University College Dublin
National University of Ireland, Dublin

Science

Session 2002/2003

Contents

Scholarships and Prizes Awarded in the Faculty of Science

Scholarships

Entrance Scholarships – Based on Leaving Certificate
The University offers a number of entrance scholarships, valued at €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 €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 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 €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 and Topical) in Science
A scholarship, of value €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 €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 €635, may be awarded in special circumstances to a student of Science who is ineligible for a normal award.

Ircset postgraduate scholarships award (new to 2002)
This scheme will offer opportunities for suitably qualified students to pursue a postgraduate degree by research supported by a scholarship awarded by the Irish Research Council for Science, Engineering and Technology. The scholarship award will be up to €19,050 per annum.

Research Demonstratorships
Up to one hundred and fifty 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
	–	Joy Carey Prize
	–	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 Prize
	–	McCrea Medal
	–	Orr Prize
	–	Fr Ciaran Ryan Prize
Pharmacology	–	ICI Pharmaceuticals Division Prize

All details on Scholarships and Prizes are available in the Student Awards Booklet, available from the Fees and Grants Office.

Academic Advisory Meetings

First Science Students: Wednesday, 11 September 2002 – 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 of 16-20 September 2002.

Pre-Second Science: Wednesday, 19 February 2003 – 2.00 p.m., Theatre A.
Additional information may be available from some departments around this time.

Third Science Students: Friday, 13 September 2002 – 2.30 p.m., Theatre A.
Compulsory 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, 17 September 2002.

Dates for Academic Session 2002/2003

Michaelmas Term (First Semester):	16 September 2002 – 6 December 2002
Hilary/Trinity Terms (Second Semester):	6 January 2003 – 1 March 2003 24 March 2003 – 17 April 2003

Degree Programmes in Science and Career Opportunities

Applied and Computational Mathematics

This is a new degree in Science that follows the rules of the Topical Degree programme. It can be taken at the *Honours* or *Pass* level. The student will take courses in Mathematics, Mathematical Physics and Statistics. The emphasis is on applicable mathematics and the mathematical modelling of real-world problems. The objective of the degree is to produce graduates who will be able to use mathematical tools to analyse and solve real-world problems in a wide range of contexts.

What sort of careers do Applied and Computational Mathematics graduates have?
Career directions for graduates include the following areas: software design, mathematical and statistical modelling, the financial sector, meteorology, agricultural, veterinary, medical and pharmaceutical research, the power industry (oil, electricity etc.), environmental services.

Biochemistry

This is a Second Science Subject leading to an Honours Degree Programme.

Biochemistry is often defined as the Chemistry of Life because it aims to explore and understand every aspect of the structure and function of all living things at the molecular level.

Biochemists study all kinds of plants, animals and microorganisms. They work with whole organisms, with isolated cells, with extracts of the cells and with purified components of cells. Any aspect of living tissue that can be studied in terms of chemical and physical principles is a subject for biochemical investigation. For example: biotechnology, extraction of energy from foods, photosynthesis, genetics and molecular biology, growth and reproduction, diseases such as cancer and AIDS.

What sort of careers do Biochemistry graduates have?
Graduates of the Department of Biochemistry have found jobs in biochemical, chemical, pharmaceutical, food and biotechnology industries; research institutes throughout the world, including UCD and other third level institutions; second level education; clinical laboratories; forensic science.

Biochemistry graduates have also made careers in diverse areas including management, marketing, accountancy, journalism and other aspects of the media, patenting, the diplomatic service and consultancy.

Biology

This introductory Biology Course is organized and run by the Departments of Botany, Industrial Microbiology and Zoology. Students wishing to pursue biological courses should choose any combination including Biology in First Science.

Botany

This is a Second Science Subject leading to an Honours Degree Programme.

Botany is the study of plants and fungi. Plants and fungi provide food, medicines, timber, paper, raw materials, and a healthy environment.

Botany embraces the complete range of plant sciences, including plant biochemistry, genetic engineering, vegetation science, mycology, taxonomy, biotechnology, photosynthesis, nutrition, cell and tissue culture for production of drugs, ecology, biodiversity, and remediation of polluted environments.

Botany is a diverse subject, encompassing all aspects of life. Botany students are interested in fundamental and practical aspects of everything from genes, biochemistry, molecular biology and development to reproduction, whole organism growth, physiology and ecology.

What sort of careers do Botany graduates have?
Botany graduates pursue careers as environmental consultants, pollution biologists, plant molecular geneticists, cell biologists, wildlife officers, national parks supervisors, conservation biologists, University lecturers, research scientists and quality control scientists in the food industry.

UCD Botany graduates are employed in all walks of life, not just for their excellence in plant sciences, but because they have also acquired skills of critical thinking, effective communication, and the use of modern information technology.

Cell and Molecular Biology

This is a Topical Degree Programme, which means that the entry requirements at Third Science are different from those of the single subject Honours Degrees in Biological Sciences. Students who pass Second Science, with at least two biological subjects, are eligible to enter. In practice, competition for places means that students who reach a qualifying standard of 55% in one or more subjects are more likely to receive a place.

At the end of Third Year, all students must pass the examinations with an average of at least 55% across six of the eight core units to proceed to Fourth Year Honours. Those who pass Third Science, but fail to reach 55% will graduate with a General B.Sc. Degree.

This Degree Programme depends on the teaching staff of many departments, all of whom have a strong interest in Cell and Molecular Biology. This subject has grown very rapidly over the past ten years.

What sort of careers do Cell and Molecular Biology graduates have?
There are good career prospects for cell biologists in universities, industry and healthcare institutions.

Chemistry

All materials and living things consist of atoms and molecules that are linked together in many different ways. Chemistry is a study of these atoms and molecules and how they interact with each other and the role they play in living things. In fact, Chemistry is everywhere!

Many students choose to specialise in Chemistry, as a detailed knowledge of the subject is essential for entry to many interesting and challenging careers. For instance, chemists are creative and can discover new substances, which can have a range of applications such as medicines (e.g. aspirin, penicillin) that fight disease or as materials (e.g. PVC, Teflon) which are very important in everyday life.

What sort of careers do Chemistry graduates have?
There are many opportunities for Chemistry graduates in industry. Chemists in industry are involved in the production and analysis of chemicals. Those in research work on the discovery of new medicines, new devices and materials and on advancing our knowledge of the world and development chemists can work with engineers and business people to turn discoveries into commercially valuable products. Chemists also have roles to play in environmental protection.

There are also teaching opportunities for chemists in second and third level education. Government Agencies such as the Civil Service, research institutes and semi-state bodies all offer employment to Chemistry graduates. In addition, some graduates have gone on to become accountants, or work in banking or marketing.

So, pursuing a career in Chemistry can lead to a significant variety of challenging careers and good opportunities in the future!

Computer Science

Computer Science is the investigation and exploration of the theory, practice and use of computers and computation. It covers topics that span the theory of computation, software construction, hardware design, computer operating systems and the applications of computers in the communications, scientific and commercial systems fields. Staff and graduates have been successful in establishing several international high-tech companies.

What sort of careers do Computer Science graduates have?
Among the career opportunities available for Computer Science graduates are: Computer Systems Analysts, Programmers, Web designers and developers, Digital circuit designers, Computer communication engineers, Computing for financial markets, Computer control systems for mission critical applications e.g. Aircraft navigation, Robotics, Neural science research or Designing new Computer Languages.

Computer Science (denominated entry course)

Students follow a different course to the DN008 Computer Science Course.

The BSc (Computer Science) allows students to study Computer Science, as a Science degree, with a significant emphasis on Computer Science *per se*. It is for students who specifically want to study Computer Science. It educates students to be software developers covering the core Computer Science subjects from hardware through to advanced software systems, along with a wide variety of advanced topics (e.g., intelligent internet systems, parallel computing).

The BSc (Hons) Computer Science program is designed to give students maximal exposure to topics within Computer Science. From the first year, BSc CS students are exposed to both applied and theoretical material. The first two years lay down a basic foundation, and in third and fourth years, students can choose many of their courses from a broad range.

This degree differs from that taken by general Science students, in that first and second year students do more Computer Science (see below) and less of other Science subjects. It is therefore most suitable for those who know or suspect in advance that Computer Science is a discipline which suits them.

Environmental Biology

Environmental Biology is the scientific study of the interactions between organisms and their natural and man-made environments. The disciplines of animal ecology, conservation biology, ecophysiology, ecotoxicology, microbial ecology, plant ecology, pollution biology, vegetation science and wildlife ecology all contribute to the understanding of environmental biology. Knowledge of environmental biology is central to man's ability to understand and manage the world's environmental problems.

What sort of careers do Environmental Biology graduates have?
Environmental biologists pursue a variety of scientific careers, such as aquaculture and fisheries managers; environmental consultants; habitat ecologists (peatland, wetland, grassland, aquatic, etc.); national park supervisors; pollution biologists; rare species conservation officers; technical and scientific officers; university professors; wildlife officers; conservation biologists and administrators.

UCD Environmental Biology graduates are also employed in non-scientific occupations, in business, management and administration, where their scientific, numeric and analytical skills are highly valued.

Environmental Geochemistry

Environmental Geochemistry is the study of how natural and man-made pollutants migrate and interact with each other and with near-surface geological materials (e.g. soils, rocks, glacial deposits, groundwater and surface waters). Many Environmental Science degrees emphasise biological interactions, whereas this topical degree programme focuses on the geological and chemical factors that influence the movement, effects and ultimate fate of pollutants. The programme also deals with whole-Earth issues that have a strong geochemical dimension including problems such as global warming, ozone depletion and sea-level rise. Geochemistry is central to modern Earth Sciences and is able to provide quantitative answers to fundamental questions. These include the age of planet Earth and its place in the solar system, its chemical evolution through time, the consequences of catastrophic events (e.g. volcanic eruptions, meteorite impacts), the nature and timing of natural climate change, the changing composition of the atmosphere and consequences for the habitability of the planet in the future.

What sort of careers do Environmental Geochemistry graduates have?
Environmental Geochemistry graduates are employed by environmental consultancy firms, government environmental protection agencies, mineral exploration companies and by universities and research institutes.

Experimental Physics

Physics is concerned with the fundamental laws that govern the construction and functioning of the Universe and is a key field within Science and Technology. It lies at the heart of Science, Engineering and much of our everyday lives. The laws of Physics govern living as well as non-living organisms. These laws help to explain the origin of the universe and behaviour of the smallest parts of matter. Electrical and nuclear power, the laser, the transistor, magnetic resonance imaging, the microchip, superconductivity, all derive from the insights of Physics. Physics is a basic Science involving the mathematical description of nature; it also serves as a foundation in the study of other Sciences, as well as in Engineering, Architecture, Agriculture, Medicine and Veterinary Medicine.

What sort of careers do Experimental Physics graduates have?
Our recent physics graduates have pursued careers in diverse areas. They include industry (electronics, computers, telecommunications), hospitals (medical imaging, nuclear medicine, radiotherapy), government and semi-state services, national laboratories, banking, insurance, and academic research. Second level physics teachers are always in demand.

Related fields employing physicists include geophysics, chemical physics, biophysics, computer science and materials science.

Genetics

Students select combinations (a), (d) or (g) in First Science.

This programme is designed as both a joint Honours programme (Molecular Genetics and a Biological Subject) and a Topical Degree programme (Cell and Molecular Biology and Plant Genetic Engineering) following the completion of Second Science and leading to the award of an honours degree.

Molecular genetics and molecular biology are core components of modern biology, medicine and biotechnology. Research in areas such as the genetic manipulation of agricultural plants and cloning of animals impacts on society at large. The genetics course covers exciting new developments such as genetic engineering, transgenic animals containing genetic material transferred from another species), genetically modified plants, medical genetics, gene therapy, prions, developmental biology and informatics.

What sort of careers do Genetics graduates have?
Many genetics graduates go on to study for a higher degree (MSc/PhD) and work in all sorts of areas, such as university and industrial research laboratories. Other graduates obtain jobs in agribiotech and other biotechnology companies, in the pharmaceutical sector, and in hospital diagnostic laboratories.

One new area of employment is in Bioinformatics – the junction between molecular genetics and information technology. Bioinformaticists use computer technology to analyse molecular data, and are employed by companies to aid in drug design and to study the inheritance of disease.

Finally, many students cross over from genetics to areas such as accountancy, business, management and law.

Geology

Geology is the study of planet Earth and planetary systems. It is concerned with the nature and origin of materials that make up the earth and planets and the processes that are or have been active on the surface and also at depths beneath the surface. Without Geology and geologists we would not have the raw materials from which to build our roads and factories, our cars and computers, or the fuel that supplies most of our energy.

Geology also seeks to answer fundamental questions regarding the structure and age of the Earth, how it has evolved, its processes and the history of life. The study of the Earth is exciting, interesting and stimulating in itself, and the more we know about our planet and how it works, the better equipped we are to manage it soundly. Studying Geology will open your eyes to the planet on which we live, and will make you more aware of the natural environment around you.

What sort of careers do Geology graduates have?
Graduates with degrees in Geology and related subjects (Geophysical Science and Environmental Geochemistry) have found interesting and rewarding employment in organisations ranging from government agencies to petroleum and mining exploration companies in Ireland and abroad. Graduates work as Geological Surveyors, Exploration Geologists in the petroleum and mining industries, Mine Geologists, Hydrogeologists, University lecturers and researchers, Oceanographers, Geochemists, Environmental consultants, Engineering Geologists, Palaeontologists, and Structural Geologists. Some of our graduates run their own Geological and Environmental consultancy firms. A BSc degree in Geology is also an excellent basis from which to undertake more specialised MSc training programmes in fields such as Engineering Geology, Hydrogeology, Remote Sensing (satellite image interpretation), Petroleum/Mineral Exploration and Environmental Science. In addition, a degree in Geology or a related area also provides valuable training for many non-geological careers.

Geophysical Science

Students select combinations: (c), (e), (i), or (n) in First Science.

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Geophysicists apply principles from physics to study the Earth and Earth processes, for example earthquakes and volcanoes, by measurements of physical properties. They can also build up ‘pictures’ of the Earth’s internal structure by looking at earthquake waves, gravity effects, magnetic effects and electrical changes, allowing us to discover which processes are operating within the Earth. This is leading to a better understanding of how the Earth works, including topics such as plate tectonics and earthquake forecasting.

We can also use some of these methods to assist in our search for oil, gas and minerals and in the evaluation of our environment, particularly in relation to waste disposal.

What sort of careers do Geophysical Science graduates have?
This course is currently filling a niche in the jobs market, since there is a greater demand for Geophysicists than there are qualified graduates available. The employment record for graduates from this course is excellent. Career options are in the petroleum, minerals, ground water, site investigation and environmental monitoring industries, in addition to postgraduate research.

Industrial Microbiology

Microbiology is the study of microorganisms e.g. bacteria, fungi and viruses and Industrial Microbiology is one of the most exciting developments in science and industry. It is a corner stone of the biological sciences, in particular of modern biotechnology. Microorganisms and microbial enzymes can be used in new industrial processes to carry out reactions that are not economically feasible by chemical means. Industrial Microbiology offers the possibility of major improvements in the way medicines are developed and manufactured, it may help to find ways to produce food for livestock and people and help exploit new energy sources. It will provide new specialised industrial enzymes and a range of pharmaceutical and other products. Currently bacteria are being engineered to produce novel therapeutic proteins and antibodies and microorganisms are used extensively in recombinant DNA technology and molecular biotechnology.

What sort of careers do Industrial Microbiology graduates have?
In Ireland, Industrial Microbiologists are employed principally in the healthcare/ pharmaceutical, fine chemical, brewing and distilling, food and food related industries etc. where they are involved in research and development, in process design and control, in management and in quality control. Graduates in Industrial Microbiology also work in research in universities and research institutes, in teaching at second and third level, in hospitals and public health laboratories and in many other areas of the public and private sectors.

Mathematical Physics

Mathematical Physics combines the areas of Applied Mathematics and Theoretical Physics. Applied Mathematics involves the mathematical modelling and solution of real-world scientific problems. Theoretical Physics aims to provide a unified description of the fundamental laws of nature through Mathematics. These laws govern the behaviour of all physical objects in the universe.

What sort of careers do Mathematical Physics graduates have?
Because both areas of Mathematical Physics provide a good training in Mathematical Modelling, our graduates are well prepared to find employment in a diverse range of

professions both in Ireland and abroad. There is always a high demand for graduates and postgraduates with skills in Mathematical Modelling. Those of our students who have not become professional Applied Mathematicians or Theoretical Physicists have pursued careers in a wide variety of professions, for example in the Financial and Banking Sector, in Software Design and in Meteorology.

Mathematical Science

The four-year Degree in Mathematical Science was set up in response to the growing demands from Industry, Commerce, Science and Technology for professional Mathematicians. In an increasing number of these areas, Mathematics is the only effective language for the analysis of problems and communication of results and ideas. This is recognition that Mathematics is now essential in many areas and plays a critical role.

What sort of careers do Mathematical Science graduates have?
The Financial and Banking Sector; Software Design; Meteorology; Pharmaceutical Research; Government Statistics; Agricultural and Veterinary Research; Health Care; Mathematical and Statistical Modelling in for example the Oil Industry, Electricity Supply and Environmental Services.

At present there is a high demand for Mathematical Science graduates and postgraduates

Mathematics

Mathematics has been solving problems since people first learnt how to count and measure. Since then, mathematics has grown steadily in content, playing a key role in the quest to fully describe and understand the natural world. Today mathematics is a basic tool in all scientific subjects, economics, engineering, geography, computer science, banking business, statistics, social science, and in many other fields.

"Applicable Mathematics" is used by scientists to solve the mathematical problems presented by their subjects, while "pure Mathematics" involves the study of mathematical problems independent of their applications. These two types of Mathematics are not independent of each other but are complementary. Many of the "pure Mathematics" results of the past have become the "applicable" techniques of the present.

What sort of careers do Mathematics graduates have?
Having Mathematics as a subject in your degree, or even just as a first year subject, can greatly increase your career prospects and is a prerequisite for graduate studies in a variety of disciplines. Each year sees new applications of sophisticated mathematical models and procedures, using computers, in insurance and actuarial services, the stock market, banking, industry, etc. Mathematics graduates are sought by employers in all of those areas.

The precision of Mathematics is highly prized in a range of professions, as indeed are the proven problem-solving skills of any Mathematics graduate. Our recent graduates have found work in diverse areas including: actuarial science, banking and financial services,

civil service executive and administrative grades, coding and cryptography, the computer industry, management consultancy, market surveying, mathematical modelling, meteorology, operations research, statistics, teaching and television.

Occupational Safety and Health

Students must take Combination (a) in First Science.

This course is available as an option to third science students, and builds on knowledge gained in First and Second Science. It focuses on scientific and legal principles related to Health and Safety in the workplace. It is part of a co-ordinated multidisciplinary training programme aimed at meeting the academic competency requirements of the Safety, Health and Welfare at Work Act, 1989. In addition to project work, and individual work placements, the course includes the following units of study:

- Safety & Health Legislation
- Risk Management & Safety Technology
- Occupational Health & Health Promotion
- Occupational Hygiene
- Chemical Safety & Toxicology
- Ergonomics & Behavioural Science
- Emergency Planning
- Epidemiology & Statistics

What sort of careers do Occupational Safety and Health (OSH) Professionals have?
Because Occupational Safety and Health is concerned with the safety and health of people at work everywhere, OSH professionals come from and work in a wide range of disciplines and there are a number of specialist areas in the field. Under OSH legislation every employer must safeguard the safety, health and welfare of employees. This means that graduates may find opportunities in any sector or area of industry, in small or large companies, in Irish or multinational organisations, in the public or private sector. The course has a multidisciplinary approach and potential positions for graduates include Health and Safety Officer, Health and Safety Manager, or Health and Safety Advisor.

Pharmacology

Pharmacology is one of the main disciplines underpinning Biomedical Science and the pharmaceutical industry which is one of Ireland's largest manufacturing sectors. There are many disciplines within the Biomedical sciences and Pharmacology specifically focuses on the study of drug action.

Pharmacology is the study of the nature, actions and uses of drugs. A drug is any substance that is given to humans or animals with the intention of changing the state of body functioning: to relieve pain, treat cancer, eliminate infection or improve health in any way or to investigate the functions of the body. The work of the science-based pharmacologist is concerned mainly with drug action.

Toxicology is an important component of the Pharmacology discipline. Toxicology is the study of the harmful effects of chemicals on living organisms. Toxic substances include certain drugs, pesticides, heavy metals, plant and microbial toxins and many organic chemicals. Such substances may have an adverse effect on the health of humans and other species.

What sort of careers do Pharmacology graduates have?
Research opportunities are available for Pharmacology graduates in research institutes, universities, and in the pharmaceutical industry. There are opportunities for postgraduate work in the Department of Pharmacology in UCD and there are currently 66 postgraduate students pursuing research projects in the Department or in associated laboratories. Careers in management, research and product developments are available for graduates in the Pharmaceutical Industry. Pharmacology graduates may also pursue careers in teaching in secondary schools, institutes of technology and universities; in regulatory agencies, e.g. drug information/registration and in publishing in science journalism.

Physiology

Physiology is an important life science that asks and answers questions about the way that cells, tissues and organs work in people, animals and plants. At UCD, Physiology concentrates on mammalian systems with a special emphasis on how the systems that make up the human body carry out their normal functions. For example, Physiologists are concerned with the functions and workings of the brain, heart and lungs. They also consider how body processes respond to changes in the environment such as temperature, altitude or motion. As well as being a branch of Science in its own right Physiology is an Applied Science in the field of medicine and fields allied to medicine such as Physiotherapy, Radiography or Sports Studies.

What sort of careers do Physiology graduates have?
Physiologists have the opportunity to follow many different career paths. Like other science graduates, physiologists gain experience in the generation, analysis and presentation of scientific information. These skills are transferable to most career paths. Options available to those wishing to remain in the field of physiology include: research (in universities and Civil Service); pharmaceutical industry (laboratory research, clinical trials, marketing); clinical scientists in the health service; publishing/science journalism; food science industry; teaching (secondary or tertiary level) and sports science.

Plant Genetic Engineering

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

This Topical Degree course is offered by the Botany Department, in conjunction with other Departments in the Faculty of Science and with other Faculties within the University. The aim of the course is not just to study the techniques of Plant Genetic Engineering but in addition to place these techniques within the broader context of Plant Science and Food Safety. As with other Topical Degree Programmes, entry into the course is at Third Year. Entry is restricted to students who at Second Year have taken Botany and Biochemistry. At Third Year students take courses in various aspects of Plant Molecular Biology, Genetics and Plant Ecology. These courses lead to the General B.Sc. Degree at the end of Third Year. Admission to Fourth Year Honours in Plant Genetic Engineering is dependent on a good performance in the Third Year. Fourth year students take specialist courses on a range of topics including Plant Food Safety, Genetically Modified Organisms in the Environment, Plant Developmental Biology, Applied Molecular Biology and Plant Breeding. In addition, the Fourth Year course includes a research project working with postgraduate students and scientists.

What sort of careers do Plant Genetic Engineering graduates have?
There is an increasing demand for graduates with a grasp of not only the molecular aspects of plant genetic engineering but for scientists who can understand the biological context of genetic engineering. In addition to further postgraduate studies graduates from this course are ideally positioned for careers that demand a knowledge of plant genetic engineering, such as regulatory authorities, food safety laboratories, plant biotechnology companies and agencies monitoring the release of GMOs.

Psychology

Only available as a degree programme in Science until September 2003

Psychology is the systematic study of mental life, behaviour and relationships. It asks how we develop over our lifetime and how we differ from one another. It studies how we see, hear, reason and remember. It investigates how we behave in groups such as families or work teams. It studies how the brain and nervous system subserve psychological functioning and how this functioning may be affected by injury to the brain or by the use of drugs.

Psychology is a diverse subject and people study it for many reasons. Some wish to use psychological knowledge to train and help people. Others have a primarily theoretical interest and are curious to know how children acquire mathematical concepts or how brain injury may affect speech. Others again are interested in the psychology of how people behave in groups, or in how cultures shape the psychology of individuals.

An undergraduate course in Psychology seeks to impart basic knowledge and theory. To practise as a psychologist in the health services, in work organisations or in a university requires the completion of a postgraduate degree. This will involve between two and six years' further study or supervised experience.

What sort of careers do Psychology graduates have?
The diversity of psychology is reflected in the kind of work that psychologists do. Clinical psychologists deal with psychological problems in hospitals or in private practice. Educational psychologists deal with the various aspects of teaching and learning in schools. Occupational psychologists deal with human performance in the workplace. A small number of psychologists work in areas like forensic psychology or sports psychology. There are also many psychologists who teach and research in universities and colleges.

Statistics

Statistics is the Science that deals with the collection, analysis and interpretation of numerical data and more than ever before, is a part of our everyday lives. It is an important tool used by researchers in actuarial science, agriculture, biotechnology, computer science, ecology, economics, marketing, mathematics, medicine, psychology, social science, veterinary medicine and many other disciplines. Statisticians also develop mathematical models for uncertainty, and investigate their properties and applicability. The power of modern computing has had a major impact on both the development and usefulness of statistical methods.

What sort of careers do Statistics graduates have?
Statisticians find job opportunities in many diverse areas of society. The Central Statistics Office is an obvious source of a career, but other Government Departments like the Departments of Health, Education and Environment, and government agencies like Bord Fáilte, Teagasc and the Meteorological Service also make good use of statisticians. Pharmaceutical companies employ many statisticians, and the whole area of industrial quality

control provides many opportunities for those qualified in statistics. Statisticians are also needed for research in marketing, medicine, agriculture and veterinary medicine. Insurance companies often hire statistics graduates, and in particular a lot of the training of an actuary is based on statistical methodology. There are opportunities for postgraduate study and research projects in the Department of Statistics in UCD.

Theoretical Physics

The aim of Theoretical Physics is to provide a unified description of the fundamental laws of nature. These laws govern the behaviour of all physical objects in the universe. This course provides an introduction to all the major areas of Theoretical Physics, including: Relativity Theory, Quantum Mechanics, Atomic Physics, Nuclear Physics and Computational Physics. Advanced topics are covered in the final two years. These include General Relativity, Electromagnetic Theory, Quantum Gravity, Quantum Field Theory, Statistical Mechanics, Theoretical Astrophysics, Fluid Mechanics High Energy Physics, Condensed Matter Physics. In addition the relevant expertise of Theoretical Physics, the course provides an excellent training in problem-solving and computing skills that can be applied in a wide variety of careers in industry, business, government, and university.

What sort of careers do Theoretical Physics graduates have?
Research opportunities are available to Theoretical Physics graduates in UCD and in other universities. Theoretical Physics graduates may also pursue careers in meteorology, software development, stock-market analysis, environmental analysis, internet/network consultancy, financial risk analysis as well as careers in teaching in secondary schools, institutes of technology and universities.

Zoology

Zoology is the study of animals, from the level of individual molecules to how populations of animals interact with their environment. Classically, Zoology is thought of in the context of David Attenborough and treks into the wild to study rare and endangered species. However, modern Zoology is much more, dealing with all aspects of animals from genetics and cell biology to ecology and animal behaviour. The Department of Zoology in UCD prides itself on maintaining a diverse curriculum allowing students to choose from a wide range of disciplines, including marine and fresh water biology, immunology, ecology, population genetics, developmental biology and zoonotic and other diseases. The policy of a broad curriculum extends into the department's research activities where post-graduates undertake research that crosses many traditional disciplines. The central goal of research is to gain a greater understanding of how animals develop and interact with their environment both as individuals and as populations.

What sort of careers Zoology graduates have?
Zoology equips students for careers in education, industry (especially with companies developing pharmaceutical or food products), research, fisheries, agriculture and aquaculture, and increasingly, in conservation and environmental management. Employers in Ireland include Government Departments e.g. Education, Wildlife service, Office of Public Works, Department of Fisheries, Health Service, Forensic Laboratories, Eolas, National Museum, Semi-state bodies such as ESB, BIM and the Salmon Research Trust; Private companies and conservation bodies, and a wide range of medical, veterinary, and health related research-based companies.

Undergraduate Programmes

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

Four-Year Degrees:

Bachelor of Science Honours in Computer Science (DN030)

Bachelor of Science Honours in Mathematical Science (DN032)

Bachelor of Science Honours in Theoretical Physics (DN031)

Bachelor of Science Omnibus Entry (DN008)

The Bachelor of Science Omnibus Entry may be offered either as a ***four year*** single honours, joint honours, or honours topical degree, or as a ***three year*** one subject or two subject general, or general topical degree as follows:

Four year BSc Single Honours offered in the following subjects:

Biochemistry	Mathematics
Botany	Mathematical Physics
Chemistry	Pharmacology
Computer Science	Physiology
Experimental Physics	Psychology
Geology	Statistics
Industrial Microbiology	Zoology

Four Year BSc Joint Honours offered as follows:

- **Genetics and a 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.

BSc Topical Degree Programmes
The BSc Topical Degree may be defined as a degree programme encompassing more than one subject area. Students need to qualify for the honours degree at the end of Third Science.

Applied and Computational Mathematics	Geophysical Science
Cell and Molecular Biology	Environmental Geochemistry
Environmental Biology	Plant Genetic Engineering

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	Mathematics
Botany	Mathematical Physics
Chemistry	Pharmacology
Computer Science	Physiology
Experimental Physics	Psychology
Geology	Statistics
Industrial Microbiology	Zoology

Bachelor of Science (BSc) in Occupational Safety and Health
Available as a Third Science option following the successful completion of the previous years. Students wishing to follow this degree course must take Combination A in First Science.

Part-Time Degree:

Bachelor of Science (BSc) in Occupational Safety and Health Management.
Applicants to this part-time BSc degree course must have completed and achieved a high standard in the NUI Diploma in Safety, Health and Welfare at Work or equivalent.

Examination Regulations for Undergraduate Science Students

Regulations governing all examinations are contained in Marks and Standards. Students should consult this publication, copies of which are available in the Library or at http://www.ucd.ie/~exams.

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.

First Science

Regulations for First Year Science Students

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

	First Science Subjects						
(a)[*]	Biol	Chem		ExpPhys		Maths	
(b)		Chem		ExpPhys		Maths	MathPhys
(c)		Chem		ExpPhys	Geology	Maths	
(d)	Biol	Chem			Geology	Maths	
(e)				ExpPhys	Geology	Maths	MathPhys
(f)			CompSc	ExpPhys		Maths	MathPhys
(g)	Biol	Chem	CompSc			Maths	
(h)		Chem	CompSc		Geology	Maths	
(i)			CompSc	ExpPhys	Geology	Maths	
(j)		Chem	CompSc	ExpPhys		Maths	
(k)			CompSc		Geology	Maths	MathPhys
(l)		Chem			Geology	Maths	MathPhys
(m)		Chem	CompSc			Maths	MathPhys
(n)	Biol			ExpPhys	Geology	Maths	
(o)	Biol		CompSc	ExpPhys		Maths	

- 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), pass 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 or on the web: *http://www.ucd.ie/~exams/).* Departments may hold examinations and continuous assessments throughout the year.

[*] *Students wishing to pursue a BSc in Occupational Safety and Health must take Combination (a)*

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.

Transfer students from other faculties in the University are subject to a one-year rule. Exemption from this regulation may be granted for grave reasons by the Academic Council on the recommendation of the Faculty of Science.

*Please note the special requirements for some courses in '4' below.

3. Re-Attendance at First Science
Students must apply to the Faculty of Science for permission to re-attend First Science courses. Generally students have satisfied practical requirements the first time around. Re-attendance at practical classes is at the discretion of the departments.

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.

Computer Science Denominated Entry
Students should be aware that they will not be permitted to enter the Second Year course in Computer Science (DN030) unless they have gained a **clear pass** in COMP 1001 and COMP 1002.

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 subject 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.

Syllabus of First Year Courses in Science
(DN008, 030, 031, 032)

Applied and Computational Mathematics

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Students planning on following this Degree Programme may choose any allowable First Science combination.

Biochemistry

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

This is a Second Science Subject leading to an Honours Degree Programme.

Biology – BIOL 1001

Three lectures and one practical class of three hours per week undertaken by the Division of Biosciences which includes the Departments of Botany, Industrial Microbiology 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.

Botany

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

This is a Second Science Subject leading to an Honours Degree Programme.

Cell and Molecular Biology

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

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Chemistry – CHEM 1001

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 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 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.

Computer Science – COMP 1001

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.

Hardware and Software Development – COMP 1002

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.

Environmental Biology

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

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Environmental Geochemistry

Prerequisite Combination: (c), (d), (h), or (l) in First Science.

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Experimental Physics – EXPH 1001

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.

Genetics

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

Genetics is designed to be taken either as a Joint Honours Programme (Molecular Genetics and a Biological Subject) or a Topical Degree programme (Cell and Molecular Biology and Plant Genetic Engineering) following the completion of Second Science and leading to the award of an honours degree.

Geology – GEOL 1001

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.

Geophysical Science

Prerequisite Combination: (c), (e), (i), or (n) in First Science.

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Industrial Microbiology

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

This is a Second Science Subject leading to an Honours Degree Programme.

Mathematical Physics – MAPH 1000

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.

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 select combinations (f), (k) or (m).

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.

Mathematics

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

***Please note that students do not gain extra marks for taking the Honours course.** Honours Mathematics is designed for those students wishing to pursue a career in Mathematics or who enjoy the challenge of Honours Mathematics.

Either the Pass or the Honours course must be attended.

Pass Course Four lectures per week.

Algebra
Vectors in two, three and more dimensions. Matrices and systems of linear equations. Introduction to complex numbers.

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

Honours Course Four lectures per week.

Algebra
Induction, solutions of systems of linear equations, matrix algebra, determinants, vectors in three-dimensional space, lines and planes in three-dimensional space, eigenvalues and eigenvectors.

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

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.

Occupational Safety and Health

Prerequisite Combination: (a) in First Science.

This is available as a Third General option.

Pharmacology

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

This is a Second Science Subject leading to an Honours Degree Programme.

Physiology

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

This is a Second Science Subject leading to an Honours Degree Programme.

Plant Genetic Engineering

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

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Psychology[1]

There are no prerequisites in first science for students wishing to study psychology.

This is a second science subject leading to an honours degree programme.

Statistics

No prerequisite needed in First Science.

This is a second science subject leading to an honours degree programme.

Theoretical Physics

Students select combinations (b), (e), or (f).

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.

Zoology

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

This is a Second Science Subject leading to an Honours Degree Programme.

[1] *Psychology only available as an option until 2003*

Second Science

Regulations for Second Year Science Students

1. Admission To Second Science

Students must have passed the First University Examination in Science.

- All First Science students must indicate their preference by completing an *Application for Admission to Second Science Subjects Form*. These forms areAvailable 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.

2. Transferring from other UCD Faculties to Second Science

The closing date for applications is 12 July 2002. Application should be made using the 'Internal Transfer Form'. Such transfers are dependent on the availability of places in Second Science. Information is available from the Admissions Office, Michael Tierney Building, UCD (*Tel. +353 1 716 1425).*

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 via an 'Internal Transfer Application Form'.

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. Application for such acceptance must be made via an 'Internal Transfer Application Form'.

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 (see Table 1). 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, Psychology
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							
	Biol	Chem	CS	EP	Geol	Maths	MP
Biochemistry	●	●				●	
Botany	●	●				●	
Chemistry		●				●	
Computer Science			●			●	
Experimental Physics				●		●	
Geology					●	●	
Industrial Microbiology	●	●				●	
Mathematics						●	
Mathematical Physics						●	●
Pharmacology	●	●				●	
Physiology	●	●				●	
Psychology						●	
Statistics						●	
Zoology	●	●				●	

* *See subjects grouped under each Second Science Subject. Students should note that certain subjects may not be taken together due to timetable or other restrictions as decided by the Faculty of Science.*

4. **Special requirements for Second Year students wishing to proceed to some Third Year 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.
- **Cell and Molecular Biology:** Students wishing to pursue a Topical Degree in Cell and Molecular Biology are required to take two biological subjects and one other subject in second year.
- **Computer Science:** Students wishing to pursue an Honours Degree in Computer Science are required to take Mathematics in second year.
- **Environmental Biology:** Students wishing to pursue a Topical Degree in Environmental Biology are required to choose two subjects out of Botany, Industrial Microbiology or Zoology and one other subject in second year.
- **Experimental Physics:** Students wishing to pursue an Honours Degree in Experimental Physics are required to take Mathematics in second year[2].
- **Industrial Microbiology:** Students wishing to pursue an Honours Degree in Industrial Microbiology are recommended, but not required, to take Chemistry in second year.
- **Plant Genetic Engineering:** Students wishing to pursue a Topical Degree in Plant Genetic Engineering are required to take Biochemistry, Botany and another subject 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 or on the web: *(http://www.ucd.ie/~exams/)*) 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.

[2] *Students who take Honours Mathematics with Mathematical Physics in First Science are permitted to substitute the Mathematics requirement for Mathematical Physics.*

Qualifying for Third Honours Courses
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.

For further details please see 'Admission to Third Science Courses' on page 58.

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.

Repeating for Honours
If a student wishes to repeat to qualify for honours all three Second Science subjects must be repeated.

Syllabus of Second Year Courses in Science

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.

Applied and Computational Mathematics

Second Year - any Second Science combination which includes Mathematics.

Note 1 Mathematics at General level is sufficient

Note 2 For this degree it is **not** necessary to have taken either Mathematical Physics or Statistics in Second Science

Biochemistry

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

Available subject groups with Biochemistry:

Biochem	Botany	Chem
Biochem	Botany	IndMicro
Biochem	Botany	Maths
Biochem	Botany	Zool
Biochem	Chem	IndMicro
Biochem	Chem	Maths
Biochem	Chem	Pharm
Biochem	Chem	Zool
Biochem	ExpPhys	Maths

Biochem	IndMicro	Maths
Biochem	IndMicro	Pharm
Biochem	IndMicro	Zool
Biochem	Maths	Pharm
Biochem	Maths	Physiol
Biochem	Maths	Zool
Biochem	Pharm	Physiol
Biochem	Pharm	Zool
Biochem	Physiol	Zool

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.

Botany

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

Available subject groups with Botany:

Botany	Biochem	Chem
Botany	Biochem	IndMicro
Botany	Biochem	Maths
Botany	Biochem	Zool
Botany	Chem	Geology
Botany	Chem	IndMicro
Botany	Chem	Maths

Botany	CompSc	Maths
Botany	Geology	Maths
Botany	Geology	Zool
Botany	IndMicro	Maths
Botany	IndMicro	Zool
Botany	Maths	Psych
Botany	Maths	Zool

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 Molecules 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.

Cell and Molecular Biology

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

Any Second Science group that includes two biological subjects.

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Chemistry

Prerequisite for all units: First Science Chemistry.

Available subject groupings with Chemistry:

Chem	Biochem	Botany
Chem	Biochem	IndMicro
Chem	Biochem	Maths
Chem	Biochem	Pharm
Chem	Biochem	Zool
Chem	Botany	Geology
Chem	Botany	IndMicro
Chem	Botany	Maths
Chem	CompSc	Maths
Chem	ExPhys	Maths
Chem	Geology	MPhys
Chem	Geology	Maths

Chem	Geology	Zool
Chem	IndMicro	Maths
Chem	IndMicro	Pharm
Chem	IndMicro	Stats
Chem	IndMicro	Zool
Chem	MPhys	Maths
Chem	MPhys	Stats
Chem	Maths	Pharm
Chem	Maths	Stats
Chem	Maths	Zool
Chem	Pharm	Stats
Chem	Psych	Zool

Second Year Courses for General and Honours Degrees
Students take the following four units:

CHEM 2001 *Synthesis and Reactivity of Organic Compounds*
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 2006 Spectroscopy and Solution Chemistry

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. 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. Mass spectrometry: principles and instrumentation, molecular fragmentation, determination of molecular weight. Use of spectroscopic techniques to provide structural information on organic compounds.

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.

CHEM 2007 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 biomolecules, including amino acids, peptides, proteins and bioinorganic compounds.

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.

Computer Science

Prerequisite: First Year Computer Science and Mathematics.

Available subject groupings with Computer Science:

CompSc	Botany	Maths
CompSc	Chem	Maths
CompSc	ExPhys	Maths
CompSc	Geology	MPhys
CompSc	Geology	Maths
CompSc	MPhys	Maths

CompSc	MPhys	Psych
CompSc	MPhys	Stats
CompSc	Maths	Psych
CompSc	Maths	Stats
CompSc	Maths	Zool

Students must take Mathematics and one other subject. Those students who took Mathematical Physics and Honours Mathematics in First Science may substitute Mathematical Physics for Mathematics.

Second Year Courses for General and Honours Degrees
Core Courses

COMP 2001 *Data Structures 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 2011 *Data Structures and Algorithms II*
Trees; graphs; pattern matching; sorting; specification techniques; complexity analysis; application.

Computer Science 2100 (Denominated Entry)

Mathematics
Students follow the Second Science honours or pass course in Mathematics.

Computer Science
In Computer Science students take the following courses:

COMP 2001 *Datastructures and Algorithms I*
For details of this unit see under Computer Science.

COMP 2002 *Computer Architecture: Systems*
For details of this unit see under Computer Science.

COMP 2003 Functional Programming
For details of this unit see under Computer Science.

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 2011 *Datastructures and Algorithms II*
For details of this unit see under Computer Science.

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.

COMP 3006 *Program Design and Verification*
For details of this unit see under Computer Science

Environmental Biology

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

In Second Science students must choose a group that includes any two of the subjects Botany, Industrial Microbiology or Zoology.

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Environmental Geochemistry

Prerequisite Combination: (c), (d), (h), or (l) in First Science.

In Second Science, students must choose a group that includes any two of the subjects Chemistry, Geology and one other subject.

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Experimental Physics

Prerequisites for all units: First Science Experimental Physics and Mathematics

Available subject groupings with Experimental Physics

ExPhys	Biochem	Maths
ExPhys	Chem	Maths
ExPhys	CompSc	Maths
ExPhys	Geology	Maths

ExPhys	MPhys	Maths
ExPhys	Maths	Physiol
ExPhys	Maths	Stats

Students must take Mathematics and one other subject. Those students who took Mathematical Physics and Honours Mathematics in First Science may substitute the Mathematics requirement with Mathematical Physics.

Prerequisites for all units: First Science Experimental Physics and Mathematics

Second Year Courses For General and Honours Degrees

EXPH 2001 *Optics and 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 and Fraunhofer). Simulation of deterministic processes including projectile motion. Computational methods for the solution of differential equations. Introduction to Monte Carlo techniques.

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. Faraday's laws of electromagnetic induction are presented together with a discussion of inductance and eddy currents. Rules governing the flow of electrons in real circuits are developed and symmetry principles applied to complex circuits. A number of DC and AC circuits are analysed, some of which are computationally modelled. Practical considerations such as complex impedance, resonance, power transfer and impedance matching are also described in the context of real circuits, some of which are computationally modelled. The effect of electric fields on materials is also presented.

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. In addition, 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. The 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.

Genetics

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

Genetics is designed to be taken either as a Joint Honours Programme (Molecular Genetics and a Biological Subject) or a Topical Degree programme (Cell and Molecular Biology and Plant Genetic Engineering) following the completion of Second Science and leading to the award of an honours degree.

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:-

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

Geology

Prerequisite for all units: First Science Geology

Available subject groupings with Geology:

Geology	Botany	Chem
Geology	Botany	Maths
Geology	Botany	Zool
Geology	Chem	MPhys
Geology	Chem	Maths

Geology	Chem	Zool
Geology	CompSc	Maths
Geology	ExPhys	Maths
Geology	MPhys	Maths
Geology	Maths	Zool

Second Year Courses for General and Honours Degrees

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.

Geophysical Science

Prerequisite combination: (c), (e), (i) or (n) in First Science.

Students take Mathematics, Experimental Physics and Geology.

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Industrial Microbiology

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

Available subject groupings with Industrial Microbiology

IndMicro	Biochem	Botany
IndMicro	Biochem	Chem
IndMicro	Biochem	Maths
IndMicro	Biochem	Pharm
IndMicro	Biochem	Zool
IndMicro	Botany	Chem
IndMicro	Botany	Maths
IndMicro	Botany	Zool
IndMicro	Chem	Maths

IndMicro	Chem	Pharm
IndMicro	Chem	Stats
IndMicro	Chem	Zool
IndMicro	Maths	Pharm
IndMicro	Maths	Stats
IndMicro	Maths	Zool
IndMicro	Pharm	Stats
IndMicro	Pharm	Zool

Second Year Courses for General and Honours Degrees

Students are recommended, not required to take Chemistry in Second Science.

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.

Mathematical Physics

Available subject groupings with Mathematical Physics

MPhys	Chem	Geology
MPhys	Chem	Maths
MPhys	Chem	Stats
MPhys	CompSc	Maths

MPhys	ExPhys	Maths
MPhys	Geology	Maths
MPhys	Maths	Psych
MPhys	Maths	Stats

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, volume integrals). Integral theorems (Divergence and Stokes' theorems). Grad, Div and Curl in orthogonal curvilinear coordinates. Variational problems, Lagrange multiplers.

Calculus of Variations: Euler's equation, geometric examples, extension to higher number of variables, conditional variation.

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. Modelling 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 2120 *Mechanics and Special Relativity*
Mechanics: Dynamics of rigid bodies, rotating earth, spinning top, moments of inertia, principal axes, Euler's equations of motion.

Special Relativity: Inertial frames, Lorentz transformations, space-time, tensors, relativistic mechanics, energy-momentum conservation.

MAPH 2130 *Analytical and Quantum Mechanics*
Analytical Mechanics: Lagrange's equation, variational principles. Small oscillations, normal modes. Hamilton's equations, canonical transformations, Poisson brackets.

Quantum Mechanics: Introduction, Postulates of Quantum Mechanics, One-dimensional examples: Potential well and harmonic oscillator, the Heisenberg uncertainty principle, Quantum tunnelling.

Mathematical Science

Students take the following courses.

Mathematics

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

Mathematical Physics

MAPH 2111 *Methods A*
MAPH 2120 *Mechanics and Special Relativity*
MAPH 2130 *Analytical and Quantum Mechanics*
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*

Mathematics

Available subject groupings with Mathematics:

Maths	Biochem	Botany
Maths	Biochem	Chem
Maths	Biochem	ExPhys
Maths	Biochem	IndMicro
Maths	Biochem	Pharm
Maths	Biochem	Physiol
Maths	Biochem	Zool
Maths	Botany	Chem
Maths	Botany	CompSc
Maths	Botany	Geology
Maths	Botany	IndMicro
Maths	Botany	Psych
Maths	Botany	Zool
Maths	Chem	CompSc
Maths	Chem	ExPhys
Maths	Chem	Geology
Maths	Chem	IndMicro
Maths	Chem	MPhys
Maths	Chem	Pharm
Maths	Chem	Stats
Maths	Chem	Zool
Maths	CompSc	ExPhys
Maths	CompSc	Geology
Maths	CompSc	MPhys
Maths	CompSc	Psych
Maths	CompSc	Stats
Maths	CompSc	Zool
Maths	ExPhys	Geology
Maths	ExPhys	MPhys
Maths	ExPhys	Physiol
Maths	ExPhys	Stats
Maths	Geology	MPhys
Maths	Geology	Zool
Maths	IndMicro	Pharm
Maths	IndMicro	Stats
Maths	IndMicro	Zool
Maths	MPhys	Psych
Maths	MPhys	Stats
Maths	Pharm	Physiol
Maths	Pharm	Psych
Maths	Pharm	Stats
Maths	Pharm	Zool
Maths	Physiol	Psych
Maths	Physiol	Stats
Maths	Psych	Stats
Maths	Stats	Zool

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 transformations*
The internal structure of a vector space. Vector spaces homomorphisms. Matrices and linear transformations.

MATH 2104 *Functions of several variables*
Partial and directional derivatives. Taylor series. Critical points and Lagrange multipliers. Implicit function theorem. Line integrals and multiple integrals.

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.

Occupational Safety and Health

Prerequisite Combination: (a) in First Science.

This is available as a Third General option.

Pharmacology

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

Available subject groupings with Pharmacology

Pharm	Biochem	Chem
Pharm	Biochem	IndMicro
Pharm	Biochem	Maths
Pharm	Biochem	Physiol
Pharm	Biochem	Zool
Pharm	Biochem	Physiol
Pharm	Chem	IndMicro
Pharm	Chem	Maths
Pharm	Chem	Stats
Pharm	IndMicro	Maths

Pharm	IndMicro	Stats
Pharm	IndMicro	Zool
Pharm	Maths	Physiol
Pharm	Maths	Psych
Pharm	Maths	Stats
Pharm	Maths	Zool
Pharm	Physiol	Psych
Pharm	Physiol	Stats
Pharm	Psych	Stats
Pharm	Psych	Zool

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.

Physiology

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

Available subject groupings with Physiology in Second Science

Physiol	Biochem	Maths
Physiol	Biochem	Pharm
Physiol	ExPhys	Maths
Physiol	Maths	Pharm
Physiol	Maths	Psych

Physiol	Maths	Stats
Physiol	Pharm	Psych
Physiol	Pharm	Stats
Physiol	Psych	Stats

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. Introduction to mechanisms of immunity. 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.

Plant Genetic Engineering

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

Any Second Science combination that includes Botany and Biochemistry.

This programme is designed as a Topical Degree programme following the completion of Second Science and leading to the award of an honours degree.

Psychology

There are no prerequisites for students wishing to take Psychology. Please note that this subject is restricted to 25 places in Second Science.

Available subject groupings for Psychology Second Science

Psych	Botany	Maths
Psych	Botany	Zool
Psych	CompSc	Maths
Psych	MPhys	Maths
Psych	Maths	Pharm
Psych	Maths	Physiol

Psych	Maths	Stats
Psych	Pharm	Physiol
Psych	Pharm	Stats
Psych	Pharm	Zool
Psych	Physiol	Stats
Psych	Stats	Zool

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.

Statistics

There are no prerequisites for students wishing to take Statistics.

Available subject groupings in Second Science Statistics

Stats	Chem	IndMicro
Stats	Chem	MPhys
Stats	Chem	Maths
Stats	Chem	Pharm
Stats	CompSc	Maths
Stats	ExPhys	Maths
Stats	IndMicro	Maths
Stats	IndMicro	Pharm
Stats	MPhys	Maths

Stats	Maths	Pharm
Stats	Maths	Physiol
Stats	Maths	Psych
Stats	Maths	Zool
Stats	Pharm	Physiol
Stats	Pharm	Psych
Stats	Physiol	Psych
Stats	Psych	Zool

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.

The following four units may only be taken by Second Mathematical Science students:

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.

Theoretical Physics

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:

For details of this course see under Mathematical Physics

MAPH 2111 *Methods A*

MAPH 2120 *Mechanics and Special Relativity*

MAPH 2130 *Analytical and Quantum Mechanics*

MAPH 2141 *Computational Physics*

Zoology

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

Available subject groupings for Second Science Zoology

Zool	Biochem	Botany
Zool	Biochem	Chem
Zool	Biochem	IndMicro
Zool	Biochem	Maths
Zool	Biochem	Pharm
Zool	Botany	Geology
Zool	Botany	IndMicro
Zool	Botany	Maths
Zool	Botany	Psych
Zool	Chem	Geology

Zool	Chem	IndMicro
Zool	Chem	Maths
Zool	CompSc	Maths
Zool	IndMicro	Maths
Zool	IndMicro	Pharm
Zool	Maths	Pharm
Zool	Maths	Stats
Zool	Pharm	Psych
Zool	Psych	Stats

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 Science

Regulations for Third Year Science Students

Application for Honours or Topical Degrees

- Students will be assigned to places in Third Science courses by the relevant Department Head/Course Director based on the results of the Second Science examinations in Summer. Students interested in pursuing a Topical Degree should note that they must register their interest with the Course Director before the summer examinations as well as fill out a subject choice form.
- 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 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

  - 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.

Description of Third Science Degree Programmes

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

The examination is taken in ten units.

The examination must be passed at the first attempt.

Honours Standards:

- First Class Honours 70%
- Second Class Honours (Grade I) 62%
- Second Class Honours (Grade II) 55%

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

Pass Standard:

The pass standard in each unit is 40%. In units including written and practical assessment candidates may be rejected or debarred from passing by compensation on grounds of extreme weakness in one or other part of the examination, in which case a pass mark for the unit will not be granted.

Candidates who attain a mark of 40% overall but who do not attain at least 45% overall or who pass by compensation with an average mark in two units of less than 35% will not be permitted to continue in the honours course but will be graduated with the BSc (General) Degree.

Compensation:

A pass by compensation may be granted provided the candidate has reached the pass mark in six units and achieved an overall average of at least 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 ten 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 (General) 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. 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 Programmes

1. Definition of a Topical Degree
The BSc Topical Degree may be defined as a degree programme encompassing more than one subject area. Students need to qualify for the honours degree at the end of Third Science.

2. 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.

3. 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.

4. 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.

5. Award of Honours
Honours are awarded based on performance at the Summer Examination of the first year of sitting only. (The regulations governing this examination are contained in *Marks and Standards*, available for consultation in the Library or at http://www.ucd.ie/~exams.)

6. 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.

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 or on the web: http://www.ucd.ie/~exams/).

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%.

Re-Attendance at Courses

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

4. 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 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.

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.

Syllabus of Third Year Courses in Science

Applied and Computational Mathematics

Ten units to be taken, selected from the following, subject to the approval of the course director.

Core units are marked with the letter *c*. Descriptions of the units may be obtained from the Third Year courses in Mathematical Physics, Mathematics and Statistics. See under the Subjects for the relevant descriptions.

MATH 3201	*Complex Analysis*	
MATH 3204	*Groups and Vector Spaces*	*c*
MATH 3207	*Graph Theory*	
MATH 3223	*Differential Equations*	*c*
MAPH 3071	*Computational Methods*	*c*
MAPH 2031	*Vector Calculus*	*c*
MAPH 3181	*Dynamical Systems*	
STAT 3205	*Statistical Theory I*	*c*
STAT 3206	*Statistical Theory II*	*c*
STAT 3207	*Statistical Theory III*	*c*
STAT 3221	*Biostatistics*	
STAT 3224	*Statistics and Visualisation*	

Biochemistry

Courses 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 industry 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 Organisation and 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.

Botany

Courses 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. Pollination, 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-Montpellier) approach to phytosociology; ordination – principles and computer-based techniques. Biogeography – studying plant distributions, Irish biogeography, ecology of 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.*

Cell and Molecular Biology

Students pick the following eight core courses and two optional courses as follows:

Core Units

BOTN 3009 *Plant-Specific Cell Biology and Metabolism*
For details of this unit see under Botany.

GENE 3001 *Genetics*
For details of this unit see under Genetics.

GENE 3002 *Genome Structure*
For details of this unit see under Genetics.

GENE 3003 *Gene Expression*
For details of this unit see under Genetics.

PHAR 3001 *Chemotherapeutic Agents*
For details of this unit see under Pharmacology.

ZOOL 3010 *Animal Development*
For details of this unit see under Zoology.

ZOOL 3012 *Immunology*
For details of this unit see under Zoology.

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.

Details of the optional units are presented under the subject listings for Biochemistry, Botany, Languages, Statistics and Zoology.

Optional Units

BIOC 3003 *Biochemist's Toolkit*

BIOC 3004 *Gene Manipulation & Regulation*

BIOC 3005 *Disease and Disease Resistance*

BIOC 3008 *Biochemistry and Environment*

BOTN 3004 *Growth & Nutrient Assimilation*

BOTN 3006 *Seed Plant Reproduction*

BOTN 3008 *Plant Biotechnology*

ZOOL 3015 *Evolutionary Biology*

STAT 3208 *Statistical Methods I*

STAT 3221 *Biostatistics*

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)*

LANG 3005 *Beginners Spanish for Science*

LANG 3006 *Beginners Chinese for Science*

Chemistry

Courses for General and Honours Degrees
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 3018, CHEM 3019 and CHEN 3025 (Process Engineering). Students

wishing to pursue a single subject General Degree in Chemistry must take units CHEM 3001 to CHEM 3005, CHEM 3018, CHEM 3019 and CHEN 3025 (Process Engineering).

Students taking an Honours Degree in Chemistry will be required to take units CHEM 3007, CHEM 3008, CHEM 3009, CHEM 3011, CHEM 3012, CHEM 3014, CHEM 3016, and CHEM 3017. Students taking a Joint Honours Degree in Chemistry will ordinarily be required to take five of the above units, 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 3018 *Environmental Chemistry*
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.

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.

CHEM 3019 *Chemical Reactivity and New Materials*

Investigations on fast reactions, flash photolysis, the use of lasers to probe biological systems. Photochemistry, the interaction of radiation with molecules, technological applications of photochemistry.

The development and production of new materials. Polymeric materials, liquid crystals, optical memory, superconductivity, nanoclusters, nanowires, nanotubes, the electronics of the future.

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.

CHEM 3007 *Synthesis and Reactivity of Organic Compounds*

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 *Structure 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 3011 *Stereochemistry, Alicyclic Chemistry and Bio-organic 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 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 3012 *Modern Inorganic Chemistry*

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

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 surfaces including Faraday's Laws; electrode potentials and the Nernst equation.

CHEM 3016 *Colloid and Surface Chemistry, Computational Chemistry and Reaction Kinetics*

Dispersions, emulsions, gels, solutions of polymers and biopolymers, surfactants. Interfaces and surface tension. Colloidal interactions. Brownian motion and colloidal dynamics. Fundamental principles of stability and self-organisation of colloid systems. Monomolecular films. Applications in biotechnology, food, pharmaceutical and other industries.

Integration of differential equations for chemical reactions. Methods of Molecular, Stochastic and Monte Carlo dynamics. Numerical solution of the Schroedinger equation and variational techniques.

Elementary reactions: complex reactions, consecutive, parallel and opposing reactions. Steady state assumption and numerical integration. Linear and branched chain reactions, explosion limits. Photchemical reactions: kinetics of photophysical and photochemical processes. Reactions in solution: diffusion controlled reactions, reactions involving ions, nature of the solvent, nature of the ions, ionic strength of the solution: electron transfer reactions.

CHEM 3017 *Symmetry Theory and Quantum Mechanics*

Chemical applications of group theory. Symmetry elements, operations and groups. Character table of a point group. Electronic structure of water and ammonia. Subgroups and correlation tables. Molecular vibrations. Spectroscopic selection rules.

Failures of classical mechanics. Particle-wave duality. Quantisation. Time evolution: Heisenberg and Schroedinger equations. Uncertainty principle. Wave function. A particle in a box. Tunnelling. Harmonic oscillator and vibrational motion. Angular Momentum and rotational motion. Hydrogen atom. Spin. Pauli principle. Born-Oppenheimer approximation. Atomic and molecular orbitals. Hybridisation and bonding. External fields: Zeeman and Stark effects.

Computer Science

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

Students are required to take the following seven core units, two of the additional Computer Science units and one other unit which may be one of the additional units as recommended by the department.

Core Units

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 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 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 3013 *Software Engineering Project*
A group project in software engineering building a complete system based on the application of analysis, design and implementation techniques.

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.

Additional Units

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 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 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 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 3207 *Graph Theory*
For details of this course see under Mathematics

STAT 3224 *Statistics and Visualization*
For details of this course see under Statistics

PHIL 3901 *History and Philosophy of Science*
For details of this course see under History and Philosophy of Science

Computer Science (Denominated Entry)

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

Environmental Biology

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.

Details of the course units are available under the subject listings for Botany, Industrial Microbiology and Zoology.

Core Units in Environmental Biology

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*

[*] *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.*

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 3013 *Animal Behaviour*

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, LANG 3005, LANG 3006, PHIL 3901, ZOOL 3017, ZOOL 3015. Optional unit selection must be agreed with the Programme Directors and fit in with the timetables.

Environmental Geochemistry

The third year Environmental Geochemistry programme comprises ten units. Eight core units (three from Chemistry and five from Geology) are combined with two optional units from the Faculty of Science programme to be decided in consultation with the Course Director.

Core Units

CHEM 3001 *Organic and Polymer Chemistry*
For details of this unit see under Chemistry

CHEM 3002 *Inorganic Chemistry*
For details of this unit see under Chemistry

CHEM 3018 *Environmental Chemistry*
For details of this unit see under Chemistry

GEOL 3002 *Phanerozoic Stratigraphy*
For details of this unit see under Geology

GEOL 3003 *Precambrian and Geotectonics*
For details of this unit see under Geology

GEOL 3004 *Applied Geology*
For details of this unit see under Geology

GEOL 3005 *Geochemistry*
For details of this unit see under Geology

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.

The Third Year course involves geological field classes.

Experimental Physics

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.

All Experimental Physics units have a practical component.

EXPH 3001 *Electromagnetism, Optics and Special Relativity*
Maxwell's equations. Electromagnetic waves. The Poynting vector. Fresnel's equations. Non-reflecting and high-reflecting films. Evanescent waves. Transmission lines. Waveguides. Interference and coherence. Michelson interferometer. Fourier transform spectroscopy. Fabry-Perot interferometer. Lasers. Introduction to Special Relativity.

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. The vectors $\vec{E}, \vec{D}, \vec{B}, \vec{H}, \vec{M}$ *and* $\vec{P}$. Maxwell's equations. Lorentz gauge. Electromagnetic waves. The scalar and vector potentials. Field-defining equations. Energy transport. Wave propagation in dielectrics and metals. Dispersion. Plasma frequency. Refractive index of plasmas and metals. Transmission lines. Resonant cavities. Waveguides.

EXPH 3009 *Optics*

Geometrical optics – thin lenses, aperture and field stops, thick lenses, aberrations, optical instruments. Matrix optics, Fourier theory and Fraunhofer diffraction. Fresnel diffraction. Coherence. Convolution and correlation. Optical processing and imaging. Holography. Interferometers.

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 equilibrium. 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 electron 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. Nuclear reactions, including direct and compound nucleus reactions.

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*
Fourier series. Fourier transforms. Convolution and correlation. The discrete and fast Fourier transforms. Windowing, sampling and aliasing. Digital filters. Power spectra. Application of the fast Fourier transform to problems, including time-series analysis and image processing.

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.

Genetics

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.
- Pass the Second Science examination, obtaining the qualifying standard for admission to the Honours course in their chosen biological subject.

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 *Genome 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 lambda 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.

Geology

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.

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.

Geophysical Science

The third year Geophysical Science programme comprises ten units. Eight core units (three from Experimental Physics and five from Geology) are combined with two optional units from the Faculty of Science programme to be decided in consultation with the Course Director.

Core Units

EXPH 3005 *Instrument Science*
For details of this unit see under Experimental Physics

EXPH 3008 *Electromagnetism*
For details of this unit see under Experimental Physics

EXPH 3010 *Electronics*
For details of this unit see under Experimental Physics

GEOL 3002 *Phanerozoic Stratigraphy*
For details of this unit see under Geology

GEOL 3003 *Precambrian and Geotectonics*
For details of this unit see under Geology

GEOL 3008 *Igneous, Metamorphic Petrology*
For details of this unit see under Geology

GEOL 3009 *Applied Geophysics*
For details of this unit see under Geology

and either

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.

or

GEOL 4013 *Data Processing and the Crust*
For details of this unit see under Geology

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

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

History and Philosophy of Science

This course may be taken as an optional unit in Third Science. Students should consult with their course director before signing up for this course.

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

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.

Languages

The Applied Language Centre offers a number of courses, one of which may be selected as an optional unit by Third Science students. Students should consult with their course director before signing up for this course.

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)*

LANG 3005 *Beginners Spanish for Science*

LANG 3006 *Beginners Chinese for Science*

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.

Mathematical Physics

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, MAPH 3120, MAPH 3130, MAPH 3141, MAPH 3151, MAPH 3161, MAPH 3171, MAPH 3180. Students who have not taken the Second Year Honours courses take MAPH 3010, MAPH 3020, MAPH 3111, MAPH 3120, MAPH 3130, MAPH 3161, MAPH 3171 and MAPH 3180.

Students taking the BSc (Joint Honours) Degree must take five units: MAPH 3111, MAPH 3120, MAPH 3130, 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.

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 electro-magnetic theory.

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.

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

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.

Mathematical Science

Students take ten units with at least two units from each subject. The combination of courses must be approved by the Course Director. Details on each unit may be found under the relevant subjects.

Mathematics

MATH 3101 *Number Theory and Group Theory*

MATH 3102 *Field Theory*

MATH 3104 *Functions of One Complex Variable*

MATH 3105 *Logic and foundation of Mathematics*

MATH 3106 *Algorithms*

MATH 3107 *History of Mathematics*

MATH 3108 *Special Topics*

MATH 3109 *Advanced Linear Algebra*

MATH 3110 *Metric Spaces*

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*

STAT 3222 *Stochastic Processes I*

Mathematics

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.

Honours Courses

MATH 3102 *Field Theory*
A review of ring theory. Construction of fields. Roots of polynomials. Finite fields . Galois theory.

MATH 3104 *Functions of one complex variable*
Cauchy-Riemann equations, Cauchy's integral theorems, Taylor and Laurent expansions, identity theorem for analytic functions, residues, applications to evaluation of integrals and summation of series, maximum-modulus principle, Schwarz's lemma, principle of the argument.

MATH 3105 *Logic and Foundations of Mathematics*
Binary logic, predicates and quantifiers, axiomatic systems, consistency and completeness, axiomatic set theory, cardinality, axiom of choice.

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*
Endomorphism algebras, matrix algebras, characteristic and minimal polynomials, direct sums, canonical forms of matrices.

MATH 3110 *Metric Spaces*
Euclidean spaces, metrics, normed linear spaces, convergence, continuity and uniform continuity, compactness, completeness, Banach fixed point theorem, connectedness, examples.

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. These courses are only available to students taking the BSc in Occupational Safety and Health. Students take all ten courses. Applications should be made to the Faculty of Science as per other courses and NOT the course director.

Applications to this Third Year Degree course should be made to the Course before 19 April 2002.

Admission is granted by the Course Director and is subject to space and number restrictions.

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*

Pharmacology

Courses for General and Honours Degrees

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 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 3007 *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.

Physiology

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.

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.

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.

Plant Genetic Engineering

Eight core courses:

BOTN 3006 *Seed Plant Reproduction*
For details of this unit see under Botany.

BOTN 3007 *Vegetation Ecology and Biogeography*
For details of this unit see under Botany.

BOTN 3008 *Plant Biotechnology*
For details of this unit see under Botany.

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

GENE 3001 *Genetics*
For details of this unit see under Genetics.

GENE 3002 *Genome Structure*
For details of this unit see under Genetics.

GENE 3003 *Gene Expression*
For details of this unit see under Genetics.

Two optional units selected from the following subject areas. Details of the optional units are presented under the subject listings for Botany, Languages and Statistics.

BOTN 3001 *Diversity and Ecology of Fungi*

BOTN 3002 *Plant Population Biology*

BOTN 3003 *Plant/Soil Interactions in Wetlands*

BOTN 3004 *Growth & Nutrient Assimilation*

BOTN 3004 *Growth & Nutrient Assimilation*

STAT 3221 *Biostatistics*

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)*

LANG 3005 *Beginners Spanish for Science*

LANG 3006 *Beginners Chinese for Science*

Psychology

Courses for General and Honours Degrees

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*

<u>Notes for Students:</u>

- 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.

Statistics

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.

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 models.

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.

Theoretical Physics

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

Details of the core course units are presented under the subject listings for Experimental Physics, and Mathematical Physics.

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 4017 *Experimental Laboratory Option*

Zoology

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 Science

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 Courses for Fourth Year Science

Applied and Computational Mathematics

Ten units to be taken, selected from the following, subject to the approval of the course director.

MATH 4108	*Financial Mathematics*	(1 unit)
MATH 3205	*Combinatorial Mathematics*	(1½ units)
MATH 3106	*Algorithms*	(1½ units)
MATH 4201	*Matrix Analysis*	(1 unit)
MATH 4115	*Transforms*	(1 unit)
MAPH 3171	*Fluid Mechanics*	(1 unit)
MAPH 3091	*Mathematical Modelling*	(1 unit)
MAPH 3120	*Mathematical Methods C*	(1 unit)
MAPH 4110	*Non-linear waves and solitons*	(1 unit)
STAT 3208	*Statistical Methods I*	(1 unit)
STAT 3209	*Statistical Methods II*	(1 unit)
STAT 3210	*Data Analysis and Statistical Software*	(1 unit)
STAT 4213	*Applied Statistics II*	(1 unit)

Biochemistry – 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 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 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-noise, 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 proteases 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.

BIOC 4014 *Bioinformatics*
This course is composed of a series of computer-based practical classes and tutorials. Areas covered include interrogation of literature and molecular databases; BLAST searches; pairwise and multiple alignments of DNA and protein sequences; design of cloning and PCR experiments; analysis of motifs; introduction to protein structure prediction.

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.

STAT 4230 Statistics – Laboratory Assays

Botany – 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 In 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 – 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 *Critiques 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 *Prion Diseases*
For details of this unit see under Zoology.

ZOOL 4018 *Genomic Imprinting, Chromatin and Epigenetics*
For details of this unit see under Zoology.

Chemistry – 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
Reaction dynamics; electrochemistry; nanochemistry; spectroscopy; molecular characterisation by advanced instrument techniques; thermodynamics and phase behaviour of solutions; statistical mechanics; colloids; biopolymers.

Statistical Mechanics
Introduction to Statistical Mechanics. The microcanonical, canonical and grand canonical equilibrium distributions. Concepts of the temperature, heat capacity, free energy and enthalpy. Relation to the laws of thermodynamics. The ideal gas law and van der Waals equation. Vibrational and rotational partition functions. Bose and Fermi statistics.

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 – 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 4006 *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 modelling; 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 *Programme 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

COMP 4009 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 Concurrent 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

COMP4028 *Parallel Programming Systems*
Vector and superscalar processors: architecture and programming model, optimising compilers (dependency analysis and code generation), array libraries (BLAS), parallel languages (Fortran 90, C[]); Shared-memory multi-processors: architecture and programming models, optimising compilers, thread libraries (Pthreads), parallel languages (Fortran 95, OpenMP); Distributed-memory multi-processors: architecture and programming model, performance models, message-passing libraries (MPI), parallel languages (HPF); Heterogeneous networks of computers: architecture and programming models, performance models, parallel programming languages (mpC).

Computer Science (Denominated Entry)

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

Environmental Biology – ENVB 4000

The Fourth Year Programme comprises ***nine*** 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.

ENVB 4002 *Environmental Impact Assessment*
Development, philosophy and structure of the EIA framework in Ireland and other countries. Practicalities of EIA, including a mock scoping exercise and lectures from environmental consultants. Biological sampling and coastal examples will be emphasised.

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

Optional courses
Students select six optional courses, with 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. Please note course descriptions may be found under the relevant subject.

Courses in Botany

BOTN 4001 *Peatland Ecology and Conservation*

BOTN 4002 *Ecotoxicology*

BOTN 4003 *Evolution in Plant Populations*

BOTN 4004 *Mycorrhizal Symbiosis*

BOTN 4012 *Ecological Significance of Different Photosynthetic Pathways*

Courses in Industrial Microbiology

INDM 4013 *Current Topics in Fungi*

INDM 4015 *Advances in Environmental Microbiology II*

INDM 4016 *Advances in Environmental Microbiology III*

Courses in Zoology

ZOOL 4001 *Biodiversity*

ZOOL 4005 *Ecology of Tropical Rainforests*

ZOOL 4016 *Marine Community Ecology*

ZOOL 4019 *Bioassessment of Freshwaters*

Project

A project in an environmental topic is carried out in Botany, Industrial Microbiology or Zoology. Project selection may be restricted by the availability of space in laboratories. 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 – ENGC 4000

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.

Core Units

CHEM 3003 *Electroanalytical, Surface and Colloid Chemistry*
For details of this unit see under Chemistry.

CHEM 3004 *Analytical Chemistry*
For details of this unit see under Chemistry

CHEM 3019 *Chemical Reactivity and New Materials*
For details of this unit see under Chemistry

GEOL 3006 *Sedimentology and Volcanology*
For details of this unit see under Geology

GEOL 3008 *Igneous, Metamorphic Petrology*
For details of this unit see under Geology

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.

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.

Experimental Physics – 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.

All Experimental Physics units have a practical component.

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

Plasma Physics

Fundamental atomic processes. Diffusion, electrical conduction and mobility. Einstein's equation. Debye length. Highly conducting plasmas. Waves in plasmas. Plasma diagnostics.

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: Concentrates on the influence of gravitational collapse including 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 the 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 algorithms and their application to optimisation problems. Random mutations, selection based on fitness. Percolation and critical phenomena. 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

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 include: 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.

PHAR 4010 *Developmental Biology*
Details available from the Department of Pharmacology

BIOC 4014 *Bioinformatics*
For details of unit see under Biochemistry

Geology – 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.

GEOL 4001 *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.

GEOL 4002 *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. Lower Palaeozoic stratigraphy, sedimentology and volcanology of the British Isles and its relationship to tectonics.

GEOL 4003 *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. Subsidence and basin analysis. Extensional, foreland and strike-slip basin fills.

GEOL 4004 *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.

GEOL 4005 *Geological mapwork and 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.

GEOL 4006 *Igneous Petrology*
Magmatism at constructive and destructive intra-plate margins and intra-plate settings. 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.

GEOL 4007 *Ore Geology*
The mineralogy, geological setting and origin of metallic mineralisation illustrated by examples of globally important ore deposit types.

GEOL 4008 *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.

GEOL 4009 *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.

GEOL 4010 *Tectonics*
Tectonic development and deep crustal structure of the Caledonides and the Variscides. Origin and superimposition of non-plane strains in orogenic belts. Salt and inversion tectonics. 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

Students take the three core units in Experimental Physics and Geology and either of GEOL 3010 or GEOL 4013, whichever has not been taken in Third Year.

Core Units

GEOL 3004 *Applied Geology*
For details of this unit see under Geology

GEOL 3006 *Sedimentology and Volcanology*
For details of this unit see under Geology

GEOL 3007 *Structural, Petroleum Geology*
For details of this unit see under Geology

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

EXPH 3006 *Thermodynamics and Statistical Physics*
For details of this unit see under Experimental Physics

EXPH 3009 *Optics*
For details of this unit see under Experimental Physics.

EXPH 4008 *Environmental Radiation and Radioecology*
For details of this unit see under Experimental Physics.

and either

GEOL 3010 *Seismology, Global Geophysics*

or

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.

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.

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

Industrial Microbiology – 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*

Mathematical Physics

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 2002/2003)*

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.

Mathematical Science

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.

[*] *This course is given jointly with the Mathematics Department.*

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 4216 *Actuarial Statistics I*
STAT 4217 *Actuarial Statistics II*
STAT 4222 *Stochastic Processes I*
STAT 4223 *Official Statistics*
STAT 4231 *Linear Models with Complex Structure*
STAT 4232 *Topics in Biostatistics*
STAT 4233 *Nonparametric Statistics*
STAT 4235 *Survival Analysis*
STAT 4237 *Stochastic Processes II*
STAT 4238 *Data Analysis II*
STAT 4239 *Stochastic Processes II*

Mathematics

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.

Pharmacology – PHAR 4100

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

PHAR 4001 Disorders of Haemostasis
PHAR 4002 Neuropharmacology
PHAR 4003 Cancer studies
PHAR 4004 CNS Dopamine Receptors/Drug Development
PHAR 4005 Nitric Oxide, Vascular Injury and Angiogenesis
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 Developmental biology/pharmacology
PHAR 4011 Renal Pharmacology and Toxicology
STAT 4230 Statistics – Laboratory Assays

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 – 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*

- *Neuromodulation of respiratory motor outputs.*

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 addition, students are required to attend departmental research seminars and discussion groups and carry out the continuous assessments set.

Plant Genetic Engineering – 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

(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*

<u>*Notes for Final Year Students:*</u>

- 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

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

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 *Data reduction, Modelling and Error Analysis*
EXPH 4016 *Interdisciplinary Computational Physics*
EXPH 4017 *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*
- *Advanced Theoretical Astrophysics*

Zoology – ZOOL 4000

Students must choose and attend seven units. Units will only be offered if sufficient students choose to take them. Each student undertakes a research project which is written and presented as a thesis. Each student must give an oral presentation based on their research project. In addition, students are required to write a literature review and an essay on an assigned topic. Attendance at Research Seminars is obligatory.

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 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 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.

ENVB 4002 *Environmental Impact Assessment*
For details on this unit, see under Environmental Biology.

ZOOL 4012 *General Zoology*
This is the coding for the examination paper on general zoology in the final examination.

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.

ZOOL 4016 *Marine Community Exology*
Patterns of community structure in benthic marine habitats, such as rocky shores, sandy beaches and kelp forests. Apatial and temporal scales of variation. Interactions between physical factors and biological processes such as recruitment, competition and predation. Detecting and reducing human impacts in a variable world.

ZOOL 4018 *Genomic imprinting, chromatin and epigenetics*
Parent of origin-dependent gene expression in mammals: molecular mechanisms, evolution and implications for embryonic development, cancer and animal cloning.

ZOOL 4019 *Bioassessment of Freshwaters*
Contemporary bioassessment approaches using fish, invertebrates and plants, ecosystem integrity, stress factors, reference conditions, typologies, biological indicators, analyses and interpretation of data, biotic metrics and indices, predictive models.

Part Time Degree Programme

BSc Degree in Occupational Safety and Health Management

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, UCD, Roebuck, Belfield, Dublin 4. Closing date for receipt of applications: 31 May 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 student'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)**

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 Mode I. Entry requirements for the MSc Mode II or an MApplSc are determined by individual Departments.

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 (Mode II) 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 or on the web: *http://www.ucd.ie/~exams/)*.

11. 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.

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 (Mode II Examination) 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 Cognitive Science (SCMXF0011)

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 Computational Science (SCMXF0025)

Computational Science is a rapidly growing multidisciplinary area encompassing applications in science, applied mathematics, numerical analysis and computer science. Computer models have become an essential part of scientific research and the complexity of 'real world' problems has generated a demand for scientists who possess sophisticated computational and mathematical modelling skills. The purpose of this one-year full time programme is to provide training in scientific computing and visualisation. Applicants for entry to this course will be required to have a 2nd Class Honours primary degree in an appropriate area.

Degree of Master of Science in Mathematical Physics (SCMXF0007)

This is a one-year full-time taught Masters course open to those who have attained at least a 2nd Class Honours primary degree or equivalent in Mathematical Physics or a cognate subject. Candidates are required to attend postgraduate lectures on branches of Mathematical Physics approved by the department of Mathematical Physics and to submit a dissertation which will be taken into account by the examiners.

Degree of Master of Science on Mathematical Science (SCMXF0010)

This is a one-year full-time taught Masters course open to those who have attained at least a 2nd Class Honours primary degree or equivalent in Mathematical Science, Mathematics, Mathematical Physics or a cognate subject. Candidates are required to attend postgraduate lectures on branches of Mathematical Science approved by the departments of Mathematics and Mathematical Physics and to submit a dissertation which will be taken into account by the examiners. The courses offered will vary from year to year, and examinations in any given year will normally only be offered on courses given in that year.

Degree of Master of Science in Plant Molecular Biology (SCMXF0002)

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 programme.

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 Radiological Sciences (SCMXF0003)

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.

Degree of Master of Science in Statistics (SCMXF0008)

This is a one-year, full-time taught Master's course open to those who have attained at least a Second Class Honours degree in Statistics or in a cognate subject or who have achieved a distinction in the Higher Diploma in Statistics. Candidates for entry must satisfy the Department of Statistics that they possess a reasonable knowledge of the basics of statistics. The purpose of the programme is to educate the student at postgraduate level in theoretical and applied statistics. The course will consist of lectures in eight topics in theoretical and applied statistics and students will also undertake a substantial project to be submitted as a minor thesis.

Course Details for MApplSc Degrees

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

Applied Physics (SCMXP0013)

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

Computer Science (SCMXF0015)

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 (SCMXF0014)

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

Food Science (SCMXP0012

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

Safety, Health and Welfare at Work (SCMXP0017)

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 *(SCHDF0018)*

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 *(SCHDF0019)*

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 *(SCHDF0020)*

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 3120, MAPH 3130, MAPH 3161 and MAPH 3171.

Part II Students take four courses from the Fourth Year courses in Mathematical Physics.

Higher Diploma in Statistics (SCHDF0021)

This is a full-time one-year course open to graduates who have attained a sufficiently high standard in a subject area that is cognate to Statistics. The course content consists of subject matter from the degree courses in Statistics and gives a grounding in theoretical and applied statistics. Students who pass the Higher Diploma in Statistics with distinction may be admitted to the MSc programme in Statistics. Candidates must be approved by the Head of Department.

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 (IFCTP0004)

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 may be obtained from the Centre for Safety and Health at Work, Roebuck Castle, Belfield (Telephone No: 716 8700).

Degree of Doctor of Science (DSc) on Published Work[*]

A candidate shall be deemed eligible to present for the Degree of Doctor by submitting published work to the National University of Ireland, which must embody the results of original research and a common theme sufficient to indicate that the candidate has achieved a special competence in this aspect of the subject. The work submitted must be of a high standard and contain original contributions to the advancement of knowledge and learning which has given the candidate international distinction in the field of study. Fifteen terms must elapse from the date of obtaining the Degree of Bachelor of Science. Further information may be obtained from the National University of Ireland, 49, Merrion Square, Dublin 2.

[*] *See Calendar of the National University of Ireland.*

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.

List of Staff

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

Faculty of Science Office

Telephone No. 716 2355
Room 128, Science Lecture Building
Fax No. 716 2439

Email: Sue.Philpott@ucd.ie
Web: http://www.ucd.ie/~science/

Dean of the Faculty:	Professor Michael J. Kennedy
Associate Dean (First Science):	Dr Bret Danilowicz
Associate Dean (Undergraduate):	Mr Hubert Fuller
Associate Dean (Research & Development):	Professor Mark Keane
Associate Dean (Postgraduate):	Professor Stephen Mayhew
Senior Faculty Administrator:	Ms Gillian Goodbody
Faculty Administrator:	Ms Sue Philpott
Student Advisers:	Rev. Tony Coote (Chaplain) Ms Aoife FitzGerald

Applied and Computational Mathematics

Telephone No. 7168265
Fax No. 7161196

Email: Breda.McMahon@ucd.ie
Web: http://mathsa.ucd.ie/

Programme Director:	Professor David Lewis, BSc, PhD, DSc

Biochemistry

Telephone No. 7161547
Fax No. 2837211

Email: Annette.Forde@ucd.ie
Web: http://www.ucd.ie/~biochem/

Head of Department	Professor Paul C. Engel
Professor of Biochemistry	Paul C. Engel, BA *(Oxon),* DPhil *(Oxon)*
Associate Professor (Redox Biochemistry)	Stephen G. Mayhew, BSc *(Sheffield)*, PhD *(Sheffield)*
Associate Professor of Biochemistry (Biochemical NMR and Enzymology)	J. Paul G. Malthouse, BSc *(Lond)*, PhD *(Lond)*

Senior Lecturer	B. Therese Kinsella, BSc, PhD Bartholomew Masterson, BSc, PhD
Lecturer	Geraldine Butler, BA *(Dub)*, PhD *(Dub)* Bronagh Hayden, BSc, PhD *(Temporary Appointment)* Gethin McBean, BA *(Dub),* PhD *(Southampton)* Joan M. Manning, MSc *(Manchester)*, PhD *(Manchester)* Philip Newsholme, BSc *(B'ham)*, DPhil *(Oxon)* Margaret Worrall, BA *(Dub),* PhD *(Cantab)*
Administrative Assistant:	Annette Forde

Botany

Telephone No. 7162253	*Fax No. 7161153*
Email: Jane.Flaherty@ucd.ie	*Web: http://www.ucd.ie/~botany/Botany.htm*
Acting Head of Department	Professor Gerard Doyle
Professor of Botany	Martin W. Steer, BSc *(Bristol)*, PhD *(QUB)*, DSc *(Bristol)*, MRIA, FRMS, MIBiolI, PresMSI
Associate Professor of Botany (Vegetation Science)	Gerard Doyle, BSc, PhD, MIBiolI
Senior Lecturer	Derek T. Mitchell, BSc *(Sheffield)*, PhD *(Sheffield)* Bruce A. Osborne, BA *(Stirling)*, PhD *(Nottingham)* James White, BSc, MSc *(Wales)*, DSc
Lecturer	Hubert Fuller, BSc Paul F. McCabe, BSc*, (NUI, Maynooth),* MSc *(NUI, Maynooth),* PhD *(NUI, Maynooth)* Carl Khee-Yew Ng, BSc *(Singapore)*, MSc *(Singapore),* PhD *(Lancaster)* Marinus L. Otte, MSc *(Vrije),* PhD *(Vrije)* Graham Wilson, BSc *(Lond)*, PhD *(B'ham)*
Lecturer (Molecular Genetics)	Thomas F. Gallagher, BSc, PhD
Administrative Assistant:	Jane Flaherty

Cell and Molecular Biology

Telephone No. 7162265 *Fax No. 7161152*

Email: Mark.Rogers@ucd.ie *Web: http://www.ucd.ie/~botany/Botany.htm*

Course Director	Dr Mark Rogers, BA *(Dub),* PhD *(Glasgow)*

Chemistry

Telephone No. 7162165 *Fax No. 7162127*

Email: Kathy.L.Murphy@ucd.ie *Web: http://chemistry.ucd.ie/*

Head of Department and Director of Laboratories (2000 – 2003)	Professor Rory More O'Ferrall
Professor of Inorganic Chemistry	
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 (Nanochemistry)	Donald Fitzmaurice, BSc, PhD
Associate Professor of Inorganic Chemistry (Organometallic Chemistry)	Anthony R. Manning, PhD *(Manchester)*
Associate Professor of Chemistry (Physical Organic Chemistry)	Rory A. More O'Ferrall, PhD *(Lond)*
Associate Professor of Chemistry (Electrochemistry)	Robert O'Neill, BSc, PhD
Associate Professor of Chemistry (Atmospheric Chemistry)	Howard W. Sidebottom, PhD *(St. Andrew's)*
Senior Lecturer	Raphael D. Darcy, PhD, FICI William K. Glass, PhD *(QUB)*, CChem, FRSC Earle W. Waghorne, PhD *(ANU)*
Senior Lecturer, Inorganic Chemistry	Noel J. Fitzpatrick, PhD, FICI
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 Grace Morgan, BSc *(QUB),* PGCE *(QUB),* PhD *(OU)*

	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)*
Administrative Assistant:	Kathy Murphy

Computer Science

Telephone No. 7162469	*Fax No. 2697262*
Email: Patricia.Geoghegan@ucd.ie	*Web: http://www.cs.ucd.ie/contents.htm*
Head of Department	Mr Gregory O'Hare (Acting Head of Department)
Professor of Computer Science	Mark T. Keane, BA, MA (Dub), PhD (Dub)
Digital Professor of Computer Science	Barry Smyth, BSc, PhD *(Dub)*
Senior Lecturer in Computer Science	Ahmed Patel, MSc *(Dub)*, PhD *(Dub)*
Lecturer	Julie Berndsen, MA (Dub), DPhil (Bielefeld) Michela Bertolotto, BSc (Genova), PhD (Genova) Joseph Carthy, BSc Arthur W.S. Cater, BA (Cantab), PhD (Cantab) Fintan Costello, BSc, PhD (Dub) Fred Cummins, BA (Dub), MA (Indiana), PhD, (Indiana) Damian Dalton, BSc, DipCompSc John Dunnion, MSc 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)* Alexei Lastovetsky, MSc *(Moscow Aviation Inst),* PhD *(Moscow Aviation Inst),*, DrSci *(Russian Academy of Sciences)* Eleni Mangina, MSc *(Edin)* Henry B. McLoughlin, BSc Liam Murphy, BE, MSc, PhD Mel Ó Cinneide, MSc Gregory O'Hare, MSc *(Ulster)* Michael Sherwood-Smith, BSc *(St. Andrews)*, PhD

	Guenole Silvestre, Ingénieur *(ISEP, Paris),* PhD (Dub) David Wilson, BA *(Rockford),* MA *(Indiana),* PhD *(Indiana)* Tony Veale, PhD *(Dub)*
Administrative Assistant:	Patricia Geoghegan Clare Comerford Angela Logue

Environmental Biology

Telephone No. 7162253	*Fax No. 7161153*
Email: Gerry.Doyle@ucd.ie	*Web: http://www.ucd.ie/~botany/Botany.htm*
Programme Director:	Professor Gerard J. Doyle
Botany	Professor Gerard J. Doyle, BSc, PhD, MIBiolI *Telephone No. 7162252*
Industrial Microbiology	Dr Evelyn M. Doyle, BSc, PhD *Telephone No. 7161300*
Zoology	Dr Thomas Bolger, BSc, PhD *Telephone No. 7162330*

Environmental Geochemistry

Telephone No. 716 2327	*Fax No. 2837733*
Email: Sarah.Procter@ucd.ie	*Web: http://www.ucd.ie/~geology/home.html*
Programme Director:	Dr J. Stephen Daly, BA (Dub), PhD (Keele) PGeo, FGS

Experimental Physics

Telephone No. 7162210	*Fax No. 2837275*
Email: Marian.Hanson@ucd.ie	*Web: http://www.ucd.ie/~physics/main.html*
Acting Head of Department	Professor Gerard O'Sullivan, BSc, PhD, CPhys, MInstP
Professor of Experimental Physics (Experimental Particle Physics)	Martin W. Grünewald, Vordiplom *(Aachen),* Diplom *(Aachen),* MS *(CalTech),* PhD *(CalTech)*
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

Senior Lecturer	Ann Breslin, MSc *(Lond),* PhD, CPhys, MInstP James P. McLaughlin, MSc, PhD, CPhys, FInstP John A. Scott, MSc, PhD, CPhys, FInstP
Lecturer	Padraig Dunne, BSc, PhD, CPhys, MInstP Hugh M. Grimley, BSc, PhD *(QUB)* Lorraine Hanlon, MSc, PhD, CPhys, MInstP Michael Hoey, BSc, PhD *(QUB*) Luis León Vintró, BSc *(Barcelona)*, PhD Eón Ó Mongáin, MSc, PhD Emma Sokell, BA *(Oxon),* PhD *(Manchester),* CPhys, MInstP
Assistant Lecturer	John Quinn, BSc, PhD Kilian Smith, BSc PhD (Temporary appointment)
Administrative Assistant:	Marian Hanson

Genetics

Programme Director:	Dr Geraldine Butler, BA (*Dub*), PhD (*Dub*)
Biological Subject Co-ordinators:	
Biochemistry	Geraldine Butler *Telephone No. 7161583*
Botany	Thomas Gallagher *Telephone No. 7162342*
Industrial Microbiology	Patrick Caffrey *Telephone No. 7161396*
Pharmacology	Finian Martin *Telephone No. 7162808*
Zoology	Catherine Nolan *Telephone No. 7162112*

Geology

Telephone No. 716 2331	*Fax No. 2837733*
Email: Sarah.Procter@ucd.ie	*Web: http://www.ucd.ie/~geology/home.html*
Head of Department	Professor Patrick M. Shannon
Professor of Geology	Michael J. Kennedy, MA *(Dub)*, PhD *(Dub),* FGS, EURGeol
Associate Professor of Geology (Petroleum Geology)	Patrick M. Shannon, BSc, PhD, FinstPet, PGeo

Senior Lecturer in Geology	J. Stephen Daly, BA *(Dub)*, PhD *(Keele),* PGeo, FGS Ian D. Somerville, BSc *(QUB)*, PhD *(QUB),* PGeo FGS
Lecturer	Christopher J. Bean, BA, MSc, PhD *(Dub)* Peter Haughton, BA *(Dub),* PhD *(Glasgow)* P. Frank McDermott, PhD *(Open University),* PGeo Julian F. Menuge, BSc *(Leicester)*, PhD *(Cantab),* PGeo John J. Walsh BSc *(UCD),* PhD *(NUIG),* PGeo
Administrative Assistant:	Sarah Procter

Geophysical Science

Telephone No. 716 2140	*Fax No. 2837733*
Email: Sarah.Procter@ucd.ie	*Web: http://www.ucd.ie/~geology/home.html*
Programme Director:	Dr Christopher J. Bean, BA, MSc, PhD *(Dub)*

Industrial Microbiology

Telephone No. 7161512	*Fax No. 7161183*
Email: Geraldine.Neylan@ucd.ie	*Web: http://www.ucd.ie/~indmicro/*
Acting Head of Department	Professor Catherine T. Kelly
Professor of Industrial Microbiology	–
Associate Professor of Industrial Microbiology	Catherine T. Kelly, BSc, PhD
Senior Lecturer, Industrial Microbiology	Caroline Hussey, BSc, PhD *(Dub)*
Lecturer	John P. Caffrey, BA *(Dub),* PhD *(Dub)* Nicholas J.W. Clipson, BSc *(Newcastle),* DPhil *(Sussex)* Evelyn M. Doyle, BSc, PhD James B. Gillespie, BA *(Oxon)*, PhD *(UWO)* Aiden J. McLoughlin, BSc, PhD Hilary E.M. McMahon, BSc, PhD Wim Meijer, MSc *(Groningen),* PhD *(Groningen)* Cormac D. Murphy *(Temporary Appointment)* Kevin E. O'Connor, BSc, PhD Mary E. Upton, MSc, PhD
Administrative Assistant:	Geraldine Neylan

Mathematical Physics

Telephone No. 7168266	*Fax No. 7161172*
Email: mathematical.physics@ucd.ie	*Web: http://www.ucd.ie/~math-phy/*
Head of Department	Professor Adrian Ottewill
Professor of Mathematical Physics	–
Associate Professor of Relativity Theory	Peter Hogan, MSc, PhD
Associate Professor of Theoretical Physics	Adrian C. Ottewill, BA *(Oxon)*, DPhil *(Oxon),* DSc *(Oxon), MRIA*
Associate Professor of Mathematical Physics	Joseph V. Pulé, BSc *(Malta)*, DPhil *(Oxon)*, DSc *(Oxon)*, MRIA
Lecturer	Daniel A. Birmingham, BA *(Dub),* PhD *(Dub)* Edward A. Cox, BSc *(QUB)*, MSc, PhD Peter Duffy, BA *(Dub),* PhD *(Dub)*
Administrative Assistant:	Veronica Barker

Mathematical Science

Telephone No. 7168225	*Fax No. 7161172*
Email: mathematical.physics@ucd.ie	*Web: http://www.ucd.ie/~mathsci/*
Programme Director:	Professor Joseph Pulé, BSc *(Malta)*, DPhil *(Oxon)*, DSc *(Oxon)*, MRIA

Mathematics

Telephone No. 7168265	*Fax No. 7161196*
Email: Breda.McMahon@ucd.ie	*Web: http://mathsa.ucd.ie/*
Head of Department (1999-2002)	Professor David Lewis
Professor of Mathematics II	Sean Dineen, DSc, PhD *(Maryland)*
Professor of Mathematics	Stephen J. Gardiner, MSc *(QUB)*, PhD *(QUB),*DSc *(QUB)*
Associate Professor of Mathematics (Algebra)	Thomas J. Laffey, MSc, DPhil *(Sussex)*, MRIA
Associate Professor of Mathematics	Roderick I.S. Gow, BA *(Cantab)*, PhD *(Liverpool)* David Lewis, BSc, PhD, DSc
Senior Lecturer	Wayne G. Sullivan, BS *(Georgia InstTech)*, DPhil *(Oxon)*

Lecturer	Christopher Boyd, BA *(Dub),* MSc *(Dub),* PhD Russell J. Higgs, BA *(Liverpool)*, PhD *(Liverpool)* Kevin Hutchinson, MA, PhD *(Cornell)* Maria Meehan, Msc, PhD Pauline Mellon, MSc, PhD 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)*
Assistant Lecturer	Michael Mackey, MSc, PhD Thomas Ungar, Lic.Wisk *(Ghent),* PhD
Administrative Assistant:	Breda McMahon

Occupational Safety and Health

Telephone No. 7168700 *Fax No. 2830669*

Email: Anne.Drummond@ucd.ie Web: http://www.ucd.ie/~science/html/OSHfull.html

Programme Director:	Dr Caroline Hussey
Lecturer:	Anne Drummond, RGN, RM, DipSHWW, MSc (Occupational Health), *(Surrey)*

Pharmacology

Telephone No. 7161557 *Fax No. 2692749*

Web: http://www.ucd.ie/~pharmacol/pharhome.htm

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
Senior Lecturer in Pharmacology	Alan K. Keenan, BSc, PhD Kathy O'Boyle, BSc, PhD
Lecturer	William Gallagher, PhD Carmel Hensey, BSc, PhD Paul Moynagh, BA *(Dub)*, PhD Kay Ohlendieck, MSc *(Konstanz),* PhD
Administrative Assistant:	

Physiology

Telephone No. 7167310 — *Fax No. 7167417*

Email: Geraldine.Duggan@ucd.ie — *Web: http://www.ucd.ie/~physiol/index.html*

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
Senior Lecturer in Physiology	John B. Moynihan, BSc, PhD John O'Connor, BA *(Dub),* PhD *(Dub)*
Lecturer	Stuart Bund, BSc (*Leicester*), PhD (*Leicester*) Helen Harty, BSc (*Sheffield*), PhD (*QUB*) Caroline Herron, BSc (Southampton), PhD (Southampton) James F.X. Jones, MB, BCh, BAO, BSc, PhD Philip Nolan, MB, BCh, BAO, BSc William O'Connor, BSc *(NUIG),* PhD *(NUIG)* Ken D. O'Halloran, BSc, PhD
Administrative Assistant:	Geraldine Duggan

Plant Genetic Engineering

Telephone No. 7162342 — *Fax No. 7161153*

Email: Jane.Flaherty@ucd.ie — *Web: http://www.ucd.ie/~botany/Botany.htm*

Programme Director	Dr Thomas F. Gallagher, BSc, PhD

Statistics

Telephone No. 7167152 — *Fax No. 7161186*

Email: Marie.Doyle@ucd.ie — *Web: http://www.ucd.ie/~statdept/*

Head of Department:	Dr John Connolly
Professor of Statistics	Philip J. Boland, BSc *(Le Moyne)*, MA *(Rochester)*, PhD *(Rochester),* DSc
Senior 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)*
Lecturer	Gareth Colgan, FIA Gabrielle E. Kelly, MSc, PhD *(Stanford)*
Administrative Assistant:	Marie Doyle

Theoretical Physics

Telephone No. 7168266 *Fax No. 7161172*

Email: mathematical.physics@ucd.ie

Web: http://www.ucd.ie/~math-phy/theor/thph-home.html

Programme Directors:

Experimental Physics	Professor Gerry O'Sullivan *Telephone No. 716 2210*
Mathematical Physics	Dr Peter Duffy *Telephone No. 716 8224*

Zoology

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

Email: Dorothy.Allen@ucd.ie *Web: http://www.ucd.ie/~zoology/zoology.html*

Head of Department	Dr Mark Rogers
Professor of Zoology	Edward J. Duke, BSc, PhD *(QUB)*, DSc
Senior 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)*
Lecturer	Bret S. Danilowicz, BSc *(Syracuse),* PhD (*Duke*) Gareth J. Dyke, BSc *(Bristol),* PhD *(Bristol)* Mary Kelly Quinn, BSc, PhD Catherine M. Nolan, BSc, PhD Thomas L. Wilkinson, BSc *(Wales),* DPhil *(Oxon)* Tasman Crowe, BSc *(Bristol)*, PhD *(Sydney)*
Administrative Assistant:	Dorothy Allen

TIME TABLES

First Science Timetable (2002-2003)

(Lectures and Practicals)

Denominated Entry Programmes please contact their departments for timetables

	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	Geology	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												Geology	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
1500												Geology			
16.00			Geology			ExpPhys			Comp Sc			Comp Sc			
17.00												Geology			

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 (2002-2003) – 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 B		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. (10-1 pm) Botany (11-1 pm)	CHEM 2002	Th E		EXPH 2001 ZOOL 2006	ID Th E	Biochem. (10-1 pm) Chem. (10-1 pm) Zool 2006 (11-1 pm)	EXPH 2003 ZOOL 2006	ID Th E	Biochem. (10-1 pm) Zool 2006 (11-1 pm)	COMP 2002 PHYS 2004/6 STAT 2221	Th C L215 Th D	
11.00	STAT 2201/2	Th A		BIOC 2001/2 GEOL 2002 PSY 2203	Th D ID L215		STAT 2201/2 STAT 2221	Th E Th F		MATH 2201	Th D		BOTN 2005 MAPH.2010 MAPH 2120 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 2001 PSY 2201 BIOC 2001/2	ThD L215 Th B	
13.00	STAT 2201/2 BIOC 2001/2	Th A Th B		MAPH 2010 MAPH 2120 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 STAT 2205/6	Th C Arts	
14.30										PHYS 2004/6	ET				
15.00	COMP 2001	ID					STAT 2205/6	Arts		MATH 2101	Arts		BOTN 2001	Th D	
16.00			C.Science (3-5 pm) Physiology (3-5.30 pm) Chemistry (3-6 pm) Zool 2005 (4-6 pm)	STAT 2205/6	Arts	C.Science (3-5 pm) Geology (3-5 pm) Ind.Micro. (3-5.30 pm) Pharmacol. (3-6 pm)			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)	COMP 2001	ID	Ind. Micro. (3-5.30 pm) Biochem. (3-6 pm) Chemistry (3-6 pm) Physiology (3.30-5.30 pm)			Exp.Phys. (2.30-5.30 pm) 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 (2002-2003) – 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 B		CHEM 2006	Th C		Ind.Micro. PHYS 2005/7	Th D L215		CHEM 2007 PSY 2202	Th C L215		Ind. Micro EXPH 2004	Th D ID	
10.00	BOTN 2003	Th D	Chemistry (10-1 pm)	CHEM 2007	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 (11-1 pm)	BIOC 2003/4 GEOL 2004 PSY 2203	Th D ID L215		STAT 2203/4	Th E	Chemistry (10-1 pm) Zool 2008 (11-1 pm)	MATH 2203	Th D	Zool 2008 (11-1 pm)	BOTN 2004 MAPH 2141 PHAR 2003/4	Th B L215 Th E	
12.00	EXPH 2002	ID		BOTN 2003 MAPH 2020 MAPH 2130 PHAR 2003/4	Th C L104 Th E Th F		MATH 2102	Arts		PHAR 2003/4	Th D		GEOL 2003 PSY 2202 BIOC 2003/4	ThD 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 2130 ZOOL 2007	L104 L215 Th E		GEOL 2003 Ind. Micro. PSY 2204	ID Th E L215		BIOC 2003/4 GEOL 2004	Th D Th E		Ind. Micro.	Th E		CHEM 2006 STAT 2206/7	Th C 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	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 2102 COMP 2003	Arts ID	Ind. Micro. (3-5.30 pm) Biochem. (3-6 pm) Chemistry (3-6 pm) Physiology (3.30-5.30 pm)	BOTN 2004	Th A	Exp.Phys. (2.30-5.30 pm) Chemistry (3-6 pm) Pharmacol. (3-6 pm) Botany (4-6 pm)
17.00				COMP 2011	ID					COMP 2011	ID				

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 (2002-2003) – 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 3008 STAT 3208 GEOL 3006	Th F ID Arts ID	BOTN 3002 (9-12 noon) GEOL 3006 (10-12 noon) Chemistry (2-5 pm) PHAR 3001-4 (2.30-5.30 pm) BIOC 3006 (3-6 pm) BOTN 3001 (3-6 pm) INDM 3005/7 (3-6 pm) PHAR 3005-6 (3-6 pm) Physiology (3-5.30 pm)	EXPH 3010 MAPH 3021 PHYS 3002/3	ID L104 ET	BIOC 3004 (9-12 noon) GENE 3001 (9-12 noon) GEOL 3005 (10-12 noon) INDM 3001 (9-12 noon) ZOOL 3010 (10-12 noon) BOTN 3003 (2-5 pm) Chemistry (2-5 pm) PHAR 3001-4 (2.30-5.30 pm) BIOC 3004 (3-6 pm) ExpPhysics (3-5 pm) PHAR 3005-6 (3-6 pm) ZOOL 3009 (4-6 pm) CompScience Psychology	BOTN 3003 COMP 3007 EXPH 3010 GEOL 3006 PHAR 3002 STAT 3208	ID Th E ID ID L123 Arts	BOTN 3009 (2-4 pm) ZOOL 3011 (2-4 pm) Chemistry (3-6 pm)	CHEM 3019 COMP 3001 MAPH 3021 PHYS 3002/3	ID Th E L104 ET	BIOC 3001 (9-12 noon) BOTN 3009 (9-11 am) GEOL 3002 (9-11 am) INDM 3002 (9-12 noon) PHAR 3005-6 (10-1 pm) BOTN 3009 (11-1 pm) BIOC 3001 (2-5 pm) BOTN 3010 (2- 5 pm) Chemistry (2-5 pm) PHAR 3001-4 (2.30-5.30 pm) PHAR 3005-6 (2.30-5.30 pm) ExpPhysics (3-5 pm) ZOOL 3016 (3-5 pm) Psychology	COMP 3009 INDM 3001 MAPH 3011 STAT 3210 PSY 3207 CHEM 3001	Th F ID L104 DB Arts ID	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)
10.00	COMP 3008 PSY 3207 ZOOL 3009 CHEM 3001	ID Arts L101 ID		EXPH 3002	ID		BOTN 3009 CHEM 3004 MATH 3203 ZOOL 3011	ID ID L215 Th D		MATH 3203	L215		EXPH 3009 PSY 3207 STAT 3221	ID Arts Th D	
11.00	INDM 3007/5 MATH 3203 MAPH 3011 PSY 3204 ZOOL 3010 CHEM 3003	ID L123 L104 Arts Th F ID		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 3005 MATH 3208 PHAR 3005 PHYS 3009	ID ID Th B Th F ET		CHEM 3004 COMP 3017 INDM 3007 PSY 3206 ZOOL 3010	ID ID 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 ID ID L104 L215 Th B		BOTN 3001 COMP 3003 EXPH 3002 PHAR 3002	ID ID ID Th F	
13.00	MATH 3202 MATH 3204 MAPH 3071 ZOOL 3016	L123 L215 L104 Th E		PHIL 3901	L123		CHEM 3019 GENE 3001 MATH 3208	ID 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		BIOC 3004 COMP 3007	Th D Th B		CHEM 3003 PSY 3201	Th A Arts		GEOL 3002 STAT 3218	ID ID		BIOC 3008 GEOL 3001 PHYS 3009 PSY 3206 STAT 3205/6	L123 ID ET Arts Arts	
15.00	PSY 3208 STAT 3218	Arts ID		ZOOL 3009	Th D		BIOC 3008 GEOL 3002 PHAR 3001 STAT 3205/6	L123 ID Th D Arts							
16.00				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 2002-2003 – 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 3004 GEOL 3009 STAT 3209	ThD ThE ID Arts	Chemistry (2-5 pm) PHAR 3001-4 (2.30-5.30 pm) PHAR 3005-6 (2.30-5.30 pm) BIOC 3007 (3-6 pm) BOTN 3007 (3-6 pm) GEOL 3008 (3-5 pm) INDM 3006/8 (3-6 pm) Physiology (3-5.30 pm)	GEOL 3013 MAPH 3041 PHYS 3004/5	ID L104 ET	BIOC 3003 (9-12 noon) INDM 3004 (9-12 noon) GEOL 3013 (10-12 noon)	CHEM 3002 EXPH 3003 MAPH 3081 STAT 3209	ID ID L104 Arts	GENE 3002/3 (9-12 noon) GEOL 3010 (9-11 am) BOTN 3006 (3-6 pm) Chemistry (3-6 pm) GENE 3002/3 (3-6 pm) INDM 3006/8 (3-6 pm) ZOOL 3014 (4-6 pm)	COMP 3002 PHYS 3004/5	ID 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 PSY 3207	ThF ID L104 DB Arts	GEOL 3009 (9-11 am) Chemistry (2-5 pm) BIOC 3005 (3-6 pm) Physiology (3-5.30 pm) ZOOL 3013 (3-5 pm)
10:00	EXPH 3001 GEOL 3009 INDM 3008/6 MAPH 3081 ZOOL 3014	ID ID ID L104 ThF		EXPH 3012 EXPH 3015 GEOL 3010 PHAR 3004 PHYS 3006/7 COMP 3013	ID ID ID L123 ET ID		BOTN 3007 GEOL 3013 PHAR 3006/7 MATH 3207	ID ID L215 L123		MATH 3207 PHYS 3006/7	L215 ET		BIOC 3007 BOTN 3006 CHEM 3001 MATH 3207 PHAR 3006/7 PSY 3207 ZOOL 3013	ThE ID ID ThD L104 Arts L101	
11:00	BOTN 3008 CELB 3001 CHEM 3002 COMP 3011 GEOL 3008 PSY 3205	ID ID ID ID ID Arts		EXPH 3001 EXPH 3008	ID ID		CHEM 3005 EXPH 3008 PSY 3205 STAT 3224	ThF ID Arts ID		GEOL 3008 MATH 3201 COMP 3013	ID L215 ID		CHEM 3005 GENE 3002 GEOL 3010 MAPH 3031 PSY 3203	ThA L101 ID L104 Arts	
12:00	BIOC 3002 GEOL 3003 MAPH 3031	ThE ID L104		COMP 3011 GEOL 3004 MAPH 3081 ZOOL 3017	ID ID L215 L101		BIOC 3003 COMP 3005 GEOL 3004 INDM 3008/6 ZOOL 3017	ThB ThD ID ID L101		EXPH 3003 INDM 3008/6 PHAR 3003 STAT 3224	ID ID ThC ID		BOTN 3004 EXPH 3005 MAPH 3081 PHAR 3003	ID ID L104 ThF	
13:00	CHEM 3001 COMP 3006 GENE 3003 ZOOL 3013	ID ThD L215 ThE		BOTN 3008 CHEM 3018 COMP 3005 MATH 3201 PHAR 3007	ID ID ThC L123 ThF	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) ExpPhys (3-5 pm) GEOL 3004 (3-5 pm) ZOOL 3012 (4-6 pm) CompSc	PHAR 3004 ZOOL 3015	ThF ThD		BIOC 3002 PHAR 3006/7	ThD ThE		COMP 3004 GENE 3003 MATH 3201 CHEM 3018	ThC L123 L215 ID	
14:00	BIOC 3007 MATH 3205 PHYS 3004/5 PSY 3208 STAT 3220 ZOOL 3012	ThA L123 ET Arts ThF ThC		BIOC 3005 GEOL 3007 ZOOL 3015	ThF ID ThC		COMP 3002 GENE 3002 PSY 3202	ID L215 Arts		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) BOTN 3004 (3-6 pm) ExpPhys (3-5 pm) GEOL 3007 (3-5 pm)	BIOC 3005 GEOL 3003 INDM 3003 PHYS 3006/7 PSY 3203 STAT 3220 STAT 3206/07	ThD ID ID ET Arts ThE Arts	
15:00	PSY 3208	Arts		MATH 3207 ZOOL 3012	ThB ThE		EXPH 3005 PSY 3202 STAT 3206/07 ZOOL 3014	ID Arts Arts ThE		MATH 3205	L123				
16:00				STAT 3206/07	Arts		MATH 3205	L123							

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.