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1 The Faculty

1.1 Location

Dawson Hall
853 Sherbrooke Street West
Montreal, QC H3A 2T6
Canada

Telephone: (514) 398-4210
Faculty Website: http://www.mcgill.ca/science
Student Affairs Office Website:
http://www.mcgill.ca/artscisao

The Student Affairs Office and the Office of the Associate Dean of the Faculty of Science are located in Dawson Hall, Rooms 110 and 115.

The Student Affairs Office serves students in both the Faculty of Science and the Faculty of Arts.

1.2 Faculty Administrative Officers

ALAN G. SHAVER, B.Sc.(Car.), Ph.D.(M.I.T.) **Dean**

MORTON J. MENDELSON, B.Sc (McG.), A.M., Ph.D.(Harv.) **Associate Dean (Academic and Student Affairs)**

KEITH FRANKLIN, B.A., M.A.(Auck.), Ph.D.(Lond.) **Associate Dean (Research)**

JOSIE D'AMICO **Assistant to the Dean**

SHARON BEZEAU, B.A.(Tor.), M.A.(C'dia) **Recorder and Chief Invigilator**

DONALD SEDGWICK, B.Sc., M.Sc.(McG.) **Senior Adviser**

1.3 Programs and Teaching in Science

The Faculty of Science is committed to providing outstanding teaching and research facilities. The Faculty draws on its involvement in cutting-edge research to ensure teaching excellence at the undergraduate level. Professors who are spearheading projects that are changing people's understanding of the world teach regularly at the undergraduate level. Also, research-based independent study courses offer students the opportunity to contribute to their professors' work, rather than just learn about it.

In an effort to supplement classroom learning with real life experience, the Faculty of Science has increased opportunities for undergraduate students to participate in fieldwork. Certain B.Sc. programs can include an internship component. This is on top of the many undergraduate students the Faculty hires for Work-Study projects and other research programs. McGill Science students have an opportunity to get involved in the structuring of their own education. A Science Undergraduate Society initiative launched Operation Open

Access, a project that gives Science students universal access to email, the Internet, and the latest in science software through computer 'infopoints' located in areas of the campus frequented by Science students.

The Faculty of Science offers programs leading to the degree of Bachelor of Science (B.Sc.). Admission is selective; fulfilment of the minimum requirements does not guarantee acceptance. Admission criteria are described under "Admission Requirements" beginning on page 13.

There are also two Diploma programs offered in Science.The Diploma in Environment, a 30-credit program available to holders of a B.Sc. or B.A. or equivalent, is described in the section on the McGill School of Environment, page 471. The Diploma in Meteorology is a one-year program available to holders of a degree in Mathematics, Engineering, Physics and other appropriate disciplines who wish to qualify for a professional career in Meteorology. For more information, see Atmospheric and Oceanic Sciences, page 362. All credits for these diplomas must be completed at McGill.

The concurrent B.Sc./B.Ed. program is designed to provide students with the opportunity to obtain both a B.Sc. and a B.Ed. after a minimum of 135 credits of study. For more information see section 11.28 and the Faculty of Education section 5.1.3.

A Bachelor of Software Engineering program (subject to Ministry of Education Approval) will be offered jointly with the Faculty of Engineering; see Faculty of Engineering section, page 252.

1.4 Student Affairs Office

The Student Affairs Office, located in Dawson Hall, provides assistance in interpreting records as well as general academic information and advice on the following: prerequisites and programs, degree requirements, registration, course change, procedures for withdrawal, deferred exams, supplemental exams, rereads, academic standing, inter-faculty transfer, year or term away, transfer credits, second programs, second degrees, and graduation.

Special requests can be made, in writing, to the Associate Dean (Academic and Student Affairs).

The Committee on Student Standing (CSS) will consider appeals of the Associate Dean's decisions. For information about CSS, see the Associate Dean's secretary.

2 Faculty Degree Requirements

Each student in the Faculty of Science must be aware of the Faculty Regulations as stated in this Calendar. While departmental and faculty advisers and staff are always available to give advice and guidance, the ultimate responsibility for completeness and correctness of course selection and registration, for compliance with, and completion of, program and degree requirements, and for the observance of regulations and deadlines *rests with the student*. It is the student's responsibility to seek guidance from the Student Affairs Office if in any doubt; misunderstanding or misapprehension will not be accepted as cause for dispensation from any regulation, deadline, program or degree requirement.

To be eligible for a B.Sc. degree, students must fulfil all Faculty and program requirements as indicated below:

Minimum Credit Requirement (section 2.1)
Residency (section 2.2)
CGPA (section 2.3)
Time Limit for the Completion of the Degree (section 2.4)
Program Requirements (section 2.5)
Course Requirements (section 2.6)

2.1 Minimum Credit Requirement

Each student's minimum credit requirement for the degree is determined at the time of acceptance and is specified in the letter of admission.

Normally, Quebec students who have completed the Diplôme d'études collégiales (DEC) or equivalent diploma are admitted to a three-year program requiring the completion of 90 credits. Quebec students with a DEC 'en sciences' have normally completed the equivalent of, and are therefore exempt from, the basic science courses in Biology, Chemistry, Mathematics and Statistics, and Physics.

Students from outside Quebec are normally admitted to a four-year program requiring the completion of 120 credits, but advanced standing of up to 30 credits may be granted to students who obtain satisfactory results in International Baccalaureate, French Baccalaureate, and Advanced Placement tests.

Students who are readmitted after interrupting their studies for a period of five consecutive years or more may be required to complete a minimum of 60 credits and satisfy the requirements of a program. In this case, a new CGPA will be calculated. The Associate Dean, in consultation with the appropriate department, may approve a lower minimum for students who had completed 60 credits or more before interrupting their studies.

Students who are readmitted after a period of absence are subject to the program and degree requirements in effect at the time of readmission. The Associate Dean, in consultation with the department, may approve exemption from any new requirements.

2.2 Residency

To obtain a B.Sc. degree, students must satisfy the following residency requirements: a minimum of 60 credits of courses must be taken and passed at McGill, exclusive of any courses completed as part of the basic science requirements defined below. At least two-thirds of all departmental program requirements (Honours, Major, Faculty Program, or Minor) must **normally** be completed at McGill. However, students in Honours, Major, and Faculty Programs who pursue an approved Study Away or Exchange Program may, with departmental approval, be exempted from the two-thirds rule. In addition, some departments may require that their students complete specific components of their program at McGill.

The residency requirement for diplomas is 30 credits completed at McGill.

2.3 Cumulative Grade Point Average (CGPA)

Each candidate for the degree must achieve a minimum cumulative grade point average (CGPA) of 2.00.

2.4 Time Limit for the Completion of the Degree

Students registered in 90-credit programs are expected to complete their program in no more than eight terms after their initial registration for the degree. Students who exceed these limits must receive permission from the Faculty to continue their studies. Permission for exceeding the time limits will normally be granted only for valid academic reasons, such as a change of program (approval of the department is required) and part-time status.

Students in the Freshman Program become subject to these regulations one year after their initial registration.

2.5 Program Requirements

2.5.1 Freshman Program and Basic Science Requirements

Students who need 97-120 credits (four years) to complete their degree requirements must register in the Science Freshman Program, which is designed to provide the basic science foundation for a student's subsequent three-year Faculty, Major, or Honours program. The basic science requirements are as follows: two semesters each of calculus, general chemistry, and general physics, and one semester of biology.

Students who have completed Advanced Placement exams, Advanced Levels, the International Baccalaureate, the French Baccalaureate, or McGill placement examinations may receive exemption and/or credit for all or part of the basic science requirements. Similarly, students who have completed courses at other universities or colleges may receive exemptions and/or credits.

For a more detailed description of the Science Freshman Program, students should consult the Arts and Science Freshman Student information available on the Internet, http://www.mcgill.ca/artscisao.

2.5.2 Faculty, Major, and Honours Programs

Science students who need 96 or fewer credits to complete their degree requirements are required to have an approved degree program and to select their courses in each term with a view to timely completion of their degree and program requirements. Students must register in one of the following types of departmental programs leading to the degree of Bachelor of Science:

A Faculty program is an approved coherent selection of courses giving students a useful concentration in a recognized area. Students in a Faculty program may choose a pattern of study that can range from one yielding a broad education to one specializing in particular areas.

Major programs are more specialized than Faculty programs and are usually centred on a specific discipline or department. For prospective teachers, the Faculty also offers Major programs in two subjects that can constitute the Science component of the Concurrent B.Sc./B.Ed. Program. For more information about this joint degree, please consult section 2.5.5.

Honours programs typically involve an even higher degree of specialization, often include supervised research, and require students to maintain a high academic standard. Although Honours programs are specially designed to prepare students for graduate studies, graduates of the other degree programs are also normally admissible to most graduate schools. Students who intend to pursue graduate studies in their discipline should consult a departmental adviser regarding the appropriate selection of courses in their field.

2.5.3 Minor and Minor Concentration Programs

In addition to the above degree programs, students in the Faculty of Science may select a Minor program. These are coherent sequences of courses in a given discipline or interdisciplinary area that may be taken in addition to the courses required for the degree program.

Science Minors consist of up to 24 credits.

Arts Minor Concentrations consist of 18 credits.

A minimum of 18 new credits must be completed in the Minor or Minor Concentration.

2.5.4 Other Second Programs

In addition to a Faculty, Major, or Honours program, students may pursue a second Faculty, Major, or Honours program, or an Arts Major Concentration program. A minimum of 36 new credits must be completed in the second program.

2.5.5 Concurrent B.Sc./B.Ed. program

This program was designed to provide students with the opportunity to obtain both a Bachelor of Science degree and a Bachelor of Education degree after a minimum of 135 credits of study. In the B.Sc. component, students must major in one of the following subject combinations: Mathematics and Physics, Mathematics and Chemistry, Chemistry and Physics, Biology and Chemistry, Biology and Geography, Biology and Mathematics. For more information about this program, students should refer to section 11.28 and to the Faculty of Education section 5.1.3.

2.5.6 Internship Program for Engineering and Science (IYES)

Certain B.Sc. programs offered by the Department of Atmospheric and Oceanic Sciences, the Department of Mathematics and Statistics, the Department of Physics, and the School of Computer Science can include an internship component (refer to section 10.7). Students from other departments are also eligible to apply for an internship year, but this will not be part of their degree designation. For program details, students should refer to the Faculty of Engineering section 2.8.

2.5.7 McGill School of Environment

The Faculty of Science is one of the three faculties in partnership with the McGill School of Environment. Please see the School section on page 471 of this Calendar.

2.5.8 Bachelor of Software Engineering and B.Sc. in Software Engineering

The School of Computer Science, jointly with the Department of Electrical and Computer Engineering, will offer a Bachelor of Software Engineering program (subject to Ministry of Education approval). Graduates of the B.S.E. program should be eligible for accreditation (once accreditation standards for Software Engineers have been adopted). For program details, students should refer to the Faculty of Engineering section, page 252.

The School of Computer Science will also offer a B.Sc. Major program in Software Engineering (subject to Ministry of Education approval). For details of the B.Sc. Major, students should refer to the Faculty of Science section 11.8. The B.Sc. program **will not** lead to accreditation.

2.6 Course Requirements

All required and complementary courses used to fulfil program requirements, including the basic science requirements, must be completed with a grade of C or better. Students who fail to obtain a satisfactory grade in a required course must either pass the supplemental examination in the course or do additional work for a supplemental grade, if these options are available, or repeat the course. Course substitution will be allowed only in special cases; students should consult their academic adviser.

Normally, students are permitted to repeat a failed course only once. (Failure is considered to be a grade of less than C or the administrative failures of J and KF.) If a required course is failed a second time, a student may appeal to the Associate Dean for permission to take the course a third time. If permission is denied by the Associate Dean and/or by the Committee on Student Standing, on appeal, the student must withdraw from the program. If the failed course is a complementary course required by the program, a student may choose to replace it with another appropriate complementary course. If a student chooses to substitute another complementary course for a complementary course in which a D was received, credit for the first course will still be given, but as an elective. If a student repeats a required course in which a D was received, credit will be given only once.

Full details of the course requirements for all programs offered are given in each unit's section together with the locations of departmental advisory offices, program directors, and telephone numbers should further information be required.

2.6.1 Course Overlap

Students will not receive credit towards their degree for any course that overlaps in content with a course passed at McGill, CEGEP, at another university or elsewhere. It is the student's responsibility to consult the Student Affairs Office or the department offering the course as to whether or not credit can be obtained and to be aware of exclusion clauses specified in the course description in the Calendar.

Sometimes the same course is offered by two different departments. Such courses are called "double-prefix" courses. When such courses are offered simultaneously, students should take the course offered by the department in which they are obtaining their degree. For example, in the case of double-prefix courses Chemistry 180-XYZ and Physics 189-XYZ, Chemistry students would take 180-XYZ and the Physics students would take 189-XYZ. If a double-prefix course were offered by different departments in alternate years, students could take whatever course best fits their schedule.

Credit for computer and statistics courses offered by faculties other than Science requires the permission of the Associate Dean of Science (Academic and Student Affairs) and will be granted only under exceptional circumstances.

Credit for statistics courses will be given with the following stipulations:

1. Credit will be given for ONLY ONE of the following introductory statistics courses: 154-227D, 154-257D, 166-350A, 177-373A, 186-215B, 189-203A/B/C/L, 204-204A/B, 280-271A/B, 360-310A.
2. Credit will be given for ONLY ONE of the following intermediate statistics courses: 154-227D, 154-257D, 166-461B, 177-483B, 183-351B, 189-204B, 204-305A/B, 280-272B, 360-411B.
3. Students in Mathematics or Computer Science programs, and students who have already received credit for 189-324B, will NOT receive credit for any of the following: 154-227D, 154-257D, 166-350A, 177-373A, 186-215B, 189-203A/B/C/L, 189-204B, 204-204A/B, 204-305A/B, 280-271A/B, 280-272B, 360-310A, 360-411B.
4. For 500-level statistics courses not listed above, students must consult a program advisor to ensure that no significant overlap exists. Where such overlap exists with a course for which the student has already received credit, credit for the 500 level course will not be allowed.
5. Credit for statistics courses offered by faculties other than Arts and Science requires the permission of the Associate Dean of Science (Academic and Student Affairs), except for students in the B.Sc. Major in Environment, who may take required statistics courses in the Faculty of Agricultural and Environmental Sciences necessary to satisfy their program requirements.

2.6.2 Project Courses

Students may normally receive no more than 12 credits for individual project or independent study courses toward a B.Sc. degree.

2.6.3 Courses Outside the Faculties of Arts and Science

Students in the Faculty of Science should consult the statement of regulations for taking courses outside the Faculties of Arts and of Science. The regulations are posted in the Student Affairs Office, Dawson Hall, and on the Internet, http://www.mcgill.ca/artscisao. A list of approved/not approved courses in other faculties is posted with the regulations; students may take courses on the approved list and may not, under any circumstances, take courses on the not-approved list. Request for permission to take courses that are not on either list should be addressed to the Associate Dean.

The regulations are as follows:

- except for Music performance courses, courses taught in other faculties *and* specifically listed in the Arts or Science section are considered as courses taught in Arts or Science;
- restrictions apply to Music courses, even those listed in the Arts or Science section, unless the courses are part of a Minor in Music;
- courses in other faculties can be taken as elective courses or as part of a program as specified in the Calendar;
- students may take only 6 credits per year, up to 18 credits in all, of courses outside the Faculties of Arts and of Science;
- students must have the necessary prerequisites and permission of the instructor for such courses;
- credit for courses in Education and Continuing Education requires the permission of the Associate Dean of Science;
- credit for computer and statistics courses offered by faculties other than Arts and Science requires the permission of the Associate Dean of Science and will be granted only under exceptional circumstances;
- students who use MARS to register for a course that exceeds the specified limitations or that is not approved will have the course flagged for no credit after the course change period;
- credit will not be given for any “how to” courses offered by other faculties that are intended to provide students with only practical or professional training in specific applied areas. Examples include courses that teach the use of certain computer packages (databases, spreadsheets, etc.) or computer languages (SQL, COBOL, FORTRAN, etc.), machine shop or electronic shop courses, technical drawing courses, and professional practice courses.
- students in the McGill School of Environment may take as many courses outside the Faculties of Arts and of Science as are necessary to complete their program of study;
- students taking the Minor in Management may take 21 credits of courses outside of the Faculties of Arts and of Science;
- the 18-credit limit applies to students taking the Minor in Nutrition; equivalent courses in Science should be taken instead of courses in the Faculty of Agriculture and Environmental Sciences.

2.6.4 Courses Taken Under the Satisfactory/ Unsatisfactory Option

Students may take one elective course per term that is to be graded under the Satisfactory/Unsatisfactory Option, to a maximum of 10% of credits taken at McGill to fulfil their degree requirements. The decision to have an elective course graded as Satisfactory/ Unsatisfactory must be made by students before the end of the Drop/Add period. For more information, students should consult the General University Information section 4.8.

2.6.5 Courses in English as a Second Language (ESL)

ESL courses are open to Science students under the regulations specified by the English and French Language Centre.

2.6.6 Auditing of Courses

No auditing of courses is permitted at McGill.

3 Advising

Fall-term advising for newly admitted students takes place during the week prior to the beginning of classes. Students who are newly admitted to the winter term should consult the Calendar of Dates for exact advising dates.

Students who need 96 or fewer credits to complete their degree requirements must consult an academic adviser in their proposed department of study to obtain advice and approval of their course selection. Quebec students with a DEC 'en sciences' have normally taken the equivalent of and are therefore exempt from the 100-level basic science courses in Biology, Chemistry, Mathematics and Statistics, and Physics, such students may also be exempt from some 200-level courses. Students with satisfactory results in International Baccalaureate, French Bacculaureate, and Advanced Placement tests may also be exempt from some or all of the basic sciences courses. To facilitate program planning, they must present their transcripts and letters of admission. For a detailed description of advising and registration procedures, students should refer to *Welcome to McGill*, which they receive upon acceptance from the Admissions, Recruitment and Registrar’s Office, as well as to the three-year program information posted on the Internet, http://www. mcgill.ca/artscisao.

Students who need 97-120 credits to complete their degree requirements will normally be registered in a Freshman Program until they complete their first year. They must consult an adviser in the Student Affairs Office to obtain advice and approval of their course selection. For a detailed description of advising and registration procedures, Freshman students should refer to *Welcome to McGill*, which they receive upon acceptance from the Admissions, Recruitment and Registrar’s Office, as well as the four-year program information on the Internet, http://www.mcgill.ca/artscisao.

Advising for all returning students takes place in March for the coming academic year. For more information, students should refer to the Returning Students information on the Internet, http://www.mcgill.ca/artscisao.

Advising is also available by email. The address is advisor@artsci.lan.mcgill.ca.

4 Registration

All students register by MARS, McGill's automated registration system.

New students register in August prior to the first day of classes. For detailed information about registration, students should refer to the General University Information and Regulations section 3, *Welcome to McGill*, and to the First-Year Student information on the Internet, http://www.mcgill.ca/artscisao.

Returning students register in March for the coming academic year. For detailed information about registration, students should refer to the General University Information and Regulations section 3, and to the Returning Students Information on the Internet, http://www.mcgill.ca/artscisao.

Students who fall into unsatisfactory standing at the end of the academic year will have their registration cancelled. They may not reregister in the Faculty. However, students who can provide proof of exceptional extenuating circumstances that affected their academic performance may appeal to the Associate Dean of Science for readmission. For more information, students should consult the Student Affairs Office, Dawson Hall, or read the information on the Internet, http://www.mcgill.ca/artscisao.

Students who have an outstanding fee balance from a previous term or outstanding fines will not be permitted to register. In addition, students who have registered for the upcoming academic year, but subsequently take summer courses without paying the fees, will have their registration cancelled. Registration on MARS will be denied until these debts are paid in full. Students must pay all debts before the end of the Registration period to be permitted to reregister. Students with financial problems should consult the Student Aid Office, Brown Student Services Building.

Students who decide not to return to McGill after initiating registration through MARS must either complete a withdrawal form in person or write a letter addressed to the Student Affairs Office, Faculty of Science, Dawson Hall, Room 115, 853 Sherbrooke Street West, Montreal, Quebec, H3A 2T6. Scholarship students should note that scholarship money is deposited directly into their University fee account; the University requires a formal request for withdrawal before the scholarship money can be released from the fee account.

4.1 Program Registration

Students should refer to *Welcome to McGill* or the Arts and Science Registration information on how to register for programs on MARS.

See section 10 for a list of programs which can be taken by Science students. MARS program codes are included with the program outlines in the units' entries unless the program is one for which program registration cannot be done on MARS, e.g. Minor in Management.

4.2 Course Registration

All courses have limited enrolment.

Subject to the course restrictions listed in this section and unless otherwise indicated, students in the Faculty of Science may register for and take for credit any course in the sections of the Calendar applicable to the Faculties of Arts and of Science.

Since the MARS system is unable to verify whether or not Faculty regulations are respected, it is technically possible to register for courses that are closed to Science students. When students' records are manually verified, however, any "closed" courses will be flagged after the end of course change period as "not for credit towards the B.Sc.". As a result, the students' expected date of graduation may be delayed.

Some courses may require special permission. Students should consult this Calendar and/or the timetable to determine if permission is required of the instructor, the department, or the Faculty, or if password cards must be obtained, for any course they wish to take.

Students who believe they have valid reasons to take a course that is normally closed to Science students must obtain permission from the Associate Dean of Science (Academic and Student Affairs) before registering for the course. Only the Associate Dean or, on appeal, the Committee on Student Standing, can make exceptions to the Faculty rules.

4.2.1 Registration for First-Year Seminars

Registration for First-Year Seminars is limited to students in their first year of study at McGill. These courses are designed to provide a closer interaction with professors and better working relations with peers than is available in large introductory courses. These seminars endeavour to teach the latest scholarly developments and expose participants to advanced research methods. Registration is on a first-come, first-served basis through MARS. The maximum number of students in any seminar is 25, although some are limited to even fewer than that. Students may take only one seminar. Please consult the departmental listings for course descriptions and availability.

180-199A	Why Chemistry? (see Chemistry)
183-199A	People, Place and Environment (see Geography)
195-199B	Weather, Climate, History (see Atmospheric and Oceanic Sciences)
308-199A	Excursions in Computer Science (see Computer Science)
555-199A	Mental Illness and the Brain (see Psychiatry)

The First-Year Seminars offered by the Faculty of Arts are also open to Science students. For a complete listing, please consult Arts section 4.2.1.

4.3 Registration for Graduation

Students in their final year must indicate their expected date of graduation on MARS and must verify this date both on MARS and on verification forms. When final-year students change their expected date of graduation, they must notify the Student Affairs Office immediately. Failure to do so may postpone graduation.

Students who complete their degree requirements at any time after their last registered term at McGill must apply to the Associate Dean (Academic and Student Affairs) to graduate. Application to graduate must be made sufficiently in advance of the expected graduation date to allow the Faculty to verify the student's record. For further information, students should contact the Student Affairs Office.

5 Grading and Credit

Before the end of the course change (drop/add) period, each instructor will inform students of the following:

- whether there will be a final examination in the course;
- how term work will affect the final mark in the course;
- how term work will be distributed through the semester;
- whether letter grades or percentages will be given in the course;
- whether there will be a supplemental examination in the course, and if so, whether term work will be included in the supplemental grade (courses normally have supplemental examinations, and courses with formal final examinations *must* have supplementals);
- whether students with marks of D, F, J or U will have the option of submitting additional work, and, if so, how the supplemental mark will be calculated with the extra work.

5.1 Incomplete Grades

An instructor who believes that there is justification for a student to delay submitting term work may extend the deadline until after the end of the course. In this case, the instructor will submit a grade of K (incomplete), indicating the date by which the work is to be completed. The maximum extensions for the submission of grades to the Student Affairs Office are as follows:

- students graduating in June: A, B, D courses: April 30
- non-graduating students: A courses: April 30
  B, D courses: July 30

Students' deadlines for submitting their work must be sufficiently in advance of these dates to ensure that the work can be graded and the mark submitted on time. Please consult the General University Information section 4.7 for more information about grading and credit.

6 Examinations

Students should refer to the General University Information section 5 for information about final examinations and deferred examinations.

7 Supplemental Assessments

7.1 Supplemental Examinations

Students who wish to write supplemental examinations for certain courses must apply to the Student Affairs Office for permission. The following conditions apply:

- students must be in satisfactory or probationary standing;
- students must have received a final grade of D, F, J or U in the course;
- students must avail themselves of this privilege at the time of the next supplemental examination period;
- special permission is required if a student wishes to write supplementals totalling more than 8 credits;
- only one supplemental examination is allowed in a course;
- the supplemental result may or may not include the same proportion of class work as did the original grade; the instructor will announce the arrangements to be used for the course by the end of the change of course period;
- the format of the supplemental examination (e.g., multiple-choice or essay questions) will not necessarily be the same as the format for the final examination, so students should consult the instructor about the format of the supplemental;
- the supplemental result will not erase the grade originally obtained, which is used in calculating the GPA; both the original mark and the supplemental result will be calculated in the CGPA;
- in courses in which both a supplemental examination and additional work are available, the student may choose the additional work or the examination or both; where both are written, only one supplemental mark will be submitted, reflecting marks for both the supplemental examination and the additional work;
- additional credit will not be given for a supplemental exam where the original grade for the course was a D and the student already received credit for the course;
- supplemental examinations in courses outside the Faculties of Arts or of Science are subject to the deadlines, rules and regulations of the relevant faculty.

For courses in the Faculties of Arts and of Science, the supplemental examination period for A courses is during the months of April and May, and for B and D courses during the last week of August. Supplemental applications are available at the Student Affairs Office. The deadline for submission of applications is March 1 for A courses and July 15 for B and D courses. A non-refundable fee for each supplemental paper is payable at the time of application. Students who register for a supplemental examination and subsequently find themselves unprepared for it should not write it; except for the loss of the registration fee, there is no penalty for not writing a supplemental examination. Students should consult the Student Affairs Office for further information.

7.2 Additional Work

Instructors of courses that include graded written term work may choose to provide the option of additional work to eligible students. The following conditions apply:

- if there is an option for additional work, it must be announced in the course outline at the beginning of the course;
- additional work involves revising one or more previously submitted papers or submitting new written work to replace the original work;
- students must be in satisfactory or probationary standing;
- students must have received a final grade of D, J, F, or U in the course;
- the weight of the additional work will be equal to the weight given the work revised or replaced when the original mark was submitted;
- the mark resulting from the revised or additional work will be recorded as a supplemental mark;
- the supplemental result will not erase the grade originally obtained, which is used in calculating the GPA; both the original mark and the supplemental mark will count in calculating the CGPA;
- in courses in which both a supplemental examination and additional work are available, the student may choose the additional work or the examination or both; where both are written, only one supplemental mark will be submitted, reflecting marks for both the supplemental examination and the additional work;
- additional work in courses outside the Faculties of Arts and of Science is subject to the deadlines, rules, and regulations of the relevant faculty.

Additional work applications are available in the Student Affairs Office. The deadline for submission of applications is Marc h1 for A courses and July 15 for B and D courses. A non-refundable fee is payable for each course at the time of application. Students should consult the Student Affairs Office for further information.

7.3 Reassessments and Rereads

In accordance with the Charter of Student Rights, and subject to the conditions stated therein, students have the right to consult any written submission for which they have received a mark as well as the right to discuss this submission with the examiner.

If, after discussion with the instructor, students request a formal final examination re-read, they must apply in writing to the Student Affairs Office. The following conditions apply:

- requests for rereads in more than one course per term will not be permitted;
- grades may be either raised or lowered as the result of a reread;
- rereads in courses outside the Faculty of Science are subject to the deadlines, rules and regulations of the relevant faculty.

Application for rereads must be made by March 31 for fall-term courses and by September 30 for winter-term and summer-term courses. Students are assessed a fee for formal rereads. Any request to have term work re-evaluated must be made directly to the instructor concerned. Students should consult the Student Affairs Office for further information.

8 Academic Standing

Academic standing is based on students' grade point average (GPA) for the fall and/or winter-term grades. Academic standing is assessed immediately following the winter-term examination period and determines if students will be allowed to continue their studies in the next academic year and if any conditions will be attached to their studies.

Satisfactory Standing

Students in satisfactory standing may continue in their program.

- New students are admitted to satisfactory standing;
- students whose GPA and CGPA are both 2.00 or greater are in satisfactory standing;
- students who were previously in probationary standing will return to satisfactory standing if their GPA is 2.50 or greater;
- students who were previously in unsatisfactory standing and who were readmitted on probation by the Associate Dean or the Committee on Student Standing will return to satisfactory standing if they satisfy the conditions specified in their letter of readmission.

Probationary Standing

Students in probationary standing may continue in their program but must carry a reduced load (maximum 12 credits per term) and raise their sessional and cumulative GPA to return to satisfactory standing (see above). Probationary students should see their departmental adviser to change their course selection accordingly.

- Students who were previously in satisfactory standing will be placed in probationary standing if their GPA falls between 1.50 and 1.99;
- students who were previously in probationary standing will remain in probationary standing if their GPA falls between 1.50 and 1.99 and their CGPA is 2.00 or higher;
- students who were previously in unsatisfactory standing and who are readmitted by the Associate Dean or the Committee on Student Standing are placed in probationary standing.

Unsatisfactory Standing

Students in unsatisfactory standing have failed to meet the minimum standards set by the Faculty. They may not continue in their program, and their registration will be cancelled.

Appeals for readmission should be addressed to the Associate Dean no later than July 15 for readmission to the fall term and November 15 for the winter term. Readmission will be considered only when proof of extenuating circumstances that affected academic performance can be provided (e.g., medical or other documentation).

Normally supplemental examinations are not permitted; however, students in unsatisfactory standing may appeal to the Associate Dean for permission to write a supplemental examination, clearly stating the reasons for special consideration and providing proof as appropriate.

- Students will be placed in unsatisfactory standing if their GPA falls below 1.50;
- students who were previously in probationary standing will be placed in unsatisfactory standing if their GP Afalls below 2.50 and their CGPA is below 2.00;
- students who were previously in unsatisfactory standing and who were readmitted to probationary standing by the Associate Dean or the Committee on Student Standing and who have not satisfied the conditions specified in the letter of readmission will be placed in unsatisfactory standing;
- students in unsatisfactory standing for the second time must withdraw permanently.

Students in the Concurrent B.Sc./B.Ed. Program who receive an F or J in any Education Field Experience course are placed in unsatisfactory standing. Although they may complete their semester, they are required to withdraw from the Concurrent Program. However, they may apply to transfer to a conventional B.Sc. program as outlined in section 11.28.

Incomplete Standings

Standing awaits deferred exam
Must clear K's, L's or SUPPS
Standing Incomplete

Students with incomplete standings may register for the following term, but their standing must be resolved by the end of course change period for that term; otherwise, their registration will be cancelled. Students whose incomplete standing changes to satisfactory or probationary standing may continue in the program. Students whose standing changes to unsatisfactory standing may not continue in their program, and their registration will be cancelled.

Students whose standing changes to unsatisfactory and who wish to ask for permission to continue in their program must make a request to the Associate Dean as soon as they are placed in unsatisfactory standing. Readmission will be considered only when proof of extenuating circumstances that affected academic performance can be provided (e.g., medical or other documentation).

Students whose standing is still incomplete by the end of course change period should immediately consult with the Student Affairs Office.

- Students whose records in any year show a mark of K, L, or && will have no GPA or CGPA calculated for that year. If the outstanding mark will not affect the result, a standing decision of satisfactory, probationary, or unsatisfactory will be made in June. Otherwise, the standing decision will only be made once final marks for K or L have been submitted.
- If marks to clear Ks have not been submitted to the Student Affairs Office by the end of April for fall-term courses or by the end of July for winter-term courses, the K is automatically changed to a KF and counts as an F in the GPA.
- Marks to clear Ls are normally submitted to the Student Affairs Office three days after the end of the deferred and supplemental exam periods in May and August.

9 Awards and Honourary Designations

9.1 Honours and First-Class Honours

Departments may recommend to the Faculty that graduating students registered in an Honours program be awarded *Honours* or *First-Class Honours* under the following conditions:

- students must complete all requirements imposed by the department;
- for *Honours*, the CGPA at graduation must be at least 3.00;
- for *First-Class Honours*, the CGPA at graduation must be at least 3.50;
- some departments may impose additional requirements, which must be met before students are recommended for *Honours* or *First-Class Honours*. These will be found in the departmental descriptions of Honours programs.

Students in an Honours program whose GPA is below 3.00 or who did not satisfy certain program requirements must consult their adviser to determine if they are eligible to graduate in a program other than Honours.

9.2 Distinction or Great Distinction

Students in Faculty or Major programs whose academic performance is appropriate may be awarded their degrees with *Distinction* or *Great Distinction* under the following conditions:

- students must have completed a minimum of 60 McGill credits to be eligible;
- for *Distinction*, the CGPA at graduation must be 3.30 to 3.49;

- for *Great Distinction*, the CGPA at graduation must be 3.50 or greater;
- these designations may be withdrawn, in the case of transfer students, if their CGPA in another faculty or at another university is not comparable to the CGPA earned in the Faculty of Science.

9.3 Dean's Honour List

The designation *Dean's Honour List* may be awarded to graduating students under the following conditions:

- students must have completed a minimum of 60 McGill credits to be considered;
- students must be in the top 10% of the Faculty's graduating students;
- this honorary designation may be withdrawn, in the case of transfer students, if their CGPA in another faculty or at another university is not comparable to the CGPA earned in the Faculty of Science.

9.4 Medals and Prizes

Various medals, scholarships and prizes are open to graduating students. Full details of these are set out in the *Undergraduate Scholarships and Awards Calendar,* available in the Admissions, Recuitment and Registrar's Office or on the ARR website (http://www.aro.mcgill.ca). No application is required except in the case of the Moyse Travelling Scholarships.

10 Lists of Programs Offered

10.1 Faculty Programs

Anatomy and Cell Biology
Biochemistry
Biology
Biology and Mathematics – see Biology
Chemistry
Chemistry and Biological Sciences – see Chemistry
Chemistry and Mathematics – see Chemistry
Mathematics and Computer Science – see Mathematics and Statistics*
Mathematics, Statistics and Computer Science – see Mathematics and Statistics*
Mathematics, Chemistry and Physics – see Mathematics and Statistics
Microbiology and Immunology – application required, see departmental entry for information.
Physics
Physiology
Psychology
* also check with the School of Computer Science, since that unit may limit enrolment.

10.2 Major Programs

Anatomy and Cell Biology
Atmospheric Science
Biochemistry
Biology
Biology and Chemistry for Teachers – see Science for Teachers
Biology and Geography for Teachers – see Science for Teachers
Biology and Mathematics for Teachers – see Science for Teachers
Chemistry
Chemistry (Bio-organic option)
Chemistry (Environmental Chemistry option)
Chemistry (Materials)
Chemistry and Physics for Teachers – see Science for Teachers
Computer Science – application required, see unit entry for information
Earth and Planetary Sciences
Environment (Atmospheric Environment and Air Quality domain) – see McGill School of Environment
Environment (Biodiversity and Conservation domain) – see McGill School of Environment
Environment (Earth Sciences and Economics domain) – see McGill School of Environment
Environment (Ecological Determinants of Health domain) – see McGill School of Environment
Environment (Environmetrics domain) – see McGill School of Environment
Environment (Food Production and Environment domain) – see McGill School of Environment
Environment (Renewable Resource Management domain) – see McGill School of Environment
Environment (Water Environments and Ecosystems domain) – see McGill School of Environment
Geography
Mathematics
Mathematics and Chemistry for Teachers – see Science for Teachers
Mathematics and Physics for Teachers – see Science for Teachers
Microbiology and Immunology – application required, see departmental entry for information.
Physics
Physiology
Psychology
Software Engineering (subject to Ministry of Education approval) – application required, see unit entry for information

10.3 Joint Major Programs

Atmospheric Science and Physics
Mathematics and Computer Science – see Mathematics and Statistics*
Physics and Computer Science – see Physics*
Physics and Geophysics
Physiology and Mathematics
Physiology and Physics
* also check with the School of Computer Science, since that unit may limit enrolment.

10.4 Honours Programs

Anatomy and Cell Biology
Applied Mathematics
Atmospheric Science
Biochemistry
Biology
Chemistry
Chemistry (Bio-organic option)
Chemistry (Environmental Chemistry option)
Chemistry (Materials)
Computer Science – application required, see unit entry for information
Earth and Planetary Sciences
Earth Sciences
Planetary Sciences
Geography
Immunology (Interdepartmental) – application required, see Faculty of Science entry for Immunology
Mathematics
Microbiology and Immunology
Physics
Physiology
Probability and Statistics
Psychology

10.5 Joint Honours Programs

Mathematics and Computer Science – see Mathematics and Statistics, also check with the School of Computer Science, since that unit may limit enrolment.
Mathematics and Physics – see Physics

10.6 Minor Programs

Atmospheric Science
Biology
Biotechnology
Chemical Engineering – see Chemistry
Chemistry
Cognitive Science
Computer Science
Earth and Planetary Sciences
Education for Science Students – see Science for Teachers
Electrical Engineering – see Physics
Environment
Geochemistry – see Earth and Planetary Sciences
Geography
Geographical Information Systems – see Geography
Human Nutrition – see Faculty of Agricultural and Environmental Sciences entry for School of Dietetics and Human Nutrition
Management* – see Faculty of Science entry for Management
Mathematics
Music – see Faculty of Science entry for Music
Music Technology – application required, see Faculty of Science entry for Music
Neuroscience
Pharmacology
Physics
Psychology
Statistics – see Mathematics and Statistics
Technological Entrepreneurship for Science Students* – see Faculty of Science entry (awaiting Final approval)

* Application procedures will be announced in September. Please consult the Student Affairs Office Website.

Notes:
1. The Minor in Computer Science is not available to students in the following programs: Honours in Computer Science; Honours in Mathematics and Computer Science; Faculty Program in Mathematics and Computer Science.
2. The Minor in Chemical Engineering is only available to students in Chemistry.
3. The Minor in Electrical Engineering is only available to students in the Major Program in Physics.

10.7 Internship Programs – Internship Year For Engineering And Science (IYES)

The following programs are also available with an Internship component. For more information, please see section 2.8 in the Faculty of Engineering section.

Atmospheric and Oceanic Sciences
Major in Atmospheric Science
Honours in Atmospheric Science

Computer Science
Major in Computer Science
Honours in Computer Science

Mathematics and Statistics
Major in Mathematics
Honours in Mathematics
Honours in Applied Mathematics
Honours in Probability & Statistics
Joint Majors in Mathematics & Computer Science
Joint Honours in Mathematics & Computer Science

Physics
Faculty Program in Physics
Major in Physics
Honours in Physics
Joint Honours Program in Physics & Mathematics
Joint Faculty Program in Mathematics, Chemistry & Physics
Joint Major Program in Atmospheric Science & Physics
Joint Major Program in Physics & Geophysics

10.8 Faculty of Arts Major and Minor Concentration Programs available to Science students

For more information, please see the relevant departmental entries in the Faculty of Arts section.

Major Concentrations
African Studies
Anthropology
Art History
Canadian Studies
Classics
East Asian Studies
Economics
English – Literature
English – Drama and Theatre
English – Cultural Studies
Langue et littérature françaises – Léttres
Langue et littérature françaises – Léttres et traduction
Langue et littérature françaises – Linguistique du français
Geography (Urban Systems)
German Language and Literature – see German Studies
German Literature and Culture – see German Studies
Contemporary German Studies – see German Studies
Hispanic Literature and Culture – see Hispanic Studies
Hispanic Languages – see Hispanic Studies
History
Humanistic Studies
International Development Studies
Italian Studies
Italian Studies (Medieval and Renaissance)
Jewish Studies
Latin-American Studies
Linguistics
Middle East Studies
Music
North American Studies
Philosophy
Political Science
Québec Studies
Religious Studies – Scriptures and Interpretation
Religious Studies – World Religions
Russian
Sociology
Women's Studies

Minor Concentrations
African Studies
Anthropological Archaeology – see Anthropology
Anthropology, Socio-Cultural
Art History
Canadian Ethnic Studies
Canadian Studies
Catholic Studies
Classics
East Asian Language and Literature
East Asian Cultural Studies
East Asian Studies, Advanced
Economics
English – Literature
English – Drama and Theatre
English – Cultural Studies
Langue et littérature françaises – Léttres
Langue et littérature françaises – Léttres et traduction
Langue et littérature françaises – Langue et traduction

Langue et littérature françaises – Langue française
Langue et littérature françaises – Théorie et critique littérraires
Geographical Information Systems – see Geography
Geography
German Language – see German Studies
German Literature – see German Studies
German Literature and Culture in Translation – see German Studies
Hispanic Languages – see Hispanic Studies
History
History and Philosophy of Science
Humanistic Studies
International Development Studies
Italian Studies
Italian Civilization – see Italian Studies
Jewish Studies
Linguistics, Applied
Linguistics, Theoretical
Middle East Studies – see Middle East Studies
Middle East Languages – see Middle East Studies
North American Studies
Philosophy
Political Science
Political Science: Canada/Québec
Comparative Politics – see Political Science
International Relations – see Political Science
Political Economy – see Political Science
Politics, Law and Society – see Political Science
South Asia – see Political Science
Québec Studies
Religious Studies – World Religions
Religious Studies – Scriptural Languages
Russian – see Russian and Slavic Studies
Russian Civilization – see Russian and Slavic Studies
Social Studies of Medicine
Sociology
Spanish Literature and Culture – see Hispanic Studies
Spanish-American Literature and Culture – see Hispanic Studies
Women's Studies

11 Academic Programs and Courses

11.1 Anatomy and Cell Biology (504)

Strathcona Anatomy and Dentistry Building
3640 University Street, Room 1/48
Montreal, QC H3A 2B2

Telephone: (514) 398-6335

Chair — John J.M. Bergeron

Emeritus Professor
Yves Clermont; B.Sc.(Montr.), Ph.D.(McG.), F.R.C.S.

Professors
Alain Beaudet; M.Sc., Ph.D., M.D.(Montr.) *(joint appt. with Neurology & Neurosurgery)*
Gary C. Bennett; B.A., B.Sc.(Sir G.Wms.), M.Sc., Ph.D.(McG.)
John J.M. Bergeron; B.Sc.(McG.), Ph.D., D.Phil.(Oxon.)
James R. Brawer; B.S.(Tufts), Ph.D.(Harv.)
M. Burnier; M.D.,M.Sc.,Ph.D.(Brazil) *(joint appt. with Ophthalmology)*
Louis Hermo; B.A.(Loyola), M.Sc., Ph.D.(McG.)
Charles P. Leblond; M.D.(Paris), Ph.D.(Montr.), D.Sc.(Acad.), F.R.S., F.R.S.C.
Sandra C. Miller; B.Sc.(Sir G.Wm.), M.Sc., Ph.D.(McG.)
Carlos R. Morales; DVM.(U.N., Argentina), Ph.D.(McG.)
Barry I. Posner; M.D.(Man.), F.R.C.P.(C) *(joint appt. with Medicine)*
Charles E. Smith; D.D.S., Ph.D.(McG.) *(joint appt. with Dentistry)*

Associate Professors
Orest W. Blaschuk; B.Sc.(Winn.), M.Sc.(Manit.), Ph.D.(Tor.) *(joint appt. with Surgery)*
Eugene Daniels; M.Sc., Ph.D.(Man.)
Samuel David; Ph.D.(Man.) *(joint appt. with Neurology & Neurosurgery)*
Paul F. Lasko; A.B.(Harv.), Ph.D.(M.I.T) *(joint appt. with Biology)*
Marc D. McKee; B.Sc., M.Sc., Ph.D. (McG) *(joint appt. with Dentistry)*
Marilyn M. Miller; B.Sc.(Marquette), M.S., Ph.D.(Loyola) *(joint appt. with Obstetrics & Gynecology)*
Alfredo Riberio-da-Silva; M.D., Ph.D.(Oporto) *(joint appt. with Pharmacology and Therapeutics)*
Hojatollah Vali; B.Sc., M.Sc., Ph.D.(Munich) *(joint appt. with Earth and Planetary Sciences)*

Assistant Professors
Chantel Autexier; B.Sc.(C'dia), Ph.D.(McG.)
Danny Baranes; B.Sc., M.Sc., Ph.D. (Jerusalem)
Philip Barker; B.Sc.(S.Fraser), Ph.D.(Alta.) *(joint appt. with Neurology & Neurosurgery)*
Michael T. Greenwood; B.Sc.,M.Sc.(C'dia), Ph.D.(McG) *(joint appt. with Medicine)*
Timothy Kennedy; B.Sc.(McM.), M.Phil, Ph.D.(Columbia) *(joint appt. with Neurology & Neurosurgery)*
Antonis E. Koromilas; B.Sc., Ph.D.(Aristotelian U., Greece) *(joint appt. with Oncology)*
Nathalie Lamarche; B.Sc., Ph.D.(Montr.)
Peter McPherson; B.Sc.(Manit.), Ph.D.(Iowa) *(joint appt. with Neurology & Neurosurgery)*
Jackson G. Snipes; Ph.D., M.D.(Vanderbilt) *(joint appt. with Neuropathology)*
Wayne Sossin; S.B.(M.I.T.), Ph.D.(Stan.) *(joint appt. with Neurology & Neurosurgery)*
Stefano Stifani; Ph.D.(Rome), Ph.D.(Alta.) *(joint appt. with Neurology & Neurosurgery)*
Dominique Walker; B.Sc., Ph.D.(Geneva) *(joint appt. with Psychiatry)*
Gary E. Wild; B.Sc., Ph.D., M.D.,C.M.(McG.) *(joint appt. with Medicine)*

Adjunct Professors
Daniel Cyr; B.Sc., M.Sc.(C'dia), Ph.D.(Manit.)
Jacques Drouin; B.Sc., D.Sc.(Laval)
Sadayuki Inoue; M.Sc., Ph.D.(Hok. U.)
André Nantel; B.Sc., M.Sc.(Laval), Ph.D.(Chapel Hill)
David Y. Thomas; B.Sc.(Brist.); M.Sc., Ph.D.(Lond.)

The Department of Anatomy and Cell Biology offers courses which deal with cell biology, histology, embryology, neuroanatomy, and gross anatomy. The Honours Program is designed as the first phase in the training of career cell biologists. This is the most desirable path for entry into graduate studies in Anatomy and Cell Biology since only a few additional courses are required for the Ph.D. degree which therefore consists almost entirely of basic research. The Major and Faculty programs offer decreasing levels of specialization in Anatomy and Cell Biology but with a broader base in other biological sciences. These programs also form a sound background for graduate studies in Anatomy and Cell Biology, or for further professional training in schools of medicine, dentistry and other health sciences. A B.Sc. in Anatomy and Cell Biology provides an excellent preparation for technical and administrative positions in laboratories of universities, research institutions, hospitals and pharmaceutical and biotechnological industries.

The teachers within the program are scientists pursuing research into the structure and function of cells, tissues and organs, usually at a detailed molecular level. For this research, modern techniques of cellular and molecular biology, including immunological and ultrastructural methodologies, are employed. The Department is equipped to perform cell fractionation, protein purification, recombinant DNA technology, micro-injection of molecules into single cells, cytochemical, immunocytochemical and fluorescent analysis and electron microscopy. The Department

has a well equipped centre for electron microscopy as well as a centre for confocal and immunofluorescence.

Inquiries about programs should be directed to the Department of Anatomy and Cell Biology.

FACULTY PROGRAM IN ANATOMY AND CELL BIOLOGY
(57 credits) [MARS Program Code 4-080100]

Required Courses (39 credits)

504-212B	(3)	Molecular Mechanisms of Cell Function
504-214A	(3)	Systemic Human Anatomy
504-261A	(4)	Introduction to Dynamic Histology (must be taken in U1)
504-262B	(3)	Introductory Molecular & Cell Biology
504-321A	(3)	Circuitry of the Human Brain
177-200A	(3)	Molecular Biology
177-202B	(3)	General Genetics
180-212A,B*	(4)	Organic Chemistry I
180-222A,B*	(4)	Organic Chemistry II
552-209A	(3)	Mammalian Physiology I
552-210B	(3)	Mammalian Physiology II
189-203A*	(3)	Principles of Statistics I
or 204-204A,B	(3)	Introduction to Psychological Statistics
or 177-373A	(3)	Biostatistical Analysis

* If the equivalents to these courses were passed in CEGEP, they are not required for the Anatomy and Cell Biology programs, and may not be re-taken at McGill. Students must take the equivalent number of credits in Elective Courses to satisfy the total credit requirement for their degree.

Complementary Courses (18 credits)
9 credits selected from:

504-322B	(3)	Neuroendocrinology
504-365A	(3)	Cell Biology of the Secretory Process
504-381B	(3)	Experimental Basis of Embryology
504-458B	(3)	Membranes and Cellular Signaling

9 credits selected from biologically oriented courses (BOC) in the following list:
177-300A, 177-301A,B, 177-303B, 177-306A, 177-313B, 177-314A, 177-357A, 177-370B, 177-389B, 177-468B, 177-475B, 177-516B, 177-518B, 177-520B, 177-522B, 177-524A, 177-530B, 177-531A, 177-532B, 177-551A, 177-588A;
202-505B; 382-307B;
504-322B, 504-365A, 504-381B, 504-432A,B,L, 504-541B;
507-311A, 507-312B, 507-450A, 507-454A, 507-455B, 507-503B;
516-401B, 516-502A, 516-503B, 516-504A, 516-506B, 516-507A, 516-508B, 516-509B, 516-510A, 516-511B, 516-512D;
528-314B, 528-323A, 528-324A, 528-386D, 528-387B, 528-413B, 528-414A, 528-465A, 528-466B, 528-509B;
531-310B; 546-300B;
549-300A, 549-301B, 549-562A,549-563B;
552-311A, 552-312B, 552-313B, 552-423A, 552-444B, 552-451A, 552-502B, 552-508A, 552-513A, 552-515A, 552-516B, 552-517B, 552-518A, 552-520B, 552-531B, 552-552B, 552-556B; 555-500B.

MAJOR PROGRAM IN ANATOMY AND CELL BIOLOGY
(68 credits) [MARS Program Code 1-080100]

Required Courses (59 credits)
all Faculty Program required courses, plus:

504-322B	(3)	Neuroendocrinology
504-365A	(3)	Cell Biology of the Secretory Process
504-381B	(3)	Experimental Basis of Embryology
504-458B	(3)	Membranes and Cellular Signaling
177-301A,B	(3)	Cell and Molecular Laboratory
528-314B	(3)	Immunology
552-212D	(2)	Introductory Physiology Lab

Complementary Courses (9 credits)
9 credits of biologically oriented courses (BOC), as defined in the Faculty Program.

HONOURS PROGRAM IN ANATOMY AND CELL BIOLOGY
(80 credits) [MARS Program Code 2-080100]

Students should register at the Major level in U1 and, if accepted, may enter the Honours Program at the beginning of U2. To enter the program, the student must obtain a CGPA of at least 3.00 at the end of U1. For promotion to the U3 year of the Honours program, or for entry into the program at this level, the student must have a CGPA of at least 3.20 at the end of their U2 year. It is expected that at the beginning of the third year the students who wish to continue in the Honours Program will be those who feel that they are seriously interested in a career in Cell Biology. The Honours Degree will be recommended after successful completion of the Program with a CGPA of at least 3.20.

Required Courses (77 credits)
all Major Program required courses, plus:

504-432D,A,B,L	(9)	Research Project in Anatomy & Cell Biology
504-541B	(3)	Cell and Molecular Biology of Aging
507-311A	(3)	Metabolic Biochemistry
507-312B	(3)	Biochemistry of Macromolecules

Complementary Courses (3 credits)
3 credits of biologically oriented courses (BOC), as defined in the Faculty Program.

COURSE DESCRIPTIONS

All courses have limited enrolment.
Admission is guaranteed for all students enrolled in programs in the Department of Anatomy and Cell Biology for which the course in question is a required course.

The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

● Denotes courses not offered in 2001-02.
★ Denotes courses taught only in alternate years.

504-205B ASTROBIOLOGY. (3) (3 hours lecture) (Not open to students who have taken or are taking 186-205A.) Astrobiology is the search for the origin, evolution and destiny of life in the universe. The course will provide insight into the formation and evolution of habitable worlds, the evolution of life and the biogeochemical cycles in the Earth's oceans and atmosphere, and the potential for biological evolution beyond an organism's planet of origin.

504-212B MOLECULAR MECHANISMS OF CELL FUNCTION. (3) (Prerequisite: 177-200A) (This course is also listed as Biochemistry 507-212B, and is not open to students who have taken or are taking the latter course or 177-201B.) An introductory course describing the biochemistry and molecular biology of selected key functions of animal cells, including: gene expression; mitochondrial production of metabolic energy; cellular communication with the extra-cellular environment; and regulation of cell division. (Restriction revision awaiting University approval)

504-214A SYSTEMIC HUMAN ANATOMY. (3) (2 hours lectures, 2 hours practical tutorial) (Open to students in biological sciences.) Introduction to the gross anatomy of the various organ systems of head, neck and trunk regions of the human body. Practical tutorials include studies of prepared specimens, use of the anatomical museum and audio-visual materials. [Selection of students (other than those requiring the course as part of their program) will be made after the first lecture. See NOTE following Course Descriptions above.]

504-261A INTRODUCTION TO DYNAMIC HISTOLOGY. (4) (3 hours lectures, 2 hours laboratory) (Must be taken in U1 by students in Anatomy and Cell Biology programs) (Open to students in biological sciences and others by special permission.) An introduction to light and electron microscopic anatomy in which cell and tissue dynamics will be explored in the principal tissues and organs of the body.

504-262B INTRODUCTORY MOLECULAR & CELL BIOLOGY. (3) (3 hours lecture) (Corequisites: 504-212B or 177-201B) (Open to students in biological sciences and others by special permission.)

The architectural, functional and temporal continuity of organelles and the cytoskeleton of mammalian cells is introduced as well as their functional integration in the phenomena of exocytosis, endocytosis, protein trafficking and cell motility and adhesion.

504-315A REGIONAL ANATOMY OF THE LIMBS AND BACK. (4) (2 hours lectures, 4 hours laboratory) (Open to students in Physical and Occupational Therapy; and to Honours students in Anatomy and Cell Biology, with permission of instructor.) A dissection course in regional human gross anatomy of the skeleton, joints, muscles and neurovascular structures of the limbs and back.

504-316B HUMAN VISCERAL ANATOMY. (2) (2 hour lecture, 2 hours laboratory) (Prerequisite: 504-315A) (Open to students in Physical and Occupational Therapy, and to others by special permission.) The gross anatomy of the various organ systems of the human body, with emphasis on those aspects of greatest relevance to physical and occupational therapists. Laboratories include studies of prepared specimens, use of the anatomical museum and audiovisual materials.

504-321A CIRCUITRY OF THE HUMAN BRAIN. (3) (2hour lectures, 2 hours laboratory/tutorial) (Prerequisite: at least one 3-credit university level course in biology or psychology.) This course explores the functional organization of the human brain and spinal cord. The course focuses on how neuronal systems are designed to subserve specific motor, sensory, and cognitive operations.

★504-322B NEUROENDOCRINOLOGY. (3) (2 hours lectures, 1 hour conference) (Prerequisite: 504-261A and 504-321A) A lecture course describing brain-endocrine relationships. Emphasis on modern experimental evidence and conceptual developments within the field.

● **★504-365A CELL BIOLOGY OF THE SECRETORY PROCESS.** (3) (2 hours lectures, 2 hours conference) (Prerequisites: 504-261A, 177-200A, 177-201B)

★504-381B EXPERIMENTAL BASIS OF EMBRYOLOGY. (3) (2hours lectures, 2 hours laboratory or conference) (Prerequisites: 504-214A, 504-261A, or by special permission.) This course will focus on the function of cell adhesion molecules as morphogenetic regulators. Modern techniques of molecular embryology will be discussed.

504-432D,A,B,L RESEARCH PROJECT IN ANATOMY & CELL BIOLOGY. (9) (Minimum 2 days per week – D, 4 days per week – A,B or 5 days per week – L) (For students in the Honours program. The course may also be taken, with special permission, by students in Anatomy Major and Faculty programs as well as by students of other Departments.) An intensive exposure to individually supervised, original research in anatomical sciences. A variety of methods, including electron microscopy, cytochemistry, immunolabeling, radioautography, and cell fractionation and biochemical analysis are applied to basic problems in cell biology. A substantial written report, followed by an oral presentation and defence are required. Students should consult the course coordinators several weeks before registration.

504-458B MEMBRANES AND CELLULAR SIGNALING. (3) (3 hours lectures) (Prerequisites: 504-212B, 504-262B, one of 552-201A, 552-209A or 177-205B; one of 507-312B or 504-365A; 507-311A recommended) (Not open to students who are taking or who have taken 507-456B.) An integrated treatment of the properties of biological membranes and of intracellular signaling, including the major role that membranes play in transducing and integrating cellular regulatory signals. Biological membrane organization and dynamics; membrane transport; membrane receptors and their associated effectors; mechanisms of regulation of cell growth, morphology, differentiation and death.

504-541B CELL AND MOLECULAR BIOLOGY OF AGING. (3) (2 hours lecture, 2 hours conference) (Prerequisites: 504-261A, 504-262B, or by special permission.) This course will focus on how the complex aging process can be studied by modern cell and molecular approaches. Topics will include discussion on animal model systems for aging, gene regulation controlling the aging process and age-dependent diseases.

11.2 Atmospheric and Oceanic Sciences (195)

Burnside Hall, Room 945
805 Sherbrooke Street West
Montreal, QC H3A 2K6

Telephone: (514) 398-3764
Fax: (514) 398-6115
Internet: uginfo@zephyr.meteo.mcgill.ca
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Chair — Charles A. Lin

Emeritus Professors
Roddy R. Rogers; B.S.(Texas), S.M.(M.I.T.), Ph.D.(N.Y.U.)
Edward J. Stansbury; M.A., Ph.D.(Tor.)

Professors
Jacques F. Derome; M.Sc.(McG.), Ph.D.(Mich.)
Lawrence A. Mysak; B.Sc.(Alta.), M.Sc.(Adel.), A.M., Ph.D.(Harv.), F.R.S.C. *(Canada Steamship Lines Professor of Meteorology)*
Isztar I. Zawadzki; B.Sc.(Buenos Aires), M.Sc., Ph.D.(McG.)

Associate Professors
John R. Gyakum; B.Sc.(Penn.), M.Sc., Ph.D.(M.I.T.)
Henry G. Leighton; M.Sc.(McG.), Ph.D.(Alta.)
Charles A. Lin; B.Sc.(U.B.C.), Ph.D.(M.I.T.)
Man Kong (Peter) Yau; S.B., S.M., Sc.D.(M.I.T.)
David Straub; B.S., M.S.(SW Louisiana), Ph.D.(Wash)

Assistant Professor
Parisa Ariya; B.Sc., Ph.D.(York) *(William Dawson Scholar) (joint appt. with Chemistry)*
Frédéric Fabry; B.Sc., M.Sc., Ph.D.(McG.) *(joint appt. with McGill School of Environment)*

Assistant Professor (Special Category)
Peter Bartello; M.Sc., Ph.D.(McG.)

Lecturer
Alan P. Schwartz

Adjunct Professors
Jean-Pierre Blanchet, Gilbert Brunet, Eddy Carmack, R.Grant Ingram, René Laprise, Stéphane Laroche

The Department of Atmospheric and Oceanic Sciences offers, at the undergraduate level, a broad range of courses and degree programs in atmospheric science. At the postgraduate level, programs of study are offered in physical oceanography, air-sea interaction, and climate research as well as in different branches of atmospheric science. The study of atmospheric science is based largely on physics and applied mathematics. All required courses except those at the introductory level generally have prerequisites or corequisites in physics, mathematics, and atmospheric science. One of the goals of the discipline is to develop the understanding necessary to improve our ability to predict the weather, but atmospheric science is more than weather forecasting. Another important area of study focuses on the possible changes in global climate caused by the changing chemical composition of the atmosphere. The approach is always quantitative. Like other parts of physics, atmospheric science attempts to create theoretical models of its complex processes, as a means of analyzing the motion and composition of the air, its thermodynamic behaviour, and its interaction with radiation and with the solid or liquid surface beneath it. From one viewpoint, the atmosphere may be studied as a large volume of gas by the methods of fluid mechanics: winds, circulation patterns, turbulence, and energy and momentum exchanges are the ideas employed in this approach. Alternatively, the atmosphere may be studied from the point of view of its detailed physics: how water condenses in the air, how cloud droplets make rain, how sunlight warms the ground and the ground warms the air above it by radiation and convection, and how the atmosphere and ocean interact to shape the weather and climate. A comprehensive understanding requires both viewpoints, and these are reflected in the curriculum.

The Department of Atmospheric and Oceanic Sciences offers four main programs in Atmospheric Science: Honours, Major, Minor, and a Joint Major in Atmospheric Science and Physics. The Honours program is meant for students with high standing. It is based on courses similar to those in the Major program, but provides the opportunity to take advanced optional courses. The Major program, although somewhat less intensive, satisfies the requirements for a professional career as a meteorologist, and like the Honours program equips the student to undertake postgraduate study in meteorology, atmospheric science, and related sciences (for example physical oceanography) at any of the leading universities. The Department also offers a special one-year Diploma program to B.Sc. or B.Eng. graduates.

A degree in Atmospheric Science can lead to a professional career in government service or private industry. The Meteorological Service of Canada has traditionally been the main employer of graduating students, but certain provincial governments and environmental consulting and engineering firms also employ graduates trained in atmospheric science. Positions in teaching and research are available to graduates with M.Sc. and Ph.D. degrees. Students interested in any of the undergraduate programs should consult the Undergraduate Adviser, Room 946, Burnside Hall.

An industrial internship year is available to students enrolled in Atmospheric Science programs. IYES, the internship year program in Engineering and Science, is a pre-graduate work experience program available to eligible students and normally taken between their U2 and U3 years. See Faculty of Engineering section 2.8 for further information on IYES.

MINOR PROGRAM IN ATMOSPHERIC SCIENCE (18 credits)
[MARS Program Code 6-662000]

The Minor may be taken in conjunction with any program in the Faculty of Science.

Required Courses (15 credits)

195-214A	(3)	Intro. to the Physics of the Atmosphere
195-215B	(3)	Weather Systems and Climate
195-219B	(3)	Intro to Atmosp. Chemistry
or 180-219B		
195-308A	(3)	Principles of Remote Sensing
or 183-308A		
195-315A	(3)	Water in the Atmosphere

Complementary Course (3 credits)

195-402A	(3)	Atmosphere-Ocean Transports
or 195-540A	(3)	Synoptic Meteorology I

MAJOR PROGRAM IN ATMOSPHERIC SCIENCE (61 credits)
[MARS Program Code 1-662000]

Required Courses (49 credits)

195-214A	(3)	Intro. to the Physics of the Atmosphere
195-215B	(3)	Weather Systems and Climate
195-308A	(3)	Principles of Remote Sensing
or 183-308A		
195-315A	(3)	Water in the Atmosphere
195-512A	(3)	Atmospheric and Oceanic Dynamics
195-513B	(3)	Waves and Stability
195-540A	(3)	Synoptic Meteorology I
195-541B	(3)	Synoptic Meteorology II
195-546B	(1)	Current Weather Discussion
189-222A,B	(3)	Calculus III
189-223A,B	(3)	Linear Algebra
189-314A,B	(3)	Advanced Calculus
189-315A,B	(3)	Ordinary Differential Equations
198-230A	(3)	Dynamics of Simple Systems
198-232B	(3)	Heat and Waves
198-257A	(3)	Experimental Methods I
308-208A,B	(3)	Computers in Engineering

Complementary Courses (12 credits)

3 - 6 credits to satisfy a statistics requirement, usually:

189-203A,B	(3)	Principles of Statistics I
or 189-323A,B	(3)	Probability Theory
and 189-324A,B	(3)	Statistics

3 credits selected from:

198-333B	(3)	Thermal & Statistical Physics
198-340A	(3)	Electricity and Magnetism

3 - 6 credits ordinarily selected from:

183-522A	(3)	Advanced Environmental Hydrology
189-317A	(3)	Numerical Analysis
189-319B	(3)	Partial Differential Equations
195-414B	(3)	Applications of Remote Sensing
195-419B	(3)	Adv. In Chem. of Atmosphere
or 180-419B		
195-515B	(3)	Turbulence
198-241B	(3)	Signal Processing
198-248A	(3)	Physics of Energy
198-331B	(3)	Mechanics
198-340A	(3)	Electricity and Magnetism
198-342B	(3)	Electromagnetic Waves
198-332B	(3)	Physics of Fluids
or 305-331A,B	(3)	Fluid Mechanics I

JOINT MAJOR PROGRAM IN ATMOSPHERIC SCIENCE AND PHYSICS (70 credits) [MARS Program Code 1-662200]

This Major provides a solid basis for postgraduate study in meteorology, atmospheric physics, or related fields, and the necessary preparation for embarking on a professional career as a meteorologist directly after the B.Sc.

The program is jointly administered by the Departments of Physics, and Atmospheric and Oceanic Sciences. Students should consult undergraduate advisers in both departments.

Required Courses (67 credits)

195-214A	(3)	Intro. to the Physics of the Atmosphere
195-215B	(3)	Weather Systems and Climate
195-308A	(3)	Principles of Remote Sensing
or 183-308A		
195-315A	(3)	Water in the Atmosphere
195-512A	(3)	Atmospheric and Oceanic Dynamics
195-513B	(3)	Waves and Stability
195-540A	(3)	Synoptic Meteorology I
195-541B	(3)	Synoptic Meteorology II
195-546B	(1)	Current Weather Discussion
198-230A	(3)	Dynamics of Simple Systems
198-232B	(3)	Heat and Waves
198-257A	(3)	Experimental Methods I
198-258B	(3)	Experimental Methods II
198-331B	(3)	Mechanics
198-333B	(3)	Thermal and Statistical Physics
198-339B	(3)	Measurements Laboratory
198-340A	(3)	Electricity and Magnetism
198-342B	(3)	Electromagnetic Waves
198-446A	(3)	Quantum Physics
189-222A,B	(3)	Calculus III
189-223A,B	(3)	Linear Algebra
189-314A,B	(3)	Advanced Calculus
189-315A,B	(3)	Ordinary Differential Equations

Complementary Course (3 credits)

198-434A	(3)	Optics
or 198-439A	(3)	Laboratory in Modern Physics

HONOURS PROGRAM IN ATMOSPHERIC SCIENCE
(70 credits) [MARS Program Code 2-662000]

Students can be admitted to the Honours program after completion of the U1 year of the Major in Atmospheric Science program with a minimum GPA of 3.30. Students having completed a U1 year in a different program with high standing may be admitted to the Honours program on the recommendation of the Department.

A minimum GPA of 3.30 in the Honours Program courses (taken as a whole) is required to remain in the program. A CGPA of 3.30 on the total program is also required to graduate with honours.

Required Courses (58 credits)
195-214A (3) Intro. to the Physics of the Atmosphere
195-215B (3) Weather Systems and Climate
195-308A (3) Principles of Remote Sensing
or 183-308A
195-315A (3) Water in the Atmosphere
195-480A,B (3) Honours Research Project
195-512A (3) Atmospheric and Oceanic Dynamics
195-513B (3) Waves and Stability
195-530A (3) Climate Dynamics I
195-540A (3) Synoptic Meteorology I
195-541B (3) Synoptic Meteorology II
195-546B (1) Current Weather Discussion
189-222A,B (3) Calculus III
189-223A,B (3) Linear Algebra
189-314A,B (3) Advanced Calculus
189-315A,B (3) Ordinary Differential Equations
189-319B (3) Partial Differential Equations
198-230A (3) Dynamics of Simple Systems
198-232B (3) Heat and Waves
198-257A (3) Experimental Methods I
308-208A,B (3) Computers in Engineering

Complementary Courses (12 credits)
3-6 credits to satisfy a statistics requirement, usually:
189-203A,B (3) Principles of Statistics I
or 189-323A,B (3) Probability Theory
and 189-324A,B (3) Statistics

3 credits selected from:
198-333B (3) Thermal and Statistical Physics
198-340A (3) Electricity and Magnetism

3-6 credits ordinarily selected from:
183-522A (3) Advanced Env. Hydrology
189-317A (3) Numerical Analysis
195-414B (3) Applications of Remote Sensing
195-419B (3) Adv. in Chem. of Atmosphere
or 180-419B
195-515B (3) Turbulence
198-241B (3) Signal Processing
198-248B (3) Physics of Energy
198-331B (3) Mechanics
198-340B (3) Electricity and Magnetism
198-342B (3) Electromagnetic Waves
198-332B (3) Physics of Fluids
or 305-331A,B (3) Fluid Mechanics I

DIPLOMA IN METEOROLOGY (30 credits)

The Department offers an intensive, one-year program in theoretical and applied meteorology to B.Sc. or B.Eng. graduates of suitable standing in Physics, Applied Mathematics, Engineering, Science, or other appropriate disciplines, leading to a Diploma in Meteorology. The program is designed for students with little or no previous background in meteorology who wish to direct their experience to atmospheric or environmental applications, or who need to fulfil academic prerequisites in meteorology to qualify for employment. For further information, consult the Graduate Coordinator, Burnside Hall, Room 945.

An exemption of up to 6 credits may be allowed for courses already taken. Students granted such exemptions are required to add complementary courses from an approved list to maintain a total credit count of 30 completed at McGill.

Required Courses (18 credits)
195-512A (3) Atmospheric & Oceanic Dynamics
195-513B (3) Waves and Stability
195-530A (3) Climate Dynamics I
195-531B (3) Climate Dynamics II
195-540A (3) Synoptic Meteorology I
195-541B (3) Synoptic Meteorology II

Complementary Courses (12 credits)
6 credits selected from:
195-308A (3) Principles of Remote Sensing
or 183-308A
195-315A (3) Water in the Atmosphere
195-414B (3) Applications of Remote Sensing
195-419B (3) Adv. in Chem. of Atmosphere
or 180-419B

6 credits ordinarily selected from:
183-522A (3) Advanced Env. Hydrology
189-317A (3) Numerical Analysis
189-319B (3) Partial Differential Equations
195-515B (3) Turbulence
198-331B (3) Mechanics
198-340A (3) Electricity and Magnetism
198-342B (3) Electromagnetic Waves
198-332 B (3) Physics of Fluids
or 305-331A,B (3) Fluid Mechanics I

INTERNSHIP PROGRAMS – INTERNSHIP YEAR FOR ENGINEERING AND SCIENCE (IYES)

The following programs are also available with an Internship component. For more information, please see section 2.8 in the Faculty of Engineering section.

Major in Atmospheric Science
Honours in Atmospheric Science

COURSE DESCRIPTIONS

All courses have limited enrolment.

The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

● Denotes courses not offered in 2001-02.
★ Denotes courses taught only in alternate years.

195-199B FYS: WEATHER, CLIMATE, HISTORY. (3) (2 hours lectures; 1 hour seminar) (FYS - for first year students only, maximum 25) A seminar course on how weather and climate have influenced human history. The impact of weather and climate on agriculture, disease, demography, economic cycles and history. The Little Ice Age in Eurpose will be used as an example for study. Methods to establish linkage between weather, climate and history.

195-210A,B INTRODUCTION TO ATMOSPHERIC SCIENCE. (3) (3 hours lectures) (Open to all students except those who have taken 195-214A.) A survey of the Earth's atmosphere, weather and climate system. Topics include the fundamental processes that determine interactions between the atmosphere, ocean and biosphere; anthropogenic effects such as global warming, the ozone hole and acid rain; a perspective on future climate change.

195-214A INTRO. TO THE PHYSICS OF THE ATMOSPHERE. (3) (3 hours lectures) (Prerequisite: CEGEP Physics.) An introduction to physical meteorology designed for students in the physical sciences. Topics include: composition of the atmosphere; heat transfer; the upper atmosphere; atmospheric optics; formation of clouds and precipitation; instability; adiabatic charts.

195-215B WEATHER SYSTEMS AND CLIMATE. (3) (3 hours lectures) (Prerequisite: CEGEP Physics or permission of the instructor.) Laws of motion, geostrophic wind, gradient wind. Surface and upper-level charts. Local wind systems, global wind systems. Air masses, fronts and middle latitude cyclones. Thunderstorms, tornadoes and hurricanes. Global climate, climate change. Weather on the "web".

★195-219B INTRODUCTION TO ATMOSPHERIC CHEMISTRY. (3) (3 hours lectures) (Prerequisite: CEGEP DEC in Science or permission of instructor.) (Not open to students who have taken 180-219, 180-419 or 195-419.) (Offered in odd years. Students should register in 180-219 in even years.) An introduction to the basic topics in atmospheric chemistry. The fundamentals of the chemical

composition of the atmosphere and its chemical reactions. Selected topics such as smog chamber, acid rain, and ozone hole will be examined.

195-220A,B INTRODUCTION TO OCEANIC SCIENCES. (3) (3hours lectures) (Not open to students who have taken 186-360A or 186-560A.) Air-sea interaction; oceanic properties; global climate change, carbon cycle; polar oceans, sea ice, polynyas; El Niño; remote sensing of oceans; physical control of biological processes in the sea.

● **195-230B CLIMATE AND CLIMATE CHANGE.** (3) (3 hours lectures) (Prerequisite: CEGEP Physics or 183-203.)

195-250A NATURAL DISASTERS. (3) (3 hours lectures) (Not open to students who have taken or are taking 186-250.)This course examines the science behind different types of disasters and our ability or inability to control and predict such events. From this course the student will gain an appreciation of natural disasters beyond the newspaper headlines, and will better understand how the effects of disasters can be reduced.

195-308A PRINCIPLES OF REMOTE SENSING. (3) (3 hours lectures) (Not open to students who have taken or are taking 183-308.) A conceptual view of remote sensing and the underlying physical principles are presented. Ground-based and satellite systems and various components of the acoustic and electromagnetic spectrum – from visible to microwave – are discussed. Substantial emphasis is devoted to the application of remote sensed data in geography and atmospheric sciences.

● **195-310B PHYSICAL OCEANOGRAPHY.** (3) (3 hours lectures) (Prerequisite: 195-220, 189-141 or equivalent. Not open to students who have taken 186-360A.)

195-315A WATER IN THE ATMOSPHERE. (3) (3 hours lectures) (Prerequisite: 195-214.) Global distribution of water in the atmosphere. Moist processes. Global and mesoscale precipitation systems.Quantitative forecasting of precipitation. Extreme precipitation events. Large-scale influences. Precipitation modification.

● **195-330A PHYSICAL METEOROLOGY.** (3) (3 hours lectures) (Prerequisite: 195-214A OR permission of instructor. Not open to students who have taken 195-320A and -321B.)

195-400D INDEPENDENT STUDY OF AN ENVIRONMENTAL PROBLEM. (3) (Restricted to students taking a joint program in Atmospheric and Environmental Science or with permission of Department.) A reading or research project, conducted under the guidance of an instructor, on the meteorological processes related to an environmental problem. A written report will be required. Students should consult the departmental undergraduate student adviser for the names of available supervisors.

195-402A ATMOSPHERE-OCEAN TRANSPORTS. (3) (3 hours lectures) (Prerequisite:189-222) The role of the atmosphere and oceans in redistributing chemical, physical and biological quantities such as heat, nutrients and pollutants. Overview of flow regimes, from global to turbulence scales, advection and diffusion processes; Reynolds averaging and turbulence; the effect of the Earth`s rotation, stratospheric transport of pollutants, oceanic CO_2 transports.

195-414B APPLICATIONS OF REMOTE SENSING. (3) (3 hours lectures) (Prerequisite: 195-308 or 183-308.) A more quantitative version of some topics covered in 195-308 with emphasis on the contribution of remote sensing to atmospheric and oceanic sciences. Basic notions of radiative transfer and applications of satellite and radar data to mesoscale and synoptic-scale systems are discussed.

★**195-419B ADVANCES IN CHEMISTRY OF THE ATMOSPHERE.** (3) (3 hours lectures) (Prerequisites: 180-213, 180-273, 189-222 and 189-315 or equivalents, or permission of instructor.) (Not open to students who have taken 180-419, 180-619, and 195-619.) (Offered in odd years. Students should register in 180-419 in even years.) Selected areas of atmospheric chemistry from field and laboratory to theoretical modelling are examined. The principles of atmospheric reactions (gas, liquid and heterogeneous phases in aerosols and clouds) and issues related to chemical global change will be explored.

195-480A,B HONOURS RESEARCH PROJECT. (3) (Restricted to U3 Honours students.) The student will carry out a research project under the supervision of a member of the staff. The student will be expected to write a report and present a seminar on the work.

195-512A ATMOSPHERIC AND OCEANIC DYNAMICS. (3) (3hours lectures) (Prerequisite: Permission of instructor.) Introduction to the fluid dynamics of large-scale flows of the atmosphere and oceans. Stratification of atmosphere and oceans. Equations of state, thermodynamics and momentum. Kinematics, circulation, and vorticity. Hydrostatic and quasi-geostrophic flows. Brief introduction to wave motions, flow over topography, Ekman boundary layers, turbulence.

195-513B WAVES AND STABILITY. (3) (3 hours lectures) (Prerequisite: Permission of instructor.) Linear theory of waves in rotating and stratified media. Geostrophic adjustment and model initialization. Wave propagation in slowly varying media. Mountain waves; waves in shear flows. Barotropic, baroclinic, symmetric, and Kelvin-Helmholtz instability. Wave-mean flow interaction. Equatorially trapped waves.

● **195-515B TURBULENCE IN THE ATMOSPHERE AND OCEANS.** (3) (3 hours lectures) (Prerequisite: 195-512A or permission of instructor.)

195-530A* CLIMATE DYNAMICS I. (3) (3 hours lectures) (Prerequisite: Permission of instructor.) Introduction to the components of the climate system. Review of paleoclimates. Physical processes and models of climate and climate change.

195-531B* CLIMATE DYNAMICS II. (3) (3hours lectures) (Prerequisite: Permission of instructor.) The general circulation of the atmosphere and oceans. Atmospheric and oceanic general circulation models. Observations and models of the El Niño and Southern Oscillation phenomena.

195-540A SYNOPTIC METEOROLOGY I. (3) (2 hours lectures; 2 hours laboratory) (Prerequisite: Permission of instructor.) Analysis of current meteorological data. Description of a geostrophic, hydrostatic atmosphere. Ageostrophic circulations and hydrostatic instabilities. Kinematic and thermodynamic methods of computing vertical motions. Tropical and extratropical condensation rates. Barotropic and equivalent barotropic atmospheres.

● **195-541B SYNOPTIC METEOROLOGY II.** (3) (2 hours lectures; 2 hours laboratory) (Prerequisite: 195-512A and -540A or permission of instructor.)

195-546B* CURRENT WEATHER DISCUSSION. (1) (2 hours) (Prerequisite: 195-540A or permission of instructor.) Half-hour briefing on atmospheric general circulation and current weather around the world using satellite data, radar observations, conventional weather maps, and analyses and forecasts produced by computer techniques.

195-550A* SPECIAL TOPICS IN METEOROLOGY AND OCEANOGRAPHY I. (1) (1 hour lecture) (Prerequisite: Permission of instructor.) Lectures and seminars on special topics such as hydrology, agricultural meteorology, the limits of predictability, planetary atmospheres, atmospheric and oceanic pollution, coastal currents, and research reviews.

● **195-551B* SPECIAL TOPICS IN METEOROLOGY AND OCEANOGRAPHY II.** (1) (1hour lecture) (Prerequisite: Permission of instructor.)

● **195-558B* NUMERICAL METHODS AND LABORATORY.** (3) (1 hour lecture; 4 hours laboratory) (Prerequisite: Permission of instructor)

195-568B* OCEAN PHYSICS. (3) (3hours lectures) (Prerequisite: 195-512A or permission of instructor.) Research methods in physical oceanography including data analysis and literature review. Course will be divided into five separate modules focussing on temperature-salinity patterns, ocean circulation, boundary layers, wave phenomena and tides.

*Restricted to Graduate students and final-year Honours Atmospheric Science students. Others by special permission.

11.3 Biochemistry (507)

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Website: http://www.biochem.mcgill.ca

Chair — David Y. Thomas

Emeritus Professors
Angus F. Graham; M.Sc.(Tor.), Ph.D., D.Sc.(Edin.), F.R.S.C.
Rose M. Johnstone; B.Sc., Ph.D.(McG.), F.R.S.C.
Samuel Solomon; M.Sc., Ph.D.(McG.), F.R.S.C.
Theodore L. Sourkes; M.Sc.(McG.), Ph.D.(Corn.), F.R.S.C.
Leonhard S. Wolfe; M.Sc.(N.Z.), Ph.D.(Cantab.), F.R.S.C.

Professors
Rhoda Blostein; B.Sc., M.Sc., Ph.D.(McG.)
Philip E. Branton; B.Sc., M.Sc., Ph.D.(Tor.) *(Gilman Cheney Professor of Biochemistry)*
Peter E. Braun; B.Sc., M.Sc.(U.B.C.), Ph.D.(Berk.)
Vincent Giguère; B.Sc., Ph.D.(Laval) *(joint appt. with Oncology)*
Philippe Gros; B.Sc., M.Sc.(Montr.), Ph.D.(McG.)
Annette A. Herscovics; B.Sc., Ph.D.(McG.) *(joint appt. with Oncology)*
Robert E. MacKenzie; M.N.S., B.Sc.(Agr.)(McG.), Ph.D.(C'nell)
Edward A. Meighen; B.Sc.(Alta.), Ph.D.(Berk.)
Walter E. Mushynski; B.Sc., Ph.D.(McG.)
Gordon C. Shore; B.Sc.(Guelph), Ph.D.(McG.)
Joseph Shuster; B.Sc.(McG.), Ph.D.(Calif.), M.D.(Alta.)
John R. Silvius; B.Sc., Ph.D.(Alta.)
Nahum Sonenberg; M.Sc., Ph.D.(Weizmann Inst.), F.R.S.C.
Clifford P. Stanners; B.Sc.(McM.), M.A., Ph.D.(Tor.) *(joint appt. with Oncology)*
David Y. Thomas; B.Sc.(Bristol), M.Sc., Ph.D.(Lond.), F.R.S.C.
Maria Zannis-Hadjopoulos; B.Sc., M.Sc., Ph.D.(McG.) *(joint appt. with Oncology)*

Associate Professors
Nicole Beauchemin; B.Sc., M.Sc., Ph.D.(Montr.) *(joint appt. with Oncology)*
Alain Nepveu; B.Sc., M.Sc.(Montr.), Ph.D.(Sher.) *(joint appt. with Oncology)*
Morag Park; B.Sc., Ph.D.(Glasgow) *(William Dawson Scholar) (joint appt. with Oncology)*
Jerry Pelletier; B.Sc., Ph.D.(McG.)
Michel L. Tremblay; B.Sc., M.Sc.(Sher.), Ph.D.(McM.)

Assistant Professors
Kalle Gehring; M.Sc.(Mich.), Ph.D.(Berk.)
Alice Vrielink; B.Sc, M.Sc.(Cal.), Ph.D.(Lond.)

Associate Members
John J. Bergeron *(Anatomy & Cell Biology)*; Katherine Cianflone *(Exp. Medicine, RVH)*; L. Fernando Congote (*Exp. Medicine, RVH)*; Robert Dunn *(Exp. Medicine, MGH);* Mark S. Featherstone *(Oncology)*; William C. Galley *(Chemistry)*; Michael A. Parniak *(JGH, Lady Davis Inst.)*; Peter J. Roughley (*Shriners Hospital)*; Erwin Schurr *(Exp. Medicine, RVH)*; Charles Scriver *(Pediatrics, MCH);* Bernard Turcotte *(Exp. Medicine, RVH);* Simon Wing *(Medicine);* Xiang-Jiao Yang *(Molecular Oncology, RVH)*

Adjunct Professors
Michael Cordingley; B.A.(Cantab.), Ph.D.(Glasgow) *(Boehringer-Ingelheim)*
Mirek Cygler; M.Sc., Ph.D.(Poland)*(B.R.I.)*
Jacques Drouin; B.Sc., Ph.D.(Laval) *(Clin. Res. Inst.)*
Feng Ni; B.A.(Lanzhou), M.Sc., Ph.D.(C'nell) *(B.R.I.)*
Donald Nicholson; B.Sc., Ph.D.(W.Ont.) *(Merck Frosst)*
Maureen D. O'Connor-McCourt; B.Sc.(Guelph), Ph.D.(Alta.) *(B.R.I.)*
Sophie Roy; B.Sc., M.Sc., Ph.D.(McG.) *(Merck Frosst)*
Andrew C. Storer; B.Sc., Ph.D.(Birm.) *(B.R.I.)*
Marc Therrien; B.Sc., Ph.D.(Montr.) *(Clin. Res. Inst.)*
Andre Veillette; B.Sc., M.D.(Laval *(Clin. Res. Inst.)*
Lee A. Wall; B.Sc., Ph.D.(McG.) *(U. de Montr., CHUM, L'Inst. du cancer)*

Biochemistry is the application of chemical, genetic, and biophysical approaches to the study of biological processes at the cellular and molecular level. Biochemists are interested in the dynamic events that occur in cells, for example, in mechanisms of brain function; cellular differentiation; energy utilization by animals and microorganisms and in the molecular basis of inheritance and disease. The biochemist seeks to determine how specific molecules such as proteins, nucleic acids, lipids, vitamins and hormones function in various cellular processes. Biochemists place particular emphasis on the regulation of reactions in living cells. The knowledge and methods developed by biochemists are applied in all fields of medicine, in agriculture and in many chemical and health related industries. Biochemistry is unique in providing basic theoretical training as well as basic practical laboratory training and research in both enzymology and genetic engineering, the two basic components in the rapidly expanding field of Biotechnology.

Three programs are offered by the Department of Biochemistry. The Honours and Major programs provide a sound background for students who wish to have a professional career in biochemistry and can lead to post graduate studies and research careers in hospital, university or industrial laboratories. The Faculty program is less specialized offering students opportunities to select courses in other fields of interest.

During the first year, each program provides basic training in organic, physical and analytical chemistry as well as in biology and physiology. The Honours and Major programs become more specialized in biochemistry during the following two years with additional work in chemistry and biology. The rigorous training in chemistry, which distinguishes the Biochemistry program from Biological Sciences, can lead to admission to the Professional Order of Chemists – a requirement needed to function as a recognized chemist in the Province of Québec.

Students interested in pursuing an *ad hoc* Joint Major or Joint Honours degree between Biochemistry and a second discipline may consult with our Chief Adviser.

The increasing involvement of complex technology in modern society requires personnel trained in both chemistry and biology. With the advent of biotechnology, the combination of chemistry, molecular biology, enzymology and genetic engineering found in the biochemistry program provides the essential background and training in this area as well. The biochemist is in an advantageous position to fulfil this role and assume a wide variety of positions in industry and the health field. These range from research and development in the chemical and pharmaceutical industries to testing as well as research in government and hospital laboratories to management. Many graduates take higher degrees in research and attain academic positions in universities and colleges.

PRE-PROGRAM REQUIREMENTS
Entrance requirements for the Faculty, Major and Honours programs are: 6 credits in elementary biology, 6 credits in general chemistry, 3 credits in organic chemistry, 6 credits in calculus, 8-9 credits in physics.

FACULTY PROGRAM IN BIOCHEMISTRY (55 credits)
[MARS Program Code 4-142000]

U1 Required Courses (16 credits)

507-212B	(3)	Molecular Mechanisms of Cell Function
177-200A	(3)	Molecular Biology
177-202B	(3)	Basic Genetics
180-204A,B	(3)	Physical Chem./Biol. Sci. I
180-222A,B	(4)	Organic Chemistry II

U1 Complementary Courses (9 credits)
6 credits selected from:

552-209A	(3)	Mammalian Physiology I
552-210B	(3)	Mammalian Physiology II
528-211A	(3)	Biology of Microorganisms
177-205B	(3)	Biology of Organisms

3 credits selected from:
177-373A (3) Biostatistical Analysis
308-202A,B (3) Introduction to Computing 1
204-204A,B (3) Introduction to Psychological Statistics
189-222A,B (3) Calculus III

U2 Required Courses (15 credits)
507-300D (6) Laboratory in Biochemistry
507-311A (3) Metabolic Biochemistry
507-312B (3) Biochemistry of Macromolecules
180-302A,B (3) Organic Chemistry III

U2 Complementary Courses (3 credits)
3 credits selected from:
177-303B (3) Developmental Biology
177-313B (3) Structure and Function of Cells
180-352B (3) Structural Organic Chemistry
180-382B (3) Organic Chemistry of Natural Products
528-314B (3) Immunology
504-262B (3) Introductory Molecular and Cell Biology

U3 Complementary Courses (12 credits)
at least 3 credits selected from:
507-450A (3) Protein Structure and Function
507-454A (3) Nucleic Acids
the remaining credits selected from the following list or the above:
507-404B (3) Biophysical Chemistry
507-455B (3) Neurochemistry
507-458B (3) Membranes and Cellular Signaling
504-261A (4) Introduction to Dynamic Histology
177-205B (3) Biology of Organisms
177-300A (3) Molecular Biology of the Gene
177-303B (3) Developmental Biology
177-304A (3) Evolution
177-314A (3) Molecular Biology of Oncogenes
180-214B (3) Physical Chem./Biol. Sci. II
180-257D (4) Analytical Chemistry
180-352B (3) Structural Organic Chemistry
180-362A,B (2) Advanced Organic Chemistry Lab.
180-382B (3) Organic Chemistry of Natural Products
180-402B (3) Advanced Bio-organic Chemistry
180-572B (3) Synthetic Organic Chemistry
528-211A (3) Biology of Microorganisms
528-314B (3) Immunology
549-300A (3) Drug Action
549-301B (3) Drugs and Disease
552-209A (3) Mammalian Physiology I
552-210B (3) Mammalian Physiology II

MAJOR PROGRAM IN BIOCHEMISTRY (67 or 70 credits)
[MARS Program Code 1-142000]

Students may transfer into the Major program at any time provided they have met all course requirements.

U1 Required Courses (20 credits)
507-212B (3) Molecular Mechanisms of Cell Function
177-200A (3) Molecular Biology
177-202B (3) Basic Genetics
180-204A,B (3) Physical Chem./Biol. Sci. I
180-222A,B (4) Organic Chemistry II
180-257D (4) Analytical Chemistry

U1 Complementary Courses (9 credits)
6 credits, selected from:
552-209A (3) Mammalian Physiology I
552-210B (3) Mammalian Physiology II
528-211A (3) Biology of Microorganisms
177-205B (3) Biology of Organisms
3 credits selected from:
177-309A (3) Math. Models in Biology
177-373A (3) Biostatistical Analysis
308-202A,B (3) Introduction to Computing 1
189-203A,B (3) Principles of Statistics
189-222A,B (3) Calculus III
204-204A,B (3) Intro to Psychological Stats

U2 Required Courses (23 credits)
all Faculty Program U2 Required Courses, plus:
180-214B (3) Physical Chem./Biol. Sci. II
180-362A,B (2) Advanced Organic Chemistry Lab.
504-262B (3) Intro. Molecular & Cell Biology

U2 Complementary Courses (3 credits)
3 credits selected from:
177-303B (3) Developmental Biology
177-313B (3) Structure and Function of Cells
180-352B (3) Structural Organic Chemistry
180-382B (3) Organic Chemistry of Natural Products
528-314B (3) Immunology

U3 Required Courses (6 credits)
507-450A (3) Protein Structure and Function
507-454A (3) Nucleic Acids

U3 Complementary Courses (6 or 9* credits)
at least 3 credits selected from:
507-404B (3) Biophysical Chemistry
507-455B (3) Neurochemistry
507-458B (3) Membrames and Cellular Signalling
507-460A* (6) Advanced Lab in Biochemistry
507-503B (3) Immunochemistry

the remainder, if any, to be selected from the following list:
177-300A (3) Molecular Biology of the Gene
177-303B (3) Developmental Biology
177-304A (3) Evolution
177-313B (3) Structure and Function of Cells
177-314A (3) Molecular Biology of Oncogenes
180-352B (3) Structural Organic Chemistry
180-382B (3) Organic Chemistry of Natural Products
180-402B (3) Advanced Bio-organic Chemistry
180-552B (3) Physical Organic Chemistry
180-572B (3) Synthetic Organic Chemistry
516-502A (3) Advanced Endocrinology I
516-503B (3) Advanced Endocrinology II
528-314B (3) Immunology
528-324A (3) Fundamental Virology
549-300A (3) Drug Action
549-301B (3) Drugs and Disease
552-311A (3) Intermediate Physiology I
552-312B (3) Intermediate Physiology II
* Students who are given special permission to take 507-460A are required to complete 9 credits of complementary courses in U3.

HONOURS PROGRAM IN BIOCHEMISTRY (76 credits)
[MARS Program Code 2-142000]

Admission to the Honours program will not be granted until U2. Students who wish to enter the Honours program in U2 should follow the U1 Major program. Those who satisfactorily complete the U1 Major program with a GPA of at least 3.20 and a mark of B or B- or better in every required course are eligible for admission to the Honours program.

Students seeking admission to the Honours program must obtain permission from the Student Affairs Officer during the Add/Drop period in September of their second year.

Promotion to U3 year is based on satisfactory completion of U2 courses with a GPA of at least 3.20 and a B in every required course. In borderline cases, the marks received in 507-311A and 507-312B will be of particular importance for continuation in the U3 Honours year.

For graduation in the Honours program, the student must complete a minimum of 90 credits, pass all required courses with no grade less than B, and achieve a CGPA of at least 3.20.

U1 Required Courses (20 credits)
as for the Major Program U1

U1 Complementary Courses (9 credits)
as for the Major Program U1

U2 Required Courses (23 credits)
as for the Major Program U2

U2 Complementary Courses (3 credits)
as for the Major Program U2

U3 Required Courses (15 credits)
507-404B (3) Biophysical Chemistry
507-450A (3) Protein Structure & Function
507-454A (3) Nucleic Acids
507-460A (6) Advanced Lab in Biochemistry

U3 Complementary Courses (6 credits)
at least 3 credits selected from:
507-455B (3) Neurochemistry
507-458B (3) Membranes and Cellular Signaling
507-491B (6) Independent Research
507-503B (3) Immunochemistry
the remainder, if any, to be selected from the following list:
177-300A (3) Molecular Biology of the Gene
177-303B (3) Developmental Biology
177-304A (3) Evolution
177-313B (3) Structure and Function of Cells
177-314A (3) Molecular Biology of Oncogenes
180-352B (3) Structural Organic Chemistry
180-382B (3) Organic Chemistry of Natural Products
180-402B (3) Advanced Bio-organic Chemistry
180-552B (3) Physical Organic Chemistry
180-572B (3) Synthetic Organic Chemistry
516-502A (3) Advanced Endocrinology I
516-503B (3) Advanced Endocrinology II
528-314B (3) Immunology
528-324A (3) Fundamental Virology
549-300A (3) Drug Action
549-301B (3) Drugs and Disease
552-311A (3) Intermediate Physiology I
552-312B (3) Intermediate Physiology II

ADVISERS
New students interested in Biochemistry should call (514) 398-7266 for information regarding academic advising.

Returning Students must schedule an advising appointment directly with the academic adviser assigned to them in their first year in Biochemistry. Students should check the advisers' schedule which will be posted on the 8th floor of the McIntyre Medical Sciences Building in mid-March or early April 2002.

INTERDEPARTMENTAL HONOURS PROGRAM IN IMMUNOLOGY The Departments of Biochemistry, Microbiology and Immunology, and Physiology offer an Immunology Interdepartmental Honours Program, see section 11.13.

COURSE DESCRIPTIONS
All courses have limited enrolment.

The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

507-212B MOLECULAR MECHANISMS OF CELL FUNCTION. (3) (Prerequisite: 177-200A) (A non-terminal course intended to be followed by 507-311A; 507-312B in the U2 year. Not open to students who have taken or are taking 177-201B or 504-212.) An introductory course describing the biochemistry and molecular biology of selected key functions of animal cells, including: gene expression; mitochondrial production of metabolic energy; cellular communication with the extra-cellular environment; and regulation of cell division. (Restriction revision awaiting University approval)

507-300D LABORATORY IN BIOCHEMISTRY. (6) (1 lecture and one 6-hour lab per week) (Prerequisites: 177-200A and 177-201B, or 507-212B, 180-222A,B; 180-257D recommended. Corequisites: 507-311A and 507-312B. Not open to students who have taken or are taking 177-301.) (For students in Biochemistry programs, others with permission of instructor.) A comprehensive course in modern biochemical techniques involving properties of enzymes, metabolism, fractionation of organelles from mammalian cells and molecular biology.

507-311A METABOLIC BIOCHEMISTRY. (3) (Prerequisites: 177-200A, 177-201B, or 507-212B, 180-222A,B) The generation of metabolic energy in higher organisms with an emphasis on its regulation at the molecular, cellular and organ level. Chemical concepts and mechanisms of enzymatic catalysis are also emphasized. Included: selected topics in carbohydrate, lipid and nitrogen metabolism; complex lipid and biological membranes; hormonal signal transduction.

507-312B BIOCHEMISTRY OF MACROMOLECULES. (3) (Prerequisites: 507-311A, 177-200A, 177-201B or 507-212B) Gene expression from the start of transcription to the synthesis of proteins, their modifications and degradation. Topics covered: purine and pyrmidine metabolism; transcription and its regulation; mRNA processing; translation; targetting of proteins to specific cellular sites; protein glycosylation; protein phosphorylation; protein turn-over; programmed cell death (apoptosis).

507-404B BIOPHYSICAL CHEMISTRY. (3) (Prerequisites: 180-204A,B, 180-214B or equivalent. (Not open to students who have taken 180-404B.) Hydrodynamic and electrophoretic methods for separation and characterization of macromolecules. Optical and magnetic resonance spectroscopy of biopolymers, and applications to biological systems.

507-450A PROTEIN STRUCTURE AND FUNCTION. (3) (Prerequisites: 507-311A, 507-312B and/or sufficient organic chemistry. Intended primarily for students at the U3 level.) Primary, secondary, tertiary and quaternary structure of enzymes. Active site mapping and site-specific mutagenesis of enzymes. Enzyme kinetics and mechanisms of catalysis. Multienzyme complexes.

507-454A NUCLEIC ACIDS. (3) (Prerequisites: 507-311A, 507-312B or permission of instructor.) Chemistry of RNA and DNA, transcription and splicing of RNA and their control; enzymology of DNA replication. Special topics on transgenics, genetic diseases and cancer.

507-455B NEUROCHEMISTRY. (3) (Prerequisites: 507-311A, 507-312B or permission of instructor) Covers biochemical mechanisms underlying central nervous system function. Introduces basic neuroanatomy, CNS cell types and morphology, neuronal excitability, chemically mediated transmission, glial function. Biochemistry of specific neurotransmitters, endocrine effects on brain, brain energy metabolism and cerebral ischemia (stroke). With examples, where relevant, of biochemical processes disrupted in human CNS disease.

507-458B MEMBRANES AND CELLULAR SIGNALING. (3) (Prerequisites: 507-212B, 504-262B; one of 552-201A, 552-209A or 177-205B; one of 507-312B or 504-365A; and 507-311A or permission of instructors.) (This course is also listed as 504-458B. Not open to students who have taken or are taking 504-458B or 507-456B.) An integrated treatment of the properties of biological membranes and of intracellular signaling, including the major role that membranes play in transducing and integrating cellular regulatory signals. Biological membrane organization and dynamics: membrane transport; membrane receptors and their associated effectors; mechanisms of regulation of cell growth, morphology, differentiation and death.

507-460A ADVANCED LAB IN BIOCHEMISTRY. (6) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) Students will select one project, employing advanced as well as standard biochemical techniques, to be performed in a research laboratory in the Department. Each student will also write a research-review paper with the advice of a professor and perform student projects in the teaching laboratory.

507-491B INDEPENDENT RESEARCH. (6) (Registration by departmental permission only) (Prerequisite: 507-460A) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) Individual work on a project to be performed in a research laboratory.

507-503B IMMUNOCHEMISTRY. (3) (Prerequisites: 507-311A, 507-312B) This course, presented in lecture format, emphasizes the molecular, genetic and structure function events that occur in the humoral immune response. Interleukins and other mediators of inflammation, a field in which rapid changes are occurring, are discussed. The clinical significance of fundamental biochemical findings is described.

11.4 Biology (177)

Stewart Biology Building, Room W4-7
1205 Avenue Docteur Penfield
Montreal, QC H3A 1B1

Telephone: (514) 398-6400
Website: http://www.mcgill.ca/Biology/biology1.htm

Chair — Paul F. Lasko

Emeritus Professors
Clark Fraser; O.C., B.Sc.(Acadia), M.Sc., Ph.D., M.D.(McG.), D.Sc.(Acadia), F.R.C.P.(C), F.R.S.C. *(Molson Emeritus Professor of Genetics) (joint appt. with Human Genetics)*
Sarah P. Gibbs; A.B., M.S.(C'nell), Ph.D.(Harv.), F.R.S.C. *(Macdonald Emeritus Professor of Botany)*
John B. Lewis; B.Sc., M.Sc., Ph.D.(McG.)
Gordon A. Maclachlan; B.Sc.(Sask.), Ph.D.(Manit.)*(Macdonald Emeritus Professor of Botany)*
Barid B. Mukherjee; B.Sc.(Calc.), M.S.(Brig.Young), Ph.D.(Utah) *(joint appt. with Human Genetics)*
Rolf Sattler; B.Sc.(Tubingen), Ph.D.(Munich), F.R.S.C.

Professors
Graham A.C. Bell; B.A., D.Phil.(Oxon.), F.R.S.C. *(James McGill Professor) (Molson Professor of Genetics)*
Gregory G. Brown; B.Sc.(Notre Dame), Ph.D.(N.Y.) *(on leave)*
A.Howard Bussey; B.Sc., Ph.D.(Brist.), F.R.S.C.
Robert L. Carroll; B.S.(Mich.), M.A., Ph.D.(Harv.), F.R.S.C. *(Strathcona Professor of Zoology)*
Ronald Chase; A.B.(Stan.), Ph.D.(M.I.T.)
Rajinder S. Dhindsa; B.Sc., M.Sc.(Punj.), Ph.D.(Wash.)
Jacob Kalff; M.S.A.(Tor.), Ph.D.(Ind.)
Donald L. Kramer; B.Sc.(Boston Coll.), Ph.D.(U.B.C.)
Paul F. Lasko; A.B.(Harv.), Ph.D.(M.I.T.) *(joint appt. with Anatomy & Cell Biology)*
Martin Lechowicz; B.A.(Mich. State), M.S., Ph.D.(Wis.)
Ronald J. Poole; B.Sc., Ph.D.(Birm.)
Rima Rozen; B.Sc., Ph.D.(McG.) *(James McGill Professor)*
Daniel J. Schoen; B.Sc., M.Sc.(Mich.), Ph.D.(Calif.) *(Macdonald Professor of Botany)*

Associate Professors
Siegfried Hekimi, M.Sc., Ph.D.(Geneva)
Louis Lefebvre; B.Sc., M.A., Ph.D.(Montr.)
Robert L. Levine; B.Sc.(Brooklyn), M.Sc., Ph.D.(Yale)
Yutaka Nishioka; B.A., M.A.(Tokyo), Ph.D.(Col.)
Gerald S. Pollack; M.A., Ph.D.(Prin.) *(on leave)*
Catherine Potvin; B.Sc., M.Sc.(Montr.), Ph.D.(Duke)
Neil M. Price; B.Sc.(New Br.), Ph.D.(Br.Col.)
Joseph Rasmussen; B.Sc., M.Sc.(Alta.), Ph.D.(Calg.)
Beat Suter; Dip., Ph.D.(Zür)
Candace S. Waddell; B.A.(Virginia), Ph.D.(UCSF)

Assistant Professors
Thomas Bureau; B.Sc.(Calif.), Ph.D.(Texas)
Joseph A. Dent; B.Sc., Ph.D.(Colo.)
Kevin McCann; B.A.(Dart), M.Sc., Ph.D.(Guelph)
Laura Nilson; B.A.(Colgate), Ph.D.(Yale) *(Canada Research Chair in Developmental Genetics)*
Richard Roy; B.Sc.(Bishop's), Ph.D.(Laval)
Amanda Vincent; B.Sc.(W.Ont.), M.Sc.(Br.Col.), Ph.D.(Cantab.) *(William Dawson Scholar)*

Associate Members
Sal Carbonetto *(MGH),* HughJ. Clarke *(RVH.),* Pierre Drapeau *(MGH),* Robert Dunn *(Neuroscience),* Michael Ferns *(Neurology & Neurosurgery),* David Green *(Redpath Museum),*
Kenneth Hastings *(MNI)*, Paul Holland *(MNI)*, Roberta Palmour *(Allan Memorial Institute)*, David Rosenblatt *(Paediatrics),*
Guy Rouleau *(MGH),* Charles R. Scriver *(Paediatrics),*
Teruko Taketo *(RVH),* Harriet S. Tenenhouse *(Paediatrics),*
David Y. Thomas *(NRC Lab)*

Adjunct Professors
Wing Cheung *(DNA Landmarks)*
Wayne Hunte *(U. West Indies)*
Benoit S. Landry *(DNA Landmarks)*
William C. Leggett; B.A., M.Sc.(Wat.), Ph.D.(McG.), F.R.S.C. *(Queen's)*
Malcolm S. Whiteway; B.Sc.(Dal.), Ph.D.(Alta.) *(NRC Lab)*

Biology is the study of living beings at the molecular, cellular and organismal levels. It deals with fundamental questions such as the origin and evolution of plants and animals, interactions between living organisms and their environment, mechanisms of embryonic development, structure and function of the living cell and its organelles, molecular basis of inheritance, biochemical and genetic basis of human diseases, and the operation of the brain and the nervous system. The study of biology also has vast practical applications. The knowledge, methods and concepts developed through research in the various fields of biology are applied extensively in agriculture, medicine, biotechnology, genetic engineering, environmental protection and wildlife management.

The Department of Biology offers two Faculty Programs, a Major Program, an Honours Program, a Minor Program and a Minor Concentration in Science for Arts students. The details of these programs are given below.

The prerequisites for Biology programs include, in addition to the minimum requirements for admission to the Faculty of Science, an additional Biology and one course in Organic Chemistry. Students who have a DEC in Science but lack either of these courses must take them as extra requirements. It is advisable to take the additional CEGEP Biology in advance, if possible. The two Biology courses together prepare students for the Biology Program at McGill. Note that an introductory course in Cell and Molecular Biology (177-112L) is offered in the summer at McGill.

The programs in Biology offer students an opportunity to specialize in more than one area of biology and provide them with a broad training in biology as compared to the more specialized programs in Biochemistry, Microbiology, Physiology and Anatomy. A B.Sc. degree in Biology, therefore, prepares students for a wide range of employment opportunities, including entry to professional schools in medicine, veterinary science, dentistry, agriculture, nursing, education and library science. It also provides solid background for those interested in careers related to environmental protection, wildlife management, biotechnology and genetic engineering. A B.Sc. degree in Biology can also lead to post-graduate studies and research careers in universities, research institutes, hospitals, and industrial or governmental laboratories.

The Department of Biology has well-equipped teaching and research laboratories and its academic staff members, research associates, post-doctoral fellows and graduate students carry out research in areas of molecular biology, human genetics, ecology, animal behaviour, developmental biology, neurobiology, marine biology, plant biology, and evolution. Its teaching and research resources are extended by the Redpath Museum; the Montreal Children's, Jewish General, Montreal General, Royal Victoria and Shriners Hospitals; Macdonald Campus; Montreal Neurological Institute; and the Sheldon Biotechnology Centre. For courses taught in the field, the stations at the Gault Nature Reserve, the Morgan Arboretum, the Bellairs Research Institute in Barbados, the Huntsman Marine Science Centre in New Brunswick, and the Smithsonian Tropic Research Institute in Panama are used. In addition, field stations near Lake Memphremagog and at Schefferville in northern Quebec are available for research projects.

The courses listed below are not described in any great detail. To provide more information, the Department has prepared a "Blue Book" (sold in the Biology Department, Room W4/8), entitled Department of Biology Undergraduate Programs 2001-2002, which describes in detail the content of each course and the level at which it is given, the aims and methods used, lectures, references, grading procedures, etc. The book also contains more information on registration, counselling, committee structure and the research interests and facilities which are represented in the Department.

Inquiries about undergraduate programs should be directed to the Undergraduate Affairs Office, in Room W4/8, Stewart Biology Building, telephone (514) 398-7045.

MINOR PROGRAM IN BIOLOGY (24 credits)
[MARS Program Code 6-144500]

The Minor in Biology may be taken in conjunction with any primary program in the Faculty of Science (other than programs offered by the Department of Biology). Students are advised to consult the Undergraduate Adviser in Biology as early as possible (preferably during their first year), in order to plan their course selection.

Six credits of overlap are allowed between the Minor and the primary program.

Required Courses (18 credits)
177-200A (3) Molecular Biology
177-201B (3) Cell Biology and Metabolism
177-202B (3) Basic Genetics
177-205B (3) Biology of Organisms
177-208A (3) Ecology
177-304A (3) Evolution

Complementary Courses (6 credits)
6 credits to be chosen from the Biology Department's course offerings, at the 300 level or above.

FACULTY PROGRAMS

In view of the constantly changing job market for B.Sc. graduates in biology, the Department has designed Faculty Programs to allow students to prepare for a wide range of employment opportunities. The programs offer students an opportunity to specialize in more than one area of biology, to broaden the scope of their scientific background. The programs can be tailored to provide a relatively broad spectrum of biology courses, or provide a degree of specialization in biology which approaches that of a Major Program (total 36 to 54 biology credits). The flexibility and scope of these programs will not only enhance the graduate's prospects for employment, but also entrance into graduate studies.

FACULTY PROGRAM IN BIOLOGY (54 credits)
[MARS Program Code 4-144500]

Required Courses (18 credits)
177-200A (3) Molecular Biology
177-201B (3) Cell Biology and Metabolism
177-202B (3) Basic Genetics
177-205B (3) Biology of Organisms
177-208A (3) Introduction to Ecology
177-304A (3) Evolution

Complementary Courses (36 credits)
18 credits of Biology courses, including 3 credits selected from:
177-206A (3) Methods in Biology of Organisms
or 177-301A,B (3) Cell and Molecular Laboratory
18 credits of Science courses including, at most, 3 credits of general interest Science courses (not listed in Science Major Programs).

Of the Complementary courses at least 6 of the 15 remaining Biology credits and 6 of the 18 Science credits must be above the 200-level, none may be at the 100-level; all are to be approved by the adviser.

FACULTY PROGRAM IN BIOLOGY AND MATHEMATICS
(57 credits) [MARS Program Code 4-144700]

Required Courses (21 credits)
189-133A,B,C,L,T* (3) Vectors, Matrices and Geometry
189-222A,B* (3) Calculus III
189-223A,B* (3) Linear Algebra
189-315A,B (3) Ordinary Differential Equations
189-323A,B (3) Probability Theory
189-324A,B (3) Statistics
308-202A,B (3) Introduction to Computing 1
* students with CEGEP equivalents of these courses must substitute other mathematics courses in consultation with the adviser

Complementary Courses (36 credits)
21 credits in Biology including
12 credits selected from:
177-200A (3) Molecular Biology
177-201B (3) Cell Biology and Metabolism
177-202B (3) Basic Genetics
177-205B (3) Biology of Organisms
177-206A (3) Methods in Biology of Organisms
177-304A (3) Evolution
552-209A (3) Mammalian Physiology I
552-210B (3) Mammalian Physiology II
and 9 credits selected from:
177-208A (3) Introduction to Ecology
or 177-307A (3) Behavioural Ecology/Sociobiology
177-303B (3) Developmental Biology
177-306A (3) Neurobiology and Behaviour
177-324A (3) Ecological Genetics
177-370B (3) Human Genetics Applied
177-470B (3) Lake Management
177-473A (3) Ecology of Aquatic Invertebrates
177-520B (3) Gene Activity in Development
177-530B (3) Neural Basis of Behaviour
177-531A (3) Neurobiology Learning Memory
6 credits of any other Biological Sciences courses
9 credits of Mathematics
including at least 3 credits selected from:
177-309A (3) Mathematical Models in Biology
198-413A (3) The Physical Basis of Physiology
and at least 3 credits selected from:
189-314A,B (3) Advanced Calculus
189-317A,B (3) Numerical Analysis
189-319B (3) Partial Differential Equations
189-327B (3) Matrix Numerical Analysis
189-407B (3) Dynamic Programming
189-423A (3) Regression and Analysis of Variance
189-447B (3) Stochastic Processes
189-525A (3) Sampling Theory and Applications
or other suitable mathematics courses chosen in consultation with the adviser.

Advisers: Drs. M. Mackey and L. Glass (Department of Physiology)

MAJOR PROGRAM IN BIOLOGY (54 credits)
[MARS Program Code 1-144500]

The Major requires 5 4credits comprising 33 as specified below and 21 additional credits which are to be chosen by students in consultation with their adviser.

U1 Required Courses (18 credits)
177-200A (3) Molecular Biology
177-201B (3) Cell Biology and Metabolism
177-202B (3) Basic Genetics
177-205B (3) Biology of Organisms
177-206A (3) Methods in Biology of Organisms
177-208A (3) Introduction to Ecology

U2 or U3 Required Courses (6 credits)
177-301A,B (3) Cell and Molecular Laboratory
177-304A (3) Evolution

U2 or U3 Complementary Courses (9 credits)
9 credits selected from:
177-300A (3) Molecular Biology of the Gene
177-303B (3) Developmental Biology
177-305B (3) Diversity of Life
177-306A (3) Neurobiology and Behaviour

Other Complementary Courses (21 credits)
To be selected in consultation with the student's adviser. All courses must be at the 300 level or higher; they are to include any seven Biology courses of which at most three may be substituted, given the adviser's consent, with science courses offered by other departments. Unless required by the Major Program, prerequisites for these courses must be taken as electives.

BIOLOGY CONCENTRATIONS

The concentrations set out below are only guidelines for specialized training. They do not constitute sets of requirements. Students interested in advanced studies in any biological discipline are strongly advised to develop their skills in computing as appropriate. As an aid to students wishing to specialize, the concentrations list key and other suggested courses by discipline.

MOLECULAR GENETICS AND DEVELOPMENT CONCENTRATION

The discoveries that have fuelled the ongoing biomedical and biotechnological revolution have arisen at the intersection of a number of fields of biological investigation, including molecular biology, genetics, cellular and developmental biology and biochemistry. A substantial and significant quantity of this research has been conducted upon model eukaryotic organisms, such as yeast, nematode, the fruit fly, and the mustard weed, Arabidopsis. In the molecular genetics and development concentration students will obtain a comprehensive understanding of how the "model eukaryotes" have advanced our knowledge of the mechanisms responsible for cellular function and organismal development. Graduates from this concentration will be well prepared to pursue higher degrees in the fields of basic biology, biotechnology, and biomedicine or to assume a wide variety of positions in government, universities, and medical and industrial institutions.

Key courses:
Biology 177-300A, -301A,B, -303B, -373A, -551A
Chemistry 180-222A,B, -203A or -204A,B and -214B

Other suggested courses:
Biology 177-314A, -471C,D, -477A, -478B,C, -516B, -518B -520B, -524A or -544A

NEUROBIOLOGY CONCENTRATION

Nervous systems are perhaps the most complex entities in the natural world, being composed of up to trillions of interconnected cells that must operate in a coordinated manner to produce behaviour which can range from the mundane (e.g., regulation of heart rate) to the magnificent (e.g., musical composition). The discipline Neurobiology, one of the fastest growing areas of modern biology, seeks to understand the evolution, development, and operation of nervous systems. The Neurobiology concentration addresses these issues by examination of neural structure, function and development at levels of organization that range from the molecular to the organismal. As a result of exposure to a wide range of experimental and intellectual approaches, students receive a sound, broadly-based education in biology.

Key courses:
Biology 177-306A, -389B, -530B, -531A, -532B, -588A

Other suggested courses:
Anatomy and Cell Biology 504-321A, 322B
Biochemistry 507-455B
Biology 177-300A, -303B, -373A or equivalent, -471C,D, -477A, -478B,C
Neurology/Neurosurgery 531-310B
Pharmacology 549-562A
Physiology 552-451A, -520B, -556B
Psychiatry 555-500B
Psychology 204-311A, -318B, -342B, -410B, -422B, -470A

HUMAN GENETICS CONCENTRATION

The courses recommended for students interested in Human Genetics are designed to offer a broad perspective in this rapidly advancing area of biology. Genetics is covered at all levels of organization (the gene, the chromosome, the cell, the organism and the population), using pertinent examples from all species, but with special emphasis on humans.

Key courses:
Biology 177-301A,B, -370B, -373A, -468B, -475B, -516B or -520B

Other suggested courses:
Biology 177-314A, -471C,D, -477A or -478B,C, -551A
Chemistry 180-222A,B, -203A or -204A and -214B
Biochemistry 507-311A, -450A
Microbiology and Immunology 528-314B

EXPERIMENTAL PLANT BIOLOGY CONCENTRATION

Research interests span modern molecular genetics, plant physiology and biochemistry, plant ecology and genetics, plant morphogenesis, and the adaptation and evolution of plant form and function. Research is carried out in the field and in the Department's large, excellent controlled environment facilities. The importance of adaptation to climate and the use of plants for food, chemicals, pharmaceuticals and materials underlie research using biotechnology and quantitative methods to improve cultivated plants and understand natural plant populations.

Key courses:
Biology 177-300A, -303B, -305B, -357A, -358A

Other suggested courses:
Biology 177-373A, -465A, -471C,D, -477A, -478B,C, -522B, -526B, -555L

EVOLUTIONARY BIOLOGY CONCENTRATION

Evolutionary biology is the study of processes that change organisms and their characteristics through time. Evolutionary biologists are concerned with adaptations of organisms and the process of natural selection.

Key courses:
Biology 177-305B, -307B, -324A, -331A, -352B, -471C,D, -477A or -478B,C, -555L, -562B, -570B, -572A

Other suggested courses in Organismal Biology:
Biology 177-327A, -335T, -350A, -351B, -358A

Macdonald Campus:
Natural Resource Sciences 375-420A

Genetics and Development:
Biology 177-300A, -303B

Ecology and Behaviour:
Biology 177-309A, -345A

ANIMAL BEHAVIOUR CONCENTRATION

Understanding the diverse ways in which animals feed, mate, care for their offspring, avoid predators, select their habitats, communicate, and process information constitute the subject matter of behaviour. Several approaches are used to study these questions. Some focus on ecological consequences and determinants, some on physiological, genetic and developmental mechanisms, others on evolutionary origins.

Key courses:
Biology 177-305B, -306A, -307B, -331A or -334E or another field course with a significant behavioural component.

Other suggested courses: 177-377B,C, -471C,D, -477A, -478B,C

Since animal behaviour builds upon the fields of behaviour, ecology, and evolutionary biology, most courses from these fields will be relevant. Some courses that focus on a particular taxonomic group such as birds (Natural Resource Sciences 375-420A), amphibians and reptiles (177-327A) and marine mammals (177-335T) include a significant amount of behaviour. Prof. A. Baker of the Psychology Department is willing to advise students on selection of relevant psychology courses on perception, learning, and motivation.

BIOLOGICAL DIVERSITY AND SYSTEMATICS

The study of biological diversity deals with the maintenance, emergence, and history of the inexhaustible variety of different kinds of organisms. It is deeply concerned with the particular characteristics of different organisms and therefore emphasizes the detailed study of particular groups and forms the basis of comparative biology. Our knowledge of diversity is organized through the study of systematics which seeks to understand the history of life and the phylogenetic and genetic relationships of living things. Appreciation and knowledge of diversity and systematics are essential in

ecology and evolutionary biology and underlie all work in resource utilization and conservation biology.

Key course:
Biology 177-305B

Other suggested courses:
Biology 177-240T, -324A, -327A, -331A or -334E, -335T, -341B, -350A, -351B, -352B, -353A, -358A, -373A, -437A, -465A, -471C,D, -477A or -478B,C, -555L, -560A -562B,

Macdonald Campus:
Zoology 349-307A, -312A, -313B, -316A, -424A
Plant Science 367-356A, -451B
Entomology 350-440B
Natural Resource Sciences 375-402B, -420A

CONCENTRATIONS AVAILABLE WITHIN THE AREA OF ECOLOGY

Ecology is the study of the interactions between organisms and environment that affect distribution, abundance, and other characteristics of the organisms. A strong analytical and quantitative orientation is common to all areas of ecology, and thus students wishing to specialize in these areas are strongly encouraged to develop their background in statistical analysis, computing, and mathematical modelling. Many of the ecology courses feature a strong analytical component, and students will find that background preparation in this area is very useful, if not essential. Ecology depends heavily on field research, and thus 177-331A and/or other field courses should be considered as vital to all concentrations in this area.

GENERAL AND APPLIED ECOLOGY CONCENTRATION

The concentration in general and applied ecology is designed to introduce the breadth of contemporary ecology, at the levels of the ecosystem, communities and populations, and at the level of the individual organism, with an accent on the application of this science to practical problems in environmental management, and the management of resources and pests. In addition to general courses dealing with general principles, there is a selection of courses dealing with particular groups of organisms. Since it is essential to know how knowledge is obtained, the concentration includes a field course in ecology.

Key courses:
Biology 177-305B, -331A or -334E, -350A
Computer Science 308-202A,B or -273A,B

Other suggested courses:
Biology 177-307B, -324A, -327A, -345A, -432A, -441B or -542B, -535B, -562B
Geography 183-302B

Macdonald Campus:
Plant Science 367-451A
Natural Resource Sciences 375-420A

AQUATIC ECOLOGY CONCENTRATION

This concentration is designed to introduce the principles of ecology as they pertain to aquatic ecosystems and aquatic biota. Since it is essential to know how knowledge is obtained, as well as what has been learned, three of the courses (limnology, fish ecology, and aquatic invertebrate ecology) involve field components that stress the techniques used to study aquatic ecology. In addition, the concentration includes a field course in ecology. There is also a variety of courses in aquatic disciplines offered in other departments that complement the aquatic ecology courses offered in Biology.

Key courses:
Biology 177-305B, -331A or another field course, -432A, -441B or -542B, -560A
Computer Science 308-202A,B or -273A,B

Other suggested courses:
Biology 177-307B
Geography 183-305A, -306B, -308A, -332A

Macdonald Campus
Zoology 349-315A

MARINE BIOLOGY CONCENTRATION

This concentration is designed to offer students a broad introduction to Marine Biology and Marine Ecology which will form the basis for graduate studies in the fields, or to employment in Aquatic Biology and Oceanography.

Key courses:
Biology 177-305B, -335T, -351B, -437B, -441B, -542B

Other suggested courses:
Biology 177-331A, -334E -432A, 560A
Earth and Planetary Sciences 186-542A
Atmospheric and Oceanic Sciences 195-220A,B, -512A, -550A, -561B

For students intending to proceed to graduate work, one independent studies course (177-477A or -478B,C) is recommended. Because of the importance of numerical analyses in all fields of Ecology, courses in Biometry (e.g. -373A) and Computer Science (308-202A,B or -273A,B) are recommended.

HONOURS PROGRAM IN BIOLOGY (67 or 70 credits)
[MARS Program Code 2-144500]

The Honours program in Biology is designed expressly as a preparation for graduate studies and research, and provides students with an enriched training in biology and some research experience in a chosen area. Acceptance into the Honours Program at the end of U2 requires a CGPA of 3.20 and approval of a 9 or 12-credit Independent Studies proposal (see listing of 177-479D,G and 480D,G for details). For an Honours degree, a minimum CGPA of 3.20 in the U3 year and adherence to the program as outlined below are the additional requirements.

U1 Required Courses (18 credits)
as for the Major program

U2 and U3 Required Courses (9 credits)

177-301A,B	(3)	Cell and Molecular Laboratory
177-304A	(3)	Evolution
177-373A	(3)	Biostatistical Analysis

U2 and U3 Complementary Courses (27 credits)
9 credits selected from:

177-300A	(3)	Molecular Biology of the Gene
177-303B	(3)	Developmental Biology
177-305B	(3)	Diversity of Life
177-306A	(3)	Neurobiology and Behaviour

18 credits in Biology at the 300 level or higher

U3 Required Courses (13 or 16 credits)

177-499D	(4)	Honours Seminar in Biology
and 177-479D,G	(9)	Independent Studies in Biology
or 177-480D,G	(12)	Independent Studies in Biology

Courses Open to Non-Biologists

Many aspects of biology interest humanists and scientists specializing in other disciplines. Therefore, several courses are offered to students with little or no background in biology. These are either CEGEP equivalent courses (177-111A and 177-112B), service courses (177-373A), or general interest courses such as 177-115B and 177-210A.

COURSE DESCRIPTIONS

All courses have limited enrolment.

The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

● Denotes courses not offered in 2001-02.
★ Denotes courses offered only in alternate years

177-101A ORGANISMAL BIOLOGY LAB. (1) (3 hours laboratory) (Exclusion: 177-111A) Laboratory component of 177-111A. May be taken only by transfer students who have completed elsewhere

the lecture component but not the laboratory of 177-111A and only with permission of the Associate Dean (Academic and Student Affairs) of Science.

177-102B CELL AND MOLECULAR BIOLOGY METHODS. (1) (3.5 hours laboratory) (Exclusion: 177-112B) The laboratory component of 177-112B. May be taken only by transfer students who have completed elsewhere the lecture component but not the laboratory of 177-112B and only with permission of the Associate Dean (Academic and Student Affairs) of Science.

177-111A PRINCIPLES OF ORGANISMAL BIOLOGY. (3) (2 lectures and 3 hours laboratory) (Prerequisite: none. Exclusions: CEGEP objective 00UK or equivalent; 177-115B) An introduction to the structure, function and adaptation of plants and animals in the biosphere. Open to all students wishing introductory biology. Attendance at first lab is mandatory to confirm registration in the course.

177-112B,L CELL AND MOLECULAR BIOLOGY. (3) (2 lectures and 3.5 hours laboratory/seminar) (Prerequisite: none. Exclusions: CEGEP objective 00XU or equivalent; 177-115B.) The cell: ultrastructure, division, chemical constituents and reactions. Bioenergetics: photosynthesis and respiration. Principles of genetics and the molecular basis of inheritance. Serves as a prerequisite for 177-200A and 177-201B and as an alternative to CEGEP Cell Biology. Attendance at first lab is mandatory to confirm registration in the course.

177-115B ESSENTIAL BIOLOGY. (3) (3 lectures) (Prerequisites: none. Restricted to non-Science astudents; not open to students who have had 177-111A, 177-112B, or equivalents.) An introduction to biological science that emphasizes the manner in which scientific understanding is achieved and evolves and the influence of biological science on society. Topics will include cell structure and function, genetics, evolution, organ physiology, ecology and certain special topics that change from year to year.

177-200A MOLECULAR BIOLOGY. (3) (3 lectures, 1 hour tutorial) (Prerequisite: 177-112B or equivalent. Corequisite: 180-212A or equivalent.) The physical and chemical properties of the cell and its components in relation to their structure and function. Topics include: protein structure, enzymes and enzyme kinetics; nucleic acid replication, transcription and translation; the genetic code, mutation, recombination, and regulation of gene expression.

177-201B CELL BIOLOGY AND METABOLISM. (3) (3 lectures, 1 hour tutorial) (Prerequisite: 177-200A. Exclusion: 507-212B and 504-212) This course introduces the student to our modern understanding of cells and how they work. Major topics to be covered include: photosynthesis energy metabolism and metabolic integration; plasma membrane including secretion, endocytosis and contact mediated interactions between cells; cytoskeleton including cell and organelle movement; the nervous sytem; hormone signalling; the cell cycle.

177-202B BASIC GENETICS. (3) (3 hours lecture, 1 hour conference optional) (Prerequisite: 177-200A. Exclusion: 177-274A.) Introduction to basic principles, and to modern advances, problems and applications in the genetics of higher and lower organisms with examples representative of the biological sciences.

177-205B BIOLOGY OF ORGANISMS. (3) (3hours lecture, optional conference hour) (Prerequisites: 177-200A,177-208A/308B. Corequisite: 177-201B or 507-212B or permission of co-ordinator.) Unified view of form and function in organisms from all five kingdoms. Focus on the principal functions that all organisms must achieve to ensure their survival.

177-206A METHODS IN BIOLOGY OF ORGANISMS. (3) (1 lecture and 4 hours laboratory) (Prerequisite: 177-111A or equivalent) Introduction to methods used in organismal biology, including ecological sampling, use of keys, measurements, use of statistics and computers in numerical analysis, microbiological methods, basic histological techniques, use of microscopes and library searching procedures. Lecture and Field trip in week one.

177-208A INTRODUCTION TO ECOLOGY. (3) (2 hours lecture, 1 hour tutorial) (Prerequisite: 177-111A or CEGEP equivalent.) (Formerly 177-308B) This course introduces the basic principles and applications of population, community, and ecosystem ecology.

177-210A PERSPECTIVES OF SCIENCE. (3) (3 hours lecture) This course is an introduction to the thinking, language and practices of scientists. Its objective is to bridge the gap between science and the humanities, and in particular to allow students enrolled in the Minor Concentration in Science for Arts to pursue their interests in specific scientific disciplines.

177-240T MONTEREGIAN FLORA. (3) (Prerequisite: 177-111A or permission.) (Not open to students who have taken 177-358A or 367-358A) Field studies emphasizing sight-recognition of ferns, fern allies, conifers and flowering plants of the St. Lawrence River Valley, and the use of plant keys for species identification. Taught for two weeks at the Gault Nature Reserve; contact instructor well in advance for specific dates, logistics.

177-300A MOLECULAR BIOLOGY OF THE GENE. (3) (3hours lecture, optional conferences) (Prerequisites: 177-200A, 177-201B.) A survey of current knowledge and approaches in the area of gene structure and function. Topics include: gene isolation and characterisation, gene structure and replication, mechanism of gene expression and its regulation in pro- and eukaryotes.

177-301A,B CELL AND MOLECULAR LABORATORY. (3) (1 lecture and one 6-hour laboratory) (Prerequisites: 177-200A, 177-201B. 177-206A recommended. Exclusion: 507-300D. Password card required.) Focus is on the experimental methods used to develop the chemical and biological concepts introduced in first year courses. Techniques by which growth, metabolism and regulation of cell systems are analyzed and by which biological macromolecules are purified and characterized.

177-303B DEVELOPMENTAL BIOLOGY. (3) (3 lectures and optional 1 hour conference) (Prerequisites: 177-200A and 177-201B. Corequisite: 177-202B) A consideration of the fundamental processes and principles operating during embryogenesis. Experimental analyses at the molecular, cellular, and organismal levels will be presented and analyzed to provide an overall appreciation of developmental phenomena.

177-304A EVOLUTION. (3) (3 hours lecture) (Prerequisite: 177-205B or 177-208A/308B or MSE 170-202.) This course will show how the theory of evolution by natural selection provides the basis for understanding the whole of biology. The first half of the course describes the process of selection, while the second deals with evolution in the long term.

177-305B DIVERSITY OF LIFE. (3) (2 lectures and 1 three-hour laboratory) (Prerequisite: 177-205B or 177-208A/308B or MSE 170-202.) This course will describe biological diversity in phylogenetic and ecological contexts, in populations and ecosystems, and from local to global scales. The practical classes will cover the relevant phylogenetic, ecological and statistical techniques needed to measure and analyze biodiversity.

177-306A NEUROBIOLOGY AND BEHAVIOUR. (3) (3 hours lecture) (Prerequisites: 177-201B, 177-205B.) Mechanisms of animal behaviour; ethology; cellular neurophysiology, integrative networks within nervous systems; neural control of movement; processing of sensory information.

177-307B BEHAVIOURAL ECOLOGY/SOCIOBIOLOGY. (3) (2hours lecture and 1 hour conference) (Prerequisites: 177-205B, 177-208A/308B or permission.) The relationship between animal behaviour and the natural environment in which it occurs. This course introduces the subject of ecology at the level of the individual organism. Emphasis on general principles which relate to feeding, predator avoidance, aggression, reproduction and parental care of animals including humans.

177-309A MATHEMATICAL MODELS IN BIOLOGY. (3) (2 hours lecture) (Prerequisite: Elementary calculus. An additional course in calculus is recommended.) Application of finite difference and differential equations to problems in cell and developmental biology, ecology and physiology. Qualitative, quantitative and graphical techniques are used to analyze mathematical models and to compare theoretical predictions with experimental data.

177-314A MOLECULAR BIOLOGY OF ONCOGENES. (3) (3 hours lecture per week) (Prerequisites: 177-200A; 177-201B or 507-212B) The genes that cause cancer are altered versions of genes

present in normal cells. The origins of these oncogenes, their genetic structure, regulation, and the biochemical properties of the oncogene-encoded proteins will be analyzed in an attempt to understand the origins of human and animal cancers.

● ★**177-324A ECOLOGICAL GENETICS.** (3) (2 hours lecture, 1 seminar) (Prerequisite: 177-202B)

177-327A HERPETOLOGY. (3) (2 hours lecture; 3 hours laboratory) (Prerequisite: 177-205B) Principles of biology as exemplified by amphibians and reptiles. Topics include: adaptation, social behaviour, reproductive strategies, physiology, biomechanics, ecology, biogeography and evolution. Laboratories will emphasize structure, systematics and identification of local and world herpetofauna as well as field methods.

177-331A ECOLOGY/BEHAVIOUR FIELD COURSE. (3) (Prerequisites: 177-206A; 177-208A/308B) (Preregistration in March and April. See Prof. Kalff.) A 12-day Field Course just before the fall term, with a project report to be prepared early in the fall term. Methods of sampling natural populations of animal and plant species in fresh water and terrestrial habitats. Estimating population size. Testing hypotheses in nature. Energy flow determinations and behavioural ecology.

177-334E APPLIED TROPICAL ECOLOGY. (3) (Prerequisites: 177-208A/308B and permission.) Aspects of tropical ecology relevant to agriculture, forestry, fisheries and conservation of natural resources. Taught at the University's Bellairs Research Institute in Barbados, for two weeks in early May. The course is organized in a series of small-group field projects of 2-3 days each. Interested students should contact the Undergraduate Office and fill out an application form.

177-335T MARINE MAMMALS. (3) (Prerequisites: 177-205B) Biology of marine mammals with special emphasis on seals and whales of the Bay of Fundy. Taught at the Huntsman Marine Science Centre, St. Andrews, N.B., for two weeks in August. The course combines lectures, laboratory exercises, field trips, and individual projects. See S. Gabe, W4/8.

177-341B HISTORY OF LIFE. (3) (3hours lecture) (Prerequisite: 177-204A/304A or permission.) The origin, history, and nature of life from 3.5 billion years ago to the present, within the context of physical and biological changes in the Earth's environment. Topics: origin of life, radiation of multicellular organisms; invasion of land by plants and animals; rise and extinction of dinosaurs; origin of modern biota.

● ★**177-345A PARASITISM AND SYMBIOSIS.** (3) (2 hours lecture and eight 3-hour laboratories) (Prerequisite: 177-205B or permission.)

177-350A INSECT BIOLOGY AND CONTROL. (3) (Exclusion: 350-330A) A lecture course designed to introduce insect structure, physiology, biochemistry, development, systematics, evolution, ecology and control. The course stresses interrelationships and integrated pest control.

● **177-351B THE BIOLOGY OF INVERTEBRATES.** (3) (2hours lecture; 3 hours laboratory) (Prerequisites: 177-204A/304A, 177-205B or permission.)

★**177-352B VERTEBRATE EVOLUTION.** (3) (2 hours lecture, 3 hours laboratory) (Prerequisite: 177-204A/304A or permission) The origin and evolution of the major groups of vertebrates; their anatomy, phylogeny and zoogeography. Structural, behavioral and physiological adaptations to different environments and energetic requirements. Evolutionary theory as applied to major events in the history of vertebrates; the origin and radiation of major taxa, patterns and rates of evolution.

177-357A PLANT PHYSIOLOGY. (3) (3 hours lecture) (Prerequisites: 177-200A and 177-201B or permission.) Advanced introduction to plant physiology. Study of processes that maintain day-to-day life of the plant and processes underlying plant development. Role of phytohormones, light and temperature on plant growth and development. Plant responses to environmental stresses. Application of modern techniques of tissue culture and molecular biology for agricultural benefits.

177-358A CANADIAN FLORA. (3) (2 hours lecture, 3hours laboratory) (Prerequisite: 177-111A or equivalent.) Practical training in plant identification combined with an emphasis on major plant families and species important in temperate boreal, and arctic regions. Four days of required, pre-semester field excursions; contact the instructor well in advance of the course.

177-370B HUMAN GENETICS APPLIED. (3) (3 hours lecture; 1hour conference optional) (Prerequisites: 177-200A and 177-201B, 177-202B) A contemporary view of what genetics can do when applied to human beings.

177-373A BIOSTATISTICAL ANALYSIS. (3) (2 hours lecture and 2 hours laboratory per week) (Prerequisite: 189-112A,B or equivalent) (Note: 177-373 may preclude credit for other statistics courses. See "Course Overlap" on page 351.) Elementary statistical methods in biology. The aim of this course is to introduce students to the analysis of biological data. Emphasis is placed on the assumptions behind statistical tests and models. The course is designed to give a student the ability to intelligently use the statistical techniques typically available on computer packages such as SYSTAT or SPSS. Preference given to Biology students; laboratory sections assigned at term's start.

177-377B,C INDEPENDENT STUDIES IN BIOLOGY. (3) (Open to U2 or U3 Biology students only.) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) For course details, see 177-477A.

177-389B LABORATORY IN NEUROBIOLOGY. (3) (1 hour lecture; 5 hours laboratory) (Prerequisites: 177-306A or 552-311A or 204-308A or 531-310A or permission.) Provides experience in the methods of neurobiological research; experiments include extracellular and intracellular recording from nerve cells, electrical stimulation, and the study of neuro-behavioural problems.

177-413 A,B,C,L,T READING PROJECT. (1) (3 hours independent work) (Prerequisites: 177-200A, 177-201B, 177-202B, 177-204A/304A, 177-205B, 177-208A/308B) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) Under the guidance of an instructor with the relevant expertise, the student explores the literature on a special topic and develops a written review in scientific format. Registration form required as for 177-477A.

177-432A LIMNOLOGY. (3) (2 hours lecture; 3 hours laboratory) (Prerequisites: 177-206A and/or permission.) A study of the physical, chemical and biological properties of inland waters, with emphasis on their functioning as systems.

● ★**177-437A ADVANCED INVERTEBRATE ZOOLOGY.** (3) (Prerequisite: 177-351B or permission.)

★**177-441B BIOLOGICAL OCEANOGRAPHY.** (3) (2hours lecture, 3 hours laboratory/conference) (Prerequisite: 177-208A/ 308B or permission.) An introduction to how the ocean functions biologically: biology and ecology of marine plankton; regulation, extent and fate of production in the sea.

177-465A CONSERVATION BIOLOGY. (3) (3 hours lecture) (Prerequisite: 177-208A/308B) (Not open to students who have taken 177-365A.) Discussion of relevant theoretical and applied issues in conservation biology. Topics: biodiversity, population viability analysis, community dynamics, biology of rarity, extinction, habitat fragmentation, social issues.

177-468B TOPICS ON THE HUMAN GENOME. (3) (3hours lecture) (Prerequisites 177-202B or 177-274A, 177-300A, 177-370B, or permission.) Cellular and molecular approaches to characterization of the human genome.

177-471C,D INDEPENDENT STUDIES IN BIOLOGY. (6) (Open only to U3 Biology students.) (Prerequisite: 177-206A or 177-301A,B or other suitable laboratory course.) (Projects must be arranged individually with a staff member of the Biology Department and a form from Ms. A. Comeau, Room W4/8, Stewart Building, must be completed to receive credit for the course.) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) Research or reading projects, permitting independent study under the guidance of a staff member in the

Biology Department specializing in the field of interest. A written report is required and a copy must be submitted to Ms. Comeau.

● **177-475B HUMAN BIOCHEMICAL GENETICS.** (3) (3 hours lecture) (Prerequisites: 177-202B and 177-300A)

177-477A/177-478B,C INDEPENDENT STUDIES IN BIOLOGY. (3 credits each) (Open only to U3 Biology students) (Prerequisite: 177-206A or 177-301A,B or other suitable laboratory course. Projects must be arranged individually with a staff member of the Biology Department and a form from Ms. Comeau, Room W4/8, Stewart Building, must be completed to receive credit for the course.) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) Research or reading projects, permitting independent study under the guidance of a staff member in the Biology Department specializing in the field of interest. A written report is required and a copy must be submitted with the mark to Ms. Comeau.

177-479D,G INDEPENDENT STUDIES IN BIOLOGY. (9) (8-12 hours per week research project and related seminars) (Restricted to Biology Honours students. Projects must be arranged individually with, and accepted by a staff member of the Biology Department.) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) The major objective of the course is to provide an introduction to the design, execution and reporting of research. The quality of projects is examined by at least two members of the Biology Department.

177-480D,G INDEPENDENT STUDIES IN BIOLOGY. (12) (10-15 hours per week research project and related seminars) (Restriction and course description: as for 177-479D,G.) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.)

177-499D HONOURS SEMINAR IN BIOLOGY. (4) (Weekly seminars) Honours students in Biology attend a selected series of guest speaker seminars of general interest and prepare five reports. In addition, students give a seminar on their research.

177-505B DIVERSITY AND SYSTEMATICS SEMINAR. (3) (3hours seminar) (Prerequisites: 177-204A/304A, 177-305B, or permission.) A course dealing in depth with a particular aspect of biological diversity and/or systematics. Topics may include the systematics of a particular taxon, issues in biodiversity, systematics theory and practice, etc. The class will discuss aspects of the chosen topic and prepare individual seminar reports.

177-516B GENETICS OF DEVELOPMENT. (3) (3hours lecture) (Prerequisites: 177-202B or 177-274A, 177-300A, 177-303B; permission.) (Not open to students who have taken 177-416B.)This course aims to examine problems, theories, and experimental evidence on several concepts of mammalian developmental processes at molecular to organogenesis levels. Most topics are in the mouse model system, where various techniques for genetic manipulation are available.

177-518B EUKARYOTIC CELL GENETICS. (3) (2hours seminar) (Prerequisite: 177-300A and permission.) This course is designed for advanced undergraduate and graduate students. Readings from recent journal articles and reviews. Variable topics, including: cell differentiation, function of oncogenes and anti-oncogenes, growth regulation and cell cycle, gene transfer, recombination, mobile genetic elements, regulation of gene expression, cellular and viral replication, signal transduction.

177-520B GENE ACTIVITY IN DEVELOPMENT. (3) (3 hours lecture and discussion) (Prerequisites: 177-300A and 177-303B or permission) (Not open to students who have taken 177-420B.) An analysis of the role and regulation of gene expression in several models of eukaryotic development. The emphasis will be on critical evaluation of recent literature concerned with molecular or genetic approaches to the problems of cellular differentiation and determination. Recent research reports will be discussed in conferences and analyzed in written critiques.

● **★177-522B PLANT MOLECULAR BIOLOGY SEMINAR.** (3) (2 hours seminar, 1 hour tutorial per week) (Prerequisite: 177-300A or permission.)

177-524A TOPICS IN MOLECULAR BIOLOGY. (3) (Prerequisite: 177-300A, 177-303B or permission.) Recent literature in the fields of molecular genetics and molecular biology. Topics include: signal transduction, cell function, genetic diseases in eukaryotes.

★177-526B PLANTS AND EXTREME ENVIRONMENTS. (3) (1hour lecture and 2hours seminar/ discussion) (Prerequisites: 177-205B, 177-357A, or permission.) Cellular and molecular responses of organisms to extremes of temperature, water availability, mineral ion concentrations, pollutants and hydrostatic pressure. Mechanisms of resistance and tolerance to these stressful environments.

● **★177-530B NEURAL BASIS OF BEHAVIOUR.** (3) (1hour lecture, 2 hours seminar) (Prerequisite: 177-306A or 552-311A or 204-308A) (Not open to students who have taken 177-430B.)

177-531A NEUROBIOLOGY LEARNING MEMORY. (3) (3 hours lecture and discussion) (Prerequisite: 177-306A or permission.) (Not open to students who have taken 177-431A.) Properties of nerve cells that are responsible for learning and memory. Recent advances in the understanding of neurophysiological, biochemical and structural processes relevant to neural plasticity. Emphasis on a few selected model systems involving both vertebrate and invertebrate animals.

177-532B DEVELOPMENTAL NEUROBIOLOGY SEMINAR. (3) (1 hour lecture, 2 hours seminar) (Prerequisites: 177-303B and 177-306A or permission.) Discussions of all aspects of nervous system development including pattern formation, cell lineage, pathfinding and targetting by growing axons, and neuronal regeneration. The basis for these discussions will be recent research papers and other assigned readings.

177-535B POLITICAL ECOLOGY. (3) (3 hour seminar) (Prerequisite: 177-208A/308B or permission of instructor.) This student-led seminar course will investigate the relationship between scientific understanding and political process, from the perspective of ecology. It will examine why policy decisions on environmental issues often fail to satisfy biological concerns, and what can be done to enhance scientific contributions. Students will each research one environmental policy (legal act and/or legislative decision) for group analysis.

● **★177-542B MARINE BIOLOGY.** (3) (2 hours lecture, 1 laboratory or conference) (Prerequisite: 177-208A/308B or permission) (Not open to students who have taken 177-442B.)

★177-544A GENETIC BASIS OF LIFE SPAN. (3) (1 hour lecture, 2 hours seminar) (Prerequisites: 177-202B, 177-300A; 177-303B recommended or permission) (Not open to students who have taken 177-444A.) The course will consider how gene action is determining the duration of life in various organisms focusing on the strengths and limitations of the genetic approach. The course will focus particularly on model organisms such as yeast, *Caenorhabditis*, *Drosophila* and mouse, as well as on the characterization of long-lived mutants.

177-551A MOLECULAR BIOLOGY: CELL CYCLE. (3) (3hours lecture) (Prerequisites: 177-200A, 177-201B, 177-300A.) (Not open to students who have taken 177-451A.) Cytological studies, biochemical and genetical information are integrated to explain molecular form and function in the eukaryotic cell. The mitotic cell cycle and its coordination with cell growth and division; maintenance of cellular architecture, protein targeting, self-assembly of macromolecular complexes, organelle biogenesis, and DNA replication and segregation are examined.

177-553B NEOTROPICAL ENVIRONMENTS. (3) (24 hours lecture and 36 hours field work over a 4-week period) Prerequisites: 144-218, 189-203, and 177-208A/308B, or equivalents, and permission of Program Coordinator. Corequisites: 170-451B, 183-498B and 336-450B) (Not open to students who have taken 177-453B.) (Restriction: location in Panama. Students must register for a full semester of studies in Panama.) Ecology theory revisited in view of tropical conditions. Exploring species richness. Historical and contemporaneous factors structuring neotropical communities. Measuring biodiversity. Conservation status of ecosystems, com-

munities and species. Guest Lecturers: Staff from Smithsonian Tropical Research Institute and Panamanian Universities.

★177-555L FUNCTIONAL ECOLOGY OF TREES. (3) (Lectures and laboratory taught in residence at the Gault Nature Reserve) (Prerequisites: 177-204A/304A, 177-205B, 177-357A) Functional organization in trees: physiology, architecture, and life history. Emphasis on trees in natural habitats.

177-560A AQUATIC CONSERVATION. (3) (2 lecture hours, 1 conference) (Prerequisites: 177-208A/308B and 177-365A or permission) (Not open to students who have taken 177-460A.) An advanced conservation course, focused on marine and freshwater environments. Begins with the ultimate, distal and proximate processes that explain current global calamities. Then considers management responses such as fisheries modifications, protected areas, alternative livelihoods, and habitat restoration. Conferences include group work to produce real conservation action plans.

● **★177-562B EVOLUTION OF LIFE CYCLES.** (3) (2hours lecture, 1 hour seminar) (Prerequisites: Core Program in Biology.) (Not open to students who have taken 177-462B.)

177-570B ADVANCED SEMINAR IN EVOLUTION. (3) (3hours seminar) (Open to undergraduates by permission.) Detailed analysis of a topic in evolutionary biology, involving substantial original research.

★177-572A MOLECULAR EVOLUTION. (3) (4hours lecture/seminar) (Prerequisite: 177-300A) (Not open to students who have taken 177-472A.) Course is concerned with the rates and patterns of change in the genetic material (DNA sequences) and its products (proteins), through evolutionary time. The emphasis will be on the processes responsibile for evolutionary change at the molecular level, such as selective neutrality, gene duplication, shuffling of exons, and transposition.

● **177-588A ADVANCES IN CELL/MOL NEUROBIOL.** (3) (1½ hours lecture, 1½ hours seminar) (Prerequisite: 177-300A and 177-306A or permission.)

11.5 Biotechnology (202)

Sheldon Biotechnology Centre
Lyman-Duff Building

Telephone: (514) 398-3998

Program Supervisor
Professor Hugh P.J. Bennett; B.A.(York), Ph.D.(Brun.)

Biotechnology, the science of understanding, selecting and promoting useful organisms and specific gene products for commercial and therapeutic purposes, is the success story of this generation. It demands a broad comprehension of biology and engineering as well as detailed knowledge of at least one basic subject such as molecular genetics, protein chemistry, microbiology, or chemical engineering.

The Minor Program in Biotechnology is offered by the Faculties of Engineering and of Science, and students combine the Minor with the regular departmental Major (or Honours or Faculty) program. The Minor emphasises an area relevant to biotechnology which is complementary to the main program.

Students should identify their interest in the Biotechnology Minor to their departmental academic adviser and to the Program Supervisor of the Minor and, at the time of registration for the U2 year, should declare their intent to embark on the Minor. Before registering for the Minor, and with the agreement of the academic adviser, students must submit their course list to the Program Supervisor who will certify that the student's complete program conforms to the requirements for the Minor. Students should ensure that they will have fulfilled the prerequisite requirements for the courses selected.

GENERAL REGULATIONS

To obtain the Minor in Biotechnology the students must:

a) satisfy the requirements both for the departmental program and for the Minor.
b) complete 24 credits, 18 of which must be exclusively for the Minor program.
c) obtain a grade of C or better in the courses presented for the Minor.

MINOR PROGRAM IN BIOTECHNOLOGY (24 credits)
[MARS Program Code 6-146400] (Program changes awaiting University approval)

PROGRAM FOR STUDENTS IN THE FACULTY OF SCIENCE*

Required Courses (15 credits)

177-200A	(3)	Molecular Biology
177-201B	(3)	Cell Biology and Metabolism
or 507-212B	(3)	Molecular Mechanisms of Cell Function
177-202B	(3)	Basic Genetics
528-211A	(3)	Biology of Microorganisms
202-505A	(3)	Selected Topics in Biotechnology

Complementary Courses (9 credits)
selected from courses outside the department of the main program, these may be taken from those listed as required courses for Engineering students. Alternatively, or in addition, courses may be taken from the lists below; in which case, at least three courses must be taken from one area of concentration as grouped.

* as 18 credits must be applied exclusively to the Minor, approved substitutions must be made for any of the specified courses which are part of the student's main program.

PROGRAM FOR STUDENTS IN THE FACULTY OF ENGINEERING*

Required Courses (12 credits)

302-200A	(3)	Intro to Chemical Engineering
302-204B	(3)	Chemical Manufacturing Processes
302-474A	(3)	Biochemical Engineering
202-505A	(3)	Selected Topics in Biotechnology

Complementary Courses (12 credits)
selected from courses outside the department of the main program, these may be taken from those listed as required courses for Science students. Alternatively, or in addition, courses may be taken from the lists below; in which case, at least three courses must be taken from one area of concentration as grouped.

* as 18 credits must be applied exclusively to the Minor, approved substitutions must be made for any of the specified courses which are part of the student's main program.

Biomedicine

504-541B	Cell and Molecular Biology of Aging
516-504A	Biology of Cancer
546-300B	Human Disease

Chemistry

180-382B	Organic Chemistry of Natural Products
180-402B	Advanced Bio-organic Chemistry
180-552B	Physical Organic Chemistry

Immunology

504-261A	Introduction to Dynamic Histology
507-503B	Immunochemistry
552-513B	Cellular Immunology
528-314B	Immunology
528-414A	Advanced Immunology

Management*

154-208	Microeconomics Analysis and Applications
280-211	Introduction to Financial Accounting
280-341	Finance 1
280-352	Marketing Management I
280-472	Operations Management

* These courses may not also be used for a Management Minor, nor for complementary, by Engineering students

Microbiology

528-323A	Microbial Physiology
528-324A	Fundamental Virology
528-413B	Parasitology

528-465A Bacterial Pathogenesis and Host Defenses
528-466B Viral Pathogenesis and Host Defenses

Molecular Biology (Biology)
177-300A Molecular Biology of the Gene
177-314A Molecular Biology of Oncogenes
177-520B Gene Activity in Development
177-551A Molecular Biology: Cell Cycle
177-524A Topics in Molecular Biology

Molecular Biology (Biochemistry)
507-311A Metabolic Biochemistry
507-312B Biochemistry of Macromolecules
507-450A Protein Structure and Function
507-454A Nucleic Acids
507-455B Neurochemistry

Physiology
552-517B Artificial Internal Organs
552-518A Artificial Cells and Biotechnology
549-562A General Pharmacology I
549-563B General Pharmacology II
516-401B Physiology and Biochemistry of Endocrine Systems
516-502A Advanced Endocrinology, Part I
516-503B Advanced Endocrinology, Part II

Plant Biology
177-357A Plant Physiology
177-526B Plants and Extreme Environments

Pollution*
303-225B Environmental Engineering
303-430A Water Treatment and Pollution Control
303-526B Solid Waste Management
303-553B Stream Pollution and Control
302-471B Industrial Water Pollution Control
* These courses may not also be used for a Environmental Engineering Minor by Engineering students.

General:
306-310A,B Engineering Economy

COURSE DESCRIPTION
All courses have limited enrolment.
The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

202-505A SELECTED TOPICS IN BIOTECHNOLOGY. (3) (Restricted to U3 students) Current methods and recent advances in biological, medical, agricultural and engineering aspects of biotechnology will be described and discussed. An extensive reading list will complement the lecture material.

11.6 Chemistry (180)

Otto Maass Chemistry Building
801 Sherbrooke Street West
Montreal, QC H3A 2K6

Departmental Office: Room 322. Telephone: (514) 398-6999
Student Advisory Office: Room 304. Telephone: (514) 398-3653
Website: http://www.mcgill.ca/chemistry

Chair — David N. Harpp

Emeritus Professors
John F. Harrod; B.Sc., Ph.D.(Birm.) *(Tomlinson Emeritus Professor of Chemistry)*
Alan S. Hay; B.Sc., M.Sc.(Alta.), Ph.D.(Ill.), D.Sc.(Alta.), F.R.S., F.N.Y., Acad.Sci.*(Tomlinson Emeritus Professor of Chemistry)*
Mario Onyszchuk, B.Sc.(McG.), M.Sc.(W.Ont.), Ph.D.(McG.), Ph.D.(Cantab,)
Donald Patterson; M.Sc.(McG.), Doc. Hon. Causa(St-Etienne) *(Otto Maass Emeritus Professor of Chemistry)*
Arthur S. Perlin; M.Sc., Ph.D.(McG.), F.R.S.C. *(E.B. Eddy Emeritus Professor of Industrial Chemistry)*
William C. Purdy; B.A.(Amherst), Ph.D.(M.I.T.), F.C.I.C. *(William C. Macdonald Emeritus Professor of Chemistry)*
Leon E. St-Pierre; B.Sc.(Alta.), Ph.D.(Notre Dame, Ind.), F.C.I.C.
Michael A. Whitehead; B.Sc., Ph.D. D.Sc.(Lond.), F.C.I.C.

Professors
Ian S. Butler; B.Sc., Ph.D.(Brist.), F.C.I.C., C.Chem., F.R.S.C.(U.K.)
Tak-Hang Chan; B.Sc.(Tor.), M.A., Ph.D.(Prin.), F.C.I.C., F.R.S.C.
Masad J. Damha; B.Sc., Ph.D.(McG.)
Adi Eisenberg; B.S.(Worcester Polytech.), M.A., Ph.D.(Prin.), F.C.I.C. *(Otto Maass Professor of Chemistry)*
Byung Chan Eu; B.Sc.(Seoul), Ph.D.(Brown)
Patrick G. Farrell; B.Sc., Ph.D., D.Sc.(Exe.)
Denis F.R. Gilson; B.Sc.(Lond.), M.Sc., Ph.D.(U.B.C.), F.C.I.C.
David N. Harpp; A.B.(Middlebury), M.A.(Wesleyan), Ph.D.(N.Carolina), F.C.I.C.
George Just; Ing.Chem.(E.T.H. Zürich), Ph.D.(W.Ont.), F.C.I.C. *(William C. Macdonald Professor of Chemistry)*
R. Bruce Lennox; B.Sc., M.Sc., Ph.D.(Tor.)
Robert H. Marchessault; B.Sc.(Loyola), Ph.D.(McG.), D.Sc.(C'dia), F.R.S.C. *(E.B. Eddy Professor of Industrial Chemistry)*
David Ronis; B.Sc.(McG.), Ph.D.(M.I.T.)
Eric D. Salin; B.Sc.(Calif.), Ph.D.(Oreg.St.)
Bryan C. Sanctuary; B.Sc., Ph.D.(U.B.C.)
Alan G. Shaver; B.Sc.(Car.), Ph.D.(M.I.T.)

Associate Professors
Mark P. Andrews; B.Sc., M.Sc., Ph.D.(Tor.)
David H. Burns; B.Sc.(Puget Sound), Ph.D.(Wash)
William C. Galley; B.Sc.(McG.), Ph.D.(Calif.)
Ashok K. Kakkar; Ph.D.(Wat.)
Romas Kazlauskas; B.Sc.(Clev.St.), Ph.D.(M.I.T.)
Joan F. Power; B.Sc., Ph.D.(C'dia)
Linda Reven; B.A.(Car.), Ph.D.(Ill.)

Assistant Professors
Parisa Ariya; B.Sc., Ph.D.(York) *(William Dawson Scholar) (joint appt. with Atmospheric & Oceanic Sciences)*
Bruce Arndtsen; B.A.(Car.), Ph.D.(Stan.)
Christopher J. Barrett; B.Sc., M.Sc., Ph.D.(Queen's)
James Gleason; B.Sc.(McG.), Ph.D.(Virginia)
Hanadi Sleiman; B.Sc.(A.U.B.), Ph.D.(Stan.)

Faculty Lecturers
John Finkenbine; B.S.(Capital), Ph.D.(McG.)
Grazyna Wilczek; M.Sc., Doctorate Chem. Sci.(Warsaw)

Associate Members
James A. Finch *(Mining & Metallurical Engineering)*
K. Gehring *(Biochemistry)*
Orval A. Mamer *(University Clinic),* Barry I. Posner *(Medicine)*

Adjunct Professors
G Ronald Brown; B.Sc.(Man.), Ph.D.(McG.)
Ariel Fenster; L.ès S., D.E.A.(Paris), Ph.D.(McG.)
Yvan Guindon; B.Sc., Ph.D.(Montr.), F.C.I.C., F.R.S.C.
Joseph A. Schwarcz; B.Sc., Ph.D.(McG.)
Youla Tsantrizos; B.Sc., Ph.D.(McG.)
Ivor Wharf; B.Sc., Ph.D.(Lond.), A.R.C.S., D.I.C.
Robert Zamboni; B.Sc., Ph.D.(McG.)

PAPRICAN Adjunct Professors
Dimitris Argyropoulos; B.Sc.(South Bank Poly.), Ph.D.(McG.)
Derek G. Gray; B.Sc.(Belf.), M.Sc., Ph.D.(Man.), F.C.I.C.
R. St. John Manley; B.Sc., Ph.D.(McG.), D.Sc.(Uppsala)
Theo G.M. van de Ven; Kand. Doc.(Utrecht), Ph.D.(McG.)

Chemistry is both a pure science, offering a challenging intellectual pursuit and an applied science whose technology is of fundamental importance to the economy and society. Modern chemists seek an understanding of the structure and properties of atoms and molecules to predict and interpret the properties and transformations of matter and the energy changes that accompany those transformations. Many of the concepts of physics and mathematics are basic to chemistry, while chemistry is of fundamental importance to many other disciplines such as the biological and medical sciences, geology, metallurgy, etc.

A degree in chemistry leads to a wide variety of professional vocations. The large science-based industries (petroleum refining, plastics, pharmaceuticals, etc.) all employ chemists in research, development and quality control. Many federal and provincial departments and agencies employ chemists in research and testing laboratories. Such positions are expected to increase with the currently growing concern for the environment and for consumer protection. A background in chemistry is also useful as a basis for advanced study in other related fields, such as medicine and the biological sciences. For a business career, a B.Sc. in Chemistry can profitably be combined with a master's degree in Business Administration, or a study of law for work as a patent lawyer or forensic scientist.

Chemistry courses at the university level are traditionally divided into four areas of specialization: 1) organic chemistry, dealing with the compounds of carbon; 2) inorganic chemistry, concerned with the chemistry and compounds of elements other than carbon; 3) analytical chemistry, which deals with the identification of substances and the quantitative measurement of their compositions; and 4) physical chemistry, which treats the physical laws and energetics governing chemical reactions. Naturally there is a great deal of overlap between these different areas, and the boundaries are becoming increasingly blurred. After a general course at the collegial level, courses in organic, inorganic, analytical and physical chemistry are offered through the university years. Since chemistry is an experimental science, laboratory classes accompany most undergraduate courses. In addition, courses are offered in polymer, nuclear, theoretical, radio- and biological chemistry to upper year undergraduates.

There are two main programs in chemistry, Honours and Major. The Honours program is intended primarily for students wishing to pursue graduate studies in chemistry. While the Major program is somewhat less specialized, it is still recognized as sufficient training for a career in chemistry. It can also lead to graduate studies although an additional qualifying year may be necessary. There are also a number of Faculty programs available. Interested students may inquire about these at the Student Advisory Office, Room 309A, Otto Maass Chemistry Building.

PRE-PROGRAM REQUIREMENTS

Students entering from the Freshman program must have included Mathematics 189-140/141, Chemistry 180-121/111 or -120/110, Biology 177-111, Physics 198-131/142, or their equivalents in their Freshman year. Québec students must have completed the DEC with appropriate science and mathematics courses.

REQUIRED COURSES IN CHEMISTRY PROGRAMS

The required courses in Chemistry programs consist of 56 credits in chemistry, physics and mathematics, listed below. The courses marked with an asterisk (*) are omitted from the program of students who have successfully completed them at the CEGEP level but the Chemistry courses must be replaced by courses in that discipline if students wish to be eligible for admission to the Ordre des chimistes du Québec. Students from outside Québec or transfer students should consult the academic adviser.

A computer science course, either 308-102 or 308-202, will be required during U1 for students who have no previous introduction to computer *programming.* Students are required to contact their adviser on this matter. Completion of Mathematics 189-222 and 189-315 during U1 is strongly recommended. Physics 198-242 should be completed during U-2.

Chemistry Majors and Honours Programs
Required Courses (56 credits)
(Program revisions awaiting University approval

180-212	(4)	Organic Chemistry I
180-213	(3)	Physical Chemistry I
180-222*	(4)	Organic Chemistry II
180-273	(1)	Chemical Kinetics
180-277	(3)	Classical Methods of Analysis
180-281	(3)	Inorganic Chemistry I
180-302	(3)	Organic Chemistry III
180-345	(3)	Molecular Properties & Structure I
180-355	(3)	Molecular Properties & Structure II
180-363	(2)	Physical Chemistry Lab
180-365	(2)	Statistical Thermodynamics
180-367	(3)	Instrumental Analysis I
180-377	(3)	Instrumental Analysis II
180-381	(3)	Chemistry of Transition Elements
180-392	(3)	Integrated Inorganic/organic Lab
180-393	(2)	Physical Chemistry Lab II
189-133*	(3)	Vectors, Matrices and Geometry
189-222*	(3)	Calculus III
189-315	(3)	Ordinary Differential Equations
198-242	(2)	Electricity & Magnetism

* asterisks denote courses with CEGEP equivalents

HONOURS PROGRAM IN CHEMISTRY (74 credits)
[MARS Program Code 2-172200]

Required Courses (56 credits)
56 credits as listed above

Complementary Courses (18 credits)
6 credits of research:

180-470	(6)	Research Project
or 180-480	(3)	Research Project
and 180-490	(3)	Research Project

and 12 credits of additional Chemistry courses:
6 credits of which must be at the 300 level or higher, and
6 credits of which must be at the 400 level or higher

Note: Students may take up to 12 Research Project credits but **only** 6 of these may be used to fulfil the program requirement.

Attainment of the Honours degree requires a CGPA of at least 3.00.

HONOURS WITH BIO-ORGANIC OPTION (78 credits)
[MARS Program Code 2-172205]

The Bio-organic Option of Honours in Chemistry consists of the requirements for Honours in Chemistry with replacement of 198-242 by 177-200 and 177-201, and replacement of the 6 complementary credits of Chemistry at the 300 level with 6 credits chosen from the following: 177-202, 177-301, 180-402, 528-211, 528-314, 528-323, 552-201, 552-202, 552-209A, 552-210B.

Attainment of the Honours degree requires a CGPA of at least 3.00.

HONOURS IN CHEMISTRY: ENVIRONMENTAL CHEMISTRY OPTION (77 credits) [MARS Program Code 2-172206]

The Environmental Chemistry Option of Honours in Chemistry consists of the requirements for Honours in Chemistry with replacement of 6 complementary credits of Chemistry at the 300 level or higher and 6 credits at the 400 level or higher by 180-219, 180-307, 180-419 plus 6 credits chosen from the following: 180-352, 180-575, 180-597, 186-542, 195-220.

Attainment of the Honours degree requires a CGPA of at least 3.00.

HONOURS WITH MATERIALS OPTION (77 credits)
[MARS Program Code 2-172207]

The Materials Option of Honours in Chemistry consists of the requirements for Honours in Chemistry with replacement of the 6 credits at the 300 level or higher and the 6 credits at the 400 level or higher by 180-455 and 180-531, plus 9 credits chosen from the following: 180-543, 180-571, 180-585, 302-487, 306-260, 306-367.

Attainment of the Honours degree requires a CGPA of at least 3.00.

MAJOR PROGRAM IN CHEMISTRY [(62 credits)
MARS Program Code 1-172200]

Required Courses (56 credits)
56 credits as listed above

Complementary Courses (6 credits)
6 credits of additional Chemistry courses at the 300 level or higher.

Attainment of the Major degree requires a CGPA of 2.00.

MAJOR WITH BIO-ORGANIC OPTION (66 credits)
[MARS Program Code 1-172205]

The Bio-organic Option of Major in Chemistry is the Honours program with Bio-Organic Option less the 6 credit Research Project and the 6 complementary credits at the 400 level or higher.

Attainment of the Major degree requires a CGPA of 2.00.

MAJOR IN CHEMISTRY: ENVIRONMENTAL CHEMISTRY OPTION (65 credits) [MARS Program Code 1-172206]
(Revisions Awaiting University Approval)

The Environmental Chemistry Option of Major in Chemistry is the 57 credits of Required Courses, to which are added 180-219, 180-307, 180-419.

Attainment of the Major degree requires a CGPA of 2.00.

MAJOR WITH MATERIALS OPTION (65 credits)
[MARS Program Code 1-172207]
(Revisions Awaiting University Approval)

The Materials Option of Major in Chemistry is the 57 credits of Required Courses, to which are added 180-455, 180-531 plus 3 credits chosen from the following: 180-543, 180-571, 180-585, 302-487, 306-260, 306-367.

Attainment of the Major degree requires a CGPA of 2.00.

FACULTY PROGRAMS IN CHEMISTRY

Faculty programs in Chemistry are constructed from the U1 courses and the general courses of U2 and U3 intended for these students. Consult the Department of Chemistry Student Advisory Office for an adviser. A computer science course, either 308-102 or 308-202, will be required during U1 for students who have no previous introduction to computer programming.

FACULTY PROGRAM IN CHEMISTRY (52 credits)
[MARS Program Code 4-172200]

Chemistry 180-212, 222 or equivalent, 180-204 and 214, or 213 and 355, 201 or 281, 277, 301 or 381, 345, 367 and 377, 302. Mathematics 189-222, 315. Physics 198-242. Nine additional credits from any of the following: Chemistry 180-352, 363, 382, 355, 392, 393 and any 400-level courses in Chemistry for which the prerequisites are satisfied.

FACULTY PROGRAM IN CHEMISTRY AND BIOLOGICAL SCIENCES (54 credits) [MARS Program Code 4-172500]

Chemistry 180-222, 204, 214, 257D, 302, 352, 362, 382. Biology 177-200 and 201, 205, 301, 304. Physics 198-242. Physiology 552-209A, -210B. Computer Science 308-102 or 308-202. Plus 3 approved credits.

FACULTY PROGRAM IN CHEMISTRY AND MATHEMATICS (52 credits) [MARS Program Code 4-172900]

Chemistry 180-212, 222, 204 and 214 or 213 and 365, 281, 277, 345, 355. Physics 198-242. Mathematics 189-222, 223, 314, 315, 317, 319, 323, 324.

Please refer to page 399 in the Mathematics and Statistics section for the Faculty program in Mathematics, Chemistry and Physics.

MINOR PROGRAM IN CHEMISTRY
[MARS Program Code 6-172200]

A Minor in Chemistry which comprises 18 credits of chemistry courses taken at McGill, including 180-203, 180-212, 180-222, 180-281 and 180-257. Substitutions for these by more advanced courses may be made at the discretion of the adviser.

MINOR IN CHEMICAL ENGINEERING
[MARS Program Code 6-163800]

A Chemical Engineering Minor will be of interest to Chemistry students who wish to study the problems of process engineering and its related subjects. A student completing this Minor will be able to make the important link between molecular sciences and industrial processing. This Minor will not provide Professional Engineering accreditation. The Minor requires 24 credits as follows: 7 credits in 302-200A and 302-204B; at least one of 302-220B or 302-314A; at least 13 credits from the following: 189-314, 302-230B, 302-315B, 302-351B, 302-370A, 302-380A, 302-438B, 302-392A and 393B, 302-452B, 302-471A, 302-472A, 302-481A, 302-487A, and either 302-494A,B,D or 302-495A,B,D.

COURSE DESCRIPTIONS

All courses have limited enrolment.

The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

● Denotes courses not offered in 2001-02.

180-110A GENERAL CHEMISTRY I. (4) (3 lectures) (Prerequisites/corequisites: College level mathematics and physics or permission of instructor; 180-120 is not a prerequisite.) (Not open to students who have taken or are taking 180-111. See "Course Overlap" on page 351) A study of the fundamental principles of atomic structure, valence theory and periodic table.

Laboratory: (2½ hours) Illustrative experiments. Lab section for students continuing from 180-120 will be the same. New students will be assigned lab sections in OM 1 on the first day of classes.
NOTE: Each lab section is limited enrolment.

● **180-111B GENERAL CHEMISTRY – PHYSICAL & ENGINEERING.** (4) (3lectures) (Prerequisites/corequisites: College level mathematics and physics, or permission of instructor: 180-121 is not a prerequisite.) (Not open to students who have taken or are taking 180-110. See "Course Overlap" on page351)

Laboratory: (2½ hours) Illustrative experiments. Lab section for students continuing from 180-121 will be the same. New students will be assigned lab sections in OM 1 on the first day of classes.
NOTE: Each lab section is limited enrolment.

180-112A GENERAL CHEMISTRY LABORATORY. (1) (2½ hours laboratory) (Open only to entering students who have the lecture equivalent of 180-110.) Illustrative experiments. Laboratory section of 180-110. Lab section for students continuing from 180-120 will be the same. New students will be issued lab sections in OM 1 on the first day of classes.
Note: Each lab section is limited enrolment.

● **180-113B GENERAL CHEMISTRY LABORATORY.** (1) (2½ hours laboratory) (Open only to entering students who have the lecture equivalent of 180-111.)

180-120B GENERAL CHEMISTRY 2. (4) (3 lectures) (Prerequisites/corequisites: College level mathematics and physics, or permission of instructor: 180-110 is not a prerequisite.) (Not open to students who have taken or are taking 180-121. See "Course Overlap" on page 351) A study of the fundamental principles of physical chemistry. Laboratory: (2½ hours) Illustrative experiments.
NOTE: Each lab section is limited enrolment.

● **180-121A GENERAL CHEMISTRY - PHYSICAL & ENGINEERING.** (4) (3 lectures) (Prerequisites/corequisites: College level mathematics and physics, or permission of instructor: 180-111 is not a prerequisite.) (Not open to students who have taken or are taking 180-120. See "Course Overlap" on page 351)

180-122B GENERAL CHEMISTRY LABORATORY. (1) (2½ hours laboratory) (Open only to entering students who have the lecture equivalent of 180-120.) Illustrative experiments. Laboratory section of 180-120.

● **180-123A GENERAL CHEMISTRY LABORATORY (PSE).** (1) (2½ hours laboratory) (Open only to entering students who have the lecture equivalent of 180-121.)

180-150B WORLD OF CHEM: FOOD. (3) (3 lectures) (No prerequisites) (Science students may take for credit only two of: 180-150, -160, -170, -180. These courses can be taken independently of each other.) A series of lectures on the historical, practical, and simple chemical aspects of: food, food additives; vitamins; minerals, diet and cancer; dieting; water.

180-160A WORLD OF CHEM: TECHNOLOGY. (3) (3 lectures) (No prerequisites) (Science students may take for credit only two of: 180-150, -160, -170, -180. These courses can be taken independently of each other.) Aspects of chemical technology including publishing of scientific articles, rocketry, chemistry of space travel, materials (metals, ceramics, wood, plastic), genetic engineering chemistry, forensic science, art and money.

● **180-170B WORLD OF CHEM: DRUGS.** (3) (3lectures) (No prerequisites) (Science students may take for credit only two of: 180-150, -160, -170, -180. These courses can be taken independently of each other.)

● **180-180A WORLD OF CHEM: ENVIRONMENT.** (3) (3 lectures) (No prerequisites) (Science students may take for credit only two of: 180-150, -160, -170, -180. These courses can be taken independently of each other.)

180-199A WHY CHEMISTRY? (3) (2 lectures and 1 seminar) (FYS – for first year students only, maximum 25) A lecture/seminar course which is expected to deal with a) color, from gemstones to lasers; b) microscopes that see atoms – with demonstrations; c)the atmosphere: the greenhouse effect, and acid rain, and d) scientific ethics in research and publication.

180-201A MODERN INORGANIC CHEMISTRY. (3) (3 lectures) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent. Not open to Honours or Majors in chemistry.) (Not open to students who have taken or plan to take 180-281.) Systematic survey of the chemistry of the main group elements and their compounds. Basic concepts of electronic structure, bonding and structure will be developed and applied to the understanding of common materials. Emphasis on elements such as oxygen, nitrogen, silicon and others in order to understand their role in our everyday lives.

180-203A SURVEY OF PHYSICAL CHEMISTRY. (3) (3 lectures) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent. Intended for students in biological science programs requiring only one course in physical chemistry.) (Not open to students who have taken or are taking 180-204 or 180-213.) A survey of the principles and methods of physical chemistry with emphasis on the use of biological examples. Topics will include thermodynamics, transport properties, kinetics, molecular structure and interactions, and spectroscopy.

180-204A,B,L PHYSICAL CHEM./BIOL. SCI. I. (3) (3lectures) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent and one full course in calculus.) (Not open to students who have taken or are taking 180-203 or 180-213.) Similar to 180-213. Emphasis on the use of biological examples to illustrate the principles of physical chemistry. The relevance of physical chemistry to biology is stressed.

180-212A,B,C ORGANIC CHEMISTRY I. (4) (3lectures and laboratory) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent courses. Not open to students who have taken CEGEP objective 00XV or equivalent.) A survey of reactions of aliphatic and aromatic compounds including modern concepts of bonding, mechanisms, conformational analysis, and stereochemistry.
NOTE: Each lab section is limited enrolment.

180-213B PHYSICAL CHEMISTRY 1. (3) (3 lectures) (Prerequisites: 180-110, 180-120 and Mathematics 189-222 or equivalent.) (Not open to students who have taken or are taking 180-203 or 180-204.) Gas laws, kinetic theory. First law of thermodynamics, enthalpy, thermochemistry, bond energies. Second law of thermodynamics; the entropy and the free energy functions. Chemical and thermodynamic equilibrium states. Phase rule. Colligative properties of ideal solutions. Topics may include: chemical kinetics, electrochemistry and others.

180-214B PHYSICAL CHEM./BIOL. SCI. II. (3) (3lectures) (Prerequisites: 180-213 or 180-204.) Emphasis is placed on the use of biological examples to illustrate the principles of physical chemistry. The relevance of physical chemistry to biology is stressed.

180-217A GENERAL ANALYTICAL CHEM. LAB. I. (1) (3hours) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent.) Laboratory portion of an individualized program in analytical chemistry.

★**180-219B INTRO TO ATMOSPHERIC CHEM.** (3) (3lectures) (Prerequisite: CEGEP DEC in Science or permission of instructor.) (Not open to students who have taken 195-219, 180-419, or 195-419.) (Offered in even years. Students should register in 195-219 in odd years.) An introduction to the basic topics in atmospheric chemistry. The fundamentals of the chemical composition of the atmosphere and its chemical reactions. selected topics such as smog chamber, acid rain, and ozone hole will be examined.

180-222A,B,T ORGANIC CHEMISTRY II. (4) (3 lectures and laboratory) (Prerequisite: 180-212. Not open to students who have taken Chemistry 302 or equivalent at CEGEP.) Modern spectroscopic techniques for structure determination. The chemistry of alkyl halides, alcohols, ethers, carbonyl compounds and amines with special attention to mechanistic aspects. Special topics.
NOTE: Each lab section is limited enrolment.

180-224A,B,C ORGANIC CHEMISTRY LABORATORY I. (1) (4 hours laboratory) (Open only to students who have the lecture equivalent of 180-212.) Illustrative experiments in organic chemistry. Laboratory section of 180-212.

180-237B GENERAL ANALYTICAL CHEM. LAB. II. (1) (3hours) (Prerequisite: 180-217) Laboratory portion of an individualized program in analytical chemistry.

180-244A,B,T ORGANIC CHEMISTRY LABORATORY II. (1) (4 hours laboratory) (Prerequisite: 180-234 or equivalent) Laboratory section of 180-222.

180-257D ANALYTICAL CHEMISTRY. (4) (1 lecture, 1 homework tutorial and 4 hours laboratory) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent.) (Not open to students who have taken or are taking 180-277.) A survey of analytical chemistry including the theory and practice of representative gravimetric, volumetric and instrumental methods.
NOTE: Each lab section is limited enrolment.

180-273B CHEMICAL KINETICS. (1) (1 lecture) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent. For Honours and Major Chemistry students. Other students with permission of the lecturer.) Order, molecularity, reaction mechanisms and rate constants. Determination of order, effect of temperature on rate, activated state theory. Collision theory. Reactions in solution, homogeneous catalysis, upper atmosphere kinetics, drug kinetics.

180-277D CLASSICAL METHODS OF ANALYSIS. (3) (2lectures and 4 hours laboratory) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent. For Chemistry Honours and Majors students only.) (Not open to students who have taken or are taking 180-257.) Qualitative and quantitative analysis. A survey of methods of analysis including theory and practice of semimicro qualitative analysis and representative gravimetric, volumetric and instrumental methods.
NOTE: Each lab section is limited enrolment.

180-281A INORGANIC CHEMISTRY I. (3) (3 lectures) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent. For Honours and Major Chemistry students.) (Not open to students who have taken or plan to take 180-201.) Basic concepts of electronic structure and molecular bonding will be developed and applied to the understanding of common materials. Acid-base chemistry. Survey of the chemistry of the main group elements. Introduction to coordination and organometallic chemistry.

● **180-301B MODERN INORGANIC CHEMISTRY II.** (3) (3 lectures) (Prerequisites: 180-110 or 111 and 120 or 121 or equivalent.) (Not open to students who have taken or plan to take 180-381.)

180-302A,B ORGANIC CHEMISTRY III. (3) (3 lectures) (Prerequisites: 180-212 and 222.) Topics covered may include the following: aromatics and heterocyclics, carbanions, rearrangements, molecular orbital considerations, polymers and biomolecules.

● **180-307A ENVIRONMENTAL ANALYSIS.** (3) (2lectures and laboratory with field trips) (Prerequisites: One course in analytical chemistry.)

180-334A ADVANCED MATERIALS. (3) (Prerequisites: 180-110/120 or 180-111/121 and 198-101/102 or 198-131/142, or CEGEP Physics and Chemistry, or equivalent. Corerequisite: one of 180-203, 180-204, 180-213, 180-214 or equivalent; or one of 198-230 and 198-232, or equivalent; or permission of instructor.) (Not open to students who have taken or are taking 198-334.) The physicochemical properties of advanced materials. Topics discussed include photonics, information storage, 'smart' materials, biomaterials, clean energy materials, porous materials, and polymers.

180-345A MOLECULAR PROPERTIES & STRUCTURE I. (3) (3 lectures) (Prerequisite: 180-213, 189-315. For Chemistry Honours and Majors only.) An introduction to quantum chemistry covering the historical development, wave theory, methods of quantum mechanics, and applications of quantum chemistry.

● **180-350A EARTH, AIR, FIRE, WATER.** (3) (3lectures) (Prerequisites: 180-212 or equivalent and 180-204 or equivalent.)

180-352B STRUCTURAL ORGANIC CHEMISTRY. (3) (3lectures) (Prerequisite: 180-302.) Modern methods of structure determination, employing spectroscopic techniques; stereochemistry.

180-355B MOLECULAR PROPERTIES & STRUCTURE II. Spectroscopy (3) (3 lectures) (Prerequisite: 180-345) A survey of the principles of electronic, vibrational and rotational spectroscopy. Magnetic resonance methods.

180-362A,B ADVANCED ORGANIC CHEMISTRY LAB. (2) (4hours) (Prerequisite or corequisite: 180-302) (Not open to Honours or Majors in Chemistry.) An advanced laboratory with experiments related to the theoretical principles and synthetic methods of modern organic chemistry.

180-363A,B PHYSICAL CHEMISTRY LAB. (2) (3hours) (Prerequisites: 180-213 and 180-273) Selected experiments to illustrate physico-chemical principles.
NOTE: Each lab section is limited enrolment.

180-365B STATISTICAL THERMODYNAMICS. (2) (2 lectures) (Prerequisite: 180-345) Molecular basis of thermodynamics with applications to ideal gases and simple solids. Topics to be covered will include: calculation of thermodynamic functions, chemical equilibrium constants, Einstein and Debye models of solids, absolute reaction rate theory, Debye-Hückel theory of strong electrolytes.

180-367A INSTRUMENTAL ANALYSIS I. (3) (2lectures and 4hours of laboratory) (Prerequisite: 180-257 or 180-277) An introduction to modern methods of instrumental analysis emphasizing chromatography and electrochemical methods. Analytical methods to be examined in detail include gas liquid chromatography, high performance liquid chromatography flow injection analysis, and electrochemical methods. Laboratory exercises give the student practical exposure to these techniques.
NOTE: Each lab section is limited enrolment.

180-371A,B,D INORGANIC CHEM. LAB. (2) (4 hours) (Prerequisite: 180-362; prerequisite/corequisite: 180-381) (Not open to students who have taken 180-392.) Modular format incorporating self-paced and selfguided instructions. In consultation with the instructors, a program of experimental modules is chosen covering projects related to theoretical principles, synthetic techniques and those instrumental methods used in modern inorganic and organometallic chemistry.

180-377B INSTRUMENTAL ANALYSIS II. (3) (2lectures and 4hours of laboratory) (Prerequisite: 180-257 or 180-277.) Spectroscopic methods of analysis will be studied with respect to fundamentals, operational aspects and instrument design. Topics will range from UV-visible to x-ray spectrometry. Methodologies will be evaluated with respect to their application in spectrometric systems. Laboratory automation will be studied and applied in the laboratory.
NOTE: Each lab section is limited enrolment.

180-381A CHEMISTRY OF TRANSITION ELEMENTS. (3) (3lectures) (Prerequisite: 180-281. For Honours and Major Chemistry students.) (Not open to students who have taken or plan to take 180-301.) The history of transition chemistry, coordination numbers and geometry, nomenclature and symmetry. Crystal field theory will be described and applied to problems in spectroscopy, magnetochemistry, thermodynamics and kinetics. Several aspects of organometallic and bioinorganic chemistry are also discussed.

180-382B ORGANIC CHEMISTRY OF NATURAL PRODUCTS. (3) (3 lectures) (Prerequisite/corequisite: 180-302.) Structure, synthesis, stereochemistry and biosynthesis.

180-392A,B OR D INTEGRATED INORGANIC/ORGANIC LAB. (3) (4 hours) (Prerequisite/corequisites: 180-381 and 180-302. Advanced laboratory for Chemistry Honours and Major students. Students enrolled in 180-392 are strongly advised to choose the D option.) (Not open to students previously enrolled in 180-362.) Modular format of self-paced and self-guided instruction. A program of modules is selected in consultation with the laboratory staff. The experimental modules consist of projects related to the theoretical principles, synthetic techniques and instrumental methods used in modern organic, inorganic and organometallic chemistry.

180-393A,B PHYSICAL CHEMISTRY LAB II. (2) (3hours) (Prerequisite: 180-363) Selected experiments to illustrate physico-chemical principles more advanced than those of 180-363.
NOTE: Each lab section is limited enrolment.

180-402B ADVANCED BIO-ORGANIC CHEMISTRY. (3) (2lectures, 1 hour seminar per week) (Prerequisite: 180-302) The application of advanced concepts of organic and physical chemistry to biological systems. The properties of amino acids, peptides, proteins, enzymes, nucleosides, etc., will be discussed and their relationship to biochemical reactions, the origins of life, coenzymes, template syntheses, neurochemistry, etc.

★**180-419B ADV. IN CHEM. OF ATMOSPHERE.** (3) (3 lectures) (Prerequisites: 180-213, 180-273, 189-222 and 189-315 (or equivalents), or permission of instructor.) (Not open to students who have taken 195-419, 180-619, or 195-619.) (Offered in even years. Students should register in 195-419 in odd years.) Selected areas of atmospheric chemistry from field and laboratory to theoretical modelling are examined. The principles of atmospheric reactions (gas, liquid and heterogeneous phases in aerosols and clouds) and issues related to chemical global change will be explored.

180-455A POLYMER CHEMISTRY. (3) (Prerequisites: 180-213 and 180-273.) A survey course on the structure of polymers, kinetics and mechanisms of polymer and copolymer synthesis; characterization and molecular weight distributions; polymer microstructure, the thermodynamics of polymer solutions; the crystalline and amorphous states, rubber elasticity and structure-property relationships.

180-462A GREEN CHEMISTRY. (3) (3 lectures) (Prerequisities: 180-302, 180-381) New reactions and methods which can be used for the production of chemicals from renewable feedstocks; the use of new environmentally benign solvents, catalysts and reagents; organic reactions in aqueous media and in supercritical carbon dioxide; bio-catalysis and bio-processes.

180-470C,D RESEARCH PROJECT. (6) (Prerequisite: registration by Departmental permission only.) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) A course designed to give students research experience. The student will be assigned a project supervisor and a research project at the beginning of the session. The project will consist of a literature survey, experimental and /or theoretical work, a written research report and an oral examination.

180-480D RESEARCH PROJECT. (3) (Prerequisite or Corequisite: 180-490. Registration by Departmental permission only.) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) A course designed to give Honours students research experience. The student will be

assigned a project supervisor and a research project at the beginning of the session. The project will consist of a literature survey, experimental or theoretical work, a written research report and an oral examination.

180-490D RESEARCH PROJECT. (3) (9 hours laboratory) (Prerequisite or Corequisite: 180-480. Registration by Departmental permission only.) (Please see regulations concerning Project Courses, section 2.6.2 in the Faculty Degree Requirements section.) For description, see 180-480.

180-503A DRUG DESIGN AND DEVELOPMENT 1. (3) (Prerequisites: 180-302, 177-200, 177-201, 507-212, 549-300, 549-301, 549-303 or permission of coordinator. U3 and graduate students. Students can register only with permission of coordinators. Priority: students registered in the Minor in Pharmacology.) (Not open to students who are taking or have taken 549-503.) Interdisciplinary course in drug design and development covering chemistry, mechanisms of action and steps in drug development, principles and problems in drug design.

180-504B DRUG DESIGN AND DEVELOPMENT 2. (3) (Prerequisite: 180-503/549-503. U3 and graduate students. Students can register only with permission of coordinators.) (Not open to students who are taking or have taken 549-504.) Interdisciplinary course in drug design and development in which teams of 2-4 students select a lead chemical compound, design the analogues, propose the preclinical and clinical studies, present possible untoward effects, and reasons for drug (dis)approval.

180-531B CHEMISTRY OF INORGANIC MATERIALS. (3) (3lectures) (Prerequisite: 180-381.) Structure, bonding, synthesis, properties and applications of covalent, ionic, metallic crystals, and amorphous solids. Defect structures and their use in synthesis of specialty materials such as electronic conductors, semiconductors, and superconductors, and solid electrolytes. Basic principles of composite materials and applications of chemistry to materials processing.

180-534A NANOSCIENCE AND NANOTECHNOLOGY. (3) (Prerequisites: 180-334, 198-334 or permission of instructor. Corequisites: one of 180-345, 198-357, or 198-446 or permission of instructor.) (Not open to students who have taken or are taking 198-534.) Topics include scanning probe microscopy, chemical selfassembly, computer modeling, and microfabrication/micromachining.

180-543A CHEMISTRY OF PULP & PAPER. (3) (2lectures plus a reading/research project.) (Prerequisites: 180-302 or permission of instructor.)The industrial processes for converting wood to paper are described with emphasis on the relevant organic, physical, surface chemistry and colloid chemistry. The structure and organization of the polymeric constituents of wood are related to the mechanical, optical and other requisite properties of paper.

180-547B LABORATORY AUTOMATION. (3) (Two 1.5 hour lectures, laboratory) (Prerequisite: 180-377, equivalent or permission of instructor.) Automation and data handling with respect to modern chemical laboratory instrumentation. Basic electronics, data acquisition, evaluation of laboratory needs, data processing methodologies.

180-552B PHYSICAL ORGANIC CHEMISTRY. (3) (Prerequisite: 180-302) The correlation of theory with physical measurements on organic systems; an introduction to photochemistry; solvent and substituent effects on organic reaction rates, etc.; reaction mechanisms.

180-555A NMR SPECTROSCOPY. (3) (3lectures) (Prerequisite: 180-355 or equivalent.) Interpretation of proton and carbon -13 nuclear magnetic resonance spectroscopy in one dimension for structural identification.

180-556A ADVANCED QUANTUM MECHANICS. (3) (3 lectures) (Prerequisites: 180-345, 198-242.) Quantum mechanical treatment of species of chemical interest. Introduction to perturbation theory, both time-dependent and time-independent. Treatment of the variational principle. Introduction to atomic spectra. Chemical bonding in terms of both the valence bond and molecular orbital theory. Elementary collision theory. Interaction of radiation with molecules.

180-567A CHEMOMETRICS: ANALYSIS OF CHEMICAL DATA. (3) (2 lectures and 3 hours of laboratory) (Prerequisites: linear algebra and experience in some computer programming language.) The course is designed to provide a background in mathematical methods for chemical experimental design, system optimization, and sensor calibration. Topics covered include: factorial analysis of chemical spectra, pattern recognition from multisensor data, linear and nonlinear optimization for the determination of optimal reaction conditions, molecular modelling, multisensor calibration, etc.

180-571B POLYMER SYNTHESIS. (3) (3 lectures) (Prerequisites: 180-302 or equivalent, or permission of instructor.) A survey of polymer preparation and characterization; mechanisms of chain growth, including free radical, cationic, anionic, condensation and trans:tion metal-mediated polymerization, and the effects of these mechanisms on polymer architecture; preparation of alternating, block, graft and stereoblock copolymers; novel macromolecular structures including dendrimers and other nanostructures.

● **180-572B SYNTHETIC ORGANIC CHEMISTRY.** (3) (3 lectures) (Prerequisite: 180-382.)

180-575B CHEMICAL KINETICS. (3) (3 lectures) (Prerequisite: 180-273 and -213.) Kinetic laws, measurement of reaction rates, transition state and collision theory. Elementary reactions in gas, solution and solid phases and on surfaces. Reaction mechanisms, laser techniques, molecular beams, chemiluminescence, explosions. Extensive use of computers to simulate the kinetic behaviour of chemical systems.

● **180-576B QUANTUM CHEMISTRY.** (3) (Lecture and/or reading course) (Prerequisite: 180-345)

● **180-577B ELECTROANALYTICAL CHEMISTRY.** (3) (Prerequisite: 180-367 and 180-377.)

180-581B INORGANIC TOPICS I. (3) (Prerequisite: 180-381. Not open to students who have taken 180-481.) An introduction to some areas of current interest in inorganic chemistry. Each year a selection of several particularly active areas will be chosen.

180-585B COLLOID CHEMISTRY. (3) (Prerequisites: 180-273 and 180-345, 189-223 and 189-315, 198-241 and 198-242 or permission of instructor.) Principles of the Physical Chemistry of phase boundaries. Electrical double layer theory; van der Waals forces; Brownian motion; kinetics of coagulation; electrokinetics; light scattering; solid/liquid interactions; adsorptions; surfactants; hydrodynamic interactions; rheology of dispersions.

180-587A SELECTED TOPICS IN MODERN ANALYTICAL CHEM. (3) (Prerequisite: 180-367 and 180-377) Current theories of aqueous and nonaqueous solutions, with application to analytical chemistry; recent advances in analytical techniques. Topics may include: chromatography; applications of kinetics, solvent extraction and thermal analysis) with emphasis on their theoretical basis.

180-591B ADVANCED COORDINATION CHEM. (3) (3hours) (Prerequisite: 180-381.) (For Honours and Major Chemistry students or with permission.) In-depth treatment of advanced coordination chemistry, including bio-inorganic chemistry and transition metal catalysis and solid state inorganic chemistry.

180-593A STATISTICAL MECHANICS. (3) (3 lectures; research project) (Prerequisite: 180-345. Recommended: 180-355.) Basic hypotheses of statistical thermodynamics; ideal monatomic, diatomic and polyatomic gases; Einstein and Debye models of solids; statistical theory of black-body radiation; Debye-Huckel theory of electrolyte solutions; absolute reaction rate theory of rate processes; theories of solutions. (Name change awaiting University approval)

180-597A ANALYTICAL SPECTROSCOPY. (3) (2lectures; 3hours laboratory) (Prerequisite 180-367 and 180-377) The design and analytical use of spectroscopic instrumentation will be examined with respect to fundamental and practical limitations. Classical emission, fluorescence, absorption and chemical luminescence will be discussed. Contemporary topics may include photo-acoustic spectroscopy, multielement analysis, X-ray fluorescence and modern multiwavelength detector systems.

11.7 Cognitive Science

Program Director — TBA

Website: http://www.cogsci.mcgill.ca

Cognitive Science is the multi-disciplinary study of cognition in humans and machines. The goal is to understand the principles of intelligence with the hope that this will lead to better understanding of the mind and of learning, and to the development of intelligent devices that constructively extend human abilities.

The Minor in Cognitive Science is intended to supplement and support Major or Honours programs in Computer Science, Linguistics, Philosophy, or Psychology. Students wishing to enrol in this Minor must register with the Program Director.

MINOR PROGRAM IN COGNITIVE SCIENCE (27 credits)
[MARS Program Code 6-265600] (Program changes awaiting University approval)

Required Course (3 credits)
204-532 (3) Cognitive Science

Complementary Courses (24 credits)
from outside of the student's home department, selected from the courses listed below.

Computer Science
308-424 (3) Topics in Artificial Intelligence I
308-426 (3) Automated reasoning

Educational Psychology
416-555 (3) Applied Cognitive Science

Linguistics
104-321 (3) Linguistics Applied to Language Learning
104-351 (3) Phonology I
104-360 (3) Syntax I
104-370 (3) Semantics I
104-440 (3) Morphology
104-491 (3) Linguistic Theory I
104-530 (3) Phonology II
104-555 (3) Linguistic Theory & Language Acquisition
104-571 (3) Syntax II
104-590 (3) Introduction to Neurolinguistics

Mathematics
189-318 (3) Mathematical Logic
189-328 (3) Computability and Mathematical Linguistics

Philosophy
107-210 (3) Introduction to Deductive Logic
107-306 (3) Philosophy of Mind
107-310 (3) Intermediate Logic
107-410 (3) Topics in Advanced Logic I
107-415 (3) Philosophy of Language
107-419 (3) Epistemology
107-506 (3) Seminar: Philosophy of Mind
107-507 (3) Seminar: Cognitive Science

Psychology
204-311 (3) Human Cognition and the Brain
204-314 (3) Thinking and Concepts
204-334 (3) Computer Simulation - Psych. Process.
204-335 (3) Formal Models of Psych. Processes
204-343 (3) Language Acquisition in Children
204-352 (3) Laboratory in Cognitive Psychology
204-353 (3) Laboratory in Human Perception
204-413 (3) Cognitive Development
204-470 (3) Memory and Brain
204-472 (3) Scientific Thinking and Reasoning

11.8 Computer Science (308)

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Tim H. Merrett; B.Sc.(Queen's), D.Phil.(Oxon.)
Monroe M. Newborn; B.E.E.(R.P.I.), Ph.D.(Ohio St.), F.A.C.M.
Prakash Panangaden; M.Sc.(I.I.T. Kanpur), Ph.D.(Wis.)
Gerald F.G. Ratzer; B.Sc.(Glas.), M.Sc.(McG.)
Denis Thérien; B.Sc.(Montr.), M.Sc., Ph.D.(Wat.)
Godfried T. Toussaint; B.Sc.(Tulsa), Ph.D.(Br.Col.)

Associate Professors
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Nathan Friedman; B.A.(W.Ont.), Ph.D.(Tor.)
Laurie Hendren; B.Sc., M.Sc.(Queen's), Ph.D.(C'nell)
Nazim Madhavji; B.Sc.(Essex), Ph.D.(Man.) *(on leave 2001-02)*
Carl Tropper; B.Sc.(McG.), Ph.D.(Brooklyn Poly.)
Sue Whitesides; M.S.E.E.(Stan.), Ph.D.(Wis.) *(on leave 2001-02)*

Assistant Professors
David Bryant; B.Sc., Ph.D.(U. of Canterbury)
Xiao-Wen Chang; B.Sc., M.Sc.(Nanjing), Ph.D.(McG.)
Karel Driesen; Licentiate, Masters (Free Brussels Univ.), Ph.D.(U.C. Santa-Barbara)
Michael Trevor Hallett; B.Sc.(Queen's), Ph.D.(Victoria)
Bettina Kemme; B.Sc.(U. of Seville), M.Sc.(UC Santa Barbara), Ph.D.(ETH, Zurich)
Michael Langer; B.Sc.(McG.), M.Sc.(U.C. Santa Barbara), Ph.D.(McG.)
Doina Precup; B.Sc.(Tech. U. of Cluj-Napoca), M.Sc., Ph.D.(Mass.)
Kaleem Siddiqi; B.Sc.(Lafayette), M.Sc., Ph.D.(Brown)
Hans Vangheluwe; B.Sc., M.Sc., Ph.D.(Ghent)
Clarke Verbrugge; B.A.(Queen's), Ph.D.(McG.)

Lecturer
Alan Greenberg; M.Sc.(McG.)

Adjunct Professors
Stefan Brands, Renato De Mori, Khaled El Emam, Syed Hyder, François Laviolette, Keith Paton, Vincent Van Dongen

The study of computer science encompasses everything from pure theory to hands-on applications including the analysis of algorithms, programming languages, compilers, databases, operating systems, robotics, computer vision, artificial intelligence and computational biology.

The School currently operates a general purpose computing facility to support teaching, a large undergraduate workstation laboratory and seven dedicated laboratories for research in computational geometry and robotics, parallel processing, compilers, concurrent programming, software engineering, database systems, mobile robotics, and cellular automata.

The teaching facility consists of a network of over 60 Pentium workstations running the Linux operating system, 25 Pentium workstations running Windows NT, 45 Windows 2K workstations and a variety of MacIntosh systems. The facility also includes several compute engines including 3 SUN sparc20 servers, 2 SUN Ultrasparc and 2 SUN Enterprise 250s. Dialup access is provided through the Computing Centre along with PPP network connections. For introductory courses most work is completed using the

NT and Windows 2K workstations and compute engines. All other courses use UNIX as a development environment.

The School of Computer Science offers a Majors program and an Honours program through the Faculty of Science, and a Minor program through the Faculties of Science and Engineering. The School also offers Major and Minor Concentrations through the Faculty of Arts. In conjunction with the Department of Mathematics and Statistics, the School offers a Joint Honours program, a Joint Majors program and two Faculty programs through the Faculty of Science. Special programs involving Computer Science are also available in the Faculties of Management, Engineering, and Music. For further details on programs outside the Faculty of Science, consult the other faculties' sections of this Calendar.

All students planning to enter Computer Science programs should make an appointment with an academic adviser through the School's Undergraduate secretary.

Software Engineering Programs

The School will offer a B.Sc. Major program in Software Engineering (subject to Ministry of Education approval). The B.Sc. program **will not** lead to accreditation.

The School, jointly with the Department of Electrical and Computer Engineering, will also offer a Bachelor of Software Engineering program (subject to Ministry of Education approval).

Graduates of the B.S.E. should be eligible for accreditation (once accreditation standards for Software Engineers have been adopted). For B.S.E. program details, refer to the Faculty of Engineering section, page 252.

Some graduate courses in Computer Science are available to suitably qualified senior undergraduates. The School also offers graduate research studies leading to M.Sc. and Ph.D. degrees. For further details, consult the Graduate Studies Calendar.

The School's courses are available as electives to Engineering students. Engineering students interested in a Minor in Computer Science should consult "Computer Science Courses and Minor Program" on page 273 in the Faculty of Engineering section.

An industrial internship year is available to Computer Science students. IYES, the Internship Year Program for Engineering and Science, is a pre-graduate work experience program for Computer Science students normally between their U2 and U3 years. See the Faculty of Engineering section 2.8 for further information on IYES.

Admission to Computer Science and Software Engineering Programs is limited. Students seeking admission to the programs are required to have completed 189-140 and 189-141 (or 189-150 and 189-151) and 189-133 or the CEGEP equivalents. They must have at least a B- average in these courses to be considered for admission which will be based on overall GPA or CEGEP grades as well as grades in the courses above. Students transferring from other programs within McGill may be admitted on the same criteria up to the maximum program capacity. Students not admitted may be placed on a waiting list for admission should vacancies occur. **Application deadline for U0 or transfer students from other departments is April 20.** All students must meet with a departmental academic adviser prior to registration in any program.

MINOR PROGRAM IN COMPUTER SCIENCE (24 credits)

The Computer Science Minor may be taken in conjunction with any program in the Faculties of Science and Engineering (with the exception of the other programs based on Computer Science) with the approval of the Adviser of the student's main program and the School of Computer Science. At the time of registration in the penultimate year, students must declare their intent to receive a Computer Science Minor and approval must be given by the School for the particular sequence of courses the student wishes to call the Computer Science Minor. All courses must be passed with a grade of C or better.

Students may receive credit towards their Computer Science Minor by taking certain approved courses outside the School of Computer Science. These courses must have a high computer science content. A student will not be permitted to receive more than six credits from such courses. These courses must be approved by the School of Computer Science in advance.

If a student's Major program requires Computer Science courses, up to six credits of Computer Science courses may be used to fulfill both Major and Minor requirements.

Required Courses (12 credits)

308-202A,B	(3)	Introduction to Computing 1
308-203A,B	(3)	Introduction to Computing 2
308-206A,B	(3)	Intro to Software Systems
308-302A,B	(3)	Programming Languages and Paradigms

Complementary Courses (12 credits)
selected from:

308-273A,B	(3)	Intro. to Computer Systems
308-304A	(3)	Object-oriented Design
308-305A	(3)	Computer System Architecture
308-310B	(3)	Comp. Systems and Organization
308-335B	(3)	Software Engineering Methods
308-350A	(3)	Numerical Computing
or 189-317A	(3)	Numerical Analysis
308-360A	(3)	Algorithm Design Techniques
308-420A	(3)	Files and Databases
308-421B	(3)	Database Systems
308-423B	(3)	Data Compression
308-424A	(3)	Artificial Intelligence 1
308-426B	(3)	Automated Reasoning
308-433A	(3)	Personal Software Engineering
308-435B	(3)	Basics of Computer Networks
308-505A	(3)	High-Performance Computer Architecture
308-506B	(3)	Advanced Analysis of Algorithms
308-507A	(3)	Computational Geometry
308-520B	(4)	Compiler Design
308-522A	(4)	Modelling and Simulation
308-524B	(3)	Theoretical Found. of Prog. Lang.
308-526B	(3)	Probabilistic Reasoning and AI
308-530A	(3)	Formal Languages
308-534B	(3)	Team Software Engineering
308-535A	(3)	Computer Networks
308-537B	(3)	Internet Programming
308-538B	(3)	Person-Machine Communication
308-540B	(3)	Matrix Computations
308-557B	(3)	Fundamentals of Computer Graphics
308-560A	(3)	Graph Algorithms and Applications
308-562A	(3)	Computational Biology Methods
308-566A	(3)	Discrete Optimization 1
308-567B	(3)	Discrete Optimization 2
308-573A,B	(3)	Microcomputers
308-575A	(3)	Fundamentals of Distributed Algorithms

or from courses outside of the School approved by the adviser, to a maximum of 6 credits.

FACULTY PROGRAM IN MATHEMATICS AND COMPUTER SCIENCE See page 398 in the Mathematics and Statistics section for complete program information.

FACULTY PROGRAM IN MATHEMATICS, STATISTICS AND COMPUTER SCIENCE See page 398 in the Mathematics and Statistics section for complete program information.

MAJOR PROGRAM IN COMPUTER SCIENCE (60 credits)

To enter the program, students must have completed 189-140 and 189-141, or their equivalents. 189-133, or its equivalent, may be taken prior to entry or concurrently with 308-250 during the first semester in the program. Freshman Program students interested in Computer Science should take 308-102. A student entering with insufficient programming background may take 308-202 but it will not count for program credit.

Required Courses (42 credits)

308-250A,B	(3)	Intro to Computer Science
308-206A,B	(3)	Intro to Software Systems
308-251A,B	(3)	Data Structures and Algorithms
308-273A,B	(3)	Intro. to Computer Systems

308-302A,B	(3)	Programming Languages and Paradigms
308-310B	(3)	Comp. Systems and Organization
308-330A	(3)	Theoretical Aspects of Computer Science
308-350A	(3)	Numerical Computing
308-360A	(3)	Algorithm Design Techniques
189-222A,B	(3)	Calculus III
189-223A,B	(3)	Linear Algebra
189-240A	(3)	Discrete Structures and Computing
189-323A,B	(3)	Probability Theory
189-340B	(3)	Abstract Algebra and Computing

Complementary Courses (18 credits)
15 credits from:

308-303B	(3)	Programming Techniques
308-304A	(3)	Object-oriented Design
308-305A	(3)	Computer System Architecture
308-335B	(3)	Software Engineering Methods
308-420A	(3)	Files and Databases
308-421B	(3)	Database Systems
308-423B	(3)	Data Compression
308-424A	(3)	Artificial Intelligence 1
308-426B	(3)	Automated Reasoning
308-433A	(3)	Personal Software Engineering
308-435B	(3)	Basics of Computer Networks
308-505A	(3)	High-Performance Computer Architecture
308-506B	(3)	Advanced Analysis of Algorithms
308-507A	(3)	Computational Geometry
308-520B	(4)	Compiler Design
308-522A	(4)	Modelling and simulation
308-524B	(3)	Theoretical Found. of Prog. Lang.
308-525B	(3)	Formal Verification
308-526B	(3)	Probabilistic Reasoning and AI
308-531B	(3)	Theory of Computation
308-534B	(3)	Team Software Engineering
308-535A	(3)	Computer Networks
308-537B	(3)	Internet Programming
308-538B	(3)	Person-Machine Communication
308-540B	(3)	Matrix Computations
308-547A	(3)	Cryptography and Data Security
308-557B	(3)	Fundamentals of Computer Graphics
308-558B	(3)	Fund. of Computer Vision
308-560A	(3)	Graph Algorithms and Applications
308-562A	(3)	Computational Biology Methods
308-566A	(3)	Discrete Optimization 1
308-567B	(3)	Discrete Optimization 2
308-573A,B	(3)	Microcomputers
308-575A	(3)	Fundamentals of Distributed Algorithms
304-323A,B	(3)	Digital System Design
304-426A,B	(3)	Microprocessor Systems
304-531B	(3)	Real Time Systems
304-548A	(3)	Introduction to VLSI Systems

3 credits from Mathematics selected from:

189-314A,B	(3)	Advanced Calculus
189-315A,B	(3)	Ordinary Differential Equations
189-322B	(3)	Dynamical Systems, Fractals and Chaos
189-324A,B	(3)	Statistics
189-348A	(3)	Topics in Geometry
189-407B	(3)	Dynamic Programming
189-417A	(3)	Mathematical Programming
189-591B	(3)	Mathematical Logic I

JOINT MAJOR PROGRAM IN MATHEMATICS AND COMPUTER SCIENCE See page 398 in the Mathematics and Statistics section for complete program information.

JOINT MAJOR PROGRAM IN PHYSICS AND COMPUTER SCIENCE See page 416 in the Physics section for complete program information.

MAJOR PROGRAM IN SOFTWARE ENGINEERING
(72 to 74 credits) (Subject to Ministry of Education approval)
(Program revision awaiting University approval)

To enter this program, students must meet the eligibility requirements for the Major program in Computer Science.

Holders of this degree will **not** be eligible for accreditation (when accreditation standards for Software Engineers are introduced). Students wishing to be accredited should enroll in the Bachelor of Software Engineering degree program, see page 252.

Required Courses (48 credits)

189-260	(3)	Intermediate Calculus
304-221	(3)	Introduction to Computer Engineering I
304-222	(3)	Introduction to Computer Engineering II
304-321	(3)	Introduction to Software Engineering
304-427	(3)	Operating Systems
304-428	(3)	Software Engineering
304-429	(3)	Validation & Verification
304-495	(3)	Software Engineering Project
308-202	(3)	Introduction to Computing 1
308-206	(3)	Intro to Software Systems
308-250	(3)	Intro to Computer Science
308-251	(3)	Data Structures and Algorithms
308-302	(3)	Programming Languages and Paradigms
308-330	(3)	Theoretical Aspects of Computer Science
308-360	(3)	Algorithm Design Techniques
308-361	(3)	Systems Programming Project

Complementary Courses (24 to 26 credits)
12 credits of mathematics, one course from each of the following four groups:

189-223	(3)	Linear Algebra
or 189-270	(3)	Applied Linear Algebra
189-240	(3)	Discrete Structures and Computing
or 189-363	(3)	Discrete Mathematics
or 189-381	(3)	Complex Variables and Transforms
189-261	(3)	Differential Equations
or 189-324	(3)	Statistics
189-323	(3)	Probability Theory
or 304-305	(3)	Probability and Random Signals

12 to 14 credits of technical complementaries, chosen from the following courses:

304-200	(3)	Fundamentals of Electrical Engineering
304-210	(3)	Circuit Analysis
304-291	(2)	Electrical Measurement Lab
304-303	(3)	Signals and Systems I
304-304	(3)	Signals and Systems II
304-323	(5)	Digital Systems Design
304-404	(3)	Control Systems
304-411	(3)	Communications Systems
304-421	(3)	Embedded Systems
304-422	(3)	Fault-Tolerant Computing
304-423	(3)	Parallel Computing
304-424	(3)	Human-Computer Interaction
304-425	(3)	Computer Organization and Architecture
304-426	(3)	Microprocessor Systems
or 308-573	(3)	Microcomputers
304-504	(3)	Computer Control
304-522	(3)	Asynchronous Circuits and Systems
304-526	(3)	Artificial Intelligence
304-529	(3)	Image Processing & Communication
304-530	(3)	Logic Synthesis
304-531	(3)	Real Time Systems
304-532	(3)	Computer Graphics
or 308-557	(3)	Fundamentals of Computer Graphics
308-305	(3)	Computer System Architecture
308-350	(3)	Numerical Computing
308-409	(3)	Concurrent Programming
308-410	(3)	Mobile Computing

308-412	(3)	Software for e-commerce
308-420	(3)	Files and Databases
308-424	(3)	Artificial Intelligence 1
308-433	(3)	Personal Software Engineering
308-505	(3)	High-Performance Computer Architecture
308-520	(4)	Compiler Design
308-524	(3)	Theoretical Found. of Prog. Lang.
308-535	(3)	Computer Networks
308-560	(3)	Graph Algorithms and Applications
308-566	(3)	Discrete Optimization
308-575	(3)	Fundamentals of Distributed Algorithms

HONOURS PROGRAM IN COMPUTER SCIENCE (72 credits)

Honours students must maintain a CGPA of 3.00 and must have at least this average upon graduation as well.

Required Courses (45 credits)
all Major Program required courses, plus
308-400A,B (3) Technical Project and Report

Complementary Courses (27 credits)
24 credits from Major Program complementary courses
3 credits from Major Program complementary courses in Mathematics

JOINT HONOURS PROGRAM IN MATHEMATICS AND COMPUTER SCIENCE See page 401 in the Mathematics and Statistics section for complete program information. Students must consult an Honours adviser in both Departments.

MINOR IN COGNITIVE SCIENCE Students following Major or Honours programs in Computer Science may want to consider the Minor in Cognitive Science.

INTERNSHIP PROGRAMS – INTERNSHIP YEAR FOR ENGINEERING AND SCIENCE (IYES)

The following programs are also available with an Internship component. For more information, please see section 2.8 in the Faculty of Engineering section.

Major in Computer Science
Honours in Computer Science

COURSE DESCRIPTIONS

All courses have limited enrolment.

The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

● Denotes courses not offered in 2001-02.

Students are strongly recommended to consult ***info*McGill** for the latest course offerings.

Notes:

A. A student cannot receive credit for both 308-202 and 308-208. 308-202 is intended as a general introductory course, while 308-208 is intended for students interested in scientific computations. The credits for either of these courses will not count towards the 60-credit Major in Computer Science.

B. 308-203 and 308-250 are considered to be equivalent from a prerequisite point of view, and may not both be taken for credit. Computer Science Major and Honours students are strongly advised to take 189-240 with 308-250 but before 308-251.

C. A student cannot receive credit for both 308-330 and 308-530.

D. A student cannot receive credit for 308-102 if it is taken concurrently with, or after any of the following: 308-202, 308-203, 308-208, or 308-250.

E. 308-431 is restricted to B.Eng. students in Electrical and Computer Engineering. A student cannot receive credit for both 308-431 and 308-251, or for both 308-431 and 308-360 or 308-405.

F. Management students may not receive credit for both 308-202 and 635-300. Likewise, they may not receive credit for both 308-203 and 635-301. In addition, Management students may not receive credit for 308-102.

G. This course is restricted to students registered in the following programs: Major and Honours in Computer Science, Joint Major in Mathematics and Computer Science, Joint Major Physics and Computer Science, Major in Software Engineering, Bachelor in Software Engineering, Joint Honours in Mathematics and Computer Science, Honours Program in Applied Mathematics, Honours Program in Mathematics, Honours Program in Probability and Statistics, Minor Concentration in Foundations of Computing, Minor Concentration in Computer Science, and Major Concentration in the Foundations of Computing.

H. Students registered in the following programs may NOT take this course: Major and Honours in Computer Science, Joint Major in Mathematics and Computer Science, Joint Major Physics and Computer Science, Major in Software Engineering, Bachelor in Software Engineering, Joint Honours in Mathematics and Computer Science, Honours Program in Applied Mathematics, Honours Program in Mathematics, and Honours Program in Probability and Statistics.

I. This course is restricted to students registered in the following programs: Major and Honours in Computer Science, Minor in Computer Science, Joint Major in Mathematics and Computer Science, Joint Major Physics and Computer Science, Major in Software Engineering, Bachelor in Software Engineering, Joint Honours in Mathematics and Computer Science, Honours Program in Applied Mathematics, Honours Program in Mathematics, Honours Program in Probability and Statistics, Minor Concentration in Foundations of Computing, Minor Concentration in Computer Science, and Major Concentration in the Foundations of Computing.

J. This course is restricted to students registered in the following programs: Major and Honours in Computer Science, Minor in Computer Science, Joint Major in Mathematics and Computer Science, Joint Major Physics and Computer Science, Major in Software Engineering, Bachelor in Software Engineering, Joint Honours in Mathematics and Computer Science, Honours Program in Applied Mathematics, Honours Program in Mathematics, Honours Program in Probability and Statistics, Minor Concentration in Foundations of Computing, Minor Concentration in Computer Science, Major Concentration in the Foundations of Computing, and Minor in Cognitive Science.

K. This course is restricted to students registered in the following programs: Major and Honours in Computer Science, Joint Major in Mathematics and Computer Science, Joint Major Physics and Computer Science, Major in Software Engineering, Bachelor in Software Engineering, Joint Honours in Mathematics and Computer Science, Honours Program in Applied Mathematics, Honours Program in Mathematics, Honours Program in Probability and Statistics, Minor Concentration in Foundations of Computing, Minor Concentration in Computer Science, Major Concentration in Foundations of Computing, and Major in Computer Engineering.

L. This course is restricted to students registered in the following programs: Major and Honours in Computer Science, Minor in Computer Science, Joint Major in Mathematics and Computer Science, Joint Major Physics and Computer Science, Major in Software Engineering, Bachelor in Software Engineering, Joint Honours in Mathematics and Computer Science, Honours Program in Applied Mathematics, Honours Program in Mathematics, Honours Program in Probability and Statistics, Minor Concentration in Foundations of Computing, Minor Concentration in Computer Science, Major Concentration in Foundations of Computing, and Major in Computer Engineering.

M. 308-250 and 308-203 cannot both be taken for credit.

N. 308-202 cannot be taken for credit with or after 308-250.

308-102A COMPUTERS AND COMPUTING. (3) (2 hours lectures; 2 hours laboratory) (Prerequisite: high school level mathematics course on functions.) (For restrictions, see Notes D and F.) A course for students with no previous knowledge of computer science who may be interested in further study. The structure of a computer; methodologies for problem solving – algorithm design and data structures, the limitations of computers. An introduction to programming in a high level language.

308-199A EXCURSIONS IN COMPUTER SCIENCE. (3) (3hours) (Prerequisite: high school mathematics) (FYS - for first year students only, maximum 25.) This is a seminar format course intended for freshman and other beginning students. The topics are chosen to encourage critical discussion of fundamental ideas. Possible topics are computability, complexity, geometry, vision, AI, pattern recognition, machine models, cryptography and security and social implications of computing.

308-202A,B INTRODUCTION TO COMPUTING 1. (3) (3hours) (Prerequisite: a CEGEP level mathematics course.) (For restrictions, see Notes A, F and N.) Overview of components of microcomputers, the internet, design and implementation of programs using a modern high-level language, and introduction to modular software design and debugging. Programming concepts are illustrated using a variety of application areas.

308-203A,B INTRODUCTION TO COMPUTING 2. (3) (3hours) (Prerequisites: 189-133 and 308-202.) (For restrictions, see Notes B, F, H and M.) Basic data structures. Representation of arrays, stacks, and queues. Linked lists and their applications to binary trees. Internal sorting. Graph representation. Elementary graph algorithms. (Restriction revision awaiting University approval)

308-206A INTRO TO SOFTWARE SYSTEMS. (3) (3 hours) (Prerequiste: 308-203 or 308-250) (For restrictions, see Note I.) Comprehensive overview of programming in C, use of system calls and libraries, debugging and testing of code; use of developmental tools like make, version control systems. (Restriction revision awaiting University approval)

308-208A,B COMPUTERS IN ENGINEERING. (3) (3 hours) (Prerequisite: differential and integral calculus. Co-requisite: linear algebra: determinants, vectors, matrix operations.) (For restrictions, see Note A.) Introduction to computer systems. Concepts and structures for high level programming. Elements of structured programming using FORTRAN 90 and "C". Assignments in both mainframe and microcomputer environment. Numerical algorithms such as root finding, numerical integration and differential equations. Non-numerical algorithms for sorting and searching.

308-250A,B INTRO TO COMPUTER SCIENCE. (3) (3 hours) (Prerequisites: Familiarity with a high level programming language and CEGEP level Math.) (For restrictions, see Notes B, K and M.) An introduction to the design of computer algorithms, including basic data structures, analysis of algorithms, establishing correctness of programs and program testing. Overview of topics in computer science. (Restriction revision awaiting University approval)

308-251A,B DATA STRUCTURES AND ALGORITHMS. (3) (3 hours) (Prerequisite: 308-250 or 308-203.) (For restrictions, see Notes B, E and G.) Design and analysis of algorithms. Complexity of algorithms. Data structures. Introduction to graph algorithms and their analysis. (Restriction revision awaiting University approval)

308-273A,B INTRO. TO COMPUTER SYSTEMS. (3) (3 hours) (Prerequisite: 308-206) (For restrictions, see Note I.) Computer structure, machine instruction execution, addressing techniques, digital representation of data. Assemblers, cross-assemblers and simulators. Interrupts. Input and output programming and devices. System support macros and software. Program segmentation and linkage. (Restriction revision awaiting University approval)

308-302A,B PROGRAMMING LANGUAGES AND PARADIGMS. (3) (3 hours) (Prerequisite: 308-250 or 308-203) (For restrictions, see Note L.) Programming language design issues and programming paradigms. Binding and scoping, parameter passing, lambda abstraction, data abstraction, type checking. Functional and logic programming. (Restriction revision awaiting University approval)

308-303B PROGRAMMING TECHNIQUES. (4) (3 hours, 3 lab hours) (Prerequisites: 308-206, 308-251, 308-302) Software architecture, design patterns, object-oriented programming concepts, profiling and optimization. Students will implement a significant programming project.

308-304A OBJECT-ORIENTED DESIGN. (3) (3 hours) (Prerequisites: 308-206, 308-251, 308-302) The object model, objects and classes, verification and testing, object-oriented analysis, unified modeling language and design patterns.

308-305A COMPUTER SYSTEM ARCHITECTURE. (3) (3hours) (Prerequisite: 308-273) (For restrictions, see Note I.) A functional description of computer hardware. Hardware concepts and current technology. Memories, memory hierarchies and dynamic address translation. CPU characteristics, performance factors, overlap, parallel and pipeline systems. Microprogramming. Interrupt mechanism and clocks. Input/Output devices including telecommunications. (Restriction revision awaiting University approval)

308-310B COMP. SYSTEMS AND ORGANIZATION. (3) (3 hours) (Prerequisite: 308-273) (For restrictions, see Note I.) Control and scheduling of large information processing systems. Operating system software – resource allocation, dispatching, processors, access methods, job control languages, main storage management. Batch processing, multiprogramming, multiprocessing, time sharing. (Restriction revision awaiting University approval)

308-330A THEORETICAL ASPECTS OF COMPUTER SCIENCE. (3) (3 hours) (Prerequisite: 308-251. For Major and Honours students.) (For restrictions, see Notes C and I.) Mathematical models of computers, finite automata, Turing machines, counter machines, push-down machines, computational complexity. (Restriction revision awaiting University approval)

308-335B SOFTWARE ENGINEERING METHODS. (3) (3hours) (Pre/co-requisite: 308-302A.) This course in software engineering teaches basic concepts and methods for software development. The focus is on engineering and analysing requirements, design and code. Small software development exercises will be given where students would learn how to apply different methods.

308-350A NUMERICAL COMPUTING. (3) (3 hours) (Prerequisites: 308-202 OR -208 OR -250, and 189-222 and -223, or equivalents.) (For restrictions, see Note I.) Computer representation of numbers, IEEE Standard for Floating Point Representation, computer arithmetic and rounding errors. Numerical stability. Matrix computations and software systems. Polynomial interpolation. Least-squares approximation. Iterative methods for solving a nonlinear equation. Discretization methods for integration and differential equations. (Restriction revision awaiting University approval)

308-360A ALGORITHM DESIGN TECHNIQUES. (3) (3 hours) (Prerequisite: 308-251.) (For restrictions, see Notes E and I.) A study of techniques for the design and analysis of algorithms. (Restriction revision awaiting University approval)

- **308-361B SYSTEMS PROGRAMMING PROJECT.** (3) (Prerequisite: 308-206) (For restrictions, see Note I.)

308-400A,B TECHNICAL PROJECT AND REPORT. (3) (Prerequisites: 15 Computer Science credits. For Honours students.) A computer related project, typically a programming effort, along with a report will be carried out in cooperation with a staff member in the School of Computer Science.

- **308-409A CONCURRENT PROGRAMMING.** (3) (Prerequisites: 308-251, 308-302, and 308-310 or 304-427) (For restrictions, see Note I.)

- **308-410B MOBILE COMPUTING.** (3) (Prerequisite: 308-310) (For restrictions, see Note I.)

- **308-412A SOFTWARE FOR E-COMMERCE.** (3) (Prerequisites: 304-427 or 308-310) (For restrictions, see Note I.)

308-420A FILES AND DATABASES. (3) (3 hours) (Prerequisite: 308-302) (For restrictions, see Note I.) Language essentials for file processing; sequential files; sorting, updating, tree files; direct files; files of structured data; basics of relational databases. (Restriction revision awaiting University approval)

308-421B DATABASE SYSTEMS. (3) (3 hours) (Prerequisites: 308-206, 308-251, 308-302) (For restrictions, see Note I.) The relational model of databases, an introduction to object-oriented concepts. Relational algebra, conceptual design of databases, concurrency control issues and databases. (Restriction revision awaiting University approval)

308-423B DATA COMPRESSION. (3) (3 hours) (Prerequisites: 308-251, 189-223, 189-323) Information Theory. Huffman, arithmetic and dictionary codes. Context Modelling. Lossy compression and quantization. Signal processing. Applications to text, image, speech, audio and video data.

308-424A ARTIFICIAL INTELLIGENCE 1. (3) (3 hours) (Prerequisites: 308-206, 308-251, 308-302) (For restrictions, see Not eJ.) Introduction to search methods in AI problems. Mechanical theorem-proving techniques, game playing by computers, the minimax and alpha-beta algorithms, and heuristic approaches to state space search problems. (Restriction revision awaiting University approval)

308-426B AUTOMATED REASONING. (3) (3 hours) (Prerequisites: 308-424; or 308-302 with 189-340.) Representing and reasoning with knowledge. The case for logics. Introduction to Logic Programming and, for example, PROLOG. Introduction to some Artificial Intelligence applications of Logic Programming: Meta-interpreters, Expert Systems and their implementation, Planning, Natural Language Processing, Machine Learning.

308-431A ALGORITHMS AND DATA STRUCTURES. (3) (3hours) (Prerequisites: 304-222 and 189-363.) (For restrictions, see Note E.) Advanced data structures: heaps, binary search trees, graphs, algorithmic analysis: space-time analysis, worst-case and expected complexity. Examples of searching sorting and merging. Algorithm design: divide-and-conquer, dynamic programming, greedy methods, backtracking. Algorithms: set manipulation, tree traversals. Memory management: hashing, dynamic storage allocation and garbage collection.

308-433A PERSONAL SOFTWARE ENGINEERING. (3) (3 hours) (Prerequisite: 308-335B.) This software engineering course teaches students how to develop, manage and improve their personal processes for developing software. Selected software development practices are introduced through 10 small programming exercises. The students then use these programs to analyse data on their personal performance, plan homework projects, and guide their process improvement.

308-435B BASICS OF COMPUTER NETWORKS. (3) (3 hours) (Prerequisite: 308-310) (For restrictions, see Note I.) Exposition of the first four layers of the ISO model for computer network protocols. Socket programming. Network administration and configuration and Security issues. (Restriction revision awaiting University approval)

308-505A HIGH-PERFORMANCE COMPUTER ARCHITECTURE. (3) (3 hours) (Prerequisites: 308-302 and 308-305 or equivalent.) Basic principles and techniques in the design of high-performance computer architecture. Topics include memory architecture: cache structure and design, virtual memory structures; pipelined processor architecture: pipeline control and hazard resolution, pipelined memory structures, interrupt, evaluation techniques; vector processing; RISC vs. CISC architectures; general vs. special purpose architectures; VLSI architecture issues.

308-506B ADVANCED ANALYSIS OF ALGORITHMS. (3) (3hours) (Prerequisite: 308-330 or 308-360 or 308-405 or 308-431.) The study of computational complexity and intractability: Cook's Theorem, NP-completeness, oracles, the polynomial hierarchy, lower bounds, heuristics, approximation problems.

308-507A COMPUTATIONAL GEOMETRY. (3) (3 hours) (Prerequisite: 308-360 or 308-405 or equivalent or co-requisite 506.) Problems in computational geometry; worst-case complexity of geometric algorithms; expected complexity of geometric algorithms and geometric probability; geometric intersection problems; nearest neighbor searching; point inclusion problems; distance between sets; diameter and convex hull of a set; polygon decomposition; the Voronoi diagram and other planar graphs; updating and deleting from geometric structures.

308-520A COMPILER DESIGN. (4) (3 hours, 1 hour consultation) (Prerequisites: 308-273 and 308-302.) The structure of a compiler. Lexical analysis. Parsing techniques. Syntax directed translation. Run-time implementation of various programming language constructs.Introduction to code generation for an idealized machine. Students will implement parts of a compiler.

308-522A MODELLING AND SIMULATION. (4) (3 hours) (Prerequisites: 308-251, 308-302, 308-350) Simulation and modeling processes, state automata, Petri Nets, state charts, discrete event systems, continuous-time models, hybrid models, system dynamics and object-oriented modeling.

308-524B THEORETICAL FOUND. OF PROG. LANG. (3) (3hours) (Prerequisite: 308-302, and 189-340 or 189-235) Operational and denotational semantics of programming languages. Equivalence theorems for first-order languages. Lambda calculus. Type-inference, typed lambda calculus. Polymorphism. Elements of domain theory and fixed-point induction.

308-525B FORMAL VERIFICATION. (3) (3 hours) (Prerequisites: 308-251, 308-310, 308-330 and 189-340) Propositional logic – syntax and semantics, temporal logic, other modal logics, model checking, symbolic model checking, binary decision diagrams, other approaches to formal verification.

308-526 PROBABILISTIC REASONING AND AI. (3) (3 hours) (Prerequisites: 308-206, 308-360, 308-424 and 189-323) Belief networks, Utility theory, Markov Decision Processes and Learning Algorithms.

308-530A FORMAL LANGUAGES. (3) (3 hours) (Prerequisite: 308-203.) (For restrictions, See Note C.) The definition of a language. Grammars. Finite automata and regular languages. Context free languages. Pushdown automata. Turing machines and undecidable problems. Context sensitive and phrase-structure languages.

308-531B THEORY OF COMPUTATION. (3) (3 hours) (Prerequisite: 308-330.) Models for sequential and parallel computations: Turing machines, boolean circuits. The equivalence of various models and the Church-Turing thesis. Unsolvable problems. Model dependent measures of computational complexity. Abstract complexity theory. Exponentially and super-exponentially difficult problems. Complete problems.

308-534B TEAM SOFTWARE ENGINEERING. (3) (3 hours) (Prerequisite: 308-433A or equivalent.) Team-work and team-processes for evolving software systems. Guided by defined processes, project teams will elicit new requirements, design code and test an enhanced software system. Team members will play various technical and managerial roles in carrying out their software project.

308-535A COMPUTER NETWORKS. (3) (3 hours) (Prerequisite: 308-310.) Exposition of the first four layers of the ISO model for computer network protocols, i.e., the physical, data, network, and transport layers. Basic hardware and software issues with examples drawn from existing networks, notably SNA, DECnet, and ARPAnet.

308-537B INTERNET PROGRAMMING. (3) (3 hours) (Prerequisites: 308-251 and 308-302, and any one of 308-310, 308-420, 308-424, or 308-433) Sockets, User Datagram Protocol (UDP), Transmission utility protocals; Remote Terminal Protocol (Telnet), Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP) Hypertext Transfer Protrocol (HTTP), Internet resource database and search engines. Remote File Systems. Distributed objects, Common Object Request Broker Architecture (CORBA).

308-538B PERSON-MACHINE COMMUNICATION. (3) (3hours) (Prerequisites: 308-251, 308-302) Introduction to programming techniques and hardware design concepts that facilitate interaction between humans and computers. Theories and models for person-machine communication, object oriented Design and Software Engineering of interfaces. Natural language facilities.

308-540B MATRIX COMPUTATIONS. (3) (3 hours) (Prerequisite: 189-327 or 308-350) Designing and programming reliable numerical algorithms. Stability of algorithms and condition of problems.

Reliable and efficient algorithms for solution of equations, linear least squares problems, the singular value decomposition, the eigenproblem and related problems. Perturbation analysis of problems. Algorithms for structured matrices.

308-547A CRYPTOGRAPHY AND DATA SECURITY. (3) (3 hours) (Prerequisite: 308-360) (Restriction: Not open to students who have taken 308-647.) This course presents an in-depth study of modern cryptography and data security. The basic information theoretic and computational properties of classical and modern cryptographic systems are presented, followed by a cryptanalytic examination of several important systems. We will study the applications of cryptography to the security of systems.

308-557B FUNDAMENTALS OF COMPUTER GRAPHICS. (3) (3 hours) (Prerequisite: 189-223, and 308-251 or -302.) The study of fundamental mathematical, algorithmic and representational issues in computer graphics. The topics to be covered are: overview of graphics process, projective geometry, homogeneous coordinates, projective transformations, quadrics and tensors, line-drawing, surface modelling and object modelling reflectance models and rendering, texture mapping, polyhedral representations, procedural modeling, and animation.

308-558B FUND. OF COMPUTER VISION. (3) (3 hours) (Prerequisites: 308-206, 308-360, 189-222, 189-223) (Restriction: not open to students who have taken 308-766 before January 2001.) Biological vision, edge detection, projective geometry and camera modeling, shape from shading and texture, stereo vision, optical flow, motion analysis, object representation, object recognition, graph theoretic methods, high level vision, applications.

308-560A GRAPH ALGORITHMS AND APPLICATIONS. (3) (3 hours) (Prerequisite: 308-360 or 308-405 or 308-431 or 189-343) Algorithms for connectivity, partitioning, clustering, colouring and matching. Isomorphism testing. Algorithms for special classes of graphs. Layout and embeddings algorithms for graphs and networks.

308-562A COMPUTATIONAL BIOLOGY METHODS. (3) (3 hours) (Prerequisites: 308-330, 308-350, 308-360 and 189-323) Application of computer science techniques to problems arising in biology and medicine, techniques for modeling evolution, aligning molecular sequences, predicting structure of a molecule and other problems from computational biology.

308-566A DISCRETE OPTIMIZATION 1. (3) (3hours) (Prerequisites: 308-360 or 308-405 and 189-223) Use of computer in solving problems in discrete optimization. Linear programming and extensions. Network simplex method. Applications of linear programming. Vertex enumeration. Geometry of linear programming. Implementation issues and robustness.

308-567B DISCRETE OPTIMIZATION 2. (3) (3 hours) (Prerequisites: 308-566 or 189-417) Formulation, solution and applications of integer programs. Branch and bound, cutting plane, and column generation algorithms. Combinatorial optimization. Polyhedral methods. A large emphasis will be placed on modeling. Students will select and present a case study of an application of integer programming in an area of their choice.

308-573A,B MICROCOMPUTERS. (3) (3 hours) (Prerequisite: 308-305.) Characteristics and internal structure of microcomputers and workstations. Architectures of current CISC and RISC micro processors. Assembler and machine languages for microcomputers. System software. Applications for single and networked microcomputers. Students will be assigned "hands-on" projects.

308-575A FUNDAMENTALS OF DISTRIBUTED ALGORITHMS. (3) (3 hours) (Prerequisite: 308-310.) Study of a collection of algorithms which are basic to the world of concurrent programming. Discussion of algorithms from the following areas: termination detection, deadlock detection, global snapshots, clock synchronization, fault tolerance (byzantine and self-stabilizing systems). Students will implement algorithms on the BBN butterfly and will present papers on topics in these areas.

11.9 Earth and Planetary Sciences (186)

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Chair — Alfonso Mucci

Emeritus Professors
Wallace H. MacLean; B.Geol.Eng.(Colorado Sch. of Mines), M.Sc.(Appl.), Ph.D.(McG.)
Eric W. Mountjoy; B.A.Sc.(U.B.C.), Ph.D.(Tor.) *(William E. Logan Emeritus Professor of Geology)*
Colin W. Stearn; B.Sc.(McM.), M.S., Ph.D.(Yale), F.R.S.C.

Professors
Jafar Arkani-Hamed; B.Eng.(Tehran), Ph.D.(M.I.T.)
Don M. Francis; B.Sc.(McG.), M.Sc.(U.B.C.), Ph.D.(M.I.T.) *(Dawson Professor of Geology)*
Andrew J. Hynes; B.Sc.(Tor.), Ph.D.(Cantab.) *(William E. Logan Professor of Geology)*
Olivia G. Jensen; B.Sc., M.Sc., Ph.D.(U.B.C.)
Robert F. Martin; B.Sc.(Ott.), M.S.(Penn. State), Ph.D.(Stan.)
Alfonso Mucci; B.Sc., M.Sc.(Montr.), Ph.D.(Miami)
A.E. (Willy) Williams-Jones; B.Sc., M.Sc.(Natal), Ph.D.(Queen's)

Associate Professors
Don Baker; B.A.(Chic.), Ph.D.(Penn.)
Jeanne Paquette; B.Sc., M.Sc.(McG.), Ph.D.(Stonybrook)
John Stix; AB (Dart.), M.Sc., Ph.D.(Tor.)
Hojatollah Vali; B.Sc., M.Sc., Ph.D.(Munich) *(Director, Electron Microscopy Centre)*

Assistant Professor
Bruce Hart; B.A.(McM.), M.Sc.(U.Q.à Rimouski), Ph.D.(W.Ont.)

The domain of Earth and Planetary Sciences includes the solid Earth and its hydrosphere and extends to the neighbouring terrestrial planets. It is a multidisciplinary field in which the principles of chemistry, physics, and mathematics are applied to the rich problems of the real world in order to understand how planets like the Earth work; in the past, the present, and the future.

Career opportunities are many and varied for graduates in the Earth and Planetary Sciences. There is presently a very strong demand for graduates with expertise in geology. Students graduating in this field are recruited for employment in the petroleum and mining industries, and in the environmental sector. In addition, government geological surveys employ goescientists. During the summer months undergraduate students are generally able to obtain employment from industry and government agencies, providing them with both financial benefits and first-hand geoscientific experience. Career opportunities in planetary science are presently limited to universities and research organizations.

The Department has a full-time staff of 12 professors and one faculty lecturer. There are approximately 5 0graduate and 60 undergraduate students. Classes are therefore small at all levels, resulting in an informal and friendly atmosphere throughout the Department in which most of the faculty and students interact on a first name basis. Emphasis is placed equally on quality teaching and research providing undergraduate students with a rich and exciting environment in which to learn and explore.

The undergraduate curriculum is designed to provide both a rigorous foundation in the physical sciences and the flexibility to create an individualized program in preparation for careers in industry, teaching, or research. In addition to the Major and Honours undergraduate programs, the Department also offers a Joint Major in Physics and Geophysics which provides a rigorous mathematics and physics preparation and a geological background in the geosciences.

The Minor in Earth and Planetary Sciences offers Science students from other departments the opportunity to obtain exposure to the Earth Sciences while the Minor in Geochemistry is oriented

towards Chemistry Major students who want to see the application of chemistry to problems in the Earth and Planetary Sciences.

Students interested in any of the programs should inquire at Room 238, Frank Dawson Adams Building, (514) 398-6767, or should consult the Undergraduate Director, Don Francis, Room 311, Frank Dawson Adams Building, (514) 398-4885, if they do not have an adviser.

MINOR PROGRAM IN EARTH AND PLANETARY SCIENCES
(18 credits) [MARS Program Code 6-480100]

Required Courses (7 credits)
186-210A (3) Introduction to Mineralogy
186-212B (4) Introductory Petrology

Complementary Courses (11 credits)
186-201A,B (3) Understanding Planet Earth
or 186-233A (3) Earth & Life History

8 credits selected from:
186-203B (3) Structural Geology I
186-231E (2) Field School I
186-243A,B (3) Environmental Geology
186-334B (3) Invertebrate Palentology
186-350B (3) Tectonics
186-430B (3) Geology of Energy Sources
186-451B (3) Hydrothermal Mineral Deposits
186-452A (3) Mineral Deposits
186-542A (3) Chemical Oceanography
177-352B (3) Vertebrate Evolution
Other Earth and Planetary Sciences courses may be substituted with permission.

MINOR PROGRAM IN GEOCHEMISTRY (25 credits)
[MARS Program Code 6-460000]

Required Courses (10 credits)
186-201A,B (3) Understanding Planet Earth
186-210A (3) Introduction to Mineralogy
186-212B (4) Introductory Petrology

Complementary Courses (15 credits)
15 credits selected from:
186-220B (3) Principles of Geochemistry
186-243A,B (3) Environmental Geology
186-501A (3) Crystal Chemistry
186-519A (3) Isotope Geology
186-542A (3) Chemical Oceanography
186-545B (3) Low-Temperature Geochemistry

MAJOR AND HONOURS PROGRAMS IN EARTH AND PLANETARY SCIENCES
[MARS Program Codes: Major 1-480100; Honours 2-480100]
Undergraduate Director: Don Francis, FDA 311, (514) 398-4885

Common U1 Year:

Required Courses (27 credits)
186-210A (3) Introduction to Mineralogy
186-220A (3) Principles of Geochemistry
186-233A (3) Earth and Life History
189-222A (3) Calculus III
186-203B (3) Structural Geology
186-212B (4) Introductory Petrology
186-312B (3) Spectroscopy of Minerals
xxx-xxx* (3) approved statistics course
186-231C (2) Field School I
*****Students intending to take the Honours Planetary Sciences Program in U2 must take 189-223B Linear Algebra instead of an approved statistics course.

Note: Students who have not had the following course or its equivalent in CEGEP or the Freshman Program may be required to take 189-133A,B Vectors, Matrices and Geometry.

U2 and U3: MAJOR PROGRAM IN EARTH AND PLANETARY SCIENCES (66 credits in total: 51 required, 15 complementary)

Required Courses (24 credits)
186-320A (3) Elementary Earth Physics
186-334B (3) Invertebrate Paleontology
186-350B (3) Tectonics
186-423B (3) Igneous Petrology
186-445B (3) Metamorphic Geology
186-452A (3) Mineral Deposits
186-455A (3) Sedimentary Petrology
186-519A (3) Isotope Geology

Complementary Courses (15 credits)
3 credits, one of the following courses:
186-331C (3) Field School II
or 186-341C (3) Field School III
plus 12 credits, 4 courses chosen from the following:
186-330B (3) Earthquakes & Earth Structure
186-425A (3) Sediments to Sequences
186-435A (3) Geophysical Applications
186-451B (3) Hydrothermal Mineral Deposits
186-501A (3) Crystal Chemistry
186-530A (3) Volcanology
186-542A (3) Chemical Oceanography
186-547A (3) High Temperature Geochemistry
186-548A (3) Processes of Igneous Petrology
186-549B (3) Hydrogeology
186-550A,B (3) Selected Topics 1
186-551A,B (3) Selected Topics 2
186-552A,B (3) Selected Topics 3
186-570B (3) Cosmochemistry
186-580A (3) Aqueous Geochemistry
186-590B (3) Applied Geochemistry Seminar

Note: Courses at the 300 or higher level in other departments in the Faculties of Science and Engineering may also be used as complementary credits, with the permission of the Director of Undergraduate Studies.

U2 and U3: HONOURS IN EARTH SCIENCES PROGRAM
(CGPA $\geq$ 3.20) (75 credits in total: 60 required, 15 complementary)
[MARS Program Code 2-480200]

Required Courses (33 credits)
186-320A (3) Elementary Earth Physics
186-350B (3) Tectonics
186-423B (3) Igneous Petrology
186-445B (3) Metamorphic Geology
186-452A (3) Mineral Deposits
186-455A (3) Sedimentary Petrology
186-480D (6) Honours Research Project
186-519A (3) Isotope Geology
189-314A (3) Advanced Calculus
189-315A (3) Ordinary Differential Equations

Complementary Courses (15 credits)
3 credits, one of the following courses:
186-331C (3) Field School II
or 186-341C (3) Field School III
plus 12 credits, 4 courses chosen from the following:
186-330B (3) Earthquakes & Earth Structure
186-334B (3) Invertebrate Paleontology
186-425A (3) Sediments to Sequences
186-435A (3) Geophysical Applications
186-451B (3) Hydrothermal Mineral Deposits
186-501A (3) Crystal Chemistry
186-530A (3) Volcanology
186-542A (3) Chemical Oceanography
186-547A (3) High Temperature Geochemistry
186-548A (3) Processes of Igneous Petrology
186-549B (3) Hydrogeology
186-550A,B (3) Selected Topics 1
186-551A,B (3) Selected Topics 2
186-552A,B (3) Selected Topics 3
186-570B (3) Cosmochemistry
186-580A (3) Aqueous Geochemistry
186-590B (3) Applied Geochemistry Seminar

Note: Courses at the 300 or higher level in other departments in the Faculties of Science and Engineering may also be used as complementary credits, with the permission of the Director of Undergraduate Studies.

U2 and U3: HONOURS IN PLANETARY SCIENCES PROGRAM
(CGPA ≥ 3.20) (81 credits in total: 69 required, 12 complementary)
[MARS Program Code 2-480300]

Required Courses (42 credits)

186-320A	(3)	Elementary Earth Physics
186-330B	(3)	Earthquakes & Earth Structure
186-350B	(3)	Tectonics
186-423B	(3)	Igneous Petrology
186-480D	(6)	Honours Research Project
186-510A	(3)	Geodynamics & Geomagnetism
186-519A	(3)	Isotope Geology
186-570B	(3)	Cosmochemistry
189-314A	(3)	Advanced Calculus
189-315A	(3)	Ordinary Differential Equations
189-317A	(3)	Numerical Analysis
189-319B	(3)	Partial Differential Equations
198-340B	(3)	Electricity & Magnetism

Complementary Courses (12 credits)
3 credits, one of the following courses:

198-251A	(3)	Classical Mechanics
or 198-230A	(3)	Dynamics of Simple Systems

plus 9 credits, 3 courses chosen from the following:

186-334B	(3)	Invertebrate Paleontology
186-425A	(3)	Sediments to Sequences
186-435A	(3)	Geophysical Applications
186-451B	(3)	Hydrothermal Mineral Deposits
186-501A	(3)	Crystal Chemistry
186-530A	(3)	Volcanology
186-542A	(3)	Chemical Oceanography
186-547A	(3)	High Temperature Geochemistry
186-548A	(3)	Processes of Igneous Petrology
186-549B	(3)	Hydrogeology
186-550A,B	(3)	Selected Topics 1
186-551A,B	(3)	Selected Topics 2
186-552A,B	(3)	Selected Topics 3
186-570B	(3)	Cosmochemistry
186-580A	(3)	Aqueous Geochemistry
186-590B	(3)	Applied Geochemistry Seminar

Note: Courses at the 300 or higher level in other departments in the Faculties of Science and Engineering may also be used as complementary credits, with the permission of the Director of Undergraduate Studies.

JOINT MAJOR PROGRAM IN PHYSICS AND GEOPHYSICS
See page 415 in the Physics section for complete program information.

COURSE DESCRIPTIONS

All courses have limited enrolment.

The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

● Denotes courses not offered in 2001-02.

The following courses are without prerequisite and could be taken by students in the Faculty of Arts: 186-200A,B; 186-201A,B; 186-233A; and 186-243A,B. Other courses assume as a prerequisite completion of the courses required in the Sciences option of the CEGEP curriculum.

186-200A,B THE TERRESTRIAL PLANETS. (3) (3hours lectures) A comparative survey of the planets of our solar system with an emphasis on the terrestrial planets and their implications for the Earth as a planet. Topics include: structure and origin of the solar system, meteorites, and comparisons of the terrestrial planets in terms of their rotational properties, magnetic fields, atmospheres, surface histories, internal structure, chemical composition, volcanism, and tectonics.

186-201A,B UNDERSTANDING PLANET EARTH. (3) (3 lectures; afternoon field trips) Learn about Earth's origin, its place in the solar system, its internal structure, rocks and minerals, the formation of metal and fossil fuel deposits, and the extinction of dinosaurs. Discover the impact of the volcanic eruptions, earthquakes and mountain chains on Earth's past, present and future. Explore 125 million-year-old Mount Royal.

186-203B STRUCTURAL GEOLOGY I. (3) (2 hours lectures, 3 hours laboratory) Primary igneous and sedimentary structures, attitudes of planes and lines, stress and strain, fracturing of rocks, faulting, homogeneous strain, description and classification of folds, foliation and lineation, orthographic and stereographic projections.

186-205B ASTROBIOLOGY. (3) (3 hours lectures) (Not open to students who have taken or are taking 504-205.) Astrobiology is the search for the origin, evolution and destiny of life in the universe. The course will provide insight into the formation and evolution of habitable worlds, the evolution of life and the biogeochemical cycles in the Earth's oceans and atmosphere, and the potential for biological evolution beyond an organism's planet of origin.

186-210A INTRODUCTION TO MINERALOGY. (3) (2hours lecture, 3 hours laboratory) Crystal chemistry and identification of the principal rock-forming and ore minerals. Elementary crystallography. Optional 2-day field trip.

186-212B INTRODUCTORY PETROLOGY. (4) (3hours lecture, 3 hours laboratory) (Prerequisite: 186-210A) Survey course of igneous, sedimentary and metamorphic rocks and the processes leading to their formation. Emphasis in the laboratory on hand-specimen description and classification, supplemented by thin sections.

● **186-215B ANALYSIS OF GEOLOGICAL DATA.** (3) (3 lectures, and problems) (Note: Credit for other statistics courses may preclude credit for this course and conversely. See "Course Overlap" on page 351.)

186-220A PRINCIPLES OF GEOCHEMISTRY. (3) (2lectures, 3hours laboratory) (Prerequisites: 186-201A, -210A) Basic concepts in geochemistry and the application of geochemical principles of chemistry to geological subdisciplines. Particular emphasis on origin of elements, controls on their distribution in Earth and cosmos, isotopes, organic geochemistry and water chemistry. Application of phase diagrams to geology.

186-231C FIELD SCHOOL I. (2) (Two-week field school in May) (Prerequisite: 186-203B, 186-212B, or equivalent.) Geological mapping of selected areas, preparation of maps, reports from field notes, aerial photographs, etc.

186-233A EARTH AND LIFE HISTORY. (3) (3 lectures) Interpretation of stratified rocks; history of Earth with special emphasis on the regions of North America; outline of the history of life recorded in fossils.

186-243A,B ENVIRONMENTAL GEOLOGY. (3) (3hours lectures) Introduction to the relationship of geological processes and materials to the human environment; geologic hazards; hydrogeology; impacts of waste disposal, energy use, land resource development.

186-250A NATURAL DISASTERS. (3) (3 lectures) (Restriction: Not open to students who have taken or are taking 195-250A.) This course examines the science behind different types of disasters and our ability or inability to control and predict such events. From this course the student will gain an appreciation of natural disasters beyond the newspaper headlines, and will better understand how the effects of disasters can be reduced.

186-312B SPECTROSCOPY OF MINERALS. (3) (6 hours laboratory and relevant in-lab lectures) (Prerequisite: 186-210A) Interaction of minerals with electromagnetic radiation. Optical mineralogy on thin and polished sections. Demonstrations of other spectroscopic techniques applied to the identification of minerals and to the analysis of their composition and structure.

186-320A ELEMENTARY EARTH PHYSICS. (3) (3hours lectures) (Prerequisite: 189-222A,B) Physical properties of Earth and the processes associated with its existence as inferred from astronomy, geodesy, seismology, geology, terrestrial magnetism and thermal evolution.

● **186-330B EARTHQUAKES & EARTH STRUCTURE.** (3) (3hours lectures, tutorial as required) (Prerequisites: 189-314B, 186-320A. Corequisites: 189-319)

● **186-331C FIELD SCHOOL II.** (3) (Two-week field school in May.)

● **186-334B INVERTEBRATE PALEONTOLOGY.** (3) (2lectures and one laboratory period)

186-341C FIELD SCHOOL III. (3) (Prerequisites: 186-210A, -203B, -212B and -231E or permission of the instructor.) A field school which will be given in May in alternate years to 186-331E. The course examines sedimentary strata in the S t.Lawrence low lands, igneous rocks of the Monteregian intrusions, and metamorphic rocks in the Grenville Province near Ottawa.

● **186-350B TECTONICS.** (3) (Prerequisites: 186-320A, Calculus III or equivalent.)

● **186-401B ADVANCED ENVIRONMENTAL GEOLOGY.** (3) (1 lecture, 2 seminar) (Prerequisite: 186-220B or 180-204A or equivalent. Corequisite: 186-580A)

● **186-402C ENVIRONMENTAL FIELD SCHOOL.** (2) (1 laboratory, 2 other) (Prerequisites: 186-220B or 180-204A or equivalent.)

● **186-405A PLANETARY GEOLOGY.** (3) (3 lecture) (Prerequisites: 186-210A, -203B, -212B or permission of the instructor.)

186-423B IGNEOUS PETROLOGY. (3) (2 hours lectures, 3 hours laboratory) (Prerequisites: 186-212B, 312B) Physical properties, nucleation, crystallization, differentiation and emplacement of magmas. Integrated studies on various rock suites.

186-425B SEDIMENTS TO SEQUENCES. (3) (2 lecture, 3 laboratory) (Prerequisites: 186-210A, 186-212B) Processes and products of modern and ancient carbonate and siliciclastic depositional environments. Sequence stratigraphy as a tool for studying the fundamental controls (sea level, tectonics, sediment supply, etc.) on stratigraphic architecture.

● **186-430A GEOLOGY OF ENERGY SOURCES.** (3) (2 lecture and 2 hours laboratory or seminar) (Corequisite: 186-425A or permission of the instructor.)

186-435A GEOPHYSICAL APPLICATIONS. (3) (3hours lecture) (Prerequisites: Calculus III, Linear Algebra and 186-320A or equivalents.) Methods in geophysical surveying including gravity, magnetism, electromagnetism, resistivity and induced polarisation, seismology and radioactivity; applications to oil and mineral exploration and near surface environmental and hydrological targets.

● **186-445B METAMORPHIC GEOLOGY.** (3) (Prerequisites: 186-212B, 303A, 312B)

186-451B HYDROTHERMAL MINERAL DEPOSITS. (3) (Prerequisite: 186-220B) The principles of hydrothermal ore-forming processes. Application of these principles to understanding the nature and mode of occurrence of selected types of metallic mineral deposits.

● **186-452A MINERAL DEPOSITS.** (3) (Prerequisite: 186-312B, 220B)

186-455A SEDIMENTARY GEOLOGY. (3) (Prerequisites: 186-210A, 186-212B) This course discusses the origin, diagenesis, classification and economic importance of sedimentary rocks. Students will learn about the physical properties of sedimentary rocks, including porosity and permeability, different techniques for analyzing those rocks (thin sections, hand specimens, wireline logs) and the types of sedimentary basins within which sediments accumulate.

186-480D HONOURS RESEARCH PROJECT. (6) (For Honours students in 3rd year.) A written proposal outlining the studies to be undertaken must be submitted to the undergraduate Student Adviser by May 1st of the U-2 year. The proposal will be reviewed by a committee and a decision forwarded by mail. If approved the investigation will be supervised by a staff member, and the results must be presented in the form of an undergraduate thesis.

186-482A,B,D INDEPENDENT STUDIES 1. (3) (May not be taken concurrently with 186-480D.) Research and/or reading project in Earth and Planetary Sciences, designed by the student in consultation with a faculty supervisor. A statement of the proposed project and the method of evaluation must be approved by the Director of Undergraduate studies before October 15. This statement will be included in the student's file.

186-483D INDEPENDENT STUDIES 2. (3) (To be taken concurrently with 182-500D.) Research and/or reading project on an environmental topic, designed by the student in consultation with a faculty supervisor. A statement of the proposed project and the method of evaluation must be approved by the Director of Undergraduate Studies by October 15. This statement will be included in the student's file.

186-501B CRYSTAL CHEMISTRY. (3) (2 hours lectures, 1 hour seminar) (Prerequisite: 180-203A or 180-213A,B) Discussion of crystal structures and compositions of important mineral groups, especially oxides, sulphides and silicates. Solid solution. Relation of structure to morphology and to chemical and physical properties of the rock-forming minerals.

186-510A GEODYNAMICS AND GEOMAGNETISM. (3) (3 lecture) (Prerequisites: 186-320A, 189-319B or permission of the instructor. Corequisite: 186-350B.) The gravity field of the Earth and planets, body and orbital dynamics the Earth, moon and planets, tidal interactions of the Earth-moon-sun system, deformation of the Earth under static and dynamic loads, the magnetic field of the Earth and planets: the magnetosphere, the external radiation belts, magnetohydrodynamic models of the core dynamo, geochemical convection in the core, fluid dynamic motions of the outer core, dynamics of the inner core.

● **186-519A ISOTOPE GEOLOGY.** (3) (3 lectures) (Prerequisites: U2 core program.)

186-525B SUBSURFACE MAPPING. (3) (Prerequisites: 186-455A or permission of instructor.) This course will provide participants the opportunity to learn how different types of data (wireline logs, seismic, etc.) are employed to map geological features in the subsurface. Lectures will teach participants about the physical basis of each of the data types, and the basic mapping and analytical techniques (e.g., geostatistics, gridding) that are employed in subsurface mapping. The principal focus will be on applying these techniques and concepts to real-world data sets.

186-530A VOLCANOLOGY. (3) (3 lecture) (Prerequisites: 186-212B and –312B, or permission of instructor) The physical mechanisms which drive volcanoes and volcanic activity are presented. Descriptive, practical and theorretical approaches to the study of volcanoes are discussed.

● **186-540B PHANEROZOIC GEOLOGY.** (3) (2hours lectures, 3 hours laboratory) (Prerequisite: U2 Major sequence. Corequisite: U3 Major sequence.)

● **186-542A CHEMICAL OCEANOGRAPHY.** (3) (Prerequisites: 180-213A,B, 180-257D or equivalents, or registration in Graduate Program in Oceanography.)

● **186-545B LOW-TEMPERATURE GEOCHEMISTRY.** (3) (Prerequisites 180-203A/213B, 186-212B, -312B)

● **186-546A DIAGENESIS.** (3) (2lecture, 3laboratory/seminars) (Prerequisites: 186-212B, -220B, -312A)

● **186-547A HIGH-TEMPERATURE GEOCHEMISTRY.** (3) (2hours lectures, 3 hours laboratory) (Prerequisites 180-203/4 or 180-213, or permission of instructor.)

● **186-548A PROCESSES OF IGNEOUS PETROLOGY.** (3) (2hours lecture, 1 hour seminar) (Prerequisite: 186-423B)

● **186-549B HYDROGEOLOGY.** (3) (3 hours lecture, 1-2 hours laboratory) (Prerequisite: permission of the instructor.)

186-550A,B SELECTED TOPICS 1. (3) (2hours seminar, permission of department undergraduate adviser.) Research seminar and/or lecture with readings in topics concerning aspects of current interest in Earth & Planetary Sciences.

186-551A,B SELECTED TOPICS 2. (3) (2hours seminar, permission of department undergraduate adviser.) Research seminar and/or lecture with readings in topics concerning aspects of current interest in Earth & Planetary Sciences.

186-552A,B SELECTED TOPICS 3. (3) Research seminar and/or lecture with readings in topics concerning aspects of current interest in Earth & Planetary Sciences.

186-570A COSMOCHEMISTRY. (3) (3hours lecture) (Prerequisites: 186-220B, -210A or permission of instructor.) Examines the implications of phase equilibria and the compositions of meteorites and the solar system for the formation and internal differentiation of the terrestrial planets and the nature of chemical fractionation processes in both planetary interiors and the solar system as a whole.

186-580B AQUEOUS GEOCHEMISTRY. (3) (3 hours lecture) (Prerequisites: 186-210A, 186-212B or permission of instructor.) The use of chemical thermodynamics to study fluid-rock interations with an emphasis on the aqueous phase. The course will introduce basic concepts and will discuss aqueous complexation, mineral surface adsorption, and other controls on crustal fluid compositions. Applications will range from considering contaminated groundwater systems to metamorphic reactions.

186-590B APPLIED GEOCHEMISTRY SEMINAR. (3) (3hours seminar) (Prerequisite: permission of instructor.) Seminar course devoted to field case studies that illustrate the applications of geochemical principles to solving geologic problems. Each student will prepare and lead a class devoted to a geochemical subject of their own choosing.

The following courses are offered by the Department of Earth and Planetary Sciences for Faculty of Engineering students:

186-221A GENERAL GEOLOGY. (3) (3 hours lecture, 3hours laboratory) A survey course in physical geology with emphasis on engineering and economic aspects.

186-225A PROPERTIES OF MINERALS. (1) (1 hour lecture, 1 hour laboratory) (Not open to students who have taken 186-210A) Survey of the physical and chemical properties of the main mineral groups. Discussion of their relationships to the chemical composition and structure of minerals. The practical exercises emphasize the physical and chemical properties that relate to industrial uses and environmental issues, and the identification of hand specimens.

11.10 Environmental Studies

Science students who are interested in studying the environment should refer to the McGill School of Environment section, page 471, where they will find information concerning the Minor, the Major, and the Diploma in Environment.

11.11 Experimental Medicine (516)

Experimental Medicine is a division of the Department of Medicine. Information regarding these courses may be obtained by calling the telephone numbers indicated below:

516-401 – (514) 842-1231, ext. 5738
516-502 and 516-503 – (514) 842-1231, ext. 5243 or 5833
516-504 – (514) 934-8038
516-506 – (514) 937-6011, ext. 2908
516-507 and 516-508 – (514) 398-3864, ext. 3249
516-509 – (514) 934-8308
516-510 – (514) 937-6011, ext. 3022
516-511 – (514) 398-3466
516-512 – (514) 987-5550

COURSES

All courses have limited enrolment.

The names of course instructors are listed on the Course Timetable available on ***info*McGill** via the Web http://www.mcgill.ca/students/courses/.

The course credit weight is given in parentheses after the title.

● Denotes courses not offered in 2001-02.

516-401B PHYSIOLOGY AND BIOCHEMISTRY OF ENDOCRINE SYSTEMS. (3) (Prerequisite: 177-200A and 177-201B) Offered in conjunction with the Department of Physiology. The course provides a basic knowledge of endocrine systems encompassing biosynthesis, metabolism and physiological actions of hormones. Specific topics covered are hormones of the hypothalamus, pituitary, adrenals, thyroids, parathyroids, pancreas, gut and the gonads. The role of hormones and growth factors in pregnancy and fetal development are also discussed.

516-502A ADVANCED ENDOCRINOLOGY – PART I. (3) (Prerequisite: 516-301A or an equivalent course.) This course is designed for U3 students who are in a major or honours program in anatomy, biology, biochemistry or physiology and for graduate students. A multidisciplinary approach will be used to teach biosynthesis and processing of hormones, their regulation, function and mechanism of action. The material will cover hypothalamic, pituitary, thyroid, atrial and adrenal hormones as well as prostaglandins and related substances.

516-503B ADVANCED ENDOCRINOLOGY – PART II. (3) (Prerequisite: 516-502A) Study of the parathyroids, gut and pancreatic hormones and growth factors. In addition, the role of hormones and growth factors in reproduction and fetal maturation will be discussed.

516-504A BIOLOGY OF CANCER. (3) (Prerequisite: A good knowledge of biology at the cellular and molecular level. Open to U3 and graduate students only.) An introduction to the biology of malignancy. A multidisciplinary approach dealing with the etiology of cancer, the biological properties of malignant cells, the host response to tumour cell growth and the principles of cancer therapy.

516-506B ADVANCED CARDIOVASCULAR PHYSIOLOGY. (3) (Prerequisite: 552-313B or by permission of Instructors.) Offered in conjunction with the Department of Physiology. Current topics, methods and techniques for studying the cardiovascular system. Basic and applied cardiac electrophysiology, mechanisms of pacemaker activity, arrhythmias, the effects of drugs on cardiac functions, fetal circulation, coronary circulation, mechanics of blood flow, cardiovascular diseases, renal and neural control of the circulation, and cardiac assist devices.

516-507A ADVANCED APPLIED RESPIRATORY PHYSIOLOGY. (3) (Prerequisite: 552-313B) Offered in conjunction with the Department of Physiology. In depth coverage of respiratory biology including: functional anatomy of the respiratory system, pulmonary statics and dynamics, chest wall and respiratory muscles, ventilation and perfusion, control of breathing, and defense mechanisms. This course is aimed at providing a solid grounding in pulmonary biology and its research applications.

516-508B ADVANCED TOPICS IN RESPIRATION. (3) (Prerequisite: 516-507A) Offered in conjunction with the Department of Physiology. In depth coverage of developmental physiology, pulmonary vascular physiology, biology of airway smooth muscle, respiratory epithelium and molecular biology of respiratory muscles. Dyspnea, mechanical ventilation and respiratory failure will also be covered. This course emphasizes application of respiratory biology to basic and applied research and touches on pulmonary pathophysiology.

516-509B GASTROINTESTINAL PHYSIOLOGY AND PATHOPHYSIOLOGY. (3) (Prerequisite: Graduate students, U3 undergraduates.) Course deals with various aspects of gastrointestinal and hepatic function in health and altered physiological states. The principal focus is on the recent literature pertaining to cell and molecular mechanisms underlying the motility secretory process, absorption and secretion. The molecular biology of the hepatic viruses and various aspects of colonic neoplasia will also be considered.

516-510A BIOANALYTICAL SEPARATION METHODS. (3) The student will be taught the capabilities and limitations of modern separation methods (gas and high-performance liquid chromatography, capillary electrophoresis, hyphenated techniques). Application of these techniques to solve analytical problems relevant to biomedical research will be emphasized, with special attention being paid to the processing of biological samples.

516-511B JOINT VENTURING WITH INDUSTRY. (3) (Offered in conjunction with the Centre for Continuing Education.) Using problem-based learning, the course examines the various business interactions between researchers and their business partners in support and development of research into commercial endeavours using models such as venture capital, business partnerships, or grants-in-aid.

● **516-512D RECENT PROGRESS IN AIDS RESEARCH.** (6)

The Faculty of Science section is divided into two parts, for access to the second part click on the link below to return to the Front Page of the Calendar.