Science for Many Futures

Excellence, Innovation and Renewal, The Faculty of Science at the University of Manitoba

Part 1. Faculty of Science Strategic Plan

Part 2. Faculty of Science Strategic Research Plan

Science for Many Futures

Executive Summary

Universities, science, and Faculties of Science are among society's great transformative agents. Our students' lives are transformed by attending university and studying science. We are a vital part of society.

The Faculty of Science at The University of Manitoba is one of Canada's largest and best Faculties of Science. We offer an extraordinary suite of academic and research programs. We are committed to excellence and innovation in teaching and research, and we strive to provide a supportive learning environment with caring and dedicated staff. We are part of the University of Manitoba, one of Canada's most comprehensive universities, with a full range of Faculties and programs. Our depth and breadth define us, and allow us to provide a suite of opportunities that only a few universities in Canada can match. We are the gateway to "Many Futures" for our students, a gateway that few other Science Faculties in Canada can provide.

The Plan presented here is a statement of what we are and what we intend to be as we enter our second century. Society and society's needs are changing, and our plan embraces these changes. We know we are good; we know we can be even better.

Our Plan goes beyond principles and directions. It strives to present an integrated picture of what we are, what we want to accomplish and why, the people and other resources we need to do so, the most important hurdles to overcome, and a multi-year "to do" list. It includes major initiatives, and a commitment to measure our progress towards our goals. At the same time, it recognizes that things change, and we will adapt – it provides the basis for us to innovate intelligently.

We understand the need for modern, innovative, flexible academic programs, we understand that science has an important role in public policy issues, and we understand the importance of excellence in all that we do. The values, strategic priorities, and initiatives presented here constitute a re-affirmation of our commitment to excellence, an enhanced commitment to innovation, and an understanding of the unique role this Faculty can play.

This Plan presents a sweeping agenda, one that reflects our ambitions to be great. It is intentionally built on our strengths, on our first century of success. We are confident of even greater successes in our second century. This Plan's overarching goal is ensure that our many students and our society all enjoy vibrant futures.

Part 1. Faculty of Science Strategic Plan

I. The Setting

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I. The Setting

I.1 Our Place in a Dynamic World

The world is changing. Now, more than ever, science lies at the core of many of the most important issues that society faces. There are many examples, including a host of critical environmental issues, the need to prepare for and deal with disease pandemics, or maintaining the environmental, economic and cultural health of communities. It is the love of science that drives scientists, but we are proud of the contributions we make to society. Society needs scientists.

However, many issues are broader than scientific, and major decisions are often made by non-scientists. Decision-makers need to understand how to incorporate science into those decisions. This can be difficult, especially when faced with apparently-conflicting scientific claims. Society also needs non-scientists who understand science.

Scientists make enormous intellectual and practical contributions. We seek to understand our universe, and life itself. We embrace technology, and our work is the basis for understanding and developing it, and for understanding its impact. Not only can we make transistors and the wealth of devices they enable, but we understand how they work, at an unimaginably small scale. At another extreme, we understand the nature and the evolution of the universe at an unimaginably large scale.

Pursuing science and addressing society's challenges require research of all kinds: individual and team, discipline-based and multi-disciplinary, and pure and applied. Our increasingly-diverse student body deserves both education and training, for meaningful and rewarding lives and careers. The needs are immense, they are diverse, and they are urgent.

The Faculty of Science is an essential contributor to people, science, and society, at the international, national and local levels. Founded over a century ago, we are a comprehensive Faculty with a powerful combination of research and teaching. We are among Canada's best Faculties of Science, and we are highly regarded at an international level. Together with the rest of The University of Manitoba, we offer a full range of undergraduate and graduate programs, engage in a wide spectrum of research, and provide invaluable, expert service to our communities. It is the excellence of our research, the broad sweep of our programs, and the breadth and excellence of the opportunities that we provide to our students that distinguish us on the national and world stages. Many of our staff have won research and teaching awards. We are responsible to large numbers of students who count on us, and we provide a solid foundation for their future lives and careers.

I.2 The Reason for a Plan

As this Faculty enters our second century, we have created this Plan as a means to look forward, to create a vision and plan to enable us to best achieve our fundamental goals of serving our students and changing society, and pursuing successful and important research and academic programs. The specific goals of this planning exercise are to:

1. develop and communicate a compelling and credible vision of the future;
2. positively influence people and events to ensure commitment, alignment and positive outcomes, and secure the resources we need from all possible sources;
3. re-affirm our values, commitment and goals;
4. set strategic directions for the Faculty;
5. help us identify our particular strengths, those we can build on;
6. guide us in aligning resource decisions with priorities, in an open and agreed-to framework;
7. best enable all members of the Faculty of Science to pursue successful academic and research careers, to maximize our individual and collective successes;
8. best ensure that the Faculty of Science delivers high quality, modern, innovative academic programs that meet the needs of our students and our changing society;
9. implement and support innovation, and encourage a willingness to advocate change, especially when risk is involved; and
10. set specific goals for the next five years hence, identify the steps necessary to achieve them, and measure our progress. This will include a "to-do" list, which will evolve over the coming years.

Our Plan is not limiting. Unexpected needs and opportunities will emerge, and we will seize them when they do.

I.3 The Faculty of Science Today: A Snapshot

As of July 1, 2007 the Faculty of Science comprises seven departments and some special units. The departments are Biological Sciences, Chemistry, Computer Science, Mathematics, Microbiology, Physics & Astronomy, and Statistics. In addition, the Faculty operates the Delta Marsh Field Station on the shores of Lake Manitoba, the Institute for Industrial Mathematics, and an astronomy program with a physical presence at Glenlea south of Winnipeg. There are formal and informal research groups, and numerous joint academic and research programs, both within the Faculty of Science and in collaboration with other Faculties. The office of the dean includes a complement of student advisors, renowned for the service they provide to students. We have co-operative education coordinators in the Department of Computer Science and the office of the dean, and co-op programs in biochemistry, chemistry, genetics, microbiology, zoology, ecology, computer science and joint mathematics and computer science. Our highly-successful genetics program is governed by a multi-Faculty committee.

Our Department of Mathematics and Department of Statistics are located in a small part of Machray Hall, which is shared with the Science Library and the Faculty offices. Biological Sciences is located in Duff Roblin and the Buller Laboratories, which it shares with Microbiology. Computer Science is located in new space in the EITC, which it shares with the Faculty of Engineering. Physics & Astronomy are in the Allen Laboratories, and Chemistry is in Parker.

Our research spans the full spectrum of science, both disciplinary and interdisciplinary. Much of it is of strategic importance both regionally and nationally, and involves local, national and international collaborations. It is funded by the national granting councils, as well as other governmental and business ventures. Approximately 75% of our professoriate hold research grants and, depending on the CFI cycle, we win over $10 million in annual funding.

We do a great deal of teaching, in all terms. At the undergraduate level, we teach approximately 22% of the university's undergraduate student credit hours (UGSCHs), amounting to about 120,000 per year, or 40,000 course registrations. The majority of our students are required to take experimental labs, a contribution not captured in the UGSCHs statistics. Teaching to our own students includes general, major, honours, and graduate teaching. Other Faculties depend on us: about 41% of our undergraduate teaching is to first year students, and 26% to other Faculties. Accreditation of Engineering relies on our courses, and some of our programs are nationally accredited. There are many interdepartmental programs, many pairs of departments offer joint major and honours programs, and there are joint programs with other Faculties. We are also home to approximately 270 graduate students, nearly all of whom are in research-based thesis programs. Nearly 1/3 of our graduate students are international.

Prior to 2006-07, our undergraduate and graduate enrollments were both increasing. However, both these trends have recently reversed.

Our staff numbers have remained essentially constant over this period. As of April 1, 2006, the Faculty of Science had 171.5 FTE academic staff (including tenured and tenure-track professorial staff, and continuing instructors), and 73 support staff. According to The University of Manitoba Resource Allocation Book, this Faculty has the highest ratio of undergraduate students to staff of any Faculty or School at The University of Manitoba, and it is two to three times higher for us than it is for other Faculties with similar profiles of labs and lectures.

This Faculty created the environmental science program at the University of Manitoba, we continue to provide a number of courses in it, and environmental science is deeply imbedded in much of our research. As we look towards the next five years, it is apparent that life and environmental sciences provide particular opportunities and needs. This does not mean that they are more important than other sciences, and care will be taken to ensure the entire Faculty is treated and valued equitably.

The Department of Biological Sciences was created effective July 1, 2007, by integrating the former Department of Botany, Department of Zoology, and Biology Teaching Unit. This will lead to many changes and innovations, but a great deal of work must be done to complete the integration.

I.4 Current Strengths of the Faculty of Science

The Faculty of Science is an intellectual powerhouse. It would be impossible to list all of our strengths. However, there are broad themes that can be identified which, together, define and distinguish us.

Quality of our People

The greatest strength of the Faculty of Science is the quality of our talented and dedicated people. We have world-class researchers who are very successful in research and grant competitions. We have excellent teachers: for example, our faculty have won six of the nine University 1 teaching awards given out to date. We have a superb group of support staff, including our very highly-regarded team of student advisors. We are proud of what we contribute, and we are ambitious to do even more.

Our faculty complement includes an excellent mixture of seasoned, mid-career and new members. Over 25% of our academic staff have been replaced over the last five years, and renewal will continue at a rapid pace over the next few years. We are well positioned to encourage our new staff, in particular, to experiment and innovate. There is a growing spirit of inter- and intra-Faculty cooperation, and we cooperate well with other Faculties and institutions. Our staff are active in national and international professional bodies, and serve on the national granting councils. In addition, they provide outreach services to the public in the form of public presentations, and TV and radio appearances.

Research

We are a research-intensive Faculty in a research-intensive university. Approximately 75% of our faculty, and virtually all our new professoriate, hold external research grants. Much of our research is of strategic importance both regionally and nationally. We now host seven Canada Research Chairs (CRCs) and an NSERC Northern Research Chair, and are searching for an eighth CRC. We have many strong individual researchers and research programs. We also have strong research themes with multiple researchers working in them. Some of our themes span much of the Faculty and university. We have a number of unique research opportunities and facilities. All of this helps define areas of special capability.

Size and Breadth

Our size and breadth are another strong, defining feature. This is the largest Faculty of Science in the province of Manitoba, and one of the best and largest in Canada. We offer a strong and comprehensive set of academic and research programs. This breadth and strength allow us to offer students a great deal of opportunities. We are part of the University of Manitoba, one of Canada's most comprehensive universities, with a full range of Faculties and programs. Our Faculty and our university are the gateway to "Many Futures" for our students, a gateway that no other university in this province, and few others in Canada, can provide.

However, we are not too big, and this is another strength. Our class sizes are reasonable, and our staff members are accessible. Our faculty and our departments work well together, and there are numerous joint academic programs and research collaborations.

Quality of our Programs

Many of our programs are of excellent quality, we maintain appropriately high standards, and our graduates are highly regarded. Our suite of degree structures, honours, major and general, provides a full range of options to students. We offer a co-operative education option in a number of programs. We have also demonstrated successful inter-disciplinary programs, for example, our very popular genetics program.

Students and Student Support

We have great students and great graduates. Typically, approximately 50% of our honours students make the dean's list, and 70% graduate with first class honours. Approximately 30% of our major and general students make the dean's list, and a similar proportion graduate with distinction. Our graduate students reap their share of external fellowships, including NSERC and CGS[1] scholarships.

We support our students and they support us. We run a substantial advising office, proud of, and known for, its dedication and service to students. We support diversity. We support the WISE[2] program, and approximately 47% of our students are women. We have a number of Aboriginal Initiatives, Let's Talk Science, Access programs in three departments, opportunity sections in others, support for the NSERC CRYSTAL[3] project which does research into factors affecting student success in mathematics and science, the Peguis First Nations Science, Engineering and Technology Symposium, and participation in the Faculty of Medicine's Centre for Aboriginal Health Education. Our

[1] Canada Graduate Scholarships
[2] Women in Science and Engineering
[3] Centres for Research in Youth, Science Teaching and Learning

students' support is reflected by their substantial annual contributions to the endowment fund.

Physical Infrastructure

Some of our physical infrastructure is superb. Excellent space includes the new EITC which houses Computer Science, recently renovated Chemistry laboratories, and other laboratories. The Buller Laboratories are undergoing major renewal. One of our recent successes is the implementation of an ongoing program of undergraduate laboratory renewal, which is making a real difference to our students. In research equipment, we have had excellent recent success with NSERC RTI (equipment) and CFI grants. The Delta Marsh Field Station is an example of a unique facility to build on.

I.5 Significant Challenges Facing the Faculty of Science

Cumulative Effects of Under-Funding

The Faculty of Science has suffered from years of under-funding. Comparison with other Faculties with similar profiles of research, and lab- and lecture-based academic programs, leads to the conclusion that our funding is at least 30% too low. This has been a long-standing problem, with a significant cumulative impact.

Number of Staff

While the quality of our staff is our greatest strength, the number of academic and support staff is our greatest weakness. As elsewhere, our staff numbers declined significantly during the 1990's. However, since 2000, our numbers have remained essentially constant, in contrast with elsewhere, and in stark contrast with our student numbers which have increased by about 20% since then. A careful benchmarking against other Faculties with similar research and teaching mandates leads to startling numbers: we need about 30% more academic staff, and at least 100% more support staff. Our needs are for all kinds of staff, academic, technical, administrative, and outreach, communications and development. Our most pressing needs are for more technical staff.

These staff shortages have many impacts. We now have the highest student:staff ratio of any Faculty at The University of Manitoba. Our classes are large, some are delivered by TV, and we employ too many sessionals. Despite all this, we still turn students away. We cannot properly support research and graduate programs, support students, compete for research funds, and recruit faculty. It is a challenge for our staff to find the time required to develop new and innovative programs. We cannot move beyond the basics in employing information and computing technology. Many of our support staff are working overtime, sometimes without compensation.

We are also vulnerable due to staff demographics. On the academic side, we have a high proportion of faculty nearing retirement in certain departments. While this provides an important opportunity for renewal, it must also be managed carefully. On the support staff side, we need to plan for succession.

Infrastructure

As noted elsewhere, we are making progress with our physical infrastructure. However, much remains to be done. Too often, we are unable to provide suitable research space to new faculty in a timely manner. Too much of our teaching equipment is outdated. Major renovation projects, though most welcome, are very slow and disruptive. Some of our faculty members have been disrupted for as long as six years. Our Mathematics and Statistics Departments have been in seriously sub-standard space for decades.

We are also greatly in need of suitable large lecture theatres. Without them, we need either many more faculty and/or we must stay with uncompetitive teaching loads and/or TV lectures and/or too many sessionals.

Graduate Student Support

We are deeply committed to graduate studies and a vibrant graduate program. We are very pleased that our graduate student numbers increased by about 40% over the three-year period of 2002 to 2005. We are disturbed that this growth suddenly stopped, and numbers are now decreasing, apparently rapidly. We have concluded that the underlying problem is uncompetitive levels of funding for graduate students available from university sources.

Faculty Recruitment

We have always hired excellent people, and will continue to. However, this is becoming harder to do. The problems identified above all contribute to this. New faculty are often dismayed by the graduate funding situation. Some are shown windowless offices, others sub-standard labs. We cannot always offer competitive salaries. It is a challenge to provide competitive start-up funding, and the funding we can provide is, too often, "cobbled together" through a variety of sources; this takes time and introduces uncertainties. This has two effects: we are prevented from pursuing some areas of research, and in those areas where we do recruit, we cannot always attract the people we want. We do not settle for second best, and so we search again.

Once hired, new faculty often face long delays in lab renovations, and securing matching funds for successful CFI projects. These delays can hinder the start of otherwise promising careers.

We face another hurdle, the SIP[4] process. The uncertainties introduced by this process make planning difficult, and the timing often exacerbates the recruitment difficulties.

Student Demographics

Until recently, our undergraduate and graduate student numbers were increasing. However, it appears that this trend has reversed. Student numbers are falling, and are likely to continue to do so in every department. The reasons for these declines are different for the undergraduate and graduate students, and will require different solutions.

Outreach, Development and Advancement

We must strengthen our efforts to promote and celebrate our successes and those of our students, make stronger connections with our current students and alumni, and do a better job communicating what we do to the public. This will take investments in time and funds.

Program Currency

As a Faculty, we have maintained very high quality programs, and our graduates are very highly respected. We have also introduced a number of new programs and options over the years. However, we have ambitions to do more, to become known as a centre of innovative programming. We can embrace the challenges of our changing world, and intend to emphasize and encourage innovation in programs and program delivery, at all levels including first year.

I.6 Changes in the Environment

As we look ahead, it is useful to reflect on the changes to the environment in which we operate that are occurring, and that we expect will continue to develop. Some of this is a summary of points made earlier.

1. Recruitment of faculty and graduate students will become even more competitive.
2. Student enrollments are decreasing, and are likely to continue to do so unless action is taken. This applies to both the graduate and undergraduate levels, but for different reasons. International student numbers are declining at both levels.
3. Public issues that require science and scientists are becoming ever-more pressing. Addressing many of them will require multi-disciplinary approaches.

[4] Strategic Initiatives Process, which governs the filling and re-distribution of acadenuc staff positions.

4. Major research funders invest strategically. The Canada Foundation for Innovation can provide major start-up packages, but numbers are limited.
5. In some cases, research funding relies increasingly on the strength of research groups and available infrastructure, not individuals, and infrastructure support can sometimes be provided to coordinated groups more effectively than to individuals. The research funding environment has shifted in the direction of group activities, and in the direction of applied/strategic research. CIHR[5] provides new opportunities for Science researchers.
6. Winnipeg is becoming a centre for health and health-related research.
7. The Aboriginal population is growing.
8. Students today use Information and Communications Technology, and communicate with each other, in very different ways compared with a few years ago. They "breathe" the Internet.
9. The university central administration has become more aware of our needs.
10. The relationship between University 1 and the Faculty of Science has changed.
11. There are many reasons to seek out partnerships and collaborations of all kinds.
12. We are renewing infrastructure, but much remains to be done. The newly-announced "Project Domino"[6] opens new doors.
13. We have now established a "program" of undergrad lab renewal.

I.7 Planning Assumptions

Our Strategic Plan rests on many assumptions. Most are obvious but implicit. It is probably worth noting a few of the most important ones.

1. The Faculty of Science will successfully argue for additional revenue from the central administration.
2. We will need to find more resources on our own, in order to fulfill our ambitions.
3. Even with increased resources, we will need to make choices.
4. Student numbers will fall unless we take steps to reverse the trend.
5. The trends in research funding indicated above will continue.
6. All our academic programs will be reviewed over the coming years.
7. We will continue to renew our staff, with some improvements in numbers in special circumstances.
8. Our staff want to introduce new program innovations.
9. Our new professorial staff will all pursue active, externally-funded research programs and supervise graduate students.
10. The SIP process will continue.

[5] Canadian Institutes of Health Research

[6] A project announced early in 2008 that will renew and re-distribute much of the older space on the Fort Garry campus.

I.8 The University of Manitoba Strategic Plan

The University of Manitoba's strategic institutional plan, Building for a Bright Future, elucidates five "Institutional Priorities for Success":

1. Provide access to an exceptional education.
2. Attract and retain the best.
3. Be a centre of research and graduate education that makes a difference to our province, our nation, and the world.
4. Provide the human, physical and technological infrastructure necessary for learning and research.
5. Be at the centre of our community: on Manitoba.

The Faculty of Science fully supports these priorities. Our Plan is consistent with the university plan.

As this is being finalized, The University of Manitoba is embarking on a new planning cycle. We look forward to seeing what new directions and emphases emerge.

Part II: Values, Vision and Mission of the Faculty of Science

II.1 Values of the Faculty of Science

1. The Faculty of Science values excellence in all that we do: research, teaching and academic programs, and service.
2. We value unrestrained intellectual inquiry, and the pursuit of knowledge for its own sake.
3. We value innovation.
4. We value integrity. It is the bedrock of scientific inquiry, and fundamental to how we interact with other people.
5. We value excellent and innovative research of all kinds, team and individual, discipline-based and interdisciplinary, pure and applied. Research is the foundation for quality in teaching and service.
6. We value people. We treat everyone with respect, and we strive to serve and help others as best we can, including students and all our staff. We embrace the responsibilities inherent in educating thousands of students each year.
7. We value the society we serve, and aim to maximize the impact and benefits of our work.
8. We value diversity.

All members of the Faculty of Science are expected to conduct themselves in relations with colleagues, staff and students across the University in such a way as to promote the academic well-being of all concerned. We treat people with respect, and pass judgment on the work of others only in the proper academic forums. We strive to be helpful, readily contributing our time and expertise for the overall benefit of the academic community. We avoid actions of a disruptive nature which hinder others from fulfilling their professional responsibilities, or that hinder students or other staff from performing their academic mission and achieving their goals. We support and foster the career development of the entire staff.

II.2 Vision of the Faculty of Science

The Faculty of Science at The University of Manitoba is a research-intensive Faculty, able to compete with the world's best. We provide our students with high quality, innovative programs that prepare them for successful lives and careers. We embrace the challenges that face our world, and recognize our role in addressing them, and in preparing graduates to do so.

We are the pre-eminent Faculty of Science in Manitoba, with a strong emphasis on research and innovation, and a commitment to our staff, our students, and the province we serve. We promote and recognize excellence in teaching. We aim to be the Faculty of Science of choice for top students and new colleagues. At the same time, we recognize

the importance of serving our evolving province. Our vision incorporates a renewed commitment to excellence, and an enhanced commitment to innovation. We owe our students the best, most modern and innovative programs we can provide, in a supportive environment with caring and dedicated staff.

Our goals include having our entire professorial staff doing internationally acclaimed research, and a healthy and thriving graduate program. Our combined commitments to research and to our students mean that we must excel in both research and teaching, and that our students must benefit from our research mission.

II.3 Mission of the Faculty of Science

The advancement and dissemination of knowledge at all levels are this Faculty's fundamental goals. We are committed to all modes of research, team and individual, discipline-based and interdisciplinary, pure and applied. Achieving our goals depends on our people, and we believe strongly in supporting and fostering the career development of the entire staff. Our people and our programs are driven by excellence in research, which is the foundation for quality and credibility in teaching and service. It is in the fulfillment of our research mission and in the training of future scientists at both the undergraduate and graduate levels that the Faculty makes its most important contribution.

As one of the faculties of the University, the mission of the Faculty of Science is to advance knowledge and culture:

- through education in science;
- through the exercise of scholarship in the creation of new ideas and knowledge; and
- through the dissemination and application of scientific knowledge in response to the needs of society.

From this mission flow the following objectives:

- To teach science from first year level to Ph.D. Our students include those in Science programs and in a wide variety of other faculties and schools. Programs and courses offered include Honours, Major, General, Access for Aboriginal Students, Co-operative, Distance Education, Non-Credit, Opportunity.
- To pursue research of international calibre in pure and applied science. To promote areas of strength and to develop areas of emerging significance. To seek and sign international cooperation agreements.
- To help prepare graduates for successful lives and careers, both scientists and non-scientists.
- To provide service to the University, the scientific community and to the community at large, including the public school system, local and national industry, and international development.

Part III: The Next Five Years

III.1 Strategic Priorities and Initiatives for the Faculty of Science

Strategic Priorities

As a result of extensive discussions and analysis, the Faculty of Science has identified three broad strategic priorities:

1. Renew our research strategies, recruit more graduate students, and enhance our image nationally and internationally as a research intensive Faculty.

2. Deliver modern, leading-edge, innovative undergraduate programs, which improve the quality of the undergraduate experience, and motivate and support student success.

3. Build stronger ties to the wider community, both internal and external, for the benefit of all concerned.

Initiatives

The Faculty is pursuing, and will pursue, a number of initiatives in support of these three fundamental strategic priorities. These initiatives overlap.

1. Strengthening external development, advancement, outreach, and communications.
2. Enhanced funding initiatives.
3. Enhanced support for research and graduate students overall, and strategic investments in certain research areas.
4. Strengthened connections to, and support for, students, including our Aboriginal programs.
5. Faculty and staff renewal, especially in departments with critical demographics, guided by strategic plans and research directions.
6. Renewal of our undergraduate programs and facilities, with emphasis on quality, innovation, and student support.
7. Renewal of aging and inadequate infrastructure throughout the Faculty: research labs, undergraduate labs, classrooms, office space, and special facilities.
8. Targeted staffing increases.
9. Development of the new Department of Biological Sciences.

The plans and recommendations that are presented in the rest of this document for the next five years are all in support of these priorities and initiatives. Naturally, numerous actions support multiple priorities and initiatives.

III.2 Enrollment Management

Manitoba demographics, of themselves, imply a significant decrease in total undergraduate enrollment over the coming years, and such decreases have occurred in recent years. Within the overall picture, we can expect changes in the make-up of our student body, such as the proportions of Aboriginal students and international students. We have also experienced recent decreases in graduate student numbers, and anticipate an ever-increasingly competitive environment for graduate recruitment.

In spite of the overall declines, we still currently turn students away from many first and second year courses. In other instances, large numbers of students are denied access. In some cases, enrollments are lower than one would expect. We have been striving to increase capacity, and will continue to do so, but it is largely limited by space and so is beyond our control.

Plans and Recommendations

1. Under the leadership of the Associate Dean (Student Affairs), the Faculty and departments will develop a coherent Enrollment Management Plan. This plan will include many of the recommendations found throughout this document. Developing the plan will involve our cadre of student advisors.

This plan will likely include issues of: overall enrollments, recruitment, transition into Science, internationalization, innovative and flexible programs, transfer credits, Aboriginal students, student support, reputation, programs for high achievers, etc.

2. Programs with low enrollment will be examined closely, including comparisons with similar programs at other comparable universities. If they are anomalously low, appropriate strategies will be developed and enacted.

III.3 Advancement, Development, Promotion, and Communications

The Faculty of Science is committed to improving communications with our internal and external communities, and to significantly increasing our efforts in development and advancement.

We have begun: we have recently partnered with the Department of Advancement and Development for a half-time Development Officer, and we are developing a communications specialist position; we have made our Celebration of Excellence an annual event; we are making more efforts to connect with alumni; we are proposing more awards for students and staff; and we have started a major fund-raising campaign for Delta Marsh Field Station.

Plans and Recommendations

3. The office of the dean and all departments will proactively promote the Faculty and its accomplishments. Better web sites will be one aspect of this.

4. The office of the dean and all departments will take active part in development, advancement and communications activities.

5. We will seek continuing funding for a shared Development Officer, and finalize and execute a Development Plan that includes priorities and funding targets.

6. We will engage a full-time communications specialist and secure ongoing funding, and create and execute a Communications Plan.

7. We will execute the planned campaign for the Delta Marsh Field Station.

8. We will develop stronger relations with alumni and external organizations.

9. We will create and publicize a "Speakers Bureau" – a list of speakers and topics available for public presentations.

10. We will develop a coordinated plan to "connect" with current and past students, at the Faculty and Departmental levels.

11. All departments will respond to requests for information, and proactively provide more. If we are able to appoint a communications specialist, coordinating this will be part of that role.

III.4 Funding Initiatives

The Faculty has benefited from budget reallocations and the introduction of laboratory fees in recent years, and significant contributions to infrastructure renewal from central resources. We are making great progress with these additional funds. However, meeting our goals and fulfilling our responsibilities require greatly enhanced resources. Many of the recommendations throughout this document, including those in the preceding section, address this imperative, but some need to be noted separately.

Plans and Recommendations

12. We will develop innovative new programs, program options and courses that will attract students and new funding.

13. Departments will continue to work with the office of the dean to make strong cases for budget reallocations and incremental staff.

14. Departments will seek external funding, for example from Western Economic Diversification, and industrial linkages that are consistent with our academic goals.

15. We will pursue the many other initiatives in this Plan that will, directly or indirectly, build support and attract resources.

III.5 Research and the Strategic Research Plan

We are a research-intensive Faculty of Science. We believe in the power of science to enrich and transform our society, and we are personally privileged to engage in the pursuit of science. As a Faculty, we aim to provide our staff with the resources and opportunities to be successful scientists. We must also adapt, and position ourselves, to take advantage of available opportunities.

The over-arching goal of the Strategic Research Plan is to help our scientists be successful. There are many decisions taken by Departments and the Faculty that have impact on research; our Plan is intended to inform those decisions in a transparent, yet effective, way.

The Strategic Research Plan is central to our overall Faculty Plan. Reflecting its importance, it is parallel to our overall Strategic Plan, and can be used separately.

III.6 Graduate Programs and Funding

The training of graduate students is a core function of this university, and these students are critical to society's future success. They are one of the keys to our research success, to our ability to win and hold research grants, and to the reputation of the Faculty of Science. We are very proud of our graduate programs and our students, and will continue to work to deliver modern, excellent programs.

Plans and Recommendations

16. We will complete the academic program reviews of all graduate programs.

17. The Department of Biological Sciences will integrate and revise its graduate programs and offerings.

18. Other departments will endeavour to take advantage of opportunities presented by the revising of life sciences.

19. We will identify new programs for development, to attract more students and engage them in modern research programs. These will, to some extent, reflect priorities in the Strategic Research Plan.

20. We will seek opportunities for synergies with other Faculties.

As previously noted, our graduate enrollment reached a peak of about 300 students in 2003-04, but has subsequently declined. This is particularly surprising in view of our continual hiring of ambitious new faculty; we would expect growing, not shrinking, numbers.

Science works in a uniquely competitive environment, and our ability to recruit graduate students, especially the best, is heavily dependent on being able to provide competitive support levels. Graduate student support normally comes from a combination of grant support, TAs, and other university support. Other major universities have far greater resources available for "university support" than we do.

The low levels of graduate student support are the single most important barrier to increasing our graduate student numbers, and the situation is worsening: many Canadian universities are aggressively increasing their graduate student support.

A related complication is the fact that nearly 1/3 of our graduate students are international. Given this fact, and our need to provide competitive stipends, changes to fees and other policies that relate to international students are of particular importance to this Faculty.

These factors have at least three major effects:

- We are unable to recruit and support as many graduate students as we would like;
- Our faculty must devote more of their grant funding to fewer students, rendering their grant applications less competitive; and
- We have difficulty recruiting faculty.

As is the case elsewhere, our Faculty of Graduate Studies provides some support, but it is far too low. Furthermore, it is based solely on student numbers, and does not reflect the different levels of competition in different areas. To be competitive, this Faculty of Science needs what other Faculties of Science typically have: much greater resources that are under our own control.

We have taken what steps we can. In the three years up to 2006-07, the Faculty of Science allocated approximately $250,000 in Faculty of Science funds to graduate student support. In 2007-08, we undertook a stringent internal budget review, and reallocated over $100,000 of our own funds to graduate studies, increasing our contributions to $378,000 per year. With this and NSERC grant support, we now offer 54, $10,000 support packages. This is a start.

The Faculty of Science believes that we should host approximately 400 graduate students, which we are setting as our target. In order to reach this level in the increasingly

competitive environment in which we operate, we are setting a related target for graduate student funding under the Faculty's control which is equivalent to $10,000 per year per student for fellowships and research assistants, in addition to TAs and external scholarships. This amounts to $4 million per year.

Reaching $4 million per year will take time, but we must work towards this goal. Our short-term goal is to increase our annual budget for these purposes by $210,000 each year. When combined with additional NSERC support, this would allow us to create 30 additional $10 K support packages each year. Alternatively, we could use these funds for "top ups" for, e.g., NSERC PGS holders.

Plans and Recommendations

21. We will set a target of a graduate student enrollment of 400.

22. We will aggressively seek more funding under the control of the Faculty of Science, as is the case in our sister universities.

23. We will increase Faculty-based graduate student support, from its current level of $358,000 per year. Our initial plans are increases of $210,000 each year, with an ultimate target being a budget of $4 million per year.

24. We will actively seek out other opportunities for graduate student support, for example the MITACS[7] program, the new CREATE[8] program, more NSERC PGS and CGS fellowships, and industrial fellowships.

III.7 The Undergraduate Years: Excellence, Innovation and Accessibility

One of our great strengths is the breadth of our program offerings. The University of Manitoba has the potential to offer virtually any program, and to connect our graduates to any future educational, research or other career option. We will build on these strengths, and we will emphasize "innovation" in our building.

Attracting the best students, both to The University of Manitoba and to the Faculty of Science, and supporting all qualified students throughout their academic programs, must be a priority. Some programs are over-subscribed, at least so far, and some are under-subscribed. Most existing programs will be reviewed in the coming few years. It is an opportune time to ensure that our programs are modern, to introduce new and innovative

[7] Mathematics of Information Technology and Complex Systems, an NSERC Network of Centres of Excellence.
[8] NSERC's new Collaborative Research and Training Experience Program.

ones, and make use of the talents of our new people. We need to ensure that students are attracted here for the right reasons, and benefit from our particular strengths.

In the last two years, student numbers and UGSCHs have shown a marked decrease. Decreasing demand appears to be here or imminent in all departments, and this speaks to the urgency of recruitment and enrollment management.

A) Program and Course Innovations

Our academic programs lie at the very heart of what we do. Keeping them current is essential. Our breadth and strength allow us to offer a particularly vibrant, innovative and modern set of offerings. Doing so will enable us to build a reputation as a place for students to come *because of* our modern and innovative programs. There are many possibilities that could be considered.

The time is ripe to further examine some of our academic regulations. Well-constructed minors can serve students well, and attract students into courses that would be under-subscribed otherwise. Our regulations on minors are more strict than elsewhere. The University of Western Ontario now structures all their offerings as "modules", which might offer more flexibility. We could also consider new structures such as "specializations" or minors that involve more than one department, or degrees with a broad focus, but not as broad as our general degree, e.g., life sciences or physical sciences.

We have a number of joint majors and honours programs. There have been suggestions that some of them are over-prescribed, unnecessarily reducing their attractiveness, and unnecessarily limiting the breadth of education.

Our three-year degree program is a major part of our offerings; nearly 50% of our graduates follow this route. It is almost unique in Canada. However, it was introduced many years ago, and it is timely to review it.

It also appears that some of our programs have fewer students in them than one would expect for a university of this size.

Plans and Recommendations

General

25. We will foster a supportive atmosphere which encourages new program and program innovations on a continuous basis. As appropriate, we will work with other Faculties in developing and offering them.

26. We will secure the resources needed to cover the incremental costs.

27. We will examine the number of specified courses in our double and joint honours degrees.

28. Each department will seek to take advantage of opportunities presented by new and revised programs in other departments.

29. The Faculty of Science will promote its work in environmental sciences, and cooperate with other Faculties on campus in developing environmental science and environmental studies.

30. Guided by the recommendations of a recent advisory committee to the dean, a new Steering Committee will work with the Director of the Delta Marsh Field Station to ensure that it plays an integral and vital role in research and teaching of biological and environmental sciences.

Minors and Modules

31. We will examine the regulations for minors, and the concept of modules, with a view to facilitating the offering of more of these options, and making them more accessible to students.

Three Year Degree

32. We will review the role and nature of the three-year degree program, and why such a large proportion of our students take it. Possible terms of reference are appended.

Program Reviews and New Programs

33. We will complete academic program reviews of all undergraduate programs.

34. All departments will examine the possibilities for new minors, modules, joint programs, and specializations. Multiple-department minors, or similar structures, will be pursued.

35. The Department of Biological Sciences will undertake a complete curriculum overhaul.

36. The Department of Mathematics will undertake a complete curriculum overhaul.

37. The Department of Physics and Astronomy will continue its development of the astronomy program.

38. New joint honours programs will be introduced, including but not only

- Computer Science and Statistics
- Computer Science and Management
- Physics and Geological Sciences
- Physics and Biochemistry

39. We will complete the introduction of a program in forensic science.

40. We will complete the review and revision of the biotechnology program.

41. With the Faculties of Medicine and Agricultural & Food Sciences, we will investigate the introduction of a bioinformatics program.

42. We will examine the possibility of other new programs, streams or minors, including but not only

    - Mathematical biology
    - Chemical biology
    - Physical biology
    - Medical physics
    - Environmental biology
    - Systems biology
    - Sustainability
    - Mathematical finance
    - Materials science
    - Biological and/or soft materials
    - Nano-science
    - Life sciences
    - Physical sciences
    - Biostatistics

B) Research-Enhanced Educational Experience

We are a research-intensive Faculty in a research-intensive university; it is important that the benefits of this emphasis accrue to our students. Currently:

- Virtually all our graduate students are in research-based programs.
- We offer undergraduate thesis options in several honours programs.
- We typically engage about 45 undergraduate students in summer research projects, jointly funded by NSERC fellowships and faculty research grants.
- We have recently re-instated our 16 annual Faculty of Science undergraduate student summer research fellowships. These are also subsidized by NSERC research grants.
- We support undergraduate and graduate students attending conferences.

- Faculty hire some undergraduate co-op students to do research for their co-op placements.
- Some of our senior undergraduate courses are research-based.

Plans and Recommendations

43. Those of our honours programs that do not yet have thesis options will be examined for possible inclusion of this option.

44. Other opportunities for using our research strength to enhance the undergraduate experience will be identified.

C) Co-operative Education

Computer science co-op education started about 1980, with the first students graduated in 1983. Other science programs were added over the years, with the most recent addition being the chemistry major and honours, which were added in 2006. Programs that currently have co-op options are biochemistry, chemistry, genetics, microbiology, zoology, ecology, computer science, and joint mathematics and computer science. This is a distinguishing feature of our Faculty of Science, and there is potential for growth, both in the programs and the numbers of students. However, the program needs to be sustainable financially. Goals for the program include:

Plans and Recommendations

45. We will expand the availability of the co-op option. Probable candidates for expansion are: additional areas of biological sciences, biotechnology, and statistics.

46. We will enhance the co-op services (career counseling, etc) offered to students.

47. We will stabilize the financing of co-op.

48. We will hire more co-op students in our research labs.

49. We will increase the numbers of students participating in the program.

50. We will increase the visibility and reputation of our co-op programs with employers.

Achieving these goals will require active partnering with stakeholder groups, internal and external to the university.

D) The First Year Experience

Our first year courses are our students' introduction to university and to the Faculty of Science. A good experience will help attract them, but a poor experience will not. It is crucial that we provide high quality, attractive and interesting first year courses.

One reality of our situation is the need to use large numbers of sessional and part-time instructors to deliver our courses. A second reality is that the people available to fill those positions cannot, usually, teach senior courses. The result is pressure to assign them to introductory courses. Within this reality, departments will strive to assign their best instructors to introductory courses, and design the courses and course content carefully.

Plans and Recommendations

51. Departments will give a high priority to assigning excellent instructors to first year courses.

52. Departments will strive to ensure that the course content and delivery are interesting and attractive, as well as of high quality and appropriate for the discipline, and that the student experience is as good as possible.

53. The Department of Biological Sciences will examine the possibility of moving to "live" lectures in first year courses, and what resources would be needed to make that possible.

54. The Faculty will explore innovative first year courses: Is there a role for an integrated first year science program, e.g., a 9-credit hour biology/physics/ chemistry course?

E) Student Success

Many of the recommendations throughout this Plan address and support student success, and the Enrollment Management Plan will address this topic. In addition,

Plans and Recommendations

55. We will continue to support our students with excellent advising and dedicated advisors.

56. We will examine and, if appropriate, restructure the advising service.

57. We will examine relationships between students' high school records and their success at university, and seek to align policies.

58. We will work to strengthen students' connections with their home departments and the dean's office.

59. We will monitor the impacts of the new academic standing rules, especially on students with weaker high school records.

60. We will examine the merits of supplementary exams, coupled with a suitable fee payable to the Faculty.

F) Aboriginal Initiatives

The Faculty of Science offers a number of special Access sections of first year courses. Very recently, we have put a major effort into the Peguis Science and Technology Symposium, and we participate in the Faculty of Medicine's new Centre for Aboriginal Health Education. The University of Manitoba has a task force examining what most needs to be done, and is currently building a university Aboriginal Student Centre. This is an area of current and growing importance.

Plans and Recommendations

61. We will seek to create an Aboriginal Science Students' Centre in Machray Hall, with a modest staff.

62. We will seek additional ways of supporting Aboriginal students, by first undertaking a needs and opportunities assessment of this important area, and respond accordingly. We will work with other units of The University of Manitoba in carrying this out.

G) Programs and Options for High Achievers

We aim to be the place of choice for top students. Many initiatives described in this Plan will help. In addition:

63. The Faculty will examine what we can do to attract and stimulate the best students. Options for consideration include: special courses, identifiable sections of multi-section courses available to those with the best academic records, student cohorts, direct entry to Science, and others.

H) Recruitment Initiatives, Entry to Science Programs, and Transfers

We must engage in more active recruitment. We have recently created a new "Recruitment CD", and are working more closely with the Admissions Office. There

have been changes to University 1 and its relationship with the Faculties of Arts and Science, Math has been eliminated as an entry requirement to University 1, and a minimum GPA of 2.0 is now required for entry into the Faculty of Science. Some other Faculties have a "direct entry" option, available for the very best high school students.

There may be ways to further enhance the transfer into Science from other universities, and colleges such as Red River College.

Plans and Recommendations

64. We will examine the option of direct entry into the Faculty of Science using, for example, the Faculty of Engineering policies as a model.

65. We will increase recruitment efforts, working with the Admissions Office and other related offices.

66. We will strive to maintain a "seamless transition" from University 1.

67. We will continue to pursue agreements with other universities to attract good students, in particular to our upper level undergraduate and graduate programs. We will work with appropriate units to improve the transfer credit processes.

68. We will investigate more arrangements with Red River College for transfers or joint programs.

I) Science for Non-Scientists

Decisions on matters of public policy must be made in the face of apparently-conflicting scientific claims: recent debates over climate change provide a good example. However, there are challenges. Scientific "findings" appear to change with new discoveries, and the occasional case of scientific misconduct fosters a climate of distrust. Non-scientists need to appreciate science, what it has to contribute, and how.

In this context, it should also be noted that Senate was asked, in early 2007, to examine related questions regarding what all graduates of The University of Manitoba should know and be able to do – the defining characteristics of an "educated person". We need to determine how the Faculty of Science can best serve those students who attend the University of Manitoba, but who will not be majoring in science.

Plans and Recommendations

69. We will examine how best to serve students who do not major in science. We will invite other Faculties to join us in this task. Innovations we develop in the context of the three-year degree may form building blocks for this.

70. If the university eliminates the M and/or W requirements, we will consider implementing our own as a Faculty requirement.

J) Student Discipline

The Faculty has recently updated its disciplinary procedures, but this will need continued monitoring.

III.8 Internationalization

The Faculty of Science is currently heavily engaged in international activities. We have numerous international collaborations. Nearly 1/3 of our graduate students are international. Many undergraduates take part in exchange programs.

Internationalization is a priority for the university. We have entered into some international agreements, but they have not yet generated many additional students. The University of Manitoba has just entered into a new agreement with Navitas to set up the "International College of Manitoba" on the University of Manitoba campus.

Plans and Recommendations

71. We will document our current international activities, including the numbers of international graduate students, collaborations, visits, etc.

72. We will examine the effects of differential tuition.

73. We will continue to pursue the internationalization of our research, graduate and undergraduate programs. We will identify our priorities for development, and suitable funding arrangements.

74. We will continue to develop arrangements such as "2+2" agreements which recruit students to senior years.

III.9 Teaching Excellence and Innovation

Excellence and innovation in teaching are important values of the Faculty of Science. They are integral to our promotion and tenure policies, and in annual faculty reports and heads' evaluations. We will continue to act on these values.

Plans and Recommendations

75. We will continue to pay careful attention to teaching excellence in faculty annual activity reports.

76. We will encourage innovation in programs and program delivery.

77. We will encourage faculty to take advantage of programs intended to support and enhance their excellence and innovations.

78. We will recognize teaching excellence and innovation.

III.10 Celebration of Excellence and Innovation

The Faculty will expand its program of recognition and rewards for excellence and innovation. The awards we introduce will reflect our priorities.

Plans and Recommendations

79. We will continue the new Faculty of Science Celebration as an annual event.

80. All departments will nominate honorary degree recipients on a regular basis.

81. We will create a Faculty of Science awards committee. It will have initial responsibility for developing terms of reference for new awards. Its ongoing responsibilities will include recommending award and honorary degree recipients.

82. We will introduce the following new awards

- Dean of Science Award of Excellence: all graduating students who were named to the dean's honour list in every semester that they were eligible.
- Faculty of Science Distinguished Scholar Medal: one annual medal, for balanced contributions to research, teaching and service (individual)
- Faculty of Science Award for Innovation in Teaching and Academic Programming (individual or team)
- Faculty of Science Support Staff Innovation Award (individual or team)
- Faculty of Science Support Staff of the Year Award (individual)
- Faculty of Science Award for Research Excellence
- Faculty of Science Award for Teaching Excellence
- Faculty of Science Outreach Award (team or individual, academic or support staff)
- Faculty of Science Annual Alumnus Award

III.11 Promotion and Tenure Policies

Promotion and tenure provide recognition for our academic staff, and assurance of excellence in our programs. We have recently revised our promotion and tenure procedures.

III.12 Information and Communications Technology

We are a Faculty of Science, and we use and are surrounded by technology. All of our staff use and are comfortable with ICT (information and communications technology), and we are investing heavily in Westgrid research computing, Access Grid video collaboration and visualization facilities, and other research and teaching computers. Today's students use ICT in ways, and to an extent, that are different from those who are only slightly older. Their expectations are well ahead of what we can provide.

We currently provide some ICT support via staff in the dean's office, and some departments have dedicated staff, but we need much more.

Plans and Recommendations

83. We will monitor the levels of ICT support in each department, and seek to augment as necessary to provide adequate ICT functions in each department.

84. We will keep abreast of things we *could* be doing if we had more resources, and seek to augment our staff as appropriate. Lessons learned in one department will be ported to other departments.

III.13 Departmental and Faculty Staffing Plans

Since 2000-01, student numbers in the Faculty of Science have risen sharply, but overall staffing levels have remained virtually unchanged. Some departments have lost staff. The Resource Allocation Book for 2008-09 reports that the Faculty of Science has the highest ratio of undergraduate students to academic staff of any Faculty or School at the University of Manitoba. Most telling, this ratio is two to three times higher for us than for other Faculties with similar profiles of labs and lectures. The support staff situation is at least as challenging.

The SIP process has created an atmosphere of uncertainty and competition, with unproductive consequences. This staffing plan is intended to minimize these effects, while explicitly supporting innovation.

The goals of our staffing plan are to:

1. attract and retain the best candidates;
2. permit a reasonable teaching load in each department;
3. provide a stable framework for departmental planning purposes;
4. encourage cooperation among departments;
5. maintain healthy and vibrant undergraduate core programs (Honours and Major);
6. promote the development of innovative interdisciplinary undergraduate programs;
7. fulfill service teaching commitments;
8. satisfy the Faculty and departmental strategic research plans;
9. encourage interdisciplinary research collaborations;
10. achieve a critical masses in selected areas of research specialization;
11. plan for succession for both academic and support staff.

Plans and Recommendations

85. Future staffing will be guided by following principles:

Academic Staff

1. Each department will develop a staffing plan that includes a short list of research priorities, with defined critical masses for each group, within the current allocations.

2. High priority will be given to maintaining at least the current number of academic positions in each department.

3. Requests to SIP for replacement positions will be prioritized according to how they support the Strategic Plans of the Faculty and departments, including: the strategic research plans and research priorities; innovations in academic programming and delivery; coping with anomalously high teaching loads and student:staff ratios; and anticipating extraordinary demographic impacts.

4. Requests for incremental positions will normally be justified by new academic programs, new modes of delivery, and/or anomalously high teaching loads.

Support Staff

5. Each department will develop a support staff plan that establishes and justifies a realistic target complement of support staff, which includes administrative staff, undergraduate laboratory staff, computer and other technical staff.

6. Departments will pay special heed to succession planning for key positions.

7. Requests for non-academic staff will be reviewed in the context of the support staff plan of the department, and special needs arising from the Strategic Research Plan.

8. It is anticipated that the following will be high priorities:

- technical support staff;
- lab teaching support in experimental sciences;
- at least one additional ICT support person, and probably many more, in order to allow the Faculty to introduce and support more modern use of ICT; and
- administrative staff to cope with the rapidly increasing administrative loads.

III.14 Space and Infrastructure

With the notable exception of EITC, as well as pockets of renewed space in other buildings, the physical infrastructure across the Faculty of Science in Allen, Parker, Buller, Duff Roblin, and Machray Hall is aging rapidly, and teaching, research and office space is at a premium.

Hiring in both Mathematics and Statistics is severely hampered by the quality of the physical space of these two departments. They both moved into Machray Hall in 1972 as a temporary measure – nearly 40 years ago. Machray Hall was built as a cavernous library, and is not suitable as an academic building. Furthermore, the space for these departments is far too small. We had hoped that the departure of Computer Science to the EITC would generate much more space for Mathematics and Statistics. Some progress was made, but far too little. Many faculty are still in tiny, windowless offices, sound-proofing in the walls between offices is non-existent, and washroom facilities are inadequate and in dire need of renovation. Hiring in the experimental sciences is hindered by the lack of suitable laboratory space. These issues present a major obstacle to the attraction and retention of new faculty.

Legislated changes to safety regulations may require major investments. In particular, there is proposed new legislation related to biosafety that, if passed in its current, would require very expensive changes.

Special issues and opportunities the Faculty of Science faces include:

- The lack of a 500-seat lecture theatre has resulted in uncompetitive teaching loads, too many sessional appointments, and difficulties in recruiting faculty.
- The ongoing infrastructure renewal, especially of Buller, is causing enormous disruption to the residents.
- The Department of Biological Sciences looks forward to the old pharmacy building, but anticipates that a great deal of work needs to be done. The Department also looks forward to re-arranging and creating research clusters, shared space, and a suitable departmental office.

- The Parker Building has reached its capacity for research labs.
- The cyclotron space in the basement of Allen represents a major opportunity for the Materials Science Initiative.
- The Department of Mathematics and the Department of Statistics are still in their "temporary", inadequate space.
- Prospective faculty are often shown sub-standard labs and/or offices when they are interviewed.
- New faculty often inhabit sub-standard labs for several years after they begin their careers here.
- Much of our research and teaching space is sub-standard.
- The Armes building, and other space, is very unattractive and in dire need of renovation.
- We now have a regular program of undergraduate laboratory renewal.
- We need, at minimum, a teaching greenhouse adjacent to Buller. A more advanced environmental building would be much preferable.

Plans and Recommendations

86. We will develop a strategic space assignment and renovation plan with the following goals to:

    a. renovate undergraduate teaching facilities, including experimental laboratories, lecture rooms, computer laboratories, and ICT capabilities;
    b. design a flexible, "generic", possibly department-specific research laboratory "shell" equipped with a suite of basic facilities which can accommodate any new hire;
    c. ensure adequate study space for graduate students;
    d. ensure adequate office space for academic staff;
    e. address equipment needs for individual departments;
    f. address needs shared by multiple departments;
    g. address the special opportunities resulting from the renewal of biological sciences, and major initiatives including materials research;
    h. address needs of special units like Glenlea and Delta Marsh;
    i. renovate common spaces (Armes);
    j. complete the renovations of Buller, including the basement; and
    k. address routine maintenance issues.

In order to implement the space plan:

87. Each department will submit an annual prioritized list of renovations which will include undergraduate teaching, research labs, office space for graduate students, office space for academic staff, computer needs, and routine maintenance issues.

88. The Faculty of Science will develop a comprehensive prioritized inventory of needs in each category, and will develop a renovation schedule in consultation with Physical Plant and IST.

89. The Faculty of Science will work with our new Development Officer to create a plan to create new, suitable space for the Mathematics and Statistics departments.

III.15 Developing and Implementing the Plan

Development

The Faculty of Science developed an Interim Integrated Plan and Interim Strategic Research Plan through a series of meetings of the Administrative Council, two Faculty of Science Town Halls, and numerous discussions within the office of the Dean of Science. Following these steps, each department, the IIMS and the Delta Marsh Field Station created a draft plan, although some departments' plans are still in early versions. Following those discussions, subsequent drafts of the Faculty Plan were developed by the Administrative Council, and then presented to the Faculty of Science for further input. A final version of the Plan was endorsed by a Faculty-wide ballot, by a vote of 67 in favour to 4 opposed.

Implementation

This Plan comprises a sweeping agenda for the Faculty of Science, with a host of action items that are all placed in the context of renewed vision and mission statements, and a set of strategic priorities. Implementing them will require annual priority setting and, although this is not an exercise in bean-counting, we will track our progress.

The Plan is a "living document". We will remain open to new opportunities, and be prepared to amend the formal Plan as appropriate.

Plans and Recommendations

90. Each fall, the Administrative Council will meet to determine the Faculty's annual goals, priorities and budget proposals.

91. We will measure our progress towards achieving our goals, and this will be reported in annual departmental and Faculty reports. Measures will include:

    - Funding Successes.
    - New academic programs and innovations.
    - Enrollment issues: changes, students turned away, etc.
    - Consideration of, and changes to, academic policies.
    - Space: new, renovated.

- Equipment.
- Academic and support staff numbers each year.
- Research successes.
- Research funding.
- Graduate student numbers and successes.
- New awards.

92. Without engaging in onerous annual exercises, we will adjust our course and modify our plans as circumstances change.

93. The Plan will be formally re-visited in 2012.

IV. Appendix

IV.1 Three-Year B.Sc. Degree Program

Background

The Faculty of Science currently offers three major undergraduate degree options: 4-year honours, 4-year majors, and 3-year general. The 3-year degree has been the subject of interest and debate in recent years. A review of this program should reflect the following:

- We are a research-intensive Faculty in a research-intensive university – a "medical-doctoral university", in the words of Maclean's. We value excellence and innovation, aim to offer modern, innovative, high quality programs, and to attract top students wanting to take top programs.

- Three-year B.Sc. degrees are offered at most Ontario universities (not U of T or Ryerson) and Saskatchewan universities, but not many others. Most of those offered elsewhere are discipline-specific. One, perhaps the only, exception is Sir Wilfrid Laurier, which appears to be a general degree like ours. It appears that 3-year degrees in Ontario are taken by students going on to professional schools, and for weaker students. This may or may not be the case here.

- It also appears that, where three-year degrees are offered elsewhere, only a small number of students take them. The number quoted is about 10%. This contrasts with our program, where approximately 45% of our students take them. A broad range of our students takes it this program.

- The existing program appears to serve many students well:

    1. It is popular, with many satisfied students.
    2. Professional schools do not distinguish between it and 4-year programs in their admission policies.
    3. It is inherently inter/multi-disciplinary, requiring breadth and depth.

- Concerns have been raised that students who pursue a 3-year degree, but are not subsequently admitted to the professional school of their choice, are not well-positioned to complete a 4-year degree, and are not well-served by our terminal 3-year degree.

- There is a growing interest in all things inter-disciplinary, and the needs for students to work effectively in interdisciplinary settings, to see connections between disciplines, and to be able to transfer their skills from one arena to another.

Review of Degree Offerings: Draft Terms of Reference

Our nearly-unique 3-year degree might form the basis for a highly innovative offering, one which meets the goals of the current degree, while at the same time meeting new and modern goals. It is not clear that it should remain a three year program. Perhaps it should be 4-year "general", with more or less specialization than now, with more or fewer "science" courses, perhaps with one or more new courses that specifically connect one discipline to another, perhaps within science, perhaps to non-science. On the other hand, perhaps we don't need it at all and it should be eliminated – the honours and majors could fill our needs, with or without modifications.

A review of this degree is timely. Considerations should include, but not be limited to, the following. Some of the review would bring in the current honours and major degrees, but the primary focus should be on the third one, currently the 3-year degree.

Questions about the Current Structure

1. What is best about each of our degrees?
2. What are the goals of each of our degrees?
3. How do the different degree options complement each other?
4. What, if any, are the weaknesses of this spectrum of degree offerings?
5. Who takes the different degrees? Why? Is it true, as we think, that an unusually large number of students take the 3-year degree? If so, why do they?
6. Is the offering of a 3-year degree consistent with how we are positioning ourselves?
7. Students who graduate with our current 3-year degree will not be scientists. Are they properly trained to apply science in whatever fields they end up working?

For the Future

1. Should we maintain three different degree options? If so, what should they be?
2. How can we incorporate what is currently best about each of our degree programs into the other ones?
3. What should the goals of each of the kinds of degree be?
4. What, if anything, is needed to facilitate a student moving from one degree to another?
5. What changes, if any, should be made to each of the degrees, to accommodate movement from one to another?
6. Does the 3-year degree provide the basis for best serving students who will not be scientists, but who need to understand and appreciate science? How could that be accomplished?
7. Within the context of our spectrum of course offerings, what changes should be made to the current 3-year degree?

Part 2. Faculty of Science Strategic Research Plan

I. Introduction

The Faculty of Science is a cornerstone of the University of Manitoba. Founded over a century ago, we now have the strongest and most comprehensive combination of research and teaching at The University of Manitoba. We are among Canada's best Faculties of Science, in terms of breadth and quality of our research programs. We offer a full range of undergraduate and graduate programs, engage in a wide spectrum of cutting-edge research, and provide valuable, expert service based on our extensive research skills to various communities and to the public at large. Our strengths are built on the abilities of our faculty and graduate students in all seven departments and associated research institutes and stations.

All members of our professoriate thrive on research, and strive to excel. As a Faculty, we expect them to maintain externally funded research programs, and to seek out new opportunities for collaboration and funding wherever possible. We also strive to hire strategically to meet both academic and research needs.

This strategic research plan serves a number of complementary needs:

- help all members of the Faculty of Science pursue successful research careers;
- summarize the current research of the Faculty of Science;
- identify what currently distinguishes us from other Faculties of Science;
- identify particular opportunities for growth and strengthening of research;
- articulate that research that does not necessarily fall within an identified theme is still important;
- articulate that providing support for certain areas of focus enhances the reputation of all of us, and thus supports the research enterprise of all faculty members;
- articulate the most important challenges we need to overcome;
- aid in related decisions on staffing, CFI support, space and infrastructure;
- provide sufficient flexibility to allow for the natural evolution of the research enterprise.

This plan exists in parallel with, and is complementary to, the research plans of all departments in Science.

II. Planning Assumptions and Principles

A research plan must be consistent with, and take advantage of, the expected research environment. While the research environment cannot be forecast with certainty, this plan makes the following assumptions:

1. The federal government will place a very strong emphasis on the training of graduate students and other highly qualified personnel (HQP) for both academic and industrial positions.
2. NSERC Discovery Grants will provide the fundamental source of funding for most faculty members, but NSERC is unlikely to provide increased levels of support sufficient to allow faculty to fund more than a small number of graduate students each.

3. Continued efforts by The University of Manitoba to lobby the provincial government for additional graduate funding will meet with partial success but to achieve our goals and to deal with increasing competitiveness, the Faculty will need to explore additional opportunities for graduate funding.
4. Growth areas for research funding will largely come from partnerships and collaborations. Federal research laboratories and/or private industry will therefore increase in importance. In part, this will be driven by the new federal policy on collaboration between non-regulatory federal labs and academic institutions. This implies that the gap in funding for "pure" versus "applied" research will also grow.
5. Additional funding opportunities will exist through partnership arrangements with other universities via the National Platforms Fund of CFI, and NSERC's Network Centres of Excellence and Strategic Network Grants, among others.
6. Winnipeg is becoming a centre for health-related research. The National Microbiology Lab and the NRC Institute for Biodiagnostics in Winnipeg present an opportunity to increase our research strength.
7. There will be increasing emphasis on supporting interdisciplinary research funded through shared agreements between the Tri-Councils (NSERC, CIHR & SSHRC). Interest in associated, broader interdisciplinary training will also grow.
8. The CFI and Genome Canada programs will continue for the foreseeable future and will remain the major sources of funding for large research initiatives. We expect these agencies will coordinate with NSERC's RTI (Research Tools and Instruments) program. The expectation is that NSERC will be responsible only for smaller equipment (less than $500,000) while CFI and Genome Canada will fund major equipment. Success in these competitions will require well-established research groups.
9. The role of Canada Research Chairs and endowed Chairs will be critical in securing major grants.
10. The number of academics within the Faculty of Science will remain approximately constant, with some growth based on special initiatives.

As we go forward, we will observe the following principles.

1. Research strength is built, first and foremost, on the strength and creativity of individuals.
2. We will build on our existing strengths, where possible, to make the Faculty of Science and the University of Manitoba a recognized international leader.
3. We will seek new opportunities balancing evolving strengths in our existing and potential research themes. The balance at any time will be directed to developing the Faculty's overall research strength.
4. The Faculty will seek to support the exploration and development of new research areas not yet identified in this plan and to enhance and extend existing and developing collaborations.

III. Research Training

Graduate student training in the Faculty of Science is almost exclusively research-based, requiring students to produce a thesis that can withstand the scrutiny of an examining committee. In the case of Ph.D. students, we expect our students to do research that is publishable in major national and/or international research journals and conferences that are appropriate to the discipline. In most cases we expect our Ph.D. students to communicate their research prior to graduation. We also expect that most of our Ph.D. students will have external examiners present for their defenses to ensure their research is of high caliber.

Increasing the number of graduate students is a top priority of the Faculty. We believe that the main barrier to increased enrollment is the low level of non-grant financial support available. Accordingly, the Faculty reallocated internal funding, and is now investing approximately $350,000 per year in graduate fellowships. We are very concerned that most Canadian universities have made graduate students a priority, and are directing additional funds to their support. We have trouble competing now and the competition is growing.

We plan to increase our graduate student enrollment to a steady state level of 400. This will require a very significant increase in non-grant funds to support them, and our goal is to secure that funding.

IV. Common Research Support and Facilities

Grant Mentoring and Support

The offices of the dean and the departments provide mentoring and advice to faculty members, with a formalized grant reviewing process. In recent years, the dean's office has also provided financial contributions to NSERC RTI grants. Faculty members have been very successful with these grants, and the dean's office intends to continue this support. The Faculty of Science also facilitates research by liaising with the office of the Vice President (Research) and various national granting agencies

Infrastructure and CFI Support

To promote the research enterprise of the Faculty of Science, we support basic infrastructure that is used throughout the Faculty and the University of Manitoba. These include our Animal Holding Facilities, a large and sophisticated aquatic holding facility (both freshwater and marine), numerous Controlled Environment Chambers in the Duff Roblin and Buller Buildings, a large greenhouse in the Crop Technology Centre, a second greenhouse adjacent to the Buller building which needs replacing, Herbarium, Museum, Delta Marsh Field Station, Electron Microscope Suite, Machine and Electronics Workshops, Glass Shop, NMR Facilities, Solvent Purification System, Helium Liquefier, Statistical Advisory Service, the Institute for Theoretical Physics and the Institute for Industrial Mathematical Sciences. Additionally, led by researchers in the Faculty of Science, the University has recently joined the largest Canadian high performance

computing (HPC) consortium, Westgrid, and was awarded close to $5 million (total contributions) in a proposal submitted to the CFI National Platforms Fund.

The Faculty of Science has already invested in a number of research programs and research-related infrastructure. Of particular note is the large current investment in the retrofitting of the Buller building to modernize research facilities and enable the creation of research-centred clusters. The Faculty has also contributed extensively to the renovation costs in support of virtually every CFI award received by Faculty of Science researchers. Additionally, the Faculty provides significant financial support for many research-related facilities such as the Delta Marsh Field Station. It also helps support WestGrid and the University's HPC technical analyst.

A primary challenge to the Faculty is that much of the basic research infrastructure is in dire need of repair. Upgrading and renewal of this infrastructure must continue. Further, a process must be created to ensure that the infrastructure does not again fall into general disrepair. Delaying infrastructure renewal is a false economy that results in higher costs, reduces the quality of training, harms morale and, during eventual renewal, produces severe rather than incremental disruption to the research process. An established "evergreening" process is needed to avoid these problems.

Shared Research Facilities

The "one lab per faculty member" model has been the norm in the Faculty of Science and has many advantages. However, in some cases, it can be more productive to create shared research space and facilities. This can be an important factor in major grant competitions, including CFI, Genome Canada, and Collaborative Health Research Programs. The general cost effectiveness of sharing facilities, where doing helps rather than hinders research efficiency, should also be considered.

Promotion of Partnerships

Academic – The Faculty will establish departmental research liaison positions to improve inter-departmental communication and facilitate collaborations and broader student training opportunities. The Faculty will also explore joint research opportunities by engaging other relevant faculties (in particular, the Faculties of Engineering, Environment, Earth, & Resources, and Medicine). Further, the Faculty will seek to support inter-institutional research initiatives where there are tangible benefits to the Faculty. Currently, the Faculty hosts the Institute for Industrial Mathematics (IIMS) with which it is cooperatively working to establish a multi-university Prairie Network for Research in the Mathematical Sciences. The Faculty also supports the University's full membership in TRIUMF1[9] and its membership in the National Institute for Complex Data Structures (NICDS).

Industrial – Particularly since we expect funding levels for applied research to grow, researchers should seek to establish partnerships with industry wherever there are opportunities. While a number of academic faculty have the credentials for positions such

[9]Canada's National Laboratory for Particle and Nuclear Physics, located on the campus of the University of British Columbia.

as NSERC Industrial Research Chairs (IRCs), the Faculty has historically been limited by the lack of local industrial partners necessary for such chairs. The potential benefit of industrial partnerships needs to be reconsidered. Additionally, our current limits on graduate student funding could be partially remedied by greater participation in the NSERC industrial graduate student scholarship program. This, too, will require renewed effort by the Faculty of Science.

V. Research

The Faculty of Science has strong research collaborations, and strong individual researchers. All are important. Some of our research is multi-disciplinary and spans departments, while other research is discipline-focused and found within individual departments. In some cases, research bridges two or more themes or departments. The Faculty is proud to have outstanding, internationally recognized researchers in all its departments, including a total of seven Canada Research Chairs (CRCs).[10]

The Faculty of Science is committed to promoting and supporting both departmental and inter-departmental research, and all researchers. In many instances, it is the thematic areas in which a significant number of researchers work that most effectively enhance our collective reputation as members of a strong research community. Such recognition benefits everyone. Recognizing that connections and collaborations can prove to be a real advantage given the current emphasis on interdisciplinary and transformational approaches in major grant competitions, the Faculty of Science will work to help identify collaborative opportunities that lie beyond the capabilities of a single department and, when possible, to address the time and cost issues associated with building collaborations

An inventory of research will be created that will facilitate the promotion of all our research, and the development of collaborations at all levels. Due to the breadth of research done in the Faculty of Science, this document focuses on the thematic research areas. Information about other research may be found in the departmental research plans.

V.1 Multi-Department Research Themes

Some important research themes and clusters span multiple departments, and some are found primarily within individual departments. We begin with the former.

Life Sciences

The Life Sciences are an important theme of the Faculty of Science, The University of Manitoba, and Winnipeg, and they are at the frontier of much of modern science. As of July 1, 2007, much of our effort in this area is organized under the newly-formed Department of Biological Sciences and the Department of Microbiology. However, other departments also participate actively in this area. For example, biochemistry is a joint effort of the Departments of Chemistry and Microbiology, and genetics is a multi-department and multi-faculty program. Further, the Department of Physics & Astronomy

[10] The CRCs awarded to the Faculty of Science are listed in Appendix A of this document.

hosts a CRC whose work includes the physics of DNA, and has just revitalized an undergraduate course in biophysics. A number of other faculty members in Science also have research interests in biological materials and the Departments of Mathematics, Computer Science, and Statistics are all actively pursuing and/or exploring mathematical biology and bioinformatics.

The Faculty of Science is now engaged in a major, multi-faceted renewal of the life sciences. This includes the development of new academic programs under the umbrella of new "thematic areas", the realignment of research areas, the formation of new research clusters and themes, the joint acquisition, development and use of new space and research infrastructure, and the renewal of the Delta Marsh Field Station.

Multi-department research themes in the Life Sciences include:

Bioanalytical Chemistry and Physics –Expertise in the departments of Chemistry, Microbiology, and Physics & Astronomy offers unique tools and insights into the understanding of biologically important chemicals. A wide range of analytical and imaging techniques and tools have been developed and used in this area. The caliber of the Biomolecular Mass Spectrometry Collaboration (which includes a Tier 2 CRC) was recognized recently by NSERC with the 2006 Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering. Infrared and Raman micro-spectroscopy are also being used to study molecular changes in Alzheimer's dementia afflicted brain tissue and fungi.

Cell and Molecular Development and Evolution –Researchers in the Departments of Biological Sciences, Chemistry, and Microbiology are developing new approaches to understanding cell and tissue metabolism, regulation and homeostasis, interaction, evolution and co-evolution. This large and growing area of research spans the full spectrum of living organisms from protists and bacteria through the plant and animal kingdoms to ecosystems. The new Tier 2 CRC in Phylogenomics will be positioned to build on these strengths and integrate this theme with others in the Faculty of Science and the University.

Structural Biology –The area of structural biology, led by a Tier 1 CRC, was recently strengthened by a CFI grant to obtain a protein X-ray diffractometer and by the recruitment of a Tier 2 CRC. Researchers in this area have also recently created the "Manitoba Group in Protein Structure and Function". A strong focus in proteomics is also developing.

Infrastructure renewal is a priority in the Life Sciences. The bulk of research and teaching programs are housed in the Buller and Duff Roblin buildings as well as the Delta Marsh Field Station, while the Parker building houses about half of biochemistry. The Buller building is currently being renovated and this is causing great disruption to all its inhabitants. Renovations of the Duff Roblin building are also needed, and Delta Marsh needs significant work. We expect to renovate and move into the pharmacy building, which will be a major effort. The existing green house facility adjacent to Buller is decrepit; we require a modern green house (or glass house) facility adjacent to the Buller building to complement the one in the Crop Technology Centre. Such a facility would also serve an important role in teaching and in public outreach.

Materials Science

Materials science is another major theme of the Faculty of Science and also the University of Manitoba. The University of Manitoba is home to seven CRCs in the area of Materials Science distributed among three Faculties (Science, Engineering, and Environment, Earth, and Resources). Three of these Chairs reside within the Faculty of Science, and we have hired six additional faculty members in the area. This discipline has been highly successful in obtaining extensive infrastructure, including $7.4 million for establishing the Manitoba Regional Materials and Surface Characterization facility and a $6 million nanofabrication laboratory. Interest in materials science also overlaps with interest in the life sciences. The development of a world class ultrasonics research laboratory is enabling new advances to be made in understanding the wave physics of complex materials, while novel applications of ultrasonic research techniques to food science have led to a significant growth in interdisciplinary research.

Multi-department research themes (in the Faculty of Science) involving materials include:

Complex Crystalline Materials and Nanostructures – This area focuses on understanding the behaviour of technologically important materials, such as catalysts, ionic conductors, superconductors, alloys, ceramics, cements, and magnets. Researchers, including a Tier 1 CRC, are pursuing such research in the magnetic, electronic and transport properties of materials, nanostructures, and phononic crystals. New research directions have emerged in the areas of magnetism in nanoscale systems, spintronics, and novel magnetic properties induced by various kinds of disorder.

Photonic and Phononic interactions with materials –This area involves the study of material properties at various scales including single atoms and molecules (excitation, ionization, probing, manipulation), complex molecular systems (biological, pharmaceutical) and beyond. Ongoing research in this theme includes imaging of complex materials, scattering and absorption in complex materials, mesoscopic wave phenomena, X-ray scattering and diffraction, NMR and Mössbauer spectroscopies, as well as photon and phonon correlation spectroscopies.

Soft and Disordered Materials; Liquid Crystals – The study of soft materials such as complex fluids, macromolecules, particulate suspensions and biological materials is of both theoretical and practical interest. Many of these materials are mesoscopic, having internal structures (on scales between atomic dimensions and bulk) that determine their properties. Soft condensed matter and biological physics are rapidly growing areas and involve a wide range of mesoscopic materials. Current research includes nanoparticles and spin glasses, polymer and biomaterials, mesoscopic materials, protein structure, tissue and cellular structure, and viral architectures.

Surfaces, Interfaces and Ultra-thin Films – The performance of many key materials with critical roles in today's technology is dominated by the structure and chemistry of their interfaces. Researchers in this area study the properties of these interfaces and seek to manipulate those properties. Ongoing research includes electronic and magnetic materials, polymer structures, and liquid crystals.

In partnership with the Faculty of Engineering, the Faculty of Environment, Earth, and Resources, and the Vice-President (Research), we have recently appointed a Director of the Materials Research Initiative to spearhead the formation of a University of Manitoba Centre for Materials Research, and to coordinate new equipment applications, and other activities. A specific goal is to convert the 650 m^2 of underground space adjacent to the Allen Physics Laboratory (formerly housing the cyclotron) to a Materials Research Centre.

Environmental Sciences

Virtually every department in the Faculty has some degree of expertise in this broad research theme. The Faculty has a large number of researchers (including a Northern Research Chair) who work in the areas of ecology, animal behaviour, plant stress responses, environmental microbiology, population behaviour and modeling, as well as areas such as the effects of environmental changes on animal and plant physiology.

Multi-department research themes in the environmental sciences include:

Aquatic Ecosystems – The Faculty of Science is home to the Aquatic Biology Research Group consisting of twenty-two laboratories. This group is a consortium of federal government scientists, and faculty members from the Faculties of Science and Environment, Earth & Resources, the University of New Brunswick, Memorial University of Newfoundland, the University of Winnipeg and the Manitoba Museum. Specific foci include studies of fish migration and behaviour, breeding, osmo-regulation, maintenance of excitable tissues and water quality stewardship and monitoring.

Environmental Health – It is critical to be able to gather evidence of changes occurring in our environment and to determine if there are direct causal relationships between human activities and those changes. Research in this area is underway in the Faculty of Science and in collaboration with researchers from the Faculty of Environment, Earth and Resources. In particular, the study of environmental trace elements (in part using instruments recently acquired from CFI) is laying the groundwork for future work in ecotoxicology. Additionally, our researchers are collaborating to use lichen health as an indicator of environmental change. A state-of-the-art ultra-clean trace element lab located in the Parker building supports these efforts. Researchers in Microbiology are continuing to isolate and characterize bacterial and fungal species, with the goal of defining those with beneficial traits and those that are pathogenic to humans, animals or plants. Other areas of current or future research in this area include stochastic process modeling of pest infestations and forest fire spread and the use of sensor networks for remote monitoring.

Research related to biological and environmental sustainability in aquatic and terrestrial ecosystems has huge potential to grow through new and strengthened collaborations. For example, organism behaviour within populations, ecosystem modeling, and further investigations in toxicology and the health of our environment are expected to grow due to collaborations between researchers in the Faculty of Science and those in the Faculties of Environment, Earth and Resources, and Agricultural and Food Sciences.

Computational Science and Visualization

Increasingly, scientific research depends on advanced analytical and computational techniques. In cases where cost, scale, and/or environmental or safety concerns preclude physical experimentation, it is often possible to apply stochastic and/or computational techniques to enable "virtual experimentation". In other cases, computation can be used to test theories, and provide insight that is simply not attainable by experiments. The use of analytical, computational and statistical techniques is also required to analyze the often-enormous volumes of data resulting from many experiments, simulations and observations.

Bioinformatics – Genomics, transcriptomics, proteomics and metabolomics all exploit analytical and computational techniques based on models of biological structures to support applications in medicine, biology and chemistry. Bioinformatics expertise currently exists in the Departments of Microbiology, Computer Science, and Statistics and includes work using Markov chains and hidden Markov Models to analyze DNA sequences as well as the application of DNA "trajectories" to understand DNA hairpins. Further developments in Bioinformatics will likely be shaped by the candidate who is recruited to the Tier 2 CRC in Phylogenomics. The Faculty has also initiated the development of academic programs in bioinformatics, in collaboration with the Faculties of Medicine, and Agricultural and Food Sciences.

Computational Science and Mathematics – The Faculty of Science is home to broad expertise in computational science in areas including astronomy, sub-atomic physics, condensed matter physics, the physics of DNA, computational chemistry, stochastic models of the spread of disease and use of limited vaccination resources, sub-cellular processes and the cytoskeleton, and the design of clinical trials and applications related to population biology. Underpinning much of this work on the mathematical side is research being done in scientific computing, finite element analysis, numerical analysis, the numerical solutions of PDEs, and physical dynamical systems.

Data Analysis and Visualization – Large, multi-dimensional and/or heterogeneous data sets arise from diverse sources, for example particle detectors, telescope images, and theoretical calculations. To understand such data requires advanced analysis, computation and visualization. The Department of Computer Science has internationally recognized expertise in data mining and information visualization and is focused on developing a presence in "visual analytics". Combined with analytical and modeling expertise in the Departments of Statistics and Mathematics, the availability of HPC, and area-specific expertise (e.g. in materials science), the Faculty is well positioned to make significant research contributions in this area.

V.2 Departmental Research Themes

In addition to the research described above, important research themes and clusters are also found primarily within individual departments.

Biological Sciences

Systems Biology – Systems Biology is the study of biology as an integrated and interacting network of genes, proteins, organisms, ecosystems, and the environment. Instead of analyzing individual components or aspects of an organism, systems biologists focus on all the components together and the interactions among them, as part of one system. The importance of such an "integrative" approach to biology has been widely recognized and is an important focus in the Department of Biological Sciences that can be built on existing research abilities. Research in systems biology could also generate collaborations within Science and with other faculties including Medicine, Engineering, Kinesiology and Environment, Earth & Resources.

Chemistry

Chemical structure and reactivity – Researchers in chemistry use and develop sophisticated experimental techniques (high-resolution microwave spectroscopy, in-situ X-ray diffraction, advanced NMR) and computational methods to analyze and model structure and reactivity of unusual molecules relevant to combustion, materials synthesis, catalysis, and solar and nuclear energy.

Drug Design and Synthesis –There is an existing group of researchers (including one CRC) that design and synthesize new drugs addressing important biological properties such as metastasis, infection, inflammation and signal transduction. This research uses CFI and NSERC funded NMR facilities, mass spectrometers, etc. to analyze molecular structure and develop cell-based production techniques. New work in this area is expected to lead to collaborations with Medical Microbiology, Biological Sciences, CancerCare Manitoba, the Faculties of Medicine and Pharmacy, and the Richardson Centre for Nutraceuticals.

Computer Science

Autonomous Systems – There is an active and internationally recognized group working on autonomous and robotic systems designed to operate in highly complex domains (e.g. the real world). This group has produced state of the art methods and algorithms for such problems as computer vision/perception under realistic conditions, reasoning and intelligent response, and cooperation between intelligent agents. They have had major and recurring success in the International Robocup and Hurocup competitions, regularly defeating teams from large institutions whose funding is orders of magnitude higher.

Computer Networks – The Department of Computer Science also has a number of researchers studying various aspects of computer networks ranging from the small scale (personal area and sensor networks) to the very large scale (distributed and parallel

systems). Research expertise includes media access control protocols, network performance analysis, parallel algorithm design and "systems" issues. This area overlaps partly with research done in Electrical & Computer Engineering and some collaborations are underway.

Mathematics

Algebra and Combinatorics –This area covers the research of many department members, including three distinguished professors and FRSCs. Two long-standing seminars are active in this area and have promoted a range of intra- and inter- departmental collaborations, evolving over time to address changing research interests. The seminar on "Universal Algebra and Lattice Theory" has a more than 40-year history and the seminar on "Rings and Modules" has met once a week for about 20 years.

Analysis and Topology –There is a wide range of research activity in this area including functional and abstract harmonic analysis, complex analysis and differential geometry, point-set topology, and approximation theory. Two weekly seminars have been active in this area for many years: the "Functional Analysis Seminar" and the "Topology and Its Applications Seminar".

Microbiology

Molecular Genetics and Molecular Biology –Molecular microbial genetics and molecular biology of fungi and bacteria lie at the core of basic microbiological research and provide the basic tools for many other disciplines. Almost every group in the department employs molecular techniques to probe such fundamental processes as gene regulation, gene structure, protein and metabolite transport processes, enzymatic catalysis, and cell growth which are at the core of research in the department.

Molecular Microbial Pathogenesis –Microorganisms from viruses to bacteria to fungi can infect plants and animals with both beneficial and deleterious outcomes. Several groups of researchers are investigating the mechanisms of infection leading to both pathogenesis and beneficial symbiosis, with the goal of designing new drugs and techniques to circumvent or combat disease or, alternatively, to enhance plant growth.

Systems Microbiology –Microorganisms are ubiquitous in nature and affect all aspects of our environment. The vast majority are either not yet identified or characterized. A broad spectrum of integrated research expertise exists in the department including molecular genetics, biochemistry, molecular biology, structural biology, microbial physiology, microbial pathogenesis, biotechnology, ecology, taxonomy, microbial biodiversity, molecular evolution, functional genomics and bioinformatics. This expertise is being applied to the study of microbiology as integrated networks of genes, proteins, organisms and ecosystems.

Physics and Astronomy

Astronomy and Astrophysics – This area addresses the origin, structure, and evolution of objects in the universe. Research includes the study of galaxies, their formation and evolution, and their dark matter content; the physics of neutron stars, supernova remnants and their interaction with the interstellar medium; theoretical investigations of star

formation, gravitational lensing, and planetary physics; as well as the development of algorithms and computational tools to model astrophysical systems. The department currently has three researchers in this area using both ground and space-based telescopes, including a Tier 2 CRC in high-energy astrophysics, using data from international X-ray and radio observatories. The department plans to hire a fourth researcher to further develop this area.

Sub-atomic Physics –This group has an internationally recognized research program in precision low-energy measurements of the fundamental symmetries in nature, making it the pre-eminent university-based group in this field in Canada. This is complemented by strategic theoretical efforts, and is supported through agreements with the TRIUMF national laboratory and international labs including Argonne and Jefferson Labs (US) and the Max Planck Institute (Germany). A new collaboration has also been formed recently to do experiments in fundamental neutron physics at the Spallation Neutron Source in Oak Ridge, TN. The group will continue to play a leadership role in large collaborations including a proposal to create a world-leading ultra-cold neutron facility at TRIUMF.

Statistics

Analysis of Complex Data in Medical and Health Sciences –Through the National Institute on Complex Data Structures (NICDS), the Department of Statistics has taken a leadership role in a "national program on statistical innovation for the analysis of complex data in medical and health sciences". This includes nonlinear modeling of longitudinal data with measurement errors and missing data.

Design and Analysis of Experiments – Researchers in the Department of Statistics also conduct research on the construction of optimally-designed experiments and the analysis of the resulting data. This includes balanced incomplete block designs in agricultural experiments, split-plot designs in industrial experiments and adaptive designs of clinical trials in medicine.

V.3 Potential New Research Themes

The Faculty of Science is positioned to take advantage of research opportunities based on its location in the City of Winnipeg and Province of Manitoba and on features that distinguish it from other Faculties of Science across Canada. These opportunities include being part of a university with a Faculty of Medicine, as well as our proximity to the National Microbiology Laboratory, Canadian Light Source and other facilities.

Biomedicine and Medical Physics– There is considerable expertise in the Faculty of Science in the areas of health and medicine. Other Faculties, as well as the City of Winnipeg, are also host to considerable expertise in this area providing the potential for high impact collaborations. The Department of Physics and Astronomy already has strong connections with CancerCare Manitoba, and is strengthening these connections and its activity in Medical Physics. This is likely an area for further growth and emphasis.

Energy and Sustainability – Our location in both time and space suggest that the Faculty of Science should develop its expertise in energy. Manitoba is a province whose economy is heavily reliant on energy, but it is also a net exporter of relatively clean

energy. Research into clean energy carriers and new fuel cell materials would lead to more efficient storage and use of hydro energy. Research in Chemistry includes ion conduction (fuel cells) and photo-catalytic splitting of water for hydrogen production as well as the establishment of reliable computational protocols with a focus on quantum-chemical approximations and solvation models. Researchers in Microbiology, in collaboration with researchers from the Faculty of Engineering, are already applying novel microorganisms to improve the efficiency of converting waste cellulose to ethanol.

Mathematical and Computational Finance – There is growing interest in this area, in the departments of Computer Science, Mathematics, and Statistics. Current research includes the use of mathematical, statistical and parallel computational techniques for the pricing of options. Some research in this area is done with the IIMS and is supported by MITACS (Mathematics of Information Technology and Complex Systems).

VI. The Planning Process

This strategic research plan was developed as part of a larger process to create an overall Strategic Plan for the Faculty of Science. Input from each department was compiled into a series of draft documents that were iteratively revised, primarily through discussions at the Faculty of Science Administrative Council. Final ratification of this document will be sought from Faculty Council in 2008.

This strategic research plan is designed as a "living" document that will evolve to reflect the changing research foci and priorities in the Faculty of Science. This evolution will be driven by changing research demands within the Faculty which, in turn, will be driven by a variety of factors, first of which will be research relevance and quality. The process of revision can be initiated either by the Faculty or by departments/researchers as required to meet specific needs.

Appendix A: Canada Research Chairs in the Faculty of Science

The Faculty of Science is committed to allocating and filling CRC positions strategically. Nominees must, of course, be excellent research scientists and mentors. Other criteria include: the importance of the proposed chair to the strategic development of research within the unit(s) proposing the chair, including research groups, and to other departments and/or Faculties; how the chair stimulates, or anchors, a critical mass; the potential of the chair to make a transformative difference; the relationship of the proposed Chair to the academic staffing plans of the appropriate unit(s); the relationship of the proposed chair to the strategic research plans of The University of Manitoba, the Faculty of Science, and the department(s) proposing the chair.

Area	Level	Department
Advanced Materials	1	Physics and Astronomy
Nanoscale Physics	1	Physics and Astronomy
Conducting Polymers and Electronic Materials	2	Chemistry
Protein Chemistry	1	Microbiology
Bioanalytical Mass Spectrometry	2	Chemistry
Supernova Astrophysics	2	Physics and Astronomy
Structural Biology	2	Chemistry
Phylogenomics – search underway	2	Biological Sciences

Appendix B: Plans and Recommendations

The Faculty of Science will support all research and researchers in the Faculty.

1. Staffing decisions will reflect the Strategic Research Plan and undergraduate teaching needs.
2. The Faculty of Science will seek additional funding to support a target enrollment of 400 graduate students. To be competitive, we estimate that we need an annual budget of $4 M per year, under the control of the Faculty of Science.
3. The Faculty will continue its mentoring of researchers and grant proposals.
4. The Faculty will continue its highly successful financial support of NSERC RTI (equipment) proposals.
5. The Faculty will build on our existing strengths, where possible, to make the Faculty of Science and the University of Manitoba a recognized international leader, especially in areas directly related to the Faculty's strategic research themes.
6. The Faculty will seek new opportunities based on a balance between evolving strengths in our existing and new strategic research themes. The balance at any time will be directed to developing the Faculty's overall research strength.
7. The Faculty will seek to find ways to support the exploration and development of new research areas not yet identified in this plan and to enhance and extend existing and developing collaborations.
8. The Faculty will seek to establish departmental research liaison positions to improve inter-departmental communication and facilitate collaborations and broader student training opportunities.
9. The Faculty will continue to foster joint research opportunities with other faculties (in particular, the Faculties of Engineering, Medicine, Environment, Earth & Resources, and Agricultural & Food Sciences) and institutions.
10. The Faculty will create an inventory of research, highlighting the facilitation of inter-departmental and inter-faculty collaborations.
11. The Faculty will continue to seek CRCs strategically, to foster the success of multiple researchers and areas.
12. Where appropriate, the Faculty will move away from the "one lab per faculty member" model to a model of shared resources.
13. The Faculty will promote more connections with industry, including Industrial Research Chairs, NSERC industrial graduate fellowships, and other funding and collaboration opportunities.
14. The Faculty will continue to renovate and renew existing labs and research facilities across the faculty.
15. The Faculty will ensure the development of space for the Department of Biological Sciences.
16. The Faculty will work to greatly enhance the research and other space occupied by the Department of Mathematics and Department of Statistics.

17. The Faculty will work to enhance the research use of the Delta Marsh Field Station.
18. The Faculty will seek to replace the greenhouse adjacent to the Buller Building.
19. The Faculty will continue to support the creation of the Manitoba Materials Research Institute, and will seek to renovate the old cyclotron space as a home for the institute.
20. In Environmental Sciences, the Faculty will explore joint research possibilities with the Faculty of Environment, Earth & Resources and others and will also actively seek out other research opportunities.
21. The Faculty will continue its considerable efforts and investment towards creating a high performance computing presence for the University of Manitoba.
22. The Faculty will support the activities of the proposed Prairie Network of Mathematical Sciences.
23. The Faculty continues to strongly support the University's full membership in TRIUMF and also promotes membership in the National Institute for Complex Data Structures (NICDS).
24. The Faculty will always be prepared to be opportunistic, and take advantage of unanticipated developments and opportunities.