UNIVERSITY COLLEGE DUBLIN

NATIONAL UNIVERSITY OF IRELAND, DUBLIN

SCIENCE

SESSION 2001/2002

CONTENTS

CONTENTS (Contd.)

POSTGRADUATE PROGRAMMES

CONTENTS (Contd.)

ACADEMIC ADVISORY MEETINGS

First Science Students: Wednesday, 12 September 2001 - 2.45 p.m., Theatre A.

First Science students must attend this meeting. The advisory meeting commences with a talk from the Dean in Theatre A, Science Lecture Building. Representatives of the Science Departments will be available on the Science Lecture Building concourse during the afternoon for consultation on the course options in Science. While First Science students register before the start of the academic year, they are not required to finalise their subject choices until the end of the first week of term. Students register their subject choices with the Faculty Office during the week 21 September 2001.

Pre-Second Science: Wednesday, 20 February 2002 – 2.00 p.m., Theatre A.
Additional information may be available from some departments around this time.

Third Science Students: Friday, 14 September 2001 - 2.30 p.m., Theatre A.

Third Science students must attend this meeting. The advisory meeting commences with a talk from the Dean in Theatre A, Science Lecture Building. Academic staff will be available on the Science Lecture Building concourse during the afternoon for consultation on the selection of course units. Students must complete and have staff sign their Course Registration Forms. Registration is completed when these forms have been handed into the Science Faculty Office on Tuesday, 18 September 2001.

DATES FOR ACADEMIC SESSION 2001/2002

Michaelmas Term (First Semester):	17 September 2001 - 7 December 2001
Hilary/Trinity Terms (Second Semester):	7 January 2002 – 9 March 2002
	2 April 2002 – 19 April 2002

LIST OF STAFF

FACULTY OFFICE

Telephone No. 716 2355 *Fax No. 716 2439*

Dean of the Faculty:	Professor Michael J. Kennedy
Associate Dean (Postgraduate):	Professor Stephen Mayhew
Associate Dean (First Year):	Bret Danilowicz, BSc, PhD
Faculty Administrator:	Gillian Goodbody
Faculty Administrative Assistant:	Sue Philpott

BIOCHEMISTRY

Telephone No. 7161547 *Fax No. 2837211*

Head of Department	Professor Paul C. Engel
Professor of Biochemistry	Paul C. Engel, BA *(Oxon),* DPhil *(Oxon)*
Associate Professor of Biochemistry	Stephen G. Mayhew, BSc *(Sheffield)*, PhD *(Sheffield)* J. Paul G. Malthouse, BSc *(Lond)*, PhD *(Lond)*
Lecturer in Biochemistry	B. Therese Kinsella, BSc, PhD* Bartholomew Masterson, BSc, PhD
College Lecturer	Geraldine Butler, BA *(Dub)*, PhD *(Dub)* Gethin McBean, BA *(Dub),* PhD *(Dub)* Joan M. Manning, MSc *(Manchester)*, PhD *(Manchester)* Philip Newsholme, BSc *(Birm)*, DPhil *(Oxon)* Margaret Worrall, BA *(Dub),* PhD *(Cantab)*
Departmental Secretary:	Annette Forde

* *Where degrees have been awarded by the National University of Ireland, the awarding university is omitted. In every other case the awarding university is listed in brackets.*

BOTANY

Telephone No. 7162253 Fax No. 7161153

Head of Department	Professor Martin W. Steer
Professor of Botany	Martin W. Steer, BSc *(Bristol)*, PhD *(QUB)*, DSc *(Bristol)*, MRIA, FRMS, MIBiolI, PresMSI
Associate Professor of Botany	Gerard Doyle, BSc, PhD, MIBiolI
Lecturer in Botany	Derek T. Mitchell, BSc *(Sheffield)*, PhD *(Sheffield)* Bruce A. Osborne, BA *(Stirling)*, PhD *(Nottingham)* James White, BSc, MSc *(Wales)*, DSc
College Lecturer	Hubert Fuller, BSc Marinus L. Otte, MSc *(Vrije),* PhD *(Vrije)* Graham Wilson, BSc *(Lond)*, PhD *(Birm)*
College Lecturer (Molecular Genetics)	Thomas F. Gallagher, BSc, PhD
Departmental Secretary:	Jane Flaherty

CELL AND MOLECULAR BIOLOGY

Telephone No. 7162253 Fax No. 7161153

Course Director	Professor Martin W. Steer

CHEMISTRY

Telephone No. 7162165 Fax No. 7162127

Head of Department and Director of Laboratories (2000 - 2002)	Professor Rory More O'Ferrall
Professor of Organic Chemistry	A. Francis Hegarty, PhD, DSc, FRSC, MRIA
Professor of Physical Chemistry	Kenneth A. Dawson, MSc *(QUB)*, DPhil *(Oxon),* MRIA

Associate Professor of Chemistry	Donald Fitzmaurice, BSc, PhD (*leave of absence)* Rory A. More O'Ferrall, PhD *(Lond)* Robert O'Neill, BSc, PhD Howard W. Sidebottom, PhD *(St. Andrew's)*
Associate Professor of Inorganic Chemistry (Organometallic Chemistry)	Anthony R. Manning, PhD *(Manchester)*
Lecturer in Chemistry	Raphael D. Darcy, PhD, FICI William K. Glass, PhD *(QUB)*, CChem, FRSC Earle W. Waghorne, PhD *(ANU)*
Lecturer in Inorganic Chemistry	Noel J. Fitzpatrick, PhD, FICI
College Lecturer	Vitaly Buckin, MSc (*Moscow*), PhD (*Acad.Sci. USSR)* Michael Casey, BSc, PhD *(Lond)*, DIC Declan G. Gilheany, BSc *(QUB)*, PhD *(QUB)* Patrick J. Guiry, BSc, PhD Paul V. Murphy, BSc, PhD Donal O'Shea, BSc, PhD Wilhelm Risse, Vordiplom *(Marburg),* Diplom *(Marburg),* PhD *(Bristol)* Matthias Tacke, Diplom *(Münster),* PhD *(Münster)* Edward G. Timoshenko, MSc *(Moscow),* PhD *(Moscow)*
Assistant Lecturer	Grace Morgan, BSc *(QUB),* PGCE *(QUB),* PhD *(OU)* (*temporary appointment: 1999-2001)*
Departmental Secretary:	Kathy Murphy

COMPUTER SCIENCE

Telephone No. 7162469 Fax No. 2697262

Head of Department	Professor Mark T. Keane
Professor of Computer Science	Mark T. Keane, BA, MA (Dub), PhD (Dub)
Lecturer in Computer Science	Ahmed Patel, MSc *(Dub)*, PhD *(Dub)*
College Lecturer	Julie Berndsen, MA *(Dub),* DPhil *(Bielefeld)* Joseph Carthy, BSc Arthur W.S. Cater, BA *(Cantab)*, PhD *(Cantab)* Fred Cummins, BA *(Dub),* MA *(Indiana),* PhD (*Indiana)* Damian Dalton, BSc John Dunnion, MSc

College Lecturer (contd)	Franz H. Geiselbrechtinger, Diplom Mathematiker *(Tech. Univ. Munich)*, Drrernat *(Munich)* Neil Hurley, MSc, PhD *(Dub)* M-Tahar Kechadi, BEng *(Algeria),* DEA *(Lille),* MSc *(Lille),* PhD *(Lille)* Nicholas Kushmerick, BSc *(Washington)*, MS *(Washington)*, PhD *(Washington)* Henry B. McLoughlin, BSc Mel Ó Cinneide, MSc Gregory O'Hare, MSc *(Ulster)* Ronan Reilly, BSc, PhD Michael Sherwood-Smith, BSc *(St. Andrews)*, PhD Barry Smyth, BSc, PhD *(Dub)*
Departmental Secretary:	Patricia Geoghegan

ENVIRONMENTAL BIOLOGY

Programme Director:	Professor Gerard Doyle
Botany	Professor Gerard Doyle *Telephone No. 7162252*
Industrial Microbiology	Evelyn M. Doyle, BSc, PhD *Telephone No. 7161300*
Zoology	Thomas Bolger, BSc, PhD *Telephone No. 7162330*

ENVIRONMENTAL GEOCHEMISTRY

Telephone No. 716 2327

Programme Director:	J. Stephen Daly, BA (Dub), PhD (Keele), FGS

EXPERIMENTAL PHYSICS

Telephone No. 7162210 *Fax No. 2837275*

Acting Head of Department (1999-2001)	Professor Peter I. Mitchell
Professor of Experimental Physics	Vacant

Associate Professor of Experimental Physics	David J. Fegan, MSc, PhD, MRIA Brian P. McBreen, BSc, PhD, MRIA Peter I. Mitchell, BSc, PhD, CPhys, FInstP Gerard O'Sullivan, BSc, PhD, CPhys, MInstP
Lecturer in Experimental Physics	Ann Breslin, MSc *(Lond),* PhD, CPhys, MInstP James P. McLaughlin, MSc, PhD, CPhys, FInstP John A. Scott, MSc, PhD, CPhys, FInstP
College Lecturer	Padraig Dunne, BSc, PhD, CPhys, MInstP Hugh M. Grimley, BSc, PhD *(QUB)* Lorraine Hanlon, MSc, PhD Michael Hoey, BSc, PhD *(QUB*) Luis Leon Vintro, BSc *(Barcelona)*, PhD Eón Ó Mongáin, MSc, PhD Emma Sokell, BA *(Oxon),* PhD *(Manchester)*
Assistant Lecturer	John Quinn, BSc, PhD
Departmental Secretary:	Marian Hanson

GENETICS

Director Genetics Teaching Programme: Geraldine Butler, BA (*Dub*), PhD (*Dub*)

Biological Subject Co-ordinators:

Biochemistry	Dr G. Butler *Telephone No. 7161583*
Botany	Dr T. Gallagher *Telephone No. 7162342*
Industrial Microbiology	Dr P. Caffrey *Telephone No. 7161396*
Pharmacology	Dr F. Martin *Telephone No. 7162808*
Zoology	Dr M. Rogers *Telephone No. 7162806*

GEOLOGY

Telephone No. 7162331 *Fax No. 2837733*

Head of Department (1999-2002)	Professor Patrick M. Shannon
Professor of Geology	Michael J. Kennedy, MA *(Dub)*, PhD *(Dub),* FGS, CGeol
Associate Professor of Geology	Patrick M. Shannon, BSc, PhD, FInstPet

Lecturer in Geology	J. Stephen Daly, BA *(Dub)*, PhD *(Keele),* FGS Ian D. Somerville, BSc *(QUB)*, PhD *(QUB),* FGS
College Lecturer	Christopher J. Bean, BA, MSc, PhD *(Dub)* Peter Haughton, BA *(Dub),* PhD *(Glasgow)* P. Frank McDermott, PhD *(Open University)* Julian F. Menuge, BSc *(Leicester)*, PhD *(Cantab)*
Departmental Secretary:	Sarah Procter

GEOPHYSICAL SCIENCE

Telephone No. 716 2140

Programme Director:	Christopher J. Bean, BA, MSc, PhD *(Dub)*

INDUSTRIAL MICROBIOLOGY

Telephone No. 7161512 Fax No. 7161183

Acting Head of Department	Professor Catherine T. Kelly
Professor of Industrial Microbiology	-
Associate Professor of Industrial Microbiology	Catherine T. Kelly, BSc, PhD
Lecturer in Industrial Microbiology	Caroline Hussey, BSc, PhD *(Dub)*
College Lecturer	John P. Caffrey, BA *(Dub),* PhD *(Dub)* Nicholas J.W. Clipson, BSc *(Newcastle),* DPhil *(Sussex)* Evelyn M. Doyle, BSc, PhD James Bailey Gillespie, BA *(Oxon)*, PhD *(UWO)* Aiden J. McLoughlin, BSc, PhD Wim Meijer, MSc *(Groningen),* PhD *(Groningen)* Mary E. Upton, MSc, PhD
Departmental Secretary:	Geraldine Neylan

MATHEMATICS

Telephone No. 7168265 Fax No. 7161196

Head of Department (1999-2002)	Professor David Lewis
Professor of Mathematics II	Sean Dineen, DSc, PhD *(Maryland)*
Associate Professor of Mathematics (Algebra)	Thomas J. Laffey, MSc, DPhil *(Sussex)*, MRIA
Associate Professor of Mathematics	Stephen J. Gardiner, MSc *(QUB)*, PhD *(QUB),* DSc *(QUB)* Roderick I.S. Gow, BA *(Cantab)*, PhD *(Liverpool)* David Lewis, BSc, PhD, DSc
Lecturer in Mathematics	Wayne G. Sullivan, BS *(Georgia Inst. Tech.)*, DPhil *(Oxon)*
College Lecturer	Christopher Boyd, BA *(Dub),* MSc *(Dub),* PhD Russell J. Higgs, BA *(Liverpool)*, PhD *(Liverpool)* Kevin Hutchinson, MA, PhD *(Cornell)* Mícheál S.A. Ó Searcóid, BSc *(Lond)*, HDip in Ed *(Dub)*, MSc, PhD J.B. Quigley, MSc, PhD *(Indiana)* David A. Tipple, MSc, PhD *(Manchester)*
Departmental Secretary:	Breda McMahon

MATHEMATICAL PHYSICS

Telephone No. 7168266 Fax No. 7161172

Head of Department	Professor Joseph V. Pulé
Professor of Mathematical Physics	-
Associate Professor of Mathematical Physics	Peter Hogan, MSc, PhD Adrian C. Ottewill, BA *(Oxon)*, DPhil *(Oxon),* DSc *(Oxon), MRIA* Joseph V. Pulé, BSc *(Malta)*, DPhil *(Oxon)*, DSc *(Oxon)*, MRIA
College Lecturer	Daniel A. Birmingham, BA *(Dub),* PhD *(Dub)* Edward A. Cox, BSc *(QUB)*, MSc, PhD Peter Duffy, BA *(Dub),* PhD *(Dub)*
Departmental Secretary:	Bridget Mangan

MATHEMATICAL SCIENCE

Telephone No. 7168225 *Fax No. 7161172*

Course Director: Professor Joseph Pulé

OCCUPATIONAL SAFETY AND HEALTH

Telephone No. 7161406 *Fax No. 2830669*

Course Director: Dr Caroline Hussey

PHARMACOLOGY

Telephone No. 7161557 *Fax No. 2692749*

Head of Department	Professor Michael P. Ryan
Professor of Pharmacology	Michael P. Ryan, BSc, PhD
Associate Professor of Pharmacology	Ciaran M. Regan, BSc, PhD Finian M. Martin, BSc, PhD
Lecturer in Pharmacology	Alan W. Baird, BSc *(Glasgow)*, PhD *(Lond),* MIBiol Alan K. Keenan, BSc, PhD Kathy O'Boyle, BSc, PhD
College Lecturer	Carmel Hensey, BSc, PhD Paul Moynagh, BA *(Dub)*, PhD Kay Ohlendieck, MSc *(Konstanz),* PhD
Departmental Secretary:	Colette O'Beirne

PHYSIOLOGY

Telephone No. 7167310 Fax No. 7167417

Professor of Physiology and Histology	Ronan G. O'Regan, MD, BCh, BAO, BSc, PhD, MRIA
Associate Professor of Physiology	Paul McLoughlin, MB, BCh, BAO, BSc, PhD *(Lond)*, MRCPI
Lecturer in Physiology	John B. Moynihan, BSc, PhD John O'Connor, BA *(Dub),* PhD *(Dub)*
College Lecturer	Stuart Bund, BSc (*Leicester*), PhD (*Leicester*) Helen Harty, BSc (*Sheffield*), PhD (*QUB*) Caroline Herron, BSc *(Southampton),* PhD *(Southampton)* Christian Holscher, Diploma in Zoology *(Tübingen),* PhD *(Open University) (Temporary appointment: 1997-2002)* James F.X. Jones, MB, BCh, BAO, BSc, PhD Philip Nolan, MB, BCh, BAO, BSc Noel McCaffrey, MB, BChg, BAO, Dip Sport Med *(Lond)*
Departmental Secretary:	Geraldine Duggan

PLANT GENETIC ENGINEERING

Telephone No. 7162342 Fax No. 7161153

Course Director	Dr Thomas Gallagher

STATISTICS

Telephone No. 7167152 Fax No. 7161186

Professor of Statistics	Philip J. Boland, BSc *(Le Moyne)*, MA *(Rochester)*, PhD *(Rochester),* DSc
Lecturer in Statistics	John F.M. Connolly, BSc, HDip in Ed, MSc *(Reading)*, PhD *(Dub)* Adrian Dunne, BSc *(Lond)*, PhD *(Dub)* David H. Williams, BA, MSc, PhD *(Manchester)*
College Lecturer	Gareth Colgan, FIA Gabrielle E. Kelly, MSc, PhD *(Stanford)*
Departmental Secretary:	Marie Doyle

THEORETICAL PHYSICS

Programme Directors:

Experimental Physics	Professor Peter Mitchell *Telephone No. 716 2210*
Mathematical Physics	Professor Joseph Pulé *Telephone No. 716 8225*

ZOOLOGY

Telephone No. 716 2265 *Fax No. 716 1152*

Professor of Zoology	Edward J. Duke, BSc, PhD *(QUB)*, DSc
Lecturer in Zoology	Thomas M. Bolger, BSc, PhD Thomas J. Hayden, BSc, PhD Patrick Joyce, BSc, PhD Declan Murray, BSc, PhD Mark Rogers, BA *(Dub),* PhD *(Glasgow)* Michael F. Ryan, BSc, PhD *(Lond)*
College Lecturer	Bret S. Danilowicz, BSc *(Syracuse),* PhD (*Duke*) Catherine M. Nolan, BSc, PhD
Departmental Secretary:	Dorothy Allen

UNDERGRADUATE PROGRAMMES

The following undergraduate degree programmes are offered in the Faculty of Science:

FOUR-YEAR DEGREES:-

BACHELOR OF SCIENCE (BSc) HONOURS IN COMPUTER SCIENCE
BACHELOR OF SCIENCE (BSc) HONOURS IN MATHEMATICAL SCIENCE
BACHELOR OF SCIENCE (BSc) HONOURS IN THEORETICAL PHYSICS
BACHELOR OF SCIENCE (BSc) – SINGLE HONOURS offered in the following subjects:

Biochemistry
Botany
Chemistry
Computer Science
Experimental Physics
Geology
Industrial Microbiology
Mathematics
Mathematical Physics
Pharmacology
Physiology
Psychology (See Note on page 98)
Statistics
Zoology

BACHELOR OF SCIENCE (BSc) – JOINT HONOURS
offered as follows:

Genetics and Biological Subject
Genetics and one of the following biological subjects: Biochemistry, Botany, Industrial Microbiology, Pharmacology, Zoology.

Any two subjects in the Science Programme
Joint Honours Degrees may be taken in any two subjects offered in the Faculty of Science, provided the student has qualified to proceed to the Honours course in both subjects and has the approval of the two Departments concerned.

BACHELOR OF SCIENCE (BSc) TOPICAL DEGREE – HONOURS OR GENERAL
offered in the following areas:

Cell and Molecular Biology
Environmental Biology
Geophysical Science
Environmental Geochemistry
Plant Genetic Engineering

The BSc Topical Degree may be awarded as a General BSc Degree, following **three years** of study, or as an Honours BSc Degree, following **four years** of study.

THREE-YEAR DEGREES:

BACHELOR OF SCIENCE (BSc) - ONE SUBJECT GENERAL OR TWO SUBJECT GENERAL offered in either one or two of the following subjects:

- **Biochemistry**
- **Botany**
- **Chemistry**
- **Computer Science**
- **Experimental Physics**
- **Geology**
- **Industrial Microbiology**
- **Mathematics**
- **Mathematical Physics**
- **Pharmacology**
- **Physiology**
- **Psychology (See Note on page 98)**
- **Statistics**
- **Zoology**

BACHELOR OF SCIENCE (BSc) in Occupational Safety and Health

PART-TIME DEGREE:

BACHELOR OF SCIENCE (BSc) in Occupational Safety and Health Management

EXAMINATION REGULATIONS FOR UNDERGRADUATE SCIENCE STUDENTS

Regulations governing all examinations are contained in *MARKS AND STANDANDS.* Students should consult this publication, copies of which are available in the Library.

COURSE REGULATIONS FOR UNDERGRADUATE SCIENCE STUDENTS

- ***Students should be aware that syllabus changes may be initiated at any time during their course of study at University College Dublin.***
- ***Students entering the Faculty of Science are notified that entry to subjects in all years is dependent on the availability of places. Where more students indicate preferences than there are places, allocation will be made by Faculty on the basis of academic performance.***

REGULATIONS FOR FIRST YEAR SCIENCE STUDENTS

ADVISORY MEETING FOR FIRST YEAR SCIENCE STUDENTS

Wednesday, 12 September 2001 - 2.45 p.m., Theatre A, Science Lecture Building.
The purpose of this meeting is to advise students on their individual choice of courses. First Science students must attend this meeting.

1. SELECTION OF COURSES

Students entering First Science must select **four** First Science subjects from among Biology, Chemistry, Computer Science, Experimental Physics, Geology, Mathematics and Mathematical Physics. They must attend for one academic year and present themselves for examination. The following combinations of First Science subjects are available:

First Science Subject Combinations

Combination Number	First Science Subjects						
	Biology	Chemistry	Comp Science	Exp Physics	Geology	Math	Math Physics
A•	*	*		*		*	
B		*		*		*	*
C		*		*	*	*	
D	*	*			*	*	
E				*	*	*	*
F			*	*		*	*
G	*	*	*			*	
H		*	*		*	*	
I			*	*	*	*	
J		*	*	*		*	
K			*		*	*	*
L		*			*	*	*
M		*	*			*	*
N	*			*	*	*	
O	*		*	*		*	

- *Students wishing to pursue a BSc in Occupational Safety and Health must take Combination A.*

No other combination is acceptable.

Students in the Mathematical Science denominated entry programme must select from the First Science subject groupings F, K or M.

Students in the Theoretical Physics denominated entry programme must select from the First Science subject groupings B, E or F.

Students in the Computer Science denominated entry programme must select the two First Science Computer Science courses (COMP 1001, 1002), Mathematics and *one* of the following subjects: Biology, Chemistry, Experimental Physics or Mathematical Physics.

2. EXAMINATIONS

The First University Examination in Science is completed in the Summer. A Supplemental Examination is held in the Autumn. (The regulations governing this examination are contained in *Marks and Standards,* available for consultation in the Library.) Departments may hold examinations and continuous assessments throughout the year.

Award of Honours at Examinations

Honours are awarded at the Summer Examination only. General papers are set in Biology, Chemistry, Computer Science, Experimental Physics, Geology and Mathematical Physics. Honours may be awarded if the appropriate standards are reached. To be eligible for Honours in Mathematics candidates must take the Honours paper in that subject. Repeat students are not eligible for Honours.

Exemption

Students who fail the examination as a whole but reach a passing grade in at least two subjects, will be exempt from further examination in those subjects. Where exemptions have been given, the remaining subject(s) must be passed at the same examination.

Pass by Compensation

Students may be allowed to pass their First Science Examination by passing three subjects (minimum 40%), and achieve 35-39% in the fourth subject, where the deficiency is compensated by excess marks in the other subjects.

Two-Year Rule

Students who do not complete the First University Examination in Science within two years from the date of entering the courses will be ineligible to remain in the Faculty of Science. Exemption from this regulation may be granted for grave reasons by the Academic Council on the recommendation of the Faculty of Science.

3. RE-ATTENDANCE AT FIRST SCIENCE

Students must apply to the Faculty of Science for permission to reattend First Science courses. Students will not be permitted to re-attend practical classes except for grave reasons and on the recommendation of the Faculty of Science.

4. SPECIAL REQUIREMENTS FOR FIRST YEAR STUDENTS WISHING TO PROCEED TO SOME SECOND YEAR COURSES

Computer Science

Students should be aware that they will not be permitted to enter the Second Year course in Computer Science unless they have gained a clear pass in Computer Science in the First Science Examination.

Four Year Honours Degree in Mathematics

Students wishing to pursue a Four-Year Honours Degree in Mathematics are required to attend the honours course in that subjects in First and subsequent years. In order to proceed to the honours course in Second Science, a qualifying mark of at least 50% in the subject concerned must be obtained in the First Science examination, Summer or Autumn.

Four Year Honours Degree in Mathematical Physics

Students wishing to pursue a Four-Year Honours Degree in Mathematical Physics are required to attend the honours course in that subject in Second and subsequent years. In order to proceed to the honours course in Second Science, a qualifying mark of at least

50% in the subject must be obtained in the First Science examination, Summer or Autumn.

Mathematical Science
Students in the Mathematical Science stream must pass the First Science examination and obtain a minimum of 50% in the Honours courses in Mathematics and 50% in the Mathematical Physics course. Students of Mathematical Science passing the First Science examination but gaining marks below these requirements revert to the General Science stream in Second Year.

Theoretical Physics
Students in the Theoretical Physics stream must pass the First Science examination and obtain a minimum of 55% in the Experimental Physics course, 50% in the Honours course in Mathematics and 55% in the Mathematical Physics course. Students of Theoretical Physics passing the First Science examination but gaining marks below these requirements revert to the General Science stream in Second Year.

ADMISSION TO SECOND YEAR SCIENCE SUBJECTS

ADVISORY MEETING FOR PRE-SECOND YEAR SCIENCE STUDENTS

Wednesday, 20 February 2002 - 2.00 p.m., Theatre A, Science Lecture Building.

The purpose of this meeting is to advise students on selecting their courses for Second Science. First Science students must attend this meeting.

- ***All First Science students must indicate their preference by completing an* Application for Admission to Second Science Subjects Form*. These forms are***
- ***available from the Faculty Office following the advisory meetings and must be returned as directed.***
- ***Students will be assigned to Second Science subjects by the Faculty based on the results of the First Science examinations.***
- ***Although every effort is made to accommodate students in the subjects of their choice, entry to a number of the Second Science subjects is limited owing to laboratory space and staffing restrictions.***

Supplemental advisory sessions may be arranged by some Departments around this time.

REGULATIONS FOR SECOND YEAR SCIENCE STUDENTS

1. ADMISSION TO SECOND SCIENCE

Students must have passed the First University Examination in Science.

2. TRANSFERRING FROM OTHER UCD FACULTIES TO SECOND SCIENCE

Such transfers are dependent on the availability of places in Second Science.

Actuarial and Financial Studies Students
Actuarial and Financial Studies students in the Faculty of Commerce wishing to transfer to Second Science in Computer Science, Mathematics and Statistics must have passed their First University Examination. Application for such acceptance must be made to the Faculty of Science.

Engineering Students
Engineering students wishing to transfer to Second Science must pass their First University Examination in Engineering and with the permission of the Faculty of Science may proceed to subject combinations that include three of the following: Chemistry, Experimental Physics, Mathematics, Mathematical Physics, Statistics. Applications for such acceptance must be made to the Faculty of Science.

3. SELECTION OF SUBJECTS

Students in Second Science study **three subjects.** Each subject consists of **four course units**, i.e. students take a **total of 12 units**. Each unit comprises **48 contact hours** (maximum) made up of lectures, laboratory practicals, field practicals and/or tutorials. Examination papers in any subject may be designed to test integrated knowledge, i.e. a single question may require knowledge drawn from more than one unit in that subject.

Second Science subjects are offered in Sets. Some subjects may have prerequisite First Science subjects. Students select three subjects, one from three of these Sets.

Table 1. Second Science Sets

Set I
Mathematics

Set 2
Mathematical Physics, Zoology

Set 3
Botany, Experimental Physics, Pharmacology

Set 4
Chemistry

Set 5
Computer Science, Industrial Microbiology, Physiology

Set 6
Biochemistry, Geology, Statistics

Table 2. First Science Pre-requisites for admission to Second Science Subjects

Second Science Subjects	**First Science Subjects**						
	Biol	Chem	CS	EP	Geol	M	MP
Biochemistry	*	*					
Botany	*						
Chemistry		*				*	
Computer Science			*			*	
Experimental Physics				*		*	
Geology					*		
Industrial Microbiology	*	*					
Mathematics						*	
Mathematical Physics						*	*
Pharmacology	*	*					
Physiology	*	*					
Statistics						*	
Zoology	*	*					

Table 3. Second Science Subjects which may be taken together

	Biochem	Botany	Chem	Comp Sci	Exp Phys	Geology	Ind Micro	Maths	M Phys	Pharm	Physiol	Stats	Zoology
Biochem		YES	YES		YES		YES	YES		YES	YES		YES
Botany	YES		YES	YES		YES	YES	YES					YES
Chemistry	YES	YES		YES	YES	YES	YES	YES	YES	YES		YES	YES
Comp Sci		YES	YES		YES	YES		YES	YES			YES	YES
Exp Phys	YES		YES	YES		YES		YES	YES		YES	YES	
Geology		YES	YES	YES	YES			YES	YES				YES
Ind Micro	YES	YES	YES					YES		YES		YES	YES
Maths	YES	YES	YES	YES	YES	YES	YES		YES	YES	YES	YES	YES
M Physics			YES	YES	YES	YES		YES				YES	
Pharm	YES		YES				YES	YES			YES	YES	YES
Physiol	YES		YES		YES			YES		YES		YES	
Statistics			YES	YES	YES		YES	YES	YES	YES	YES		YES
Zoology	YES	YES	YES	YES		YES	YES	YES		YES		YES	

- Subjects listed in the first column may only be paired with subjects listed along the top row as indicated by "YES". Biochemistry CAN be taken with Botany, Chemistry, Experimental Physics, Industrial Microbiology, Mathematics, Pharmacology, Physiology or Zoology; Biochemistry CANNOT be taken with Computer Science, Geology, Mathematical Physicsy or Statistics.
- Having selected two subjects, check that your third choice can be taken **with both**, e.g. should you chose Botany and Zoology, you cannot take Statistics (Botany and Statistics are not a valid combination).
- No other combinations will be allowed. Some combinations may be excluded by the Timetable.
- Students taking Experimental Physics must also take Mathematics.
- Students taking Experimental Physics with Physiology cannot also take Biochemistry.
- Students taking Computer Science must also take Mathematics.
- Zoology cannot be taken with both Mathematics **and** Statistics.

4. SPECIAL REQUIREMENTS FOR SECOND YEAR STUDENTS WISHING TO PROCEED TO SOME THIRD YEAR HONOURS COURSES

In selecting their subjects, students should be aware of additional requirements for entry to some Third Science Honours courses.

- **Biochemistry**: Students wishing to pursue an Honours Degree in Biochemistry are recommended, but not required, to take Chemistry in second year.
- **Industrial Microbiology**: Students wishing to proceed to an Honours Degree in Industrial Microbiology are recommended to take Chemistry in second year.

5. SECOND SCIENCE COMPUTER SCIENCE (DENOMINATED ENTRY) PROGRAMME

Students in Computer Science (denominated entry) programme take the prescribed courses in Computer Science and Mathematics.

6. SECOND SCIENCE THEORETICAL PHYSICS PROGRAMME

Students in the Theoretical Physics programme take the prescribed courses in Experimental Physics, Mathematics and Mathematical Physics.

7. SECOND SCIENCE MATHEMATICAL SCIENCE PROGRAMME

Students in the Mathematical Science programme take the prescribed courses in Mathematics, Mathematical Physics and Statistics

8. EXAMINATIONS

The Second University Examination in Science is completed in the Summer. A Supplemental Examination is held in the Autumn. (The regulations governing this examination are contained in *Marks and Standards,* available for consultation in the Library.) Some departments may hold examinations and continuous assessments throughout the year.

Award of Honours

Honours are awarded at the Summer Examination of the first year of sitting only. To be eligible for Honours in Mathematics or Mathematical Physics students must take the honours papers in these subjects.

Exemption

Students who receive a mark of 40% in any subject may be recommended by the Examiners for exemption from further examination in that subject (c.f. *Marks and Standards).*

Students should be aware that where such exemptions have been awarded, they must present for examination in all three subjects if they wish to be considered for admission to a Third Science Honours course.

Pass by Compensation

Students may be allowed to pass their Second Science Examination by passing two subjects (minimum 40%), and achieve 35-39% in the third subject, where the deficiency is compensated by excess marks in the other subjects.

Two-Year Rule
Students must pass the Second University Examination in Science within two years of entering the courses. Exemption from this regulation may be granted for grave reasons by the Academic Council on the recommendation of the Faculty of Science.

9. RE-ATTENDANCE AT SECOND SCIENCE COURSES

Students may re-attend their courses with the approval of the department(s) concerned, provided that places remain available in the relevant subject. Where a student wishes to change a subject, formal permission of the Faculty must be sought.

ADMISSION TO THIRD YEAR SCIENCE COURSES

ADVISORY MEETING FOR THIRD SCIENCE STUDENTS

Third Science Students: Friday, 14 September 2001 - 2.30 p.m., Theatre A.

Third Science students must attend this meeting and select and obtain approval for the registration of their course units. The advisory meeting commences with a talk from the Dean in Theatre A, Science Lecture Building. Academic staff will be available on the Science Lecture Building concourse during the afternoon for consultation on the selection of course units. Students must complete and have staff sign their Course Registration Forms. Registration is completed when these forms have been handed into the Science Faculty Office on Tuesday, 18 September 2001.

Application for Honours or Topical Degrees

- All Second Science students wishing to proceed to an Honours or Topical Degree course must indicate their preference by completing an *Application for Admission to Third Science Honours/Topical Course Form.*
- These forms are available from the Faculty Office at the beginning of the Trinity Term and must be returned as directed by the end of the Trinity Term.
- Students will be assigned to places in Third Science courses by the relevent Department Head/Course Director based on the results of the Second Science examinations in Summer.
- Students reaching the qualifying standard at the repeat Autumn examinations will be accommodated in an Honours/Topical course provided places are still available. Such students should contact the relevant Department Head/Course Director.

SPECIAL REQUIREMENTS FOR ADMISSION TO SOME THIRD SCIENCE COURSES

- **Availability of Places in some Third Science Honours Courses**
  The number of places available in some Third Science Honours courses is limited by the availability of laboratory space, staffing and facilities. Qualification in a particular subject will not necessarily guarantee a place. Students should consult with the Heads of the Departments regarding the availability of places.

- **Single Honours**
  Students qualify for admission to a Third Year honours course on the results of the Second University Examination in Science by passing all three subjects at the same examination (either Summer or Autumn) and reaching a minimum of 55% in the subject that the student proposes to study at honours level. A minimum of 60% will apply if the examination is passed in an academic year later than the academic year of entry to the courses or if it is passed by compensation. Exemption from this regulation may be granted for grave reasons by the Faculty of Science.

- **Single or Joint Honours – Mathematics and Mathematical Physics**
  To qualify for admission to an honours course in Mathematics or Mathematical Physics students must take the honours papers in these subjects. In the case of Mathematical Physics, however, students who take the pass papers may qualify for admission to the Single Honours Degree Course, but not to the Joint Honours Degree Course, by obtaining a minimum of 70% in these papers. If the examination is passed in an academic year later than the academic year of entry to the courses, or if it is passed by compensation, then a minimum of 75% in the pass papers will apply.

- **Mathematical Science**
  To qualify for admission to the Third Year of the Mathematical Science degree, students must qualify for the third Science Honours Courses in at least two of the subjects, Mathematics, Mathematical Physics and Statistics, and, in addition, must obtain a minimum of 50% in the other subject. These qualifying standards must be gained at a single sitting, at either the Summer or Autumn examination. Students passing the examinations but gaining marks less than the requirements revert to the general Science stream.

- **Theoretical Physics**
  To qualify for admission to the Third Year of the Theoretical Physics degree, students must obtain the qualifying standard for admission to Honours courses in both Experimental Physics and Mathematical Physics, and in addition, must obtain a minimum of 50% in the Honours course in the Mathematics. These qualifying standards must be gained at a single sitting, at either the Summer or Autumn examination. Students passing the examinations but gaining marks less than the requirements revert to the general Science stream.

- **Joint Honours Degrees**
  Students wishing to proceed to a Joint Honours Degree course must pass the Second Science Examination and reach a qualifying standard in the two subjects in which they wish to follow a joint honours degree at a single sitting of the Examination, Summer or Autumn. The approval of the Heads of the relevant departments must be obtained.

- **Genetics and a Biological Subject**
  Students seeking admission to the Joint Honours Degree in Genetics and a Biological Subject, select one of the following biological subjects: Biochemistry, Botany, Industrial Microbiology, Pharmacology and Zoology. They must:-

- have followed a Second Science programme containing at least two biological subjects, one of which must be Biochemistry or Industrial Microbiology or Zoology and
- must pass the Second Science examination, obtaining the qualifying standard for admission to the Honours course in their chosen biological subject.

♦ **Topical Degrees**
Students wishing to proceed to a Topical Degree Course follow the Second Science programme outlined in the relevant Course Syllabus for that Topical Degree.

Admission to the Third Year of the Topical Degrees is granted by the Course Director, following consultation with the relevant departments. Admission is based on academic merit, subject to space and number restrictions in the departments concerned. Students must show a clear ability at the Second Science University Examination in the two subjects that form the core of the Topical Degree in Third Science.

REGULATIONS FOR THIRD YEAR SCIENCE STUDENTS

In Third Science, students study **10 units**. Each unit comprises **48 contact hours** (maximum) made up of lectures, laboratory practicals, field practicals and/or tutorials.

SINGLE HONOURS DEGREE

1. SELECTION OF UNITS

Students admitted to honours courses must attend, for one academic year, *eight units in their major subject and two other units.* The choice of optional units is at the discretion of the honours subject department. These optional units may be Third Year units from the honours subject or from other Third Year units offered in the Faculty of Science, including language units.

2. EXAMINATIONS

Major Subject
The Third University Examination in the major subject or the equivalent BSc Part IIA Examination will be taken in *eight units.* The examination must be passed at the first attempt. A pass by compensation may be granted in these examinations provided the candidate has reached the pass mark in *six units* and achieved an overall average of at least 40%. Students who fail these examinations will revert to BSc (General) courses.

Minor Units
The BSc Part I is taken in the *two optional units* (minor units). Students should pass these two units with an average of 40% with no less than 35% in one unit in the Summer Examination. Students failing minor units may repeat examinations in those units in the

Autumn of the same year. On passing the Autumn Examination, candidates will be awarded a pass and assigned a numeric value of 40%.

Award of Honours
Honours are awarded (in the major subject) at the Summer Examination of the first year of sitting only.

Minimum required to continue in Honours Courses
To continue in the Honours course, students must obtain a *minimum average of at least 45% in their eight units.* Students who have passed the examination but obtain an average of less than 45% or who pass by compensation with an *average mark in two units of less than 35%* will be graduated with a BSc (Pass) Degree.

3. THEORETICAL PHYSICS

Students following the Theoretical Physics Degree programme will take a combination of Third and Fourth year courses as set out in the syllabus (pages 101-102). The choice of courses is approved by the Heads of the Departments of Experimental Physics and Mathematical Physics.

4. MATHEMATICAL SCIENCE

Students following the Mathematical Science Degree programme will take ten units from the Third year Honours programme of the three subjects with at least two units from each subject. The choice of courses must be approved by the Course Director.

JOINT HONOURS DEGREE

1. APPROVAL OF SUBJECTS AND UNITS FOR JOINT HONOURS DEGREES

The combination of two subjects for a Joint Honours Degree must have the approval of the Heads of the two departments concerned. Students should pursue at least five units in each of the two subjects with an overall maximum total of twelve units. The selection of units must be approved by the two departments concerned.

2. AWARD OF HONOURS

Honours are awarded at the Summer Examination of the first year of sitting only.

BSc TOPICAL DEGREE PROGAMMES

1. DEGREES AWARDED FROM TOPICAL PROGRAMMES

The BSc Topical Degree may be awarded as a General BSc Degree, following three years of study, or as an Honours BSc Degree, following four years of study.

2. SELECTION OF UNITS

The BSc General Topical Degree will be taken in *ten units* made up of *eight core units and an additional two units.* The Course Directors will advise students on their choice of units.

3. EXAMINATIONS

The BSc General Topical Degree Examination will be held in the *ten selected units* following completion of the courses. A Supplemental Examination will be held in Autumn.

4. AWARD OF HONOURS

Honours are awarded based on performance in the core units at the Summer Examination of the first year of sitting only. (The regulations governing this examination are contained in *Marks and Standard*, available for consultation in the Library.)

5. QUALIFICATION FOR FINAL HONOURS YEAR

Students wishing to proceed to a BSc Honours Topical Degree must pass the BSc General Topical Degree Examination at the first attempt, obtaining a minimum average of 55% *in six of the eight core units*. Students who fail to reach this standard but pass the examination will be awarded the BSc General Topical Degree.

GENERAL DEGREE – ONE OR TWO SUBJECT PROGRAMME

1. SELECTION OF UNITS

Students taking the BSc General Degree study *ten units* as part of either (a) a two subject programme consisting of *four units from each of two subjects* together with *two optional units*, or (b) a one subject programme made up of *eight units in one subject* together with *two optional units*.

The two optional units must be taken at the Third Science level. The main subject departments will advise students on the choice of units and must approve the students' ten units before they can be registered.

2. EXAMINATIONS

The Final Examination for the Degree of BSc (General) will be held in the *ten selected units* in the Summer following completion of the units. A Supplemental Examination will be held in the Autumn. (The regulations governing this examination are contained in *Marks and Standards,* available for consultation in the Library).

Exemption
Students who receive a mark of 40% in any unit may be recommended by the Examiners for exemption from further examination in that unit (c.f. *Marks and Standards).*

Pass by Compensation
A pass by compensation may be granted at the discretion of the Board of Examiners provided a candidate has passed at least *seven units* and has an *overall average* of 40%.

3. RE-ATTENDANCE AT COURSES

Permission to re-attend courses may be granted on application to the Faculty of Science and the relevant department(s).

5. ADMISSION TO HONOURS COURSES BASED ON THE BSc (GENERAL) DEGREE

Students who complete the BSc (General) Degree Examination at their first sitting and reach specified standards may be admitted to Honours courses, subject to the availability of places. Faculty does not allow admission to Honours courses based on supplemental or repeat BSc General examinations.

From a two-subject programme
Students who obtain an average of 55% in *four of the major subject units* and pass the examination may be admitted to a Third Science Honours course. The permission of the Head of Department of the major subject is required. Students so admitted to a Third Science Honours course must attend a minimum of six units as recommended by the major subject Department.
In the case of Botany and Computer Science, students who obtain an average of 55% in *six appropriate units* from the major subject and pass the examination may be admitted to a Fourth Science Honours course. Permission of the Head of Department is required.
Students following a two-subject programme will not be considered for admission to the Honours course in Industrial Microbiology.

From a one-subject programme
Students who obtain an average of 55% in *six of the major subject units* and pass the examination may be admitted to a Fourth Science Honours course, subject to the approval of the Department concerned.

Chemistry and Experimental Physics
In the case of Chemistry and Experimental Physics, students who obtain an average of *55% in four of the major subject units* and pass the examination, in either the two-subject or one-subject programme, may only be admitted to the Third Science Honours course, subject to the approval of the Department concerned.

REGULATIONS FOR FOURTH YEAR HONOURS SCIENCE STUDENTS

1. SELECTION OF COURSES

All Fourth Year Honours Science students select courses of study as indicated by the relevant Head of Departments or Course Directors.

2. EXAMINATIONS

Having passed the Third Year Honours Examinations, students must attend, for one academic year, courses in the major subject, and must present at the end of that academic year for the Final Examination for the Degree of BSc (Honours). The distribution of marks for the Final Examination will be provided to students by the Departments concerned.

Candidates may present only once for the BSc (Honours) Degree Examination or the BSc Honours Topical Degree Examination. Exemption from this regulation may be granted for grave reasons by the Academic Council on the recommendation of the Faculty of Science.

The BSc (Honours) Degree may be awarded with First Class Honours; Second Class Honours, Grade I; Second Class Honours, Grade II; Third Class Honours or at a Pass standard.

SYLLABUS OF FIRST YEAR COURSES IN SCIENCE

BIOL 1001: BIOLOGY

Three lectures and one practical class of three hours per week shared between the Departments of Botany and Zoology.

1. *Cell Biology and Genetics:* History of cell theory; macromolecules; preparation of tissues for light and electron microscopy; structure and function of cells; cell cycle; mitosis, meiosis; DNA structure and replication; gene expression; Mendel's Laws; Mendelian inheritance patterns in humans.

2. *Diversity of Life:* The structure, reproduction and evolutionary relationships of living organisms: bacteria, fungi and viruses - their relevance in the biosphere, as parasites and agents of disease, and their use in biotechnological processes: protists: animals - classification, study of the increasing complexity of multicellular organisation from the Porifera (sponges) through Coelenterates, Platyhelminthes, Nematodes, Annelids, Arthropods, Molluscs, Echinoderms and Chordates: plants - structure and function of plant cells, tissues and organs; plant tissue culture; life cycles of bryophytes, pteridophytes and seed plants.

3. *Animal and Plant Physiology:* Bioenergetics, tissue respiration and photosynthetic pathways; nutrition; circulatory systems; respiratory systems; excretion; muscles and movement; nervous systems; hormones; reproduction.

4. *Environmental Biology:* Plant and animal ecology; climate and biome distribution; adaptation of plants and animals in major biome types; environmental problems - desertification, destruction of rain forests, ecosystem ecology, energy transfers, ecosystem models and nutrient cycling.

5. *Evolution:* Darwin, neodarwinian theory, sources of evidence for evolution, macroevolution, outline of the fossil record, evolution of primates.

CHEM 1001: CHEMISTRY

Three lectures and one practical class per week.

1. *Introduction*
Early chemical discoveries and the atomic theory, quantum mechanics and atomic structure, quantum numbers and electron orbitals. Electron configurations of the elements. The periodic law and the periodic table. Atomic radius, ionisation energy and electron affinity. Chemical bonding, ionic and covalent bonds, valence bond theory, stoichiometric equation, the Avogadro constant and the concept of hybridisation of atomic orbitals, molecular orbitals. Chemical reactions, the the mole.

2. *Physical Chemistry*
States of matter, properties of gases and kinetic theory of gases. The energy changes involved in chemical reactions, the first law of thermodynamics, endothermic and exothermic reactions, entropy and free energy. The nature of chemical equilibrium, the law of mass action, external effects on equilibria. Application and interpretation of reaction rate data with respect to elucidation of reaction mechanisms. The importance of chemical equilibrium and catalysis in biological and industrial systems will be emphasised.

3. *Inorganic Chemistry*
Periodic classification of elements. Chemistry of selected elements. Transition elements and an introduction to co-ordination chemistry.

4. *Organic Chemistry*
Why life is based on carbon. Types of organic compounds. Shapes of molecules, stereochemistry and chirality. The importance of chirality in biological systems and drug design. Reactions of organic compounds, concepts of reactivity in terms of energy and steric control. Survey of the reactions of important functional groups in organic chemistry with examples from biological processes and the synthesis of new materials.

5. *Laboratory Work*
A number of techniques, including volumetric analysis, mass spectroscopy, fluorimetry, uv-visible and infrared spectroscopy and are employed to analyse unknown mixtures. Experimental studies are also carried out in reaction kinetics, equilibria, thermochemistry, organic synthesis and qualitative analysis of inorganic anions and cations.

COMP 1001: COMPUTER SCIENCE

This course is taken by all students taking Computer Science as a subject in First Science.
There are three lectures per week plus programming practicals and tutorials.

1. *Introduction to Computer Programming*
Nature of computation; algorithms; correctness and efficiency of algorithms; basic complexity measures; sequence, selection and iteration constructs; program construction using these constructs; reasoning about programs; various methods of problem decomposition; reuse of existing software components.

2. *Introduction to Information Technology*
Basic computer hardware; practical usage of current software applications and operating systems; the Internet and World-Wide Web.

COMP 1002: HARDWARE AND SOFTWARE DEVELOPMENT

This course is taken by students in the Computer Science denominated entry programme, in addition to COMP 1001.

There are three lectures per week plus programming practicals and tutorials:

1. *Formal Foundations*

The role of mathematics and logic in Computer Science; Logic fundamentals: propositional and predicate logic and proof techniques.

2. *Hardware*

Boolean algebra. Introduction to combinational and sequential circuits.

3. *Software Development*

A group software development project involving the functional or logic programming paradigm.

EXPH 1001: EXPERIMENTAL PHYSICS

Lectures: Three lectures and one three-hour practical class per week.

A thematic approach to Experimental Physics is adopted in this introductory course, which does not assume any previous knowledge of the subject. Topics include: Physics at the atomic, molecular and macroscopic levels. Mechanics and the dynamics of large scale systems. Gravitation. Physics of fluids. Thermodynamics and thermal physics. Waves. Sound. Optics. Spectroscopy. Physics of solids. Electrons at rest and in motion. Electric fields. Electrical potential and capacitance. Magnetism and magnetic fields. Electromagnetic induction and alternating current flow. Photons and waves. Atomic physics. Nuclear physics and nuclear energy. In addition, contemporary developments in physics are used to illustrate the course content, where possible.

GEOL 1001: GEOLOGY

Three lectures and one two-hour practical class per week. The course is designed to provide a broad background in all the major aspects of Geology and to be interesting and stimulating. No previous knowledge of the subject is required. Four afternoon field classes to areas of particularly spectacular geology in the Dublin area are held in place of laboratory classes in the early and later part of the session.

1. The Earth's surface features and processes. Their origin and controls on their formation and development.
2. Shallow and deeper earth structures and processes. The crust, mantle and core. Geophysics and lithosphere plates. Formation and classification of faults, joints and folds.
3. Minerals. Their occurrence, identification and properties.
4. Rocks. Occurrence, classification, distribution and environments of igneous, sedimentary and metamorphic rocks.

5. Earth resources. Minerals, hydrocarbons, water resources, engineering geology and environmental geology.

6. Geologic time. Concepts, measurement of relative and absolute time. Radiometric dating, other concepts of relative dating and their historical development.

7. Origin of life and evolution. The fossil record, mass extinctions, sea level changes and ice ages. Development of floras and faunas through geological time.

8. Evolution of the Irish geological landscape, changing geological environments through time. Climates, marine incursions, volcanoes and mountains.

MATHEMATICS

MATH 1200: Mathematics Pass course
MATH 1100: Mathematics Honours course

Either the Pass or the Honours course must be attended.

Pass Course
Four lectures per week.

Algebra
The elements of logic and set theory. Vectors in two and three dimensions. Matrices and systems of equations.

Calculus
Functions and Sets. Differential calculus, graphing and optimization. Integration, areas and volumes. Introduction to differential equations.

Honours Course
Four lectures per week.

Algebra
Vector geometry in two and three dimensions. Matrices and linear systems. Determinants, eigenvalues and eigenvectors.

Calculus
Limits of functions and continuity. Differentiation, extreme values, mean value theorem, applications. Riemann integration. Differential equations.

MAPH 1000: MATHEMATICAL PHYSICS

Six lectures/tutorials per week

1. Mathematical Modelling and Numerical Methods

First order differential equations: Examples of modelling leading to differential equations; homogeneous equations with constant coefficients; separable equations; integrating factors. Inhomogeneous equations. Linear second order differential equations: Independent solutions and Wronskians; reduction of order; variation of parameters; initial and boundary value problems. Systems of equations: phase plane, classification of critical points. Approximate solutions of nonlinear equations. Chaotic dynamics.

Numerical methods: Solutions of ordinary differential equations, quadrature formulae, root finding

2. *Introduction to Mechanics*

Motion in a line, displacement-time graphs, velocity-time graphs and acceleration. Motion with constant acceleration, free fall under gravity. Introduction to vectors, scalar product, relative velocity. Force, momentum and Newton's laws of motion. Statics and friction.

Kinetic and potential energy, work and power. Elastic strings and springs, Hooke's law and elastic potential energy. Projectiles. Impulse, collisions and the law of restitution. Circular motion. Simple harmonic motion, motion in a plane and under variable forces. Stability and small oscillations.

Coplanar forces in equilibrium. Centre of gravity and moments of inertia. Dynamics of a rigid body in two dimensions. The compound pendulum. Polar coordinates. Central forces, angular momentum and orbits. Satellite motion.

SYLLABUS OF COURSES FOR THE DEGREE OF BACHELOR OF SCIENCE

SECOND, THIRD AND FOURTH YEARS

Each unit comprises 48 contact hours (maximum) made up of lectures, laboratory practicals, field practicals and/or tutorials.

Note: Not all units may be on offer in any one year.

BIOCHEMISTRY

Prerequisite Combination: (a), (d) or (g) in First Science.

Second Year Course for General and Honours Degrees

BIOC 2001 *Structure, Evolution and Diversity*
Structure and properties of the amino acids; introduction to protein structure and folding; biochemical spectroscopy. Nucleic acid structure and replication; mechanisms of transcription and translation. Protein evolution.

BIOC 2002 *Bioenergetics, Structure & Metabolism*
Properties of carbohydrates and lipids. Thermodynamics and the proton motive force. Bioenergetics and energy conservation. Metabolism of carbohydrates and lipids. Metabolic control.

BIOC 2003 *Applied Biochemistry*
Enzyme catalysis. Introduction to applied biochemistry; biochemical analysis; biosensors. Genetic manipulation; introduction to gene cloning.

BIOC 2004 *Cell Communication & Immunology*
Structure and functions of cell walls and membranes. Membrane transport & cell signalling. Introduction to immunology. Free radical defence mechanisms.

Third Year Course for General and Honours Degrees

Students taking Biochemistry as a subject for a General Degree will be required to take the four core units BIOC 3001 to BIOC 3004. Additional units may be chosen from BIOC 3005 to BIOC 3008.

BIOC 3001 *Biochemistry of Nitrogen*
Metabolism of dinitrogen, amino acids, purines, pyrimidines and nucleotides.

BIOC 3002 *Biological Catalysts*
Basic analysis of enzyme reaction rates. Chemical mechanism of enzyme action. Protein engineering, ribozymes and catalytic antibodies.

BIOC 3003 *Biochemist's Toolkit*

Survey of techniques and methods required for a modern biochemical approach to problems of biology, including absorption and emission spectroscopy such as NMR and fluorescence; separation techniques; techniques for analysis and manipulation of nucleic acids and proteins, etc.

BIOC 3004 *Gene Manipulation & Regulation*

DNA replication; control of gene expression in prokaryotes and eukaryotes; recombinant DNA technology in inudstry and medicine; cloning and expression of heterologous genes; generation of transgenic organisms; PCR and DNA fingerprinting.

BIOC 3005 *Disease and Disease Resistance*

Discussion of molecular basis of selected diseases such as diabetes, cardiovascular disease and cancer. Inherited disorders; gene therapy. The immune system. Blood clotting.

BIOC 3006 *Cell Structure, Function, Communication*

Cell structure, function, communication. Relationships between molecular organisation and function in mammalian cells. Biochemistry of cell signalling, neurotransmission, sensory transduction.

BIOC 3007 *Advanced Enzymology*

X-ray crystallography of proteins. Kinetic analysis of multi-substrate enzymes, effects of pH and allosteric regulation.

BIOC 3008 *Biochemistry and Environment*

The environment as an entity; pollution as a challenge to biochemistry. Biochemical approaches to environmental remediation, protection and enhancement. Xenobiotics; the biochemical effects and transformations of compounds foreign to organisms and the environment.

Fourth Year Course for Honours Degree – BIOC 4000

BIOC 4001 *Biochemical Immunology*

Structure and function of ion-channels. Aetiology of Type-I & Type-II diabetes. Antigen presentation and activation of the adaptive immune system. Mechanisms of T-lymphocyte activation, deletion and anergy. Receptor and non-receptor Tyrosine Kinases and signal transduction in cells of the immune system. Cytokine networks.

BIOC 4002 *Redox enzymes*

The properties of enzyme redox centres found in enzymes are surveyed, with an emphasis on recent work. The redox properties of flavoproteins are studied in detail, using the electron carrier flavodoxin to illustrate how these properties are modulated by interactions with protein.

BIOC 4003 *Neurotransmitters*

Topics include neurotransmitter release, transport and synthesis. Structure and diversity of receptors in the CNS. Mechanisms of excitotoxicity and neurodegenerative disease.

BIOC 4004 *Protein structure*

This course addresses two main questions; "What are the principles stabilising the main classes of protein fold", and "How do porteins achieve their folded state". The relationship between structure and function is also discussed using complex structures such as ATP synthase, the K^+ channel and cytochrome oxidase.

BIOC 4005 *Extracellular matrix*

Molecular basis of connective tissue structures and mechanical properties. Collagen and proteoglycan types, structures, biosynthesis and extracellular assembly.

BIOC 4006 *Oxygen and Life*

"Fitness" of dioxygen. Electronic structure, redox potentials, ionisation constants. Fenton, Haber-Weiss reactions. Dioxygen reduction products: production, toxicity, detoxification. Dioxygen activating enzymes: superoxide dismutase. Singlet oxygen. Oxidative stress, lipid peroxidation. Oxygen free radicals in cell defence. Consumption and production: mitochondrial respiration, photophosphorylation and their regulation.

BIOC 4007 *Complex modes of gene regulation*

Investigation of aspects of regulation of gene expression: DNA topology and nucleosome structure; interaction of transcription factors with chromatin; identification of nuclear localisation signals; regulated nuclear localisation of transcription factors; nuclear gradients in Drosophila development; comparison of immune response pathways in Drosophila and mammals; effect of phosphorylation on nuclear transport.

BIOC 4008 *Biological NMR*

Basic NMR theory, relaxation mechanisms in small and large molelcules, optimising signal-to-noice, 1D-pulse sequences used in biological NMR, ^{13}C-NMR of biological molecules, protein structure determination.

BIOC 4009 *Cell signalling*

This course details the signal transduction cascades of G-protein coupled receptors and heterotrimeric G proteins; growth factor receptor tyrosine kinases; monomeric G proteins; mitogen activated protein kinase (MAPK) and stress activated protein kinases (SAPKs). Attention is paid to structure/function aspects of signalling components and to integration of the various cascades.

BIOC 4010 *Proteases and inhibitors*

Introduction to classes and mechanisms of porteases and protease inhibitors. Extracellular and intracellular proteolytic events including plasma cascades, proteasome protein degradation and antigen processing. Mechanisms of programmed cell death (apoptosis).

BIOC 4011 *Cancer studies*

BIOC 4012 *Protein engineering*

Academic and practical reasons for engineering proteins. Alternatives. Prerequisites: High-resolution structure, homology, conserved residues? Tyrosyl tRNA synthetase: H-bonds. Subtilisin: thermostability. Homology-based engineering: coenzyme specificity in disulphide reductases. Substrate specificity in α-hydroxyacid dehydrogenases. Engineering without 3-D structure: E2 lipoyl domains. Criteria of success. Limitations. Hybrid approaches; SDM/random. Amino acid dehydrogenases.

Two supervised projects are carried out, a library project and a laboratory-based research project. Oral and written reports are required for both of these and contribute to the final assessment.

BOTANY

Second Year Course for General and Honours Degrees

BOTN 2001 *Biology of Fungi*

A course dealing with growth, development and physiology of fungi – as organisms in the biosphere and in their biotechnological applications. Characteristic and noteworthy features of fungal structure and growth: osmotrophy and extracellular enzymes; nutritional requirements; responses to environment; hyphal tip growth, mycelium, differentiation and reproduction; spore characteristics, dispersal and germination.

BOTN 2003 *Plant Anatomy and Morphology*

Anatomical development of plants. The range and distribution of cell types, relationships between structure and function, structural aspects of cell differentiation. The structure and identification of woods. Development and morphology of vegetative and reproductive structures in conifers and flowering plants. Identification of plants in the Irish flora.

BOTN 2004 *Environment, Plants and Vegetation*

Plant/environment interactions: plant ecotoxicology; soil; rhizosphere; nutrients; effects of and tolerance to salt, drought, waterlogging and pollutants. Vegetation and environment: saltmarshes, sand-dunes, heathlands, peatlands, grasslands and woodlands.

BOTN 2005 *Plant Signalling Molelcules in Growth and Development*

Introduction to the five major groups of signalling molecules, auxin, gibberellins, cytokinins, abscisic acid, ethylene and other biologically-active

signalling molecules; the influence of signalling molecules on different categories of development such as, apical dominance, differentiation of vascular tissue, embryogenesis, root hair development and senescence.

Third Year Course for General and Honours Degrees

BOTN 3001 *Diversity and Ecology of Fungi*
Life cycles, morphology, and ecology of fungi. Examples of important fungal pathogens causing diseases of plants and animals along with aspects of host/pathogen relationships and control. Ecology of soil fungi including those associated with roots of plants.

BOTN 3002 *Plant Population Biology*
Plant census – origins and development. Modular nature of plant growth and its demographic consequence. Life history – birth, growth, death; varieties of life history, including clonal growth. Population and metapopulation structure and dynamics. Demography and conservation of rare populations.

BOTN 3003 *Plant/Soil Interactions in Wetlands*
Geochemistry of wetland soils: oxidation/reduction processes, chemical speciation and availability of nutrients. The rhizosphere: root/soil interactions, rhizosphere oxidation by wetland plants. Nutrient cycling. Behaviour of heavy metals and metalloids in soil and plants: uptake and translocation in plants, turnover by vegetation.

BOTN 3004 *Growth & Nutrient Assimilation*
Growth measurement patterns of growth in response to the environment. Plant growth regulators: assays, synthesis, transport and metabolism. Tropisms, problems with mechanics. Photosynthetic metabolism: interaction with light and nutrient supply. Nitrogen assimilation of plants; nitrogen fixation.

BOTN 3006 *Seed Plant Reproduction*
Breeding systems of gymnosperms and angiosperms. Genetic control of flower formation. Development of female gametophytes and pollen grains. Pollinstion, pollen tube growth mechanisms, gamete formation, fertilization and zygote development. Incompatibility systems and male sterility. Sexual selection, pre- and post-zygotic. Species isolation mechanisms and their breakdown.

BOTN 3007 *Vegetation Ecology and Biogeography*
Vegetation description and analysis: field methods; the Braun-Blanquet (Zürich-Monpellier) approach to phytosociology; ordination – principles and computer-based techniques. Biogeography – studying plant distributions, impact of climate change, islands, Irish biogeography, the Burren.

BOTN 3008 *Plant Biotechnology*
Commercial exploitation of biosynthetic capacities of plants. Seed and gene plasma banks. Tissue and organ culture and its use in propagation and production of secondary metabolites: plant cell transformation, molecular probes in study of plant differentiation and development. Micro organisms as biofertilisers and biocontrol agents. Basic aspects of business administration.

BOTN 3009 *Plant-Specific Cell Biology and Metabolism*
Short distance solute transport, plasma membrane, cell walls, plasmodesmata, transfer cells. Symplastic and apoplastic flows in organs and glands; motor cells. Models for the functioning of the Golgi apparatus in plant and animal cells; exocytosis, endocytosis.
Chloroplasts: light harvesting, electron transport and carbon assimilation. Photosynthetic diversity among plants (C3, C4, CAM). Photorespiration, nitrogen metabolism and sucrose synthesis.

GENE 3001 Genetics 3001 is part of the Botany programme.

Fourth Year Courses for Honours Degree – BOTN 4000

The following courses are offered in a range of topics, reflecting the specialist interests of the Department's staff. Students must select their courses in consultation with the Head of Department.

BOTN 4001 *Peatland Ecology and Conservation*
Characteristics of peatland habitats. Ecology of peatland plants. European and world distribution of peatlands. Peatland classification systems. Variation in European peatlands. Peatland vegetation types. Irish peatlands - distribution, ecology, vegetation, habitat destruction, restoration and conservation.

BOTN 4002 *Ecotoxicology*
Pollutants in ecosystems. The behaviour of pollutants in, and their effects on, ecosystems; predictions of effects of pollutants in ecosystems, and biomonitoring of pollutants in the environment.

BOTN 4003 *Evolution in Plant Populations*
The existence of infraspecific genetic variation: ecotypes, clines. Gene flow in populations; neighbourhood size. Spatial and temporal scales of population differentiation. Natural selection in plant populations: life-cycle components of selection.

BOTN 4004 *Mycorrhizal Symbiosis*
Structure and function of the main mycorrhizal types. Mycorrhizal populations in forest, heathland and grassland ecosystems. The role of mycorrhizal associations in improving the nitrogen and phosphorus nutrition of trees, crops and heathland plants.

BOTN 4005 *Light Utilisation by Plants*
Optical properties of cells, colonies and tissues. Consequences of variations in cell/pigment/tissue characteristics on light absorption. Case studies on 1) the 'package effect' in phytoplankton, 2) unusual strategies for enhancing light absorption by understory plants, and 3) the significance of leaf movements on light utilisation and carbon gain.

GENE 4001 *Eukaryotic Genome*
For details of unit see under Genetics.

BOTN 4008 *Plant - Pathogen Interactions*
Disease and disease resistance in plants; the ways in which pathogens gain entry and colonise host tissues; toxins, cell-wall-degrading enzymes, growth de-regulators; the constitutive and induced defensive responses of plants; mechanical and biochemical resistance, including hypersensitive response, phytoalexins and PR proteins.

BOTN 4009 I*n vitro Techniques*
Regulatory aspects of growth and metabolism of plant cells in culture. Growth and production kinetics of cultured plant cells; screening for chemical variants; cloning, clonal analysis and stability of isolates; possible origins of cellular heterogeneity; selection by amino acid analogue resistance.

BOTN 4010 *Organogenesis*
Molecular and cellular controls of cell shape, cell division planes, and organ formation. Generation of primordia at stem apex.

BOTN 4011 *Critiques of Scientific Papers*
Essential skills in the analysis and writing of scientific papers: titles, abstracts, presentation of materials and methods, data presentation and analysis, validity of conclusions. This tutorial course is designed to provide critical reading and writing skills.

BOTN 4012 *Ecological Significance of Different Photosynthetic Pathways*
Fundamental characteristics of carbon assimilation in terrestrial C3, C4, C3-C4 and CAM plants. Photosynthetic mechanisms in aquatic plants. Plant distribution and photosynthetic pathway. Examination of the effects of irradiance, temperature, CO_2, water and nutrients on carbon assimilation. Predicting the response of plants and vegetation to global changes in climate.

BOTN 4013 *Science and Society*
Social creation of scientific knowledge: theories of Merton, Kuhn, Feyerabend. Role of science in society: reliability, use and abuse of scientific knowledge; should science be planned to meet social needs?; the public understanding of science. Limits of science: does science have conceptual or ethical limits? Emergence of anti-science culture.

BOTN 4014 *Developmental Plant Genetics*
Developmental and environmental control of plant gene expression and pattern formation. Embryogenesis, root, shoot and leaf development, formation of reproductive structures. Formation of the photosynthetic apparatus.

BOTN 4015 *Plants in Changing Environments*
Underlying causes of differences in relative growth (RGR). Ecological and evolutionary significance of differences in RGR. Using RGR and related traits to explain and predict vegetation dynamics. Plant functional types and "scaling-up" in ecology.

BOTN 4020 *Programmed Cell Death in Higher Plants*
Introduction to programmed cell death and examination of its role in a number of different organisms; molecular and biochemical mechanisms that control the cell death process in different organisms including plants; the role of cell death in plant development and disease resistance.

BOTN 4021 *Burren Field Course*
This five-day residential field course takes place after the Third Science summer examinations each year. It is compulsory for students pursuing (a) a single honours degree in Botany or (b) taking Botany as a core element in the Environmental Biology programme. The course is also available to other students who have completed BOTN 3007: *Vegetation Ecology and Biogeography*. The course covers field methods in vegetation ecology, including species identification, habitat description, vegetation description and vegetation classification. A variety of habitat types are examined, including coastal systems (cliff tops, rocky shores, salt marshes, shingle beaches, sand beaches and sand-dune systems); lake and lake shore systems (acid lakes and Burren turloughs); limestone pavement systems; mountain vegetation (arctic alpine species, species changes with increasing altitude); peatlands (raised bogs, blanket bogs and fens); river and wetland systems; and woodland systems (Corylo-Fraxinetum woodlands, Blechno-Quercetum woodlands, hazel scrub, yew/juniper scrub, pine woodland). Discussion of conservation of habitats and rare plant species take place during field excursions. Evening sessions involve confirmation of field identifications, analysis of species distributions and habitat report writing.

Project
Each student will carry out a research project, to be presented as a thesis and seminar for part of the Degree examination assessment.

CELL AND MOLECULAR BIOLOGY

Programme Director: Professor Martin Steer

Prerequisite: First Science Biology – group (a) preferred.

Second Year Courses for General and Honours Degrees

Any Second Science combination that includes two biological subjects.

Third Year Topical Degree Course

Eight core courses: BOTN 3009, CELB 3001, GENE 3001, GENE 3002, GENE 3003, PHAR 3001, ZOOL 3010, ZOOL 3012.

Two optional units selected from: BIOC 3003, BIOC 3004, BIOC 3005, BIOC 3008, BOTN 3004, BOTN 3006, BOTN 3008, ZOOL 3015, STAT 3208, STAT 3221, LANG 3001, LANG 3002, LANG 3003, LANG 3004.

CELB 3001 *Cytoskeletons*
Microtubules, actin, intermediate filaments, motor proteins, microtubule- and actin-associated proteins; assembly of cytoskeletons; function of cytoskeleton assemblages; synthesis of tubulin and G-actin; expression of cytoskeleton genes; evolution of cytoskeleton genes.

Fourth Year Honours Courses – CELB 4000

Each student must attend ten of the following courses and undertake a Research Project. The Project is to be presented as a seminar and submitted as a thesis. Selection of courses and project are subject to the approval of the Programme Director.

CELB 4001 *Animal and Plant Cell Tissue Culture*
Introduction to techniques of animal and plant tissue culture, factors influencing proliferation and differentiation of cells in vitro. Applications of: a) animal cell culture techniques to topics such as intracellular protein targeting, antigen processing and presentation, signal transduction and gene expression in development; b) plant cell culture techniques to plant improvement programs; plant regeneration, variation, selection.

CELB 4002 *Immunobiology*
Basic concepts in immunobiology. Antigen recognition by B and T cells. T cell development and T cell mediated immunity. Host defence mechanisms. Control and manipulation of the immune response.

CELB 4003 *Neurobiology*
Molecular mechanisms underlying memory and learning. Neurodegenerative states: Alzheimer's disease. Psychotic states: schizophrenia and depression. Molecular mechanisms involved in processing and storing information derived from the internal condition and the external environment.

GENE 4002 *Human Genetic Diseases*
For details of unit see under Genetics.

CELB 4005 *Complex Modes of Gene Regulation*
Investigation of aspects of regulation of gene expression: DNA topology and nucleosome structure; interaction of transcription factors with chromatin; identification of nuclear localisation signals; regulated nuclear localisation of transcription factors; nuclear gradients in *Drosophila* development; comparison of immune response pathways in *Drosophila* and mammals; effect of phosphorylation on nuclear transport.

CELB 4006 *Cell Extension and Locomotion*
Cytoskeleton-plasma membrane interactions, F-actin assembly and force generation, role of calcium and calmodulin, amoeboid locomotion, nerve growth cones, fibroblast locomotion.

BOTN 4014 *Developmental Plant Genetics*
For details of this unit see under Botany.

BOTN 4011 *Critical Analysis of Scientific Papers*
For details of this unit see under Botany.

BOTN 4020 *Programmed Cell Death in Higher Plants*
For details of this unit see under Botany.

GENE 4001 *Eukaryotic Genome*
For details of this unit see under Genetics.

ZOOL 4014 *Transmissible Spongiform Encephalopathies*
For details of this unit see under Zoology.

CHEMISTRY

Second Year Courses for General and Honours Degrees

Prerequisite for all units: First Science Chemistry.

CHEM 2001 *Synthesis and Reactivity of Organic Compounds - I*
The preparation and reactions of molecules containing double bonds. Reactivity and stereochemistry of ionic and free-radical additions to alkenes and alkadienes; resonance and aromaticity; electrophilic and nucleophilic aromatic substitution. Chemistry of aldehydes and ketones including nucleophilic addition to carbonyl groups and addition following by elinination. Chemistry of carboxylic acids and their derived amides, esters, halides and anhydrides including nucleophilic acyl transfer reactions. Concept of resonance and delocalisation. Acidity of carboxylic acids. Base hydrolysis of an ester as an example of the investigation of a mechanism. Concept and control of consecutive reactions including the Grignard synthesis of tertiary alcohols. Chemistry of amines, amides and amino acids.

CHEM 2002 *Co-ordination and Solid State Chemistry*
Co-ordination chemistry: This section of the course will introduce a class of compounds referred to as co-ordination compounds, metal complexes or just complexes. These compounds contain a central metal atom surrounded by several ions or molecules. The surrounding ions or molecules are known as ligands and the types and classification of these will be discussed along with the geometry, isomerism and an introduction to bonding in co-ordination compounds.
Solid state chemistry: This introductory course will deal with single crystals, polycrystalline solids and glasses. After determining symmetry in molecules and crystals approximately 20 ionic, layer and molecular structures of the A,

AB, AB_2 and AB_3 type are presented. The bonding in ionic solids, metals, semiconductors and insulators are discussed applying the Born-Haber cycle, Born-Landé and band theory. An introduction to X-ray methods and their application to silicate and cement chemistry as well as to heterogeneous catalysis will follow.

CHEM 2004 *Chemical Applications of Spectroscopy: Chemistry at work: Chemistry and Biology*

Applications of Spectroscopy: Infrared spectroscopy: experimental methods and instrumentation of carbonyl groups. Functional group identification by IR in organic chemistry. Mass spectrometry: principles and instrumentation, molecular fragmentation, determination of molecular weight. Nuclear Magnetic Resonance spectroscopy: nuclear spin, influence of magnetic field, instrumentation. Proton chemical shifts, integration, spin-spin splitting. Ring current effects in aromatic compounds, hydroxyl groups and isotope exchange. Solving spectroscopic problems.

Chemistry at Work: Case studies focusing on several compounds of practical importance, e.g. some pharmaceuticals and agrochemicals. Overview of the discovery, chemistry, use, environmental impact, economics etc. of the compounds chosen. Rational design of compounds with desirable properties, especially biological activity.

Chemistry and Biology: The objective of this course is to provide a broader perspective on chemistry by considering the central role that chemistry plays in many important biological processes. Particular attention will be paid to the properties of large biological molecules, such as proteins.

CHEM 2005 *Molecular Spectroscopy and Solution Chemistry*

Molecular Spectroscopy

Electromagnetic radiation, radiation and energy. Molecular energy levels. The interaction between electromagnetic radiation and atoms or molecules. Rotational spectra, the rigid rotor, the non-rigid rotor, the rotational spectra of polyatomic molecules. Vibrational spectra, the harmonic oscillator, the anharmonic oscillator, vibrational –rotational spectra of diatomic molecules, vibrational spectra of polyatomic molecules. Electronic spectra, atomic spectra, atomic absorption and emission spectroscopy, molecular spectra, electronic spectra of diatomic molecules, vibrational –electronic spectra, the Franck – Condon Principle, electronic spectra of polyatomic molecules.

Solution Chemistry

The experimental and theoretical basis for the driving forces for chemical transformations in solution. Equilibrium systems in solution. The freezing and boiling points and other properties of solutions, conformational transitions in polymers, the binding of drugs to proteins and nucleic acids.

Third Year Courses for General and Honours Students

Prerequisite for all units: Units CHEM 2001, CHEM 2002, CHEM 2004 and CHEM 2005.

Students taking Chemistry as one of two main subjects for a General Degree will be required to take units CHEM 3001 to CHEM 3004. Additional units suitable for a General Degree are CHEM 3005, CHEM 3006, CHEM 3015 and CHEN 3025 (Process Engineering). Students wishing to pursue a single subject General Degree in Chemistry must take units CHEM 3001 to CHEM 3006, CHEM 3015 and CHEN 3025 (Process Engineering).

Students taking an Honours Degree in Chemistry will be required to take the eight units CHEM 3007 to CHEM 3014. Students taking a Joint Honours Degree in Chemistry will ordinarily be required to take five of the eight units CHEM 3007 to CHEM 3014, but other units may be selected subject to the approval of the Head of Department.

CHEM 3001 *Organic and Polymer Chemistry*
Functional group chemistry including reactions of carbonyl compounds, pericyclic reactions and stereochemistry. Preparation and reactions of heteroaromatic compounds. Preparation and properties of polymers.

CHEM 3002 *Inorganic Chemistry*
Fundamentals of main group chemistry. Structure and bonding in inorganic compounds.

CHEM 3003 *Electroanalytical, Surface and Colloid Chemistry*
Electrolyte dissociation and solvation; conductance measurements and applications; redox reactions at electrodes; electrode potentials and the Nernst equation; dynamic electrochemistry and analytical applications. Colloids, dispersions and self-assembled systems. Fundamental principles of stability in colloidal mixtures. Applications to biological cells and drug delivery systems.

CHEM 3004 *Analytical Chemistry*
Principles, practice and instrumentation for chemical analysis: sample preparation. Detection, and qualitative and quantitative determination of substances using chemical and spectroscopic techniques. Chromatographic methods, especially GC and HPLC. Statistics in analytical chemistry. Analysis and characterisation of polymers. Practical applications of industrial and biological significance will be discussed throughout.

CHEM 3005 *Chemistry of Biomolecules*
Structure, preparation and chemical reactivity of biomolecules, including carbohydrates, amino acids, peptides and bioinorganic compounds. Biopolymers and their chemical interactions with small molecules, including mechanism of drug-target interaction. Drug discovery and development.

CHEM 3006 *Environmental Chemistry I*
Analytical techniques for measurement of critical pollutant concentrations in the environment. Chemistry and pollution of the atmosphere including, types of pollutants, atmospheric dispersion and transfer of pollutants, photochemical smog, acid deposition, and effect of halocarbon and nitrogen oxide emissions on stratospheric ozone. Case studies of reductions in airborne pollutants.

CHEM 3007 *Synthesis and Reactivity of Organic Compounds II*

Introduction to the philosophy and practice of organic synthesis with emphasis on the disconnection approach and based mainly on the reactions of carbonyl compounds. Enol/enolate reactivity including aldol and Claisen condensations, the Michael, Wittig and Mannich reactions and the alkylation of enolates under thermodynamic or kinetic control. Structure and reactivity relationships of heterocyclic compounds; formation, substitution reactions and importance in biology. Application to the syntheses of some target molecules, including naturally occurring compounds, pharmaceuticals and fine chemicals.

CHEM 3008 S*tructure Determination by Spectroscopic Methods: Mechanisms of Organic Reactions*

This course will consist of two parts:

(a) The use of mass spectrometry, ultraviolet/visible spectroscopy, infrared spectroscopy and, in particular, advanced methods of nuclear magnetic resonance spectroscopy for determining the structure of organic compounds.

(b) An account of methods of studying organic reaction mechanisms and reactivity, illustrated by nucleophilic substitution and carbocation reactions.

CHEM 3009 *Chemistry of the Main Group Elements*

Structure and bonding of the main group elements and their compounds, including clusters, hypervalent compounds, fluxionality and inorganic materials and polymers.

CHEM 3010 *Statistical Mechanics, Thermodynamics and Reaction Processes*

The first part of the course gives an introduction to Statistical Mechanics and Thermodynamics. The following topics are included: The microcanonical, canonical and grand canonical equilibrium distributions. Concepts of the temperature, heat capacity, entropy, free energy and enthalpy. Derivation of the three laws of thermodynamics. The ideal gas law. Polytropic processes. Mixing of gases.

The second part of the course is devoted to study of Reaction Processes applying the principles of Statistical Mechanics. The following topics are discussed: Theories of bimolecular reactions: collision theory; transition state theory; comparison with experiment. Reaction dynamics: collisions of real molecules; potential energy surfaces; predictions of rate parameters based on potential energy surfaces. Unimolecular reaction rate theories: theory and comparisons with experimental data.

CHEM 3011*Stereochemistry, Alicyclic Chemistry and Bioorganic Chemistry*

Properties and analysis of stereoisomers. Stereoselectivity in organic reactions. Comparative discussion of the structure, preparation and reactivity of alicyclic compounds from cyclopropane to large rings. Chemistry of biomolecules, including carbohydrates, nucleotides and amino acids, and derived polymers.

CHEM 3012 *Modern Inorganic Chemistry*

Organometallic chemistry of the transition metals. Coordination chemistry. Acid-base chemistry. Non-aqueous solvents. Analytical chemistry.

CHEM 3013 *Symmetry and Computer Simulations in Chemistry*

The first part of this course will introduce and develop chemical applications of group theory. In doing so the following topics will be covered: Symmetry

elements, operations and groups. Character table of a point group. Electronic structure of water and ammonia.
Subgroups and correlation tables. Molecular vibrations. Spectroscopic selections rules.
The second part of the course will introduce numerical methods in chemistry and emphasise the use of symmetry arguments to simplify numerical calculations. The topics here include: Integration of differential equations. Calculation of integrals. Methods of Molecular, Stochastic and Monte Carlo Dynamics. Numerical solution of the Schroedinger equation. Quantum variational Monte Carlo.

CHEM 3014 *Thermodynamics and Electrochemistry*
Solution thermodynamics; partial molar quantities; the chemical potential; the Gibbs-Duhem relationship; ideal and real solutions; activity and the activity coefficient; Gibbs phase rule; liquid vapour equilibrium; and phase diagrams. Electrolyte dissociation and solvation; conductance measurements including Kohlrausch's Laws; transport numbers and ionic mobility; redox reactions at electrode surface including Faraday's Laws; electrode potentials and the Nernst equation.

CHEM 3015 *Environmental Chemistry II*
Chemical pollution of fresh water and the oceans: types of pollutants and their chemical effects. Case studies illustrating the wide range of problems which arise in considering the effects of chemical releases on the environment. The examples will illustrate the various sources of pollution, their fate and analysis, and the factors which influence the type of control procedures which may be needed. The legal control of pollution: functions of pollution law, sources of law, and integrated pollution control.

CHEN 3025 *Process Engineering*
Introduction to industrial processes; description of typical processes, flow sheets, flow and batch systems, general concepts of unit operations, stoichiometry. Principles of analysis of distillation units and crystallisers and of chemical reactors.

Fourth Year Courses – CHEM 4000

Core Courses

Organic Chemistry
Structure and reactivity, pericyclic reactions, reaction co-ordinate diagrams; rearrangements; acid-base and enzymatic catalysis; asymmetric synthesis; biosynthesis; catalysis in chemistry and biology; retrosynthetic analysis.

Inorganic Chemistry
Organometallic and related chemistry; structural methods in inorganic chemistry; bonding and electronic spectroscopy of coordination compounds; inorganic solid-solution chemistry; boranes, carboranes and their complexes; transition metal catalyzed polymerizations.

Physical Chemistry
Complex reaction kinetics; electrochemistry; spectroscopy; molecular characterization by advanced instrument techniques; thermodynamics and phase behaviour of solutions; statistical mechanics; colloids; biopolymers.

In addition, students will choose from a selection of optional courses, examples of which are given below.

Optional Courses
Bioelectrochemistry/Neurochemistry; solution chemistry; supramolecular chemistry; atmospheric chemistry; nucleic acids and their functioning in biological systems; biomaterials; organo-main-group chemistry; organometallics in organic synthesis; reactive intermediates; transition metal complexes in catalysis; synthesis and properties of polymer materials; solution-phase NMR techniques applied to structural determination; computational chemistry; biomacromoleular chemistry; bioinorganic chemistry; bioorganic and medicinal chemistry; heterocyclic and combinatorial chemistry; environmental applications of heterogeneous catalysis; solvent effects and chemistry in water; statistical mechanics of phase transition and kinetics.

Practicals
Individual research projects and a course on modern instrumentation and analysis are carried out under the direction of members of staff.

COMPUTER SCIENCE

Second Year

Prerequisite: First Year Computer Science.

COMP 2001 *Datastructure and Algorithms I*
Software design principles; data abstractions; dynamic data types, lists, queues, stacks, trees, graphs and operations on them; hashing.

COMP 2002 *Computer Architecture: Systems*
Microcomputer architecture; bus systems; i/o interface adaptors; parallel and serial devices; interrupts: types; handling of; polling and vectored interrupts; direct memory access; putting systems together; advanced memories: associative cache, virtual, multiprocessor architectures; programming.

COMP 2003 *Functional Programming*
Expression evaluation; notation; types; conditionals; lists and primitive functions; DEFUN; applicative functions; iteration; declarations; macros; EVAL; compilation; association lists; assignment; structures; I/O; CLOS; garbage collection; other functional languages.

COMP 2004 *Foundations of Computing*
Mathematical notation and terminology; finite automata and regular languages; definitions and properties, regular expressions; universal models and computability theory: Turing machines, primitive recursive functions; complexity of algorithms: efficiency of algorithms, complexity classes, complexity analysis in practice.

COMP 2011 *Datastructures and Algorithms II*
Trees; graphs; pattern matching; sorting; specification techniques; complexity analysis; application.

COMP 2006 *Databases and Information Systems*
Types of information system; database organisation; introduction to relational, hierarchical and network data models; data definition and manipulation languages; information retrieval systems; retrieval strategies; intelligent knowledge based systems.

COMP 2007 *Operating Systems I*
Introduction to Oss. processes: memory management; file management; introduction to security and protection; case studies; Unix, Win NT.

COMP 2008 *Multimedia Systems*
Introduction to the World Wide Web; web design and authoring tools; web servers; HTML; java script; GCI scripting; typography; page and graphic design; graphics formats; dynamic HTML; cascading style sheets; audio and video on the web; future trends.

Third Year

Students are reminded that choice of third year options may constrain fourth year options available to them.

COMP 3001 *Computer Architecture: Digital Systems*
Logic Design; gates; multiplexors; decoders; arithmetic circuits; flip-flops, synchronous/asynchronous circuits, clocks, counters, registers; buses;
integrated circuits; field programmable gate arrays; bit slices; memory elements; testing, hardware description language.
Prerequisite: COMP 2002

COMP 3002 *Operating Systems I*
Introduction to OSs, OS Structure, Hardware features and OSs. Processes: Independent and Co-operative processes, Sychronisation Mechanisms, Deadlocks and Starvation. Memory Management: Binding and Relocation, Memory Organisations (fixed and variable partitions), Paging Technique, Segmentation Technique, Virtual Memory. File Management: File System structures, Files, Directories, File System Implementation. Introduction to Security and Protection: Basic Issues,

Security Problem, Authentication, Encryption, Protection Problem, Trusted Systems. Case Studies: Unix, Win NT.

COMP 3003 *Visual Computing: Graphics*

Graphics hardware and languages; colour models; window to viewport transformation. clipping algorithms; two dimensional transformations;. three-dimensional object representation; parallel and perspective projections; image enhancement; grey level histogram stretching, equalisation, specification; filtering; edge detection.

COMP 3004 *Software Design & Development I*

Information systems: Users, the technology, the value of information, systems development life cycle (overview): analysis and design methodologies; structured methods; selected system analysis and design techniques; designing structured programs; data environments; programming; software development tools, project management (overview); systems justification.

COMP 3005 *Information Systems I*

Kinds of information system; DBMS: concepts; 3-level architecture; entity-relationship model; network model and CODASYL; relational model; SQL; database design; normalisation. Information retrieval: classification (heuristic – automatic classification) – graph-theoretic – cluster-based retrieval – user models.

COMP 3006 *Program Design & Verification 1*

Propositional and predicate calculus; theorem proving; the correctness of programs; WP-calculus; derivation of loop programs; efficiency considerations; strengthening invariants.

COMP 3007 *Formal Syntax*

Formal languages and their descriptions; grammars; Chomsky hierarchy; regular language; finite state automata; context free grammars; push-down automata; top-down/bottom-up parsing.

COMP 3008 *Computer Networks*

Network types, functions, topologies, transmission, switching, routing, management, reference models, architectures, protocols and standards; network user applications; flow and congestion control strategies; design and implementation considerations.
Prerequisite: COMP 2002

COMP 3009 *Artificial Intelligence*

Problem Solving & Search: knowledge representation; search techniques; expert systems. Machine learning: inductive learning; learning from mistakes; case-based reasoning, connectionist computing: basic neurobiology; history of connectionism; connectionist models. Natural language processing. Applications of artificial intelligence; case-studies; recommender systems & the world wide web.
Prerequisite: COMP 2003

COMP 3010 *Advanced Computer Architectures*

Fundamentals of Computer Design: Measuring and Reporting Performance, Quantitative Principles of Computer Design, Concept of Memory Hierarchy. Instruction Set Principles. Pipelining: The Major Hurdle of Pipelining, Data and Control Hazards, Pipelining Implementation. Advanced Pipelining and Instruction-Set Parallelism: Instruction-Level Parallelism, Overcoming Data Hazards. CISC and RISC Architectures. Parallel Architectures: Fundamental Design Issues, Shared Memory Multiprocessors (UMA and NUMA), Distributed Parallel Architectures, Programming Paradigms. Systolic Architectures. Data-Flow Architectures.

COMP 3011 *Object Oriented Programming*

Fundamental object-oriented concepts: classes, objects, messages, encapsulation, inheritance, polymorphism, dynamic binding; elementary object-oriented design; practical programming in an object-oriented language, e.g. C++.

COMP 3012 *Object-Oriented Design*

Survey of existing software development methodologies; The Unified Modelling Language; Use cases; Modelling static and dynamic aspects of a system; Case studies; Product and process quality.

COMP 3013 *Software Engineering Project*

A group project in software engineering building a complete system based on the application of analysis, design and implementation techniques.

COMP 3014 *Introduction to Multi-Media*

Physical Foundations: The nature of sound and light: physical, perceptual, digital representations; Capture, conversion, storage, transport, and display of digital multimedia information; Digital typography; Basic Graphics, Audio, Video, Multimedia devices and architectures; Encoding mechanisms: MPEG, MPEG IV, QuickTime. Multi-Media Production Tools.

COMP 3015 *Logic Programming*

Introduction to logic programming; The logic programming computational model; Problem solving and practical programming in Prolog.

COMP 3016 *Networks and Internet Systems*

Network types, functions, topologies, transmission, switching, routing, management, reference models, architectures, protocols and standards; network user applications; flow and congestion control strategies; design and implementation considerations; use in internet systems.

COMP 3017 *Foundations of Computing*
Mathematical notation and terminology; finite automata and regular languages; definitions and properties, regular expressions; universal models and computability theory; Turing machines, primitive recursive functions; complexity of algorithms: efficiency of algorithms, complexity classes, complexity analysis in practice.

MATH 3208 *Mathematical Logic* is considered to be part of the Computer Science course for some Joint Honours Degrees. For details of course, see under Mathematics.

Fourth Year – COMP 4000

Students will be required to take a total of eight units. These units will be drawn from core units (COMP4001, COMP4007, COMP4008, and COMP4010) and additional units offered in a given year.

COMP 4001 *Computability*
Effective procedures; the spectrum of computability, from simple problems to undecidable ones; what is and is not computable; models of computability; turing machines, partial recursive functions; markov algorithms; what is and is not tractable; complexity classes, P, NP, co-NP and NPC; coping with NCP problems; problem restriction, approximation algorithms.

COMP 4002 *Information Systems II*
Databases: recovery; concurrency; security; integrity; distributed databases; extended relational data model; object oriented data model.
Prerequisite: COMP 3005

COMP 4003 *Systems Design & Development II*
Systems development life cycle (issues/problems); Tools and techniques for analysis and design; implementation approaches; soft methodologies; CASE tools: analysis, design, code generation; distributed system issues; evaluation; usability; quality assurance; security; project management tools and techniques.
Prerequisite: COMP 3004

COMP 4004 *Interactive Computer Graphics*
The rendering pipeline; visible surface determination; local illumination and shading models; curve and curved surface generation; solid modeling; texture mapping; global illumination: ray tracing, radiosity and monte carlo methods; computer animation; scientific visualization.
Prerequisite: COMP 3003

COMP 4005 *Image Processing*

Geometric operations; linear system theory; convolution and correlation; continuous Fourier transform; Fast Fourier Transform; frequency filtering; segmentation; image encoding; applications.
Prerequisite: COMP 3003

COMP 4006 *Problem Design and Verification II*

Calculating programs; advanced derivational techniques; refinement calculus; reifying abstract data types; the use of simple algebras in program construction.

COMP 4007 *Formal Semantics*

Formal semantics; needs and uses; semantics; recursive programs; fixed point theory; structural induction; computational induction; denotational semantics; algebraic semantics; axiomatic semantics.

COMP 4008 *Topics in Object-Oriented Design*

Object-oriented methods in the software development cycle; practical design techniques using e.g. Unified Modelling Language technique; alternative approaches to object-oriented design; frameworks and design patterns.
Prerequisite: COMP 3011

COMP4009 *Design Patterns*

Introduction to Patterns. Use of patterns in the design process. Documentation of new patterns. Creational patterns. Structural patterns. Behavioural patterns. Introduction to Frameworks. Data-driven and architecture-driven approaches. Synergy between patterns and frameworks. Case studies.
Prerequisite: COMP 3011

COMP 4010 C*oncurrent Programming*

Nature of concurrent programming shared memory; message passing; interference; synchronisation; mutual exclusion; semaphores; deadlock; fairness; high level constructs for concurrency; communicating sequential processes; applications to operating systems; formal verification.

COMP 4011 *Formal Specifications*

Need for formal specifications; specification methods e.g. VDM, algebraic specifications; techniques for specifying complex systems; developing systems for specifications; case studies.

COMP 4012 *Operating Systems II*

Language mechanisms for concurrency. Security and Protection – formal models (access matrix, BLP, lattice, take grant models). Scheduling Algorithms. Distributed Operating Systems –design and implementation, Synchronisation in Distributed OS, Distributed Process Scheduling, Distributed Concurrency control (deadlock and recovery), Distributed File Systems, Distributed Shared Memory, Distributed Computer Security. Case Studies: CHORUS, MACH, AMOEBA.
Prerequisite: COMP 3002

COMP 4013 *Language Engineering*

Fundamentals of natural language processing; formal models and corpus-based methods in speech and language; resources, standards and evaluation methodology; applications of human language technology.
Prerequisite: COMP 3009

COMP 4014 *Distributed Systems*

Distributed systems processing and interconnection architectural/reference models and concepts; open and closed systems; distributed operating system kernels, decomposition and consequences of distribution; security and management of distributed systems; transparency, remote operations, coordination replication, shared transactions, concurrency control, recovery and fault tolerance.
Prerequisite: COMP 3008

COMP 4015 *Exploring Computer Science*

Special topics related to current research and state of art applications not covered in other units.

COMP 4016 *The Intelligent Internet*

Applications of Artificial Intelligence techniques to the Internet; information integration, information extraction, information retrieval, clustering, recommender systems, and semi-structured information.
Prerequisite: COMP 3009

COMP 4017 *Foundations of Artificial Intelligence*

The importance of representation, First Order Logic, Predicate Calculus, Normalised FOPL forms, Skolemisation, Conversion to Clausal Form, Resolution, Logic Programming, Prolog, Extra Logical features of Prolog, Semantic Networks, Frames, The Frame Problem.
Prerequisite: COMP 3009

COMP 4018 *Connectionist Computing*

Basic neurobiology; cortical and sub-cortical structure and function. History of connectionism: the McCulloch and Pitts neuron, Hebbian learning, the Perceptron. Modern connectionist learning: simple associators, the Boltzmann machine, Hopfield networks, Kohonen networks, error backpropagation. Connectionist natural language processing. Connectionist visual processing.
Prerequisite: COMP 3009

COMP 4019 *Multi-Agent Systems (MAS)*

Definition of Distributed Artificial Intelligence (DAI). Motivations for MAS, Strong versus weak notions of agency. Intentional agent systems. Agent communication. Speech act theory. Collaboration, planning, belief desire intention (BDI) architectures. Agent oriented design, agent oriented programming and languages (Agent0, Agentalk), Multi-agent systems prototyping environment, industrial and commercial applications.
Prerequisite: COMP 3009

COMP4020 *Speech Processing*
Speech production: the vocal tract, basic articulatory phonetics; Acoustic phonetics; Waveform segmentation; Sampling and digital encoding; FFT and spectral representations; Spectrogram reading; Source-filter model of the vocal tract; Speech coding - LPC, Cepstra; Voicing and pitch extraction; Principles of synthesis.

COMP4021 *Parallel Algorithms: Design & Analysis*
Performance and Scalability of Parallel Systems, Metrics, Sources of Parallel Overhead; Arrays and Trees - Elementary Sorting and Counting, Matrix Algorithms, Graph Algorithms; Meshes and Trees - 2-Dimensional Mesh of Trees, Elementary O(log N)-Step Algorithms, Higher-Dimensional Meshes of Trees; Hyper-cubes and Related Networks - Hypercube, Butterfly Cube-Connected-Cycles and Benes Network, Shuffle-Exchange, Packet Routing Algorithms, Sorting, FFT, Other Hypercube Networks; Parallel Systolic Algorithms - Mapping 1-D and 2-D Systolic Arrays onto Parallel Computers.
Prerequisite: COMP 3001

COMP4022 *Randomised Algorithms & Stochastic Simulation*
Basic concepts in the design and analysis of randomised algorithms; Randomness and non-uniformity, Game-Theoretic Techniques, Markov Chains and Random Walks, Algebraic Techniques; Linear and Non-linear Programming; NP-complete applications; Graph Algorithms; Meta-heuristic techniques: simulated annealing, genetic algorithms, tabu search.

COMP4023 *Hardware-Software Codesign*
Models and Architectures; Hardware languages; Target architectures; Compilation techniques and tools for embedded systems; Design specification; Prototyping and Emulation.
Prerequisite: COMP 3001

COMP4024 *Parallel Environments & Applications*
Parallel Programming: Parallelism and Computing, Parallel Programming Paradigms. Designing Parallel Applications: Methodical Design, Partitioning, Communication, Agglomeration and Mapping. Parallel Programming Languages: Compositional C++, C*, HPF, MPI, C-LINDA. Performance Tools: Performance Analysis, Data Collection, Data Transformation and Visualisation, Tools (Paragraph, Upshot, ParAide, and IBM's Parallel Environment).
Prerequisite: COMP 3001

COMP 4025 *Spatial Information Systems*
Databases issues in information systems storing and handling spatial data: representation and manipulation of spatial data; models; relations; indexing methods for spatial data; geometric problems and algorithms;

query processing in spatial databases; geographic applications; emerging research directions.
Prerequisite: COMP 3005

COMP 4026 *Knowledge Based Computation*
Knowledge-based methods for artificial intelligence systems. Knowledge representation, organization, application and maintenance. Principles of memory organization, indexing and retrieval. Memory-based, analogical and case-based reasoning. Applications to understanding, explanation, planning, and advisory systems.
Prerequisite: COMP 3009

COMP 4027 *Integrated Services and Multimedia Networks*
Introduction to multimedia networking issues; broadband applications: characteristics and performance requirements; B-ISDN and ATM basics; ATM switching; ATM traffic management issues; internet protocols; internet traffic and quality of service issues; ISDN; network performance issues, modelling and analysis.
Prerequisite: COMP 3008

COMPUTER SCIENCE (DENOMINATED ENTRY)

First Year Courses

For details of First Year Courses, see pages 34 to 38.

Second Year Courses

Mathematics
Students follow the Second Year Honours or General course in Mathematics.

Computer Science
In Computer Science students take the following courses:

COMP 2001 Datastructures and Algorithms I
COMP 2002 Computer Architecture: Systems
COMP 2003 Functional Programming
COMP 2011 Databases and Information Systems
COMP 2006 Datastructures and Algorithms II
COMP 2007 Operating Systems I
COMP 2008 Multimedia Systems
COMP 3006 Program Design and Verification

Third Year Courses

Students follow Third Year courses as directed by the Department of Computer Science.

Fourth Year Courses

See pages 56 to 60.

ENVIRONMENTAL BIOLOGY

Programme Director: Professor Gerard J. Doyle

Departmental Directors:
Botany: Professor Gerard J. Doyle
Industrial Microbiology: Dr Evelyn M. Doyle
Zoology: Dr Thomas Bolger

Prerequisite: First Science Biology

Regulations covering Topical Degrees are listed on page 31.

Second Year Programme for General and Honours Degrees

Students must follow course combinations that include at least two of the subjects Botany, Industrial Microbiology or Zoology. Students take each of the course units listed for these subjects for Second Year.

Third Year Programme for General and Honours Degrees

The Third Year Environmental Biology programme comprises ten course units. Eight core units (four from Botany and/or Industrial Microbiology and/or Zoology) are combined with two optional units from the Faculty of Science programme. Selection of core units depends on the student's Second Year subject combination. Selection of all units, both core and optional, must be agreed by the Programme Directors.

Core Units in Environmental Biology
Details of the core course units are presented under the subject listings for Botany, Industrial Microbiology and Zoology.

Botany core course units*
BOTN 3001 Diversity and Ecology of Fungi
BOTN 3003 Plant/Soil Interactions in Wetlands
BOTN 3004 Plant Growth and Nutrient Assimilation
BOTN 3007 Vegetation Ecology and Biogeography

Industrial Microbiology core course units
INDM 3001 Bacteriology and Mycology
INDM 3002 Physiology and Biochemistry
INDM 3004 Environmental Microbiology
INDM 3007 Gene Expression and Regulation

Zoology core course units

ZOOL 3011	Arthropoda
ZOOL 3014	Systems Ecology
ZOOL 3016	Diversity of Vertebrates
ZOOL 3017	Wildlife and Fisheries Management

**Students taking Botany as part of their core course must attend the Burren Field Course (BOTN 4021) after the Summer Examination in their Third Year.*

Optional units in Environmental Biology

All students take Biostatistics (STAT 3221). The following optional units have been found appropriate and to fit in with the timetable for Environmental Biology students – BOTN 3002, INDM 3003, INDM 3005, LANG 3001, LANG 3002, LANG 3003, LANG 3004, ZOOL 3013, ZOOL 3015. Optional unit selection must be agreed with the Programme Directors and fit in with the timetables.

Fourth Year Courses for Honours Degree – ENVB 4000

The Fourth Year Programme comprises ***n****ine* lecture courses.

Compulsory Courses

ENVB 4001 *Environmental Regulation: Policy and Practice*
Environmental regulation in Ireland and the EU: policy, administrative and legislative framework with regard to species/habitat conservation, pollution, and resource management in terrestrial, freshwater and marine environments.

BOTN 4011 *Critical Analysis of Scientific Papers*

Optional courses

Students select seven optional courses, with a minimum of three from each of the two main subject areas contributing to their degree programme (i.e. Botany, Industrial Microbiology, Zoology). Course selection will depend on the student's subject background and must be agreed by the Programme Directors and the relevant Heads of Departments.

Courses in Botany

BOTN 4001	Peatland Ecology and Conservation
B0TN 4002	Ecotoxicology
BOTN 4003	Evolution in Plant Populations
BOTN 4004	Mycorrhizal Symbiosis
BOTN 4012	Ecological Significance of Different Photosynthetic Pathways

Courses in Industrial Microbiology

Compulsory courses

INDM 4013	Current Topics in Fungi
INDM 4015	Advances in Environmental Microbiology II
INDM 4016	Advances in Environmental Microbiology III

Optional Courses

INDM 4012	Current Topics in Bacteria

INDM 4014 Microbial Genetics
INDM 4017 Food Microbiology

Courses in Zoology
ZOOL 4001 Biodiversity
ZOOL 4005 Ecology of Tropical Rainforests
ZOOL 4007 Wildlife Management
ZOOL 4010 Environmental Impact Assessment
ZOOL 4015 Marine Ecology

Honours Project
A project in an environmental topic is carried out in Botany, Industrial Microbiology or Zoology. The project is a significant component of the final year course and is presented in thesis form as part of the final degree examination assessment.

Written Assignments
A library-based written assignment on an environmental topic forms part of the final degree examination assessment.

ENVIRONMENTAL GEOCHEMISTRY

Programme Director: Dr J. Stephen Daly, Department of Geology

This programme is primarily designed as a two-year programme following completion of Second Science, leading to the award of an honours Topical degree. (See regulations for Topical Degree p. 31)

Second Year Courses for General and Honours Degrees
Students take Geology, Chemistry and one other subject in Second Science.

Third Year Courses for General and Honours Degrees
Students take eight core units which are CHEM 3001, CHEM 3002, CHEM 3006, GEOL 3002, GEOL 3003, GEOL 3004, GEOL 3005, GEOL 3013 and two optional courses to be decided in consultation with the Course Director. The Third Year course involves geological field classes.

Fourth Year Course for the Honours Degree – ENGC 4000
Students take eight core units which include CHEM 3003, CHEM 3004, CHEM 3015, GEOL 3006, GEOL 3008, GEOL 4011, GEOL 4012.

In addition, all Fourth Year students are required to complete a field, laboratory or combined field laboratory project(s) during the course of the year. In the case of field projects, the data are collected in the Summer before the start of the Fourth Year. This will be presented in thesis form as part of the final degree examination assessment. The Fourth Year course involves geological field classes.

Courses in Environmental Geochemistry
A wide range of economic activities including the provision of clean water supplies, mining, the siting and operation of landfill sites, disposal of hazardous and radioactive waste, now draw on the expertise of environmental science graduates. A key requirement, hitherto largely neglected, is to produce graduates who understand the physical and chemical interactions of contaminants and pollutants with the geosphere (e.g. groundwater, aquifers, soils, glacial and fluvioglacial deposits, different bedrock lithologies). Hence the need for graduates with a strong geoscience as well as a chemistry background.

GEOL 3013 *Applied Geochemistry*
Geochemistry of groundwaters, rivers, lakes, estuaries, coasts and the marine environment. Kinetics of mineral-water interactions. Role of particulates, colloids, sorption, desorption, ligand interactions in the hydrosphere. Eh-pH diagrams. Role of organics and organometallic compounds. Bioavailability. Mechanisms and timescales of pollutant recycling and dispersal.

GEOL 4011 *Isotope Geochemistry I*
Radiogenic isotopes as geochronometers and tracers. Quaternary geology and short-lived nuclides. Actinide geochemistry. $^{230}Th/^{234}U$, $^{234}U/^{238}U$, $^{231}Pa/^{235}U$ and ^{210}Pb dating methods. U-series mobilisation and surface hydrology. Groundwater dating and tracing. Applications to radioactive waste disposal studies. Pb isotopes as environmental tracers. Cosmogenic isotopes. Radiocarbon dating.

GEOL 4012 *Isotope Geochemistry II*
The carbon cycle. Organic compounds in mineral inclusions, humic acids, lipids, kerogen. The organic geochemistry of peat, coal, crude petroleum and recent sediments. Extraction techniques and analytical methods. Compound specific stable isotope analysis. Stable isotope fractionation processes and temperature effects.

Students study a number of optional courses (see page 53) which form part of the fourth year single honours course in Chemistry. These courses are chosen in consultation with the Course Director.

EXPERIMENTAL PHYSICS

Prerequisites for all units: First Science Experimental Physics and Mathematics

Second Year Courses for General and Honours Degrees

EXPH 2001 *Optics & Computational Physics*
Wave motion. Superposition. Electromagnetic theory of light. Light propagation (reflection, refraction, Fermat's principle). Polarisation. Interference (Young's slits, Michelson & Fabry-Perot interferometers). Diffraction (Fresnel & Fraunhofer). Simulation of deterministic processes. Generation of pseudo-random numbers. Simulation of random processes. Random walks. Computational methods in optics.

EXPH 2002 *Electromagnetism*

This course builds on electrostatics and evolves to a discussion of the conservative nature of the electric field and to the formulation and application to electrostatics of both the Divergence theorem and Stokes' theorem. Rules governing the flow of electrons in real circuits are developed and symmetry principles applied to complex circuits. Special circuits such as LR, CR and LCR are analysed in detail. The effect of electric fields on materials is presented. Practical considerations such as complex impedance, resonance, power transfer and impedance matching are all described in the context of real circuits some of which will be computationally modelled.

EXPH 2003 *Atomic and Quantum Physics*

Introduction. Distribution functions. Blackbody radiation. Quantisation. The Bohr Atom. Wave particle duality. The wave packet. Heisenberg's uncertainty principle. The Schrödinger Wave Equation and simple systems. Applications of Quantum Mechanics to different scale systems i.e. solids, atoms, nuclei. The Compton effect, Rutherford scattering and Brownian motion are modelled as exercises.

EXPH 2004 *Solid State Physics and Devices*

Introduction to the physics of materials in the solid state, with particular reference to electron behaviour. Electronic band structure of conductors, semiconductors and insulators. Intrinsic and extrinsic conductivity and doping in semiconductors. p-n junction. Practical semiconductor devices, including FET transistors and the solid state laser. Computer modelling of devices. Superconducting properties of materials at low temperatures.

Third Year Courses for General and Honours Degrees

Students taking a *General Degree* in Experimental Physics will be required to take a minimum of 4 units from the following: EXPH 3001, EXPH 3005, EXPH 3006, EXPH 3012 and EXPH 3016.

Students taking an *Honours Degree* in Experimental Physics will be required to take modules EXPH 3006 to EXPH 3013 inclusive.

Students wishing to take third year honours units in Computational Physics should note that units EXPH 3014 and EXPH 3015 will be offered on a limited basis to interested students as alternatives to EXPH 3010 and EXPH 3012. Units MAPH 3071 and MAPH 3081 will be co-requisites for students wishing to pursue the Computational Physics option.

EXPH 3001 *Electromagnetism and Optics*

Maxwell's equations. Electromagnetic waves. The Poynting vector. Fresnel's equations. Non-reflecting and high reflecting films. Absorption and dispersion. Polarization. Magneto-optic, electro-optic and acousto-optic effects. Vector and scalar potentials. Transmission lines. Waveguides. Interference. Michelson

interferometer. Fourier transform spectroscopy. Fabry-Perot interferometer. Twyman and Green interferometer. Lasers. Non-linear optics.

EXPH 3005 *Instrument Science*
Introduction to measurement systems. Instrument definition, static and dynamic characteristics. Zero, first and second order instrument systems. Deterministic and random noise. Noise reduction and signal processing techniques. Digital to analogue and analogue to digital conversion. Sensor conversion processes. Mechanical, electrical, electronic, optical and opto-electronic transducers. Thermoelectric and piezo-electric systems.

EXPH 3006 *Thermodynamics and Statistical Physics*
Temperature. First law of thermodynamics. Work and energy. Second law. Carnot cycle. International temperature scale. Entropy. Maxwell relationships. Applications of thermodynamics. Phase changes. Thermal radiation. Introduction to statistical physics. Maxwell-Boltzmann statistics and applications. Fermi-Dirac statistics. Bose-Einstein statistics. Planck's Law. B-E condensation. Properties of liquid Helium.

EXPH 3007 *Solid State Physics*
Binding forces in crystals. Lattice dynamics - Vibrational modes. Acoustic and optical branches, phonons. Lattice specific heats - Einstein and Debye models. Classical free electron gas, quantum effects, Fermi energy, pressure of an electron gas, specific heat of a degenerative electron gas. Periodic lattices, Bloch functions, Kronig-Penney model - band structures. Paramagnetism.

EXPH 3008 *Electromagnetism*
Vector and scalar fields. Laplace equation. Lorentz gauge. Magnetic vector potential. Aharanov-Bohm effect. Maxwell's equations. Electromagnetic waves. Energy transport. Irradiance. Radiation pressure. Lorentz force. Relativistic transformation of E-field. Relativistic field due to moving point charge. AC circuit elements. "Idealised inductance". Transmission lines. Ladder networks. Low and high pass filters. Very high frequency effects. Resonant cavity. Waveguides. Electromagnetic waves with boundary conditions. Momentum density of electromagnetic fields.

EXPH 3009 *Optics*
History of optics. Diffraction. Introduction to Fourier optics. Diffraction gratings. Fabry-Perot interferometer. Fourier transform spectroscopy. Michelson interferometer. Coherence. Optical systems, matrix optics, point spread function, OTF, MTF, deconvolution. Optical processing. Holography. Optical radiation detectors.
Prerequisite: EXPH 2001.

EXPH 3010 *Electronics*
An introduction to analog electronics with emphasis on operational amplifiers and their applications to analog signal processing. Topics covered include negative feedback, analog computation, linear and non-linear circuits. An introduction to digital electronics is also presented with emphasis on the TTL logic family, in particular, gates, monostables, counters and applications. The influence of noise in electronic circuits is also discussed.

EXPH 3011 *Classical Mechanics and Relativity*
Variational principles and Lagrange's equations. Hamilton's equations. Special relativity - classical background. Michelson-Morley and related experiments. Einstein's postulates. Lorentz transformation equations - experimental confirmation. Transformation of velocity. Geometrical representation. The clock paradox. Four vectors and relativistic invariance. Energy-momentum transformation equations. Relativistic momentum energy relationship and applications. The transformation of force.
Prerequisite: EXPH 2003.

EXPH 3012 *Nuclear Physics*
Introduction. Natural and artificial radioactivity. Radioactive equilibrum. Interaction of alpha, beta and gamma radiation with matter. Cherenkov radiation. Prediction and observation of the positron. Theory of alpha decay. Theory of beta decay, double beta decay and electron capture. Detection and mass of the neutrino. Concept of parity and its non conservation in beta decay. Gamma decay. Radiative transitions in nuclei, including lifetimes of excited and isomeric states. Internal conversion and pair internal conversion. Angular correlations. Liquid drop model of the nucleus. Spontaneous and induced fission. Fission cross-sections and fission reactors. Neutron activation analysis.

EXPH 3013 *Quantum Mechanics*
Postulates of Quantum Mechanics. Operators, observables and eigenfunctions. Co-ordinate and momentum representations. Hermitian operators. Matrix methods. Uncertainty Principle. Ehrenfest's theorem. Harmonic oscillator. Ladder operators. Angular momentum. Schrödinger theory of the hydrogen atom. Degeneracy. Fine structure. Normal Zeeman effect. Pauli theory of electron spin. Stern-Gerlach experiment. Spin-orbit interaction. Total angular momentum. Clebsch-Gordan coefficients.

EXPH 3016 *Atomic, Molecular and Materials Physics*
Brief review of Quantum Mechanics. Hydrogen atom: spectrum and structure. Spin, the Zeeman effect and spin orbit interaction. Structure and spectra of many electron atoms. Covalent, ionic and van der Waals bonding. Molecular structure and spectra. Lithography, epitaxy and other semiconductor fabrication processes. Impurity and defect analysis in surfaces and bulk materials. Gallium arsenide, silicon and diamond structures. Quantum wells, wires and dots. Magnetic properties of materials. New magnetic materials.

Courses for Computational Physics alternatives

EXPH 3014 *Linear Methods and Transforms in Physics*
Computational physics methods and techniques are developed for application to data analysis and reduction. Emphasis will be on developing algorithms and computer programs which may be applied to real systems. Topics will include: Linear equations, Matrices, Bezier curves, Lagrange interpolation, Spline

fitting, Eigenvalues, Singular value decomposition. Fourier transform spectral methods, filtering and convolution, power spectra, applications to image processing and time series analysis.

EXPH 3015 *Chaotic Dynamics and Fractals*
Non-linear dynamics forms the basis of this course which is given expression in the study of chaotic systems and fractals. Emphasis will be on computational methods and exercises aimed at gaining insight into how non-linear systems shape our world. Topics to be covered will include: Simple and driven pendula, Chaotic motion and bifurcation, Period doubling, Stability, Lyapunov exponents, Lorenz simplified weather model, numerical integration of particle moving in two dimensions e.g. Henon-Heiles potential. Theory of fractals, visualization of fractals, fractal Brownian motion, fractal dimension.

Fourth Year Courses for Honours Degree – EXPH 4000

Students taking an Honours Degree in Experimental Physics will be required to take units EXPH 4001 to EXPH 4006 inclusive plus any two of units EXPH 4007 to EXPH 4014. It should be noted that not all of the optional units will necessarily be offered each year.

Students wishing to take fourth year honours units in Computational Physics should note that units EXPH 4015 and EXPH 4016 will be offered to students, who have taken the Computational Physics alternative at third year honours level. They will be required to take units EXPH 4001, EXPH 4003, EXPH 4004, EXPH 4006, EXPH 4015 and EXPH 4016 inclusive, plus any two of the Fourth Year units EXPH 4007 to EXPH 4014 or one of these units combined with one of the Third Year units, EXPH 3010 or EXPH 3012. It should be noted that not all of the optional units will necessarily be offered each year.

EXPH 4001 *Quantum Mechanics*
Linear vector spaces. Discrete and continuous representations. Dirac general transformation theory. Schrödinger and Heisenberg representations as special cases. Time development of quantum systems. Definition of Hamiltonian in quantum theory. Two state systems. The photon. Ammonia molecule. Hydrogen molecular ion and neutral K-meson. Symmetry in quantum theory. Conservation laws. Quantum theory of charged particles in electromagnetic field. Introduction to relativistic quantum mechanics. The Klein-Gordon equation. Dirac four component wave function. Dirac equation and its solution for free electron. “Quantum reality”. Einstein Podolski Rosen paradox. Bell inequality. Aspect experiments.

EXPH 4002 *Quantum and Nuclear Physics*
Quantum theory for Bosons and Fermions. Theory of the deuteron. Scattering theory; including partial wave analysis, scattering length and effective range concepts, proton-neutron scattering, the Born approximation and resonant scattering. Nuclear fusion including solar fusion and the solar neutrino flux. Single-particle shell model of the nucleus. Neutron physics including neutron detectors.

EXPH 4003 *Applied Electromagnetism and Plasma Physics*

Electromagnetism

Fields due to an oscillation dipole. Rate of radiation from an oscillating charge. Scattering including Thompson scattering and Rayleigh scattering. The invariance of Maxwell's equations. The current-potential four vector.

Plasma Physics

Fundamental atomic processes. Plasma electron oscillations. Highly conducting plasmas.

EXPH 4004 *Atomic and Molecular Physics*

Hydrogen atom in a magnetic field: Anomalous Zeeman effect, Paschen-Back effect and Chaos. Approximation methods: Non-degenerate and degenerate perturbation theory, variation principle. Stark effect. Helium atom: spin and exchange in two-electron systems, energy level structure and spectrum. Many-electron atoms. Central field theory. Coupling schemes. Autoionisation. Time-dependent perturbation theory. Transition probabilities.

The covalent bond. Properties of simple diatomic molecules.

EXPH 4005 *High Energy Particle Physics*

Fundamental particles and their interactions. Quantum numbers. Conservation laws. Resonant states. Gell-Mann Pais theory of neutral K meson. CP violation. Pais-Piccioni effect. The fundamental constituents of matter - leptons, quarks, gauge mesons. The fundamental interactions. Some ideas introduced by quantum field theory - antiparticles; exchange mechanism for interactions, Feynman diagrams. Quark structure of Hadrons, other evidence for quarks. Colour and the strong interaction. Weak interactions. Survey of experimental techniques. Charm, Beauty and Top quark searches. Heavy leptons. pp physics and the weak field mediators. Neutrinos.

EXPH 4006 *Solid State Physics and Lasers*

Solid State Physics: Reciprocal Space. Crystalline structure. Brillouin zones. Landau levels. Measurement of the Fermi surface. Location of the Fermi level in intrinsic and extrinsic semiconductors. Low dimensional systems. Quantum Hall effect.

Lasers: Einstein's theory of radiation. Resonant cavities and modes. Threshold value of population inversion. Optical pumping. Types of laser. Laser output. Semiconductor lasers.

EXPH 4007 *Applied Optics*

Polarisation and birefringence. Acousto-optic, electro-optic and magneto-optic effects. Modulators, deflectors and displays. Liquid crystals. Non-linear optics. Harmonic generation. Parametric oscillation. Phase conjugation. Memory devices. Detectors: PMT, photoconductive and junction, CCD. Planar dielectric waveguides. Optical fibres: Step and graded-index, attenuation and dispersion. Optical communications. Fibre optic sensors.

EXPH 4008 *Environmental Radiation and Radioecology*
Radiation doses, risk factors, limits and regulatory aspects. The natural radiation environment, cosmic radiation and radon doses. Detection techniques. Properties of aerosols. Lung dosimetry of alpha emitters. Radioecology. Radioecological modelling. Speciation effects. Radioanalytical techniques, including principles of environmental sampling, sample variability, radiochemical analysis, radiometry and mass spectrometry. Radioisotope dating.

EXPH 4009 *Perspectives in Modern Astrophysics*
A number of selected topics are presented in this two part course.
Part I: Emphasises the Sun, stellar evolution, gravitational potential energy, temperature, pressure, luminosity and fusion reactions, galaxy formation, dark matter and large scale structure of the galaxy. Neutrino flux.
Part II: Concentration on the influence of gravitational collapse to include supernovae, pulsars, primordial black holes, supermassive black holes and active galactic nuclei, with an emphasis on high energy processes and radiation mechanisms.

EXPH 4010 *Atomic Structure and Spectra*
Single particle and many body models. Hartree and Hartree-Fock methods. Slater F and G integrals. Energy level structure in complex systems. Configuration interaction. Series perturbations. Selection rules and quantum mechanical treatment of transition probabilities. Autoionization, inner shell photoionization and non-radiative decay. Unresolved arrays and statistical methods. Modern developments in atomic physics.

EXPH 4011 *Physics of Ionised Gases*
States of matter. Collective model - some general characteristics - plasma oscillations. Debye length. Classical Collision Theory. Processes leading to creation of an ionised gas. Derivation of Boltzmann equation. Derivation of macroscopic hydromagnetic equations. Conservation laws. Motion of particles in electric and magnetic fields. Plasma diagnostics. Waves in plasmas.

EXPH 4013 *Condensed Matter Physics*
Type-I and type-II superconductors. Meissner effect. Thermodynamics of normal to superconconducting phase change. Electrodynamics and Maxwell's equations. London penetration depth. Coherence length. Phenomenological theories. Virtual phonon scattering and the Cooper ground state. BCS theory. Energy gap. Josephson effects. SQUIDs and SLUGs. High-temperature superconductors. Superfluidity in liquid helium. First and second sound. Rotons. Vortex states. Laser cooling and trapping of atoms and ions. Bose-Einstein condensation of alkali vapours.
Co-operative magnetic phenomena.

EXPH 4014 *Medical Physics*
Photon interactions in matter. X-ray spectra and filtration. Charged particle interactions. Production of medical radiation beams. Charged particle equilibrium. Kerma and dose. Bragg and Gray cavity theory. Absolute dosimetry. Detection of ionising radiation. Radiation Protection. Medical uses

of ionising radiation, external teletherapy, bracytherapy. Nuclear Medicine and diagnostic imaging.

Courses for Computational Physics alternatives

Each of the following units will include continuous assessment of worked exercises and a short project.

EXPH 4015 *Data reduction, Modelling and Error Analysis*
This course is an introduction to methods of data analysis and reduction for the perspective of Computational Physics. Topics covered include: characterization of data, probability distributions; error analysis and error propagation; least squares fitting; matrix computation and eigenvalue problems; singular value decomposition and principal component analysis; maximum likelihood methods; testing and goodness of fit; minimisation and maximisation of functions; method of simulated annealing; time series analysis; application of techniques to physical systems.

EXPH 4016 *Interdisciplinary Computational Physics*
Genetic algroithms and their application to optimisation problems. Random mutations, selection based on fitness. Percolation. Neural networks: computational networks, optimisation and applications to pattern recognition. Cellular automata. Simulating the Ising model and phase transitions. Relaxation in dissipative natural systems. Self organised criticality: earthquakes and propagation of forest fires.

GENETICS

Third Year Courses for General and Honours Degrees

GENE 3001 *Genetics*
Mendelian Genetics: comprehensive treatment of basic concepts; genetic crosses; continuous variation; partial and co-dominances; gene interactions; linkage and chromosome mapping.
Molecular Genetics: DNA structure; transcription; chromatin structure. Recombinant DNA technology: restriction enzymes; DNA cloning; sequence analysis; PCR.
Applied Molecular Genetics: Map based cloning. Tools for genetic analysis; mini-satellites; RFLPs. Genetic analysis of human diseases: cystic fibrosis.

GENE 3002 G*enome Structure*
Gene 3002 outlines the structure of the Eukaryotic genome with an emphasis on the dynamic nature of the evolving genome. The unit covers topics in gene splicing, C-value and multigene family paradoxes, repetitive elements, and examples of programmed genetics variation such as the mechanism underpinning antibody diversity.

GENE 3003 *Gene Expression*
Regulation of gene expression: transcription, termination, anti-termination, attenuation, translational feedback control, antisense RNA. Bacteriophage lamda as a model system. Regulation of gene expression in eukaryotes: basal transcription complex; enhancers, signal chain transduction in plants. Genomic imprinting. Mechanisms of recombination: gene conversion, transposition, retroposons and retroviruses. Homologous recombination, its use in transgenesis.

BIOC 3004 *Gene Manipulation, Regulation and Evolution*
For details of unit see under Biochemistry.

Fourth Year Honours Courses in Molecular Genetics

GENE 4001 *The Eukaryotic Genome*
cDNA and genomic libraries, subtractive cDNA techniques. Identification of novel genes through transposon tagging. The control of gene expression in animals and plants with reference to the use of transgenics. DNase sensitivity and heat-shock proteins, gene activation by steroids and homeotic genes and the homeobox.

GENE 4002 *Human Genetic Diseases*
This course offers students an overview of genetic disorders and the application of molecular techniques to identify disease causing genes. Topics covered invlude: the inheritance pattern, molecular basis and clinical consequences of inherited genetic defects: the relevance of chromosomal abnormalities and gene-environment interaction to human disease and the techniques used in identifying disease causing genes.

GENE 4003 *Developmental Biology (formerly Seminar Series)*
Using a format of literature review and presentation by the participating students this course offers an introduction to selected aspects of the molecular biology of development of the Drosophila embryo and Drosophila eye. Topics covered include: maternal contribution to embryo development; the patterning of the embryo; and cell signalling in eye development.

GEOLOGY

Second Year Courses for General and Honours Degrees

Prerequisite for all units: First Science Geology

GEOL 2001 *Mineralogy and Petrography*
Crystal optics and the use of the polarising microscope; examination and identification of minerals from their optical properties and in hand specimen. Atomic structure, properties and occurrence of minerals - silicates, oxides, sulphides, sulphates, carbonates and others.

GEOL 2002 *Structure and Sedimentology*
Brittle, ductile and viscoelastic behaviour. Conditions for brittle failure, faults and fault geometrics. Folds and fold classification. Simple shear belts and their features. Kink bands, boudinage. General consideration of pure shear. Sediment generation and deposition. Clastic sedimentary rocks. Fluid dynamics, sediment transport and sedimentary structures. Gravity driven sediment transport and turbidity currents. Diagenesis, depositional environments of mudrocks and carbonates. Chemical sediments.

GEOL 2003 *Igneous and Metamorphic Petrology*
The occurrence, composition, origin and classification of igneous and metamorphic rocks. Granite structures and intrusion mechanisms. Experimental petrology. Generation of magmas in a variety of tectonic settings. Physics of magmatic systems. Metamorphic grade, zones and facies. Metapelite, metabasite and calc-silicate assemblages. Description and interpretation of textures. Pre-, syn- and post-tectonic (static) metamorphic mineral growth. Compositional dependence of metamorphic assemblages. Phase diagrams. The Phase Rule. Regional and contact metamorphism.

GEOL 2004 *Field Studies and Tectonics*
Half of this course consists of formal lectures and practical classes and half consists of field investigations. Interplay between tectonics and sedimentation. Strain theory and measurement. Depositional environments and reconstruction of ancient sedimentary basins. Practical work will consist of map problems and exercises in sedimentological interpretation. Four one-day field classes and one seven-day field class held in the Spring vacation which is devoted to mapping techniques.

Third Year Courses for General and Honours Degrees

Honours students in Geology take GEOL 3001 to 3009 inclusive. Students following a two subject BSc (General) degree programme will normally take GEOL 3001 to 3004 inclusive. Students following a single subject BSc (General) degree programme will take GEOL 3001 to 3009 inclusive.

GEOL 3001 *Invertebrate Palaeontology*
Classification, evolution, adaptive morphology and stratigraphical range of the following invertebrate phyla: Mollusca (Bivalvia, Cephalopoda, Gastropoda), Echinodermata (Crinoidea, Echinoidea), Brachiopoda, Cnidaria, Arthropoda (Trilobita), and Porifera. Microfossils, trace fossils, mass-extinctions and colonising of the land by plants. Practical work involves description and recognition of major forms from each phylum.

GEOL 3002 *Phanerozoic Stratigraphy*
Stratigraphic principles. Study of Cambrian to Recent stratigraphy of Britain and Ireland, using the concept of orogenic cycles and plate tectonic models. Pleistocene stratigraphy and climate. Practical work includes geological survey map sheets.

GEOL 3003 *Precambrian and Geotectonics*
Introduction to radiogenic isotope systems and geochronology. Precambrian time subdivisions. Precambrian geological evolution of Canada, Scandinavia, Britain and Ireland. The Dalradian Supergroup. Seafloor spreading. Plate motion studies: Magnetic, seismic and geological methods. Rifts. Destructive plate margins. Accretionary prisms. Orogenic belts: Caledonian, Variscan (Hercynian), Alpine-Himalayan. Practical work on geological survey maps.

GEOL 3004 *Applied Geology*
Occurrence, mode of formation of metallic ore and industrial mineral deposits. Geochemistry exploration. Petroleum Geology and seismic interpretation. Coal geology. Hydrogeology and engineering geology.
Prerequisite: Second Science Geology.

GEOL 3005 *Geochemistry*
Radiogenic and stable isotope geochemistry. Geochronology. Analytical methods. Use of geochemical variation diagrams in crystal-liquid systems. Meteorites and the composition of the solar system; composition and chemical evolution of the Earth and Moon. Element partitioning between crystals and melts; partial melting and fractional crystallization. Silicate magma structure. Chemical weathering, sediment geochemistry and provenance. Use of stable isotopes.

GEOL 3006 *Sedimentology and Volcanology*
Principals of facies and sequence analysis. Earth surface processes. Depositional models. Sedimentary structures and deposits of the main continental, paralic and marine environments. Palaeocurrents and provenance. Volcano eruption mechanisms, pryoclastic and epiclastic deposition. Stratigraphic and plate tectonic context of volcanic and volcaniclastic rocks. Volcanic hazards.
Prerequisites: GEOL 2002, GEOL 2003.

GEOL 3007 *Structural, Petroleum Geology*
Coaxial and non-coaxial deformation and the brittle and ductile structures produced. Volume change and slaty cleavage. Transpression and transtension. Recognition of shear sense and kinematic indicators. Multiple deformation. Shallow and deep crustal structure. Basin development and analyses. Seismic reflection profiling and seismic stratigraphy. Origin, migration and accumulation of hydrocarbons. Oil exploration.
Prerequisite: Second Science Geology.

GEOL 3008 *Igneous, Metamorphic Petrology*
Classification of igneous rocks. Petrogenesis of mid-ocean ridge, subduction-related, intraplate, rift-related, potassic, ultrapotassic and granitic rocks. Magmatic processes in layered basic intrusions, ophiolites and Alpine peridotites. Geothermobarometry, equilibrium thermodynamics and Schreinemakers' method. Metamorphic reactions, isograds and metamorphic zonal schemes for pelites. Scottish and Irish Dalradian. Blueschist and Granulite facies. Migmatites. Metamorphism of ultramafic rocks. PTt paths and tectonic setting of regional metamorphism.
Prerequisite: GEOL 2003.

Fourth Year Courses for Honours Degree – GEOL 4000

A more advanced course with further emphasis on the main branches of Geology with additional material on petroleum and ore geology, geotectonics, micropalaeontology, invertebrate palaeontology and isotope geology. Honours students carry out an independent mapping project in the Summer before the Fourth Year to be presented as a thesis and a seminar. In addition students attend regular research seminars.

Palaeontology
Fossil Taxonomy and Micropalaeontology; study of foraminifera, conodonts and calcareous algae; Faunal Provinces; evolution of reefs and their biota; Precambrian fossils and evolution of the biosphere.

Stratigraphy
Upper Palaeozoic Stratigraphy and Sedimentology of NW Europe. North Sea Basin case study: structural control and evolution of sedimentation and hydrocarbon prospectivity in rocks of Devonian to Palaeogene age. Stratigraphic development of the northern Appalachians and the Caledonides.

Sedimentology
Sediment yield and erosion rates. Sea level change. Principals and applications of sequence stratigraphy in alluvial, paralic, carbonate and deep-water settings. Carbonate petrography. Compaction and diagenetic modelling. Reservoir architecture. Basin analysis. Extensional, foreland and strike-slip basin fills.

Metamorphic petrology and Precambrian geology
Crustal evolution and tectonics of Laurentia-Baltica from Archaean to Neoproterozoic; tectonics and metamorphism of the Dalradian; geochronology of metamorphic processes; thermobarometry and relative thermobarometry; mixed fluid equilibria; eclogites; granulites and thermal aureoles.

Geological mapwork and tectonic analysis of orogenic belts
Crustal evolution based on integrated analysis of orogenic belts using published geological maps and problem maps and structural, petrological, geochemical and geophysical (including palaeomagnetic) data. Examples include the Lapland-Kola orogen; Caledonian orogen in Ireland, Scotland and Norway; Sveconorwegian orogen in Sweden and Norway.

Igneous Petrology
Magmatism at constructive, destructive and intra-plate margins. Evolution of magmatism through geological time. The origin of komatiites and massif anorthosite and their implications for Precambrian earth evolution. The origin and evolution of carbonatitic magmas. Igneous rocks as tracers of the composition and evolution of the mantle.

Ore Geology
The mineralogy, geological setting and origin of metallic mineralisation illustrated by examples of globally important ore deposit types.

Petroleum Geology
The principles and application of wireline logging, seismic and sequence stratigraphy and drill stem testing. Basin analysis and petroleum play synthesis with special emphasis on the basins of the Middle East and the Irish offshore.

Structural Geology
Derivation of kinematics from structural features. Geometry and growth of normal fault systems. Models for thrusting and gravity sliding. The effects of faults and fractures on fluid flow.

Tectonics
Tectonic development and deep crustal structure of the Caledonides and the Variscides. Origin and superimposition of non-plane strains in orogenic belts. Models for extensional basin evolution.

Field Work in Geology
Field work is an important part of geological training. In addition to field classes referred to under the First and Second Science courses, Third Year honours students and those taking the single subject BSc (General) degree programme are required to attend an 8 day field class in southern UK, southern Spain, Cyprus or Greece during the Spring vacation, two weekend field classes in Ireland and occasional one day field classes. Fourth Year honours students attend an 8 day field class in southern Spain, Cyprus or Greece in the Spring vacation, a 7 day mapping course in Ireland following the Summer examinations, and occasional weekend and one day field classes in Ireland. Honours students carry out an independent mapping project before the start of the Fourth Year. The costs of field classes in Second, Third and Fourth Years are subsidised by the Department but students are required to make a financial contribution to the field classes.

GEOPHYSICAL SCIENCE

Programme Director: Dr Christopher J. Bean, Department of Geology

This degree programme is primarily designed as a two-year programme following completion of Second Science, leading to the award of an honours degree. (See regulations for Topical Degree p. 31).

Second Year Course for General and Honours Degrees

Students take Mathematics, Experimental Physics and Geology.

Third Year Course for General and Honours Degrees

Students take eight core units which are GEOL 3002, GEOL 3003, GEOL 3008, GEOL 3009, EXPH 3005, EXPH 3008, EXPH 3010 and either GEOL 3010 or GEOL 4013.

Students also take two additional units to be decided in consultation with the Course Director.

Fourth Year Course for the Honours Degree

Students take GEOL 3004, GEOL 3006, GEOL 3007, GEOL 4014, EXPH 3006, EXPH 3009, EXPH 4008 and either of GEOL 3010 or GEOL 4013, whichever has not been taken in the Third Year.

In addition, all fourth year students are required to complete a geophysical field or laboratory project during the course of the year. In the case of field projects, the data is collected in the summer before the start of the Fourth Year. This will be presented in thesis form as part of the final degree examination assessment.

The Third and Fourth Year courses involve both geological and geophysical field classes.

It is intended that graduates with the honours degree will have the relevant background in Geology, Geophysics and Experimental Physics to obtain employment as geophysicists or to proceed to MSc or PhD programmes in Geophysics.

Courses in Geophysics

GEOL 3009 *Applied Geophysics*
Gravity methods. Magnetic methods. Engineering and exploration seismology. Applied tomography. Electromagnetic exploration techniques. Electrical methods in exploration. Side scan sonar. Borehole methods. Ground penetrating radar. Survey design. Position fixing.

GEOL 3010 *Seismology, Global Geophysics*
Material flow properties, strain rate and viscosity. Time and temperature effects on rheology. Earthquake location, quantification, source mechanisms. Models for earthquake genesis. Friction. Fracturing, failure, brittle-ductile transitions. Seismic cycle, earthquake prediction. Seismotectonics. Seismic radiation and deep structure. Wave attenuation. Tomography. Long period oscillations of the earth.

GEOL 4013 *Data Processing and the Crust*
Time series analysis. Seismic reflection and refraction data processing. Forward modelling techniques and synthetic seismograms. Synthetic random media. Ray tracing. Vertical seismic profiles. P- and S-wave studies of the crust. Reflection seismic data interpretation. Sequence stratigraphy. Petrophysics. Potential field data processing and analysis.

GEOL 4014 *Topics in Geophysics*
Topics related to current research and state-of-the-art ideas not covered in other units.

These courses are available to Third Year students in other departments provided they have an adequate background in Experimental Physics and/or Geology.

HISTORY AND PHILOSOPHY OF SCIENCE

PHIL 3901 *History and Philosophy of Science*
Origins and growth of 'western' science from ancient Greece to seventeenth century Europe. The role of mathematics in science; foundations of mathematics. Unification, explanation and causality in science: physics from 17th to 20th century; reductionism in biology. The logic of science: induction; structure of scientific revolutions; incommensurability and scientific realism.

INDUSTRIAL MICROBIOLOGY

Second Year Courses for General and Honours Degrees

INDM 2001 *The Microbial World*
An introduction to the biodiversity of microorganisms; contrasts between prokaryotic and microeukaryotic organisms; systems for classifying bacteria and fungi together with the biology of the main groups; an examination of growth, reproduction and survival of microorganisms and their applications.
Corequisite: INDM 2002.

INDM 2002 *Nutrition and Metabolism*
Growth, energy and nutrition; carbon utilisation in aerobic and anaerobic growth; fermentation and respiration; ATP generation and growth rate. Key metabolic intermediates and their relevance in industrial microbiology. Protein structure, classification, quantification and properties of enzymes. Introduction to enzyme technology.
Corequisite: INDM 2001.

INDM 2003 *Microbial Genetics*
Nucleic acid structure and functions. The bacterial chromosome and reproduction. Extrachromosomal genetic elements. Gene transfer in bacteria. Mutagenesis. Control of gene expression. Diploids and merodiploids. Phenotype expression.
Prerequisites: INDM 2001, INDM 2002.

INDM 2004 *Microbes, Man and Environment*
Assessment of microbial activity in the environment with reference to important environmental processes mediated by microorganisms. Microorganisms and the infection cycle. Microorganisms and the food chain. Industrial products of economic significance from microorganisms.
Prerequisites: INDM 2001, INDM 2002, INDM 2003.

Third Year Courses for General and Honours Degrees

Prerequisite for all units: INDM 2001 to INDM 2004 inclusive.

Students not taking Industrial Microbiology as a full subject but wishing to select optional units from the Industrial Microbiology programme, must have the approval of the Head of the Department of Industrial Microbiology.

INDM 3001 *Bacteriology and Mycology*
Structure-function relationships within the prokaryotic cell. Methods of studying cell structure and function. The contribution of organelles to bacterial activities. Fungal nutritive modes. Fungi as agents of decay and disease in plants and animals. Bacteria and fungi as producers of secondary metabolites.

INDM 3002 *Physiology and Biochemistry*
Biosynthesis of amino acids and nucleotides. Metabolic pathways and molecular biotechnology. Industrial production of amino acids. Principles of microbial growth and cultivation. Fermentation systems - development and application of batch, fed-batch and continuous culture techniques. Environmental factors influencing microbial growth.

INDM 3003 *Industrial Microbiology*
Principles of biotechnological processing: Bioreactor design, process analysis and models. Case studies from the brewing and fermentation industries. Food Microbiology: Microbial sources of contamination. Food spoilage and factors influencing it. Traditional and alternative methods of preservation.

INDM 3004 *Environmental Microbiology*
Ecology and environmental interactions of microorganisms in diverse ecosystems. An assessment of microbial activities within the soil, freshwater and marine environments. Pollution of natural waters and the role of microorganisms in waste treatment. Microorganisms in extreme environments.

INDM 3005 *Healthcare Microbiology*
Microbial spoilage. Prediction of product shelf-life. Antiseptics, disinfectants and preservatives. Principles and practice of sterilisation. Application of microorganisms in biotransformation/synthesis of pharmaceuticals. Quality function in the healthcare industry. Process monitoring and validation. Controlled environments, clean-air maintenance and standards. Antibiotics, activity spectra and mechanisms of anti-microbial action. Infectious drug resistance.

INDM 3006 *Medical Microbiology*
Basic immunology and antigen/antibody reactions. Spread of infection and 'host-parasite' relationships. Bacteriology: Anaerobic infections, zoonoses, enterobacteria, bacterial chemotherapy and sterilisation. Virology: Introduction, morphology, replication and classification of DNA and RNA viruses. Enteroviruses, herpes-viruses, myxoviruses, tumor viruses, hepatitis and diagnostic virology.

INDM 3007 *Gene Expression and Regulation*
Theory and practice of mutation. Principles and practice of gene manipulation. Industrial strain development. Gene expression in prokaryotes and eukaryotes. Overexpression of cloned genes.

INDM 3008 *Applied Enzymology*
Enzymes as industrial catalysts. Enzyme development for large scale processes - screening, production, purification and applications. Kinetics and applied enzymology.

INDM 3011 ***Special Topics***
A wide range of topics covering the special interests of the staff in the Department will be offered and students will be expected to undertake a literature survey on one of those topics and make written and oral presentations.

Fourth Year Courses for Honours Degree – INDM 4000

Courses are selected, in consultation with the Head of Department, from the topics listed below. All students are required to undertake a substantial laboratory-based research project. Successful students may opt to undertake a project in a research laboratory in industry or a research institute. On completion of the project it is presented in the form of a thesis, which forms part of the degree examination. An oral presentation is also required for assessment. Attendance of students at Department seminars is obligatory.

INDM 4001 Topics in Bacteria and Fungi
INDM 4002 Enzyme Technology
INDM 4003 Applied Microbial Genetics
INDM 4004 Food Science
INDM 4005 Fermentation Science
INDM 4006 Advances in Environmental Microbiology I
INDM 4007 Medical Microbiology
INDM 4008 Process Microbiology
INDM 4009 Developments in Biotechnology
INDM 4010 Bio-separation Techniques
INDM 4011 Advances in Food Microbiology
INDM 4012 Current Topics in Bacteria
INDM 4013 Current Topics in Fungi
INDM 4014 Microbial Genetics
INDM 4015 Advances in Environmental Microbiology II
INDM 4016 Advances in Environmental Microbiology III
INDM 4017 Food Microbiology

LANGUAGES

The Applied Language Centre offers a number of courses, one of which may be selected as an optional unit by Third Science students.

LANG 3001 *Beginners German for Science*
LANG 3002 *Beginners Japanese for Science*
LANG 3003 *Advanced French for Science (Post- Leaving Certificate)*
LANG 3004 *Advanced German for Science (Post-Leaving Certificate)*

For *Beginners* courses, no previous knowledge of the language is needed. The following topics are covered: oral communication in everyday situations; introduction to scientific reading texts; basic grammatical structures; functional writing.

For *Post-Leaving Certificate* courses, students should note that Leaving Certificate or the equivalent standard is required. Courses cover the following topics: communicating in face-to-face professional situations; making oral presentations; skills in listening comprehension; functional writing skills, e.g. report-writing, correspondence, etc.

MATHEMATICS

Second Year General Courses

MATH 2201 *Calculus of Several Variables*
Functions of several variables. Partial derivatives. Optimization and Lagrange multipliers. Double integrals. Gradient, divergence, curl.

MATH 2202 *Linear Algebra*
Vector spaces, bases and dimensions. Linear transformations. Diagonalization of real symmetric matrices.

MATH 2203 *Infinite Series*
Convergence tests for sequences and series. Power series. Taylor series and Fourier series. Series solutions of ordinary differential equations.

MATH 2204 *Probability and Statistics*
Random variables, expected values and variance. Conditional probability. Sampling, confidence intervals and hypothesis testing.

Second Year Honours Courses

MATH 2101 *Vector Spaces and Linear Transformation*
Linear independence, bases and dimension. Kernel and images. The rank-nullity theorem. Determinants.

MATH 2104 *Functions of Several Variables*
Partial and directional derivatives. Critical points and Lagrange multipliers. Implicit function theorem. Integration.

MATH 2105 *Number Theory and Group Theory*
Euclid's algorithm. The algebra of congruences. Groups, subgroups and homomorphisms. Lagrange's theorem. The Fermat-Euler theorem.

MATH 2106 *Introduction to Analysis*
The supremum axiom, sequences and series. Properties of continuous functions. Power series.

Third Year General Courses

Courses offered are chosen from the list of courses set out below.

MATH 3201 *Complex Analysis*
Analytic functions. Cauchy's theorem and Cauchy's integral formula. Integrals and residues.

MATH 3202 *Mathematical Techniques*
Functions of one and several variables. Partial derivatives and differential equations. Eigenvectors and eigenvalues. Applications to chemistry.
This course is not available to students who have taken Second Year Mathematics.

MATH 3203 *Advanced Calculus*
Vector fields. Green's theorem. Stokes's theorem and the divergence theorem. Fourier and Laplace transforms with applications to differential equations.

MATH 3204 *Groups and Vector Spaces*
Permutation groups, matrix groups and symmetry groups. General properties of groups. Representations of groups by matrices.

MATH 3205 *Combinatorial Mathematics*
Congruences and finite fields. Error-detecting and error-correcting codes. Hamming codes, Huffman codes, RSA codes. Information and entropy. Shannon's first theorem.

MATH 3206 *Linear Programming*
Formulation of linear programmes problems. The simplex algorithm. Duality.

MATH 3207 *Graph Theory*
Trees. Paths and circuits in graphs. Planar and dual graphs. Graph-theoretic algorithms.

MATH 3208 *Mathematical Logic*
Formal systems and rules of deduction. Consistency and completeness. First order languages. Godel-Henkin completeness theorem. Resolution in the propositional calculus.

MATH 3209 *Special Topics*
Courses on special topics may be offered, depending on demand. Students may also be given permission to take part of an Honours course as a Special Topic.

Third Year Honours Courses

MATH 3102 *Field Theory*
Extensions of fields. Algebraic closure. Norms and traces. Galois theory and solvability by radicals.

MATH 3103 *Foundations of Analysis*
Set theory and cardinality. The axiom of choice. The supremum axiom and its consequences. Introduction to Riemann integration.

MATH 3104 *Functions of One Complex Variable*
Cuachy's integral theorem and residue theory. Principle of the argument. Rouche's theorem. Schwarz's lemma. Conformal mappings and Riemann mapping theorem.

MATH 3105 *Logic and Discrete Mathematics*
Binary logic. Predicates and quantifiers. Axiomatic systems, consistency and completeness. Axiomatic set theory. Lattices and Boolean algebras.

MATH 3106 *Algorithms*
Graph-theoretic algorithms. Greedy algorithms. Divide and conquer methods. Number-theoretic algorithms. Matrix problems and linear systems. Efficiency and complexity.

MATH 3107 *History of Mathematics*
Mathematics of ancient civilizations. Number systems. Euclid and Archimedes. Development of algebra. Discovery of calculus. Geometric construction problems. Greek astronomy.

MATH 3108 *Special Topics*

MATH 3109 *Advanced Linear Algebra*
Rings. Polynomial algebra. Characteristic and minimal polynomials. Canonical forms of matrices.

Fourth Year Honours Courses

Eight units must be chosen. A student's choice of units is subject to the approval of the Head of the Mathematics Department.

MATH 4101 *Ring Theory*
Rings and modules. Noetherian rings. Hilbert's Nullstellensatz. Simple rings and semisimple rings. Artin-Wedderburn theorem. Burnside's theorem.

MATH 4102 *Group Theory*
Sylow theorems. Advanced topics in the theory of groups: finite *p*-groups, local analysis, *p*-nilpotence, the transfer.

MATH 4103 *Combinatorics*
Recurrence relations and generating functions. Principle of inclusion and exclusion. Ramsey theory. Latin squares. Designs. Finite geometries.

MATH 4104 *Measure Theory*
Measure spaces and measurable functions. Integrability. Dominated convergence theorem. Product measures. Radon-Nikodym theorem.

MATH 4105 *Differential Geometry*
Differentiable atlases. Manifolds and submanifolds. Tangent bundles and vector fields. Riemannian manifolds. Curvature and torsion. Dynamical systems.

MATH 4106 *Functional Analysis*
Topological vector spaces and linear mappings. Hahn-Banach theorem. Banach-Steinhaus theorem. Hilbert spaces. Riesz-Fischer theorem. Geometry of Banach spaces.

MATH 4107 *Numerical Analysis*
Weierstrass approximation theorem. Cubic splines. Functional iteration. Newton's method. Aitken's method. Ordinary differential equations. Partial differential equations and Poisson's equation in two dimensions.

MATH 4108 *Financial Mathematics*
Rates of interest. Annuities, discount, capital redemption policies. Consumer credit, immunization, stochastic interest rate, mortality.

MATH 4109 *Topology*
Topological spaces and continuous maps. Compactness, connectedness. Separation axioms. Compactification. Quotient spaces.

MATH 4110 *Commutative Algebra*
Polynomial algebras and affine varieties. Dimension theory of comutative rings. Localization and completion. Projective varieties and graded algebras. Spectra of rings.

MATH 4111 *Several Complex Variables*

MATH 4112 *Special Topics*

Fourth Year Honours students may, with the consent of the Head of Department, substitute an appropriate course or courses in Mathematical Physics for one or more of their Mathematics courses.

MATHEMATICAL PHYSICS

Second Year Courses

The Common courses and *either* the Pass *or* Honours courses must be attended.

Common Courses

MAPH 2111 *Methods A*

Vector Calculus:
Vector differentiation (Frenet-Serret formulae).
Directional derivatives, Grad, Div, Curl.
Vector integration (line, surface and volume integrals).
Integral Theorems (Divergence theorem and Stokes' theorem with proofs).
Grad, Div and Curl in Orthogonal curvilinear coordinates.
Linear Differential Equations:
Existence and uniqueness of solutions, dimension of solution space, Wronskians, Green's functions.

MAPH 2141 *Computational Physics*

Ordinary Differential Equations : Euler and Runge-Kutta methods. Adaptive techniques. Satellite motion, three-body problem. Projectiles. Lorenz model.
Finite Differences : Difference schemes, linear advection equation. FTCS and Lax methods. Modellng traffic flow.
Linear equations : Gaussian elimination, iterative methods. Coupled harmonic oscillators.
Monte-Carlo Methods : Uniform and non-uniform deviates. Integration. Ideal gas model.

Pass Courses

MAPH 2010 *Mechanics 1*

Forced and damped harmonic oscillations. Resonance. Motion of a particle under central forces. Central orbits. Planetary and satellite motion.
Introduction to Special Relativity.

MAPH 2020 *Mechanics 2*

Rigid body motion in three dimensions about a point fixed. Angular velocity. Inertia tensor. Kinetic energy. Angular momentum. Applied torque. Spinning top.

Honours Courses

MAPH 2121 *Mechanics A*

Dynamics of rigid bodies, rotating earth, spinning top, moments of inertia, principal axes, Euler's equations of motion. Lagrange's equation, variational principles. Small oscillations, normal modes.

MAPH 2131 *Mechanics B*

Hamiltonian Mechanics: Hamilton's equations, canonical transformations, Poisson brackets, Hamilton-Jacobi theory.
Special Relativity: Inertial frames, Lorentz transformations, spacetime, tensors, relativistic mechanics, energy-momentum conservation.

Third Year Courses

Students taking the BSc (General) Degree must take a minimum of four units: MAPH 3010, MAPH 3020, MAPH 3030 and either MAPH 3041 or MAPH 3071.

Students taking the BSc (Single Honours) Degree must take eight units. Students who have taken the Second Year Honours courses take MAPH 3111 to MAPH 3181. Students who have not taken the Second Year Honours courses take MAPH 2111, MAPH 2121, MAPH 2131, MAPH 3111, MAPH 3121, MAPH 3131, MAPH 3161 and MAPH 3171.

Students taking the BSc (Joint Honours) Degree must take five units: MAPH 3111, MAPH 3121, MAPH 3131, MAPH 3161 and MAPH 3171.

Students should consult the Department about prerequisites. Units MAPH 3081, MAPH 3211, MAPH 3220, MAPH 3231 and MAPH 3241 may not be offered every year. Unit MAPH 3030 cannot be taken as a minor unit.

MAPH 3010 *Mechanics 3*

Dynamics of rigid bodies, rotating earth, spinning top, moments of inertia, principal axes, Euler's equations of motion. Lagrange's equations, variational principles. Small oscillations, normal modes.

MAPH 3020 *Mechanics 4*

Hamiltonian Mechanics: Hamilton's equations; canonical transformations, Poisson brackets, Hamilton-Jacobi theory.
Special Relativity: Inertial frames, Lorentz transformations, spacetime, tensors, relativistic mechanics, energy-momentum conservation.

MAPH 3030 *Electrostatics/Quantum Mechanics*

Electrostatics: electrostatic potential; Gauss's law; Poisson's equation; dielectrics; electrostatic energy.
Quantum Mechanics: Postulates of quantum mechanics, uncertainty principle, one-dimensional systems including the harmonic oscillator, angular momentum, hydrogen atom, time evolution.

MAPH 3041 *Methods 3*

Partial Differential Equations of Physics
First order ordinary differential equations. Systems of first order linear and non-linear ordinary differential equations; critical points and stability. First order

linear and non-linear partial differential equations and the method of characteristics. Classification of second order linear partial differential equations. Integral transforms.

MAPH 3071 *Numerical Methods*
Solution of equations by iteration. Numerical integration and differentiation. Numerical methods for differential equations. Systems of linear equations. Gauss elimination.

MAPH 3081 *Computational Physics*
Ordinary differential equations; initial value (satellite motion and chaotic systems) and boundary value problems (energy eigenvalues of Schrödinger's equation). Partial differential equations; finite differences and finite elements (wave motion, heat transfer equation, Schrödinger's equation and Poisson's equation). Monte Carlo methods; kinetic theory of gases and the Ising model for ferromagnetism.

MAPH 3111 *Methods B*
Complex Variables:
Cauchy-Riemann equations, singular points. Complex integration (Cauchy's theorem, line integrals). Taylor and Laurent series. The Residue Theorem.
Euclidean Spaces:
Convergence, Bessel's inequality, Parseval's equality. Fourier series (Piecewise continuous functions, Riemann-Lebesgue lemma, Weierstrass approximation theorem, Pointwise convergence). Orthogonal series of polynomials (Legendre polynomials, Hermite polynomials, Laguerre polynomials, Bessel functions).

MAPH 3120 *Methods C*
First order partial differential equations. Second order linear partial differential equations - classification, uniqueness, stability. The wave equation, diffusion equation and Laplace's equation. Separation of variables, Laplace and Fourier transforms. Green's functions. Perturbation methods.

MAPH 3130 *Thermal & Statistical Physics*
Thermodynamics: Laws of thermodynamics, temperature, entropy, Clausius's theorem, Maxwell's relations.
Kinetic Theory: Maxwell's distribution, the Boltzmann equation, Maxwell-Boltzmann distribution.
Introduction to Statistical Mechanics: The microcanonical, canonical and grandcanonical ensembles, the classical ideal gas, quantum statistical mechanics, the ideal Fermi and Bose gases, the imperfect Fermi gas.

MAPH 3141 *Potential Theory**
Electrostatics: electrostatic potential; Gauss's law; Poisson's equation; dielectrics; electrostatic energy. Magnetic fields due to steady currents: vector potential; Ampère's circuital law; magnetic materials.

MAPH 3151 *Electromagnetic Theory* (Hons) *
Maxwell's equations. Energy and momentum: Poynting vector. Plane waves in non-conducting and conducting media. Wave guides. Radiation from bounded sources. Liénard-Wiechert potentials. Relativistic formulation of electromagnetic theory.

* Units MAPH 3141 and MAPH 3151 must be taken together.

MAPH 3161 *Quantum Mechanics*
This course is an introduction to Quantum Mechanics:
Hilbert spaces, operators, probability measures, spectral measures. Postulates of quantum mechanics, uncertainty principle, harmonic oscillator, creation and annihilation operators, angular momentum, hydrogen atom, Rayleigh's variational principle, time evolution in the Schrödinger picture and Heisenberg picture.

MAPH 3171 *Fluid Mechanics*
Representation of fluid flow, elementary physical considerations, Stokes' analysis, velocity potential for irrotational flows, stream functions for incompressible flows, Navier Stokes' equations, inviscid flow equations, motion of a sphere through an incompressible fluid, 2D incompressible flows, conformal transformations, sound waves, water waves.

MAPH 3180 *Dynamical Systems and Chaos*
Phase portraits, flows and evolution
Linear systems: Classification of linear systems, phase portraits of linear systems.
Non-linear systems in the plane: Local and global behaviour, fixed points, linearization, stability of fixed points, limit points and limit cycles, Poincaré-Bendixson theory.
Non-linear systems in higher dimensions: Hyperbolic and non-hyperbolic fixed points, closed orbits, attracting sets and attractors.
Chaotic orbits.

MAPH 3211 *General Relativity & Cosmology*
This course is an introduction to General Relativity and Cosmology:
Tensor calculus. Einstein's field equations. Static and stationary black holes. Energy extraction from rotating black holes. Cosmological models.

MAPH 3220 *Electromagnetic Theory (Minor)*
Electrostatics. Magnetostatics. Maxwell's equations. Plane electromagnetic waves. Scalar and vector potentials, radiation. Relativistic formulation of electromagnetic theory.

MAPH 3231 *Gauge Field Theory*
This course is an introduction to Gauge Field Theory:
Introduction to Lie groups and Lie algebras. Yang-Mills field equations. Magnetic monopole and instanton solution. Gauge theory of the standard model of Electro-Weak interactions.

MAPH 3241 *Continuum Mechanics*

Cartesian Tensors: Change of frame, alternating symbol, decomposition theorems of Gibbs and Hamilton, polar decomposition theorem, isotropic tensors, integral theorems, reciprocal triads, spectral decomposition.

Continuum Mechanics: Kinematics. Change in volume, area. Shear, special deformations, infinitesimal strain. Material, spatial coordinates, material time derivative, stretching, shearing. Balance laws. Equations of motion. The stress tensor.

Fourth Year Courses for Honours Degree

Students taking the BSc (Single Honours) Degree must take seven courses and students taking the BSc (Joint Honours) Degree must take four courses. Subject to the approval of the Head of Department, appropriate Honours courses in Mathematics or Experimental Physics may be taken in place of some of these courses.

MAPH 4110 *Nonlinear Waves and Solitons*

Nonlinear model wave equations: Korteweg-deVries equation, nonlinear Klein-Gordon equation, nonlinear Schrödinger Equation, Burgers equation, Ginzburg-Landau equation. Multiple scale perturbation techniques.

Instabilities: Linear and nonlinear instability.

Hyperbolic waves and shocks: Method of characteristics, wave distortion, shock jump conditions.

Solitons: KdV equation, nonlinear dispersive phenomena, conservation laws, Backlund transformations, inverse scattering theory.

MAPH 4121 *Methods*

Differential Geometry:

Tensor algebra. Differentiable manifolds. Affine connections. Torsion tensor. Curvature tensor of a connection. Pseudo-Riemannian manifolds. Riemann curvature tensor. Bianchi identities, Ricci identities.

Functional Analysis:

Hilbert spaces. Bounded and unbounded operators. Adjoints of operators. Self-adjoint extensions. Spectral theory. The Spectral Theorem for bounded and unbounded self-adjoint operators.

MAPH 4131 *Continuum Mechanics*

Analysis of strain - finite and infinitesimal. Balance of mass, momentum, moment of momentum. Stress. Existence of stress tensor. Principal stresses. Maximum shear stress. Equations of motion. Finite elasticity. Classical linear elasticity. Beltrami-Mitchell equations. Uniqueness theorem. Reciprocal theorem. Elastic waves. Waves in ideal fluids. Viscous flow problems.

MAPH 4141 *Quantum Mechanics*

Periodic potential, energy bands. Approximation methods of bound states, Helium atom. Zeeman effect. Angular momentum, Clebsch-Gordon

coefficients, Wigner-Eckart theorem. Non-relativistic hydrogen atom with spinning electron. Relativistic theory of the electron. Scattering theory.

MAPH 4151 *Statistical Mechanics*

Classical Statistical Mechanics:

The microcanonical ensemble, time averages, ergodicity. The canonical and grand-canonical ensemble, equivalence of ensembles, the thermodynamic limit and phase transitions. Lattice gases and magnetic systems.

Quantum Statistical Mechanics:

Trace class operators, density matrices, Fock space, ideal Bose and Fermi gases, Bose-Einstein condensation, lattice models, the Mermin-Wagner argument.

MAPH 4161 *Computational Physics (from session 2001/2002)*

Parabolic equations in one space variable (Schrödinger equation, Diffusion equation). Parabolic equations in two and three dimensions – ADI methods. Hyperbolic equations – Lax Wendroff scheme, flux-limiter methods (fluid dynamics, wave equation). Consistency, convergence and stability. Elliptic equations (Poisson's equation). Finite element method. Metropolis Algorithm (Ising Model), Quantum Monte Carlo (Molecular dynamics).

MAPH 4171 *General Relativity*

Einstein's field equations. Physical interpretations of the energy-momentum-stress tensor. Newtonian approximation. The Schwarzschild solution. The Kruskal extension of the Schwarzschild manifold. Experimental tests. Interior Schwarzschild solution. Kinematics of a continuous medium. The Robertson-Walker cosmos. The equation of geodesic deviation. Plane gravitational waves and their interaction with clusters of test particles.

(This course requires MAPH 4181, or MAPH 3141 and MAPH 3151, and parts of MAPH 4121 as pre/corequisites.)

MAPH 4181 *Electromagnetic Theory*

Electrostatics: electrostatic potential; Gauss's law; Poisson's equation; dielectrics; electrostatic energy. Magnetic fields due to steady currents: vector potential; Ampère's circuital law; magnetic materials. Maxwell's equations. Energy and momentum: Poynting vector. Plane waves in non-conducting and conducting media. Wave guides. Radiation from bounded sources. Liénard-Wiechert potentials. Relativistic formulation of electromagnetic theory.

(This course may only be taken in conjunction with MAPH 4131, MAPH 4141 or MAPH 4171. Students who have taken modules MAPH 3141 and MAPH 3151 cannot take module MAPH 4181).

MAPH 4190 *Theoretical Astrophysics*

The universe observed.

Stellar Physics : Star formation, heat transfer, nucleosynthesis. Equations of stellar structure.White Dwarfs, Neutron stars.

Astrophysical Hydrodynamics : Basic equations, accretion, shock waves, jump conditions, similarity solutions, supernova remnants. Jets.

Astrophysical Plasmas : Debye length, plasma frequency, dispersion measure, pulsars. Faraday rotation. Magnetohydrodynamics, Magnetic virial theorem. Alfven waves.

MAPH 4211 *Numerical Analysis**

Berstein polynomials. Weierstrass approximation theorem. Lagrange and Hermite interpolation polynomials. Cubic splines. Functional iteration. Second order functional iteration. Newton's method. Method of false position. Aitken's method.

Integration. Ordinary differential equations. Introduction to partial differential equations and Poisson's equation in two dimensions. Linear algebraic equations. Iterative methods. Matrix eigenvalues.

* This course is given jointly with the Mathematics Department.

MATHEMATICAL SCIENCE

First Year Courses

For details of First Year Courses, see pages 34 to 38.

Second Year Courses

Students take the following courses.

Mathematics
MATH 2101 *Vector Spaces and Linear Transformations*
MATH 2105 *Number Theory and Group Theory*
MATH 2106 *Introduction to Analysis*
MATH 2104 *Functions of Several Variables*

Mathematical Physics
MAPH 2111 *Methods A*
MAPH 2121 *Mechanics A*
MAPH 2131 *Mechanics B*
MAPH 2141 *Computational Physics*

Statistics
STAT 2205 *Statistical Theory I: Probability*
STAT 2206 *Statistical Theory II: Statistical Inference*
STAT 2207 *Statistical Theory III: Bayesian Statistics and Stochastic Processes*
STAT 2221 *Introduction to Statistical Methods*

Third Year Courses
Students take ten units with at least two units from each subject. The combination of courses must be approved by the Course Director.

Mathematics
MATH 3101 *Number Theory and Group Theory*
MATH 3102 *Field Theory*
MATH 3103 *Foundations of Analysis*
MATH 3104 *Functions of One Complex Variable*
MATH 3105 *Logic and Discrete Mathematics*
MATH 3106 *Algorithms*
MATH 3107 *History of Mathematics*
MATH 3108 *Special Topics*

Mathematical Physics
MAPH 3111 *Methods B*
MAPH 3120 *Methods C*
MAPH 3130 *Thermal and Statistical Physics*
MAPH 3141 *Potential Theory*
MAPH 3151 *Electromagnetic Theory* (Hons)
MAPH 3161 *Quantum Mechanics*
MAPH 3171 *Fluid Mechanics*
MAPH 3180 *Dynamical Systems and Chaos*

Statistics
STAT 3208 *Statistical Methods I*
STAT 3209 *Statistical Methods II*
STAT 3210 *Data Analysis and Statistical Software*
STAT 3216 *Actuarial Statistics I*
STAT 3217 *Actuarial Statistics II*

Fourth Year Courses

Students take the equivalent of 12 units chosen from the courses listed below. The courses in Mathematics and Mathematical Physics are equivalent to 1.5 units and the courses in Statistics are equivalent to one unit. The combination of courses must be approved by the Course Director.

Mathematics
MATH 4101 *Ring Theory*
MATH 4102 *Group Theory*
MATH 4103 *Combinatorics*
MATH 4104 *Measure Theory*
MATH 4105 *Differential Geometry*
MATH 4106 *Functional Analysis*
MATH 4107 *Numerical Analysis*
MATH 4108 *Financial Mathematics*
MATH 4109 *Topology*
MATH 4110 *Commutative Algebra*
MATH 4111 *Several Complex Variables*
MATH 4112 *Special Topics*

Mathematical Physics
MAPH 4110 *Nonlinear Waves and Solitons*
MAPH 4121 *Methods*

MAPH 4141 *Quantum Mechanics*
MAPH 4151 *Statistical Mechanics*
MAPH 4161 *Computational Physics*
MAPH 4171 *General Relativity*
MAPH 4181 *Electromagnetic Theory*
MAPH 4190 *Theoretical Astrophysics*

Statistics
STAT 4211 *Data Analysis I*
STAT 4212 *Applied Statistics I*
STAT 4213 *Applied Statistics II*
STAT 4214 *Time Series Analysis*
STAT 4215 *Multivariate Analysis*
STAT 4232 *Topics in Biostatistics*
STAT 4233 *Nonparametric Statistics*
STAT 4235 *Survival Analysis*
STAT 4238 *Data Analysis II*

PHARMACOLOGY

Second Year Courses for General and Honours Degrees

PHAR 2001 *Introduction to Pharmacological Principles*
Membrane structure and transport of drugs across cell membranes. Drug disposition including drug routes of administration, absorption, distribution, metabolism and excretion. Pharmacokinetics. Drug receptors and receptor theory. Introduction to nerve and muscle pharmacology.

PHAR 2002 *Neuropharmacology I*
Structure and function of autonomic nervous system. Autonomic pharmacology. Cholinergic and adrenergic drugs. Structure and function of central nervous system. Introduction to CNS pharmacology: Membrane stabilizing drugs and neurotransmitter modulators with CNS activity.

PHAR 2003 *Cardiovascular, Respiratory, Renal and Gut Pharmacology*
Body fluids. Cardiovascular system. Introduction to antihypertensive therapy. Respiratory system. Antiasthmatic drugs. Renal pharmacology. Diuretics. Alimentary tract, gut movements, digestion and absorption.

PHAR 2004 *Introductory Endocrine Pharmacology and Immunopharmacology*
Chemotherapy. Introduction to endocrinology, insulin and cortisol. The immune system: Immunopharmacology. Inflammation. Anti-inflammatory drugs. Introduction to chemotherapeutic agents.

Third Year Courses for General and Honours Degree Students

PHAR 3001 *Chemotherapeutic Agents*
Introduction to microbial cell biology. Mechanism of action of antibacterial drugs. Antimicrobial therapy. Cytotoxic drugs and cancer treatments.

PHAR 3002 *Neuropharmacology II*
Advanced pharmacology including structure activity relationships of drugs affecting peripheral and central nervous systems. Behavioural and psychopharmacology.

PHAR 3003 *Endocrine and Reproductive Pharmacology. Autocoids.*
Pharmacology of the endocrine and reproductive systems. Audocoids, local hormones, biogenic amines, prostaglandins, kinins, substance P.

PHAR 3004 *Toxicology*
General principles, statistical evaluation, toxicity testing, routes of entry, metabolism, excretion, pollutants, pesticides, heavy metals, food additives. Mutagenesis, teratogenesis, carcinogenesis.

Courses for Third Year Science Honours Degree Students

PHAR 3005 Topics covered with associated tutorials and reference lists on novel aspects include: advanced central nervous system Pharmacology (neuroactive agents); advanced central nervous system Pharmacology (dopamine receptors); advanced renal Pharmacology and Toxicology; and muscle Pharmacology.

PHAR 3006 Topics covered with associated tutorials and reference lists on novel aspects include: intracellular signalling (heterotrimeric G-proteins, tyrosine kinases and estrogen receptor action) and peptide Pharmacology.

PHAR 3008 *Molecular biological analysis of therapeutic targets*
General structure and function of a group of membrane receptors and kinases; 3-D structural analysis of these proteins; primary structure of receptor proteins – functional and structural motifs; receptor encoding genes, structure and expression; cloning of receptor genes/gene families and bioinformatic and functional characterisation of the cloned genes; recombinant receptors as drug discovery tools; receptor and kinase gene polymorphisms and their analysis; natural receptor mutations and associated diseases; strategies for mutant receptor replacement by gene therapy; pharmacogenomics (selected topics).

STAT 3221 *Biostatistics*
For course details see under Statistics.

GENE 3001 For course details see under Genetics.

Fourth Year Courses for Honours Degree Students – PHAR 4100

Advanced courses (10 lectures/tutorials per course) are given in specialised areas of pharmacology. These include:

PHAR 4001 *Atherosclerosis/antithrombotic agents*

PHAR 4002 *Neuropharmacology*
PHAR 4003 *Cancer studies*
PHAR 4004 *CNS Dopamine Receptors/Drug Development*
PHAR 4005 *Biology of Nitric Oxide*
PHAR 4006 *Cytokine Receptors/Muscle Pharmacology*
GENE 4001 *Eukaryotic Genome* (For details of unit see under Genetics).
PHAR 4009 *Molecular Biology of Steroid Hormone Receptors*
PHAR 4010 *Immunopharmacology*
PHAR 4011 *Renal Pharmacology and Toxicology*

A research project is carried out under the direction of individual academic staff members and the completed project is presented in thesis form for the degree examination. Oral presentations of research work are also required.

Students are required to attend at departmental research seminars and small-group discussion sessions.

PHYSIOLOGY

Prerequisite Combination: (a), (d) or (g) in First Science.

Second Year Courses for General and Honours Degrees

PHYS 2004 *General Physiology*
Cell structure, intracellular organelles. Body fluids. Cell membrane receptors, second messenger systems. Connective tissue. Epithelia: absorption, secretion, mucosa, skin. Muscle: skeletal, cardiac, smooth. Neural structure and function. Intercellular communication; synaptic transmission, hormones, chemical messengers.

PHYS 2005 *Circulation and Respiration*
Blood; structure and function. Organisation of the circulation. Heart as a pump. Structure and function of blood vessels. Capillary exchange. Structure of the respiratory system. Mechanics of breathing. Transport of gases in the blood.

PHYS 2006 *Digestion and Excretion*
Structure of the alimentary tract; movement, secretion, absorption. Functions of the liver. Kidneys; homeostatic functions, structure, blood vascular system. Glomerular filtration, tubular reabsorption and secretion. Investigation of renal function.

PHYS 2007 *Nervous and Endocrine Systems*
Structure of the nervous system. Sensation. Spinal reflexes and reflex arcs. Hormonal control of physiological function, metabolism, growth and reproduction.

Third Year Courses for General and Honours Degrees

PHYS 3002 *Regulatory Mechanisms*
Ion channels and membrane potential, mechanisms of action potential generation, receptors, second messengers and signal transduction, regulation of excitation-contraction coupling (skeletal, cardiac and smooth), mechanisms of synaptic transmission, gap junctions, transmembrane/cellular transport of solutes and water, secretion, homeostasis, control systems, feedback and feed-forward control.

PHYS 3003 *Circulation and Respiration*
Cardiac electrophysiology. Regulation of myocardial contractile function. Arterial circulation; short- and long-term control of pressure. Microcirculation; Capillary exchange and regulation of tissue blood flow. Venous circulation. Respiratory mechanics; resistance and compliance. Blood gas transport. Pulmonary circulation and gas exchange. Introduction to the control of breathing.

PHYS 3004 *Digestion, Absorption, Excretion*
Alimentary canal; control of motility. Salivary, gastric, intestinal, pancreatic and biliary secretions. Digestion and absorption. Dietary factors, dietary disorders. Metabolic rate, energy balance, body temperature. Hormonal regulation of metabolism: insulin, glucagon, thyroid hormones, glucocorticoids. Control of growth. Renal circulation, glomerular filtration, tubular functions. Renal regulation of water and electrolyte balance.

PHYS 3005 *Neurophysiology I*
Central neurotransmitter release; mechanisms and modulation, sensory processing and tracts, muscle receptors and spinal reflexes, visual system, olfaction, gustation and hearing.

PHYS 3006 *Cardiorespiratory Integration*
Cardiovascular and respiratory systems; sensory receptors and efferent control mechanisms. Brain stem and supramedullary systems in cardiorespiratory control. Integrated cardiorespiratory responses to hypoxia, hypovolaemia, exercise and altitude.

PHYS 3007 *Neurophysiology II*
Cortical control of movement, corticospinal tracts and extrapyramidal system, brainstem, basal ganglia, cerebellum, control of posture, learning and memory, cellular mechanism and neurotransmitters, synaptic plasticity.

STAT 3221 *Biostatistics*
Honours students of Physiology must take this unit (details under Statistics) or an alternative appropriate unit approved by the Department of Physiology.

PHYS 3009 *Physiological Measurement.*
Signals and signal processing. Instrumentation; transducers, amplifiers, filters, recorders. Analogue to digital conversion. Computers and data analysis. Measurements of pressure, flow volume concentration and potential difference. Assay techniques and their limitations. Methods in microscopy, cell physiology,

neurophysiology, cardiovascular physiology, respiratory physiology and biochemical physiology.

Fourth Year Course for Honours Degree – PHYS 4001

The following courses are offered in a range of topics reflecting the specialised interests of the staff in the department. Each student must attend all of the courses offered.

Local control of vascular resistance
Adaptive responses in the pulmonary circulation
Central cardiorespiratory control
Exercise physiology
Renal physiology and electrolyte homeostasis
Gastrointestinal physiology
Neurotransmitters and ion channels in the CNS
Circuitry and plasticity in the CNS

Each student is required to carry out a supervised laboratory-based research project, which has to be presented orally and submitted in minor thesis form as part of the Degree examination assessment. In assition, students are required to attend departmental research seminars and discussion groups and carry out the continuous assessments set.

PLANT GENETIC ENGINEERING

Programme Director: Dr Thomas Gallagher

Prerequisite: First Science Biology – group (a) preferred.

Second Year Courses for General and Honours Degrees

Any Second Science combination that includes Botany and Biochemistry.
Third Year Topical Degree Course

Eight core courses: BOTN 3005, BOTN 3006, BOTN 3007, BOTN 3008, BOTN 3010, GENE 3001, GENE 3002, GENE 3003.

Two optional units selected from: BOTN 3001, BOTN 3002, BOTN 3003, BOTN 3004, STAT 3221, LANG 3001, LANG 3002, LANG 3003, LANG 3004.

BOTN 3010 *Plant Development and Metabolism*
Photoregulation, germination and growth. Primary and secondary metabolism and regulatory mechanisms.

Fourth Year Honours Courses (BOTN 4100)

Each student must attend ten of the following courses and undertake a Research Project in consultation with the Course Director.

BOTN 4003 *Evolution in Plant Populations*
For details of this unit see under Botany.

BOTN 4006 *Eukaryotic Genome*
For details of this unit see under Botany.

BOTN 4007 *Organelle Biogenesis*
For details of this unit see under Botany.

BOTN 4008 *Plant - Pathogen Interactions*
For details of this unit see under Botany.

BOTN 4009 *In Vitro Techniques*
For details of this unit see under Botany.

BOTN 4011 *Critiques of Scientific Papers*
For details of this unit see under Botany.

BOTN 4013 *Science and Society*
For details of this unit see under Botany.

BOTN 4014 *Developmental Plant Genetics*
For details of this unit see under Botany.

BOTN 4016 *Plant Transformation*
Agrobacteria-mediated transformation, direct gene transfer, selection, screening, use of transgenics in modifying plant metabolism and development. Co-supression and anti-sense strategies.

BOTN 4017 *Plant Food Safety*
Testing procedures for dietary compatibility of modified plant proteins, lectins, haemagglutinines. Consequences of alteration of enzyme activities in metabolic cassettes.

BOTN 4018 *GMOs in the Environment*
The release of GMOs and their consequences. Regulatory procedures.

BOTN 4019 *Molecular Biology and Plant Breeding*
RFLP, PAPD, microsatellite and repeated sequences in genotyping and haplotyping, varietal identification and pathogen detection. Transformation and genetic engineering in plant breeding. Identification of differentially expressed genes.

CELB 4002 *Immunobiology*
For details of this unit see under Cell and Molecular Biology.

PSYCHOLOGY

NOTE: No admission to Second Science Psychology after 2001-2 academic session

Second Year Courses for General and Honours Degree

PSY 2201 *General Psychology*
History of Psychology and biological foundations of behaviour.

PSY 2202 *Introductory Cognitive Psychology*
Information processing and visual and auditory perception.

PSY 2203 *Developmental and Social Psychology*
Introduction to developmental and social psychology.

PSY 2204 *Statistics/Psychology & Society*

Notes for Students:

- Participation in tutorials and essay writing is an important feature of the course.

Third Year Courses for General and Honours Degree

PSY 3201 *Biopsychology*
Physiological psychology and psychopharmacology.

PSY 3202 *Personality & Philosophical*
Introduction to personality theory; Philosophical questions relevant to psychology.

PSY 3203 *Cognitive Psychology*
Perception and learning.

PSY 3204 *Developmental Psychology*
Cognitive, language, social and emotional development.

PSY 3205 *Social Psychology and Language*
Introduction to social psychology; psychology of language.

PSY 3206 *Psychology of Special Needs*
Developmental disabilities and persons with exceptional needs: abnormal psychology.

PSY 3207 *Psychological Statistics and Experimental Research Methods*

PSY 3208 *Design & Application of Research*

Notes for Students:
- Students are required to attend tutorials and departmental seminars, and to submit essays.
- Practical work may also be required in certain courses.
- Up to 25% of the marks allocated to any unit may be awarded for practical work.
- It is strongly recommended that students taking individual third year courses will have taken PSY 2201 - PSY 2204.
- Some courses may not be offered in a particular year.

Additional Third Year Course for Honours Degree

In addition to *all* of the above third year courses, Honours Psychology students are required to take the following course. (This course is *not available* to students taking individual units of Psychology).

Laboratory Practicals in Psychology
Honours Psychology students are required to attend two laboratory sessions per week. Laboratory work covers experimental techniques employed in psychological research and students are required to submit written reports of experimental work.

Fourth Year Honours Courses

(Available only to those students taking Honours Psychology. All Honours students take PSY 4201 – PSY 4215 inclusive and select *two* Optional Units from PSY 4216 – PSY 4224.)

Core Units:

PSY 4201 *Neuropsychology*
PSY 4202 *Advanced Cognitive Psychology*
PSY 4203 *Social: Social Cognition*
PSY 4204 *Social: Group Theory and Processes*
PSY 4205 *Social: Constructivism and Gender*
PSY 4206 *Aspects of Self and Identity*
PSY 4207 *Applied Psychology & Work*
PSY 4208 *Language: Symbols to Societies*
PSY 4209 *Perspectives on Development*
PSY 4210 *Applied Developmental*
PSY 4211 *Intelligence*
PSY 4212 *Current Debates in Psychology*
PSY 4213 *Philosophical Psychology*
PSY 4214 *Advanced Stats/Computer Analysis*
PSY 4215 *Research Project*
Honours Psychology students are required to undertake a research project and to write a minor thesis under the direction of individual academic staff members for the degree examination. In addition, students are required to attend departmental research seminars and discussion groups.

Optional Units:

PSY 4216 *History and Psychology*
PSY 4217 *Behavioural Paediatrics*

PSY 4218 *Counselling and Psychotherapy*
PSY 4219 *Psychology and Education*
PSY 4220 *Reading*
PSY 4221 *Comparative Psychology*
PSY 4222 *Attachment Theory*
PSY 4223 *Emotions and Mind*
PSY 4224 *Organisational Psychology*

Notes for Final Year Students:
- Students are required to attend tutorials and departmental seminars, and to submit essays.
- Practical work may also be required in certain courses.
- Up to 25% of the marks allocated to any unit may be awarded for practical work.
- Some courses may not be offered in a particular year.

STATISTICS

Second Year Courses

STAT 2201 *Descriptive Statistics and Statistical Computing*
Types of variables and data. Stem-and-leaf displays. Frequency distributions. Histograms. Samples and populations. Transforming data. Numerical summary measures. Summarising bivariate data. Introduction to statistical programming and MINITAB.

STAT 2202 *Introduction to Probability and Statistical Inference*
Probability concepts. Random variables and probability distributions. The binomial distribution. The normal distribution. Checking for normality. The distribution of a sample mean. Point and interval estimation using a single sample. Hypotheses and test procedures. Errors in hypothesis testing. Tests for population means and proportions using a single sample. P-values.

STAT 2203 *Statistical Inference and Goodness-of-fit*
Tests and estimation procedures for a difference between two population means or proportions using two independent samples. Tests and estimation procedures for differences using paired data. Distribution free procedures. One- and two-way frequency tables. Hypothesis testing for proportions and independence. Testing the fit for a population model.

STAT 2204 *Linear Regression and Analysis of Variance*
The simple linear regression model. Inferences based on the estimated regression line. Inferences on the population correlation. Checking model adequacy. Single factor ANOVA. Multiple comparisons. Randomized block experiment. Two-factor ANOVA.

STAT 2205 *Statistical Theory I: Probability*
Probability Theory. Combinatorics. Random Variables: univariate, bivariate and multivariate. Moment Generating Functions. Functions of a random variable. Standard Probability Laws.

STAT 2206 *Statistical Theory II: Statistical Inference*
(a) Estimation Theory: Chebyshev Inequality. Law of Large Numbers. Central Limit Theorem. Methods of moments and maximum likelihood. Point estimation and interval estimation.
(b) Hypothesis Testing: Neyman Pearson Lemma. Likelihood ratio tests.

STAT 2207 *Statistical Theory III: Bayesian Statistics and Stochastic Processes*
Bayesian statistical inference. Stochastic processes. Poisson processes. Birth and death processes. Branching processes.

STAT 2221 *Introduction to Statistical Methods*
Data reduction and representation. Probability distributions. Sampling. Confidence intervals. Hypothesis testing. Independent and paired samples. Sample size calculations. Design of experiments. Correlation. Linear regression.

Second Science students studying Statistics normally take units STAT 2201 - STAT 2204. Instead, the units STAT 2205, STAT 2206, STAT 2207 and STAT 2221 may be taken with the permission of the Department of Statistics.

Third Year Courses for General and Honours Degrees

STAT 3205 *Statistical Theory I: Probability*
Probability Theory. Combinatorics. Random Variables: univariate, bivariate and multivariate. Moment generating functions. Functions of a random variable. Standard Probability Laws.
This unit is not available to students who have taken STAT 2205.

STAT 3206 *Statistical Theory II: Statistical Inference*
(a) Estimation Theory: Chebyshev Inequality. Law of large numbers. Central Limit theorem. Methods of moments and maximum likelihood. Point estimation and interval estimation.
(b) Hypothesis testing: Neyman Pearson Lemma. Likelihood ratio tests.
This unit is not available to students who have taken STAT 2206.

STAT 3207 *Statistical Theory III: Bayesian Statistics and Stochastic Processes*
Bayesian statistical inference. Stochastic processes. Poisson processes. Birth and death processes. Branching processes.
This unit is not available to students who have taken STAT 2207.

STAT 3208 *Statistical Methods I*
Simple linear regression. Hypothesis testing and inferences concerning the regression equation. Polynomial and multiple regression. Regression diagnostics and transformations. Selecting the best regression model.

STAT 3209 *Statistical Methods II*
One- and two-way analysis of variance. Fixed random and mixed effect models. Contrasts. Interaction. Multiple comparison procedures. Introduction to experimental design. Nonparametric statistics. Introduction to generalized linear models.

STAT 3210 *Data Analysis and Statistical Software*
Data screening and cleaning. The SAS software package for data analysis.

STAT 3216 *Actuarial Statistics I*
Decision theory. Loss distributions. Reinsurance. Risk models. Run off triangles and experience rating systems.

STAT 3217 *Actuarial Statistics II*
Ruin theory. Bayesian statistics. Credibility theory. Introduction to generalised linear modles.

STAT 3218 *Survey Sampling*
Elements of the sampling problem. Simple random sampling. Stratified random sampling. Radio estimation. Cluster sampling. Systematic sampling.
Prerequisite: MATH 2104 or Second Science Statistics.

STAT 3219 *Quality Control and Reliability*
Aims of quality control. Acceptance sampling. Operating characteristic curves. Sampling schemes. Sampling by variables. Control and Cusum charts.
Prerequisite: MATH 2104 or Second Science Statistics.

STAT 3220 *Statistics for Chemists*
Probability. Basic distributions. Measures of precision. Sample size determination. Estimation of differences. Regression and calibration. Analysis of variance. Quality and process control. Introduction to statistical software.

STAT 3221 *Biostatistics*
Data reduction and representation. Probability distributions. Sampling. Confidence intervals. Hypothesis testing. Independent and paired samples. Sample size calculations. Design of experiments. Correlation. Linear regression.

STAT 3222 *Stochastic Processes I*
An introduction to the classification and simulation of stochastic processes. Discrete and continuous time models. Stochastic calculus

STAT 3223 *Official Statistics*
Collection of official statistics including macro-economics, business, demographic and social statistics. Accessing official statistics and their applications. Estimation, imputation and seasonal adjustment.

STAT 3224 *Statistics and Visualization*
Descriptive statistical and graphical methods for displaying data. From data to information. Visualization and presentation of data. Aspects of multivariate analysis. Simulation. S-plus software.

Fourth Year Courses for Honours Degree

STAT 4211 *Data Analysis I*

STAT 4212 *Applied Statistics I*
Design and Analysis of Experiments. Complete Block Designs (Randomized Block and Latin Square Designs). Incomplete Block Designs. Factorial Designs. Confounding and Fractional Factorial Designs. Statistical Software.

STAT 4213 *Applied Statistics II*
Introduction to Sample Surveys. Contingency Table Analysis. Logistic Regression. Log-linear Models. Statistical Computing.

STAT 4214 *Time Series Analysis*
Characteristics of time series. Autocorrelation and cross-correlation function. Stationary time series. Autoregressive and moving average processes. Nonstationary time series. Model specification and estimation. Model diagnostics. Forecasting. Special topics.

STAT 4215 *Multivariate Analysis*
Random vectors. Multivariate Normal Distribution, Correlation and Regression. Hotelling's T^2 Statistic. Discriminant Analysis. Canonical Correlation. Principal Components Analysis. Multivariate Analysis of Variance.

STAT 4216 *Actuarial Statistics I*
Economics of Uncertainty. Risk Theory and Utility. Jensen's Inequality. Sums of Random Variables and Convolutions. Loss Distributions. Reinsurance. Risk Models. Mixtures of Random Variables and Mixtures of Distributions.
This unit is not available to students who have taken STAT 3216.

STAT 4217 *Actuarial Statistics II*
Ruin theory. Lundberg's Inequality. Credibility Theory. No Claims Discounting. Applications in Insurance.
This unit is not available to students who have taken STAT 3217.

STAT 4222 *Stochastic Processes I*
An introduction to the classification and simulation of stochastic processes. Discrete and continuous time models. Stochastic calculus.

STAT 4223 *Official Statistics*
Collection of official statistics including macro-economics, business, demographic and social statistics. Accessing official statistics and their applications. Estimation, imputation and seasonal adjustment.

STAT 4230 *Statistics – Laboratory Assays*

STAT 4231 *Linear Models with Complex Structure*
Analysis of unbalanced data from surveys and experiments. Partitions of data in orthogonal designs. Means model. Estimation of variance components in unbalanced mixed and random effect models. Methods for the analysis of repeated measures data.

STAT 4232 *Topics in Biostatistics*
This course covers specialised applications of statistics in biology. Topics include the following: Pharmaceutical statistics, ecological statistics, medical and epidemiological statistics.

STAT 4233 *Nonparametric Statistics*
Distribution-free statistics; statistics utilizing counting and ranking; Wilcoxon statistics; Kruskal-Wallis statistic. Friedman statistic; Spearman's statistics; Permutation procedures; Power functions and asymptotic distribution. Nonparametric regression.

STAT 4234 *Regression Theory*
Simple and Multiple Linear Regression. Weighted Least Squares. Lack of Fit. F tests. Residuals and Influence. Model Building.

STAT 4235 *Survival Analysis*
Censoring. Life tables. Kaplan Meier estimate. Mantel-Haenzel statistics. Parametric methods. Cox's proportional hazards model. Goodness-of-Fit.

STAT 4236 *Statistical Computing*
Fixed point and floating point arithmetics. A review of programming style. Random number generators. Monte Carlo applications. A review of maximum likelihood. Unconstrained nonlinear optimizations. Accessing Fortran libraries.

STAT 4237 *Stochastic Processes II*
General principles of stochastic processes. Markov chains. Markov processes. Special topics in time series models.

STAT 4238 *Data Analysis II*

STAT 4239 *Stochastic Processes III*
Gauss Wiener processes and levy processes. Monte Carlo simulation of stochastic processes. Stochastic actuarial modelling.

STAT 4240 *Data Mining*

THEORETICAL PHYSICS

First Year Courses

For details of First Year courses, see pages 34 to 38.

Second Year Courses (MAPH 2201)

Students follow the Second Year Honours course in Mathematics and Second Year course in Experimental Physics. In Mathematical Physics students take the following courses:

MAPH 2111 *Methods A*
MAPH 2121 *Mechanics A*
MAPH 2131 *Mechanics B*
MAPH 3161 *Quantum Mechanics*

Third Year Courses

Students must take the *Core Courses* and one of the *Optional Courses* listed below.

Core Courses

MAPH 3111 *Methods B*
MAPH 3120 *Methods C*
MAPH 3171 *Fluid Mechanics*
MAPH 4141 *Quantum Mechanics*
MAPH 4181 *Electromagnetic Theory*
EXPH 3006 *Thermodynamics and Statistical Physics*
EXPH 3007 *Solid State Physics*
EXPH 3012 *Nuclear Physics*

Optional Courses

MAPH 3180 *Dynamic Systems and Chaos*
MAPH 4121 *Methods*
MAPH 4151 *Statistical Mechanics*
MAPH 4161 *Computational Physics*
MAPH 4171 *General Relativity*
EXPH 4002 *Quantum Mechanics and Nuclear Physics*
EXPH 4004 *Atomic and Molecular Physics*
EXPH 4005 *High Energy Particle Physics*
EXPH 4009 *Perspectives in Modern Astrophysics*
EXPH 4010 *Atomic Structures and Spectra*
EXPH 4011 *Physics of Ionized Gases*
EXPH 4013 *Condensed Matter Physics*
EXPH 4015 *Experimental Laboratory Option*

Fourth Year Courses

Students take the equivalent of 12 units. These are chosen from the courses listed below. The courses in Group A are equivalent to 1.5 units and the courses in Group B are equivalent to one unit.

Group A
MAPH 4110 *Nonlinear Waves and Solitons*
MAPH 4121 *Methods*
MAPH 4151 *Statistical Mechanics*
MAPH 4161 *Computational Physics*
MAPH 4171 *General Relativity*
MAPH 4191 *Theoretical Astrophysics*

Group B
EXPH 4002 *Quantum Mechanics and Nuclear Physics*
EXPH 4004 *Atomic and Molecular Physics*
EXPH 4005 *High Energy Particle Physics*
EXPH 4009 *Perspectives in Modern Astrophysics*
EXPH 4010 *Atomic Structures and Spectra*
EXPH 4011 *Physics of Ionized Gases*
EXPH 4013 *Condensed Matter Physics*
EXPH 4015 *Experimental Laboratory Option*

Also, at most 1.5 units may be in a more advanced topic, which will normally be in one of the following areas.

Quantum Field Theory
Quantum Gravity
Advanced Mathematical Statistical Mechanics
Advanced General Relativity
Non-linear Waves
Elasticity
Advanced Theoretical Astrophysics

ZOOLOGY

Second Year Courses for General and Honours Degrees

ZOOL 2005 *Animal Form and Function 1*
Comparative anatomy and physiology of invertebrate and vertebrate systems (digestion; respiration/circulation; excretion/osmoregulation; reproduction). Enzymology and metabolism. Correlation between form and function. Adaptation to environment.

ZOOL 2006 *Cell and Molecular Zoology*
Topics covered include chromosome organisation and genome stability; mutation, repair and recombination; genetic linkage and chromosome mapping; gene expression and its regulation; protein targeting; cytoskeleton and extracellular matrix (ECM); cell-cell and cell-ECM interactions; cell-cycle regulation, apoptosis and cancer.

ZOOL 2007 *Animal Ecology*
Biotic and abiotic determinants and limiting factors in growth and control of animal populations/communities. Food webs, decomposition processes, nutrient cycling. Features, habitats and fauna of terrestrial, freshwater and marine ecosystems.

ZOOL 2008 *Invertebrate Diversity*
The Bauplan concept, constraints in body design and comparative biology of the following invertebrate phyla: Protista, Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Mollusca and Echinodermata. Species of economic and medical importance.

Third Year Courses for General and Honours Degrees

Students in the General degree programme must choose their courses in consultation with the Head of Department. Students in the Honours degree programme must take units ZOOL 3009 to ZOOL 3016 inclusive. ZOOL 3017 is an optional unit.

ZOOL 3009 *Functional Morphology*
Anatomy/biochemistry of muscle, bone-muscle systems, supporting tissues, aquatic and terrestrial locomotion, flight, brain and sensory systems, temperature and energy metabolism, thermal strategies of animals.

ZOOL 3010 *Animal Development*
Pattern formation, cell signalling, sex determination, differentiation, morphogenesis, evolution and development. Morphological and genetic basis of development, in model organisms such as *C. elegans*, *Drosophila*, sea urchin, zebrafish and mouse.

ZOOL 3011 *Arthropoda*
Diversity, classification, biology, functional morphology, life cycles and strategies for survival of arthropods and related taxa; cladistics and phylogenetic relationships; impacts of pest, parasitic and beneficial species.

ZOOL 3012 *Immunology*
Antigens, antibody structure and function, B cells, Tcells, MHC, diversity, cytokines, complement, inflammation, immunity to viruses, bacteria and parasitic infections, polyclonal, monoclonal and phage display antibodies.

ZOOL 3013 *Animal Behaviour*
Sensory inputs. Chemical cues and escalating responses, stereotyped and modifiable. Integration of information. Evolution of behaviour. Social systems. Measuring behaviour. Genes and environment. Learning. Dominance. Aggression. Cooperation. Mating systems.

ZOOL 3014 *Systems Ecology*
Global change, greenhouse effect, carbon cycle, nitrogen cycle, acid precipitation, stream and lake ecology/succession, stream habitats, indicator species, water quality, marine ecology, deep-sea and polar systems, larval ecology, benthic ecology.

ZOOL 3015 *Evolutionary Biology*
Quantitative genetics; Gene flow in populations; Genetic drift; Heterozygosity; Heredity; Selection Models, Fitness/Relative Fitness; Molecular Evolution; Evolutionary Ecology; Species Concept; Speciation.

ZOOL 3016 *Diversity of Vertebrates*
Study of phylogeny/diversity, pre-vertebrate chordates, vertebrate skeletons, transition from water to land, phylogeny, diversity, radiation and biogeography of fishes, amphibians, reptiles, birds and mammals.

ZOOL 3017 *Wildlife and Fisheries Management*
The necessity of management, estimating population size, using models (types and estimation of parameters), habitat analysis and GIS, species re-introductions, the use of Protected Areas, case studies.

Fourth Year Course for Honours Degree – ZOOL 4000

Students must attend seven units. There are four core units and three optional. Each student undertakes a research project which is written and presented as a thesis. In addition, attendance at Research Seminars is obligatory. The following units may be offered.

ZOOL 4001 *Biodiversity*
Evolution and maintenance of biodiversity within systems. Equilibrial and nonequilibrial models of community organisation. Global patterns of species diversity. Functional redundancy. The Irish fauna.

ZOOL 4004 *Immunology*
This course builds on material discussed in Third Year. Complement, T cell maturation, antigen processing and T cell activation are discussed and topics such as the evolution of the immune response, immunity to viruses and bacteria, mucosal immunity and the generation of diversity in the immune response are introduced.

ZOOL 4005 *Ecology of Tropical Rainforests*
The paradox of tropical luxuriance: climate, soil, vegetation and nutrient cycling. Biodiversity in tropical forests. Rainforests as a vanishing resource with emphasis on ethnopharmacology. Accounts of expeditions to West Central Africa and Amazonia. Models for sustainable use.

ZOOL 4006 *Animals and Genes*

Provides a basic understanding of genome structure, the nature of polymorphism and its application in genome mapping and identification of individuals and the principles of gene expression. Specific topics include gene families, introns, gene evolution, genome instability, regulation of gene expression.

ZOOL 4007 *Wildlife Management*

The logic and management of conservation. Discussion of the roles of parks, reserves and zoos, including discussions of minimal viable populations etc. International aspects of conservation and the control of trade in wildlife.

ZOOL 4008 *Comparative Physiology*

The nature of physiological adaptation to the environment with particular reference to the principle of homeostasis. Systems to be considered include osmoregulation, respiration, nutrition and energy metabolism.

ZOOL 4009 *Parasitology*

Deals with classical aspects of parasitology. The biology, pathology, diagnosis and treatment of a number of parasitic infections, in humans and other animals are described. The parasites include protozoan and helminth endoparasites and ectoparasites.

ZOOL 4010 *Environmental Impact Assessment*

Definition of Environmental Impact Assessment and a discussion of the Irish and EU legislation associated with environmental issues. Case studies are used to illustrate the sequence of work and practical considerations necessary in preparing such statements.

ZOOL 4011 *Readings in Contemporary Zoology*

This is a literature-based course, in which the students select from a number of topics (9) which they study themselves (i.e. no lectures). Each staff member contributes a topic to the list and recommends a key text.

ZOOL 4012 *General Zoology*

This is the coding for the three hour paper on general zoology in the final examination.

ZOOL 4013 *Fisheries Science*

Course will include: Van Bertalannfy growth equations, sustainable yields in marine fisheries, total and natural mortality in fish stocks, recruitment mechanisms, catch-effort statistics, fecundity and use of otoliths as an ageing tool.

ZOOL 4014 *Prion Diseases*

This course examines the current research into the agents responsible for the animal and human Transmissible Spongiform Encephalopathies. It includes the nature of the agent, its genetics, cell biology and epidemiology.

ZOOL 4015 *Marine Ecology*

Oceanography via remote sensing. The ecology of corals and fishes on coral reefs. The unusual biology and ecology of deep-sea animals. The unexpected impacts of humans in the marine environment. The ecology of polar environments.

BSc DEGREE IN OCCUPATIONAL SAFETY AND HEALTH

Students who pass Second Science in any combination of subjects, having taken Combination A in First Science, may apply for admission to this Degree course.
Applications to this Third Year Degree course should be made to the Course Director (see page 13) before 20 April 2001.
Admission is granted by the Course Director and is subject to space and number restrictions.

Third Year Courses
These courses are only available to students taking the BSc in Occupational Safety and Health. Students take all ten courses.

SHWW 3001 *Safety and Health Legislation*

This unit provides the opportunity for understanding the important developments in legislation relating to safety and health in the workplace at both Irish and European levels.

SHWW 3002 *Risk Management and Safety Technology*

All aspects of occupational risk are considered and how they can be managed like any other workplace activity, to eradicate or reduce the adverse effects of accidents and occupational disease in the workplace. The structure and content of Safety Statements are examined in detail.

SHWW 3003 *Occupational Health and Health Promotion*

A broad definition of occupational health is introduced covering the most common occupational diseases and their prevention. Health promotion in the workplace is explored. The organisation of occupational health services, first aid, disability and rehabilitation are other issues which are addressed.

SHWW 3004 *Occupational Hygiene*

Occupational hygiene is concerned with the recognition, evaluation and control of physical (e.g. noise) and chemical (e.g. gases) agents in the workplace. Basic monitoring equipment is demonstrated practically.

SHWW 3005 *Chemical Safety and Toxicology*

Chemical actions and interactions in the human body and the toxic effects of major classes of toxicants are examined. The principles of chemical hazards

and risk assessment are addressed and appropriate control and preventative strategies for toxic chemicals.

SHWW 3006 *Ergonomics and Behavioural Science*
Human attitudes and behaviour are examined in relation to safety and health and how this knowledge can be applied to improve the workplace environment and motivate safe working practices. It gives an appreciation of the complexity of dealing with individuals, in groups and in organisations.

SHWW 3007 *Emergency Planning*
The unit concentrates on emergency planning and evacuation procedures for possible workplace disasters. It also considers Fire and Electricity in depth, as two of the major potential "killers" in most working environments.

SHWW 3008 *Epidemiology and Statistics*
An overview of the epidemiological approach to the monitoring of health in the workplace is given. Data collection methods, the choice of an appropriate study design, the interpretation and use of medical statistics and the role of computers in the research process are examined.

SHWW 3009 *Industrial Placement*
SHWW 3010 *Projects*

BSc DEGREE IN OCCUPATIONAL SAFETY AND HEALTH MANAGEMENT (PART TIME DEGREE)

1. Applicants to this part time BSc degree course must have completed and achieved a high standard in the NUID Diploma in Safety, Health and Welfare at Work or equivalent. Applicants should also have at least two years' relevant work experience.

2. A limited number of places are available on the course. Applications should be made to: Assistant to the Academic Director, Centre for Safety and Health at Work, University Industry Programme, UCD, Roebuck, Belfield, Dublin 4. Closing date for receipt of applications: 30 June each year.
3. The degree course is a part time course and will normally be completed in two years.

4. The foundation unit, SHWW 3201 Research Methods, Data Processing and Analysis, is offered each year. This unit is compulsory for students in the first year of the programme. Thereafter each core and elective unit is offered once every second year to both first and second year students who attend lectures together.

5. Project work is based on individual work placements in industry (which may be in the students's own workplace), which takes place over both first and second years of the degree programme.

6. Examinations will be held each year in Summer with repeat examinations in Autumn.

Core Units

SHWW 3201 *Research Methods, Data Processing and Analysis*
Introduction to programme, its objectives and knowledge and skills needed to carry out workplace placement and research project. Builds on and adds to Epidemiology and Statistics in the Diploma course. Use of software packages for data analysis, and report/thesis writing skills.

SHWW 3202 *Risk Management*
Advanced risk management techniques relating to management of safety and health in the workplace, including cost benefit analysis, claims investigation and analysis, practical legal issues that relate to risk management and stages of litigation process.

SHWW 3203 *Applied Management for Occupational Safety and Health*
Practical management skills, communication skills, strategic planning and project management. Relevant industrial relations and human resource issues relating to occupational safety and health in organisations. Builds on Ergonomics and Behavioural Science and Safety and Health Legislation in the Diploma course.

SHWW 3204 *Occupational Safety and Health and Environmental Management*
Legislative and practical links between management of occupational safety and health and management of workplace environmental issues. Addresses needs of occupational safety and health professionals whose brief includes environmental issues. Explores roles of organisations involved in managing health and safety and the environment.

SHWW 3205 *Safety Management and Quality Auditing*
Quality Auditing and Standard Setting: how these principles can be applied to Occupational Safety and Health Management. Existing standards, contemporary trends and legislative requirements. Safety Management Systems are addressed in detail.

SHWW 3209 *Industrial Placement*

SHWW 3210 *Project*

Elective Units
Students must choose one of the following units:

SHWW 3206 *Occupational Hygiene – the Working Environment*
Occupational Hygiene practice, including personal and environmental monitoring in workplace. Builds on Occupational Hygiene in the Diploma course.

SHWW 3207 *Occupational Health*

Issues that relate to occupational health practice; skills required to run an occupational health department; legislation; the occupational health professional as part of multidisciplinary team; models of occupational health and occupational health nursing; and contemporary issues in occupational health practice.

SHWW 3208 *Ergonomics*

Ergonomic issues in contemporary work setting: the person, the environment, the equipment and the job. Legislation; the ergonomist as part of multidisciplinary team; ergonomic assessment; job and task analysis; analytical tools; and contemporary issues in workplace ergonomics.

PHAR 3004 *Toxicology*

For details of this unit see under Pharmacology.

BSc HONOURS DEGREE IN MEDICAL SUBJECTS FOR MEDICAL STUDENTS OR GRADUATES

1. The Degree of BSc with Honours in Medical subjects may be conferred in any one of the following subjects: *(a)* Anatomy, *(b)* Biochemistry, *(c)* Medical Microbiology, *(d)* Pathology, *(e)* Pharmacology, *(f)* Physiology.

2. Students who have passed the appropriate University examination in Medicine in the corresponding subjects at a standard of at least Second Class Honours are eligible to take the BSc Degree in that subject. To be eligible to pursue the Degree of BSc in Anatomy or Biochemistry, students must have passed the University Examination of the Second Year of Medicine with Honours and must also have passed the University Examination of the Third Year of Medicine.

3. Candidates who hold the Degrees of MB, BCh and BAO may be recommended by the Faculty of Science for admittance to the Honours Degree courses in any one of the subjects (a) to (f).

4. For admission to the Honours Degree Examination in subjects (a) to (f), candidates must have attended the prescribed courses for at least one academic year.

5. Particulars of the prescribed courses are given in the booklet for the Faculty of Medicine. At the discretion of the Professors concerned, special instruction in related subjects may be arranged.

POSTGRADUATE PROGRAMMES

The following postgraduate programmes are offered in the Faculty of Science:

DEGREE OF DOCTOR OF PHILOSOPHY (PhD)
- **by research and thesis**

DEGREE OF MASTER OF SCIENCE (MSc)
- **by Mode I (research and thesis)**
- **by Mode II (course and examination)**
- **by Mode III (external study and research)**

DEGREE OF MASTER OF APPLIED SCIENCE (MApplSc)
- **by course and examination**

HIGHER DIPLOMA
DIPLOMA
CERTIFICATE

ADMISSION AND ENTRY REQUIREMENTS FOR PhD DEGREE

Candidates are required to have reached a high Honours standard at the examination for the primary degree or equivalent before they can be allowed to enter a course of study and research for the Degree of PhD.

Candidates for this degree are required to be admitted by the Faculty on the recommendation of the Professor; their admission must then be confirmed by the Academic Council.

The degree is normally (except in Science) to be taken six terms after the Master's Degree, but in special cases candidates may be permitted to take it six terms after the primary degree. In the Faculty of Science, six terms after the BSc Degree is the minimum period.

This degree will not be awarded unless the examiners report that the work is worthy of publication as a whole or in part.

Candidates for PhD Degrees will be allowed six years from the date of registration in which to complete their degree. If they have not done so within that period, they must re-apply to Faculty for registration.

ADMISSION AND ENTRY REQUIREMENTS FOR MSc AND MApplSc DEGREES

1. Application for admission to the MSc Degree programmes should be made to the Head of the relevant department.

2. Application for admission to the MApplSc Degree programmes should be made to the Director of the relevant programme.

3. Candidates for the MSc Degree and MApplSc Degree must have the permission of the Faculty and the Department concerned to enter a course. Except by permission of the Faculty, they cannot at the same time engage in any other course.

4. Only those candidates who have obtained at least a Second Class Honours primary degree, or equivalent, will be permitted to proceed directly to an MSc Degree by Modes I, II or III or an MApplSc Degree.

5. Candidates who hold a Third Class Honours primary degree, the BSc General Degree with Distinction, or the BSc General Degree followed by two years' approved postgraduate experience, may be admitted to the MSc on the recommendation of the Faculty and the Department concerned. Such candidates would normally be required to pass a qualifying examination during their first year and attend the College for at least six terms.

6. The MSc Degree (Mode I) by thesis is an Honours degree. Candidates must attend for at least three terms and carry out research, under the direction of the Professor or Lecturer, in the subject concerned. The thesis presented by the candidate is to embody the results of this research. Candidates may be required to pass an examination in the subject-matter of the thesis if the Examiners so decide. Three copies of the thesis must be lodged with the Supervisor of Examinations, University College Dublin, on or before the date fixed by the University.

7. The Degree of Master of Science (MSc) may be awarded in any one of the following subjects: Anatomy, Biochemistry, Botany, Chemistry, Computer Science, Experimental Physics, Geology, Industrial Microbiology, Mathematical Physics, Mathematical Science, Mathematics, Medical Microbiology, Pathology, Pharmacology, Physiology, Psychology, Statistics, Zoology.

8. Students who pass the Higher Diploma in Mathematical Science with distinction may be admitted to the MSc Degree course in Mathematical Physics or Mathematics.

9. Students who pass the Diploma in Statistics (see Arts Faculty regulations) with distinction may be admitted to the MSc Degree in Statistics.

10. The MSc Degree (Modes II and III) by examination and the MApplSc Degree may be awarded with First or Second Class Honours. (The regulations governing these examinations are contained in *Marks and Standards*, available for consultation in the Library).
Candidates must attend a postgraduate course for three terms. An examination will be held in the subject-matter of the course selected. Candidates may be required to submit a

dissertation on a project undertaken as part of their course and this dissertation will be taken into account by the Examiners in making their recommendations.
Courses leading to the MSc Degree are offered in the Departments of Botany, Computer Science, Mathematics, Mathematical Physics, Psychology and Statistics.

11. MSc by External Study and Research (Mode III) - Candidates will be required to present themselves for an examination, theoretical and practical, involving detailed and critical knowledge of the principal branches of the subject concerned. Candidates must also present a satisfactory dissertation embodying the results of original research. Candidates will also be examined on the subject-matter of the dissertation and on cognate subjects.
Candidates must normally have obtained First or Second Class Honours in the BSc Degree examination and must be graduates of at least six terms standing. Other candidates may be admitted by the Faculty on the recommendation of the Department concerned.

12. Candidates for the MSc Degree (Mode 1 Research) will be allowed a maximum of four years from the date of registration in which to complete their degree. If they have not done so within that period, they must reapply to Faculty for registration.

13. Candidates for the MSc Degrees (Modes II and III Examinations) and MApplSc will be allowed a maximum of three years from the date of registration in which to complete their degree. If they have not done so within that time period, they must reapply to Faculty for registration.

COURSE DETAILS FOR TAUGHT MSc DEGREES (MODE II)

DEGREE OF MASTER OF SCIENCE IN PLANT MOLECULAR BIOLOGY

Advanced theoretical and practical training in a wide range of modern techniques in molecular biology as applied to Plant Science is provided in a one year full-time course. There is a strong emphasis on laboratory-based training to complement the theoretical aspects of molecular biology. A practical research project forms an essential part of the year's program.

Candidates should possess an honours degree in a biological subject, a BSc General with Distinction or equivalent by practical experience. An Examination will be held in the subject matter of the course; marks will also be awarded for the year's practical and for the research project. Candidates must pass separately the written papers, the year's practical work and the minor thesis.

DEGREE OF MASTER OF SCIENCE IN COGNITIVE SCIENCE

Cognitive Science is an interdisciplinary enterprise, the primary goal of which is to integrate the efforts of academic disciplines concerned with the main facets of human cognition. The course will comprise three main content areas: sensory-motor processes, cognition, and language. After an initial grounding in the first semester in these three strands, as well as in various research and modelling methodologies, the course will focus on specific computational models in the various topic domains. Students will specialise in one of the three strands in their choice of a project.

DEGREE OF MASTER OF SCIENCE IN RADIOLOGICAL SCIENCES

Advanced academic, practical and radiological training in all branches of diagnostic imaging is provided by a one year, full-time course in collaboration with the Institute of Radiological Sciences at the Mater Misericordiae Hospital and the Diagnostic Imaging and Nuclear Medicine Departments at St. Vincent's Hospital.

Candidates should be graduates in medicine who have passed their fellowship examination in Radiology or equivalent (i.e. MD in Radiology) and actively engaged in diagnostic radiology.

COURSE DETAILS FOR MApplSc DEGREES

Courses leading to the Degree of Master of Applied Science are offered in the following areas:

Applied Physics:
A two-year, part-time course open to graduates in Science and Engineering.

Computer Science:
This is a one year, full-time taught Master's course open to those who have achieved a good Second Class Honours in the Higher Diploma in Computer Science or equivalent and to suitably qualified Science graduates. The course has been designed with a specific emphasis on practical applications of relevance to the internet and e-commerce sector. The course will comprise six modules as prescribed by the Department of Computer Science. Students will be required to undertake a substantial project to be written up as a thesis to be submitted by the end of the academic year.

Environmental Science:
A one-year, full-time course open to graduates in Science, Engineering and Architecture.

Food Science:
A two-year, part-time course open to graduates in Science, Agriculture, Engineering, Veterinary Medicine, Commerce and Medicine.

***Safety, Health and Welfare at Work**:*
The course is open to graduates who achieve a high standard in the Diploma in Safety, Health and Welfare at Work. It can be taken on a one year, full-time basis or on a two year, part-time basis.

The entry requirements for Science graduates will be the same as for the MSc. Suitably qualified graduates of other faculties and universities will be admitted on the recommendation of the Faculty. Candidates must attend the prescribed course of lectures and practicals. An examination will be held in the subject-matter of the course selected. Candidates may be required to submit a dissertation on a project undertaken as part of their course and this dissertation will be taken into account by the Examiners in making their recommendation.

COURSE DETAILS FOR HIGHER DIPLOMAS, DIPLOMAS AND COLLEGE CERTIFICATES

Candidates for the Higher Diploma in the Faculty of Science will be allowed a maximum of two years from the date of registration in which to complete their diploma. If they have not done so within that period, they must reapply to Faculty for registration.

HIGHER DIPLOMA IN COMPUTER SCIENCE

The diploma course is full-time for one year and the course content consists of subject matter from the honours degree course in Computer Science. Admission will normally be restricted to graduates of disciplines other than Computer Science. The course is designed to give graduates of other disciplines a sound theoretical foundation and practical exposure to Computer Science.

HIGHER DIPLOMA IN COMPUTATIONAL METHODS AND NUMERICAL SOFTWARE

This one year, full-time diploma course is open to graduates with a suitable level of previous experience (e.g. BSc, BE or BA involving quantitative course work). Entry to the course is restricted to graduates who obtain the permission of the Course Directors in the Departments of Mathematical Physics and Computer Science.

HIGHER DIPLOMA IN MATHEMATICAL SCIENCE

The diploma course is full-time for one year and the course content consists of subject matter from the honours degree course in either Mathematics or Mathematical Physics. There will be a Mathematics stream and a Mathematical Physics stream.

Entry to the course is restricted to graduates who obtain the permission of the Head of the Department of Mathematics or of Mathematical Physics, as appropriate. Permission will normally be given to university graduates who have attained a sufficiently high standard in Mathematics or Mathematical Physics.

The examination may be taken once only and must be taken in the academic year of registration. (Exceptions to this rule may be granted by the Faculty but only for grave reasons). Students who pass with distinction will qualify for admission to the MSc course in Mathematical Science, Mathematics or Mathematical Physics.

A student's choice of options must be approved by the departments concerned.

Mathematics Stream

Part I
1. Algebra
2. Analysis

Part II
3. Algebra
4. Real and Complex Analysis

Mathematical Physics Stream

Part I Students take four courses from MAPH 3111- MAPH 31321 and MAPH 3161-MAPH 3181.

Part II Students take four courses from MAPH 4111 - MAPH 4191.

HIGHER DIPLOMA IN STATISTICS

The diploma course is full-time for one year and the course content consists of subject matter from the honours degree course in Statistics. Permission will normally be given to BA, BSc and BE graduates who have attained a sufficiently high standard in a subject area which is cognate to Statistics.

DIPLOMA IN SAFETY, HEALTH AND WELFARE AT WORK

This is a two-year, part-time course intended for persons with a professional interest in safety and health in the workplace. It comprises the following modules:

Safety and Health Legislation
Risk Management and Safety Technology
Occupational Health and Health Promotion
Occupational Hygiene
Chemical Safety and Toxicology
Ergonomics and Behavioural Science
Emergency Planning
Epidemiology and Statistics

Admission to the course is not restricted to graduates. Preference is given to applicants with relevant experience.

CERTIFICATE IN SAFETY AND HEALTH AT WORK

This one-year, part-time course provides an introduction to all aspects of occupational safety and health; theoretical and scientific aspects are introduced as well as practical applications of risk management and hazard control. The course is designed as an extra-mural course

which can be offered at UCD and/or other centres throughout Ireland. Candidates would normally be required to have Leaving Certificate or equivalent. Further information can be obtained from the Centre for Safety and Health at Work, Roebuck Castle, Belfield (Telephone No: 706 8712).

DEGREE OF DOCTOR OF SCIENCE (DSc)*

This degree may be awarded on original published work, to be submitted not less than fifteen terms after obtaining the primary degree.

Degrees which may be granted under the provisions of University Statute LXXXVI, Chapter LV, to students who shall have carried on independent research:

The Degrees of the Faculty of Science, which are here included, are the Degree of MSc and the Degree of DSc.

***** See Calendar of the National University of Ireland.

SCHOLARSHIPS AND PRIZES AWARDED IN FACULTY OF SCIENCE

SCHOLARSHIPS

Entrance Scholarships – based on Leaving Certificate

The University offers a number of entrance scholarships, valued at £1,000 (€1,270) for one year, on the basis of points achieved at the Leaving Certificate examination. All new entrants to Science who achieve a CAO points total on or above 550 points, will be guaranteed a scholarship. In addition, all Entrance Scholars will be given priority in the application for places in student residences on the Belfield Campus.

Scholarships on the Results of the First University Examination in Science

One scholarship, of value £500 (€635), may be awarded in each of the subjects: Biology, Chemistry, Computer Science, Experimental Physics and Geology. One scholarship will be awarded jointly with results in the Faculty of Arts in Honours Mathematics and in Honours Mathematical Physics. These scholarships are awarded to students gaining first place in their class and obtaining a First Class Honours mark.

Scholarships on the Results of the Second University Examination in Science

One scholarship, of value £500 (€635), may be awarded in each subject of the Second University Examination in Science which leads to an Honours Degree. These scholarships are awarded to students gaining first place in their class and obtaining a First Class Honours mark.

Scholarships on the Results of the Third University Examination (Honours) in Science

A total of not more than ten scholarships, of value £500 (€635), will be offered on the marks obtained at the Third University Examination in Science in the major subject or in a Topical Degree course. These scholarships are awarded to students gaining first place in their class and obtaining a First Class Honours mark.

Scholarship on the Results of the Third University Examination (Honours) in Science in the Joint Honours Degree Courses

One scholarship, of value £500 (€635), will be awarded. These scholarships are awarded to students gaining first place in their class and obtaining a First Class Honours mark.

Open Scholarship in Science

One second year or one third year or one fourth year scholarship, of value £500 (€635), may be awarded in special circumstances to a student of Science who is ineligible for a normal award.

Research Demonstratorships

One hundred and eighty Research Demonstratorships may be awarded to students registered for postgraduate degree programmes in the Faculty of Science.

Open Postgraduate Scholarships

The scholarships are awarded on the basis of academic merit and are available equally to graduates of University College Dublin and other universities. They are tenable for one year of full-time postgraduate study at University College Dublin. Application forms are available from the Office of Postgraduate Studies, University College Dublin, Library Building, Belfield, Dublin 4.

PRIZES

Biochemistry	-	**ALLTECH Travel Award**
	-	**Michael G. Harrington Medal**
Chemistry	-	**Eva Philbin Medal**
	-	**Hugh Ryan Memorial Medal**
Computer Science	-	**John Kelly Memorial Medal**
Experimental Physics	-	**Thomas E. Nevin Medal and Prize**
Geology	-	**Patrick J. O'Donoghue Prize**
Mathematical Physics	-	**Conway Medal**
	-	**Keating Prizes**
	-	**McCrea Medal**
	-	**Orr Prize**
	-	**Fr Ciaran Ryan Prize**
Pharmacology	-	**ICI Pharmaceuticals Division Prize**

Full details of all above-mentioned scholarships can be found in the booklet ***Student Awards.***

EUROPEAN CREDIT TRANSFER SYSTEM (ECTS)

CREDIT SCHEME FOR THE UNDERGRADUATE DEGREE PROGRAMME IN SCIENCE FOR VISITING STUDENTS FROM EUROPEAN UNIVERSITIES

YEAR	SUBJECTS	UNIT COURSES	CREDITS	TOTAL PER YEAR
First Science	4	-	15 per subject	60 credits
Second Science	3	12	5 per unit	60 credits
Third Science	*	10	6 per unit	60 credits
Fourth Science	*	-	60 per year	60 credits

* See regulations for Single Honours, Joint Honours, Topical, One-Subject General and Two-Subject General Degrees for number of subjects involved.

FIRST SCIENCE TIMETABLE (2001-2002)

(Lectures and Practicals)

	MONDAY			TUESDAY			WEDNESDAY			THURSDAY			FRIDAY		
	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals
09.00	Chemistry	Th A		Maths (Pass) Maths(Hons)	Th A/D Th E		Chemistry	Th A		Maths (Pass) Maths (Hons)	Th A/D Th F		Chemistry	Th A	
10.00	Exp. Physics	Th A		COMP 1001	Th A		Exp.Phys.	Th A		COMP 1002 Geology	ID Th D		ExpPhysics	Th A	
11.00	MathPhys	Th E		Biology MathsPhys	Th A Th E		Maths (Pass)	Th A/B		Biology MathPhysics	Th A Th E		COMP 1002 Geology	ID Th D	
12.00	Maths(Pass) Maths (Hons)	Th B/C Th D		COMP 1002 Geology	ID Th D		COMP 1001	Th A		COMP 1001	Th A		Biology MathPhysics	Th A Th E	
13.00													Maths (Hons)	Th E	
14.00			CompSc ExpPhys Geology			Comp Sc ExpPhys			Biology Comp Sc			Biology Comp Sc			CompSc
14.30			Chem			Chem			Chem			Chem			Chem
16.00			Geology			ExpPhys			Comp Sc			Comp Sc			

NOTE: Practical classes are held in the relevant Department. ID=Lecture held in relevant Department. Allocation of students to practical classes and tutorials will be made by individual Departments.

SECOND SCIENCE TIMETABLE (2001-2002) – FIRST SEMESTER

(Lectures and Practicals)

Time	MONDAY			TUESDAY			WEDNESDAY			THURSDAY			FRIDAY		
	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals
09.00	MATH 2201	Th C		CHEM 2001	Th C		Ind.Micro. PHYS 2004/6	Th D L215		CHEM 2002 PSY 2201	Th C L215		Ind. Micro EXPH 2003	Th D ID	
10.00	BOTN 2005	Th D	Chemistry (10-1 pm) Pharmacol.	CHEM 2001/2	Th E		EXPH 2001 ZOOL 2006	ID Th E	Biochem. (10-1 pm) Chem.	EXPH 2003 ZOOL 2006	ID Th E	Biochem. (10-1 pm) Zool 2006	COMP 2002 PHYS 2004/6 STAT 2221	Th C L215 Th D	
11.00	STAT 2201/2	Th A	(10-1 pm) Botany (11-1 pm)	BIOC 2001/2 GEOL 2001 PSY 2203	Th D ID L215		STAT 2201/2 STAT 2221	Th E Th F	(10-1 pm) Zool 2006 (11-1 pm)	MATH 2201	Th D	(11-1 pm)	BOTN 2005 MAPH.2010 MAPH 2121 PHAR 2001/2	Th F L104 L215 Th E	
12.00	EXPH 2001	ID		BOTN 2001 MAPH 2111 PHAR 2001/2	Th B L215 Th F		MATH 2101	Arts		COMP 2002 PHAR 2001/2	Th E Th D		GEOL 2002 PSY 2201 BIOC 2001/2	ID L215 Th B	
13.00	STAT 2201/2 BIOC 2001/2	Th A Th B		MAPH 2010 MAPH 2121 ZOOL 2005	L104 L215 Th E		STAT 2201/2	Th E		MATH 2202 MATH 2103	Th B Arts		MATH 2202 MATH 2103	Th D Arts	
14.00	MAPH 2111 ZOOL 2005	L123 Th E		GEOL 2002 Ind. Micro. PSY 2204	ID Th E L215		BIOC 2001/2 GEOL 2001	Th D ID		Ind. Micro.	Th E		CHEM 2001/2 STAT 2205/6	Th B Arts	
14.30										PHYS 2004/6	ET				
15.00 16.00	COMP 2001	Th E	C.Science (3-5 pm) Physiology (3-5.30 pm) Chemistry (3-6 pm) Zool 2005 (4-6 pm)	STAT 2005/6	Arts	C.Science (3-5 pm) Geology (3-5 pm) Ind.Micro. (3-5.30 pm) Pharmacol. (3-6 pm)	STAT 2205/6	Arts	C.Science (3-5 pm) Geology (3-5 pm) Biochem. (3-6 pm) Chemistry (3-6 pm) Exp.Phys. (3-6 pm) Pharmacol. (3-6 pm)	MATH 2101 COMP 2001	Arts Th D	Ind. Micro. (3-5.30 pm) Biochem. (3-6 pm) Chemistry (3-6 pm) Exp.Phys. (3-6 pm) Physiology (3.30-5.30 pm)	BOTN 2001	Th D	Chemistry (3-6 pm) Pharmacol. (3-6 pm) Botany (4-6 pm)

NOTE: Practical classes are held in the relevant Department; ID = Lecture held in relevant Department; ET = Lecture held in Earlsfort Terrace; Arts = Lecture held in Arts Building. Allocation of students to practical classes will be made by the relevant Department.

SECOND SCIENCE TIMETABLE (2001-2002) – SECOND SEMESTER

(Lectures and Practicals)

Time	MONDAY			TUESDAY			WEDNESDAY			THURSDAY			FRIDAY		
	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals
09.00	MATH 2203	Th C		CHEM 2003	Th C		Ind.Micro. PHYS 2005/7	Th D L215		CHEM 2004 PSY 2202	Th C L215		Ind. Micro EXPH 2004	Th D ID	
10.00	BOTN 2003	Th D	Chemistry (10-1 pm)	CHEM 2003/4	Th E		EXPH 2004 ZOOL 2008	ID Th E	Biochem. (10-1 pm)	EXPH 2002 ZOOL 2008	ID Th E	Biochem. (10-1 pm)	PHYS 2005/7	L215	
11.00	STAT 2203/4	Th A	Pharmacol. (10-1 pm) Botany	BIOC 2003/4 GEOL 2004 PSY 2203	Th D ID L215		STAT 2203/4	Th E	Chemistry (10-1 pm) Zool 2008	MATH 2203	Th D	Zool 2008 (11-1 pm)	BOTN 2004 MAPH 2141 PHAR 2003/4	Th A L215 Th E	
12.00	EXPH 2002	ID	(11-1 pm)	BOTN 2003 MAPH 2020 MAPH 2131 PHAR 2003/4	Th C L104 Th E Th F		MATH 2102	Arts	(11-1 pm)	PHAR 2003/4	Th D		GEOL 2003 PSY 2202 BIOC 2003/4	ID L215 Th B	
13.00	STAT 2203/4 BIOC 2003/4	ThA Th B		MAPH 2141 ZOOL 2007	L215 Th E		STAT 2203/4	Th E		MATH 2204 MATH 2104	Th B Arts		MATH 2204 MATH 2104	Th D Arts	
14.00	MAPH 2020 MAPH 2131 ZOOL 2007	L104 L215 Th E		GEOL 2003 Ind. Micro. PSY 2204	ID Th E L215		BIOC 2003/4 COMP 2006 GEOL 2004	Th D Th E ID		Ind. Micro.	Th E		CHEM 2003/4 STAT 2206/7	Th B Arts	
14.30										PHYS 2005/7	ET				
15.00 16.00	COMP 2003	ID	C.Science (3-5 pm) Physiology (3-5.30 pm) Chemistry (3-6 pm) Zool 2007 (4-6 pm)	 STAT 2206/7	 Arts	C.Science (3-5 pm) Geology (3-5 pm) Ind.Micro. (3-5.30 pm) Pharmacol. (3-6 pm)	STAT 2206/7 COMP 2006	Arts Th E	C.Science (3-5 pm) Geology (3-5 pm) Biochem. (3-6 pm) Chemistry (3-6 pm) Exp.Phys. (3-6 pm) Pharmacol. (3-6 pm)	MATH 2102 COMP 2003	Arts ID	Ind. Micro. (3-5.30 pm) Biochem. (3-6 pm) Chemistry (3-6 pm) Exp.Phys. (3-6 pm) Physiology (3.30-5.30 pm)	BOTN 2004	Th A	Chemistry (3-6 pm) Pharmacol. (3-6 pm) Botany (4-6 pm)

NOTE: Practical classes are held in the relevant Department; ID = Lecture held in relevant Department; ET = Lecture held in Earlsfort Terrace; Arts = Lecture held in Arts Building. Allocation of students to practical classes will be made by the relevant Department.

THIRD SCIENCE TIMETABLE (2001-2002) – FIRST SEMESTER

Time	MONDAY			TUESDAY			WEDNESDAY			THURSDAY			FRIDAY		
	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals	Lectures	Loc.	Practicals
09.00	BIOC 3004 COMP 3004 STAT 3208	Th F Th E Arts		EXPH 3010 MAPH 3021 PHYS 3002/3	ID L104 ET	BIOC 3004 (9-12 noon) GENE 3001 (9-12 noon) INDM 3001 (9-12 noon)	BOTN 3003 COMP 3004 EXPH 3010 GEOL 3006 PHAR 3002 STAT 3208	ID Th E ID ID L123 Arts		CHEM 3003 COMP 3001 MAPH 3021 PHYS 3002/3	EP129 Th E L104 ET	BIOC 3001 (9-12 noon) BOTN 3009 (9-11 am) GEOL 3002 (9-11 am)	COMP 3009 INDM 3001 MAPH 3011 STAT 3210	Th F ID L104 DB	
10.00	CHEM 3006 COMP 3008 PSY 3207 ZOOL 3009	L215 Th F Arts L123	BOTN 3002 (10-12 noon) GEOL 3006 (10-12 noon)	EXPH 3002 GEOL 3006	ID ID	ZOOL 3016 (10-12 noon)	BOTN 3009 CHEM 3001 MATH 3203 ZOOL 3011	ID Th C L215 Th D		MATH 3203	L215	INDM 3002 (9-12 noon) PHAR 3005-6 (10-1 pm)	EXPH 3009 PSY 3207 STAT 3221	ID Arts Th D	
11.00	CHEM 3003 INDM 3007/5 MATH 3203 MAPH 3011 PSY 3204 ZOOL 3010	Th D ID L123 L104 Arts Th F		EXPH 3004 EXPH 3006 PHAR 3005	ID ID Th F		COMP 3017 GEOL 3005 PSY 3204 STAT 3221	ID ID Arts Th F		EXPH 3009 GEOL 3002 MATH 3208 PHAR 3005 PHYS 3009	ID ID Th B Th F ET	BOTN 3009 (11-1 pm)	CHEM 3001 COMP 3017 INDM 3007 PSY 3203 ZOOL 3010	Th A Th C ID Arts L101	
12.00	BOTN 3002 EXPH 3004 EXPH 3006 MATH 3208 PHAR 3001	ID ID ID Th F Th E		GENE 3001 MAPH 3071	Th C Th E		BIOC 3001 GEOL 3001 INDM 3005 INDM 3007 MATH 3202 MATH 3204	Th B ID ID ID L215 L123		BOTN 3010 COMP 3003 INDM 3005 MATH 3202 MATH 3204 ZOOL 3011	ID Th C ID L104 L215 Th B		BOTN 3001 COMP 3003 EXPH 3002 PHAR 3002	ID Th D ID Th F	
13.00	MATH 3202 MATH 3204 MAPH 3071 ZOOL 3016	L123 L215 L104 Th E		PHIL 3901	L123		CHEM 3006 GENE 3001 MATH 3208	Th F Th A Th D		BIOC 3001 COMP 3009 ZOOL 3016	Th E Th D Th F		PHIL 3901	L123	
14.00	BIOC 3006 INDM 3002 PHY 3002/3 PSY 3201	Th C ID ET Arts	Chemistry (2-5 pm) PHAR 3001-4 (2.30-5.30 pm)	BIOC 3004 COMP 3008	Th D Th B	BOTN 3003 (2-5 pm) Chemistry (2-5 pm) PHAR 3001-4 (2.30-5.30 pm)	CHEM 3003 PSY 3201	Th A Arts	BOTN 3009 (2-4 pm) ZOOL 3011 (2-4 pm)	GEOL 3005 STAT 3218	ID ID	BIOC 3001 (2-5 pm) BOTN 3010 (2- 5 pm) Chemistry (2-5 pm)	BIOC 3008 GEOL 3001 PHYS 3009 PSY 3203 STAT 3205/6	L123 ID ET Arts Arts	Chemistry (2-5 pm) BIOC 3008 (3-6 pm) GENE 3001 (3-6 pm) GEOL 3001 (3-5 pm) INDM 3005/7 (3-6 pm) Physiology (3-5.30 pm)
15.00	PSY 3208 STAT 3218	Arts ID	BIOC 3006 (3-6 pm) BOTN 3001 (3-6 pm) INDM 3005/7 (3-6 pm) PHAR 3005/6/8 (3-6 pm) Physiology (3-5.30 pm)	ZOOL 3009	Th D	BIOC 3004 (3-6 pm) ExpPhysics (3-5 pm) PHAR 3005/6/8 (3-6 pm) ZOOL 3009 (4-6 pm) CompScience Psychology	BIOC 3008 GEOL 3002 PHAR 3001 PSY 3002 STAT 3205/6	L123 ID Th D Arts Arts	Chemistry (3-6 pm)			GEOL 3005 (2-4 pm) PHAR 3001-4 (2.30-5.30 pm) PHAR 3005-6 (2.30-5.30 pm) ExpPhysics (3-5 pm) ZOOL 3010 (3-5 pm) Psychology			
16.00	PSY 3208	Arts		STAT 3205/6	Arts		BIOC 3006 COMP 3001	Th E Th F							

NOTE: Practical classes are held in the relevant Department; ID = Lecture held in relevant Department; ET = Lecture held in Earlsfort Terrace. Arts Building. DB = Daedelus Building, Eng = Engineering Building.

THIRD SCIENCE TIMETABLE 2001-2002 – SECOND SEMESTER

Time	MONDAY			TUESDAY			WEDNESDAY			THURSDAY			FRIDAY		
	Lectures	**Loc**	**Practicals**	**Lectures**	**Loc**	**Practicals**	**Lectures**	**Loc**	**Practicals**	**Lectures**	**Loc**	**Practicals**	**Lectures**	**Loc**	**Practicals**
09:00	BIOC 3003 COMP 3007 GEOL 3009 STAT 3209	ThD ThE ID Arts		GEOL 3013 MAPH 3041 PHYS 3004/5	ID L104 ET	BIOC 3003 (9-12 noon) INDM 3004 (9-12 noon)	CHEM 3002 EXPH 3003 MAPH 3081 STAT 3209	E ID L104 Arts	GENE 3002/3 (9-12 noon) GEOL 3010 (9-11 am)	COMP 3002 PHYS 3004/5	ThE ET	BIOC 3002 (9-12 noon) BOTN 3008 (9-12 noon) GEOL 3003 (9-11 am) ZOOL 3017 (9-11 am) INDM 3003 (9-12 noon) PHAR 3005-6 (9-12 noon) CELB 3001 (10-12 noon)	COMP 3006 INDM 3004 MAPH 3041 STAT 3210	ThF ID L104 DB	GEOL 3009 (9-11 am)
10:00	CHEM 3012 EXPH 3001 GEOL 3009 INDM 3008/6 MAPH 3081 ZOOL 3014	ID ID ID ID L104 ThF		EXPH 3012 EXPH 3015 GEOL 3010 PHAR 3004 PHYS 3006/7	ID ID ID L123 ET	GEOL 3013 (10-12 noon)	BOTN 3007 GEOL 3013 PHAR 3006/9 MATH 3207	ID ID L215 L123		MATH 3207 PHYS 3006/7	L215 ET		BIOC 3007 BOTN 3006 CHEM 3004 MATH 3207 PHAR 3006/9 PSY 3207 ZOOL 3013	ThE ID L123 ThD L104 Arts L101	
11:00	BOTN 3008 CELB 3001 CHEM 3002 COMP 3006 GEOL 3008 PSY 3205	ID ID ThD Th F ID Arts		EXPH 3001 EXPH 3008	ID ID		CHEM 3005 EXPH 3008 PSY 3205 STAT 3224	ThF ID Arts ID		GEOL 3008 MATH 3201	ID L215		CHEM 3005 GENE 3002 GEOL 3010 MAPH 3031 PSY 3206	ThA ThC ID L104 Arts	
12:00	BIOC 3002 GEOL 3003 MAPH 3031	ThE ID L104		COMP 3011 GEOL 3004 MAPH 3081 ZOOL 3017	Th B ID L215 ?		BIOC 3003 COMP 3005 GEOL 3004 INDM 3008/6 ZOOL 3017	ThB Th D ID ID Th C		EXPH 3003 INDM 3008/6 PHAR 3003 STAT 3224	ID ID ThC ID		BOTN 3004 EXPH 3005 MAPH 3081 PHAR 3003	ID ID L104 Th F	
13:00	CHEM 3004 COMP 3011 GENE 3003 ZOOL 3013	ThC ThD L215 ThE	Chemistry (2-5 pm)	BOTN 3008 CHEM 3015 COMP 3005 MATH 3201 PHAR 3008	ID Th D ThC L123 ThF		PHAR 3004 ZOOL 3015	ThF ThD		BIOC 3002 PHAR 3006/8	ThD ThE		CHEM 3015 COMP 3007 GENE 3003 MATH 3201	Th F Th C L123 L215	
14:00	BIOC 3007 MATH 3205 PHYS 3004/5 PSY 3208 STAT 3220 ZOOL 3012	Th A L123 ET Arts ThF ThC	PHAR 3001-4 (2.30-5.30 pm) PHAR 3005-6 (2.30-5.30 pm) BIOC 3007 (3-6 pm)	BIOC 3005 GEOL 3007 ZOOL 3015	ThF ID ThC	Chemistry (2-5 pm) PHAR 3001-4 (2.30-5.30 pm) PHAR 3005-6 (2.30-5.30 pm) BIOC 3003 (3-6 pm)	COMP 3002 GENE 3002	ThC L215		GEOL 3007	ID	BIOC 3002 (2-5 pm) Chemistry (2-5 pm) PHAR3001-4 (2.30-5.30 pm) PHAR 3005-6 (2.30-5.30 pm)	BIOC 3005 GEOL 3003 INDM 3003 PHYS 3006/7 PSY 3206 STAT 3220 STAT 3206/07	ThD ID ID ET Arts ThE Arts	Chemistry (2-5 pm) BIOC 3005 (3-6 pm) Physiology (3-5.30 pm) ZOOL 3013 (3-5 pm)
15:00	PSY 3208	Arts	BOTN 3007 (3-5 pm) GEOL 3008 (3-5 pm) INDM 3006/8 (3-6 pm)	MATH 3207 ZOOL 3012	ThB ThE	ExpPhys (3-5 pm) GEOL 3004 (3-5 pm) ZOOL 3012 (4-6 pm)	EXPH 3005 PSY 3202 STAT 3206/07 ZOOL 3014	ID Arts Arts ThE	BOTN 3006 (3-6 pm) Chemistry (3-6 pm) GENE 3002/3 (3-6 pm) INDM 3006/8 (3-6 pm)	MATH 3205	L123	BOTN 3004 (3-6 pm) ExpPhys (3-5 pm) GEOL 3007 (3-5 pm)			
16:00			Physiology (3-5.30 pm)	STAT 3206/07	Arts	CompSc	MATH 3205	L123	ZOOL 3014						

Locations : Lecture theatres and class rooms in the Science Complex are indicated ThA or L124. ID = in the subject department. Arts = Arts Building. ET =Earlsfort Tce. DB = Daedalus Building.