in the Beartooth Mountains of southern Montana.
Bruno Lafrance

Structural geology of hydrothermal ore systems

A grant of $21,100 per year.
Une subvention de 21 100 $ par année.

Discovery Grant – Subvention à la découverte

Natural resources are important for the economic future of Canada. The proposed research will aid the discovery of new copper-zinc deposits in Flin Flon, Manitoba, and gold deposits in the Kirkland Lake - Larder Lake area, Ontario. The research addresses the less studied effects of rock deformation on the genesis and subsequent modification of ore deposits. Faults play an important role in the genesis of ore deposits by creating conduits that focus metal-bearing hydrothermal fluids. Ore deposits commonly form along active tectonic margins and are subsequently deformed during mountain-building closure of past oceans. Copper-zinc deposits in Flin Flon formed in an oceanic island in the ancestral Manikewan Ocean and were deformed during closure of that ocean and collision of continental tectonic plates. This deformation affected both the geometry and distribution of the deposits. Gold deposits in the Kirkland Lake - Larder Lake area were emplaced along presently inactive faults and were deformed during subsequent reactivation of the faults. The main objective of the proposed research is to understand how deformation controlled the genesis of these ore deposits, changed their geometry, and redistributed the deposits within two of Canada’s important mining areas.
Bruno Lafrance with/avec Michael Lesher

In partnership with/En collaboration avec Inco Technical Services Limited

Structural controls on Ni Cu sulfide mineralization and metal mobility at the Garson Mine, Sudbury

A grant of $50,990 for four years.
Une subvention de 50 990 $ pour quatre ans.

Collaborative Research and Development Grant – Subventions de recherche et développement coopérative

The Garson Mine is one of several nickel-copper mines in the world-class Sudbury mining camp in Ontario. Two thirds of Canada’s annual nickel production is from Sudbury mines. The nickel-copper deposits occur at the base of the 1850 million years old Sudbury Igneous Complex. They formed as heavy sulphide metal droplets segregated from the cooling magma and accumulated along the floor of the igneous complex.

Several millions of years after crystallization of the complex, the Sudbury rocks were faulted, folded, and sheared during tectonic collisional growth of the North American continent. Several deposits, including the Garson deposit, were deformed during this tectonic event. This changed the shape of the deposits, their metal content, and distribution of sulphide minerals. At the Garson Mine, Ni-Cu sulfide mineralization occurs within two main shear zones. The degree to which shear deformation has affected the nature and distribution of the mineralization is uncertain. Mineralization either remained largely in place during deformation, or was mobilized during ductile flow of sulfide minerals as high-temperature malleable pastes and during transport of metals and sulfur in solution within hydrothermal fluids that migrated along the shear zones.

The proposed research will establish the degree to which sulfide minerals have been affected by this deformation and will determine the relative importance of solution transport versus ductile solid flow during mobilization of the sulfides. It will further characterize favorable structural sites for the concentration of metals along the shear zones.
and will identify geochemical enrichment/depletion signatures that can be used to vector toward nickel-copper mineralization.
C. Michael Lesher

Petrogenesis of mafic ultramafic magmas and magmatic Ni Cu PGE deposits

A grant of $41,980 per year.
Une subvention de 41 980 $ par année.

Discovery Grant – Subvention à la découverte

The aim of this research program is to understand how some of the world’s largest nickel-copper-platinum deposits in Canada, China, and Russia have formed, in order to aid in the discovery of new deposits. Each project includes detailed mapping of field exposures, logging of diamond drill cores, examinations of the rocks using light optical and electron optical microscopic techniques, analysis of the chemical and isotopic compositions of the ores and the rocks in which they occur, and mathematical models of the geochemical and fluid dynamic processes involved in their formation. The data and interpretations generated in this program will extend our knowledge of the processes involved in generating nickel-copper-platinum deposits, and the geological, genetic, and exploration models generated in the various projects will have broad applications and will aid in their exploration worldwide.
Darrel Long

Precambrian and Early Paleozoic Rivers

A grant of $26,690 per year.
Une subvention de 26 690 $ par année.

Discovery Grant – Subvention à la découverte

The objective of this research is to understand how and why the deposits of Precambrian and Early Paleozoic river systems differ from those that formed after the advent of rooted plants. Many of the processes that influenced these systems were significantly different from those of the present. For example, the lack of sediment binding, baffling, and trapping by plant roots would have promoted flashy surface run-off, lower bank stability and faster rates of channel migration. It has been suggested that some pre-vegetation rivers were tens of kilometers wide, but this has yet to be confirmed in out-crop studies. In this study the three-dimensional character of pre-vegetation sandy and gravelly river systems will be investigated by examination using laterally extensive (> 1 km) lake, sea and canyon side exposures of the Paleoproterozoic Fair Point Formation and Martin Group (SK); and the Early Paleozoic Bateau Fm (NFDL). Sandy fluvial systems will be investigated in the upper part of the Paleoproterozoic Athabasca Group (SK); the Mesoproterozoic Mackenzie Mountains Supergroup (NWT); the Neoproterozoic Signal Hill Group (NFDL), and the Early Paleozoic Blanc-Sablon member of the Bras dore Formation (NFDL). Further Proterozoic examples and modern dry-land systems will be examined in the Flinders Ranges of Australia. Studies of modern rivers using ground-penetrating radar have indicated that the internal geometry of in-channel bars in large braided rivers can be used to model accretionary depositional processes on a bar and reach scale. A similar architectural approach will be used to determine the characteristics of the pre-vegetation systems in order to develop a spectrum of models that can be used to facilitate understanding of terrestrial depositional processes before the advent of land-plants. These
models may be of economic use in understanding heavy-mineral distributions and the influence of permeability barriers on the reservoir characteristics of Precambrian and Early Paleozoic fluvial sand bodies.
Andrew McDonald

Applied crystal chemistry, earth materials

A grant of $27,150 per year.
Une subvention de 27 150 $ par année.

Discovery Grant – Subvention à la découverte

My research focuses on the chemical and structural-state characterization of minerals (and their synthetic analogues) associated with magmatic ores. The long-term goal is to apply obtained data as a means of quantifying the geological conditions under which these minerals developed. Currently, I am most interested in applying data obtained from analyses of minerals in the Fe-Ni-Cu-PGE system to quantitatively assess primary conditions of crystallization and growth and secondary processes that may have modified them. This work currently involves two directives, the first involving Fe-Ni sulfides (Pyrrhotite Mineral Family, PMF). Pyrrhotite is a family of Fe-deficient sulfides that constitute the most abundant sulfide in magmatic ore deposits. The PMF exhibits fairly simple phase relations at $T > 350^\circ C$, but complex relations below this, owing to the way that Fe ions and vacancies are arranged. In general, two basic PMF minerals are known, hexagonal (hpo) and monoclinic (mpo) pyrrhotite, and understanding how the two vary in terms of modal abundance, their intergrowths, minor-element chemistry, etc. is critical to assessing how an ore body has evolved. My goal is therefore to determine the hpo:mpo ratios in natural ore bodies to apply the data obtained as means of understanding how the chemistry and conditions of formation have been modified with time. The second directive involves Platinum-Group Minerals (PGM) that host the economically and technologically important Platinum-Group Elements (PGE). Traditionally, PGM have been poorly understood owing to their small grain sizes, complex and highly varied chemistries and because of their overall rarity. However, PGE constitute important industrial commodities, owing to their use in high-tech industries (fuel
cells, electronics) so an understanding of PGM and how they can be found is important. My research goal is to resolve some of the outstanding complexities associated with these minerals, through analyses of the atomic arrangements, and to combine results from studies into their synthesis with field-based data as a means of understanding their formation.
Stephen Piercey

Magmatic, tectonic, sedimentary and hydrothermal evolution of cordilleran rifts

A grant of $36,000 per year.
Une subvention de 36 000 $ par année.

Discovery Grant – Subvention à la découverte

Volcanic-hosted massive sulphide (VMS), volcanic- and sediment-hosted massive sulphide (VSMS), and sediment-hosted massive sulphide (SEDEX) deposits are important sources of Canada’s zinc, lead, copper, silver and gold. These deposits are commonly associated with environments where tectonic plates are separating relative to one another called ‘rifts’. Rift environments are commonly associated with magmas, volcanoes, and the deposition of sedimentary rocks - most of which are formed underwater in ancient ocean and sedimentary basins. In addition, heated metal-rich fluids called ‘hydrothermal fluids’ circulate through the rock packages within the rifts ultimately forming the VMS, VSMS, and SEDEX deposits.

This research grant is aimed at studying the interrelationships between magmatism, sedimentary rocks, and hydrothermal fluid history associated with these rifts within the rocks of the Cordilleran mountain system in the Yukon and northern British Columbia (+/-NWT).

The research is primarily aimed at understanding the temporal variation in the style of magmatism as well as the sedimentary rock depositional history within rift environments. These studies will increase our understanding of how rift magmatism and sedimentation result in the formation of ancient VMS, VSMS, and SEDEX deposits. This research has important implications for the Canadian economy (and in particular the northern economy) and will improve predictive models and methods for the discovery, exploration, and exploitation of these important metal resources. Furthermore, it will train highly qualified persons for the careers in academia, government, or industry in the Canadian (and international) mineral exploration and mining sector.
Phillips Thurston

Autochthonous construction of Archean greenstone belts

A grant of $21,100 per year.
Une subvention de 21 100 $ par année.

Discovery Grant – Subvention à la découverte

The research Project will examine how the 2.5 billion year old Precambrian volcanic rocks in the Canadian Shield vary with time and the causes of that variation. The research will attempt to demonstrate that some of the variation is due to cyclical mountain-building events and some of the variation is due to the rise and fall of sea level. This research will examine ancient volcanic rocks in the Abitibi area of the Canadian Shield, in northwestern Ontario and in the Precambrian shield of Australia and Greenland. The work will also produce the first 3 dimensional computer-generated model of the Abitibi greenstone belt, a zone of Precambrian volcanic rocks extending from Timmins and Kirkland Lake through to Chibougamau in Québec. The 3D model will help to make the exploration for copper and zinc deposits more effective and efficient by predicting the extent of units beneath the cover of glacial deposits and younger sedimentary rocks. This project will be the first study to demonstrate that major units of Greenstone belts, including those with copper-zinc mineral deposits can be traced and correlated over large distances and in the third dimension. The impact of the work on exploration for new mineral deposits will be substantial in that it should increase the success in finding new deposits and thus supporting the northern economy.
Douglas Tinkham

Metamorphic phase equilibria and the evolution of orogenic belts

A grant of $21,100 per year.
Une subvention de 21 100 $ par année.

Discovery Grant – Subvention à la découverte

In modern mountain belts it is sometimes difficult to gain an understanding of the processes that work deep in the crust. Exposed roots of old mountain belts, however, consist of rocks that experienced great physical forces of mountain building: pressure, temperature, and stress. Our ability to decipher this record from modeling the composition of minerals in rocks has greatly increased. Add to this the ability to determine the absolute time of mineral formation and the four-dimensional picture of mountain building can be constructed. This research program will investigate our ability to

1. constrain the pressures and temperatures at which particular rock types recrystallized at depth in the earth, and
2. constrain the depths and temperatures at which rocks were buried, partially melted, and began their exhumation path back towards the surface of the earth.

Detailed thermodynamic modeling of rocks derived from sediment that was originally deposited in an oceanic or near-continental margin setting will be used to decipher the pressure and temperature changes these rocks experienced during the tectonic evolution of the Superior Province in western Ontario. Minerals will be dated using Sm-Nd and U-Pb geochronology to constrain the timing of burial and exhumation of these rocks.

Together, this data will allow us to discover the tectonic processes that led to the construction and stabilization of the crust approximately
2.7 billion years ago in western Ontario. The novelty of this research lies in the integration of thermodynamic modeling of individual rock systems with geochronology to constrain the complicated history of metamorphism experienced by Archean rocks of the western Superior Province.
Elizabeth Turner

Proterozoic and early Paleozoic carbonate sedimentology: Influence of Earth system evolution on depositional systems

A grant of $25,300 per year.
Une subvention de 25 300 $ par année.

Discovery Grant – Subvention à la découverte

The fossil and geochemical records contained in carbonate sedimentary rocks (limestone and dolostone) represent the single most important repository of information about biological and chemical evolution of the Earth’s surface. Earth’s earliest atmosphere was oxygen-free, and accumulated oxygen slowly over about 3 billion years (66% of earth’s total lifespan to date). Significant levels of oxygen in the atmosphere, and the protecting ozone layer that accompanies it, permitted multicellular and terrestrial life-forms to emerge eventually. Earth’s earliest biota was limited to single-celled organisms, many of which proliferated and produced oxygen by photosynthesis in shallow, tropical water where carbonate sediment accumulated. The initial emergence of more complex organisms (such as plants and animals) is documented in 1.2 billion year old carbonate rocks, and their population of most marine niches was complete by about 475 million years ago. Many significant gaps remain in our collective understanding of this 3-billion-year-long series of events. By studying carbonate systems of Proterozoic age (544 to 2500 million years old), this project will address two of these salient issues:

1. when and how carbonate sedimentary environments changed from settings that reflect geochemically challenged conditions of the early Earth to those we consider biologically and sedimentologically ‘modern’; and
2. how this affected biotic evolution.

In addition to contributing to ongoing research into early earth systems, this project will also augment the understanding of Mesoproterozoic sediment-hosted ore deposits in the Arctic, information which
is needed to support the long-term economic development of Canada’s north. Field locations will include Proterozoic basins exposed in the Arctic and Paleozoic rocks exposed in Newfoundland and the Canadian Rocky Mountains.
Elizabeth Turner

Proterozoic and early Paleozoic carbonate sedimentology: Influence of Earth system evolution on depositional systems

A grant of $20,000 for the year.
Une subvention de 20 000 $ pour l’année.

Discovery Grant (Northern Supplement) – Subvention à la découverte (supplément aux subventions à la découverte en recherche nordique)

The fossil and geochemical records contained in carbonate sedimentary rocks (limestone and dolostone) represent the single most important repository of information about biological and chemical evolution of the Earth’s surface. Earth’s earliest atmosphere was oxygen-free, and accumulated oxygen slowly over about 3 billion years (66% of earth’s total lifespan to date). Significant levels of oxygen in the atmosphere, and the protecting ozone layer that accompanies it, permitted multicellular and terrestrial life-forms eventually to emerge. Earth’s earliest biota was limited to single-celled organisms, many of which proliferated and produced oxygen by photosynthesis in shallow, tropical water where carbonate sediment accumulated. The initial emergence of more complex organisms (such as plants and animals) is documented in 1.2 billion year old carbonate rocks, and their population of most marine niches was complete by about 475 million years ago. Many significant gaps remain in our collective understanding of this 3 billion year long series of events. By studying carbonate systems of Proterozoic (> 544 million years old) age, this project will address two of these salient issues:

1. when and how carbonate sedimentary environments changed from settings that reflect geochemically challenged conditions of the early Earth to those we consider biologically and sedimentologically ‘modern’; and

2. how this affected biotic evolution.

In addition to contributing to ongoing research into early earth systems, this project will also augment the understanding of ore deposits
hosted by Mesoproterozoic rocks. The research is primarily field-based. Field locations will consist of areas of Proterozoic rock exposed in the Arctic islands.
Department of Forensic Science
Département de la science médico-légale

James Watterson

Characterization of drug disposition in skeletal tissues: A forensic context

A grant of $20,000 per year.
Une subvention de 20 000 $ par année.

Discovery Grant – Subvention à la découverte

In many notorious death investigations, the remains under investigation have decomposed to the point of partial or complete skeletonization. In such cases, elucidating the role of drugs or poisons in the events leading up to or associated with the death is extremely challenging. Conventional toxicological analyses, usually done on fluids such as blood or urine, or tissues such as liver, are often not possible. In these cases, analysis of skeletal tissues (mineralized bone and/or bone marrow) may be the only remaining option. This research program will address this problem through characterization of drug concentrations in skeletal tissues in a forensic context. Animal models will be used to investigate the concentration of drug in bone tissue under various conditions of drug administration, bone type and postmortem environmental conditions. Different drugs of forensic relevance will be examined
to better understand the effect of variations in the chemical properties of the drugs on the observed concentration in bone tissue. The results of this research will provide insight into how long after exposure a given drug may be detected in bone tissue, the stability of drugs within postmortem skeletal tissues, bone drug concentration ranges expected following exposure to a given dose as well as the optimal bone type, and location within a particular bone, for skeletal drug analysis. This work serves as a basis for extension to studies with human tissues. Once this data has been collected, work may begin in its application to relevant cases within the justice system.
James Watterson with/avec Nelson Belzile

Automated solid phase extraction for analysis of complex environmental and forensic samples

A grant of $49,432.
Une subvention de 49 432 $.

Research Tools and Instruments – Subvention d’outils et d’instruments de recherche

An automated Solid Phase Extraction (SPE) instrument for the preparation and extraction of compounds of interest from complex samples is proposed. The device is a diverse instrument that will be applied to the forensic analysis of skeletal tissue samples for drugs and poisons, as well as the analysis of environmental samples for organometallic compounds and pesticides. The proposed equipment is critical for both analytical method development and ongoing research characterizing drug disposition in skeletal tissues in a forensic context and the fate of important pollutants in aquatic environments (e.g., sediments, aquatic organisms).

This research is vital to the development of analytical methods for use in death investigations where the remains have decomposed to the point of partial or complete skeletonization. In these cases, analysis of skeletal tissues (mineralized bone and/or bone marrow) may be the only option for toxicological analysis. This methodology is not currently used with any regularity as a result of the lack of basic research in the area. The proposed research program will address this problem through characterization of drug concentrations in skeletal tissues in a forensic context.

The proposed research is also important to understanding the fate of pesticides and other toxins such as mercury in the natural environment, which is critical to environmental resource management and remediation.
Department of Geography
Département de géographie

Randy Dirszowsky

Sediment budget and paleolimnological analysis of environmental change in a disturbed boreal shield landscape

A grant of $15,000 per year.
Une subvention de 15 000 $ par année.

Discovery Grant – Subvention à la découverte

It is well known that Boreal Shield ecosystems in the Sudbury area are sensitive to environmental pollution related to nearby mining activities and urban development. To date, environmental studies in the Sudbury area have focused on water quality and ecological modeling, soil contamination and effects on terrestrial biota, in most cases emphasizing industrial pollution and recovery since the 1970’s. A limited number of lake sediment studies using fossil organisms have extended the record of acidification and metal contamination, demonstrating variable lake response and raising questions concerning ecosystem function within and beyond lakes. This research will combine established methods in paleolimnological and surface process study (e.g. radiocarbon dating, sediment budgeting, geophysical survey, etc.) with more novel approaches (e.g. geochemical fingerprinting and microtextural analysis of natural
and anthropogenic particles in soils and lake sediments). In so doing, the work will consider impacts other than acidification, industrial metal contamination and municipal pollution, for example, deforestation, fires, agriculture, consequent soil erosion, hydrological change, and more recent urban expansion. As the cumulative effects of environmental pollution begin to abate, the effects of larger scale climate change are beginning to be felt as well, and rates of change are expected to increase. It is therefore critically important that multidisciplinary research of the type proposed here be carried out as soon as possible, before evidence of past change is lost, so that appropriate adaptation strategies may be developed if necessary. The Government of Canada has identified research into climate change scenarios, impacts and adaptation as a national priority. Given Sudbury’s international recognition for environmental restoration work, the proposed research will support Canada’s international reputation for environmental management while facilitating the exchange of information, expertise and appropriately trained personnel.
Department of Mathematics and Computer Science
Département de mathématiques et d’informatique

Fabrice Colin

Méthodes variationnelles pour les systèmes d’équations aux dérivées partielles non linéaires

A grant of $8,000 per year.
Une subvention de 8 000 $ par année.

Discovery Grant – Subvention à la découverte

Les impacts indéniables de la recherche fondamentale dans le domaine des équations aux dérivées partielles (ou EDP) que ce soit en physique, sciences appliquées, calcul scientifique ou même en sciences de la vie sont sans cesse plus nombreux et importants. Dans ces diverses disciplines, les systèmes et phénomènes étudiés sont souvent modélisés à l’aide d’EDP. Les solutions de ces dernières peuvent fournir de précieux renseignements quantitatifs mais également d’importantes informations qualitatives comme : le comportement à long terme du phénomène, sa périodicité éventuelle, etc.

La révolution conceptuelle, introduite en mathématiques il y a plus d’un siècle, consiste à voir cette solution, qui est en fait une fonction, comme un « point » d’un espace qualifié de fonctionnel et qui est de dimension infinie. Nous considérons donc une nouvelle fonction, nommée
fonctionnelle, définie sur cet espace fonctionnel de telle sorte qu’une solution de l’EDP examinée soit également un point critique de cette fonctionnelle. Un point critique étant un point dont la « géométrie » s’apparente au creux d’une vallée ou bien au sommet ou au col d’une montagne.

Disposant de la fonctionnelle associée à l’EDP qui nous intéresse, nous tenterons de démontrer l’existence de points critiques (donc de solutions), puis de caractériser si possible ces derniers. Notre tâche étant rendue ardue principalement à cause du comportement particulier des espaces fonctionnels, dû au fait qu’ils comprennent une infinité de dimensions. Les impacts de notre recherche risquent d’être appréciables puisque certaines des EDP étudiées ont une grande importance dans le domaine dont elles sont issues. Nous pensons, entre autres, à l’équation semi-linéaire de Schrödinger qui est de première importance en mécanique quantique dans la compréhension profonde de la nature de la matière qui nous entoure.
Stephanie Czapor

Applications of symbolic algebraic computation in applied Mathematics

A grant of $8,200 per year.

Une subvention de 8 200 $ par année.

Discovery Grant – Subvention à la découverte

My research involves the use of systems for symbolic algebraic computation (e.g. Maple, Mathematica) in solving computationally challenging problems in mathematical physics and applied mathematics. One such problem concerns the validity of Huygens’ Principle (HP; from his “Treatise on Light”, 1690), or rather its precise formulation due to J. Hadamard (1923), for the wave equation on curved spacetimes. Roughly speaking, this states that waves do not exhibit “ripples” behind the wave front. While this problem is well-understood in two and three dimensions, it becomes far more difficult in spaces involving four dimensions (e.g. as in general relativity). The modern formulation of the problem is in terms of the so-called Cauchy problem, and as such its role is rather central to the theory of partial differential equations. My present goal is to precisely determine the validity of HP for the non-self-adjoint form of the wave equation, when considered in an underlying four-dimensional space of a particular algebraic type. This forms the next logical step in a program to eventually treat all of the possible cases.

Another (related) problem concerns investigating the so-called conformal structure of space-time. A conformal transformation is one of a particular kind imposed on the metric tensor (which measures distances) of a space, which preserves angles but not distances. Despite its simplicity, its exact physical significance is difficult to understand. Still, such transformations have played an important role in relativity (e.g. in studying conformally invariant wave propagation in HP, as above). The particular problem I am now investigating concerns finding the precise conditions under which a given space-time is conformally related to
one which is empty (in the sense that the Ricci part of its curvature vanishes).
Julien Dompierre

Cadre général pour la génération intelligente de maillages non structurés

A grant of $18,000 per year.
Une subvention de 18 000 $ par année.

Discovery Grant – Subvention à la découverte

Les générateurs de maillages non structurés de type Delaunay sont maintenant complètement automatiques, rapides et peuvent traiter des géométries complexes. Cependant, les usagers ont peu de contrôle sur la taille et la qualité du maillage final. Les tailles sont données manuellement sur les arêtes et les faces frontières du domaine pour être ensuite diffusée vers l’intérieur du domaine. Un meilleur maillage tiendrait compte de la distance aux frontières du domaine, de la courbure de ces frontières, de l’épaisseur locale du domaine, de la proximité de discontinuités telles des coins, des bords de fuite, etc. Ces caractéristiques géométriques du domaine de calcul devraient piloter le générateur de maillage. Le maillage serait plus fin là où l’épaisseur locale du domaine est petite. Il serait aussi étiré et aligné avec les frontières du domaine, les tailles tangentielles étant des fonctions des courbures principales de la frontière et la taille normale étant une fonction de la distance à la paroi. Ce qui est appelé un « bon » maillage dépend du domaine d’application, tel la mécanique des fluides, le transfert de chaleur, l’analyse des contraintes, l’électromagnétisme, etc. Pour un domaine donné, un maillage peut être satisfaisant pour simuler le transfert de chaleur mais inadéquat pour simuler un écoulement de fluide. Mais dans tous les cas, l’adéquation du maillage dépend des caractéristiques géométriques du domaine, mais d’une manière différente, fonction du domaine d’application. Ce programme de recherche consiste à étudier la génération automatique et intelligente d’un maillage non structuré. Cette recherche consiste essentiellement à:

1. extraire des caractéristiques géométriques du domaine de calcul;
2. transformer ces caractéristiques géométriques en spécifications (un cahier des charges) qui dépendent du domaine d’application, et
3. construire un maillage qui satisfait ces spécifications.

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State of the art Delaunay unstructured mesh generators are automatic, fast and handle complex geometries. However, users have little control on the size and quality of the final computational mesh. Typically, dimensions are specified by the user on the domain boundary and are diffused to the interior of the domain. A better mesh generation scheme would explicitly take into account geometrical information such as the distance to the domain boundaries, the boundary curvature, the local thickness of the domain, and the proximity of discontinuities such as corners and trailing edges. More precisely, such geometrical characteristics of the computational domain should control the mesh generator. For example, the mesh should have thinner cells where the domain is thin and be aligned with the domain boundary, the tangential sizes being functions of the boundary principal curvatures and the normal size being a function of the distance to the wall.

In addition, what makes a mesh “good” depends on the field application: fluid mechanics, heat transfer, stress analysis, electromagnetism, and so on. For example, a mesh which is satisfactory to simulate heat transfer may be inadequate to simulate fluid flow. In general, the mesh dependence on the geometrical characteristics of the computational domain should be linked to its use.

We will research the automatic and intelligent generation of unstructured meshes with a three step approach:

1. extraction of the key geometrical characteristics of the computational domain;
2. transformation of the geometrical characteristics into application dependent specifications;
3. construction of a mesh which satisfies these specifications.
Kalpdrum Passi

Incremental Maintenance of XML Schemas

A grant of $14,000 per year.
Une subvention de 14 000 $ par année.

Discovery Grant – Subvention à la découverte

XML (eXtensible Markup Language) is a new standard for data representation and exchange on the Internet. XML provides tags on data elements, which identify the meaning of data, rather than specifying how the data should be formatted, as in HTML.

The nature of data on the web and the flexibility of XML have resulted in data encoded in XML’s being semi-structured. The availability of large amounts of heterogeneous distributed data necessitates integrating data from multiple sources. The data might be stored in different formats in different companies. Some of the formats include browser formats (HTML); database formats (relational and object-oriented models); and legacy data. The integration, transformation and translation of such data are increasingly important for modern information systems and e-commerce applications.

XML provides a common platform for integration and exchange of data for the different formats. We provide a methodology to integrate data from various sources using XML. It is not enough to provide a mechanism for integration alone as this might be a one-time operation. The data might change at the various local sources and it is very expensive and time consuming to update the integrated data from scratch. It is cost effective to maintain the integrated data incrementally rather than redoing the operation again. We propose to address this problem as part of this research.
A symmetric space refers, in plain words, to the kind of “universe” that I am studying. The general context of my work is harmonic analysis of this universe. The basic idea of harmonic analysis, itself a generalization of Fourier analysis, is to represent general functions in terms of more basic ones, i.e. spherical functions.

Historically, such studies concerned spaces such as the real line (the one-dimensional space); the plane (the two-dimensional universe); or space (the three-dimensional universe). A natural extension was then the Euclidean $n$-dimensional space. There are more complicated objects mathematicians want to work with (the sphere being a natural example).

Symmetric spaces are sufficiently complex objects to be of interest as a generalization, while sufficiently well-behaved to make their study relevant and interesting (not to mention accessible!).

Not only can one consider questions such as the heat diffusion on a symmetric space, but it also makes sense to study probability theory using such objects. As well, the behaviour of the basic functions i.e. the spherical functions becomes important. Natural assumptions as to how a well-known phenomenon in the Euclidean setting will behave in a different situation are either confirmed or contradicted.

These questions can be addressed by finding explicit formulae for the spherical functions (when possible) or by using general principles.

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Le type d’« univers » que j’étudie est un espace symétrique. Ma recherche porte sur l’analyse harmonique sur ce type d’univers. L’ana-
alyse harmonique, une généralisation de l’analyse de Fourier, consiste à représenter les fonctions à l’aide de fonctions de base, c’est-à-dire, les fonctions sphériques. Historiquement, de telles études concernaient la droite réelle (espaces unidimensionnels), le plan (espaces bidimensionnels) ou l’espace (espaces tridimensionnels). Une généralisation naturelle était l’espace euclidien de dimension $n$. Il y a d’autres objets plus compliqués que les mathématiciens veulent étudier (la sphère est un bon exemple). Les espaces symétriques sont des espaces suffisamment complexes pour être intéressants comme sujet d’étude mais se comportent suffisamment bien pour que leur étude soit pertinente et intéressante (et accessible!).

Non seulement, nous pouvons étudier des questions telles que la diffusion de la chaleur sur les espaces symétriques mais il est aussi pertinent d’étudier des questions probabilistes sur de tels objets. Le comportement des fonctions de base, les fonctions sphériques, est donc important. Des hypothèses sur comment un phénomène classique bien connu sera transposé dans un espace symétrique sont soit confirmées, soit réfutées. Ces questions sont étudiées en découvrant des formules explicites pour les fonctions sphériques, si cela est possible, ou en utilisant des principes généraux.
Abdellatif Serghini

Unconventional finite element methods

A grant of $12,000 per year.
Une subvention de 12 000 $ par année.

Discovery Grant – Subvention à la découverte

Numerical analysis is the area of mathematics and computer science that creates, analyzes, and implements algorithms for solving numerically the problems of continuous mathematics. Such problems occur throughout the natural and social sciences, psychology, engineering, medicine, and business. In the 21st century, the life sciences and even the arts have adopted elements of scientific computations. We use a wide variety of methods, but finite element methods are some of the most powerful methods in modern computational mathematics.

One of the prime targets of many efforts in numerical simulation is the computation of the solutions for the convection-diffusion (CD) physical phenomena which are modeled by the CD equations. These latter are our model problem in this project. The convection-diffusion problems are of great practical importance since they arise in fluid flows, reactive flows, ground water flows, traffic flows, two-phase flows in oil reservoirs etc. They also govern a variety of physical phenomena that appear in aeronautics, astrophysics, meteorology, semiconductors, financial modeling, and other areas. However, the numerical approximation of those problems is a major source of trouble, and no standard finite element can be used to approximate them. The weaknesses of the classical finite element methods to treat such problems have pressed upon the attention to improve some methods and/or to develop new methods for more precise representative simulation.

For these reasons, the objectives addressed here are to improve the popular Streamline-Upwind Petrov-G method and to develop new finite element methods, in order to avoid undesirable pathologies in the approximation of the solution of the CD equations. We apply these
methods to perform numerical simulations of the general convection diffusion physical phenomena, to the semiconductor, and to traffic flow problem, etc.
Department of Physics
Département de physique

Mohamed Azzouz

The quantum states in the strongly correlated electron systems

A grant of $11,000 per year.
Une subvention de 11 000 $ par année.

Discovery Grant – Subvention à la découverte

My research activities consist of investigating the electronic properties of the high-temperature superconductors, and of studying the Heisenberg spin (magnetic) systems. High-temperature superconductors are poor electric conductors at high enough temperatures, but become superconductors (that conduct electricity without energy loss) when they are cooled below a certain critical temperature, which depends on the chemical composition of the material. For these materials, I am interested in understanding the differences that exist between their electronic properties and those of ordinary metals like copper for example. This understanding would likely help us understand the interplay between superconductivity and antiferromagnetism, which constitutes currently one of the most difficult issues of condensed matter physics.
I use the concept of rotating magnetism in my research work on the high-temperature superconductors. More precisely, rotating antiferromagnetism is utilized in the modeling of the pseudogap behavior in these materials. For the spin systems, I look for the possible spin states that are realized in the so-called antiferromagnetic Heisenberg ladders and layers. These states are nontrivial arrangements of the spin average orientations. The spin arrangements depend on the number of legs in the ladders, or the number of layers in the Heisenberg coupled layers, and on the spin-spin coupling constant.

Also, I am interested in the state that results from the interaction of the magnetic and lattice degrees of freedom. In the one-dimensional spin systems, this interaction leads to the spin-Peierls instability of the crystal lattice. A dimerization of the lattice parameter and the spin coupling constant results from this instability.
Gennady Chitov

**Ordering and correlation effects in quasi-two-dimensional magnetic and fermionic systems**

A grant of $18,000 per year.

Une subvention de 18 000 $ par année.

**Discovery Grant – Subvention à la découverte**

This proposal addresses several problems of the physics of strongly correlated electrons and magnetic systems. In broad terms, my research is devoted to the analysis of the physical systems showing various types of orders or ordering correlations.

This research has direct applications for different types of materials: compounds demonstrating charge or structural order; various magnetics with competing types of order; two-dimensional electron gas; and the high-temperature cuprate superconductors, which demonstrate an extremely rich phase diagram with different types of order.

The physical problems this proposal deals with lie in the core of interests of the world’s condensed matter community. I anticipate that my work will help in understanding of some of the many fascinating phenomena that physics of quantum materials unveils in abundance.
Robert Leclair

Biomedical x ray diffraction technology to improve diagnosis of breast cancer

A grant of $22,724 per year.
Une subvention de 22 724 $ par année.

Discovery Grant – Subvention à la découverte

A potential new way of detecting cancers within the breast would be to devise a system that can capture the x-ray diffraction signals of the tissue. The x-ray diffraction signals are contained within the low-angle x-ray scattered field. It has been shown that there exist differences in the x-ray diffraction signals between healthy and cancerous breast tissue. The x-ray diffraction signals of tissue are fingerprints of their molecular and intermolecular structures. The detection of these signals may improve the diagnosis of breast cancers.

We have built an energy dispersive x-ray diffractometer to measure the x-ray diffraction signals of breast tissue. The results are encouraging. In this research grant, we will determine if we can identify structures within a breast specimen phantom using a digital imaging system in conjunction with a CdZnTe detector. The protocol is as follows: An image of the phantom would be captured with a digital camera. Suspicious structures within the phantom would be highlighted. A CT slice will reveal the xyz coordinates of the lesions. The lesions would then be interrogated with pencil beams of x-rays and the scattered x rays would be detected with a CdZnTe detector.

The measurements will be simulated using the diffraction data in a catalogue. The data that gives a signal that is closest to the measured signal would reveal the type of the lesion. This could lead to a new biomedical x-ray diffraction technology that could be useful to analyze breast biopsies.
Clarence Virtue with/avec Jacques Farine and Doug Hallman

Sudbury Neutrino Observatory research at Laurentian University

A grant of $427,500 for three years.
Une subvention de 427 500 $ par année pour trois ans.

Subatomic Physics Project – Projet en physique subatomique

Laurentian University is one of five Canadian institutions that, along with collaborators from the United States and Great Britain, have designed, built and now operate the Sudbury Neutrino Observatory (SNO) to solve an enduring enigma: the “solar neutrino problem”. Neutrinos are fundamental particles created in large numbers by the nuclear reactions that fuel the sun. They interact with matter to only the slightest degree and the overwhelming majority escape the sun and radiate out, traversing all obstacles.

Measurements of the flux of these solar neutrinos are notoriously difficult and yet have been done by several independent techniques. For over thirty years these measurements have been at odds with the best calculated predictions. SNO has solved this problem by convincingly demonstrating that all of the predicted neutrinos are in fact present.

The beauty of this solution is that the SNO measurement, all previous measurements, and the theoretical prediction are now consistent under a new picture in which neutrinos change their character as they
travel. Previous experiments were capable of detecting only the unchan-
ged neutrinos whereas SNO detected all neutrinos.

The researchers at Laurentian University are committed to advan-
cing some of the base technologies that have played a large role in the 
success of SNO and that are certain to be crucial for next generation 
experiments. These extremely sensitive experiments demand the near 
elimination of radioactivity from the materials used in their construc-
tion and the ability to measure the miniscule amounts that remain. 
Pushing these frontiers of purity and sensitivity to radioactive conta-
minants is enabling science for future experiments.

The SNO detector is also a uniquely sensitive instrument for the de-
tection of neutrinos from supernovae. An exciting Laurentian responsi-
bility within SNO is the operation of SNO’s supernova trigger and its 
participation in the inter-experiment collaboration SNEWS (the Super-
nova Early Warning System) which would actually alert astronomers 
to a new galactic supernova in advance of the star having appeared to 
explode.
Wichoski, Ubi

**PICASSO group at Laurentian University**

*A grant of $40,000 per year.*

*Une subvention de 40 000 $ par année.*

**Discovery Grant – Subvention à la découverte**

Although astronomical and astrophysical observations of the Universe indicate that dark matter is everywhere, its nature represents a problem for modern science that has not been solved yet. Nevertheless, there is a strong belief among physicists that dark matter is made of elementary particles. Observations indicate that dark matter forms halos that involve spiral galaxies like ours (the Milky Way). Scientists believe that dark matter particles are zooming around in the Milky Way in such a number that 10 million particles would pass through the cap of a soda bottle every second. Many experiments are under way to detect these particles but no one has been able to indisputably claim the detection of dark matter particles.

The elementary particles presently known and described in the Standard Model of Particle Physics do not have the properties that scientists believe dark matter particles must have. These properties include

(i) no electromagnetic interaction with ordinary matter (that is why they are dark);

(ii) creates a gravitational pull (that is why we know they are there);

(iii) a feeble interaction with ordinary matter.

It is this feeble interaction of dark matter particles with ordinary matter what we hope will reveal dark matter’s nature. The PICASSO (Project In Canada to Search for Super Symmetric Objects) dark matter search experiment has recently achieved one of the best performances in the search for dark matter. The PICASSO Collaboration, which uses the superheated droplet technique, develops its own detectors, which allows for a low cost of production and operation. The PICASSO Collaboration is now developing and installing larger detectors.
at SNOLAB and refining its technique in order to maximize even more the chance of detecting dark matter particles. The next generation of dark matter search experiments is going to be more sensitive, i.e., will be able to detect dark matter particles even if their interaction with ordinary matter is 1,000 times weaker than the levels we can detect today.

The PICASSO Collaboration is in an excellent position to get there first.
School of Commerce and Administration
École de commerce et d’administration

Belaïd Aouni

Modélisation des préférences du décideur dans le modèle du Goal Programming dans un contexte d’information imparfaite

A grant of $12,000 per year.
Une subvention de 12 000 $ par année.

Discovery Grant – Subvention à la découverte

Généralement, dans le modèle du Goal Programming, nous préconisons que le décideur est en mesure de cerner avec précision et sans peine, les paramètres technologiques et les valeurs des buts associés aux objectifs relatifs à la situation décisionnelle. De plus, nous considérons que les paramètres technologiques de la situation décisionnelle sont déterministes et précis. Or, ces valeurs peuvent être stochastiques ou imprécises. Un tel contexte décisionnel est caractérisé par l’imperfection de l’information et par son ambiguïté. Les techniques proposées pour résoudre ce genre de contexte décisionnel n’intègrent pas explicitement les préférences du décideur.
Dans notre programme de recherche, nous exploitons le concept des fonctions de satisfaction pour intégrer explicitement les préférences du décideur dans le modèle du GP en présence d’informations imparfaites. Le modèle à développer fera l’objet des applications en ordonnancement multicritère où le temps de traitement est stochastique, et en sélection de portefeuille où plusieurs critères sont à considérer tels que le rendement du titre boursier, la diversification et la préférence d’investissement dans des titres particuliers. Dans ces deux cas d’application, l’information disponible sur les différents paramètres est considérée comme étant imparfaite.
School of Engineering
École de génie

Laxman Mahendra Amaratunga

Development and processing of mine fill as an engineered composite using waste and its environmental benefits

A grant of $23,000 per year.
Une subvention de 23 000 $ par année.

Discovery Grant – Subvention à la découverte

A novel concept of Cold-Bond Tailings Agglomeration (CBTA) process for mine backfill was first presented by the applicant in 1989. Mill tailings, which are too fine for use as underground backfill, and normally disposed of in tailings ponds, can be agglomerated to produce environmentally safe aggregate for backfill. High-density paste backfill, which incorporates a fair proportion of fine tailings, is becoming increasingly popular in today’s mining industry. However, pastefill operations demand the addition of imported aggregate materials to enhance their mechanical strength. Studies carried out by the applicant at the Laurentian University Waste Agglomeration Research Laboratory have shown that the tailings’ pastefill strength and modulus can be greatly enhanced (sometimes tripled) by the mere addition of in-situ agglomerated fine tailings
instead of imported aggregates. This composite fill is called Agglomerated Total Tailings Paste Fill (ATPF). The applicant’s ongoing research (with NSERC funding) on CBTA and ATPF processes has conclusively shown that mine tailings fills can be perfectly engineered as a Particle Strengthened Composite (PSC) material to obtain high strength, stability and integrity by modification of the matrix component as well as the aggregate (particulate) component of the composite fill.

The major objective of the current application is to continue the fundamental work to investigate the possibility of processing and utilizing the solid waste generated by the mining and metallurgical processing industry, by incorporating these wastes into the proposed composite tailings mine fills, either in the fill matrix as a complimentary binder or as aggregates via an agglomeration process similar to CBTA and ATPF processes. The long-term objective of the proposed work is to develop green technologies for the mining and metallurgical industries for “zero-waste”. This would be of direct benefit to these industries, and may result in a novel and safe waste processing, utilization and disposal technology to improve the mine environment in a sustainable manner.
Gregory Baiden

Telemining research laboratory – Technology change and its impact on production systems

A grant of $19,000 per year. 
Une subvention de 19 000 $ par année.

Discovery Grant – Subvention à la découverte

Mining is entering an era where technology is being applied to the industry via telerobotic operations. This work will outline a number of key areas that need to be investigated in applying telerobotic technology to the mining industry and taking into account its impact on the mining process, the operations and the minerals we mine.

Telerobotics offers many opportunities for Canadian researchers around the world. This specific work will focus on three main questions:

1. How many machines/robots can a single operator run given virtual communication?
2. How does one operator cause a group of machines to work together to accomplish a given task?
3. Given that an operator can be virtually present on a machine from any location in the world and operate the machines/robots instantaneously, how does this affect what the technology looks like and what can be mined?

The Telerobotic Laboratory where we will be conducting most of these experiments will be a unique facility that links Laurentian University and the Penguin Research Centre through a high bandwidth network that will allow the study of teleoperation issues for students as well as enable demonstrations for the public. The laboratory consists of a teleoperation chair at the Laurentian Site, a fibre link and space
at the Penguin Research Centre to test scale model LHD’s. With these facilities in place this investigation will lead to developing new and innovative systems for mining.
Paul Dunn

Optimisation of rock excavation processes

A grant of $18,000 per year.
Une subvention de 18 000 $ par année.

Discovery Grant – Subvention à la découverte

Canada’s hard rock mining industry faces challenges in an internationally competitive market. Mines are becoming more difficult to justify and there is a growing need to improve the planning of underground operations to maximise the financial return from existing mines and optimise the extraction of new orebodies. This grant is to facilitate an increased research effort in the area of optimizing mining schedules and mine planning. An increase in the research effort for optimising rock excavation process is needed to maximise the financial returns or minimise costs from current mining and civil projects. Mining companies can now currently use mine specific scheduling packages to help with the planning process and quickly see the impact of a schedule on a computer screen. The process is too complex to optimize with the data at hand and hence the produced plan is normally a compromise between a couple of main objectives and the time constraints at that particular operation. A number of research tasks have been proposed to: combine drift development (tunneling) access optimization with the existing stope sequence optimization capability; develop alternative financial risk evaluation techniques for mining and civil projects which incorporate technical and market risk factors into the method; incorporate uncertainty within the optimization process for available spatial data; and finalise a strategic ventilation planning method for mining and civil projects based on excavation activities and basic rock and climatic parameters. The results of this research will contribute to the development of modified mine planning techniques to optimize the rock excavation sequences and maximize financial returns, whilst still adhering to the operational constraints. The novelty of this research lies in producing optimized mine schedules which cannot currently be performed within the industry. Training of highly qualified personnel is
part of this research through the use of graduate students and research associates, for whom funding is requested.
Eduard Guerra

Optimization of current distribution in EW reactors

A grant of $24,000 per year.
Une subvention de 24 000 $ par année.

Discovery Grant – Subvention à la découverte

Canada is a major producer of base metals, such as zinc, copper, nickel, and cobalt that are typically produced by electrodepositing the dissolved metals from aqueous electrolytes in large rectangular tanks in which alternating plate-shaped anodes and cathodes are suspended in a parallel circuit arrangement. Since metal deposition proceeds by the passage of electrical current, an even distribution of current to each of the cathodes and over their respective surfaces is desired to deposit metal of uniform thickness and quality. Though firmly entrenched in the base metal production industry, these reactors suffer from inherent problems in current distribution due to wrap-around currents at electrode edges and the presence of gas bubbles in the electrolyte (electrode misalignment and contact resistances are significant causes of uneven current distribution, but are avoidable through proper maintenance and monitoring).

The short-term goal of the research is to design easy to implement modifications to enhance the current distribution within existing electrowinning, EW, reactors to increase their productivity. The ultimate goal is to increase our fundamental knowledge of EW processes in order to design better reactors that will lower the energy requirements for the electrolytic production of base metals. The scientific approach will be both fundamental and applied in nature. In order to assist in designing modifications to EW reactors, a computer model will be generated to simulate the coupled current distribution and hydrodynamic conditions in virtual models of EW reactors. Once a design modification has been tested using the computer model, laboratory experiments
will be conducted in order to validate and refine the predictions of the computer model. The validated model will be used to refine the design changes which will be retrofitted into existing industrial EW cells. The proposed research will lead to the design of modifications to existing EW reactors, and, potentially, to the design of new EW reactors to lower the energy costs for production of base metals.
Miroslaw Hajdasinski

Optimization of the size and the production schedule of an underground hard-rock mine

A grant of $15,015 per year.
Une subvention de 15 015 $ par année.

Discovery Grant – Subvention à la découverte

An underground hard-rock ore mine is a dynamic 3-D structure housing the mine production system as well as several support systems, such as the ore and material handling and ventilation systems. This complex structure is composed of mine development and production workings which consume by far the largest portion of the total capital expenditures of the mine. One of the strategically most important parameters of any underground mine is its size, or equivalently, its production capacity.

The size of the mine, its reserves and the resultant mine life, have a profound impact on mine economics. As the mine size increases, initially economies of scale are realized, and the unit production cost decreases. This trend continues until a certain size of the mine is reached, above which the unit production costs start going up due to the disproportionate mine development costs, relative to the available reserves.

Further, the mine layout becomes too dense and complex, causing logistic and operational problems with the flows of production, materials, and air. This implies that there exists an optimal size of a mine, that will result in maximum economic benefits within the mine’s lifetime. It is important to design a mine at its optimal size, because once a mine is fully developed, it is difficult and prohibitively expensive to significantly change a design that had already been virtually “carved into hard-rock.”

The objective of the proposed research is to optimize not only the production capacity of the mine, but also its life-time production schedule, as well as its cut-off grade policy. The intended optimization tools
are Dynamic Programming (DP), as the optimization platform, and the simulation of the ore, materials, and air flows, as the means for obtaining realistic input parameters for the DP model. The proposed optimization approach will be applicable not only to designing new mines, but will also serve as a tool for:

1. The continual verification of the capacities, production schedules, and cut-off grade policies of the mines, as the time progresses.
2. Detecting the need for a mine reconstruction, and for designing the reconstruction’s size and timing.

Since the cost of developing an underground hard-rock mine can easily exceed $100 million, the economic benefits achieved through the optimization of mine size, its production schedule, and its cut-off grade policy cannot be overemphasized.
Redhouane Henda

Numerical analysis of the nonlinear dynamics of complex chemical systems using wavelets

A grant of $19,000 per year.
Une subvention de 19 000 $ par année.

Discovery Grant – Subvention à la découverte

Chemical processes are becoming increasingly sophisticated and require a thorough understanding from inception to development. This is especially true for complex far-from-equilibrium chemical systems such as those exhibiting strong nonlinearity and intricate interactions between transport phenomena and reaction mechanisms. These systems exhibit different spatial and temporal scales corresponding to various phenomena such as chemical reactions, diffusion, and flow, and require solution procedures that can resolve these varying scales in the most efficient manner. To assemble a portrait of the operation of chemical reactors wherein complex nonlinear chemical processes take place, it is fundamental to understand the couplings between the phenomena involved. Issues related to reactor design, analysis, and scale-up can be tackled with the ability to solve the strongly nonlinear mathematical models describing the different phenomena.

The proposed research is concerned with the thorough understanding and analysis of nonlinear chemical systems far from equilibrium using efficient numerical methods. Wavelets, with their multi-resolution analysis properties, will be used as a new tool for the numerical analysis of complex chemical systems that most conventional techniques fail to solve with acceptable accuracy and over a reasonable time. Initially, the focus of the research will be on the quantitative and qualitative analysis of instabilities and patterns in yeast processing, with important applications in the baking, food manufacturing, and genetic engineering industries. Further systems of technological importance in areas such as chemical process engineering, materials processing, and bioprocessing will be investigated. The knowledge generated will provide
the Canadian chemical-process industries with viable solutions to their process-related problems, and will alleviate reliance on empiricism – very expensive and lengthy because of its inherent “trial and error” approach – to describe and design chemical reactors.
Peter Kaiser

Advanced geomechanics design of underground structures

A grant of $69,000 per year.
Une subvention de 69 000 $ par année.

Discovery Grant – Subvention à la découverte

As mining and civil engineering structures are being constructed at greater depths, geomechanics issues impose greater constraints on design and construction in mining. At these depths, the ground becomes “less forgiving” and advanced geomechanics engineering is required to prevent costly mistakes. In high stress environments, rock failure processes near excavation walls (e.g. spalling and bursting) are not well represented by conventional failure criteria. Since these processes dominate instability mechanisms and support design, research is required to develop models for behaviour prediction. Because these failure processes cannot be properly simulated and investigated in the laboratory, but can be observed in the field, they will be studied using field monitoring data and back-analysis techniques.

Mining is now proceeding to depths in excess of 2 km in Canada (e.g. Creighton mine) and deeper in other parts of the world (e.g. > 4 km in S.A.). The longest tunnels under construction in Switzerland (52 and 37 km) penetrate the Alps at depths exceeding 2 km. The applicant is currently involved in research projects in Canada (mining), Japan (cavern construction), Switzerland (tunnelling), and in the U.S.A. (nuclear waste disposal).

Thesis projects and the encountered stability issues will provide the focus and data for the proposed field-based research program. These projects will also provide an opportunity to train students in a real-world engineering setting.

To stay competitive, industry has to develop new enabling technologies. The findings of our brittle failure research will be applied to
resolve issues of mechanized excavation for tunnel boring machine development.

This proposal builds on past research and presents a research program to improve mechanized rock excavation techniques, for mining and civil engineering applications.

Laurentian University has established a state-of-the-art virtual reality data visualization facility. Funded in part by CFI/OIT, it will be used to interpret complex data interactions (geology, stress and geometry).
Peter Kaiser with Fidelis Suorineni & Ming Cai

In partnership with/En collaboration avec International Nickel Company Ltd & Roll Form Group

Hazard assessment and mitigation in the mining of ore bodies under shear loading

A grant of $77,800 for four years.
Une subvention de 77,800 $ pour quatre ans.

Collaborative Research and Development Grant – Subventions de recherche et développement coopérative

Orebodies are in-situ rocks containing minerals such as gold and nickel in sufficient quantities to be mined at profit. When orebodies form below the ground surface they are subjected to stresses from the material above and other sources from dynamic earth activities. These stresses are varying in magnitude and orientation.

The challenge in this research program is how to better understand the behaviour of orebodies under shear loading and, in particular, the unusually seismically active nature of such orebodies even at shallow depths. Based on identified case examples, the objectives of the research are to:

– develop fundamental knowledge on the behaviour of orebodies in shear;
– to establish procedures to properly simulate such orebodies;
– to produce means to simulate offset failure between ore lenses;
– to develop methods to reliably predict anticipated damage from potential rockbursts; and
– to develop a methodology for incorporating dynamic loading into a formal risk assessment and support selection process.

The approach to be adopted is a combined application of observational and numerical modeling or back-analysis approach. This observational approach will take data from past and current monitoring programs as well as field experience for the calibration and validation of advance methods for stope design in orebodies under shear loading.

Campbell and Creighton Mines provide a unique opportunity for this research. Both mines have an extensive microseismic monitoring
network that can be complemented with in-situ stress change and stress flow monitoring systems. These mines also provide good test sites to develop a new procedure for prediction of burst potential, and provide the data necessary to further develop a means for drift stability risk assessment.

These developments will provide the Canadian mining industries new capabilities for safe and economic mining of highly stressed orebodies and for mining at depth. Two graduate students and possibly one Post-Doctoral Fellow will be trained in the course of these projects.
Mining has a strong influence on our nation’s economy. In 2003, mining accounted for 12.6% of Canada’s export earnings, contributed $41 billion to the economy, and directly employed 389,000 Canadians. With the growing demand for raw and processed materials, the discovery and development of world-class ore deposits has become a key nation sustainer.

However, industry faces serious challenges: lack of HQP, limited discovery of economic deposits, costly and risky mining methods, and challenges related to deep mining.

The proposed research is designed to impact the mineral resources recovery process, assist the mining industry in adapting to these challenges, to new regulations, and to increased international competition.

Today, high metal prices place tremendous pressure on Canadian mines to increase extraction rates and transform deep reserves into economic mines. However, due to increased depths (> 2500 m), these reserves are more difficult to extract within Canada’s renowned safety standards. Sudden violent rock failures (rockbursts) are difficult to predict and pose a major hazard to deep mining. Despite inherent difficulties and complexities involved in forecasting rockbursts, the strategic importance for risk management is evident.

This project aims to develop, test and demonstrate the validity of a new approach to numerically predict mine-wide brittle failure migration patterns caused by rock excavation. The research will utilize complex multidimensional geophysical and seismological data to validate an innovative geomechanical interpretation hypothesis called “mining
The new knowledge will be disseminated by training HQP and by supporting decision-making with new methodologies of data integration, modeling and information retrieval.

The expected outcome of this research will result in novel mining strategies that will enable Canadians to develop more efficient and economical mining processes. It will also assist in better managing similar problems in other fields such as in siting nuclear waste repositories, understanding the behavior of CO₂ sequestration reservoirs, fluid injection and oil and gas reservoir management.
Flexibility and quality assessment to counter ground problem delays in the design of deep underground hard rock mining systems

A grant of $22,000 per year.
Une subvention de 22 000 $ par année.

Discovery Grant – Subvention à la découverte

Deep mining faces technological and operational challenges that require intensive research focus to manage the risks associated with Greenfield projects. These risks are related to higher temperatures/stress compared to “normal” mining conditions. Among the strategies to counter the risk associated with mine production systems at depth is the greater control of variables and the introduction of new technologies.

Ground-related problems will be a particular focus in deep mines, and will require the justification of design alternatives that optimize the overall risk profile of a mining system. The question of which measures are appropriate to be introduced for deep mining is posed at the feasibility stage, where irreversible decisions in terms of infrastructure, method and technology needs are being made. The proposed work evaluates the interaction of quality and flexibility assessment in the planning and design of underground mines with ground-problem delays being the risk impediment to the production system. Quality measures can be introduced to enhance the performance of mine operations through statistical analyses that require cost and uncertainty data in a process capability/performance simulation analysis. Flexibility assessment through the application of real options and process simulation can provide the justification of alternatives that improve the robustness of a production system to meet its targets and the optimization of a system.

The methodology in this research project includes the application of statistical methods and real options analysis to process simulation modeling, through case study work where ground-problem delays and the potential alternative to ameliorate their impact are considered. Quality
enhancement and introduction of flexibility will have important capital and operating cost implications in the design of deep mining systems with the justification of alternatives being a function of the frequency and the impact of ground problems. The result will provide a vehicle for the evaluation of alternatives containing both flexibility and quality components.
Vassilios Kazakidis

In partnership with/En collaboration avec Xstrata Nickel

Evaluation of frozen backfill for open stope underground mining in permafrost conditions

A grant of $137,230 over two years.
Une subvention de 137 230 $ pour deux ans.

Collaborative Research and Development Grant – Subventions de recherche et développement coopérative

The Canadian mining industry needs to find viable and economical alternatives to the conventional cemented pastefill/hydraulic methods of backfilling open stopes for underground mines located within a permafrost zone. The harsh environment and the isolated location of a mine north of 60° impose additional challenges, as well as opportunities, to the technological and operational issues related to the use of frozen fill.

In most cases, underground open stoping mining methods require the placement of fill material to enable the controlled recovery of ore from secondary and tertiary stopes. The design of the fill material is a function of the strength and stiffness requirements, the availability of inert material, the water and the binder, while the distribution system is determined based on operating, technical, and economic constraints.

A mine in permafrost presents the additional design variable of sub-zero temperatures which affects the properties of the material used for backfill (Bandopadhyay & Izaxon, 2004, Archibald & Nantel, 1996, and Swan & Kazakidis, 1992), the distribution/mixing/placement system, and the time required for the fill to freeze in the stope. The seasonal variations and the temperature of the permafrost mass can further limit the feasible alternatives which are available to an operation. The research analysis that will be conducted in this study will provide design guidelines for the use of frozen fill as it relates to the mixing, placement, time effects and property distribution of the fill material. These variables will be linked to economic parameters for evaluating process alternatives.
The proposed research project provides an opportunity for collaboration between the mining industry, Laurentian University, and Université Laval, to investigate the potential use of backfill and ice for placement in open stopes within permafrost. Mines in the north will require the development of appropriate design guidelines in order to ensure their competitiveness by realizing the economic benefit of the specific process in their operations (i.e. Diavic Mine, Eskay Creek Mine, Polaris Mine and Raglan Mine).
Helen (Huilan) Shang

Identification of distributed parameter systems by means of the combination of partial least square with Karhunen Loeve decomposition

A grant of $19,000 per year.
Une subvention de 19 000 $ par année.

Discovery Grant – Subvention à la découverte

Distributed Parameter Systems are widespread in industry (e.g. metallurgical processes, fixed-bed reactors, polymer extrusion, and sheet coating processes). Conventional control approaches for these systems use the approximate simplified models and often lead to poor control performance. The control techniques that consider the inherent distributed nature of the processes yield higher performance and product quality, with substantial economic savings and less environmental impact.

High performance control requires high fidelity models for distributed parameter systems. The proposed research will focus on the development of empirical modeling techniques based on experimental or industrial operating data. The statistical tools of analyzing correlation between process variables in both time and spatial directions will be used to produce models that reflect the distributed nature of industrial processes. The resulting models will be suitable for control development. It is expected that the proposed research has the prospect of decreasing the gap between current theoretical research and industrial applications in distributed parameter systems.

The proposed research program explores a developing body of knowledge in the area of distributed parameter systems control. The proximity to the local mineral processing industry provides the potential application of the research results.
Helen (Huilan) Shang

In partnership with/En collaboration avec International Nickel Company Inc.

Model-based control development for semi-autogenous grinding mills

A grant of $49,040 for two years.
Une subvention de 49,040 $ pour deux ans.

Collaborative Research and Development Grant – Subventions de recherche et développement coopérative

Most industrial semi-autogenous grinding (SAG) mills use heuristic control approaches such as expert systems to achieve stable operations and improved performance. Model-based control techniques have not received successful applications in industrial SAG mills due to complexity of the processes and lack of accurate models.

Owing to the need to improve the performance of SAG mills beyond that of the experience-based heuristic control approach, this project proposes to develop high fidelity models for industrial SAG mills and investigate the effect of industrially important variables on their operation.

Both fundamental modeling based on first principles and statistical techniques using industrial operating data will be used in model development. Model-based control will be developed and its performance will be investigated using simulations.

Results of this project will generate important information for new control implementation as well as existing control improvement with minimal costs for industrial SAG mills.
Helen (Huilan) Shang

In partnership with/En collaboration avec Xstrata Nickel

Integrated modeling of a smelter off-gas system

A grant of $37,528 for two years.
UNE SUBVENTION DE 37 528 $ POUR DEUX ANS.

Collaborative Research and Development Grant –
Subventions de recherche et développement coopérative

In mineral and metallurgical industry, smelters process sulfide ores to produce nickel, copper, cobalt, and precious metals. Smelting and refining of the metals are usually accompanied by sulfur dioxide and other gas emissions, which may cause undesirable working environment and polluted air. Smelter off-gas cleaning systems treat the off-gas emissions and minimize the environmental impact of the smelter processes.

With growing awareness of the importance of environmental protection and tightened environmental policy, extensive study on smelter off-gas system is necessary.

Optimal operation of the smelter systems requires tight monitoring and automatic control of the processes. Reliable models of the smelter systems are necessary to improve control and monitoring of the operation.

This project proposes to model the smelter system in Falconbridge Ltd. using industrial operating data and fundamental principles. The smelter system includes many fundamental engineering unit operations. This project will investigate modeling techniques of these individual units, followed by plant-wide modeling with interactions of the engineering units. According to the dynamics of the variables, different model structures will be tested using conservation laws, semi-physical modeling or empirical identification. Model reduction will be conducted to generate the models that can be easily incorporated into process control development.

An adaptive identification method with learning schemes will be investigated and developed specifically for modeling the time-varying characteristics of the smelter off-gas system. With the derived models,
the control schemes for the smelter off-gas system will be investigated. Results of this project are expected to build necessary foundation to further improve the smelter operation and result in better environment and significant economic benefits.
Ramesh Subramanian

Development of novel synthetic water-soluble polymers

A grant of $18,000 per year.
Une subvention de 18 000 $ par année.

Discovery Grant – Subvention à la découverte

Flocculation is a very important step in many strategically important solid-liquid separation processes and it is widely used in mineral processing (improves separation of mineral particles from liquids); raw and wastewater treatment (removal of turbidity-causing suspended particles and contaminants); sludge dewatering (improves separation of solids from liquids); papermaking (as drainage and retention aids); and petroleum recovery (removes drilling residue, enhances water-flooding, keeps flow channels open, and increases permeability).

In the past 50 years, synthetic water-soluble polymers (cationic, anionic, ampholytic and nonionic) have largely replaced traditional inorganic chemicals like alum, lime, and ferric chloride, and natural products like starch and gum as coagulants and flocculants. However, with increasing public awareness and governmental regulations for the environment, both municipal and industrial effluents are required to meet higher standards.

The overall objective of the proposed research is to develop new and improved water-soluble polymers that provide improved coagulation and flocculation in mineral processing, raw and wastewater treatment, sludge dewatering, papermaking, and oil or petroleum recovery.

The synthesis, characterization, solution properties and performance of water-soluble polymers as coagulants and flocculants will be studied. A fundamental understanding of molecular processes and reaction mechanisms involved during synthesis will be undertaken, and the effect of synthesis techniques on structural characteristics of synthesized polymers will be investigated.
Reliability assessment of mining equipment using genetic algorithms with probability distribution based fitness function

A grant of $20,070 per year.
Une subvention de 20 070 $ par année.

Discovery Grant – Subvention à la découverte

This proposal is a continuation of an NSERC grant in the field of Genetic Algorithms (GAs) for reliability assessment of mining equipment. Compared to classical reliability analysis, this research offers a novel approach which may lead to the formulation of a reliability assessment methodology based on GAs. Genetic algorithms are stochastic search techniques based on the principles of natural selection. The reliability of a machine changes over time due to its dependence upon several factors (e.g. the operating environment, number and quality of repairs). The use of GAs is intended to capture the impact of the factors on the reliability function of a machine by mimicking the process of heredity and natural selection.

In GA models, to progress from one population to the next, members of the current population are reproduced, crossed over and mutated based on the value of their current fitness using a Fitness Function (FF). So far, it has been found that the use of the exponential probability distribution as the FF in a GA-based reliability model offers acceptable reliability estimates. However, the statistical properties of the exponential distribution conflict with the assumptions of heredity and survival of the fittest assumed by GAs.

Furthermore, the maximum number of generations required to achieve statistically acceptable reliability estimates appear to vary significantly. Thus, it is now proposed to develop GA-based models incorporating
other theoretical distributions (e.g. Weibull) as FFs, as well as to in-
vestigate the criteria for the size of the initial population and for the
maximum number of generations. The characteristics of the new models
are expected to reduce the constraints associated with the statistical
assumptions imposed by the applied FFs and to enhance the ability of
these models to converge to acceptable solutions within a narrow span
of iterations.

The research involves:

1. development of models using other than the exponential distri-
bution as the theoretical probability distribution for the fitness
function;
2. verification and testing with available field data; and
3. comparison of the models.
Turgut Yalcin

Dissolved gas and ultrasound applications in mineral processing

A grant of $19,000 per year.
Une subvention de 19 000 $ par année.

Discovery Grant – Subvention à la découverte

This proposal is part of the applicant’s ongoing efforts to explore the potential uses and benefits of dissolved gas and ultrasound technologies, and to encourage and promote their implementation in the mineral processing industry. Dissolved gas and ultrasound have important roles to play in mineral processing, but much research and development work are needed before industry becomes convinced of their benefits and considers implementing them in industrial practice.

“Dissolved gas” can be used as a source for generating gas bubbles for mineral flotation processes. It is known that bubbles derived from dissolved gas are much finer than mechanically produced conventional bubbles and are better suited to the flotation of fine and ultra-fine minerals. Dissolved gas bubbles are obtained by first dissolving a gas (usually air) in the flotation pulp under pressure and then releasing the pressure. Depressurization causes the dissolved gas to come out of solution in the form of fine bubbles, but what is perhaps more interesting is that bubbles nucleate on mineral surfaces as they form and this further enhances the recovery of fine particles by eliminating the need for bubble-particle collision that would otherwise be necessary for bubble attachment to occur.

With respect to the use of ultrasound, two areas of application will be considered: (a) mineral flotation and, (b) gold extraction by cyanidation.
The benefits of ultrasound in these applications are derived from the unique phenomenon known as “acoustic cavitation” which occurs when ultrasonic waves are passed through a liquid. The main effect of this process in flotation is the cleaning of mineral particles to enhance or modify their surface properties. In the cyanidation process for gold extraction, ultrasound can significantly increase the gold dissolution rate which is otherwise a very slow process.
As the world’s largest produced polymers, polyolefins play an extremely important role in our industry and society. Despite their size and commodity nature, polyolefins are the fastest-growing sector of the polymer industry and remain highly technology driven. Improving product quality and developing advanced polyolefin materials with controlled chain structure and tailored materials properties are two of the most important directions in polyolefins research and development.

The overall objective of the proposed research is to develop advanced polyolefin materials with unique structure and superior properties by using novel polymerization processes. Funds are requested to support two graduate students each year to work on two well-defined projects in this area.

Project #1 is to develop novel functionalized polyolefin block/graft copolymers with well-defined chain architecture and excellent surface properties by using a new polymerization technology that which uniquely combines catalyzed olefin polymerization with atom transfer radical polymerization of functional monomers. Project #2 is to develop novel long-chain-branched (LCB) polyolefins with superior processing properties through olefin copolymerization with nonconjugated dienes.

The proposed research is highly multidisciplinary and interfaces diverse disciplines including polymer chemistry and physics, materials science, catalysis, and polymer reaction engineering. The fundamental knowledge generated from this research will have significant impacts...
on research in polyolefins area. The novel polyolefin materials and new polymerization processes developed will be promising for industrial applications.

The research will also provide excellent training opportunities for students to gain useful knowledge and skills and to prepare them for future employment in Canadian industry and institutes.
Zhibin Ye

Multi angle laser light scattering (MALLS) detector for triple detection high temperature gel permeation chromatography (HTGPC) system

A grant of $48,135.
Une subvention de 48,135 $.

Research Tools and Instruments – Subvention d’outils et d’instruments de recherche

Triple detection Gel Permeation Chromatography (GPC) incorporating a Multi-Angle Laser Light Scattering (MALLS) detector is an important instrumentation for research on synthesis and characterization of polymers with tailor-designed chain architectures. The incorporated MALLS detector enables the matchless capability to accurately measure the absolute polymer molecular weight and distribution, polymer coil size and distribution, and many other important polymer structural properties.

The funds are requested in this proposal to acquire a Wyatt mini DAWN MALLS detector for the establishment of a powerful triple-detection High-Temperature Gel Permeation Chromatography (HTGPC) system for the urgent need in Dr. Ye’s research on chain architecture-controlled polyolefins. Dr. Ye currently has in his lab a Polymer Laboratory PL220 HTGPC system with a dual concentration and viscosity detector array. Owing to the lack of a MALLS detector, the capability and performance of the existing HTGPC system is significantly limited. Many important properties of polymers synthesized currently cannot be fully and/or accurately characterized. The award of the requested detector will therefore tremendously boost the capability of the instrument and significantly help the successful progress of the research programs.

The requested equipment is the first of its kind both at Laurentian University and in the region of Northern Ontario. Its acquisition is critical to the establishment of a cutting-edge polyolefin research field at Laurentian University and is important for the training and retention
of high-qualified polymer researchers in the region of Northern Ontario and the rest of Canada.
Zhibin Ye

In partnership with/En collaboration avec Imperial Oil

Developing functionalized high-molecular-weight hyperbranched polyethylenes as superior viscosity index improvers for high-performance lubricants

A grant of $25,913 for four years.
Une subvention de 25 913 $ pour quatre ans.

Collaborative Research and Development Grant – Subventions de recherche et développement coopérative

As an important lubricant additive, polymer-derived viscosity index (VI) improvers have been extensively used and play a critical role in enhancing the viscosity index and maintaining the all-season properties of lubricants. Owing to the drive for more gas-efficient, more environmentally friendly, lighter, and smaller engines for modern automobiles, in recent years there has been an increasingly stringent demand in the lubricant industry for superior polymer VI improvers, which possess strong viscosity thickening powers combined with high shear stability.

This proposed CRD research aims at developing a novel series of functionalized high-molecular-weight hyperbranched polyethylenes for applications as superior VI improvers. Owing to their compact hyperbranched chain topology, this novel series of high-molecular-weight polymer VI improvers are anticipated to possess excellent viscosity thickening capacity and outstanding shear stability, which can impart the formulated lubricants with long life-time and low operating viscosity for enhanced fuel saving potentials.

If proved successful, the polymers to be developed in this research will have the potential for applications in Canada’s strategically important oil and lubricant industry and thus contribute to the economic growth. The fundamental knowledge to be generated in this research on polymer architecture-performance relationships will help lubricant industry develop advanced polymer additive technologies for lubricant formulations. This research will also lead to a significant fundamental advance in the area of design and functionalization of polyolefin materials.
In addition, this industry-relevant research will also provide excellent training opportunities to our graduate students, who constitute the nation’s future high-tech workforce.
Cytoarchitectural organization and mitochondrial distribution and respiratory function of Bpag1-deficient skeletal muscle

A grant of $27,000 per year.
Une subvention de 27 000 $ par année.

Discovery Grant – Subvention à la découverte

Cells that make up tissues of the human body and of multicellular organisms come in a variety of shapes and sizes. The cellular architecture accounts for this diversity of cell morphology and plays an important role in allowing cells to function properly. Mutations of genes encoding crosslinking proteins, which are important components of the cellular architecture, are associated with several diseases including a specific form of muscular dystrophy in humans. It is therefore important to further elucidate the precise function of these linker proteins and to identify cellular events that are governed through either direct or indirect interactions with these molecules.
In this context, the proposed sets of experiments described in the present proposal are intended to begin to highlight the contribution of crosslinking proteins in the maintenance of the structural integrity of skeletal muscle cells. Furthermore, the proposed studies are aimed at identifying other possible roles of crosslinking proteins in skeletal muscle physiology. Concepts emerging from the proposed research are also intended to provide clues and a useful framework for delineating possible therapeutic interventions for human diseases associated with mutations of crosslinking proteins.
Northern Ontario School of Medicine (NOSM)

École de médecine du Nord de l’Ontario (EMNO)

David MacLean

Mechanisms regulating blood flow during hypoxia: The role of the interstitial space

A grant of $28,420 per year.
Une subvention de 28 420 $ par année.

Discovery Grant – Subvention à la découverte

Hypoxia (a reduction in oxygen content in the blood) is commonly seen in a variety of disease states including heart failure, shock, pulmonary embolism, and lung disease. When this occurs a number of mechanisms are activated to try and compensate for the deceased in oxygen delivery to tissues. These include an increase in ventilation, heart rate, and cardiac output as well as an increase in (muscle) blood flow. A number of compounds have been identified that contribute to an increase in muscle blood flow (vasodilatation). These include adenosine, nitric oxide and potassium (to name only a few).

Many of these compounds are produced by endothelial cells that line the inside of the blood vessels. However, some may be produced by muscle or even in the interstitial space (the space between the vasculature and muscle). This space is extremely important as it may function to integrate all the chemical signals at the tissue (cell) level.
Therefore, it is vitally important to simultaneously measure putative regulators of vascular tone in this space. Currently the microdialysis technique allows for the measurement and quantification of compounds in the interstitial space and represents a powerful research tool. Thus, the studies in this research proposal will determine the relative contribution of these compounds to vasodilatation by decreasing the amount of oxygen in the blood of rodents. A number of other unique methodologies (in addition to the microdialysis technique) will be employed including the use of the isolated perfused rat hindlimb preparation to induce ischemia (a decrease in blood flow), an alternative method for inducing hypoxia.

Understanding the role that the interstitial space plays in regulating mechanisms associated with vascular function is an important question to basic scientists as well as clinicians as it contributes to our understanding of how chemical signaling systems are integrated.
Tze-Chun Tai

**Regulation of the phenylethanolamine N-methyltransferase gene by hypoxia**

*A grant of $28,942 per year.*
*Une subvention de 28 942 $ par année.*

**Discovery Grant – Subvention à la découverte**

The perinatal period is a critical time of development whereby alterations in the normal environment can result in long term changes in homeostatic functions that contribute to the development of human adult diseases. This concept of fetal and neonatal programming was established based on seminal epidemiological studies by Barker in 1992, who demonstrated that an adverse in utero environment due to undernutrition resulted in fetal growth restriction and enhanced the risk of development of cardiovascular and endocrine disorders such as hypertension and diabetes in adult life.

In addition to nutritional requirements, oxygen is a critical component of normal cellular function and homeostasis in mammalian cells. In accordance with the developmental origins of adult diseases model, hypoxia (reduced oxygen tension) during perinatal development results in long-term changes in physiological systems, including alterations in cardiovascular function and behaviour in adults. Hypoxia alters the development of the adrenergic neurotransmitter system. The catecholamine neurotransmitter adrenaline, synthesized by specific neurons of the brain and the adrenal gland, is an important regulator of physiological systems.

Adrenaline synthesis is regulated by the biosynthetic enzyme, phenylethanolamine N-methyltransferase (PNMT). Using in vitro cellular and molecular biology techniques, my research will delineate the mechanism by which hypoxia regulates adrenaline synthesis via regulation of the PNMT gene.
Partners with Laurentian University

Partenaires de l’Université Laurentienne

Mark Chen with/avec M. Boulay, A. L. Hallin, Doug Hallman, A. McDonald & Clarence Virtue

SNO+ Initial Construction and Continued Development

A grant of $400,000 per year.
Une subvention de 400 000 $ par année.

Subatomic Physics Project – Projet en physique subatomique

A new experiment is being developed at the Sudbury Neutrino Observatory, Canada’s world-leading neutrino physics facility. The experiment is called SNO+ and it consists of filling the SNO detector with liquid scintillator after the heavy water currently in SNO is removed in 2007. By turning SNO into SNO+, a multipurpose experiment with diverse scientific goals would be created.

SNO+ will be able to address fundamental questions in particle physics, in geophysics, and in astrophysics. SNO+ will start where SNO leaves off and it will stretch our understanding of the neutrino and its impact on the physical universe. A liquid scintillator emits 100 times more light when a neutrino interacts in it compared to a neutrino interaction in water. This means that SNO+ will be able to detect neutrinos

\[ \text{1The names of the researchers from Laurentian University are shown in italics./Les noms des chercheurs de l’Université Laurentienne sont en italiques.} \]

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with lower energies. Lower energy neutrinos from the Sun could be studied. Separately, antineutrinos from natural radioactivity in the Earth will be observed. By doing this, SNO+ will be able to assay the total amount of radioactivity in the deep Earth. The fraction of Earth’s heat that originates from radioactivity is a fundamental question that could be answered. An extremely rare nuclear decay might be studied in SNO+ by loading neodymium into the liquid scintillator. Observation of this process, known as neutrinoless double beta decay, would shed light on the fundamental nature of the neutrino with potential impact on our understanding of matter and antimatter in the Universe.

SNO+ has been conducting research & development work funded by NSERC since April 2005. This grant supports initial construction and continued development work to convert SNO to SNO+. 
Fiona Hunter with/avec M. J. Bidochka, R. J. Brooks, J. Richardson, L. Rowe, *Albrecht Schulte-Hostedde*, & G. Tattersall

Wildlife Research Station Algonquin Park

A grant of $108,000 for three years.
Une subvention de 108 000 $ pour trois ans.

Major Facility Access Grant – Subvention d’accès aux installations majeures

The Algonquin Park Wildlife Research Station (WRS) was established in 1944 for the long-term study of terrestrial ecology in an undisturbed tract of the boreal coniferous, mixed and northern hardwood forests. The WRS land is owned by the Ontario Ministry of Natural Resources (OMNR) but the WRS facilities are operated and administered by a consortium of seven Ontario Universities. The station provides access to a 400 km\(^2\) forested “wilderness zone” protected from anthropogenic disturbances; this area contains a variety of terrestrial habitats, numerous headwaters, and several lakes and streams that have been the research foci of seven major users and nine minor users from various universities across Ontario. In addition, there have been both major and minor International researchers who have used the station because it is such a unique research venue on the Canadian Shield.

Undergraduate field courses from 5–10 Universities are taught in the early spring, late summer and fall, when academic research use is less intense. WRS provides accommodation, three meals a day (seven days a week), and laboratory space for up to 40 full-time users in 25 buildings (cabins, laboratories, cookhouse, etc.). The day-to-day running of the station was formerly under a nine month manager who would oversee an assistant manager and two cooks for the six month summer field season (mid-April to mid-October). The manager also opened the station for winter research and for winter field courses, as required. The current proposal is designed to keep the WRS fully functional for 12 months of the year in keeping with new Major User requirements.

\(^2\)The names of the researchers from Laurentian University are shown in italics./Les noms des chercheurs de l’Université Laurentienne sont en italiques.
Claude Leroy with/avec G. Azuelos, Jacques Farine, Doug Hallman, L.Lessard, J-P. Martin, Clarence Virtue, Ubi Wichoski & V. Zacek

Major Resource Support for the Particle Physics Group at the Université de Montréal

A grant of $525,000 for three years.
Une subvention de 525 000 $ pour trois ans.


The infrastructure program of the Particle Physics Group at the Université de Montréal (GPP/U de M) maintains facilities supporting the research program of researchers from the Université de Montréal (U de M) and from Laurentian University (LU). The research program involves eight grant co-applicants from the GGP/U de M and LU and a number of main users.

The GPP/U de M experimentalists are active in three experiments:

i) ATLAS at LHC, CERN;
ii) BaBar at SLAC, Stanford USA;
iii) PICASSO at the SNO laboratory.

The LU experimentalists are active in four experiments at the SNO laboratory:

i) EXO,
ii) SNO+,
iii) HALO and
iv) PICASSO.

The resource is also used by groups from other U de M departments (physics, physiology) and by groups from other universities in Canada and in the world such as VERITAS and POLARBEAR (McGill), ILC (Carleton, Aachen University-Germany, Cornell-US, CEA Saclay, Berkeley, Max-Plank Institute Munich, TIGRESS (TRIUMF, McMaster,

3The names of the researchers from Laurentian University are shown in italics./Les noms des chercheurs de l’Université Laurentienne sont en italiques.
Laval, Guelph), TACTIC (TRIUMF York-UK), ALPHA (TRIUMF, CERN), Medical physics-Liquid Xenon PET prototype (TRIUMF).

Theorists from GPP/U de M and from the Université du Québec à Montréal (UQAM) collaborate with the experimental groups through their participation to phenomenological studies of physics at LHC energies, physics of beauty, CP-violation and field theory. They are among the users of the resource using its computing facilities.

Sudbury Neutrino Observatory project grant B On-site.

A grant of $5,000,000 for three years.
Une subvention de 5 000 000 $ pour trois ans.

Subatomic Physics Project – Projet en physique subatomique

This proposal (SNO Project Grant B) is a request for three years of support for the Canadian part of the on-site research costs for the Sudbury Neutrino Observatory experiment (SNO), a large international project to study fundamental particles called neutrinos. International project participants also pay their portion of on-site research costs.

Neutrinos are able to penetrate out from the thermonuclear furnaces powering the Sun and are detected in the SNO detector, situated 2 km underground near Sudbury, Ontario. Observation of these neutrinos gives specific information about the energy generation processes in the Sun, basic properties of neutrinos themselves and information about the influence of neutrinos on the evolution of the Universe. The experimental program for the present phase of SNO with neutron detectors in the heavy water will continue to provide unique information on solar neutrinos, while also studying neutrinos produced in the Earth’s atmosphere, in supernovae and in other astrophysical sources. Properties of solar neutrinos will be studied through more accurate measurements of flavour change, including day-night flux comparisons to search for regeneration in the Earth and measurements of possible periodic variations in neutrino fluxes. These studies can define the allowed range of masses and coupling parameters for electron neutrinos much more strongly than at present. A protocol has been developed for providing

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early information to the astronomical community in the event of a supernova in our Galaxy.

The Sudbury Neutrino Observatory – L’Observatoire de neutrinos de Sudbury

A prize of $250,000 for two years.
Une prix de 250 000 $ pour deux ans.

John C. Polanyi Award – Prix John C. Polanyi

The inaugural John C. Polanyi award for a major scientific achievement was presented to Canadian team members of the Sudbury Neutrino Observatory on November 15, 2006 “in recognition of its outstanding discoveries”.

Scientists have spent years puzzling over the apparent gap between the number of neutrinos thought to be generated in the core of the sun and the number detected on earth. Either something was profoundly wrong with our model of fusion reactions in the sun, or many of the elusive subatomic particles that are considered the basic building blocks of the universe somehow disappeared en route.

After painstakingly designing and building the Sudbury Neutrino Observatory (SNO) and making three years of measurements, a Canadian-led scientific team confirmed in 2002 the presence of solar neutrinos that had previously escaped detection because they spontaneously change their “flavour” or type, after leaving the sun. The new results for total neutrino numbers confirmed not only that the models of energy generation in the sun are correct, but that the most basic laws of physics are incomplete. The discovery provided revolutionary insight into the fundamental nature of matter and was one of the top scientific breakthroughs of the year.

5The names of the researchers from Laurentian University are shown in italics./Les noms des chercheurs de l'Université Laurentienne sont en italiques. In the picture, from left to right/Dans la photo, de gauche à droite: Doug Hallman, Clarence Virtue and Jacques Farine.
The SNO detector is located two kilometres underground in Vale Incos Creighton Mine near Sudbury. The massive rock shield overhead and the cleanliness of the laboratory provides the world’s lowest-radioactivity location for the experiment.

As neutrinos pass through the 1,000 tonnes of “heavy” water in an acrylic vessel which forms the detector core, they produce flashes of light called Cherenkov radiation which are detected in some of the surrounding 9,600 photo multiplier tubes and analyzed to reveal neutrino interactions.

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Le 15 novembre 2006, le premier prix John C. Polanyi pour une découverte scientifique majeure a été décerné aux membres canadiens de l’équipe de l’Observatoire de neutrinos de Sudbury (ONS) pour récompenser leur « recherche de pointe sur les neutrons ».

Les scientifiques tentent d’élucider depuis des années l’écart apparent entre le nombre de neutrinos qui seraient produits au coeur du soleil et le nombre de neutrinos détectés sur Terre. Cet écart signifie soit que notre modèle des réactions de fusion dans le soleil est terriblement erroné ou qu’un grand nombre des énigmatiques particules subatomiques, considérées comme les éléments fondamentaux de l’univers, ont disparu en route, d’une façon ou d’une autre.

Après s’être laborieusement employée à concevoir et à construire l’Observatoire de neutrinos de Sudbury (ONS), une équipe de recherche dirigée par des Canadiens a enfin confirmé, en 2002, que les neutrons échappent à la détection parce qu’ils changent spontanément de « saveur », ou de type, lorsqu’ils quittent le soleil. Les résultats ont confirmé, d’une part, que les modèles de production d’énergie dans le soleil étaient exacts et, d’autre part, que les lois les plus fondamentales de la physique étaient incomplètes. Cette découverte, qui a constitué l’une des plus importantes percées scientifiques de 2002, a révolutionné la compréhension de la nature fondamentale de la matière.

L’ONS est situé à deux kilomètres de profondeur dans un puits de mine. Le gigantesque plafond rocheux et la propreté du laboratoire en font le lieu de recherche où la radioactivité est la plus faible au monde.

Le détecteur de l’ONS consiste en une sphère d’acrylique qui contient
1 000 tonnes d'eau lourde et est entourée de 9 600 photomultiplicateurs. L'interaction des neutrinos avec l'eau lourde produit des flashes de lumière Cherenkov, qui sont détectés par les photomultiplicateurs.
Operating Support for SNOLAB

A grant of $1,250,000 for one year.
Une subvention de 1 250 000 $ pour un an.

Subatomic Physics - Major Resource Support Program –
Subventions en physique subatomique – accès aux ressources majeures

This grant is to support the operating costs associated with the new SNOLAB facility. The construction of the facility was made possible through an award of about $40 M from the Canada Foundation for Innovation (CFI).

The core physics program is to investigate the properties of elusive neutrinos, to search for “dark matter”, to observe cataclysmic supernovae explosions, and to probe the inner workings of the sun and the earth. We know very little about neutrinos, the most prolific form of matter in the Universe. Experiments planned for SNOLAB will investigate neutrino properties, ultimately discovering the nature of this fundamental particle and determining how it shaped the structure and evolution of the Universe.

Other experiments will search for dark matter. It is now clear that 95% of the content of the Universe is in forms completely unknown to us. Dark matter may exist as massive particles, left over relics from the big-bang. Neutrinos can also be used as a probe into the inner workings of the earth. By observing neutrinos from radioactive decay in the earth, we can learn something of the poorly understood heat production processes.

SNOLAB will build on the success of the Sudbury Neutrino Observatory (SNO) and will allow Canadian physicists to remain at the forefront of the field of astroparticle physics. SNOLAB will be the deepest and cleanest facility on the planet when it becomes operational.

6The names of the researchers from Laurentian University are shown in italics./Les noms des chercheurs de l'Université Laurentienne sont en italiques.
It will be staffed by a highly experienced technical staff accustomed to working on complex detectors deep underground in a clean-room environment. This grant will support the salaries of SNOLAB personnel and the operational costs of the laboratory. It does not intend to support the direct costs of the experiments.

It is expected that a partnership will be developed between NSERC and other potential funding agencies. The pooled resources will enable us to operate the world’s premier facility of its kind. Canadian physicists will lead this scientific renaissance.
Scott Petrie, Shannon Bazinski, Nelson Belzile & Yuwei Chen

Food chain transfer and effects of selenium in waterfowl

A grant of $20,000
Une subvention de 20 000 $

Strategic Network Grant – Subvention de réseaux stratégiques

The combined continental population of Lesser (Aythya affinis) and Greater Scaup (Aythya marila; hereafter scaup) declined by 50% between the mid-1980s and the late 1990s (Austin et al. 2000). One hypothesis for the decline is that birds are acquiring unhealthy contaminant burdens on the lower Great Lakes (LGL). This project has three interrelated parts:

1. to determine levels of contaminant, particularly selenium (Se), acquired by scaup (and other diving ducks) staging and wintering on the LGL;
2. to evaluate the contribution of Se contamination from food as well as surrounding water and sediments; and
3. to determine contaminant levels in Greater Scaup breeding on the Yukon-Kuskokwim Delta (YKD), Alaska.

The names of the researchers from Laurentian University are shown in italics. This is a project within the “Metals in The Human Environment” strategic network./Les noms des chercheurs de l’université Laurentienne sont en italiques. Un project qui se situe a l’intérieur du réseau stratégique « Metals in The Human Environment ».
David Sinclair with/avec M. Dixit, C. K. Hargrove, Jacques Farine, Doug Hallman, Clarence Virtue & Ubi Wichoski

EXO Development

A grant of $590,000 for two years.

Une subvention de 590 000 $ pour deux ans.

Subatomic Physics Project – Projet en physique subatomique

Scientists around the world are searching for a very rare decay process in the cores of atoms of special materials as they seek to explore physics at energy scales far beyond the reach of high energy accelerators. If this neutrino-less double beta decay process exists, it is extremely rare, calling for very special detection techniques and careful attention to low levels of background radioactivity.

The EXO detector, to be located deep underground, will search for this decay in the inert gas xenon. This research award supports the development of the EXO experiment and new detection techniques for it.

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