7 Art History

Department of Art History
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Chair — Christine Ross *(on leave winter 2000)*

Director of Graduate Studies — H. J. Böker *(on leave fall 1999)*

7.1 Staff

Emeritus Professor
G. Galavaris; M.A.(Athens), M.F.A., Ph.D.(Prin.), F.R.S.C.

Professors
H.J. Böker; Ph.D.(Saarbrücken), Dr. Ing.-habil (Hannover) *(on leave fall 1999)*
J.M. Fossey; B.A.(Birm.), D.U.(Lyon II)

Associate Professors
T.L. Glen; B.A.(McG.) M.F.A., Ph.D.(Prin.)
C. Ross; M.A.(C'dia.), Ph.D.(Paris I) *(on leave winter 2000)*

Assistant Professor
T. Chang; B.A.(McG.), M.A.(Tor.), Ph.D.(Sussex)

Adjunct Professors
D. W. Booth; B.A., M.A., M.Phil., Ph.D.(Toronto)
J. Lamoureux; B.A., M.A.(UdM), Ph.D.(E.H.E.S.S. Paris)
L. De Moura Sobral; M.A., Ph.D.(Louvain)
C. Naubert-Riser; B.A., M.A.(Ottawa), Ph.D.(Lyon III)

7.2 Programs Offered

M.A. and Ph.D.

Areas of Specialization:
1. Classical and Aegean Archaeology
2. Greek Epigraphy
3. Archaeological Methods and Archaeometry
4. Western Medieval Art
5. Medieval Architecture
6. Post Medieval Architecture
7. Renaissance Art
8. Baroque Art
9. Late Eighteenth, Nineteenth and Early Twentieth-Century Art
10. The Art of W.W. I to the Present
11. Canadian Art
12. Methodology
13. Feminist Art History

7.3 Admission Requirements

Entrance into either the M.A. or Ph.D. programs is limited to the best qualified applicants. A minimum CGPA of 3.3 or the equivalent, i.e. 75%, is required.

To apply to the M.A. program, candidates are normally expected to have a B.A. Honours degree either in Art History alone or in Art History and one other closely related field. But regardless of the program, the Department normally requires a minimum of 39 credits (at least 13 courses) in Art History with emphasis on European art and architecture. For candidates from institutions not offering the above number of credits in Art History, provision is made, upon consultation with the Director of Graduate Studies, for a program of study which would then qualify the candidate to apply for M.A. work.

In order to apply to the Ph.D. program, candidates must normally hold an M.A. degree preferably in Art History or an M.A. degree in a closely related field together with an appropriate number of Art History credits such as are described for entrance into the M.A. program. Applicants are strongly encouraged to consult with the Director of Graduate Studies. The number of entrants to the doctoral program is necessarily limited to the most highly qualified applicants.

It should be noted that courses in studio practice, although useful, cannot be counted among the 39 Art History credits for either the M.A. or Ph.D programs. Also please see as well the language requirements given under the degree programs below.

The Department also requires a 200-250 word statement outlining the candidate's major interest in Art History as well as an example of his/her written work. Applicants should send complete dossiers by December 15.

7.4 Application Procedures

Applications will be considered upon receipt of:
1. application form;
2. transcripts;
3. two letters of reference;
4. $60 application fee;
5. a statement (200-50 words) outlining the candidate's major interest in Art History;
6. an example of written work;
7. Test result (TOEFL)

All information is to be submitted directly to the Graduate Coordinator.

Deadline: December 15.

7.5 Program Requirements

M.A. Degree (48 credits)
1) Five 3-credit courses approved by the Department. (15 credits)
2) The M.A. written examinations. (123-601, 123-602) (9 credits)
3) Thesis (123-699) on a topic approved by the Department in one of the following areas:
Classical and Aegean Archaeology, Greek Epigraphy, Archaeological Method and Archaeometry, Western Medieval Art, Medieval Architecture, Post Medieval Architecture, Renaissance Art, Baroque Art, Late Eighteenth, Nineteenth and Early Twentieth-Century Art, The Art of W.W.I to the Present, Canadian Art, Methodology, Feminist Art History (24 credits)

Language requirements for the M.A. degree: reading knowledge of English and French and a minimum of one additional approved classical or modern language, before admission to the second year of the M.A. program.

Ph.D. Degree

The Ph.D. requirements are fulfilled progressively with five 3-credit courses, the Ph.D. examinations both written and oral, the Doctoral dissertation and its oral defence.

Language requirements for the Ph.D. degree: reading knowledge of three modern languages and, depending on the field, at least one classical language, approved by the Department.

The Department is prepared to direct dissertations in fields wherein adequate supervision and resources can be provided. See section 7.2. Candidates are also advised to consult the General Information and Regulations section of the Faculty of Graduate Studies and Research Calendar.

7.6 Courses for Higher Degrees

Each year, courses, given in the form of seminars or tutorials (the material varies yearly), are offered in some of the areas listed below. For a precise list of topics for the forthcoming session, students should contact the Graduate Coordinator.

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

▭ Denotes limited enrolment.

123-601A,B MASTERS COMPREHENSIVE PREPARATION. (3)

123-602A,B MASTERS COMPREHENSIVE EXAM. (6)

The general examination for the M.A. degree (123-602, 6 credits; including preparation for it, 123-601, 3 credits) carries a total of nine (9) credits.

123-617A,B MODERN ART. (3)
123-618A,B STUDIES IN ART HISTORY FROM 1400-1900 I. (3)
123-619A,B STUDIES IN ART HISTORY FROM 1400-1900 II. (3)
123-641A,B GREEK ART AND ARCHAEOLOGY I. (3)
123-642A,B GREEK ART AND ARCHAEOLOGY II. (3)
123-643A,B GREEK ART AND ARCHAEOLOGY III. (3)
123-645A,B MEDIEVAL ART AND ARCHAEOLOGY I. (3)
123-646A,B MEDIEVAL ART AND ARCHAEOLOGY II. (3)
123-648A,B ART OF THE ITALIAN RENAISSANCE I. (3)
123-649A,B ART OF THE ITALIAN RENAISSANCE II. (3)
123-650A,B NORTHERN RENAISSANCE ART I. (3)
123-651A,B NORTHERN RENAISSANCE ART II. (3)
123-654A,B BAROQUE ART AND ARCHITECTURE I. (3)
123-655A,B BAROQUE ART AND ARCHITECTURE II. (3)
123-657A,B 19TH CENTURY PAINTING AND SCULPTURE I. (3)
123-658A,B 19TH CENTURY PAINTING AND SCULPTURE II. (3)
▭ **123-660A,B CONTEMPORARY ART AND CRITICISM I.** (3)
▭ **123-661A,B CONTEMPORARY ART AND CRITICISM II.** (3)
123-675A,B RENAISSANCE AND POST-RENAISSANCE STUDIES I. (3)
123-678A,B RENAISSANCE AND POST-RENAISSANCE STUDIES II. (3)
123-679A,B ROMAN ART AND ARCHAEOLOGY I. (3)
123-680A,B ROMAN ART AND ARCHAEOLOGY II. (3)
123-681A,B ROMAN ART AND ARCHAEOLOGY III. (3)
123-684A,B SEMINAR IN THE ART OF BYZANTIUM. (3)
123-687A,B PROBLEMS IN WESTERN MEDIEVAL ARCHITECTURE AND SCULPTURE. (3)
123-689A,B STUDIES IN MANUSCRIPT ILLUMINATION I. (3)
123-690A,B STUDIES IN MANUSCRIPT ILLUMINATION II. (3)
123-693A,B ARTISTIC THEORY IN THE RENAISSANCE. (3)
123-699D THESIS RESEARCH. (24)
123-701D PH.D. COMPREHENSIVE EXAMINATION. (6)
123-713A,B STUDIES IN THE GRAPHIC ARTS. (3)
123-714A,B RESEARCH IN MODERN ART AND ARCHITECTURE – 1750 TO THE PRESENT I. (3)
123-715A,B RESEARCH IN MODERN ART AND ARCHITECTURE – 1750 TO THE PRESENT II. (3)
123-719A,B SEMINAR IN URBAN PLANNING AND TOPOGRAPHY. (3)
123-722A,B STUDIES OF DRAWINGS. (3)
123-723A,B ART CRITICISM I. (3)
123-724A,B ART CRITICISM II. (3)
123-725A,B METHODS IN ART HISTORY. (3)
123-730A,B CURRENT PROBLEMS IN ARCHITECTURAL HISTORY I. (3)
123-731A,B CURRENT PROBLEMS IN ARCHITECTURAL HISTORY II. (3)

8 Atmospheric and Oceanic Sciences

Department of Atmospheric and Oceanic Sciences
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Chair — C.A.Lin

8.1 Staff

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

Professors
J.F. Derome; M.Sc.(McG.), Ph.D.(Mich.)
R.G. Ingram; B.Sc., M.Sc.(McG.), Ph.D.(M.I.T.) *(on leave)*
L.A. Mysak; B.Sc.(Alta.), M.Sc.(Adel.), A.M. Ph.D.(Harv.), F.R.S.C.
I.I. Zawadzki; B.Sc.(Buenos Aires), M.Sc., Ph.D.(McG.)

Associate Professors
J.R. Gyakum; B.Sc.(Penn.St.), M.Sc., Ph.D.(M.I.T.)
H.G. Leighton; M.Sc.(McG.), Ph.D.(Alta.)
C.A. Lin; B.Sc.(Br.Col.), Ph.D.(M.I.T.)
T. Warn; B.Sc.(Br.Col.), M.Sc., Ph.D.(McG.)
M.K. Yau; S.B., S.M., Sc.D.(M.I.T.)

Assistant Professors
P. Ariya; B.Sc., Ph.D.(York) *(joint appt. with Chemistry)*
D. Straub; B.S., M.S.(SW Louisiana), Ph.D.(Wash.)

Assistant Professors (Special Category)
P. Bartello; B.Sc., M.Sc., Ph.D.(McG.)
F. Fabry; B.Sc., M.Sc., Ph.D.(McG.)

Lecturer
A.P. Schwartz

Adjunct Professors
J.-P. Blanchet, G. Brunet, E. Carmack, R. Laprise, S. Laroche

8.2 Programs Offered

The Department of Atmospheric and Oceanic Sciences offers courses and research opportunities in atmospheric, physical oceanographic, and climate fields leading to the M.Sc. and Ph.D. degrees. Research programs include the main areas of atmospheric science, such as cloud and precipitation physics, dynamic meteorology, numerical weather prediction, atmospheric chemistry, radar and satellite meteorology, and mesoscale meteorology. Research projects in physical oceanography include the modelling of ocean circulations as well as studies of sea ice and paleoclimates. Some faculty members are associated with the Centre for Climate and Global Change Research, which brings together researchers from several departments to work on problems affecting the evolution of our planet, with emphasis on climate-related questions. Topics of research of this nature in the Department include large scale air-sea interaction, air-sea-ice interaction, interannual and longer term variability of the atmosphere and oceans, and cloud-radiation climate interaction.

Other faculty members are associated with the Cooperative Centre for Research in Mesometeorology which also includes researchers in several other departments at McGill, in the Département de Physique at the Université du Québec à Montréal, and in Montreal offices of the Atmospheric Environment Service of Canada. The objective of the Centre is to study the evolution, maintenance and decay of mesoscale precipitation systems. Such systems, whose sizes range from 10 to 300 km, are important for the precipitation climatology of southern Quebec.

Facilities include the J. Stewart Marshall Radar Observatory, a radar wind profiler and a laser ceilometer and several years of global atmospheric data. Graduate students have access to large and small computers, including the NEC supercomputer of the Atmospheric Environment Service. Financial assistance in the form of research or teaching assistantships is available for all qualified graduate students.

8.3 Admission Requirements

Applicants for the M.Sc. program must meet the general requirements of the Faculty of Graduate Studies and Research and hold a bachelor's degree with high standing in atmospheric science, physics, mathematics, engineering, or equivalent.

The normal requirement for admission to the Ph.D. program is an M.Sc. degree in atmospheric science, physical oceanography, or related discipline with acceptably high standing. Students without a Master's degree in Atmospheric Science (Meteorology) or Physical Oceanography but with a strong background in related disciplines (physics, mathematics, engineering) may be admitted to the Ph.D. program. They enter at the Ph.D. I rather than the Ph.D. II level, and devote the first year of the program mainly to course work.

Inquiries should be addressed directly to the Chair of Admissions, Department of Atmospheric and Oceanic Sciences.

8.4 Program Requirements

M.Sc. Degree

Depending on their background, students must take from 9 to 27 credits of courses chosen from any course offered by the Department at the 500 and 600 levels, up to but not including 195-691. Normally, students select either an atmospheric or joint atmosphere-ocean stream of courses during the first year of the program. In some instances, courses in this Department may be replaced by courses given by other departments at the 500 level or higher with the approval of the Department. Usually, students with no previous background in atmospheric science (or physical oceanography) are requested to take 27 credits of courses, while students with a strong B.Sc. or Diploma in meteorology or a related field may take as few as 9 credits of courses.

Students must also complete a minimum of 24 thesis-research credits from 195-691, -692, -693, -694, -695, -696 and 195-699. All students must take seminar course 195-694 and complete 195-699. The M.Sc. degree requires a minimum of 45 credits in total. This includes course credits, a minimum of 12 thesis credits and the completion of a thesis satisfying all the requirements of the Faculty of Graduate Studies and Research. Normally the equivalent of 12 months of full-time work is required to obtain these thesis-research credits, in addition to the time needed for the courses mentioned in the preceding paragraph. It is possible for students to write a thesis based on research in atmospheric, oceanic, or climate topics.

Ph.D. Degree

The Ph.D. program consists of supervised research and normally a minimum of two approved courses. Candidates are required to submit a written thesis proposal and to take the Ph.D. oral comprehensive examinations. The ordinary Faculty requirements concerning a thesis must be satisfied.

Ph.D. students may also register in the Collaborative McGill-UQAM Ph.D. program. These students register at McGill University but are supervised by a faculty member at l'Université du Québec à Montréal. Further details are available from the Department's Graduate Coordinator and from the Chair.

8.5 Courses for Higher Degrees

● Denotes not offered 1999-2000.

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

195-512A ATMOSPHERIC AND OCEANIC DYNAMICS. (3) (3 hours) 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) 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)

195-530A CLIMATE DYNAMICS I. (3) (3 hours) 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) (3 hours) 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-hour lecture, 2-hour lab) 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-hour lecture, 2-hour lab) Analysis of current meteorological data. Quasi-geostrophic theory, including the omega equation, as it relates to extratropical cyclone and anticyclone development. Frontogenesis and frontal circulations in the lower and upper troposphere. Cumulus convection and its relationship to tropical and extratropical circulations. Diagnostic case study work.

195-546B CURRENT WEATHER DISCUSSION. (1) (1.5 hours) Thrice-weekly briefings 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.

195-550A SPECIAL TOPICS IN METEOROLOGY AND OCEANOGRAPHY I. (1) (1 hour) 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) (1 hour)

195-558B NUMERICAL METHODS AND LABORATORY. (3) (1 hour lecture; 4 hours lab) Numerical simulation of atmospheric and oceanic processes. Finite difference, finite element, and spectral modelling techniques. Term project including computer modelling of convection or large-scale flows in the atmosphere or ocean.

195-568B OCEAN PHYSICS. (3) (3 hours) (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.

● **195-616A OR B TOPICS IN GEOPHYSICAL FLUID DYNAMICS.** (3) (3 hours)

195-620A PHYSICAL METEOROLOGY I. (3) (2 hours) Thermodynamics of the atmosphere. Instability and convection. Solar and terrestrial radiation. Radiative transfer. Radiation budgets.

195-621B PHYSICAL METEOROLOGY II. (3) (2 hours) Atmospheric aerosols, nucleation of water and ice. Formation and growth of cloud droplets and ice crystals. Initiation of precipitation. Severe storms and hail. Weather modification. Numerical cloud models.

● **195-626A OR B ATMOSPHERIC AND OCEANIC REMOTE SENSING.** (3) (3 hours)

195-646A OR B MESOSCALE METEOROLOGY. (3) (3 hours) Examination of the theory of important mesoscale phenomena, including fronts, cumulus convection and its organization, and tropical and extratropical cyclones. Application of the theory with detailed case studies of these phenomena. Mesoscale processes in numerical simulations.

● **195-666B TOPICS IN OCEAN CIRCULATION.** (3) (3 hours)

195-670A,B,C READING COURSE IN METEOROLOGY I. (3) Assigned reading of a specialized topic in meteorology with formal evaluation.

195-671A,B,C READING COURSE IN METEOROLOGY II. (3) Assigned reading of a specialized topic in meteorology with formal evaluation.

195-672A,B,C READING COURSE IN OCEANOGRAPHY I. (3) Assigned reading of a specialized topic in oceanography with formal evaluation.

195-673A,B,C READING COURSE IN OCEANOGRAPHY II. (3) Assigned reading of a specialized topic in oceanography with formal evaluation.

195-691A,B,C MASTER'S THESIS LITERATURE REVIEW. (3) Review of relevant literature in preparation for the M.Sc. research.

195-692A,B,C MASTER'S THESIS RESEARCH I. (6) Independent research under the supervision of the student's M.Sc. supervisor.

195-693A,B,C MASTER'S THESIS RESEARCH II. (6) Independent research under the supervision of the student's M.Sc. supervisor.

195-694A,B,C MASTER'S THESIS REPORT AND SEMINAR. (3) Written report on the M.Sc. research progress and oral presentation of the report in seminar form to staff and students.

195-695A,B,C MASTER'S THESIS RESEARCH III. (6) Independent research under the supervision of the student's M.Sc. supervisor.

195-696A,B,C MASTER'S THESIS RESEARCH IV. (6) Independent research under the supervision of the student's M.Sc. supervisor.

195-699A,B,C MASTER'S THESIS. (12) Independent research under the supervision of the student's M.Sc. supervisor leading to the M.Sc. thesis.

195-700D PH.D. COMPREHENSIVE. (COGNATE SUBJECTS)

195-701D PH.D. COMPREHENSIVE. (GENERAL)

195-751D SEMINAR IN PHYSICAL METEOROLOGY. (1) Seminars on topics in physical meteorology. Students are required to present one or more seminars during the year on their thesis research and to participate actively in the seminars given by others.

195-752D ATMOSPHERIC, OCEANIC & CLIMATE DYNAMICS SEMINAR. (1) Seminars on topics in atmospheric, oceanic and climate dynamics. Students are required to present one or more seminars during the year on their thesis research and to participate actively in the seminars given by others.

9 Biochemistry

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Chair — P.E. Branton

9.1 Staff

Emeritus Professors
A.F. Graham; M.Sc., Ph.D., D.Sc.(Edin.)
R.M. Johnstone; B.Sc., Ph.D.(McG.)
N. Solomon; M.Sc., Ph.D.(McG.)
T.L. Sourkes; M.Sc.(McG.), Ph.D.(C'nell)
L.S. Wolfe; M.Sc.(N.Z.), Ph.D.(Cantab.)

Professors
R. Blostein; B.Sc., M.Sc., Ph.D.(McG.)
P.E. Branton; Gilman Cheney Professor, B.Sc., M.Sc., Ph.D.(Tor.)
P.E. Braun; M.Sc.(Br.Col.), Ph.D.(Berk.Calif.)
P. Gros; B.Sc., M.Sc.(Montr.), Ph.D.(McG.)
A.A. Herscovics; B.Sc. M.Sc. Ph.D(McG.) *(joint appt. with Oncology)*
R.E. MacKenzie; B.Sc.(Agr.)(McG.), M.N.S., Ph.D.(C'nell.)
E.A. Meighen; B.Sc.(Alta.), Ph.D.(Berk.)
W.E. Mushynski; B.Sc., Ph.D.(McG.)
G.C. Shore; B.Sc.(Guelph), Ph.D.(McG.)
J. Shuster; B.Sc.(McG.), Ph.D.(Calif.), M.D.(Alta.)
J.R. Silvius; B.Sc., Ph.D.(Alta.)
N. Sonenberg; M.Sc., Ph.D.(Weizmann Inst.)
C.P. Stanners; B.Sc.(McM.), M.A., Ph.D.(Tor.) *(joint appt. with Oncology)*
M. Zannis-Hadjopoulos; B.Sc., M.Sc., Ph.D.(McG.) *(joint appt. with Oncology)*

Associate Professors
N. Beauchemin; B.Sc., M.Sc., Ph.D.(Montr.) *(joint appt. with Oncology)*
V. Giguère; B.Sc., Ph.D.(Laval) *(joint appt. with Oncology)*
A. Nepveu; B.Sc., M.Sc.(Montr.), Ph.D.(Sher.) *(joint appt. with Oncology)*
M. Park; B.Sc., Ph.D.(Glas.) *(joint appt. with Oncology)*
J. Pelletier; B.Sc., Ph.D.(McG.)
M.L. Tremblay; B.Sc., M.Sc.(Sher.), Ph.D.(McM.)
A. Veillette; M.D.(Laval) *(joint appt. with Oncology)*

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

Associate Members
J.J. Bergeron *(Anatomy & Cell Biology)*; K. Cianflone *(Exp. Medicine, RVH)*; L.F. Congote *(Exp. Medicine, RVH)*; R. Dunn *(Exp. Medicine, MGH)*; M. Featherstone *(Dept. of Oncology)*; W.C. Galley *(Chemistry)*; P. Roughley *(Shriners' Hosp.)*; E. Schurr *(Exp. Medicine, RVH)*; C. Scriver *(Pediatrics, MCH)*; B. Turcotte *(Exp. Medicine, RVH);* S.S. Wing *(Dept. of Medicine);* Z.-J. Yang *(Mol. Oncol., RVH)*

Adjunct Professors
M. Cordingley (Biomega); M. Cygler (B.R.I.); J. Drouin (Clin.Res.Inst.); M. Gresser (Merck Frosst); F. Ni (B.R.I.); D. Nicholson (Merck Frosst); M. O'Connor-McCourt (B.R.I.); A. Storer (B.R.I.)

9.2 Programs Offered

The Department of Biochemistry offers training at both the M.Sc. and Ph.D. levels There are a wide variety of areas in which specialized training for the Ph.D. can be obtained.

The Department concentrates on the following key areas of research: signal transduction; molecular genetics; gene regulation; oncogenes; structure, function & regulation of proteins; membrane structure, function and assembly; intracellular protein targeting; embryonic development and cellular neurobiology. A summary of the research interest of faculty members is available on the Department homepage at http://www.biochem.mcgill.ca.

Funding

All graduate students in Biochemistry receive financial support. Any faculty member who agrees to supervise a graduate student who does not have their own funding (i.e. a fellowship), is financially responsible for that student. All students can expect a minimum of $14,765 per annum.

Prospective students are urged to make every effort to secure their own funding. Applications may be made for a variety of fellowships administered by the University or by various private, provincial or federal agencies. Deadlines for completion of most fellowship applications vary from October to February for studies beginning the following September. For more information on fellowships and awards, see the Faculty of Graduate Studies and Research website http://www.mcgill.ca/fgsr/).

9.3 Admission Requirements

Candidates holding a B.Sc. in biochemistry or in related disciplines (e.g. biology, chemistry, physics, physiology and microbiology) are

eligible to apply to a graduate program in Biochemistry. The minimum cumulative GPA for admission is 3.3 (75%).

All successful applicants to the graduate program must be accepted by a research director in the department prior to registration.

Applicants who are considered inadequately prepared for research in Biochemistry, may, upon recommendation by the Graduate Admissions Committee (GAC), be admitted to a Qualifying Year (QY). The courses to be taken in the QY are determined by the GAC. A QY does not automatically guarantee admission to the graduate program.

International Applicants

International students whose undergraduate degree was received outside of North America and whose mother tongue is not English, are required to submit the following documents in order to be considered for admission to the graduate program:

TOEFL: **Minimum score of 600**.

GRE: Subject Test in **Biochemistry, Cell and Molecular Biology** with a **minimum score of 550.**

9.4 Application Procedures

Applications will be considered upon receipt of:

1. completed application form including C.V.;
2. application fee ($60);
3. two (2) letters of recommendation from professors;
4. two (2) official transcripts;
5. test results (GRE,TOEFL).

All information is to be submitted to the Student Affairs Officer. Interested candidates should contact the Department for an application package. Email requests should be addressed to: admbioch@ med.mcgill.ca

Deadlines

Applications should be submitted as early as possible in order to meet the following deadlines:

January 1st for September term and May 1st for January term for visa students;
May 1st for September admission;
October 1st for January admission.

9.5 Program Requirements

All students are required to complete two 3-credit courses at the 400-600 course level as part of their M.Sc. or Ph.D. program. The Graduate Admissions Committee may stipulate additional course work depending on the background of the student.

Departmental Seminars: Members of the staff and visiting scientists present their work to the Department at weekly and bi-weekly intervals respectively throughout the academic year. Graduate students are required to attend all the above seminars and other informal seminars, and are encouraged to attend meetings of scientific communities.

Master's

The requirements for the M.Sc. comprises a minimum of 45 credits: Research Seminar 507-696A,B,C – 3 credits; Thesis I 507-697A,B,C – 9 credits; Thesis II 507-698A,B,C – 12 credits; Thesis III 507-699A,B,C – 15 credits and a minimum 6 credits of course credits. Additional courses may be required, depending on the student's background.

The M.Sc. program usually requires a minimum of two years of study. Students in the M.Sc. program are required to complete all course requirements and submit a thesis.

Transfer to the Ph.D.

After 18 months students may transfer to the Ph.D. program if all transfer requirements have been fulfilled. This includes completion of a preliminary seminar (Research Seminar) and the successful completion of a transfer seminar (Ph.D. Thesis Proposal). The M.Sc. thesis requirement is then waived.

Student Comprehensive Seminars

M.Sc. students in the Department who plan to proceed to the Ph.D. degree as well as students entering at the Ph.D. level must present and pass the following seminars: Research Seminar I (507-701); the Ph.D. Thesis Proposal (507-702) and, lastly, Research Seminar II (507-703).

Ph.D.

Candidates who have fulfilled the M.Sc. degree requirements, as described above, with satisfactory standing from this Department or candidates who have completed an acceptable M.Sc. degree from another university enter the graduate program at the Ph.D. level. Students in the Ph.D. program are required to complete all course requirements as well as the Student Comprehensive seminars, submit a thesis and defend it orally.

9.6 Graduate Courses

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

507-503B IMMUNOCHEMISTRY. (3) (Prerequisites: 507-311A, 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. **Professor Shuster**

507-603B RECENT ADVANCES IN MOLECULAR GENETICS. (3) (Prerequisites: 507-454A and permission of instructor.) Recent advances in our understanding of gene function and its control in normal and diseased cellular systems will be discussed in depth. Course given based on minimum registration of 10 students. Contact Student Affairs Officer for information. **Professors Stanners, Gros and Veillette**

507-604A MACROMOLECULAR STRUCTURE. (3) (Prerequisite: 507-450A or equivalent) (Lectures in French and English) X-Ray crystallography, NMR spectroscopy, computational methods and theoretical approaches to the determination and analysis of macromolecular structures. Theory and practical applications will be covered. Examples will include interpretation of structure as it applies to biological functions. In conjunction with the Université de Montréal. Offered in alternate years (offered in 1999-2000). **Professors Vrielink (Coodinator) and Gehring**

507-623B IMMUNOCHEMISTRY. (3) (Prerequisite: permission of instructor.) **Professor Shuster**

507-696A,B,C RESEARCH SEMINAR. (3) (Open to M.Sc. Biochemistry students only.) Compulsory participation in the departmental seminar series. Graded pass/fail, based on participation.

507-697A,B,C THESIS RESEARCH I. (9)

507-698A,B,C THESIS RESEARCH II. (12)

507-699A,B,C THESIS RESEARCH III. (15)

507-701A,B RESEARCH SEMINAR I. (Biochemistry graduate students.) Presentation on original current laboratory research carried out by student.

507-702A,B PH.D. THESIS PROPOSAL. (Biochemistry graduate students.) Disseration presented to Committee.

507-703A,B RESEARCH SEMINAR II. (Ph.D. students in Biochemistry.) Presentation of the planned thesis including central findings and original contribution to knowledge in the field of research.

ADVANCED UNDERGRADUATE COURSES

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. **Professor Mushynski**

507-312B BIOCHEMISTRY OF MACROMOLECULES. (3) (Prerequisites: 507-311A, 177-200A, 507-212B or 177-201B) 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; targeting of proteins to specific cellular sites; protein glycosylation; protein phosphorylation; protein turn-over; programmed cell death (apoptosis). **Professor Nepveu**

507-404B BIOPHYSICAL CHEMISTRY. (3) (Prerequisites: 180-204A,B, 180-214B or equivalent.) (This course is also listed as Chemistry 180-404B. Not open to students who have taken or are taking 180-404B) Hydrodynamic and electrophoretic methods for separation and characterization of macromolecules. Optical and magnetic resonance spectroscopy of biopolymers, and applications to biological systems. **Professors Silvius and Galley**

507-450A PROTEIN STRUCTURE AND FUNCTION. (3) (Prerequisites: 507-311A, 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.
Professors Meighen (Coordinator), Gehring and Vrielink

507-454A NUCLEIC ACIDS. (3) (Prerequisites: 507-311A, 312B or permission of the 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. **Professor Shore and Staff**

507-455B NEUROCHEMISTRY. (3) (Prerequisites: 507-311A, 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, endocrines effects on brain, brain energy metabolism and cerebral ischemia (stroke). With examples, where relevant, of biochemical processes disrupted in human CNS disease. **Professors Boksa, Srivastava (Coordinators), Walker & Young (Psychiatry Dept.)**

507-456B BIOCHEMISTRY OF MEMBRANES. (3) (Prerequisites: 507-311A, 312B; 180-214B or equivalent, or permission of instructors. Intended for U3 level students.) Composition, organization and dynamics of biological membranes. Molecular mechanisms of membrane receptor functions, membrane transport and energy transduction. Membrane biogenesis and membrane traffic in eukayotic cells. **Professors Silvius and Blostein**

10 Bioethics

For information, write to:
Chair, Master's Specialization in Bioethics
Biomedical Ethics Unit
3690 Peel Street
Montreal, QC, Canada H3A 1W9
Telephone: (514) 398-6980
Fax: (514) 398-8349
Email: Glass_K@falaw.lan.mcgill.ca

Chair — K. Glass

10.1 Staff

Professors
N. Gilmore, E. Keyserlingk, M.A. Somerville, K. Young

Assistant Professors
E. Bereza, K. Glass

10.2 Programs Offered

Master's Specialization in Bioethics

The Master's Specialization in Bioethics is sponsored by the:
Faculty of Medicine, Department of Experimental Medicine;
Faculty of Law, Institute of Comparative Law;
Faculty of Religious Studies; and
Faculty of Arts, Department of Philosophy.

Students receive an M.A., LL.M. or M.Sc. degree in the discipline chosen with a specialization in Bioethics.

10.3 Admission Requirements

M.D., bachelor's level professional training in a health science, or bachelor's degree in law, philosophy or religious studies. Other students may be considered on an individual basis.

Enrolment is limited to 12 students.

10.4 Application Procedures

Applications to the base faculty are made initially through the Biomedical Ethics Unit in the Faculty of Medicine, which administers the program and teaches the core courses.

Applicants must be accepted first by the appropriate Faculty and then by the Bioethics Graduate Studies Advisory Committee.

10.5 Program Requirements

The curriculum is composed of required courses (for 6 credits) offered in the Biomedical Ethics Unit, bioethics courses (3 credit minimum) offered by the base faculty or department and any graduate courses required or accepted by a base faculty for the granting of a Master's degree, for a total of 18 to 21 credits. A minimum of 45 credits is required including the thesis.

Registration Requirements: Depending upon the requirements of the base discipline, a minimum of three terms is required for completion of the program, including course work and thesis.

Thesis Supervision: Thesis supervision for students in the specialization is provided by a participating faculty member in the program. Those students whose supervisors are not appointed to a student's base discipline will have a co-supervisor appointed from the base discipline. Thesis examination will be conducted according to the base discipline norms.

Required Courses – Biomedical Ethics Unit (6 credits)
508-680A (3) Bioethics Theory
508-681B (3) Bioethics Practicum

Required Course – base faculty (3 credits)
one of the following:
508-682 (3) Seminar: Medical Basis of Bioethics
389-642 (3) Seminar: Law and Health Care
107-543 (3) Seminar: Medical Ethics
260-571 (3) Seminar: Bioethics and World Religions

Complementary Courses (12 credits)
the remaining credits are to be taken in any graduate courses required or accepted by the base faculty for the granting of a Master's degree

Thesis Component – Required (24 credits)
508-690 (3) Thesis Literature Survey
508-691 (3) Thesis Research Proposal
508-692 (6) Thesis Research Progress Report
508-693 (12) Thesis

10.6 Courses

Biomedical Ethics Unit Courses

508-680A BIOETHICS THEORY. (3) A survey of some of the main problem areas and common argument forms used in current bioethics. Problem areas include consent, decisions to withhold or withdraw treatment, allocation of scarce resources, research with human subjects and confidentiality. Argument forms include those

drawn from diverse ethical theories and traditions. Limited enrolment.

508-681B BIOETHICS PRACTICUM. (3) Four hours per week supervised placement within health care settings (e.g., intensive care, family practice, clinical ethics committees). In addition, students shall be assigned for the last month of the term to a single intensive placement. Participation in rounds, care discussions, and a weekly seminar. Limited enrolment.

508-690 THESIS LITERATURE SURVEY. (3)

508-691 THESIS RESEARCH PROPOSAL. (3)

508-692 THESIS RESEARCH PROGRESS REPORT. (6)

508-693 THESIS. (12)

Base Faculty Courses

508-682 SEMINAR: MEDICAL BASIS OF BIOETHICS. (3) The seminar examines the medical basis of timely ethical dilemmas in health care. Content includes: clinical concepts of pathogenesis, disease, screening, diagnosis, therapeutic interventions and prognosis; decision-making in clinical care and institutional policy development; organization of health care systems including socialized medicine, public health and institutions providing health care; medical research. Limited enrolment.

389-642 SEMINAR: LAW AND HEALTH CARE. (3) Topics in this seminar will include philosophical and ethical foundations of law as applied in medicine, legal structures and their impact on health care, law and ethics of the health care professions, administrative and legal control of health care systems and other selected issues. Limited enrolment.

107-543 SEMINAR: MEDICAL ETHICS. (3) An advanced seminar devoted to a particular philosophical problem as it arises in the context of medical practice or the application of medical technology. Limited enrolement.

260-571B BIOETHICS AND WORLD RELIGIONS. (3) Every world religion has its own way of understanding what we now call "bioethical" problems (surrogacy, abortion, euthanasia, circumcision, cloning). A selected problem will be studied in connection with the ethical system of religions such as Hinduism, Buddhism, Confucianism, Taoism, Judaism, Christianity and Islam.

11 Biology

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Website: http://www.mcgill.ca/Biology/biology1.htm

Chair — D.L. Kramer

Chair of Graduate Program — R. Levine

11.1 Staff

Emeritus Professors
F.C. Fraser; O.C.; B.Sc.(Acad.), M.Sc., Ph.D., M.D., C.M.(McG.), D.Sc.(Acad.), F.R.S.C., F.R.C.P.S.(C) (*Molson Emeritus Professor of Genetics)*
S.P. Gibbs; A.B., M.S.(C'nell), Ph.D.(Harv.)
J. Lewis; B.Sc., M.Sc., Ph.D.(McG.)
G.A. Maclachlan; B.Sc., M.A.(Sask.), Ph.D.(Man.), F.R.S.C.
J.R. Marsden; M.Sc.(McG.), Ph.D.(Calif.)
R.O. Sattler; B.Sc.(Tübingen), Ph.D.(Munich)

Professors
G.A.C. Bell; B.A., D.Phil.(Oxf.) (*Molson Professor of Genetics)*
G. Brown; B.Sc.(Notre Dame), Ph.D.(N.Y.)
A.H. Bussey; B.Sc., Ph.D.(Brist.)
R.L. Carroll; B.Sc.(Mich.), M.Sc., Ph.D.(Harv.) (*Strathcona Professor of Zoology*)
R. Chase; A.B.(Stan.), Ph.D.(M.I.T.)
R.S. Dhindsa; B.Sc., M.Sc.(Punj.), Ph.D.(Wash.)
J. Kalff; M.S.A.(Tor.), Ph.D.(Ind.)
D.L. Kramer; B.Sc.(Boston Coll.), Ph.D.(Br.Col.); Chair
M.J. Lechowicz, B.A.(Mich. St.), M.S., Ph.D.(Wis.)
R.E. Lemon, M.Sc., Ph.D.(W. Ont.)
B.B. Mukherjee, B.Sc.(Calc.), M.S.(Brigham Young), Ph.D.(Utah)
R.J. Poole, B.Sc., Ph.D.(Birm.)
D.A. Roff; B.Sc.(Syd.), Ph.D.(Br.Col.)
D.J. Schoen; B.Sc., M.Sc.(Mich.), Ph.D.(Calif.) (*Macdonald Professor of Botany)*

Associate Professors
P. Hechtman; M.Sc.(Minn.), B.Sc., Ph.D.(McG.)
S. Hekimi; M.Sc., Ph.D.(Geneva)
P.F. Lasko; A.B.(Harv.), Ph.D.(M.I.T.)
L. Lefebvre; B.Sc., M.A., Ph.D.(Montr.)
R.L. Levine; B.Sc.(Brooklyn), M.Sc., Ph.D.(Yale)
Y. Nishioka; B.A., M.A.(Tokyo), Ph.D.(Col.)
V.M. Pasztor; B.Sc.(Birm.), Ph.D.(McM.)
G.S. Pollack; M.A., Ph.D.(Prin.)
C. Potvin; B.Sc., M.Sc.(Montr.), Ph.D.(Duke)
N.M. Price; B.Sc.(U.N.B.), Ph.D.(Br.Col.)
J. Rasmussen; B.Sc., M.Sc.(Alta.), Ph.D.(Cal.)
R. Rozen; B.Sc., Ph.D.(McG.)
B. Suter; Ph.D.(Zur) *(on leave)*

Assistant Professors
T.E. Bureau; B.Sc.(Calif), Ph.D.(Texas)
J. Dent; B.Sc.(Mich), Ph.D.(Colorado)
R. Roy; B.Sc.(Bishop's), Ph.D.(Laval)
L. Sieburth; B.Sc.(Humboldt), Ph.D.(Georgia)
A.E. Vincent; B.Sc.(W. Ont.), Ph.D.(Camb.)
C. Waddell; B.A.(Va.), Ph.D.(U.C.S.F.)

Associate Members
S. Carbonetto (Mtl. General Hospital); H. Clarke; (Royal Victoria Hospital); P. Drapeau (Mtl. General Hospital); R. Dunn (Mtl. General Hospital); W.F. Grant (Plant Science, Macdonald College); R. Gravel (Mtl. Children's Hospital Research Inst.); D. Green (Redpath Museum); K. Hastings (Mtl. Neurological Inst.); P. Holland (Mtl. Neurological Inst.); W. Hunte (Bellairs Inst.); R. Palmour (Allan Memorial Institute); L. Pinsky (Lady Davis Institute); H. Reiswig (Redpath Museum); D. Rosenblatt (Royal Victoria Hospital); G. Rouleau (Mtl. General Hospital); C.R. Scriver (Mtl. Children's Hospital Research Inst.); T. Taketo (Royal Victoria Hospital); H.S. Tenenhouse (Mtl. Children's Hospital Research Inst.)

Adjunct Professors
W.Y. Cheung (DNA Landmarks); B. Landry (DNA Landmarks); W.C. Leggett (Queen's University); D.Y. Thomas (Bio Tech Inst.); M.S. Whiteway (Bio Tech Inst.)

11.2 Programs Offered

The Department offers graduate training in many areas of biology with particular strengths in Molecular Genetics and Development, Evolutionary and Behavioural Ecology, Human Genetics, Limnology, Marine Biology, Neurobiology, and Experimental Plant Biology.

Graduate programs leading to the M.Sc. and Ph.D. degrees are offered. The emphasis in both programs is on development of the intellectual and technical skills necessary for independent research. The main component of both degrees is a thesis embodying the results of original research. Formal course requirements are few and are largely intended to fill gaps in the student's background.

The Stewart Biology Building is well equipped for graduate training and research in a wide variety of areas of biology. Its resources are greatly extended by affiliation with other organizations such as the Redpath Museum; the Groupe Interuniversitaire

de Recherches Océanographiques du Québec (GIROQ); the Biotechnology Research Institute of the National Research Council of Canada; Macdonald Campus; the Montreal Neurological Institute; the Jewish General Hospital; the Montreal General, Montreal Children's and Royal Victoria Hospitals. Field research facilities include the Mont St. Hilaire Field Station (Québec); the Huntsman Marine Science Centre (New Brunswick); the Subarctic Research Laboratory (Québec); the Bellairs Research Institute (Barbados); and the Memphremagog Field Station (Québec).

The Department specifies a minimum level of support for all graduate students. This amount is $12,500 per annum plus tuition fees. The required minimum duration of support is 2 years for the M.Sc. program, 5 years for a Ph.D. student entering as Ph.D.1 (from a Bachelor's) and 4 years for a Ph.D. student entering as Ph.D.2.

11.3 Admission Requirements

Applicants must have a B.Sc. in a discipline relevant to the proposed field of study with an overall Cumulative Grade Point Average (CGPA) of 3.0/4.0 or a CGPA of 3.2/4 for the last 2 full-time academic years. Graduate Record Examination (GRE) scores are not required, but may be submitted. The Test of English as a Foreign Language (TOEFL) is required of students who have graduated from a non-English language university outside of Canada. A score of 550 on the TOEFL or 6.5 on IELTS, is the minimum standard for admission.

Admission is based on an evaluation by the Graduate Training Committee and on acceptance by a research director who can provide adequate funding for personal and research expenses. Prospective graduate students are encouraged to contact staff members with whom they wish to study before applying for admission.

11.4 Application Procedures

Application packages must be obtained directly from the Department. The application package contains specific information on the application process, program information, a summary of the research areas of the staff and contact information.

Deadlines for applications and all supporting documents are March 1 for September admission and October 15 for January admission. If application materials are received after these dates, it may be necessary to delay review of the applicant's file until the following admittance period. All inquiries pertaining to admission procedures should be directed to the Graduate Admissions Secretary.

11.5 Program Requirements

The graduate program of each student is established and regularly evaluated by a three-member supervisory committee appointed by the Graduate Training Committee and chaired by the student's thesis supervisor.

All graduate students are required to participate regularly in the various seminar series and journal clubs offered by the Department.

M.Sc. Requirements

Length of Program – Three full-time terms of resident study at McGill University is the minimum time requirement to complete the Master's degree. The normal and expected duration is 2 years.

Course Requirements – Forty-five credits are required for the M.Sc. degree. Students must complete the courses 177-697, -698 and -699 (Master's Thesis Research I, II, III). The research courses each carry a credit weight of 13 credits. In addition, six course credits are required and may be taken in Biology or in other departments and must be numbered -300 or higher. Additional course work may be required if the student's background is insufficient. A graduate pass (65% or better) is mandatory for all courses required for the M.Sc. degree.

Thesis – In Biology, the M.Sc. degree is considered to be a research degree and the candidate must present a thesis which should contain original contributions to knowledge.

Transfer from M.Sc to Ph.D. Program – The student's Supervisory Committee may recommend to the Graduate Training Committee that the student be permitted to transfer to the Ph.D. program. This is normally done at the end of the first year of the Master's program. Students who transfer into the Ph.D. program are required to take their Ph.D. Qualifying Examination within eight months of the transfer.

Ph.D. Requirements

Length of Program – Candidates entering Ph.D.1 must complete at least three years of full-time resident study (6 terms). The normal and expected duration of the Ph.D. program is 4-5 years. A student who has obtained a Master's degree at McGill, or at an approved institution elsewhere, and is proceeding in the same subject towards a Ph.D. degree may, upon the recommendation of the Graduate Training Committee, enter at the Ph.D.2 level.

Course Requirements – Students are required to take 12 course credits. These courses may be taken in Biology or in other departments and must be numbered -300 or higher. Additional courses may be required if the student's background is insufficent. A graduate pass (65% or better) is mandatory for all courses required for the Ph.D. degree.

Ph.D. Qualifying Examination – The Qualifying exam is a formal evaluation of the student's ability to proceed to the attainment of the Ph.D. Students must pass the Qualifying Examination (177-700D) no later than 15 months from the date of registration in the program. Students who transfer from the Master's program must take the exam within 8 months. Students who enter the Ph.D. program after completing an M.Sc. in Biology at McGill must take the exam within 12 months.

Ph.D. Seminar – All Ph.D. students must deliver a research seminar (177-702D) at some time during the academic session (September -April) towards the end of their studies and preferably at least 3 months prior to the thesis submission.

Thesis – The Ph.D. is a research degree. The candidate must present a thesis which represents high scholastic attainment in a specialized field, demonstrated by independent and original research. After the thesis has been submitted and approved, the candidate is required to orally defend their thesis in an open forum.

11.6 Courses

General Courses

- ● Denotes not offered in 1999-2000.
- ▭ Denotes limited enrolment.

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

177-650, 177-651, 177-652 (A, B OR C) RECENT ADVANCES IN BIOLOGY. (3 credits each) Directed reading, seminar and discussion courses in subjects of current interest in biological research. Intended for students working individually or in classes on selected areas under the supervision of one or more staff members. Content and form are flexible to allow the Department to meet specific student demands or needs. Such courses are arranged by consultation with individual staff.

177-655, 177-656 (A, B OR C) LABORATORY PROJECTS AND TECHNIQUES. (3 credits each) Directed training in selected methods used in areas of current interest in biological research. Intended for individuals or classes working in selected areas under the supervision of one or more staff members. Form and content are flexible to allow the Department to meet specific student demands and needs. Each course is arranged by consultation with individual staff.

177-697 (A, B OR C) MASTER'S THESIS RESEARCH I. (13) Independent research work under the direction of the Thesis Supervisor and the Supervisory Committee.

177-698 (A, B OR C) MASTER'S THESIS RESEARCH II. (13) Independent research work under the direction of the Thesis Supervisor and the Supervisory Committee.

177-699 (A, B OR C) MASTER'S THESIS RESEARCH III. (13) Independent research work under the direction of the Thesis Supervisor and the Supervisory Committee.

177-700D PH.D. QUALIFYING EXAMINATION. The oral Qualifying Examination is a formal evaluation of the candidate's ability to proceed to the attainment of the Ph.D. Candidates must submit a thesis proposal in advance of the exam.

177-702D PH.D. SEMINAR. Doctoral candidates are required to give a public oral presentation of their major results before submitting a thesis.

SPECIFIC COURSES

177-518B MOLECULAR GENETICS OF EUKARYOTIC CELL GENETICS. (3) (2 hour seminar) (Prerequisites: 177-300A or permission.) 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.

Professors Mukherjee (Coordinator) and Nishioka

177-522B EXPERIMENTAL PLANT BIOLOGY. (3) (2 hour seminar; 1 hour tutorial) (Prerequisites: 177-300A or permission.) Student seminars on recent literature focussing on the use of genetic and molecular biology techniques to address fundamental problems in plant development, e.g. flower development, stomatal spacing. Each student must write an NSERC-styled grant proposal and give an oral defense of the proposal.

Professors Sieburth (Coordinator) and Waddell

177-524A TOPICS IN MOLECULAR BIOLOGY. (3) (Prerequisites: 177-300A;177-303B or permission.) Recent literature in the fields of molecular genetics and molecular biology of development. Topics include gene structure and the regulation of gene expression in eukaryotic organisms, especially during cellular differentiation.

Professors Bussey and Thomas

● **177-526B PLANTS AND EXTREME ENVIRONMENTS.** (3) (1 hour lecture, 2 hour seminar/discussion) (Prerequisites: 177-205B, -357A, or permission.)

177-532B DEVELOPMENTAL NEUROBIOLOGY SEMINAR. (3) (1 hour lecture; 2 hour seminar) (Prerequisites: 177-303B and -306A or permission.) Development of the nervous system is examined with particular emphasis on the processes which underlie the appearance of complex but highly ordered neural circuits during embryonic development e.g. synaptogenesis, process outgrowth and guidance, early growth of the nervous system. The basis for these discussions will be recent research papers and other assigned readings. **Professors Levine and Ferns**

177-535B POLITICAL ECOLOGY. (3) (3 hour seminar) (Prerequisite: 177-308B or permission.) 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.

Professor Vincent

177-555L FUNCTIONAL ECOLOGY OF TREES. (3) (Lectures and laboratory taught in residence at Mont St. Hilaire Research Reserve.) (Prerequisites: 177-204A; -205B; -357A) Functional organization in trees: physiology, architecture, and life history. Emphasis on trees in natural habitats. **Professor Lechowicz**

● **177-570B ADVANCED SEMINAR IN EVOLUTION.** (3) (3 hour seminar) (Prerequisites: Permission of instructor.)

177-588A MOLECULAR/CELLULAR NEUROBIOLOGY. (3) (1½ hour lectures, 1½ hour seminar) (Prerequisites: 177-300A, or permission.) Fundamental molecular mechanisms underlying the general features of cellular neurobiology. Advanced course based on lectures and on critical analysis of primary research papers. Intended for final-year undergraduates and for neuroscience graduate students interested in recent developments in molecular neurobiology. **Professors Carbonetto and Hastings**

● **177-593B BEHAVIOUR/SOCIOBIOLOGY SEMINAR.** (3) (3 hour seminar) (Prerequisites: 177-307B and 306A)

● **177-632A LIMNOLOGY.** (3) (2 hour lectures, 3 hour laboratory) (Prerequisites: 177-204A, -206A; and/or permission of instructor.)

12 Biomedical Engineering

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Chair — R.E. Kearney

12.1 Staff

Professors
T.M.S. Chang; B.Sc., M.D., C.M., Ph.D.(McG.), F.R.C.P.(C) *(joint appt. with Physiology)*
A.C. Evans; B.Sc.(Liv.), M.Sc.(Sur.), Ph.D.(Leeds) *(joint appt. with Neurology & Neurosurgery)*
H.L. Galiana; B.Eng., M.Eng., Ph.D.(McG.) *(joint appt. with Otolaryngology)*
R.E. Kearney; B.Eng., M.Eng., Ph.D.(McG.) *(joint appt. with Physiology)*

Associate Professors
J.D. Bobyn; B.Sc., M.Sc.(McG.), Ph.D.(Tor.) *(joint appt. with Surgery)*
W.R.J. Funnell; B.Eng., M.Eng., Ph.D.(McG.) *(joint appt. with Otolaryngology)*

Assistant Professors
D.L. Collins; B.Sc., M.Eng, Ph.D.(McG.) *(joint appt. with Neurology & Neurosurgery)*
G.B. Pike; B.Eng., M.Eng., Ph.D.(McG.)*(joint appt. with Neurology & Neurosurgery)*
M. Slawnych; B.Sc., M.Sc., Ph.D.(Br.Col.)

Associate Members
J. Gotman *(Neurology & Neurosurgery)*; B.N. Segal *(Otolaryngology)*; R. Sipehia *(Physiology)*; C. Thompson *(Neurology & Neurosurgery)*

Adjunct Professors
I.W. Hunter (M.I.T.), T.M. Peters (U.W.O.), P.L. Weiss (Hebrew)

Research Associates
C. Baker, D. Guitton, A. Katsarkas

12.2 Programs Offered

The Department offers a graduate training program leading to Master's and Ph.D. degrees in Biomedical Engineering.

It provides instruction and opportunities for interdisciplinary research in the application of engineering, mathematics, and the physical sciences to problems in medicine and the life sciences. Courses are offered for graduate students in the life sciences and in engineering and the physical sciences.

Excellent laboratory facilities for basic and applied research are available in the Department and in the laboratories of associated staff located elsewhere in the Medical Faculty. The Department operates a network of high performance workstations and well-equipped mechanical and electronics workshops.

Basic research in the Department concentrates on the application of quantitative engineering analysis methods to basic biomedical research problems. Currently active areas of research include: neuromuscular and postural control, muscle mechanics, the vestibular system, oculomotor control, the auditory system, joint prosthetics, biomaterials, artificial cells and organs, and medical imaging. Staff members are also active in more applied research related to the development of quantitative analysis tools and instruments for biomedical research. Areas of activity here include: signal analysis, system identification, modeling, simulation and parameter estimation, image processing, pattern recognition, ultrasound, and biorobotics.

12.3 Admission Requirements

See minimum admission requirements in Section 5 of the General Information section of the Graduate Faculty Calendar.

12.4 Application Procedures

Please address enquiries directly to the Department.

12.5 Program Requirements

Master's degrees require students to complete a minimum of 45 credits (24 thesis credits and 21 graduate course credits).

Graduate students may also be registered through departments of Medicine, Science and Engineering, and must then fulfill the requirements for advanced degrees imposed by their respective departments.

In addition, all students are required, through course work and independent study, to achieve a degree of inter-disciplinary competence appropriate to their area of specialization.

12.6 Courses for Higher Degrees

399-501A SELECTED TOPICS IN BIOMEDICAL ENGINEERING. (3) An overview of how techniques from engineering and the physical sciences are applied to the study of selected physiological systems and biological signals. Using specific biological examples, systems will be studied using: signal or finite-element analysis, system analysis and identification, modelling and simulation, computer control of experiments and data acquisition.
Professor Pike

399-503B BIOMEDICAL INSTRUMENTATION AND MEASUREMENT TECHNIQUE. (3) (2 hours lecture, 1 hour laboratory) A review of the principles and practice of making biological measurements in the laboratory, including theory of linear systems, data sampling, computer interfaces, basic electronic circuit design and machining. Laboratory facilities allow students to experiment with computer-based data acquisition. **Professor Slawnych**

399-519A ANALYSIS OF BIOMEDICAL SYSTEMS AND SIGNALS. (3) (Prerequisites: Satisfactory standing in U3 Honours Physiology (Neurophysiology option); or U3 Major in Physics-Physiology; or permission of instructor.) An introduction to the theoretical framework, experimental techniques and analysis procedures available for the quantitative analysis of biomedical systems and signals. Lectures plus laboratory work using the Biomedical Engineering computer system. Topics include: amplitude and frequency structure of signals, filtering, sampling, correlation functions, time and frequency-domain descriptions of systems. **Professor Kearney**

563-607A INTRODUCTION TO MEDICAL IMAGING. (3) (3 hours lectures/week) A review of the principles of medical imaging as applied to conventional diagnostic radiography, digital subtraction radiography, computed tomography and magnetic resonance imaging. The course emphasizes a linear system approach to the formation, processing and display of medical images.
Professor Pike

399-650B ADVANCED MEDICAL IMAGING. (3) (Prerequisite: 563-607B) Review of advanced techniques in medical imaging including: fast magnetic resonance imaging (MRI), functional MRI, MR angiography and quantitative flow measurement, spiral and dynamic x-ray computed tomography, 2D/3D positron emission tomography (PET), basic PET physiology, tracer kinetics, surgical planning and guidance, functional and anatomical brain mapping, 2D and 3D ultrasound imaging, and medical image processing.
Professor Pike

Related courses offered in other departments include the following:

Computer Science
308-425B Topics in Artificial Intelligence II. (3)

Electrical Engineering
304-523B Speech Communications. (3)
304-526B Artificial Intelligence. (3)

Mechanical Engineeering
305-560B Biomechanics of Tissues. (3)
305-561B Biomechanics of Musculoskeletal Systems. (3)
305-575B Control of Robots and Human Arms. (3)

Physics
198-413A Topics in the Physical Basis of Physiology. (3)

Physiology
552-423A Dynamics, Function and Control of Physiological Systems. (3)
552-517B Artificial Internal Organs. (3)
552-518A Artificial Cells and Immobilization Biotechnology. (3)

For full course descriptions refer to appropriate Calendar entry.

13 Chemical Engineering

Department of Chemical Engineering
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Email: dept@chemeng.lan.mcgill.ca

Chair — R.J. Munz

13.1 Staff

Professors
D.G. Cooper; B.Sc., Ph.D.(Tor.)
J.M. Dealy; B.S.(Kansas), M.S.E., Ph.D.(Mich.), Eng.
W.J.M. Douglas; B.Sc.(Queen's), M.S.E., Ph.D.(Mich.)
M.R. Kamal; B.S.(Ill.), M.S., Ph.D.(Carn.-Mellon), Eng.
A.S. Mujumdar; B.Ch.E.(Bomb.), M.Eng., Ph.D.(McG.)
R.J. Munz; B.A.Sc., M.A.Sc.(Wat.), Ph.D.(McG.), Eng.
J.H. Vera; B.Mat.(Chile), Ing.Quim.(U.T.E.), M.S.(Calif.), Dr.Ing.(Santa Maria), Eng.
B. Volesky; M.Sc.(Czech. Tech. Univ.), Ph.D.(W.Ont.)
M.E. Weber; B.S.E.(Prin.), Sc.D.(M.I.T.), P.Eng.

Associate Professors
D. Berk; B.Sc.(Bosphorus), M.E.Sc.(W.Ont.), Ph.D.(Calg.), P.Eng.
J.-M. Charrier; Dipl.Ing., (E.N.S.A.M. Paris), M.S., Ph.D.(Akron), Eng.
J.-L. Meunier; D.Ing.(E.P.F.L.), M.Sc., Ph.D.(I.N.R.S.), Eng.
A.D. Rey; B.Ch.E.(C.C.N.Y.), Ph.D.(Calif.)
J. Simandl; B.Eng.(McG.), Ph.D.(Calg.), P.Eng.

Assistant Professor
W.A. Brown; B.Eng, M.Eng., Ph.D.(McG.)

Assistant Professor (Special Category)
P. Wood-Adams; B.Eng.(Alta), M.Eng., Ph.D.(McG.)

Paprican Adjunct Professors
G. Garnier; B.Eng.(Sherbrooke), Ph.D.(Virginia Tech.), P.Eng.
G.J. Kubes; B.Sc., M.Sc.(Prague), Ph.D.(Bratislava), P.Eng.

Adjunct Professors
B. Alince; M. Berube, P. Bisaillon; R. Campeau; L. Chartier; E.J. Chin; N.E. Cooke; P. Csakany; E. Denman; P. Duhaime; A. Garcia-Rejon; S. Gendron; R.W. Gooding; N. Gurnagul; B. Huang; R.B. Kerr; T. Kudra; C. Ladanowski, P. Lagacé; D.C. Lamond; N. Liebergott; D.J. McKeagan; R. Nayar; K.T. Nguyen; J.R. Paris; M. Perrier; N.P. Peters; I.I. Pikulik; A. Roche; J. Sarlis; P. Stuart; K. Tran; R.C. Urquhart; L.A. Utracki

Associate Members
T.M.S. Chang *(Physiology)*
R.H. Crotogino; H.L. Goldsmith *(Experimental Medicine)*

13.2 Programs Offered

The Department offers programs leading to the Master of Engineering and the Doctor of Philosophy degrees.

Two options are available for the M.Eng. degree: the thesis option and the project option. The M.Eng. (Thesis) is a research-oriented degree requiring a limited number of courses and a research thesis; the M.Eng. (Project) is a course-oriented degree which includes a project. Three specialized versions of the M.Eng. (Project) are offered: specialization in pulp and paper; specialization in petrochemicals, polymers and plastics; specialization in environmental engineering.

The Ph.D. is a research degree requiring a thesis which makes a distinct contribution to knowledge.

The Department's offices and research laboratories are located in the M.H. Wong Building, which was completed in 1996. Members of the Department are active in a number of research areas, including heat transfer; mass transfer; separation processes; coupled transport processes; thermodynamics and transport properties; chemical reaction engineering; plasma reactor studies; process control; biochemical engineering; environmental engineering; polymer engineering and rheology. Most staff are members of one or more research groups.

Research in Pulp & Paper is closely associated with the Pulp & Paper Research Institute of Canada (Paprican). Specialized equipment and facilities of the Paprican main laboratory near Montreal are made available, and several staff are associated jointly with the Paprican and the Department.

Research in Thermal Plasma Technology includes fundamental studies in high temperature transport phenomena and reactor design, as well as applied studies in plasma processing and torch design. Close collaboration is maintained with the the Université de Sherbrooke through the Interuniversity Plasma Technology Research Centre (CRTP) and with the thermal plasma technology group of Hydro-Québec.

Researchers in Polymer Engineering are members of Polymer McGill which also includes researchers from the Department of Chemistry and Paprican. The group cooperates with researchers at Ecole Polytechnique de Montréal and the Industrial Materials Institute of the National Research Council of Canada.

Research in Biochemical Engineering involves both the microbiology and technology of the production of new products, the development of novel biological reactors including their control and optimization as well as down-stream processing.

Research related to the Environment is pursued on many fronts; for example, the polymer group is exploring the recycling of plastics into chemicals by thermal and chemical means, the plasma group is investigating plasma-assisted incineration, the biochemical group is evaluating biosorbents for heavy metals. Other projects involve dewatering sludges by electroosmosis, electrokinetic soil remediation, membrane distillation to remove volatile organic compounds from waster, etc.

13.3 Admissions Requirements

Admission to graduate study requires a minimum CGPA of 3.0/4.0 (or equivalent) for the complete Bachelor's program or a minimum GPA of 3.2/4.0 (or equivalent) in each of the last two years. Non-Canadian applicants whose mother tongue is not English must achieve a minimum TOEFL score of 550 prior to admission.

M.Eng. (Thesis), M.Eng. (Project)

Admission requires a Bachelor's degree (or equivalent) in chemical or other engineering. Students whose degrees are not in chemical engineering may be required to complete some undergraduate courses during their studies. Students with Bachelor's degrees in science first enter a Qualifying Program, normally of two semesters, to prepare for entry into the M.Eng. program.

Ph.D.

Admission requires a Master's degree (or equivalent) from a recognized university. Students in the Department's M.Eng. (Thesis) program may transfer to the Ph.D. program after one year without submitting the M.Eng. thesis following a formal "fast track" procedure.

13.4 Application Procedures

Application materials are obtained by writing or email to Chair, Graduate Admissions Committee, Department of Chemical Engineering at the above address. Students within North America will receive the formal application by return mail. Students from outside North America will receive a one-page preliminary application form. The completed form is evaluated by the Admissions Committee who send the formal application form only if there is a reasonable probability of admission.

Applications will be considered when the Graduate Admissions Committee has received:

1. application form of the Faculty of Graduate Studies and Research;
2. official transcripts;
3. two letters of reference;
4. application fee of $60 Canadian;
5. TOEFL test results (if required).

Application deadlines are March 1 for September (Fall term) admission, September 15 for January (Winter term) admission and January 31 for May (Summer term) admission.

13.5 Program Requirements

M.Eng.
The Master of Engineering requires the completion of 45 credits and three terms of residence at McGill.

M.Eng. (Thesis)
Courses: 12 credits (a minimum of 9 credits in chemical engineering)
Research: 33 credits which include completion of a thesis proposal, presentation of a seminar and submission of a thesis

M.Eng. (Project)
Courses: 33-39 credits (a minimum of 18 credits in chemical engineering)
Project: (design or research): 6-12 credits

The specialized versions of the M.Eng. (Project) follow the above distribution between courses and project.

The specialization in Pulp and Paper, which is offered in cooperation with the Pulp and Paper Research Institute of Canada, consists of a sequence of courses over three consecutive semesters (12 months) beginning in May. The project and the majority of the courses are specialized in pulp and paper. Since the 3 term sequence begins with the summer term, entry into the Pulp and Paper program is only in May.

The specialization in petrochemicals, polymers and plastics, which is offered in cooperation with the Institute Français du Pétrole (IFP), requires that the Winter semester be spent at IFP in Paris where 15 course credits are completed. This program may be entered in September, January or May.

The specialization in environmental engineering requires the completion of a Core of 12 credits of environmental engineering courses and a research or design project related to the environment.

Ph.D.
The Ph.D. requires 3 years of residence at McGill.
Courses: 2 chemical engineering courses
Research: completion of a thesis proposal, its defense, presentation of 2 seminars, and submission and defense of a thesis

13.6 Courses

● Denotes not offered in 1999-2000.

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

302-571B SMALL COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING. (3) The use of small computers employing a high level language for data acquisition and the control of chemical processes. Real-time system characteristics and requirements, analog to digital conversion, digital to analog conversion and computer control loops. **Dr. Huang**

302-581B POLYMER COMPOSITES ENGINEERING. (3) Characteristics of thermoplastic and thermosetting polymeric matrices and particulate/fibre dispersed elements. Associated structure characterization. Processing techniques. Quantitative engineering analyses to correlate structure with properties and processing. Product/process design. Applications in chemical process equipment, construction, transportation (land, marine, aerospace), general industrial and consumer goods. **Professor Charrier**

302-591B ENVIRONMENTAL BIOREMEDIATION. (3) Presence and role of microorganisms in the environment, role of microbes in environmental remediation either through natural or human-mediated processes. Application of microbes in pollution control and in monitoring of environmental pollutants.

302-611B HEAT AND MASS TRANSFER. (4) Heat and mass transfer in laminar and turbulent flows; scaling; models for interphase transport. **Professors Mujumdar and Weber**

302-621B THERMODYNAMICS. (4) Theory and application of phase and chemical equilibria in multicomponent systems. **Professor Vera**

302-630T STRUCTURE & PROPERTIES OF PAPER. (4) Structure and chemistry of wood and wood pulp fibres; network and pore structure of paper; optical, mechanical and sorption properties of paper, end-use requirements of paper. Laboratory practice in pulp and dpaper testing. (Awaiting University Approval) **Drs. Gray and Gurnagul**

302-631A FOUNDATIONS OF FLUID MECHANICS. (4) Rigorous derivation of equations of motion; creeping flow inviscid flow; boundary layer theory; hydrodynamic stability; turbulent flow, separated flows, drag on submerged bodies. **Professor Dealy**

302-632T PULPING ENGINEERING. (4) Analysis of mechanical and chemical pulping processes in terms of chemistry, fundamental principles, process design and control. (Awaiting University Approval) **Professor Kubes**

302-633A BLEACHING AND RECOVERY. (3) Analysis of the liquor recovery and pulp bleaching processes; chemical recovery cycles; energy management, environment aspects. (Awaiting University Approval) **Dr. Kubes and Mr. Liebergott**

302-636T UNIT OPERATIONS OF PAPERMAKING. (4) Analysis of the papermaking process in terms of fluid mechanics, heat and mass transfer, and kinetics. (Awaiting University Approval) **Professor Garnier**

302-638T TOPICS IN PULP AND PAPER. (4) Treatment of specialized areas in pulp and paper selected from coating and filling, maintenance of mill equipment, environmental engineering, deinking and recycling. (Awaiting University Approval) **Professor Garnier**

302-641A CHEMICAL REACTION ENGINEERING. (4) Interpretation of chemical reaction data, especially for heterogeneous systems. Residence time, complete segregation, maximum mixedness, other advanced concepts. Reactor design. **Professor Berk**

302-643B THERMAL PLASMA TECHONOLOGY. (3) (Prerequisite: Permission of the instructor) An introduction to thermal (high temperature) plasmas as applied to chemical and materials engineering. Degree of ionization, velocity distribution function, plasma parameters, collisions and diffusion, energy states, plasma generation, diagnostic techniques for plasma and particles, particle-plasma interaction, mathematical modelling of plasma systems, applications. **Professors Meunier and Munz**

302-652T DRYING: PRINCIPLES AND PRACTICE. (2) Transport phenomena in porous media; heat transfer to particles, beds and surfaces; evaporation from drops and surfaces; drying characteristics for batch and continuous drying; selection of dryers. **Professor Mujumdar**

302-653B ADVANCED PROCESS DESIGN. (3) Advanced techniques and concepts in the design of chemical processing plant and equipment.

302-655B PULP & PAPER DESIGN PROJECT. (6) Application of advanced process design and economic analysis methods to the design of a pulp and paper mill. This work must lead to a comprehensive project report. **Professor Douglas and staff**

302-662A COMPUTATIONAL METHODS. (4) Methods of weighted residuals; solution to non-linear algebraic equations; stability in nonlinear equations; bifurcations; mesh refinement strategies; convection dominated transport; hyperbolic equations, particle simulation methods. **Professor Rey**

302-672A PROCESS DYNAMICS AND CONTROL. (4) (Prerequisite 302-455A) Process representation and identification and simulation; sensor stability; sensitivity of feedback control systems; feedward control; discrete representation of continuous systems; controller tuning; adaptive control. **Dr. Perrier**

302-674B CONTROL IN PULP AND PAPER. (3) (Prerequisite 302-672A or permission of instructor.) Applications of process control to pulp and paper operations: paper machine, refiner control, continuous digester, Kraft recovery cycle, washing and bleaching operations, mill-wide process control. **Mr. Roche and Mr. Gendron**

302-681A POLYMER CHEMICAL ENGINEERING. (3) Application of chemical engineering fundamentals to the preparation and processing of polymers. Classification and characterization of polymers, reaction media and kinetics of polymerization, reactor design, viscoelasticity and rheology, processing techniques, extrusion, molding, composite formation, adhesion. **Professor Kamal and Dr. Utracki**

302-682A ENGINEERING PROPERTIES OF POLYMERIC MATERIALS. (3) Mechanical and transport properties of non-crystallizing and crystallizing thermoplastics, rigid thermosets, fibers, films, elastomers and composites with particle and fiber reinforcement. Elasticity, visco-elasticity, ultimate properties, diffusion of liquids and gases, thermal and electrical properties. **Professor Charrier**

● **302-683B POLYMER RHEOLOGY.** (3)

302-684A POLYMER PROCESSING. (3) Survey of engineering properties of polymers and processing operations, degradation of polymers, extrusion, injection molding, fiber spinning, film blowing, blow molding, thermoforming, miscellaneous other processes. Lectures, plant visits, problem assignments. **Professor Kamal, Dr. Garcia-Rejon and Dr. Tran**

302-685A POLYMER PRODUCT AND PROCESS DESIGN PROJECT. (3) Principles of product design, optimization and processing conditions for the production of plastics articles. Selection of resins, process and equipment and tool design, considering cost, safety and environmental aspects of production. Students undertake projects to define specifications for the manufacture of selected plastics articles. **Professor Charrier and staff**

302-686A POLYMER ENGINEERING LABORATORY. (3) Study of experimental aspects of polymer characterization. Areas of study are selected from molecular weighlt determination, polymer morphology, mechanical and rheological behaviour. Polymer process-

ing areas available for study include extrusion, mixing and injection and compression molding. **Professor Kamal and staff**

302-690A,B,T RESEARCH TECHNIQUES. (3) This course introduces techniques and develops skills necessary for commencing a particular thesis research project. A written report is required.

302-691A,B,T SELECTED TOPICS IN CHEMICAL ENGINEERING. (1) **Staff**

302-692A,B,T SELECTED TOPICS IN CHEMICAL ENGINEERING. (2) **Staff**

302-693A,B,T SELECTED TOPICS IN CHEMICAL ENGINEERING. (3) **Staff**

302-694A,B,T SELECTED TOPICS IN CHEMICAL ENGINEERING. (4) **Staff**

302-695A,B,T PROJECT IN CHEMICAL ENGINEERING. (6) Independent work under the general direction of a full-time staff member, on a problem of industrially-oriented design or research leading to a comprehensive report. **Staff**

302-696A,B,T EXTENDED PROJECT. (6) Extended independent work on a problem of industrially-oriented design or research, leading to a comprehensive project report. **Staff**

302-697A,B,T M.ENG. THESIS PROPOSAL. (6) Independent work under the supervision of the thesis advisor(s) leading to a thesis proposal. **Staff**

302-698A,B,T M.ENG. THESIS RESEARCH I. (12) (Prerequisite 302-697) Ongoing research pertaining to thesis. **Staff**

302-699A,B,T M.ENG. THESIS RESEARCH II. (15) (Prerequisite 302-698) Ongoing research pertaining to thesis. **Staff**

302-795A,B,T PH.D. THESIS PROPOSAL. Independent work under the supervision of the thesis advisor(s) leading to a thesis proposal.

302-796A,B,T PH.D. PROPOSAL DEFENCE. Presentation and defence of thesis proposal at an oral examination.

302-797A,B,T PH.D. SEMINAR. (Prerequisite 302-796) Required for all Ph.D. candidates. Presentation of a seminar on an aspect of their thesis work.

14 Chemistry

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Chair — D.N. Harpp

Director of Graduate Studies — R.B. Lennox

14.1 Staff

Emeritus Professors
J.T. Edward; D.Phil.(Oxon.), Ph.D., D.Sc.(Dub.), F.C.I.C., F.R.S.C.
J.F. Harrod; B.Sc., Ph.D.(Birm.)
M. Onyszchuk; B.Sc.(McG.), M.Sc.(W.Ont.), Ph.D.(Cantab. and McG.), F.C.I.C.
D. Patterson; M.Sc.(McG.)
A.S. Perlin; M.Sc., Ph.D.(McG.), F.C.I.C., F.R.S.C.
L.E. St-Pierre; B.Sc.(Alta.), Ph.D.(Notre Dame), F.C.I.C.

Professors
I.S. Butler; B.Sc., Ph.D.(Brist.), F.C.I.C.
T.H. Chan; B.Sc.(Tor.), M.A., Ph.D.(Prin.), F.C.I.C.
B.J. Chin; B.Sc., M.Sc., Ph.D.(Tor.)
A. Eisenberg; B.S.(Wor. Poly.), M.A., Ph.D.(Prin.), F.C.I.C.
B.C. Eu; B.Sc.(Seoul), Ph.D.(Brown)
P.G. Farrell; B.Sc., Ph.D., D.Sc.(Ex.)
D.F.R. Gilson; B.Sc.(Lond.), M.Sc., Ph.D.(Br.Col.), F.C.I.C.
D.N. Harpp; A.B.(Middlebury), M.A.(Wesleyan), Ph.D.(N.Carolina), F.C.I.C.
A.S. Hay; B.Sc.(Alta.), Ph.D.(Ill.), F.R.S.
J.J. Hogan; B.S.(Renss.), Ph.D.(Chic.)
G.E. Just; Ing.Chem.(E.T.H. Zürich), Ph.D.(W.Ont.), F.C.I.C.
R.H. Marchessault; B.Sc.(Montr.), Ph.D.(McG.), F.C.I.C., F.R.S.C.
W.C. Purdy; B.A.(Amh.), Ph.D.(M.I.T.), F.C.I.C.
D.M. Ronis; B.Sc.(McG.), Ph.D.(M.I.T.)
E.D. Salin; B.Sc.(Calif.), Ph.D.(Oregon)
B.C. Sanctuary; B.Sc., Ph.D.(Br.Col.)
A.G. Shaver; B.Sc.(Carl.), Ph.D.(M.I.T.)
M.A. Whitehead; B.Sc., Ph.D., D.Sc.(Lond.), F.C.I.C.

Associate Professors
M.P. Andrews; B.Sc., M.Sc., Ph.D.(Tor.)
D.H. Burns; B.Sc.(Puget Sound), Ph.D.(Wash.)
M. Damha; B.Sc., Ph.D.(McG.)
W.C. Galley; B.Sc.(McG.), Ph.D.(Calif.)
A.E. Grosser; A.B.(C'nell.), Ph.D.(Wis.)
R.J. Kazlauskas; B.Sc.(Clev. State), Ph.D.(M.I.T.)
R.B. Lennox; B.Sc., M.Sc., Ph.D.(Tor.)
J.F. Power; B.Sc., Ph.D.(C'dia)
L. Reven; B.A.(Carl.), Ph.D.(Ill.)

Assistant Professors
P. Ariya; B.Sc., Ph.D.(York)
B.A. Arndtsen; B.A.(Carl.), Ph.D.(Stan.)
C.J. Barrett; B.Sc., M.Sc., Ph.D.(Queen's)
J.L. Gleason; B.Sc.(McG.), Ph.D.(Va.)
A. Kakkar; B.Sc., M.Sc.(Chan. U., India), Ph.D.(Wat.)
H. Sleiman; B.Sc.(A.U.B.), Ph.D.(Stanford)

Lecturers
J. Finkenbine, G. Wilczek

Paprican Adjunct Professors
D. Argyropoulos, D.G. Gray, R. St. John Manley, T.G.M. Van de Ven

Associate Members
J.A. Finch (Mining and Metallurgical Engineering), O.A. Mamer (University Clinic, RVH), B.I. Posner (Medicine)

Adjunct Professors
G.R. Brown, A. Fenster, E. Roberts, J. Schwarcz, Y. Tsantrizos, I. Wharf, R. Zamboni, L.O. Zamir

14.2 Programs Offered

M.Sc., Ph.D. and the M.Sc. (Applied).

Research in Chemistry
Members of the Department are active in directing research in the following fields:

Analytical – Atomic and molecular spectroscopy; laboratory automation; artificial intelligence; instrument design; optimization of data processing techniques; application of modern analytical techniques to biochemical and medical systems; detectors for liquid chromatography; electroanalytical chemistry; chiral separations; photothermal analytical methods; thermal wave imaging; thermal analysis of ultrathin films; development of analytical techniques for studies of diffusion and photodegradation in thin films. Technique development for quantitative spectroscopy in scattering media. Statistical analysis of chemical data. Analytical spectroscopy of bioenergetics.

Bio-organic – Enzyme chemistry; protein and nucleic acid structure and function; drug design and modification; active site stereochemistry; molecular basis of regulation and pharmacological action; lipid and lipid analogue chemistry.

Biophysical – Excited electronic states of proteins and nucleic acids; spectroscopic probes of biopolymer conformation; sensitized photochemistry in biopolymers; dynamics of protein and nucleic

acid conformations. Spectroscopic analysis of oxygen transport in aerobic metabolism.

Colloid and Polymer – Monomolecular layers; solution properties of high polymers; molecular morphology; rheology and stability of dispersions; phase transitions in polymers and polymer blends; polymer reinforcement; radiation effects and solid-state polymerization; mechanisms of polymerization reactions; wetting and spreading; the glass transition; molecular dynamics and polymer properties; ionic polymers; cellulose and paper; carbohydrate biopolymers; pollution abatement; polymer melt rheology; synthetic latex; rheo- and electro-optical phenomena; polymers at interfaces.

Inorganic – Synthesis of new classes of organometallic complexes and inorganic polymers; homogeneous and heterogeneous catalysis; coordination compounds of organotin and organolead halides; catenated polysulfur and polysulfoxide complexes; organosilicon chemistry; spectroscopic studies (e.g., FT-IR, laser Raman, multinuclear NMR, and mass) of complexes; kinetics and mechanisms of inorganic and organometallic reactions; bioinorganic chemistry; inorganic materials chemistry; metal atom synthesis; asymmetric catalysis; surface chemistry.

Organic – Synthesis and structure of heterocyclic compounds; natural products; carbohydrates; cellulose; plant-growth regulators; organic sulphur, phosphorus, tin and silicon chemistry; stereochemistry; reaction mechanisms; charge transfer complexes; new synthetic methods; conformational analysis; solvation effects; substituent effects; polymer supports; nucleic acids, anti-sense and anti-gene oligonucleotides.

Physical – Laser excited luminescence and novel optical materials. Order-disorder phenomena in molecular crystals and liquid crystals. Vibrational spectroscopy at high pressures. Nuclear quadrupole resonance spectroscopy.

Pulp and Paper – Research in areas of chemistry of interest to the Canadian pulp and paper industry is also performed at the Pulp and Paper Research Centre, adjacent to the Chemistry Department. Current research topics include cellulose and lignin chemistry, the chemistry of pulping and bleaching, colloidal aspects of papermaking, physical chemistry of cellulosic materials, and de-inking and recycling of paper.

Theoretical – Non-equilibrium statistical mechanics, kinetic theory of fluids and plasmas, non-equilibrium thermodynamics of non-linear transport processes for systems far from equilibrium and fluid dynamics are studied. Theories of nuclear magnetic resonance and multiquantum NMR spectra are developed with emphasis on the determination of the structures of proteins from NMR. Molecular structure, chemical bonding, intermolecular forces in solids and isolated molecules in dimers and metastable polymers are studied quantum mechanically.

14.3 Admission Requirements

The minimum academic standard for admission to research thesis M.Sc., Ph.D. and the M.Sc. (Applied) degree programs is a minimum standing equivalent to a Cumulative Grade Point Average (CGPA) of 3.0 out of a possible 4 or a CGPA of 3.2/4.0 for the last two full-time academic years. Applicants from other institutions should have an academic background equivalent to that of a McGill graduate in the Chemistry Honours/Major programs. If possible, candidates should specify the field of research in which they are interested.

14.4 Application Procedures

All inquiries concerning graduate work in the Department should be addressed to the Director of Graduate Studies, Department of Chemistry.

FINANCIAL ASSISTANCE

M.Sc. and Ph.D. Degrees

Financial assistance for accepted graduate students who do not hold fellowships or scholarships is normally available in the form of laboratory demonstratorships/assistantships, and occasionally by payment from research funds. Graduate students devote 12 hours per week (contact hours, plus grading of reports, etc.) during the academic session to their teaching duties. Financial assistance during the remainder of the year is provided from research funds. Most students receive partial fee waivers. Scholarship holders, such as NSERC or awards of similar value, receive a tuition fee waiver.

M.Sc. (Applied) Degree

Financial assistance for candidates in the M.Sc. (Applied) program is not available during the two academic sessions when courses are taken, unless candidates are recipients of scholarships. During the four-month project, candidates are paid at rates established by participating companies.

14.5 Program Requirements

M.Sc.* and Ph.D. Degrees

1. Students must take such examinations as may be required in (a) assigned courses given in the Department of Chemistry, (b) assigned cognate courses given in other departments. Courses are assigned after taking into consideration the student's previous training and research interest.
2. Students must successfully complete a research project and submit an acceptable thesis.
3. Students must satisfy the examiners in an oral examination on the thesis and related subjects (required only of candidates for the Ph.D. degree).
4. All the usual requirements of the Faculty of Graduate Studies and Research must be satisfied.

* This program requires 45-50 credits.

A minimum of 6 credits of course work is required; the balance of credits will be made up from either a combination of course work (graduate and undergraduate) and thesis credits, or from thesis research credits only. There will be a minimum of 24 credits in the thesis research component.

M.Sc. (Applied) Degree

This program requires a minimum of 45 credits, 30 credits of course work (graduate and undergraduate) plus a 15-credit project in some aspect of chemical industry, normally completed during a four-month project.

Examinations in Chemistry

1. Examinations in assigned courses are normally taken by the candidates in December and May. In special circumstances, and with the permission of the Department and the Faculty, they may be taken in September.
2. A candidate for the Ph.D. degree shall pass all such examinations, other than those in certain special courses, before the final year, except in special circumstances and then only with the approval of the Department.

14.6 Courses for Higher Degrees

Advanced Undergraduate Courses

Undergraduate courses may be required of a student who is admitted to the Graduate Faculty if deficiencies are perceived in the student's previous training. Descriptions of undergraduate courses may be found in the Faculty of Science Calendar.

Graduate Courses

- Denotes not offered in 1999-2000.

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

180-511A INTRODUCTION TO RADIOCHEMISTRY. (3) (Prerequisite: 180-214 or equivalent) The basic concepts of radiochemistry described in a qualitative way. Topics include: radioactive decay

and its detection, radioactivity in the environment, interaction of radiation with matter, theories of nuclear structure, nuclear reactions and fission, nuclear reactors, radiocarbon dating, tracer techniques. **Professor Hogan**

180-531A CHEM. OF INORGANIC MATERIALS. (3) (3 lectures) (Prerequisites: 180-201 or -281. Co-requisite: 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. **Professor Andrews**

180-543C THE CHEMISTRY OF PULP AND PAPER. (3) (2 lectures) (Undergraduate prerequisite/corequisite: Core curriculum in chemistry.) The processes for converting wood to paper are described with emphasis on the relevant organic, physical and surface chemistry. **Professor Gray**

180-547B LABORATORY AUTOMATION. (5) (Two 1.5 hour lectures, lab) (Prerequisite: 180-377B, equivalent or permission of instructor.) Automation and data handling with respect to modern chemical laboratory instrumentation. Basic electronics, data aquisition, evaluation of laboratory needs, data processing methodologies. **Professor Salin**

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

180-555A NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY. (3) (2 lectures) (Prerequisite: 180-355 or equivalent.) Interpretation of proton and carbon-13 nuclear magnetic resonance spectroscopy in one dimension for structural identification. **Professor Gilson**

● **180-556A ADVANCED QUANTUM MECHANICS.** (3) (3 lectures) (Prerequisites: 180-345, 198-242)

● **180-557A INSTRUMENTAL METHODS OF ANALYSIS.** (3) (2 lectures and 3 hours lab) (Prerequisite: 180-367 and 180-377)

180-567A CHEMOMETRICS: ANALYSIS OF CHEMICAL DATA. (3) (Prerequisite: Linear Algebra and experience in some computer programming language, or permission of instructor.) 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 modeling, multisensor calibration, etc. **Professor Burns**

180-572B SYNTHETIC ORGANIC CHEMISTRY. (3) (3 lectures) (Prerequisite: 180-382) Synthetic methods in organic chemistry and their application to the synthesis of complex molecules. **Professor Just**

● **180-574B OPTICAL METHODS AND MATERIALS.** (3) (Prerequisite: 180-355B)

180-575B CHEMICAL KINETICS. (3) (3 lectures) (Prerequisite: 180-273 and -255) (Not open to students who have taken 180-475.) Kinetic laws, measurement of reaction rates, transition state and collision theory, elementary gas phase reactions. Elementary reactions in solution, reaction mechanisms in solution, reactions on surfaces and in solid state. Complex reactions and mechanisms, laser techniques, molecular beams, chemiluminescence, computer generated studies. Explosions. Dynamic simulation by computer. **Professor Grosser**

180-576B QUANTUM CHEMISTRY. (3) (Lecture and/or reading course) (Prerequisite: 180-345) (Not open to students who have taken 180-476) A survey of current theoretical approaches to relativistic quantum chemistry, molecular structure, spectroscopy and one electron properties. **Professor Whitehead**

180-577B ELECTROANALYTICAL CHEMISTRY. (3) The application of electroanalytical techniques including polarography, coulometry and chronopotentiometry to inorganic, organic and biochemical analysis. **Professor Purdy**

● **180-581B INORGANIC TOPICS I.** (3) (Prerequisite: 180-381) (Not open to students who have taken 180-481.)

180-585C COLLOID CHEMISTRY. (3) (Prerequisite: Chemistry core curriculum or equivalent.) 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; adsorption; surfactants; hydrodynamic interactions; rheology of dispersions. **Professor van de Ven**

180-587A SELECTED TOPICS IN MODERN ANALYTICAL CHEMISTRY. (3) (Prerequisites: 180-387 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. **Professor Purdy**

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

180-593B INTRODUCTION TO STATISTICAL THERMODYNAMICS. (3) (2 lectures) (Research project) (Prerequisite: 180-345. Recommended: 180-355) (Not open to students who have taken 180-493.) Basic hypotheses of statistical thermodynamics; ideal monatomic, diatomic and polyatomic gases; Einstein and Debye models of solids; statistical theory of black-body radiation; Debye-Hückel theory of electrolyte solutions; absolute reaction rate theory of rate processes; theories of solutions. **Professor Eu**

180-597A ANALYTICAL SPECTROSCOPY. (3) (2 lectures; 3 hours lab) (Prerequisites: 180-367 and 180-377, or permission of instructor.) The design and analytical use of spectroscopic instrumentation with respect to fundamental and practical limitations. Classical emission, fluorescence, absorption and chemical luminescence. Topics may include photo-acoustic spectroscopy, multielement analysis, X-ray fluorescence and modern multiwavelength detector systems. **Professors Salin and Power**

● **180-603A INFRARED AND RAMAN SPECTROSCOPY.** (5)

● **180-611A INORGANIC TOPICS II.** (4) (Restricted to graduate students in Chemistry.)

180-612B ORGANOMETALLIC CHEMISTRY. (5) (Restricted to graduate students in Chemistry.) A first course at the graduate level in organometallic chemistry. The theory and practice of the field is treated starting from basic principles of inorganic and organic chemistry. **Professor Arndtsen**

180-621A RECENT ADVANCES IN ORGANIC CHEMISTRY. (5) A systematic survey of the mechanisms of the most common organic reactions from studies of reactions in the current literature. **Professor Gleason**

● **180-622B HETEROCYCLIC COMPOUNDS.** (5)

180-623A ORGANIC STEREOCHEMISTRY. (5) Recent advances in conformational analysis, with particular reference to steroids, alkaloids, and carbohydrates, application of optical rotation, rotary dispersion, u.v., i.r., and n.m.r. spectroscopy to conformational problems. **Professor Kazlauskas**

● **180-624A SPECIAL TOPICS IN ORGANIC CHEMISTRY.** (4)

● **180-626D THE FUNDAMENTALS OF MEDICINAL CHEMISTRY.** (4)

180-627B SPECIAL TOPICS II. (5) An advanced course on subjects of current interest in chemistry. For graduate students only, given at the same time as 180-572B. **Professor Just**

● **180-628B RECENT ADVANCES IN THE ORGANIC CHEMISTRY OF BIOLOGICAL COMPOUNDS.** (4)

180-631D SELECTED TOPICS IN ANALYTICAL CHEMISTRY. (4) A directed reading course with individual student-professor conferences, and intended mainly for students specializing in analytical chemistry. Topics are chosen to meet the individual needs of each student. **Professor Salin and Analytical Staff**

180-636A,B CHEMICAL LABORATORY AUTOMATION II. (5) (Prerequisite: 180-547B) Students will undertake a chemical laboratory automation project. Design and implementation problems will be discussed by the students in seminars and advanced topics in automated chemical instrumentation will be presented. Several experiments will be required. **Professor Salin**

180-643A ORGANIC CHEMISTRY OF WOOD COMPONENTS. (4) The course concerns the organic chemistry of the wood components with emphasis on their biosynthesis and biodegradation, isolation and structural elucidation, analysis, synthesis and reactions. **Professors Argyropoulos and Marchessault**

180-645A,B,D QUANTUM MECHANICS. (5) Brief review of solvable problems in non relativistic quantum mechanics; theory of many-electron systems and its application to molecules and atoms. Additional topics are chosen to meet the interests of the students. **Professor Whitehead**

● **180-646A STATISTICAL MECHANICS.** (4)

180-650A SEMINARS IN CHEMISTRY (1) (1 seminar) (Required of first year graduate students in Chemistry.) A seminar course designed for graduate students in chemistry which in conjunction with McGill Chemical Society will provide exposure to a broad range of special topics within the discipline.

180-651B SEMINARS IN CHEMISTRY (1) (1 seminar) (Required of first year graduate students in Chemistry.) A seminar course designed for graduate students in chemistry which in conjunction with McGill Chemical Society will provide exposure to a broad range of special topics within the discipline.

180-655B ADVANCED NMR SPECTROSCOPY. (4) (1 lecture) (Prerequisite: 180-555 or equivalent.) Advanced techniques of nuclear magnetic resonance spectroscopy, Fourier transform methods, multiple pulsing, two-dimensional pulse sequencing. **Professor Reven**

180-661A LITERATURE REVIEW AND RESEARCH PROPOSAL. (3) (Restricted to graduate students in Chemistry.) Students will review the relevant literature concerning their particular area of research and describe plans for future work with professors of the division. **Professor Hogan and Inorganic staff**

180-662A RESEARCH REPORT I. (3) (Restricted to graduate students in Chemistry.) Students will prepare a research proposal, and give a seminar with professors of the division. **Professor Hogan and Inorganic staff**

180-666D SPECIAL TOPICS. (6) Critical and original essays are required on various subjects of current interest in chemistry. **Staff**

180-667A,B SPECIAL TOPICS. (4) Critical and original essays are required on various subjects of current interest in chemistry. **Staff**

● **180-671B ORGANIC CHEMISTRY OF SYNTHETIC POLYMERS.** (4)

180-672B THE POLYMER SOLID STATE. (4) Melting and crystallization phenomena in linear high polymers; crystal structure, defects, and morphology in macromolecular crystals. **Professor Manley**

● **180-673B POLYMERS IN SOLUTIONS.** (4)

180-674A INTRODUCTORY PHYSICAL CHEMISTRY OF POLYMERS. (4) A survey course on the structure of polymers; kinetics and mechanisms of polymer synthesis; molecular weight distributions; polymer configurations and the thermodynamics of polymer solutions; rubber, elasticity, osmometry and viscosity. **Professor Marchessault**

180-675A MECHANICAL PROPERTIES AND RHEOLOGY OF POLYMERS. (4) Mechanical properties of polymers; glass transition, visco-elasticity, rubber elasticity, failure. Relation to molecular properties, mechanical spectroscopy, dielectric properties, birefringence. **Professor Eisenberg**

● **180-678B POLYMER KINETICS.** (5) (Restricted to graduate students in Chemistry or Chemical Engineering or permission of instructors.)

● **180-681A SELECTED TOPICS IN RADIOCHEMISTRY.** (4)

● **180-682D NUCLEAR CHEMISTRY.** (6)

180-686A WET-END PAPERMAKING CHEMISTRY. (3) (Restricted to graduate students in Chemistry or Chemical Engineering or permission of instructor.) (Prerequisites 180-543C and 180-585C) Review of the chemistry of various additives used in papermaking, such as wet and dry strength agents, sizing agents, fillers, filler retention aids, antifoam agents, biocides, dyes, dewatering agents, drainage and formation aids. The course also addresses the chemistry of deinking of waste papers and the treatment of effluents. **Professor van de Ven**

180-691A,B,C M.SC. THESIS RESEARCH. (3) Independent research work leading to writing of M.Sc. thesis for final submission to the Faculty of Graduate Studies and Research. **Staff**

180-692A,B,C M.SC. THESIS RESEARCH. (6) Independent research work leading to writing of M.Sc. thesis for final submission to the Faculty of Graduate Studies and Research. **Staff**

180-693A,B,C M.SC. THESIS RESEARCH. (9) Independent research work leading to writing of M.Sc. thesis for final submission to the Faculty of Graduate Studies and Research. **Staff**

180-694A,B,C M.SC. THESIS RESEARCH. (12) Independent research work leading to writing of M.Sc. thesis for final submission to the Faculty of Graduate Studies and Research. **Staff**

180-695A,B,C M.SC. THESIS RESEARCH. (15) Independent research work leading to writing of M.Sc. thesis for final submission to the Faculty of Graduate Studies and Research. **Staff**

180-696A,B,C M.SC. THESIS RESEARCH. (6) Independent research work leading to writing of M.Sc. thesis for final submission to the Faculty of Graduate Studies and Research. **Staff**

180-697A,B,C M.SC. THESIS RESEARCH. (9) Independent research work leading to writing of M.Sc. thesis for final submission to the Faculty of Graduate Studies and Research. **Staff**

180-698A,B,C M.SC. THESIS RESEARCH. (12) Independent research work leading to writing of M.Sc. thesis for final submission to the Faculty of Graduate Studies and Research. **Staff**

180-699A,B,C PROJECT. (15) Restricted to students in the M.Sc. (Applied) program in Chemistry and designed to give them practical experience through a four-month project in some aspect of chemical industry **Professor Gray**

180-720D COLLOQUIUM. Each student is required to participate in Research Colloquia which are held regularly in the Department. These involve the presentation and discussion of papers dealing either with the student's own research or with recent research publications.

180-721A,B ORGANIC CHEMISTRY RESEARCH SEMINAR. (3) Upon completion of the organic cumulative examinations, students will present a seminar on their research work (including background and future plans). **Professor Gleason, Coordinator**

180-763A RESEARCH REPORT II. (3) (Restricted to graduate students in Chemistry.) Students will present a seminar on a complete or nearly complete research project and discuss these results with professors of the division. **Professor Hogan and Inorganic staff**