McGill

Report of the
Academic Policy Committee D11-18

432nd REPORT OF THE ACADEMIC POLICY COMMITTEE TO SENATE

on APC meeting held on 27th October 2011 (or as indicated)

I. TO BE APPROVED BY SENATE

(A) NEW TEACHING PROGRAMS REQUIRING SENATE APPROVAL (approvals of new minors and options added to existing programs and major revisions to programs are reported in Section IV.A.1.a. for information)

None.

(B) ACADEMIC PERFORMANCE ISSUES / POLICIES / GOVERNANCE/AWARDS - *none.*

(C) CREATION OF NEW UNITS / NAME CHANGES / REPORTING CHANGES

Faculties of Dentistry, Engineering, Medicine, and Science

Creation of the Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM) – APPENDIX A

At a meeting on 6th October 2011, APC reviewed a proposal for the creation of a research centre, the Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM) in the Faculty of Dentistry, the Faculty of Engineering, the Faculty of Medicine, and the Faculty of Science. As stated in the proposal, the thrust behind the creation of CAMBAM is twofold: 1. It is as a result of a desire to unite specialists working in the field of mathematics with application to problems in bioscience and medicine under one organizational umbrella thereby constituting a cohort of experts in the field who could work together in a more cohesive manner; and 2. To bridge the gap between academia and industry by providing opportunities for the former to work more closely with the latter. Through its various research activities, CAMBAM will respond to several questions relating to the application of mathematics to problems in biology and medicine that have either not been addressed or been under-addressed. The proposal, fully endorsed by the Deans of the four faculties involved, was approved by the Research Advisory Committee on 26th May 2011.

APC therefore recommends that Senate approve the following resolution:

> *Be it resolved that Senate approve the proposal for the creation of the Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM) / Centre des mathématiques appliquées en bioscience et médicine (CMABM) in the Faculties of Dentistry, Engineering, Medicine, and Science and so recommend to the Board of Governors.*

(D) CHANGES IN DEGREE DESIGNATION - *none.*

II. TO BE ENDORSED BY SENATE / PRESENTED TO SENATE FOR DISCUSSION - *none*

III. APPROVED BY APC IN THE NAME OF SENATE

(A) DEFINITIONS – *none*

(B) STUDENT EXCHANGE PARTNERSHIPS / CONTRACTS / INTERUNIVERSITY PARTNERSHIPS

1. Université de Strasbourg – Student Exchange Partnership

At a meeting on 27th October 2011, APC approved a University-wide Student Exchange Partnership with the Université de Strasbourg. The university has its origins in 1538 when Jacques Sturm created an institution (*Gymnase protestant*) which gradually evolved into a *Université royale* (1631) for the study of theology, philosophy, medicine and law. In 1971, three separate universities were established in Strasbourg focusing on the sciences (Louis Pasteur), the arts and humanities (Marc Bloch) and legal, political, social and technological education (Robert Schuman). In 2009, out of a concern for international institutional visibility and the promotion of interdisciplinary education and research, the three universities merged to form the Université de Strasbourg, a unique, comprehensive institution covering all major disciplinary fields of higher education. It is currently France's largest university in terms of numbers of students and staff members, with 42,000 students (including 20.5% international students), 11,500 trainees, and 4,600 permanent staff (including approximately 2,500 teaching staff, 1,900 technical and administrative staff). The university is strongly research-oriented; nearly 400 doctoral theses are submitted annually. It is a founding member of EUCOR (European Confederation of the Upper Rhine Universities, a Franco-German-Swiss network) and LERU (the League of European Research Universities, which includes 21 institutions, three of which are French). Courses are taught in 38 faculties, schools and institutes, and research is performed in 86 laboratories and research centers, in five broad areas: Arts, Literature and Languages; Law, Economics, Management, Political and Social Sciences; Science and Technology; Health.

2. Student Exchange Partnerships with the McGill Desautels Faculty of Management

At a meeting on 27th October 2011, APC approved Student Exchange Partnerships between McGill's Desautels Faculty of Management and the schools listed below. The Faculty has been involved in the Partnerships in International Management (PIM) Consortium of universities and is setting up bilateral exchanges with specific institutions within that Consortium. The Council of Graduate and Postdoctoral Studies approved the partnership proposals on 17th October

a) New York University, Stern School of Business

Founded in 1831, NYU is one of the largest private, nonprofit institutions of higher learning in the United States (43,000 students and 6,800 academic staff). NYU is a comprehensive university organized into 18 schools, colleges and institutes. It has six locations around New York City, as well as several campuses abroad, including study abroad facilities in London, Paris, Prague, Florence, Madrid, Berlin, Accra, Shanghai, Buenos Aires, and Tel Aviv. NYU is one of 60 member institutions in the Association of American Universities. The Stern School of Business, founded in 1900, is one of the oldest business schools in the world and consistently ranks in the top 10 in the United States. It is a founding member of the international accreditation body, the Association to Advance Collegiate Schools of Business (AACSB). Its student exchange program, IBEX (International Business Exchange Program), allows students to spend one semester at top business schools around the world. The Stern School of Business currently has about 5,780 students. Its unique course offerings and the consistently high ranking of its MBA program (15th in the Financial Times Global MBA rankings in 2011) explain the significantly high demand from students to attend this school.

b) Université Libre de Bruxelles, Solvay Brussels School

The Free University of Brussels (founded in 1834), split into two separate entities in 1970: the Université Libre de Bruxelles (ULB) and the Vrije Universiteit Brussel (VUB). Today, ULB is a comprehensive and multicultural university; almost one third of its 21,000 students come from abroad. ULB is increasing the number of integrated courses it offers with international partners and joint Masters and Doctoral degrees. The Solvay Brussels School Economics & Management (SBS-EM) is the largest school of its type in Belgium's French speaking community; it has

exchange agreements with about 100 business schools around the world. SBS-EM is accredited by the European Quality Improvement System (EQUIS) and the Association of MBAs (AMBA). McGill's Desautels Faculty of Management has had successful exchanges with the SBS-EM for the past 18 years through PIM. The SBS-EM is considered to offer one of the top two MBA programs in Belgium (2nd in Belgium, 35th in Europe according to the Financial Times European MBA ranking in 2010). McGill has bilateral exchange agreements also with l'Université Catholique de Louvain Institut d'administration et de gestion (Management) and l'Institut supérieur d'architecture Saint-Luc de Bruxelles (Architecture).

c) University of Witswatersrand, Wits Business School

The University of Witswatersrand grew out of the South African School of Mines, established in Kimberley in 1896 and moved to Johannesburg in 1906. Full university status was granted in 1922 upon inauguration as the University of Witswatersrand. In 2009-10 the university had about 1,300 faculty and 28,400 students, 7% of whom were international. It has five faculties: Commerce, Law & Management; Engineering & the Built Environment; Health Sciences; Humanities; Science. Created in 1968, the Wits Business School joined the School of Public and Development Management in 1992. In 2001, it was incorporated into the Faculty of Commerce, Law & Management. Wits, the only South African member of PIM, is accredited by the South African Council for Higher Education and the Association of MBAs (AMBA) and is exclusively a graduate school, although certain executive education programs are open to experienced (but not necessarily graduate) executives. The Desautels Faculty of Management has had successful exchanges with Wits through PIM for the past 11 years.

IV. FOR THE INFORMATION OF SENATE

(A) APPROVAL OF COURSES AND TEACHING PROGRAMS

1. Programs

a) APC approvals (new options/concentrations and major revisions to existing programs)

i. New concentrations/options within existing programs - *none*
ii. Major revisions of existing programs - *none*

b) APC Subcommittee on Courses and Teaching Programs (SCTP) approvals Summary reports: http://www.mcgill.ca/sctp/documents/

i. Moderate and minor program revisions - *none*
ii. Program retirements - *none*

2. Courses *(SCTP meeting dates, as indicated)*

a) New Courses:

Faculty of Arts: 1 (27th May); 3 (20th Oct).

b) Course Revisions:

Faculty of Arts: 5 (20th Oct);
Desautels Faculty of Management: 4 (20th Oct);
Faculty of Religious Studies: 1 (20th Oct).

c) Course retirements: *none*

(B) OTHER – *none*

Research Centre Proposal

Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM)

I. Identification

a. Name

Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM)
Centre des Mathématiques Appliquées en Biosciences et Médecine

b. Faculties

Faculty of Medicine (lead faculty), Faculty of Science, Faculty of Engineering and Faculty of Dentistry

c. Name of proposer:

Professor Michael Mackey, Director, Centre for Nonlinear Dynamics in Physiology and Medicine, Department of Physiology, McGill University

d. Consultations

Montreal Neurological Institute and Hospital	March 30, 2009
Institut de génie biomédical, Université de Montréal	March 30, 2009
Department of Computer Science, McGill University	March 31, 2009
Department of Electrical and Computer Engineering, McGill University	March 31, 2009
Department of Physiology, Université de Montréal	April 1, 2009
Department of Epidemiology, Biostatistics and Occupational Health, McGill University	April 2, 2009
Department of Mathematics and Statistics, McGill University	April 3, 2009
Department of Physiology, McGill University	April 5, 2009
Department of Human Genetics, McGill University	April 6, 2009
Faculty of Pharmacy, Université de Montréal	April 6, 2009
Department of Mathematics, UQAM	April 8, 2009
Department of Biology, McGill University	April 13, 2009

II. Rationale

a. Context

The thrust behind the creation of CAMBAM is twofold: 1. It is as a result of a desire to unite specialists working in the field of mathematics with application to problems in bioscience and medicine under one organizational umbrella thereby constituting a cohort of experts in the field who could work together in a more cohesive manner; and 2. To bridge the gap between academia and industry by providing opportunities for the former to work more closely with the latter. Through its various research activities, CAMBAM will respond to several questions relating to the application of mathematics to problems in biology and medicine that have either not been addressed or under-addressed. These include:

1. How do local dynamics shape and determine global dynamics in large complex systems? For example, how do the dynamics of single cardiac cells, viewed as non-linear oscillators, when coupled in a large interconnected network influence the dynamics of the whole heart?

2. How do these properties influence the evolution of these complex systems? For example, how can alterations in the dynamics of the large interconnected network of cardiac cells undergo bifurcations from a normal cardiac rhythm to that of an arrhythmia?

3. What is the effectiveness in applied settings of mathematical models? For example, in the application of mathematical models of disease spread to surveillance there has been considerable academic activity to develop models of disease spread retrospectively. However, they are used infrequently in public health practice and even more rarely evaluated to determine how, if at all, they improve outcomes in the context of epidemic detection and management.

b. Past history

CAMBAM hopes to build on the successes of its predecessor, the Centre for Nonlinear Dynamics in Physiology and Medicine (CND, whose creation was approved in 1989), and also on the less institutionalized but all important partnership that exists among current members. Although CAMBAM members currently work on a host of different biological problems, they all use common mathematical tools to analyze these biological problems. These tools include dynamical systems theory, stochastic analysis, signal processing and signal identification, combinatorics and graph theory, machine learning and optimization and statistics.

Evidence of previous as well as ongoing collaboration among members can be seen in the representative publications that some of them have produced together. These include:

- Belair, J. & **Glass, L**., Introduction to Dynamics in Nonlinear Difference and Differential Equations, in Nonlinear Dynamics in Physiology and Medicine, A. Beuter, L. Glass, M. Mackey & M. Titcombre, eds. Springer, pp. 9-40, 2003.

- Sadeghi, S.G., **Chacron, M.J**., Taylor, M.C., **Cullen, K.E**. (2007) Neural Variability, Detection Thresholds, and Information Transmission in the Vestibular System. Journal of Neuroscience 27, pp. 771-781.

- Massot C., **Chacron M. and Cullen, K.E.** (2010) Information Transmission in the Vestibular System: a Population Study. Society for Neuroscience Abstracts.

- Massot C, **Chacron M.J., Cullen K.E.** (2011) Information Transmission and DetectionThresholds in the Vestibular Nuclei: Single Neurons versus Population Encoding. *J Neurophysiol*. 2011 (epub; February 9, 2011).

- **Chacron, M.J.**, Doiron, B., Maler, L., **Longtin, A**., Bastian, J. (2003) Non-classical receptive field mediates switch in a sensory neuron's frequency tuning. Nature 423, pp. 77-81.

- Hajj-Hassan, M., **Chodavarapu, V., Musallam**, **S.** (2008) "NeuroMEMS: Neural Probe Microtechnologies", Sensors, vol. 8, pp. 6704-6726.

- Hajj-Hassan, M., **Chodavarapu**, **V.**, **Musallam**, **S.** (2009) "Microfabrication of Ultra-long Reinforced Silicon Neural Electrodes", Micro & Nano Letters, vol. 4, pp. 53-58.

- Schneider A.D, **Cullen K.E, Chacron, M.J.** (2010) The high-conductance state brought about by synaptic bombardment gives rise to linear behavior in vestibular nuclei neurons. Society for Neuroscience Abstracts.

- Gohore Bi, D., **Fenneteau, F**., Barrière, O., **Li, J**., **Nekka, F.** (2010) Rational Drug Delineation: A Global Sensitivity Approach Based on Therapeutic Tolerability to Deviations in Execution, *Pharmacology and Pharmacy*, 1, 2, pp. 42-52.

- **Fussmann, G.F., Loreau, M.** & Abrams, P.A. (2007) Eco-evolutionary dynamics of communities and ecosystems. Functional Ecology 21, pp. 465-477.

- **Glass, L., Perkins, Ted**, Mason, J., Siegelmann, H.T. and Edwards, R. (2005) "Chaotic dynamics in an electronic model of a genetic network". Journal of Statistical Physics 121, pp. 969-994.

- **Glass, L. & Mackey. M**., From Clocks to Chaos: The Rhythms of Life. Princeton University Press, 1988.

- **Glass, L.** and **Mackey, M.C.** (2010) Mackey--Glass equation. *Scholarpedia*, 5 (3), 6908.

- **Guevara, M.R., Glass, L., Mackey**, **M.C**. & Shrier, A. (1983) "Chaos in neurobiology", IEEE Trans. on Systems, Man and Cybernetics , *SMC--13*, pp. 790-798.

- Gravel, D., Mouquet, N., **Loreau, M**., **Guichard, F**. (2010) Competition colonization dynamics and species coexistence in metaecosystems. *The American Naturalist*, 176, pp. 289–302.

- Gravel, D., **Guichard, F.**, **Loreau, M.**, Mouquet, N. (2010) Source and sink dynamics in meta-ecosystems. *Ecology*, 91, pp. 2172–2184.

- Marleau, J., **Guichard, F**., Mallard, F., **Loreau, M**. (2010) The role of nutrient fluxes in metaecosystems. *Journal of Theoretical Biology*, 266, pp. 162-174.

- Bouchard, S., **Jacquemet, V**., **Vinet, A**. (2011) Automaticity in acute ischemia: Bifurcation analysis of a human ventricular model. *Phys, Rev. E*, 83: 011911.

- Jacquemet, V., Dubé, B., Nadeau, R., LeBlanc, A.R., Sturmer, M., Becker, G., Kus, T., **Vinet, A**. (2010) Extraction and Analysis of T Waves in Electrocardiograms. *IEEE trans. Biomed*. 2010. [Epub ahead of print]

- Jacquemet, V., Dubé, B., Knight, R., Nadeau, R., LeBlanc, A.R, Sturmer, M., Becker, G., **Vinet, A**., Kus, T. (2011) Evaluation of a Subject-Specific Transfer-Function-Based Nonlinear QT Interval Rate-Correction Method, *Physiol. Meas*., 32, pp. 619-635.

- Jacquemet, V., Dubé, B., van Dam, P., Leblanc, A. R., Nadeau, R., Sturmer, M., Kus, T., **Vinet, A**. (2010) Modulation of ECG Atrial Flutter Wave Amplitude by Heart Motion: A Model-based and a Bedside Estimate," in *Proc. Computing in Cardiology*, 37, pp. 121-124.

- Plank G., **Leon**, **L.J. ,** Kimber, S., **Vigmond, E.J.** (2005) Defibrillation depends on conductivity fluctuations and the degree of disorganization in reentry patterns. J. Cardiovasc. Electrophysiol., 16, 02, pp. 205-216.

- Longtin, A., Laing, C., **Chacron, M.J**. (2003). Correlations and Memory in Neurodynamical Systems. In: Long-Range Dependent Stochastic Processes: Theory and Applications, G. Rangarajan and M. Ding eds. (Springer, Berlin). (invited contribution).

- Loreau, M., and de Mazancourt, C.. (2008) Species synchrony and its drivers: Neutral and nonneutral community dynamics in fluctuating environments. American Naturalist 172, pp. E48-E66

- Mackey, M., Haurie, C., **Belair, J**., (2003) Cell Replication and Control, in Nonlinear Dynamics in Physiology and Medicine, A. Beuter, L. Glass, M. Mackey & M. Titcombre, eds. Springer, pp. 231-268.

- Santillan, M. and **Mackey, M.C.** (2010) Stochastic modeling of enzymatic reactions employing the Fokker-Planck approach, *Phys. Rev. E.* (submitted).

- Milton, J., **Longtin**, **A. ,** Beuter, A., **Mackey, M.C., Glass, L.** (1989) *Complex dynamics and bifurcations in neurology*. Journal of Theoretical Biology 138, pp. 129-147.

- Perkins, T. J. , Hallett, M. T., Glass. **L.** (2004) Inferring models of gene expression dynamics. Journal of Theoretical Biology 230, pp. 289-299.

- Perkins, **T. J.,** Jaeger, J., Reinitz, J., **Glass, L.** (2006) Reverse Engineering the Gap Gene System of Drosophila Melanogaster. PLoS Computational Biology, Vol. 2, No. 5, e51.

- Perkins, T. J., Wilds, R., **Glass. L.** (2010) "Robust dynamics in minimal hybrid models of genetic networks" *Philosophical Transactions of the Royal Society A*, 368, pp. 4961-4975.

- Syed. Z. , **Vigmond, E.,** Nattel, S., **Leon, LJ**. Atrial cell action Potential parameter fitting using genetic algorithms. Medical and Biological Engineering and Computing Sup: 43, 5, pp. 567-71.

- Vigmond, **E.J.,** Tsoi, V., Yalin, Y., Page, P., **Vinet**, **A**. (2009) ``Estimating Atrial Action Potential Duration from Electrograms,'' IEEE Trans Biomed Eng, in press.

Other Existing Partnerships

Partner	Matching funds /yr	CAMBAM partner
FQRNT	$25K	Chacron
Faculty Startup Funds	$15K	Chodavarapu
EJLB Foundation	$40K	Cook
NIH	$115K	Cullen
McDonnell Foundation	$25K	Fussman
Réseau Aquaculture Québec	$12K	Fussman
Société de développement de l'industrie maricole inc	$5K	Fussman
Medtronics	$40K	Glass
James S. McDonnell Foundation	$90K	Guichard
Acceleware (Calgary)	$10K	Leon
National Research Agency (France)	$50K	Loreau
Quebec Nature and Technologies Research Fund (Canada)	$60K	Loreau & Guichard
Pfizer Canada	$60K	Nekka
Pfizer Canada	$30K	Ribiero da-Silva
EJLB Foundation	$117K	Pack
NARSAD	$35K	Pack
Canadian National Institute for the Blind	$35K	Pack
Sloan Foundation	$40K	Pack
Quebec Research Assistance Program	$50K	Pack
St. Jude Medical	$52K	Vigmond
Canadian Heart & Stroke Found.	$22.5K	Vigmond
Total	$898.5K	

III. Objectives

a. Description

Consistent with the MITACS (Mathematics of Information Technology and Complex Systems) and its partner organization MPrime mandate of being a 'network of centres of excellence' we hereby propose a new Centre under the MITACS/MPrime umbrella to build on the many productive but distributed areas of excellence in the domain of applied mathematics in biology and medicine.

The McGill Centre for Nonlinear Dynamics in Physiology and Medicine (CND) has an impressive 20-year-long history of building inter-disciplinary and inter-university partnerships and programs examining primarily applications in physiology.

Building on this expertise the Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM) will add a significant number of new members drawn from the fields of bioinformatics/systems biology, computational and systems neuroscience, evolutionary biology, ecology, medical informatics and pharmacometrics. The CAMBAM proposes to

- promote and foster research, teaching, and industrial applications of quantitative biology and medicine in basic problem driven research at all organizational levels ranging from the molecular/genetic through single cell and whole organ physiology and biology, ecology, evolutionary biology, and population dynamics, and

- conduct applied research within basic clinical and public health settings.

CAMBAM will have a much broader knowledge and expertise base than the CND, incorporating the best of the CND while expanding its scope.

b. Missions and Goals

Our objectives are to serve as a leader in Québec, Canada, North America, and the rest of the world in the development and application of mathematics to problems in biology and medicine, and to partner with industry and government to deliver the outcomes and insights of our research directly to the user communities.

We will accomplish these objectives

- through a system of workshops and study groups targeted at non-academic and academic partners, unique in Canada in their frequency and organization; and

- deliver significant teaching and training opportunities through summer schools, workshops, and study groups to transfer our considerable body of knowledge and expertise into the applied mathematics, biological and medical academic and non-academic communities; while

- offering a unique interdisciplinary training to postdoctoral fellows, undergraduate and graduate students.

c. Proposed activities

Our mandate is, first and foremost, to produce problem driven basic research of the highest caliber and apply it to practical problems as defined by private and public institutions. This effort will occur on several different levels. To accomplish this, the CAMBAM will bring together researchers at different career stages working on a host of different biological problems of significance in both basic science and practical applications. We are united by the use of common mathematical tools to analyze biological systems. These tools include: dynamical systems theory; signal processing and signal identification; combinatorics and graph theory; machine learning and optimization; statistics. Most of us have adequate funding support but this is oriented towards defined projects and approaches. Current university departmental structures and funding schemes make it difficult to pursue high risk projects - especially for younger researchers and interdisciplinary and intergroup projects. Our intention is to facilitate collaborations through funding of students who will work with at least two supervisors who would not normally collaborate. The supervisors will typically be in different departments and have different approaches with respect to mathematical methodology, experimental systems and techniques, and practical goals.

Two key scientific questions, cutting across biological disciplines and theoretical methods, will underlie our projects:

- How do processes at the subcellular and cellular levels translate into dynamics at the organ and organismal level? How does the organism interact with exogenous factors? Analysis of these problems necessarily involves modelling and theoretical study at multiple time and space scales.

- **What rules regulate the organization, dynamics, and evolution of complex networks arising at all scales of organization?**
For example, recent advances have provided evidence for the existence of scale free networks in diverse systems from the neural wiring of *C. elegans* to interactions of proteins in yeast, to food webs, but the way such networks arose and evolved are still matters of conjecture. Further, the functional significance of these networks is not clear.

To give the reader a better idea of our vision we give examples of the types of projects that are either now underway and will be facilitated by the creation of CAMBAM, or which will be initiated with the resources made available by the funding of the CAMBAM. This list is not meant to be exhaustive. Indeed, the essence of our Centre will be to catalyze novel approaches emerging from the novel combinations of research expertise.

1. *Evolution of gene control networks.* Biochemical approaches are clarifying mechanism controlling gene transcription via transcription factors and histone modification, Bioinformatics (Blanchette, Hallett, Majewski) is making contributions by analyzing conserved sequences and thus identifying regulatory regions of genomes. Yet the evolution of function in genetic networks is still poorly understood. Modelling studies of gene networks (Glass, Mackey) with experimentalist (Abouheif) is identifying how similar phenotypes can arise from multiple mutations at different control points in the genome. But the underlying principles for evolving control of gene expression as evolution proceeds are still open. Similar potassium channels are present in heart and nerve, but the control of expression in both must be different and must have co-evolved. The Centre will facilitate and integrate bioinformatics approaches with evolutionary and developmental studies.

2. *Bioinformatics.* The new generation of omics technologies pose new challenges in bioinformatics and computational biology. For example, current high throughput sequencers produce 4 billion nucleotides of DNA sequence in a single run of the apparatus. By the end of this year, the output is expected to reach 95 billion nucleotides. In particular, the machines allow us to sequence entire microbial systems from samples taken from our environment or measure expression levels of mRNA transcripts or epigenomics for an organism or tumor. Beyond laboratory management software to efficiently process this information, these applications also require sophisticated new analytic approaches rooted in statistical inference and machine learning in order to distill this mass of information into physiologically relevant, testable hypotheses. A number of our researchers including Blanchette, Majewski and Hallett have worked with these areas and analogous proteomics-related efforts.

3. *Evolution and dynamics of neural networks.* One of the most challenging aspects of neuroscience research is the highly interconnected and nonlinear nature of even the simplest nervous systems. Such systems exhibit emergent behaviors that cannot be studied with reductionist approaches that focus on any one brain region. Thus the Centre will strive to develop novel mathematical methods for studying neural networks, with a focus on dynamical systems. One example of this approach is the effort to model the effects of transcranial magnetic stimulation (TMS) on the brain (see above). TMS has been used successfully in the treatment of numerous conditions, including stroke, depression, and Parkinson's Disease. The technique works by transiently activating large networks within targeted brain regions, with consequences that are poorly understood at the neuronal level. The Centre has brought together researchers who have expertise in neurophysiology and behavioral techniques (Cullen, Musallam, and Pack) with those who are skilled in modelling complex single neuron responses (Cook) to develop a detailed understanding of the effects of TMS on the brain. This in turn will lead to clinical protocols that have improved efficacy and specificity. Another important application concerns the development of brain-machine interfaces that can be used to restore movement or sensation in humans who have suffered injury or illness. This work involves a synthesis of physiological, engineering, and computational methods, as part of a collaboration among several labs (Musallam, Chacron, and Cook). As part of the same effort, some of these labs (Musallam, Chodavarapu) have worked together to engineer new devices for monitoring oxygen consumption in the brain.

4. *Information processing in neural systems.* The ability of the nervous system to respond to external stimuli and to initiate actions represents the outcome of computations performed at many spatial and temporal scales. Through collaborations among members of the Centre we are developing experimental protocols and computational models that span these various levels of investigation. A common theme in this work is the use of mathematical techniques such as system identification, machine learning, and signal processing that relate neuronal responses to sensory stimuli or motor outputs. For example, the capacity of a single neuron to encode sensory information is affected by intracellular signaling cascades, which are in turn triggered by the release of neuromodulators. Recent studies of these processes in the electric fish by one member of the Centre (Chacron) has led to a collaboration with another member (Cullen) to study the link between the spiking

responses of primary vestibular afferents and head movements in the alert monkey. This research therefore forms a bridge from the molecular to the behavioral level by extracting computational principles that are common to multiple species and multiple sensory systems. A similar collaborative effort between two labs (Cook and Pack) is currently underway to understand the neuronal correlates of conscious perception of time in the primate brain, and this work is being used to formulate mathematical models of information processing in mental disease.

5. *Pathological dynamics in physiological systems related to ion channel modifications induced by drugs or mutations.* In cardiac physiology the existence of arrhythmias associated with ion channel pathologies are now well known. We are bringing together systems modelling expertise (Vigmond) and nonlinear dynamics models (Glass) to analyze dynamics in model experimental systems (cardiac aggregates subjected to drugs that block potassium channels in experiments carried out in the Shrier laboratory). This will be extended to analyze initiation of arrhythmia in whole heart models and in patients with drug induced arrhythmias. This has long range potential signficance for better assessment of risk of sudden cardiac death.

6. *Normal and abnormal neural control of cardiac activity.* The cardiac autonomous nervous system (CAS) constantly modulates electrical dynamics of the heart, and its dysfunction often leads to cardiac arrhythmia. Members of our groups (Glass, Vigmond, Vinet) are involved in a cell to bedside investigation of the CAS. It involves the recording of long lasting ECGs in patients, of multichannel electrograms as well as neural signals in the different location of the CAS in animal preparation. The analysis of these data is complemented by modelling work spanning from the isolated cardiac myocyte to complete heart-torso, including the hierarchical organisation of the CAS. The problems encountered are within the expertise of many other members of the CAMBAM (e.g. statistical multiple time series analysis, modelling of control systems, cell behaviour and neural system) and this will catalyze fruitful collaborations.

7. *Linking intracellular, individual and ecosystem dynamics.* Rhythms are a pervasive phenomenon at all levels of life on Earth. Neurons fire in synchrony to keep the heart beating, internal cell cycles determine how fast cells divide, populations and whole ecosystems wax and wane over time. Physiologists and ecologists traditionally study these phenomena within their disciplines but there is evidence that synchronization of oscillatory dynamics can occur across biological levels of organization. The Centre will be a vector of collaborations between pioneers of biological synchronization at the sub-individual level (Mackey, Glass, Guevara) and ecologists adapting this work to whole populations at regional to continental scales (Fussmann, Guichard, de Mazancourt). The synergistic effect is two-fold. First, the tools of mathematical analysis in both fields can be combined. Second, oscillatory phenomena that propagate from the cellular to the population level can be studied in novel ways with the combined expertise. For example, progression of the cell cycle of unicellular organisms (such as algae) often depends on extracellular conditions (e.g. nutrient concentration). This can lead to population-level oscillations because individual cells synchronize their cycles by communicating through the common medium. The mechanisms that lead to the emergence of such synchronized behaviour are scarcely studied.

8. *Spatial dynamics of coupled ecosystems.* Most local ecosystems are coupled through spatial flows of inorganic nutrients, dead organic matter and living organisms. These spatial flows can strongly affect the dynamics and functioning of coupled ecosystems, but knowledge of these effects is still rudimentary. In particular, food webs in which consumer satiation or other physiological and ecological phenomena tend to generate endogenous cyclic population fluctuations can show complex dynamics when they are coupled by diffusion of nutrients or dispersal of organisms. Incorporating the body of theory and mathematical tools developed in physiology to study coupled oscillators would be particularly useful to understand such dynamics. The Centre will foster collaborations between physiologists who have this expertise (Glass, Guevara) and ecologists at the leading edge of spatial community and ecosystem dynamics (Guichard, Loreau, de Mazancourt) to speed up progress in this rapidly growing field of ecology.

9. *Translation of in vitro results into in vivo applications.* Unlike the ideal *in vitro* conditions in which major guidelines for drug efficacy are routinely established in the laboratory under static conditions, it is natural that high variability arises in the clinical situation, which is intrinsically dynamic, and thus brings up concerns about the applicability of principles established *in vitro*. Founding of a theoretical framework for the information transfer from *in vitro* to *in vivo* conditions is crucial for the design of clinical studies. When the experimental results are ready to be transferred into clinical practice, the intrinsic variability has to be accounted for by moving from the static description to more developed dynamic and stochastic versions. Hence, there is a need for novel mechanistic-based studies to be undertaken which will increase the explanatory power for the interaction of the organism with drugs in a therapeutic assessment (Atherton, Nekka).

10. *Optimizing clinical and public health decision-making.* In clinical and public health settings, precise knowledge must be combined with increasingly large volumes of data to make rapid decisions in order to treat individuals and protect populations. Current information systems provide data, but offer little guidance in making optimal decisions in these environments. Where decision-support exists in these systems, it tends to be deterministic or rule-based, relying on cross-sectional information. Longitudinal and spatial statistical models and mathematical models of disease and epidemic progression have the capacity to combine complex knowledge with large volumes of data in real-time, but researchers have yet to successfully translate these basic advances into systems that can support decision-making in clinical and public health. The Centre will enable collaboration between researchers in biostatistics (Hanley), computer science (Precup) and medical informatics (Buckeridge, Tamblyn) with clinicians and information systems developers to develop, evaluate and commercialize software with embedded statistical and mathematical models for detection of cases and outbreaks of disease and for decision-support.

d. Value added

We will run six (6) **workshops** per year at which academic and non-academic individuals from all research sectors will be invited to present work that might benefit from an applied mathematics component. The intention is not to have a presentation of finished research, but rather to have the presentation of open or unsolved research problems. The format

would be informal with a 45 minute presentation of the problem followed by an hour plus of brain storming over lunch about possible ways of attacking the problem. For non-academic presenters with the potential to make significant financial commitments to the training of PDF's or graduate students we will develop a mechanism of writing a formal report with the invitation to enter into an agreement for financing in return for results. It is through these that we expect to identify significant and relevant areas for problem driven research that will form the core of training for the CAMBAM graduate and post-doctoral students. Following the workshop, a subset of the Centre participants will continue work on the problem with financial support from the non-academic partners.

Non-academic outreach.

The MITACS/MPrime Centre will advertise to non-academic members of the bioscience and medical communities (hospitals, public health agencies, biotechnology, diagnostic and pharmaceutical companies) the opportunity to participate in our bi-weekly workshops, study groups, and in yearly open houses. The intention of these events will be to bring representatives of the research departments within these units into close contact with our investigators, to present to them on-going work in the field, and offer them opportunities to present aspects of their work, focusing on areas where mathematical approaches are useful and needed, and facilitate the development of intellectual collaborations.

An additional innovative aspect of our proposal is to advance a similar effort towards the information technology (IT), computing and technical consulting companies. Here the open house/workshop would present to these companies that have little a priori experience in the medical sciences, where current information technologies and mathematical analysis could find utility within the biomedical sector. Consulting agencies such as the Montréal-based CGI, smaller IT start-ups, or established computing firms would be brought closer to the forefront of challenges in biomedical research. The Centre would help facilitate synergies between our researchers, the biomedical sector, and the information sector.

We see both of these activities as ideal ways to identify training opportunities for graduate students and postdoctoral fellows through the MITACS ACCELERATE programme.

Seminar series

Three seminar series currently run by Centre members are: the weekly seminar series in Quantitative Biology and Medicine; the Organismal Biology seminar series which has always had a large applied mathematical component; and the Pharmacokinetics seminars at the Université de Montréal.

We will develop a new seminar series (totalling 12 per year) with appeal to Centre members whose topics cut across all of the areas in Section 4.1.1. This will be a bi-weekly event. We will also develop a student seminar series which will run concurrently to the CAMBAM seminar series. A total of ten (10) student seminars per year will be organized by CAMBAM students and these will address topics that they identify as being relevant to their research activities.

Summer schools

Since 1996, the CND has run a biennial Summer School in nonlinear dynamics applied to biology and medicine. In the last few years this endeavor has been expanded to include

significant aspects of bioinformatics/systems biology and computational biology. We have typically had between 50 and 80 students attending from a variety of countries throughout North and South America, Europe, and Asia. Over the years that we have offered these summer schools, we have had the pleasure of training over 500 graduate students and postdoctoral fellows from 22 countries. The ties formed while here have borne fruit in professional interactions far beyond our expectations. Through our managerial and academic experience in running these, we will be able to deliver on this aspect of the proposed agenda for the new Centre.

Another important training initiative is the computational neuroscience summer school, directed by Longtin and run under the auspices of the Center for Neural Dynamics at the University of Ottawa. This summer school, aimed at graduate students and postdoctoral fellows is unique in Canada and has quickly gained worldwide recognition as one of the five main schools in this area. The school will continue to fulfill the need of creating scientists who are conversant in both neuroscience and mathematical modelling.

In 2010 as well as in 2011 CAMBAM, in collaboration with the Mathematical Sciences Institute in Ohio, organized two (2) summer schools. CAMBAM hosted the first of these summer schools which was held from 17 May, 2010 to 28 May, 2010. In terms of content, during the first year, the applied emphasis would be on network dynamics, and the biological aspect would focus on neural and gene networks. The second summer school was held at the MBI between 25 July, 2011 to 05 August, 2011. The focus was on ecological problems. Quantitative ecologists who are a part of CAMBAM (Lea Popovic and Frédéric Guichard) participated in the program.

CAMBAM will continue to host summer schools as a part of its training and transfer of knowledge missions. Additionally, we will invite other Centre-members who are not based at McGill or non-centre members who share our vision to submit proposals for the sponsorship of summer schools that fall within our mandate.

Research round-tables

We plan to create research round-tables that bring in non-academic information technology, computer, and small start-up modelling companies to explore the challenges and opportunities in biology today through seminars and roundtable discussions. These will be closely integrated with the Industrial Outreach initiatives discussed in Section 4.2.4.

A second initiative will see the development of round-tables for basic quantitative scientists (physics, mathematics, statistics, chemistry) by the Centre to help them better understand how their tools and talents can be of used in the biomedical sector. Similar round-tables will be organized by students and will tap into using the resources

A third initiative will be to develop, in conjunction with MITACS/MPrime, a data base of names and expertise of individuals in physics, mathematics, statistics, and chemistry who, though not Centre members, would be interested in occasional consultation on problems in the biosciences or medicine for which they are especially qualified to be of assistance.

International workshops in conjunction with INRIA (France), Matheon (Germany), DKFZ (German Cancer Research Centre), BioQuant (University of Heidelberg) and OCCAM (Oxford)

The signing of memoranda of understanding between MITACS and INRIA and Matheon have resulted in a variety of workshops and small meetings in Canada, Germany, and France, and more are being planned. We intend to maintain these important links and ties which are so crucial to the training of future researchers as well as to researchers keeping abreast of their respective fields.

The recently formed Oxford Centre for Collaborative Applied Mathematics (OCCAM) incorporates the Oxford Centre for Industrial and Applied Mathematics (OCIAM), the Computational Biology Group (in the Oxford University Computing Laboratory), and the Centre for Mathematical Biology. Because of the close association of Prof. Mackey with these groups we have the opportunity to develop formal ties with them which will expand our efforts to include the UK, with its strong and vibrant community of mathematical biologists and computational/systems biologists.

Public outreach and education

Development of a web site highlighting the activities of the Centre for the non-academic and academic communities as well as the public.

The Cutting Edge-RSC Public Science Lectures in Montréal: CAMBAM will continue to support the Cutting Edge Lecture Series, an initiative which was first embers of the Centre have organized a monthly series of popular public science lectures at McGill University for the last five years. Each year eight local, national, or international speakers give publicly accessible lectures on timely research topics of interest and concern to the population at large. Typical attendance ranges from 75 to 125, and we will continue this public teaching activity.

e. Contibution to training

In addition to the very strong current ongoing research efforts in each of the domains listed above in Section 4.1.1, a mandate of the MITACS Centre will be to foster and help initiate research collaborations between these areas in the larger Montréal, Québec, Canadian and world scientific communities. To this end, we specifically seek support for students and postdoctoral fellows who are working under the direction of supervisors spanning two or more of the above groups.

A key focus of the CAMBAM will be to promote the advancement of a new generation of researchers with the tools to tackle problems at the interdisciplinary frontier between applied mathematics, biology and medicine. To this end, members will work collaboratively with the goal of further enhancing student training to better prepare our research trainees for their future careers in industry, government or academia. Trainees at the undergraduate, graduate (master's and doctoral) as well as postdoctoral level will be targeted.

We will create an innovative and internationally recognized training program to prepare Master's and PhD students for a future in the bioscience industry. The core training program will have seven components:

1) Individually tailored course work Graduate students will take two (Master's) or three (PhD) courses to complement their undergraduate training including *Mathematical & Computational Biology,* a survey course to be taught by the co-applicants. This course will provide broad exposure to mathematical and computational approaches in the

biosciences. Because we will recruit students with diverse backgrounds, the other courses will be selected to strengthen either their biological or quantitative expertise. An advisory committee will guide students in selecting courses.

2) Academic research All trainees will have a home laboratory with an academic adviser(s) who will supervise their Master's or PhD research thesis. To provide a rich interdisciplinary training environment, many students will be co-supervised by two researchers with strengths in mathematics/ computation or biology. There are currently over 40 potential advisors associated with CAMBAM offering trainees a wide range of research topics. Undergraduates will also have an advisor.

3) Internship experience or industry-sponsored research project All trainees will be required to spend at least 20% of their research effort working in an internship with an industrial partner. When students are involved in an industry-sponsored research project, the student will spend his/her internship with that partner. There will be some flexibility in how a graduate student selects an industrial partner: either a 3-8 month industrial research internship with a suitable partner organization or a research project that involves close collaboration with an industrial laboratory. CAMBAM already has industrial links in place to support internships through our past affiliation with MITACS.

4) Participation in academic/industrial research seminars All trainees will participate in CAMBAM's active seminar and symposia series. In the 2010-2011 academic year, CAMBAM sponsored 19 seminars and one symposium. These included participants and speakers from both academic and industry. This will provide extensive exposure to the application of mathematical methodologies to biological problems.

5) Participation in CAMBAM sponsored research events and summer schools CAMBAM organizes several meetings and events each year that allow our students to have scientific interactions and meet our industrial partners in an informal setting. For example, in 2010 we had both a **Research Day,** where students presented their research, and an **Industrial Day** that featured representatives from several local companies. It is our experience that bringing faculty, industrial researchers and students with diverse backgrounds together leads to significant cross-fertilization. CAMBAM has also supported summer schools with different themes. Our most recent, *Nonlinear Dynamics in Biological Networks,* was held in 2010. These activities will be supported by non-CREATE funds provided by McGill.

6) Support of student-run events and networking Current CAMBAM students are very active at organizing their own activities. For example, this year saw the launch of the **By-Students-For-Students** seminar series (no PIs allowed), a student-run **CAMBAM Facebook** page and a **CAMBAM student blog**. CAMBAM fully supports and encourages these initiatives, which will surely grow as more students are recruited to the proposed training program.

7) Integration with McGill's professional development program CAMBAM will coordinate with McGill's SKILLSETS Program to provide professional development workshops and training to postdocs and graduate students. For example, two workshops held in early 2011 were directly related to the proposed training mission: *Science Careers Outside Academia* and *Pharma Careers 101*.

In this area we continue a long tradition.

- *Undergraduate education:* McGill University has a long tradition of interdisciplinary training of undergraduate students through the Joint Major Programmes in Physiology and

Physics and Physiology and Mathematics, as well as the newly formed Biomathematics Major Programme. McGill Courses for these students include Biology 309 (Mathematical Models in Biology, Glass), Mathematics 437 (Mathematical Methods in Biology, Mackey), Physics 413 (Physical Basis of Physiology, Mackey), Physiology 425 (Analysis of Physiological Systems, Chacron & Cook), and Biology 434 (Theoretical Ecology, Guichard & Loreau).

- *Graduate education:* As with undergraduate students, the CND has a long track record of training top quality graduate students. Since its inception we have seen the graduation of 42 M.Sc. students and 17 Ph.D. students. This tradition is enshrined in the Department of Physiology Computational and Quantitative Option as well as in the Bioinformatics option offered through several departments. Additionally, there are ECSE 517 (Neural Prosthetic Systems, Musallam), Neuro 603 (Computational Neuroscience, Pack), Physiology 610, (Biophysics, Mackey), Biology 590 (Linking Community & Ecosystem Ecology, Loreau), Pharmacy (UdeM) 7040 (Advanced Pharmacokinetics, Nekka), Neurocomputing (UdeM) 6084 (Vinet), Biomedical Modelling (UdeM) GBM6102 (Vinet), Bioelectricity GBM6105, (Vinet), and Computational analysis of temporal and spatial health data (McGill) EPIB 647 (Buckeridge) available to graduate students with concentrations in these areas.

- *Postdoctoral training:* The founding members of this new Centre have collectively trained 34 postdoctoral fellows since 1989, and many of these individuals now hold professorial and industrial positions throughout the world.

An aggressive recruitment strategy including the use of direct mailings, list-serves, as well as web-based advertising will be used to facilitate the attraction of a group of high quality trainees. Trainee's stipends will be supplemented by 25 percent of their value with funds coming from the industry contributions, institutional funding, and/or supervisors own funding. Novel training initiatives will be developed which will supersede existing programs offered by the CND. All trainees will be required to attend CAMBAM workshops and study groups for the duration of the award.

- At the undergraduate level, 16 week summer research awards will be made so that students can focus on a short term project that exposes them to the utility of quantitative approaches in solving biological and medical problems. This program will be very competitive and will result in producing a cadre of high caliber students with an interest in furthering interdisciplinary research as graduate students and/or medical students.

- At the level of graduate students and postdoctoral fellows, we will encourage applicants with undergraduate backgrounds from both the quantitative and the biological sciences. Joint supervision will be strongly encouraged in order to facilitate links within and between disciplines (mathematics and biosciences) as trainees work to solve identified problems. In addition, supervision involving CAMBAM members from both McGill and affiliated universities (Université de Montréal, Dalhousie University, University of Calgary, University of Ottawa) will be encouraged to promote the development of novel approaches.

> * One scenario we see is that some trainees will have expertise in both mathematical and bioscience realms and able, with guidance, to bridge research interests that seem on the surface to be totally disparate.

* As an alternate model, neither superior nor inferior to the previous one, we envision trainees from two different backgrounds (mathematics and biosciences) coming together under joint supervision to work on and solve an identified problem.

Graduate students funded by the CAMBAM will be expected to complete multi-disciplinary course work not usually required in a traditional departmental graduate program. While some trainees will have solid expertise in both mathematical and bioscience realms, we predict that many students will need additional guidance to bridge research areas required to address critical questions. Thus, an additional focus will be the design and development of additional courses to be taken in the early stages of training. Courses, offered at both the undergraduate and graduate levels, will be designed to enhance the ability of trainees with expertise in either the mathematical or biosciences to successfully carry out high caliber interdisciplinary research.

- The Centre will establish collaborative initiatives for research and training of graduate students and postdoctoral fellows with various institutes of the National Research Council of Canada such as the Biotechnology Research Institute, Institute for Biodiagnostics, Genomics and Health Initiative, and Institute for Biological Sciences where there are several ongoing programs that involve applied mathematics.

f. Research funding opportunities

MITACS (**as of academic year 2011-2012, funding for CAMBAM will come from MPrime**) has committed to providing a minimum of $180,000 per year for three years which will go towards funding research initiatives and graduate and post-graduate student training. This $180,000 will supplement the $60,000 that the Centre will be expected to raise through collaborations with non-industrial and industrial partners. In the first year and second years (2009-2010 and 2010-2011, respectively), CAMBAM is expected to raise $40,000 from non-industrial partners and $20,000 from industrial partners. In the third year, CAMBAM is expected to raise $60,000 from industrial partners.

IV. Strategic Positioning

McGill University, through its strategic planning has identified *computation and modelling* as one of its 7 strategic areas for growth and investment. McGill actively promotes and supports the creation of centres as a viable co-ordinating delivery agent for new program development, new partnership development and internal investment. As the host institution, McGill will review the activities and budgets of the Centre and make strategic investment decisions based on competitive metrics.

The University has managed successful networks in the past, and will support the establishment of appropriate financial and organizational structures for the CAMBAM. For the new MITACS Centre, McGill will be the host institution, and will provide space for the Centre members within their home departments. McGill University will invest in the activities of the Centre through multiple avenues including graduate student and PDF support. The university, through Vice-Principal Thérien, has given this proposal its strongest support.

IV. Membership and Structure

a. Directorship

The inaugural director of the CAMBAM will be Prof. Michael C. Mackey, who will serve for a maximum period of two years (until 30 June, 2011). After that time another director will be selected from the membership of the Centre. Since 01 July, 2011, Professors Erik Cook and Frédéric Guichard have assumed the post of Directors of the Centre.

b. Membership by category

The following are current full and associate members of the Centre.

Juli Atherton	Department of Epidemiology, McGill University
Jacques Bélair	Department of Mathematics and Statistics, Université de Montréal
Mathieu Blanchette	School of Computer Science, McGill University
David Buckeridge	Department of Epidemiology, McGill University
Maurice Chacron	Department of Physiology, McGill University
Vamsy Chodavarapu	Department of Electrical and Computer Engineering, McGill University
Philippe Comtois	Department of Biomedical Engineering, Université de Montreal
Erik Cook	Department of Physiology, McGill University
Kathleen Cullen	Department of Physiology, McGill University
Eusebius Doedel	Department of Statistics and Mathematics, Concordia University
Alan Evans	Department of Neurology, McGill University
Frederique Fenneteau	Hibe
Paul Francois	Department of Physics, McGill University
Gregor Fussmann	Department of Biology, McGill University
Leon Glass	Department of Physiology, McGill University
Mladen Glavinovic	Department of Physiology, McGill University
Michael Guevara	Department of Physiology, McGill University

Frédéric Guichard	Department of Biology, McGill University
George Haller	Department of Mechanical Engineering, McGill University
Michael Hallett	Department of Computer Science, McGill University
Anas Hamoui	Department of Electrical and Computer Engineering, McGill University
Tony Humphries	Department of Mathematics and Statistics, McGill University
Vincent Jacquemet	Department of Physiology and Institut de Génie Biomédical, Université de Montréal
Svetlana Komarova	Faculty of Dentistry, McGill University
Genevieve Lefebvre	Department of Mathematics, UQAM
Vincent Lemaire	Labopharm Inc.
L. Joshua Leon	Department of Electrical Engineering, Dalhousie University
Jun Li	Department of Pharmacology, Université de Montréal
André Longtin	Department of Physics, University of Ottawa
Michel Loreau	Department of Biology, McGill University
Michael Mackey	Department of Physiology, McGill University
Jacek Majewski	Department of Human Genetics, McGill University
Mircea Alexandru Mateescu	Department of Chemistry, UQAM
Sam Musallam	Department of Physiology and Department of Electrical and Computer Engineering, McGill University
Claire de Mazancourt	Department of Biology, McGill University
Fahima Nekka	Department of Pharmacology, Université de Montréal
Christopher Pack	Department of Neurology and Neurosurgery, McGill University
Theodore Perkins	Ottawa Health Research Institute and McGill University
Lea Popovic	Department of Statistics and Mathematics, Concordia University

Michael Rabbat	Department of Electrical and Computer Engineering, McGill University
Alejandro Rey	Department of Chemical Engineering, McGill University
Alfredo Ribiero da-Silva	Department of Pharmacology and Therapeutics, McGill University
Edward Vigmond	Department of Electrical Engineering, University of Calgary
Alain Vinet	Department of Physiology and Institut de Génie Biomédical, Université de Montréal
Brian Wilhelm	Department of Biomedical Engineering, Université de Montreal
Moises Santillan Zeron	CIVESTAV, Universidad Monterrey, Mexico

Associate Member:

John Milton	Joint Science Department, The Claremont Colleges

c. Board

Executive Council

For the first 2 years, an Exective Council will be created which will govern in conjunction with the Director. The Executive Council will comprise 4 persons (Erik Cook-Deaprtment of Physiology, McGill; Juli Atherton-Department of Epidemiology, Biostatistics and Occupational Health, McGill; Frederic Guichard-Department of Biology, McGill; Vamsy Chodavarapu-Department of Electrical and Computer Engineering, McGill). The Executive Committee will meet bi-monthly and will be responsible for the management of policy decisions in the Centre, including the hiring of administrative staff, allocation of funds, and operational decisions (e.g. reporting, budgeting and management of the outreach activities). After the first 2 years, the Centre will be governed by two co-Directors- Erik Cook-Deaprtment of Physiology, McGill and Frédéric Guichard-Department of Biology, McGill.

Scientific Advisory Board (SAB)
A Scientific Advisory Board consisting of experts in the field mathematics with application to bioscience and medicine and key industrial players working also in the field has been established. The CAMBAM SAB which comprises 11 members will review the past year activities of the Centre, and meet yearly by video conference to make recommendations for goals in the next year (See Appendix 1 for a list of SAB members and their affiliations).

Technology and Knowledge Transfer
A team of Research Liaison Officers (RLOs) will be responsible for establishing ties with the academic and non-academic communities to develop workshop and study group topics. The RLO team comprises Juil Atherton-Department of Epidemiology, Biostatistics and Occupational Health, McGill; Fahima Nekka-Department of Pharmacology, Université de Montréal; Jo-Ann Kwadzo-Research Administrator, CAMBAM; Eric Bosco-Director Business

Development-MITACS Quebec; and Jesse Vincent-Herscovici- Director Business Development-MITACS Quebec. A designate of the RLO team will report to the Executive Committee and the Director at the end of every three month period on the team's activities.

We view this as an essential part of our mandate and this committee, reporting to the Executive Committee, will form an integral part of our activities. Their work will include, but not be limited to, the establishment of ties with relevant industrial and other non-academic clients, the organization of workshops with regional, national and international partners, and the establishment and continuation of academic training (through summer schools, seminar series, topical and international workshops, new public education initiatives, etc.).

Computer Management

Jean Robertson, the Computer Liaison Officer (CLO), will be responsible for overseeing the maintenance of all software, computers and computer networks within the centre. These will be a combination of Windows and Linux based machines, and will incorporate the existing CND computer network.

V. Resources: required and obtained

a. Budget

Year I (2009-2010)

Item	Yr. Cost	McGill	MITACS	Non-Industrial Partner (s)	Industrial Partner (s)
Research Administrator	42K	42K			
Office expenses	10K	10K			
Computer Supplies	15K	15K			
HQP Training[1]	68K		60K		
Internships[2]	120K		60K	40K	20K
Networking (summer schools, seminars, conferences, workshops)	75K	23K	60K		
Total	330K	90K	180K	40K	20K

Year II (2010-2011)

Item	Yr. Cost	McGill	MITACS	Non-Industrial Partner (s)	Industrial Partner (s)
Research Administrator	43K	43K			
Office expenses	9K	10K			
Computer Supplies	15K	14K			
HQP Training[1]	68K		60K		
Internships[2]	120K		60K	40K	20K

Networking (summer schools, seminars, conferences, workshops)	75K	23K	60K		
Total	330K	90K	180K	40K	20K

Year III (2011-2012)

Item	**Yr. Cost**	**McGill**	**MPrime**	**Non-Industrial Partner (s)**	**Industrial Partner (s)**
Research Administrator	44K	44K			
Office expenses	8K	10K			
Computer Supplies	15K	13K			
HQP Training[1]	68K		60K		
Internships[2]	120K		60K	-	60K
Networking (summer schools, seminars, conferences, workshops)	75K	23	60K		
Total	330K	90K	180K	-	60K

Budget notes:

1. HQP- Highly Qualified Person which includes postdoctoral fellows (PDFs) and graduate students.

2. Additional funding from MITACS for internships may be obtained if industrial partner funding increases above the agreed proportions throughout the 3 years.

b. Staffing

The day-to-day running of Centre is overseen by a full-time research administrator who assists the Director(s) in carrying out his/their duties of governing the Centre.

c. Physical Resources

The Centre will be located in the Department of Physiology in the Faculty of Medicine. In the short-term, it will occupy office space that was previously allocated to its predecessor organization on the 11th floor of the McIntyre Building. The room that is being currently used by the Research Administrator is a computer lab that is used for office and research purposes. In the future, CAMBAM hopes that specific office space will be allocated to the Research Administrator.

Appendix I - Scientific Advisory Board Members

Our SAB members include the following prominent mathematical biologists, statisticians, mathematicians and executives.

1. Mr. Sion Balass (balass@matrix-as.com), Chief Executive Officer, Matrix Advanced Solutions, *http://www.matrix-as.com/*
2. Dr. Arndt Benecke (Arndt@ihes.fr), Institut des Hautes Études Scientifiques, Bures-sur-Yvette, France
3. Mme. Diane Côté, Vice President MEDEC-AITS, http://www.aits.ca
4. Prof. Sandrine Dudoit (Sandrine@stat.berkeley.edu), Division of Biostatistics, School of Public Health, University of California Berkeley
5. Prof. Marty Golubitsky (mg@mbi.osu.edu), Director, Mathematical Biology Institute, Ohio State University
6. Mr. Colin Hill (colin@gnsbiotech.com), Chief Executive Officer, President, Chairman & Co-Founder of Gene Network Sciences, http://www.gnsbiotech.com
7. Prof. Simon A. Levin (slevin@princeton.edu), Director, Center for Biocomplexity, Department of Ecology and Evolutionary Biology, Princeton University
8. Prof. Michael R. Reed (reed@math.duke.edu), Department of Mathematics, Duke University
9. Prof. John J. Tyson (tyson@vt.edu), University Distinguished Professor, Virginia Polytechnic Institute
10. Prof. Gerda de Vries (devries.math.ualberta.ca), Department of Mathematical and Statistical Sciences, University of Alberta
11. Prof. Frances Skinner (fskinner@uhnres.utoronto.ca), Department of Medicine (Neurology), University of Toronto

Jo-Ann Marie Kwadzo, Mrs.

From: Andrew Kirk, Prof.
Sent: Monday, October 11, 2010 1:03 PM
To: Michael C. Mackey, Prof.
Cc: Jo-Ann Marie Kwadzo, Mrs.; Ananda Tay, Ms.; Anne Broadhurst, Ms.; Christophe Pierre, Prof
Subject: Faculty of Engineering comments on CAMBAM proposal

Dear Professor Mackey
As requested, and on behalf of Dean Christophe Pierre, please find the response of the Faculty of Engineering to your proposal for a Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM). Your proposal was circulated to the Chairs and Directors of the five departments and two schools within the department, so that they could obtain feedback from their members, and I understand that you have also consulted directly with the Department of Electrical and Computer Engineering.
The Faculty of Engineering lists bioengineering of one of five interdisciplinary research areas of high strategic importance, and so we were very interested to read your proposal. What you propose appears to be both exciting and important, and promises to play a key role in bringing researchers together in the areas of applied mathematics and biological systems from across the university. We fully support your proposal, although we note that this does not imply any funding commitment from the Faculty.

I should also add that I do apologize for the time taken in getting this report back to you, and wish you good luck in completing your proposal.

Best wishes

Andrew Kirk

Associate Dean for Research and Graduate Education
Faculty of Engineering, McGill University
Macdonald Engineering Building, 817 Sherbrooke Street West
Montreal, Quebec H3A 2K6, Canada

Tel: 514 398 6991 Fax: 514 398 7379
Email: andrew.kirk@mcgill.ca

Jo-Ann Marie Kwadzo, Mrs.

From: Michael C. Mackey, Prof.
Sent: Tuesday, January 19, 2010 10:31 AM
To: Jo-Ann Marie Kwadzo, Mrs.
Subject: FW:

Michael C. Mackey, Ph.D. FRSC
Joseph Morley Drake Professor of Physiology
Department of Physiology
Centre for Applied Mathematics in Bioscience & Medicine
(CAMBAM)
McGill University
3655 Promenade Sir William Osler, Room 1124
Montreal, Quebec H3G 1Y6
CANADA

email: michael.mackey@mcgill.ca
tel: 514-398-4336
fax: 514-398-7452
mobile (Montreal & North America): 1-514-476-4336
mobile (World): 1-407-506-0634
internet: http://www.mcgill.ca/cambam

From: Marnie Taylor, Ms.
Sent: January 18, 2010 10:04 AM
To: Michael C. Mackey, Prof.
Cc: Paul Allison, Dr.; Marc D. McKee, Prof.
Subject:

(Message from Dean Paul J. Allison, Faculty of Dentistry)

Dear Professor Mackey,

At the Dentistry Faculty Council meeting that was held on Wednesday, January 13, 2010, the Faculty unanimously approved the creation of a McGill Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM).

We strongly support this initiative.

Marnie Taylor, Assistant to the Dean
Office of the Dean, Faculty of Dentistry
McGill University
3640 University Street, Room M/31
Montreal, QC H3A 2B2
Tel: 514-398-7222 Fax: 514-398-8900

McGill

Faculty of Medicine
3655 Promenade Sir William Osler
Montreal, QC H3G 1Y6

Faculté de médecine
3655, Promenade Sir William Osler
Montréal, QC, H3G 1Y6

Fax/Télécopieur: (514) 398-3595

February 1, 2010

Dr. Michael Mackey
Centre for Nonlinear Dynamics
Department of Physiology
McIntyre Building

Re: Faculty support of CAMBAM

Dear Dr. Mackey,

We in the Faculty read the documentation about your proposal for the creation of the Centre for Applied Mathematics in Bioscience and Medicine which is an off shoot of MITACS, with interest. In principal we are certainly behind your proposed centre, however at present we are not in the position to commit to either extra office space or financial support. As you may know we are just forming a Research Space Planning and Management committee and all such requests for space will be under their purview. They should be up and running in the next couple of months and they will come up with recommendations for Department Chairs or Directors for space management so that the process is both fair and transparent and not ad hoc as it is at present.

In addition, as part of our strategic planning in the Faculty we are developing recommendations about the support of centers by the faculty, financial or otherwise. We certainly realize that centers are a valued mode for facilitating research programs. The committee is considering the number of centers that the faculty can realistically support, and to what level and for how long. At present, the Faculty only provides financial support to 5 of the 29 known and recognized centres that are solely "Medicine", with the VP supporting 7 others (i.e. no centre currently receives financial support from both the Faculty and the VP). As you see many centres are self sustained. It is likely that there will be an annual accountability required and a mechanism to create or dissolve centers developed. We are also aware that some centers previously supported by the Vice Principal will be transferred to the Faculty. The back to back budget cuts that have been imposed University wide, and lack of discretionary funds making additional commitments very difficult. Thus given this current flux, we don't want to promise something that we cannot deliver.

Once we have our own policies in place we will certainly entertain new proposals, and we do wish you success with the founding of your centre as we are very much in favour of partnerships such as you propose that link academia with non-academics.

With kind regards,
Marianna Newkirk

Marianna Newkirk, Ph.D.
Associate Dean (Research)

Cc Richard I. Levin, M.D.
Vice Principal (Health Affairs) & Dean, Faculty of Medicine

Cc Remi Quirion, Ph.D.
Vice Dean (Life Sciences & Strategic Initiatives)& Senior University Advisor (Health Sciences Research)

From Michael Mackey **Date** Tuesday, November 30, 2010 1:36:06 PM
To Jo-Ann Marie Kwadzo, Mrs.
Cc
Subject FW: CAMBAM electronic version

-----Original Message-----
From: Martin Grant, Prof [mailto:martin.grant@mcgill.ca]
Sent: Monday, March 01, 2010 9:16 AM
To: Michael C. Mackey, Prof.
Subject: RE: CAMBAM electronic version

Mike, sorry for the delay, I just realized I forgot to write you back about this. We discussed this at the Council of Chairs in the Faculty, and support your initiative. Martin

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Martin Grant, Dean of Science, Dawson Hall, McGill University,
853 Sherbrooke St W, Montreal QC H3A 2T6 Canada, 514-398-4211, Fax 3932,
martin.grant@mcgill.ca, http://www.physics.mcgill.ca/~grant/