Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Science at Trinity

Faculty of Science, Technology, Engineering and Mathematics (STEM)

TR063 Physical Sciences
Senior Freshman Programme 2021 - 2022

tcd.ie/science

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TR063: Physical Sciences introduction

Welcome to the handbook for your second year of the Physical Sciences course in Trinity College! This year will see you consolidate your initial understanding of physics and of how the world around you depends upon physical processes successfully described by physical laws. These physical laws are underpinned by insights into these physical processes which obey the “laws of physics” as we understand them and elucidated by the mathematical tools that can be used to describe them. On occasions the accepted laws of physics get overturned through a paradigm shift and a new way of looking at the world and its interactions then emerges that both supersede the previous understanding and is capable of making new predictions. An example of that is the emergence of special relativity which superseded the Galilean relativity while making new predictions. The consequences of these new predictions allow us to understand nuclear processes such as how nuclear fusion and fission is energetically allowed and also how stars, such as our sun, shine!

These and the other elements of the foundations of all physics such as the laws of thermodynamics, the nature of oscillations, the phenomena of electricity and magnetism, all coupled with our theory of electromagnetism and the propagation of light, materials properties and our knowledge of the universe around us through astrophysical observations are the topic of primary concern in this second foundational year of your Physics degree. Combined with appropriate mathematical tools encompassing multivariable calculus, vector calculus, and Fourier analysis, all required for the mathematical description of almost all physical phenomena, will help prepare you for your choice of Moderatorship for the two remaining Sophister years of your chosen degree.

In addition, the training in more advanced experimental physics within our laboratories, inclusive of further training in computational simulations, as well as your participation in group research work and presentations will equip you with the further foundational tools to progress.

Importantly in this year, you will also receive instruction on how the scientific method developed and the philosophy of thought that underpins any scientific query. An outcome of this instruction should be that you obtain a clear understanding of how science is not fixed, but is a set of theories and knowledge that is constantly evolving but must stay anchored to empirical and experimental observations and requires predictive power from any given theory. All such theories can be superseded, for instance via a paradigm shift such as that referred to above with regards to special relativity superseding the Galilean relativity, but only if the new theory is better by which it has more predictive power and can be tested to a higher level of accuracy than the previous theory. Thus, science and physics can advance but only through training the future generation of scientists and physicists in the power of independent, logical and critical thinking informed by experimental data.

Lastly, this year will see you decide on which of the three possible Moderatorship degrees that you wish to progress in, these being either **Physics**, or **Physics and Astrophysics** or **Nanoscience** where competition for places can occur. To guide you in this, in addition to your lectures and your natural curiosity (this is why you are here?), we will provide an appropriate series of insightful prospective seminars on what these degree choices entail so that you are well informed in making the most appropriate choice for you and for your future career as a graduate of this university.

May the Physics continue!

Cormac McGuinness

Professor Cormac McGuinness
Director, TR063: Physical Sciences Course

TR063: Physical Sciences overview and module (pre)-selection

The Senior Freshman year will build on the material covered in the Junior Freshman year which will help decide on which career path to follow. The Senior Freshman year is divided into Semester 1 (Michaelmas term) and Semester 2 (Hilary term) and you must select modules to the value of 60 credits for the year with no more than 30 credits from Semester 1 and 30 credits from Semester 2.

OVERVIEW OF MODULE SELECTION

Students must take 40 core credit modules (20 per semester) as follows:

PYU22P10	Physics	Semester 1	10
PYU22P20	Physics	Semester 2	10
MAU22S01	Multivariable calculus for Science	Semester 1	5
MAU22S03:	Fourier analysis for Science	Semester 1	5
MAU22S02:	Vector calculus for Science	Semester 2	5
PIU22992:	History, Philosophy and Ethics of Science	Semester 2	5

Students also take Open modules to the value of 20 credits (10 per semester) from the following:

BYU22201:	From Molecules to Cells	Semester 1	10
BYU22202:	From Cells to Organisms	Semester 2	10
CHU22201:	Chemistry	Semester 1	10
CHU22202:	Chemistry	Semester 2	10
GSU22201:	From atoms to rocks: introduction to geochemistry	Semester 1	5
GSU22205:	Sedimentary Processes & Environments in a Changing World	Semester 1	5
GSU22006:	Dynamic Earth	Semester 2	10

Moderatorships

In the Junior and Senior Freshman years TR063: Physical Science students complete a course of study which will qualify them to compete for a place in one of the following Moderatorships after the Senior Freshman year:

- Nanoscience
- Physics
- Physics and Astrophysics

Note that there are limitations on Open module choices across the Junior and Senior Freshman years **due to prerequisites in the Senior Freshman year that depend upon or require Open modules in the Junior Freshman year**.

All current students will have already made module choices in the Junior Freshman year that completely determine the modules they will take in the Senior Freshman year.

Semester structure

Semester one		Semester two	
CORE MODULES (Mandatory) – 20 per semester			
PYU22P10: Physics 1	10	PYU22P20: Physics 2	10
MAU22S01: Multivariable Calculus for Science	5	MAU22S02: Vector Calculus for Science	5
MAU22S03: Fourier analysis for Science	5	PIU22992: History, Philosophy and Ethics of Science	5

OPEN MODULES (Optional): Students choose 10 credits from each Semester

Open modules (optional)	Credits	Open modules (optional)	Credits
BYU22201: From Molecules to Cells	10	BYU22202: From Cells to Organisms	10
CHU22201: Chemistry	10	CHU22202: Chemistry	10
GSU22201: From atoms to rocks: introduction to geochemistry	5	GSU22006: Dynamic Earth	10
GSU22205: Sedimentary Processes & Environments in a Changing World	5		

Open Module Choices in Junior and Senior Freshman Years

Year 1: JUNIOR FRESHMAN	
CORE MODULES – 40 credits 20/20	
Semester 1	**Semester 2**
PYU11P10: Physics 1	PYU11P20: Physics 2
MAU11S01: Mathematics	MAU11S02: Mathematics

Year 2: SENIOR FRESHMAN	
CORE MODULES – 40 credits 20/20	
Semester 1	**Semester 2**
PYU22P10: Physics 3	PYU22P20: Physics 4
MAU22S01: Multi-variable calculus for Science	MAU22S02: Vector Calculus for Science
MAU22S03: Fourier analysis for Science	PIU22992: History, Philosophy and Ethics of Science

OPEN MODULES – choose 20 credits 10/10	
CHU11101 General and Physical Chemistry	CHU11102 Introduction to Inorganic and Organic Chemistry
GSU11004 Spaceship Earth: An introduction to Earth System Science	GSU11005 Geology: A Beginner's guide to Planet Earth
BYU11101 From Molecules to Cells	BYU11102 From Organisms to Ecosystems

OPEN MODULES – choose 20 credits 10/10	
CHU22201 Chemistry	CHU22202 Chemistry
GSU22201: Geochemistry …	GSU22006: Dynamic Earth
GSU22005: Sedimentary …	
BYU22201 From Molecules to Cells 2	BYU22202 From Cells to Organisms

TR063: Moderatorships and Open Module Choice Diagram

Moderatorships in **Physics** or in **Physics and Astrophysics** are available to all students regardless of the choice of Open modules in the Junior Freshman and Senior Freshman years. To qualify for the Moderatorship in **Nanoscience**, a student must take all available Chemistry Open modules in both semesters of the Junior and Senior Freshman years.

Five patterns of Open Modules are available to students across Junior Freshman and Senior Freshman years. These are denoted A, B, C, D and E. **Your choice of last year determines** the subject choices: **X**, **Y** and **Z** in the TR063 Physical Sciences Senior Freshman module choice form.

	Year 1: JUNIOR FRESHMAN			Year 2: SENIOR FRESHMAN	
	Semester 1	**Semester 2**		**Semester 1**	**Semester 2**
A	CHU11101 General and Physical Chemistry	CHU11102 Introduction to Inorganic and Organic Chemistry	**X**	CHU22201 Chemistry	CHU22202 Chemistry
B	CHU11101 General and Physical Chemistry	GSU11005 Geology: A Beginner's Guide to Planet Earth	**Y**	GSU22201 Geochemistry … GSU22205 Sedimentary …	GSU22006 Dynamic Earth
C	GSU11004 Spaceship Earth: An intro. …	GSU11005 Geology: A Beginner's Guide …	**Y**	GSU22201 Geochemistry … GSU22205 Sedimentary …	GSU22006 Dynamic Earth
D	BYU11101 From Molecules to Cells	BYU11102 From Organisms to Ecosystems	**Z**	BYU22201 From Molecules to Cells	BYU22202 From Cells to Organisms
E	BYU11101 From Molecules to Cells	GSU11005 Geology: A Beginner's Guide …	**Y**	GSU22201 Geochemistry … GSU22205 Sedimentary …	GSU22006 Dynamic Earth

Moderatorship

- **Nano-science** (pattern X only)
- **Physics** (all patterns)
- **Physics and Astro-physics** (all patterns)

Applications to choose a specific Moderatorship after the Senior Freshman year occur via a preferred Moderatorship choice form that will be available in Semester 2 of the Senior Freshman year. There are quotas and hence competition for admission to each Moderatorship.

Senior Freshman module choice form

Please submit module choice forms online by 4pm on Friday 23rd April 2021. Forms are available online via the following link: https://forms.office.com/r/FdRS35TvcA

BLOCK CAPITALS PLEASE

Name: ______________________ E-mail: ______________________

Date: ______________________ Student No: ______________________

SENIOR FRESHMAN MODULES 2021/22

Your Open modules in SF are predetermined by your Open module choices in the JF year due to each SF modules having specified pre-requisites or dependencies on JF modules. No changes are possible.

Module Code	Module Title	Semester	Credits	
Core modules – 20 credits per semester				
PYU22P10:	Physics	Semester 1	10	MANDATORY
PYU22P20:	Physics	Semester 2	10	
MAU22S01	Multivariable calculus for Science	Semester 1	5	
MAU22S03:	Fourier analysis for Science	Semester 1	5	
MAU22S02:	Vector Calculus for Science	Semester 2	5	
PIU22992	History, Philosophy and Ethics of Science	Semester 2	5	
Open modules – 10 per semester **Please circle either X, Y or Z in appropriate box**				
Semester 1 and Semester 2				
CHU22201	Chemistry	Semester 1	10	**X**
CHU22202:	Chemistry	Semester 2	10	
or				
GSU22201:	From atoms to rocks: introduction to geochemistry	Semester 1	5	**Y**
GSU22205:	Sedimentary Processes & Environments in a Changing World	Semester 1	5	
GSU22006:	Dynamic Earth	Semester 2	10	
or				
BYU22201:	From Molecules to Cells 2	Semester 1	10	**Z**
BYU22202:	From Cells to Organisms	Semester 2	10	

In brief and reflecting the choice of progression pattern made when entering Physical Sciences:

- If your **Semester 2 JF** module was **CHU11102** you **must circle X** and take both of the designated Open Chemical Sciences modules in the SF year.
- If your **Semester 2 JF** module was **GSU11005** you **must circle Y** and take both of the designated Open Geosciences modules in the SF year.
- If your **Semester 2 JF** module was **BYU11102** you **must circle Z** and take both of the designated Open Biology and Biomedical Sciences modules in the SF year.

Signature of student: ______________________

Date: ______________________

The European Credit Transfer Accumulation System (ECTS)

The European Credit Transfer and Accumulation System (ECTS) is an academic credit system based on the estimated student workload required to achieve the objectives of a module or programme of study. It is designed to enable academic recognition for periods of study, to facilitate student mobility and credit accumulation and transfer. The ECTS is the recommended credit system for higher education in Ireland and across the European Higher Education Area.

The ECTS weighting for a module is a **measure of the student input or workload** required for that module, based on factors such as the number of contact hours, the number and length of written or verbally presented assessment exercises, class preparation and private study time, laboratory classes, examinations, clinical attendance, professional training placements, and so on as appropriate. There is no intrinsic relationship between the credit volume of a module and its level of difficulty.

The European **norm for full-time study over one academic year is 60 credits**. 1 credit represents 20-25 hours estimated student input, so a 10-credit module will be designed to require 200-250 hours of student input including class contact time, assessments and examinations.

ECTS credits are awarded to a student only upon successful completion of the course year. Progression from one year to the next is determined by the course regulations. Students who fail a year of their course will not obtain credit for that year even if they have passed certain component courses. Exceptions to this rule are one-year and part-year visiting students, who are awarded credit for individual modules successfully completed.

https://ec.europa.eu/education/resources-and-tools/european-credit-transfer-and-accumulation-system-ects_en

TR063: Physical Sciences - CORE MODULES

Tuition will consist of lectures, practicals and tutorials in physics at intermediate level. Lectures are given on oscillations, optics, electricity and magnetism, thermodynamics, special relativity, nuclear physics, materials physics, and astronomy. Practicals include set experiments, computational exercises and group study projects. This tuition may only be taken by students reading the appropriate elements of Senior Freshman mathematics as required in Physical Sciences.

Lectures in Physics in SF year are given in two modules, one in each semester. Students must take both modules, comprising Lectures, Laboratory Classes, Group Study Project, and Small Group Tutorials (see below).

Practical Laboratory Classes – both Semester 1 and 2 All SF students are required to attend one 3-hour laboratory session each week. A series of experiments and computational exercises are provided to illustrate some key results presented in the lecture courses. The experiments are longer than in the JF year and are designed to continue the development of personal initiative as well as experimental and computational skills. Students prepare written reports on these experiments, which are assessed during the year.

Group Study Projects – Semester 1 All students are required to investigate a given topic in Physics and present their findings in the form of a poster. Students work in groups of about five.

Small Group Tutorials – both Semester 1 and 2 Students are required to attend tutorials, which are intended to deepen their understanding of concepts taught in lectures.

Homework Problems – both Semester 1 and 2 Students are required to complete one homework set for each of four topics taught in each module. Problems are available and solutions are entered online. Lecturers provide a solution class after the homework submission deadline.

PYU22P10: Physics 1

Semester 1, 10 Credits

PYU22P10 Physics
(G. Cross, H. Zhang, S. Dooley, M. Hegner; Co-ordinator: Prof Martin Hegner)

This module combines four elements of classical physics as follows:
Thermodynamics – 15 lectures
Electricity and Magnetism II – 14 lectures
Oscillations – 12 lectures
Materials – 12 lectures

Syllabus:

- **Thermodynamics: - 15 lectures**
  Kinetic theory and the ideal gas equation. Van der Waals model for real gases. First law of thermodynamics. Internal energy, heat and work. Reversible and irreversible processes. Specific heat. Second law of thermodynamics. Heat engines, Carnot cycles. Entropy. Probability and disorder. Combined first and second laws. Central equation. H, F, G. Maxwell's relations. Energy equations. Cooling processes. Joule-Kelvin effect. Third law of thermodynamics.

- **Electricity & Magnetism II: - 14 lectures**
  Magnetism, magnetic field lines and flux; Lorentz force on moving charge; Energy of and torque on a current loop in a magnetic field; magnetic fields of moving charges; Biot-Savart Law illustrated by magnetic fields of a straight wire and circular loop; forces between current-carrying straight wires; Ampere's Law in integral form illustrated by field of a straight conductor of finite thickness. Electromagnetic induction and Faraday's Law in integral form; Lenz's Law; induced electric fields and motional emf's; summary of Maxwell equations in integral form; Mutual inductance and self-inductance; Kirchhoff rules and circuit analysis methods; Thevenin theorem; R-C and R-L circuits and R-L-C circuits; AC circuits, phasor diagrams reactance, resonance, transformers and complex representation of reactance. Power analysis. R-C integration and differentiation, R-C low- and high-pass filters and active filters.

- **Oscillations: -12 lectures**
  Review of simple harmonic motion. Forced and damped oscillations. Resonance. Two coupled oscillators, modes and normal coordinates. Many coupled oscillators. Transition to continuous systems. Examples of experimental measurements using MEMS resonators. Waves. Nonlinear behaviour. Anharmonic behaviour.

- **Materials Physics: - 12 lectures**
  Foundational molecular properties, inter and intra-molecular forces, potential energy curves, polarity, translational, rotational and vibrational degrees of freedom, heat capacity, thermal expansion and thermal conductivity. Stress, strain, shear, elastic and plastic deformations of solids. Structures of solids in crystalline, glass, plastic phases. Insulators, conductors and semiconductors. Point defects and imperfections in solids – Iron/Carbon system. Density, pressure, surface tension, buoyancy and hydrodynamic-incompressible and compressible flows in fluids. Bernoulli's equation. Viscosity, diffusion, laminar and turbulent flow. Gas laws, kinetic theory and collisions, PVT diagrams, thermal expansion, surface tension. Conductive, convective and radiative transport of heat. Stefan-Boltzmann law.

PYU22P10 Learning Outcomes:
On successful completion of this module, the students will be able to:
- Solve basic problems in relation to harmonic oscillators
- Relate the concept of oscillations to optical properties of matter and AC circuits
- Describe elementary crystal structures and the response of materials to external forces
- Describe how the laws of thermodynamics react to properties of matter
- Employ web-based research techniques in a small group project and present the results in the form of a poster
- Either prepare an extensive report detailing methodology, data gathering and interpretation of a physical experiment and obtain, pre-process, display and analyse experimental data using software packages such as Origin or analyse, modify and run Python language programs to perform computer experiments

Laboratory Classes:
Students are required to attend one 3-hour laboratory session each week. The experiments are designed to continue the development of personal initiative and experimental and computational skills. Reports on these experiments are assessed during the year.

Group Study Projects:
Students are asked to investigate a given topic in Physics and present their findings in the form of a poster. Students work in groups of about five.

Small Group Tutorials:
Students are required to attend tutorials and to complete associated homework.

Assessment	**Weighting**
Examination	60%
Experimental / Computational laboratories	25%
Project	5%
Tutorials	10%

Examination
Information about examinations will be made available on the Examination Office's website. Each module, PYU22P10 and PYU22P20, is examined in a separate 2-hour examination paper during the relevant end of semester exam session.

Web: http://www.physics.tcd.ie/

Contact Details:

Module Coordinator:		
Professor Martin Hegner		E-mail: hegnerm@tcd.ie
		Phone: 01 896 2285
Executive Officer:		
Ms. Una Dowling		E-mail: dowlingu@tcd.ie
		Phone: 01 896 1675

PYU22P20: Physics 2

Semester 2, 10 Credits

PYU22P20 Physics

(C Patterson, M Stamenova, A Vidotto, D McCloskey: Co-ordinator: Prof David McCloskey)

This module combines four elements of modern physics as follows:

Special Relativity – 12 lectures
Nuclear and Particle Physics – 14 lectures
Astrophysics – 12 lectures
Waves and Optics II – 14 lectures

Syllabus:

- **Special relativity: - 12 lectures**
  Frames of reference and relativity principles. The Michelson-Morley experiment. Einstein's postulates. Simultaneity. The Lorentz transformations. The Fitzgerald-Lorentz contraction. Time dilation. Transformation of velocities. Relativistic dynamics - mass, energy and momentum.

- **Nuclear & Particle Physics: - 14 lectures**
  Models of the atom. Rutherford scattering. Cross-sections. Nucleons. Nuclear force. Nuclear binding. Nuclear masses. Mass defect. Mass dependence of binding energy per nucleon. Beta decay. Electron, positron emission. Electron capture. Decay chains. Alpha decay. Heavy element decay chains. Barrier penetration mechanism. Gamma decay. Radioactive decay law. Analysis of parent-daughter activity relationships. Nuclear fission. Liquid drop model. Fission products. Induced fission. Nuclear reactors. Neutron moderation. Control and delayed neutrons. Reactor types. Environmental and other concerns. Fuel cycle. Nuclear fusion. Fusion reactors. Fundamental particles, Bosons and Fermions, Leptons and Hadrons, Mesons and Baryons, Quarks. Particle interactions and conservation laws. The Standard model of particle physics.

- **Astrophysics: - 12 lectures**
  Continuous radiation of stars: flux, luminosity, magnitudes, colours. Spectral lines in stars: spectral classification, origin of spectral lines, the Hertzsprung-Russell diagram. Basic nucleosynthesis and stellar equilibrium. Life and death of stars: stellar evolution, end stages of stellar evolution, planetary nebulae, white dwarfs, supernovae, neutron stars and black holes. Close binary evolution: mass transfer, supernova Type Ia, gravitational waves. Interstellar medium. Star formation: gravitational collapse, initial mass function. Galaxies and galaxy clusters: Milk Way, galactic rotation, dark matter, galaxy classification, distribution of galaxies, expansion of the Universe, galaxy clusters, active galaxies. Cosmology and the early Universe: gravitational lensing, cosmology, the evolution of the universe, dark energy, big bang theory.

- **Waves & Optics II: - 14 lectures**
  Maxwell equations in differential form. Coulomb's and Gauss' Laws; Biot-Savart and Ampere's Laws; absence of magnetic monopoles; Faraday’s Law and magnetic induction. Electric dipoles, dielectric polarisation and dielectric susceptibility; magnetic dipoles, magnetisation and diamagnetic susceptibility; continuity equation, displacement current and Maxwell’s generalisation of Ampere’s Law. Electromagnetic waves in vacuum and isotropic matter. Energy density in time-varying electromagnetic fields and Poynting vector. Reflection,

refraction, plane, circular and elliptic polarisation of light; dichroism, birefringence; interference, interferometers, coherence, Young's slits, near and far field diffraction.

PYU22P20 Learning Outcomes:

On successful completion of this module, the students will be able to:

- Describe how modern physics is underpinned by nuclear and particle physics; waves and optics
- Express relativistic effects as observed in different inertial reference frames
- Explain a broad variety of astrophysical phenomena with simple physics
- Prepare calculations and present in small groups
- Analyse, modify and run Python language programs to perform computer experiments
- Obtain, pre-process, display and analyse (fit to analytical models) actual experimental data using software packages such as Origin

Laboratory Classes:

Students are required to attend one 3-hour laboratory session each week. The experiments are designed to continue the development of personal initiative and experimental and computational skills. Reports on these experiments are assessed during the year.

Small Group Tutorials:

Students are required to attend tutorials and to complete associated homework.

Assessment	**Weighting**
Examination	60%
Experimental / Computational laboratories	30%
Tutorials	10%

Examination

Information about examinations will be made available on the Examination Office's website. Each module, PYU22P10 and PYU22P20, is examined in a separate 2-hour examination paper during the relevant end of semester exam session.

Web: http://www.physics.tcd.ie/

Contact Details:

Module Coordinator:		
Professor David McCloskey		E-mail: dmcclosk@tcd.ie
		Phone: 01 896 1148
Executive Officer:		
Ms Una Dowling		E-mail: dowlingu@tcd.ie
		Phone: 01 896 1675

MAU22S01: Multivariable calculus for science

Semester 1, 5 credits

Contact Hours

11 weeks, 3 lectures including tutorials per week

Lecturer

Prof Miriam Logan (t.b.c.)

Learning Outcomes

On successful completion of this module, students will be able to:

- Write equations of planes, lines and quadric surfaces in the 3-space;
- Determine the type of conic section and write change of coordinates turning a quadratic equation into its standard form;
- Use cylindrical and spherical coordinate systems;
- Write equations of a tangent line, compute unit tangent, normal and binormal vectors and curvature at a given point on a parametic curve; compute the length of a portion of a curve;
- Apply above concepts to describe motion of a particle in the space;
- Calculate limits and partial derivatives of functions of several variables
- Write local linear and quadratic approximations of a function of several variables, write equation of the plane tangent to its graph at a given point;
- Compute directional derivatives and determine the direction of maximal growth of a function using its gradient vector;
- Use the method of Lagrange multipliers to find local maxima and minima of a function;
- Compute double and triple integrals by application of Fubini's theorem or use change of variables;
- Use integrals to find quantities defined via integration in a number of contexts (such as average, area, volume, mass)

Module Content

- Vector-Valued Functions and Space Curves;
- Polar, Cylindrical and Spherical Coordinates;
- Quadric Surfaces and Their Plane Sections;
- Functions of Several Variables, Partial Derivatives;
- Tangent Planes and Linear Approximations;
- Directional Derivatives and the Gradient Vector;
- Maxima and Minima, Lagrange Multipliers;
- Double Integrals Over Rectangles and over General Regions
- Double Integrals in Cylindrical and Spherical Coordinates;
- Triple Integrals in Cylindrical and Spherical Coordinates;
- Change of Variables, Jacobians

Module Prerequisite

MAU11S01 & MAU11S02

Recommended Reading
Calculus. Late trancendentals. by H.Anton, I.Bivens, S. Davies
Multivariable Calculus 7th ed. Early Transcendentals by James Stewart

Assessment Detail
This module will be examined in a 2 hour **examination** in Michalmas term. **Continuous assessment** will contribute 20% to the final grade for the module at the annual examination.

Contact Details:

Module Coordinator: MAU22S01		
Professor Miriam Logan		E-mail: loganmi@tcd.ie
		Phone: 01 896 1211
Executive Officer:		
Ms Emma Clancy		E-mail: clancyem@maths.tcd.ie
		Phone: 01 896 1949

MAU22S03: Fourier analysis for Science

Semester 1, 5 Credits

Contact Hours

11 weeks. There are 3 lectures per week, which do not include tutorials. Tutorials are separate, and tutorial attendance is mandatory for continuous assessment purposes. These tutorials will last 1 hour per week.

Lecturer

Dr Anthony Brown

Learning Outcomes

- Calculate and interpret the real and complex Fourier series of a given periodic function;
- Obtain and interpret the Fourier transform of non-periodic functions;
- Evaluate integrals containing the Dirac Delta;
- Solve ordinary differential equations with constant coefficients of first or second order, both homogenous and inhomogenous;
- Obtain series solutions (including Frobenius method) to ordinary differential equations of first or second order;
- apply their knowledge to the sciences where relevant.

Module Content

- Vector spaces and inner products of functions
- Fourier series
- Fourier transform
- Dirac delta function
- Applications of Fourier analysis
- Ordinary differential equations (ODE)
- Exact solutions of 1st and 2nd order ODE
- Series solutions of ODE and the Frobenius method

Module Prerequisite

MAU11S01 & MAU11S02, co-requisite MAU22S01

Suggested Reference

Advanced Engineering Mathematics, E. Kreyszig in collaboration with H. Kreyszig, E. J. Norminton; Wiley (Hamilton 510.24 L21*9)

Assessment Detail

This module will be examined in a 2 hour **examination** in Michaelmas term. Continuous Assessment will contribute 20% to the final annual grade, with the examination counting for the remaining 80%.

Contact Details:

Module Coordinator: MAU22S03: Fourier analysis for Science		
Dr Anthony Brown		E-mail: Anthony.brown@ucd.ie
		Phone: 01 896 8491
Administrative Officer:		E-mail: clancyem@maths.tcd.ie
Ms Emma Clancy		Phone: 01 896 1949

MAU22S02: Vector calculus for science

Semester 2, 5 Credits

Contact Hours

11 weeks, 3 lectures including tutorials per week

Lecturer

Dr. Joe Ó hÓgáin (t.c.b.)

Learning Outcomes

On successful completion of this module, students will be able to:

- Manipulate vectors in R^3 to evaluate dot products and cross products and investigate if vectors are linearly independent;
- Understand the concepts of vector fields, conservative vector fields, curves and surfaces in R^3;
- Find the equation of normal lines and tangent planes to surfaces in R^3;
- Evaluate line integrals and surface integrals from the definitions;
- Use Green's Theorem to evaluate line integrals in the plane and use the Divergence Theorem (Gauss's Theorem) to evaluate surface integrals;
- Apply Stokes's Theorem to evaluate line integrals and surface integrals;
- Solve first order PDEs using the method of characteristics and solve second order PDEs using separation of variables;

Module Content

- Vector algebra in R^3. Vector fields, curves and surfaces in R^3.
- Theorems of Green, Stokes and Gauss.
- PDEs of first and second order

Module Prerequisite

MAU22S01

Assessment Detail

This module will be examined in a 2 hour **examination** in Trinity term.
Continuous assessment will contribute 20% to the final grade for the module at the annual examination session.

Contact Details:

Module Coordinator: MAU22S02: Vector calculus for Science		
Professor Joe Ó hÓgáin		E-mail: johog@maths.tcd.ie
		Phone: 01 896 1949
Executive Officer:		
Ms Emma Clancy		E-mail: clancyem@maths.tcd.ie
		Phone: 01 896 1949

PIU22992: History, Philosophy and Ethics of Science

Semester 2, 5 credits

Contact Hours:
20 hours of lectures + 10 hours of tutorials

Module Personnel: Prof. Alison Fernandes (Philosophy) & Prof. Linda Hogan (Ecumenics)

Science looks to be our best hope of discovering the way the world is. We use it to predict climate change, map the human genome and identify the Higgs boson. Science seems to give us an objective view on the world. How does it manage to do this? Does it succeed in its aims? How can we tell? This course will examine the workings of science through four core topics: how we reason to science, how scientific theories explain, the role of values in science, and what scientific theories tell us about the world.

Module Learning Outcomes
On successful completion of this module students will be able to:

- Think critically about philosophical problems and their relevance for scientific practice.
- Communicate ideas effectively to others, both in discussion and in writing.
- Reflect on the aims and methodology of science, in ways that facilitate ongoing exploration of scientific practice.
- Demonstrate awareness of ethical issues that arise in scientific practice, and of the role of the individual and communities in upholding ethical standards.

Module content: Programme of Lectures and Tutorials

Week	Lecture Topic	Lecturer
1	What is Science?	Prof Fernandes
	The Demarcation Problem	Prof Fernandes
2	Early History and the Scientific Revolution	Prof Fernandes
	Justifying Theories in Science	Prof Fernandes
	Tutorial: What is Science?	
3	The Problem of Induction	Prof Fernandes
	The Problems of Confirmation	Prof Fernandes
	Tutorial: Justifying Theories in Science	
4	Falsificationism	Prof Fernandes
	Probabilities in Confirmation	Prof Fernandes
	Tutorial: Problems of Induction and Confirmation	
5	What is Explanation?	Prof Fernandes
	Problems for Law-based Accounts of Explanation	Prof Fernandes
	Tutorial: Alternative Approaches to Confirmation	
6	Causal Accounts of Explanation	Prof Fernandes
	Explanation and Understanding	Prof Fernandes
	Tutorial: Law-based and Causal Accounts of Explanation	
7	**Reading Week**	
8	Trust in Science: Why Ethics Matters	

	What Makes Something Ethical? Ends and Means	
	Tutorial: Ethics in Science	
9	What Makes Something Ethical? Duties and Virtues	
	From Principle to Practice: Navigating the Ethics Ecosystem	
	Tutorial: Accounts of Ethics in Science	
10	Epistemic Values in Science	Prof Fernandes
	Non-epistemic Values in Science	Prof Fernandes
	Tutorial: Values in Science	
11	The Aims of Science: Scientific Realism	Prof Fernandes
	The No-Miracles Argument for Scientific Realism	Prof Fernandes
	Tutorial: Scientific Realism	
12	The Aims of Science: Scientific Anti-Realism	Prof Fernandes
	Module review	Prof Fernandes
	Tutorial: Scientific Anti-Realism	
13	**Revision Week** **Open MCQ**	
14	**Assessment Week**	

Lecture Content and Assessment Schedule

W1L1: What is Science?
Introduction to the module. What is science? What does it aim to achieve?

W1L2: The Demarcation Problem
Contemporary attempts to demarcate science from non-science. Popper's approach to demarcation. The aims and methods of science.

W2L1: Early History and the Scientific Revolution
The early practice of science, including the use of mathematics and geometry in pursuit of explanation and prediction. How the Scientific Revolution changed the practice of science, with a focus on experimentation.

W2L2: Justifying Theories in Science
The distinction between two forms of inference: deduction and induction. How do observations of past behaviour constrain our predictions about future behaviour?
W3L1: The Problem of Induction
Can induction be justified? Hume's 'Problem of Induction'.

W3L2: The Problems of Confirmation
Two problems with how theories are 'confirmed' by evidence: Goodman's 'New Riddle of Induction' and Hempel's 'Ravens Paradox'. What do we learn about the confirmation of scientific theories by the problems raised for them? Contextual accounts of scientific confirmation.

<End of material for Response 1. Response 1 due end of Week 4.>

W4L1: Falsificationism
Popper's deductive scientific method (conjecture and refutation), which claims that science can do without induction and rely instead on deduction. Criticisms of Popper from Quine and Duhem.

W4L2: Probabilities in Confirmation
Attempts to use probabilities to account for theory confirmation: Bayesian approaches to theory confirmation.

W5L1: What is Explanation?
How does science provide understanding? Law-based models of scientific explanation: Hempel's 'Deductive-Nomological Model' of Explanation.

W5L2: Problems for Law-based Accounts of Explanation
Problems for law-based accounts of explanation. The role of laws and probability in explanation. The case of the flagpole and the shadow: the 'Asymmetry Problem'.

W6L1: Causal Accounts of Explanation
Does causal information explain phenomena? What causal information is relevant?

W6L2: Explanation and Understanding
How do explanations provide understanding? Causal and unificationist accounts of understanding.

<End of material for Response 2. Response 2 due beginning of Week 8.>

W8L1: Trust in Science: Why Ethics Matters
This lecture considers the role ethics plays in the creation and maintenance of a culture of trust in science, looking specifically at issues of integrity, transparency, autonomy and accountability.

W8L2: What Makes Something Ethical? Ends and Means
This lecture considers some approaches to ethics and ethical reasoning, namely, Ends and Means, and assesses their relevance and persuasiveness in the context of a range of examples from science.

W9L1: What Makes Something Ethical? Duties and Virtues
This lecture considers some approaches to ethics and ethical reasoning, namely, Duties and Virtues, and assesses their relevance and persuasiveness in the context of a range of examples from science.

W9L2: From Principle to Practice: Navigating the Ethics Ecosystem
This lecture examines how institutional cultures affect individual decision-making, whether that be in the context of the university lab or the professional work environment. Topics for consideration will include ethical blind-spots, group-think, ethical fading and the question of whistle-blowing.

W10L1: Epistemic Values in Science
What 'epistemic' values are in play in the practice of science? Kuhn's approach to 'paradigms' and the distinction between normal and revolutionary science.

W10L2: Non-epistemic Values in Science
Do other (non-epistemic) values play a role in science? Should we aim for science to be value-free? Does the role of values in science compromise the objectivity of science?

W11L1: The Aims of Science: Scientific Realism
What do scientific theories aim to achieve? Can they provide us with an objective *description* of reality? Do they *correspond* with reality?

W11L2: The No-Miracles Argument for Scientific Realism
What explains the success of scientific theories? Must we be 'realists' about science in order to explain their success?

W12L1: Alternative Approaches to the Aims of Science
What makes a scientific theory objective? Can scientific theories depend on our interests? Can scientific theories be mere instruments for making predictions, rather than descriptions of reality?

W12L2: Module Review

<End of material for Response 3. Response 3 due beginning of Week 13.>

Recommended Reading List

Introductory reading:
Lewens, T. (2016) *The Meaning of Science*. Penguin.
Chalmers, A. (2013) *What is this Thing Called Science?* Hackett Publishing.

Full reading list: See Module Syllabus on Blackboard.

Assessment Details:
3 Written Responses of 750 words (1–2 pages) (25% each)
7 Discussion Posts (15%)
Attendance (10%)

Module Website (See Blackboard)

Module Coordinator: PIU22992: History, Philosophy and Ethics of Science		
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TR063: Physical Sciences – OPEN Modules

BYU22201: From Molecules to Cells II

Semester 1, 10 credits

Prerequisite: BYU11101

Module coordinator: Prof Emma Creagh, ecreagh@tcd.ie Phone: 01 8962539

Contact Hours: 35 hours lectures, 21 hours practicals

Module Personnel: E. Creagh, K. Mok, N. Nic a' Bháird, J. Hayes, D. Nolan, R. Porter, M. Ramaswami, S. Martin, M. Campbell, K. Roberts.

Learning Aims:
This module aims to give students a detailed understanding of cellular structure, composition and function. The molecular composition of organelles, the processes carried out in each organelle, and how these processes are integrated in cellular function are presented in detail. Students are also introduced to enzyme kinetics; cellular metabolism; DNA structure and replication, transcription, and translation; the regulation of gene expression; Mendelian inheritance and genetic disease. This module also introduces students to virology – how viruses replicate, mutate, enter cells and take over cellular processes during infection.

Module content:
Programme of lectures and practicals: four lectures a week, Monday at 13:00, Wednesday at 17:00, Friday at 9:00 and 12:00, practicals Tuesday or Wednesday

Lecture Topic	Lecturer	Practical
Introduction to Module BYU22201 “From Molecules to Cells”	Prof Creagh	Practical 1. Solutions & Dilutions
Cell structure & intracellular transport	Prof Creagh	
Cell cytoskeleton I	Prof Creagh	
Cell cytoskeleton II	Prof Creagh	
Proteins & amino acids	Prof Mok	Practical 2. Spectrophotometry & Chromatography
Protein folding and purification	Prof Mok	
Oxygen binding proteins	Prof Mok	
Enzymes, catalysis and assays	Dr Nic a' Bháird	
Enzyme kinetics, inhibition & regulation	Dr Nic a' Bháird	
Enzymes – online Q&A session	Dr Nic a' Bháird	
Lipids - fatty acids & phospholipids	Prof Hayes	
Lipids – beta-oxidation & fatty acid synthesis	Prof Hayes	
Powering Life: energy transduction & life	Prof Nolan	

Bioenergetics 1: oxidative phosphorylation	Prof Nolan	Practical 3. Enzyme Kinetics
Bioenergetics 2: the universality of chemiosmosis	Prof Nolan	
Harvesting the light: photosynthesis	Prof Nolan	
Glycolysis	Prof Porter	
Gluconeogenesis	Prof Porter	Practical 4. Oxidative Phosphorylation
TCA cycle	Prof Porter	
Glycogen biosynthesis & degradation	Prof Porter	
Summary & integration of metabolism	Prof Nolan	
DNA – structure, replication, repair, recombination I	Prof Ramaswami	
DNA – structure, replication, repair, recombination II	Prof Ramaswami	
Reading Week - Lecture MCQ 1		
DNA – structure, replication, repair, recombination III	Prof Ramaswami	Practical 5. Gene Analysis I
Transcription – RNA types, mRNA processing	Prof Ramaswami	
Transcription – RNA types, mRNA processing	Prof Ramaswami	
Regulation of gene expression: general principles	Prof Martin	Practical 6. Gene Analysis II
Gene expression in prokaryotes and eukaryotes	Prof Martin	
Chromatin and epigenetic effects on gene expression	Prof Martin	
Alternative splicing and protein translation	Prof Martin	
Mendelian inheritance	Prof Campbell	Practical 7. Assessment of Genetic Variation through Computational Analysis
Mapping Mendelian traits	Prof Campbell	
Quantitative traits and heritability	Prof Campbell	
Genetics of common diseases	Prof Campbell	
Virology: genetic diversity of viruses	Prof Roberts	
Virology: replication cycle 1- from entry to transcription	Prof Roberts	
Virology: replication cycle 2- from translation to virion formation & release	Prof Roberts	
Virology: emerging viruses – mutation, adaptation & transmission	Prof Roberts	
Revision Week Lecture MCQ 2		

Lecture Content:

- Introduction to the BYU22201 Module 'from Molecules to Cells'
- Revision of Cell structure (Podcast), Membrane structure & Intracellular protein transport mechanisms. (Elements Flipped classroom)
- Cellular cytoskeleton I (Actin filaments, myosin motor protein) (combination of flipped classroom & traditional lectures material) - Principles of cellular movement & the process of muscle contraction.
- Cellular cytoskeleton II – Importance of Microtubules & Intermediate filaments for cellular function (combination of flipped classroom & traditional lectures material). Specialised microtubules involved in the motility of cilia/flagella will be discussed.

- What are proteins? The 20 amino acids and their structures and properties, acid-base equilibria, the isoelectric point. (Combined flipped classroom and traditional lectures) The polypeptide chain and general properties of proteins. The hierarchy of protein structure (primary / secondary / tertiary / quaternary structures).
- Protein folding and protein misfolding diseases / neurodegenerative diseases. Protein purification and protein characterization techniques.
- Oxygen-binding proteins as an example of protein-ligand binding. Comparison of myoglobin and haemoglobin. Cooperativity. Bis-phosphoglycerate's role in oxygen affinity. Sickle cell anaemia.

- Catalysis and the enzyme substrate relationship; Activation energy and the transition state. Michaelis-Menten kinetics; The active site- physicochemical properties; Enzyme assays.
- Principles of enzyme catalysis; Mechanisms of catalysis with examples; Reversible Inhibition; Allosteric regulation; Enzyme inhibitors as drugs Michaelis-Menten kinetics, limiting velocity, rate/enzyme correlation (in class activity supported by podcasts). Reversible inhibition and allosteric regulation. *Material covered in Enzyme lectures 1 & 2 will be reinforced with an online Q&A session.*

- Lipids-Fatty Acids and phospholipids. What are lipids? Chemical and functional properties of diverse lipids such as steroid hormones, fat soluble vitamins and ketone bodies. Fatty acids, phospholipids and membranes.
- Lipids- β-oxidation and fatty acid synthesis. Energy production through the mobilisation of fatty acids from triacylglycerols and their oxidation in mitochondria. Energy storage through the synthesis of fatty acids and storage of triacylglycerols in adipocytes.

- Powering Life: Energy transduction & life. Introduction to basics: energy transduction in biological systems: concept of displacement from equilibrium, chemical potential, electrochemical potential and redox potentials. ATP and energy coupling: key concepts: Is ATP a high energy compound?
- Bioenergetics 1: Oxidative Phosphorylation. The machinery of oxidative phosphorylation: The electron transport chain and the universal turbine of life: the F_1F_0-ATPase.
- Bioenergetics 2: The Chemiosmotic view of Life and the universality of the concept.
- Harvesting the light: Photosynthesis. The light reactions of photosynthesis: photophosphorylation, the Z scheme, PSI & II and C_1C_0-ATPase. A comparison of oxidative and photo phosphorylation.

- Catabolism and anabolism. Sources of sugars in our diet. Glycolysis, its control and regulation. Catabolism of fructose and galactose. Fermentation.

- The necessity for gluconeogenesis. Its control and regulation. Substrate sources. Reciprocal control of gluconeogenesis and glycolysis in liver.
- Pyruvate dehydrogenase and control of regulation of oxidative catabolism of substrates via the tricarboxylic acid (TCA) cycle. The TCA cycle as a source of biogenic amines. The TCA cycle as a source of anabolic substrates. Anapleurotic reactions.
- What is glycogen? Breakdown of glycogen/glycogenolysis in liver and skeletal muscle. Its control and regulation. Flight or fight! The effect of starvation. Glycogen biosynthesis.
- Summary & Integration of Metabolism

- DNA – Structure, Replication, Repair, Recombination I. Discovery of DNA as the genetic material; structure, properties and conformation(s) of DNA; mechanism for DNA replication in prokaryotes and eukaryotes: DNA polymerases and the replisome.
- DNA - Structure, Replication, Repair, Recombination II. The role of telomeres in DNA replication in eukaryotes. Spontaneous and induced mutations; mutagens and the effects of mutations.
- DNA - Structure, Replication, Repair, Recombination III. DNA repair mechanisms; non-homologous end joining and homologous recombination.

- Transcription - RNA types and processing I. Discovery of RNA; properties and classes of RNAs; types of RNA polymerases; transcription in prokaryotes: initiation, elongation and termination.
- Transcription - RNA types and processing II. Types of RNA polymerases; transcription in eukaryotes: initiation, elongation and termination.
- Regulation of gene expression. The general principles of the regulation of gene expression in prokaryotes and eukaryotes.
- Gene expression in prokaryotes and eukaryotes. Mechanisms of the regulation of gene expression in prokaryotes and eukaryotes: promoters. Sigma factors, transcription factors, enhancers, silencers, insulators
- Chromatin and epigenetic effects on gene expression. Introduction to epigenetics; structure and composition of chromatin; histone and DNA modifications and their effects on chromatin and gene expression.
- Alternative splicing – protein translation. Mechanisms of alternative splicing. Initiation, elongation and termination of translation

- Mendelian Inheritance. Mendel's laws (revision of BYU11101) and molecular basis of inheritance patterns; pedigree analysis; gene interactions: dominance, co-dominance, incomplete dominance, recessivity, penetrance, expressivity, and epistasis.
- Mapping Mendelian traits: This lecture outlines the historical methods that were used to identify mutations in genes associated with Mendelian diseases. It highlights the methodology and underlying analysis with a focus on linkage and recombination.
- Quantitative traits and heritability: This lecture will focus on more complex traits, somatic mutations and heritability and how they pertain to human disease. The lecture uses examples of conditions such as breast cancer to describe the identification of genes that ascribe relative risk scores to disease.
- Genetics of common diseases: This lecture focuses on giving a wide range of examples of human disease that show Mendelian and non-mendelian modes of inheritance. It aims to give the student a broad understanding of the complexities of these diseases and the underlying genetic causes.

- Virology: genetic diversity of viruses. The diversity of viral genomes and particle structures will be explored in this lecture.
- Virology: Replication cycle 1 – from entry to transcription. In this lecture we will compare how different viruses enter cells and a range of viral strategies for producing mRNA.

- Virology: Replication cycle 2 – from translation to virion formation and release. In this lecture we will explore how the location within the cell of viral genome replication and assembly of new virions is dependent on the cellular processes a virus needs to utilise during replication.
- Virology: Emerging viruses – mutation, adaptation and transmission. In this lecture we will discuss a range of viruses causing emerging infections and explore how their replication cycles changed to adapt to new hosts or cell types.

Practical Content:
Practical 1 - Solutions & dilutions – This numerical skills tutorial will prepare students for numerical calculations relevant for lab work (eg. Calculating molarites, how to make up buffers, dilution factors, *etc*.).
Practical 2 - Chromatography & spectrophotometry – During this practical students will perform (1) **Gel filtration chromatography**: oxidised sheep's blood is used to observe colour changes (methaemoglobin-haemoglobin-oxyhaemoglobin); and **(2) a spectrophotomeric enzyme assay**: increasing alcohol dehydrogenase (ADH) concentrations will be assayed - measuring the spectrophotometric production of NADH as the readout.
Practical 3 – Enzyme Kinetics - Students perform a stopped enzyme assay, using increasing substrate and inhibitor concentrations. They calculate the final concentrations in the assay, calculate Km and Vmax for uninhibited series, use Lineweaver-Burk plots to demonstrate competitive inhibition, and determine the Ki.
Practical 4 – Oxidative phosphorylation. Students will measure the P:O ratio of succinate and glutamate/malate; measure respiratory control ratios; inhibit Complexes I/III using rotenone/Antimycin A; uncouple mitochondria using DNP and inhibit ATP synthase using oligomycin.
Practicals 5 and 6: DNA analysis
Practical 7: Assessment of Genetic Variation through Computational Analysis
Introduction to Bioinformatics; accessing and retrieving DNA sequence information from *Genbank*; comparison of homologous gene sequences using *BLAST*; identification of polymorphisms.

Learning Outcomes:
On completion of this module students should be able to demonstrate an understanding of fundamental concepts in the following cellular structures and processes: the structure and function of cells and organelles; structures and functions of nucleic acids, proteins, carbohydrates and lipids; the fundamental concepts and regulation of metabolism; the composition, structure, synthesis and function of DNA and RNA; regulation of gene expression in prokaryotes and eukaryotes; chromatin structure and epigenetic regulation of gene expression; the principles of genetic inheritance; genetic diseases and fundamental concepts in virology.

Recommended Reading List:
The topics and concepts presented in this module will be found in many general textbooks on cell biology, biochemistry and genetics. The following are recommended for your guidance:

Essential Cell Biology. Alberts, Hopkin, Johnson, David Morgan, Raff, Roberts, Walter. (4^{th} / 5^{th} Editions). W. W. Norton & Company.
Biochemistry. Berg, Tymoczko, Gatto, Stryer (8^{th} edition). Macmillan International.
Introduction to Genetic Analysis. Griffiths, Wessler, Carroll, Doebley (11^{th} edition). W.H. Freeman and Co.

Assessment Details:
(A) **End of semester written examination: 50% of module mark**
Exam is comprised of:
- 25%: 10 short answer questions, testing understanding of concepts and deduction.

- 25%: 1 essay-type question from a choice of 3 questions on paper

(B) **Two MCQ tests: 15% of module mark,** testing knowledge of lecture content

(C) **Practical write-ups/assessments: 35% of module mark.**

Contacts:

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Biology Course Coordinator: Glynis Robinson, **robinsog@tcd.ie,** Phone: 01 8962895

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Executive Officer: Helen Sherwin-Murray btcadmin@tcd.ie, Phone: 01 8961117

BYU22202: From Cells to Organisms

Semester 2, 10 credits

Prerequisite: BYU11101

Module coordinator: Prof Colm Cunningham, colm.cunningham@tcd.ie, Phone: 01 8963964

Contact Hours: 39 hours lectures, 12 hours practicals

Module Personnel: C. Cunningham, M. Martins, C. Dorman, D. Zisterer, R. Rolfe, Á. Kelly, T. Ryan, A. Witney

Learning Aims:
This module aims to bring the student from the functioning of prokaryotic unicellular organisms right up to the integrated functioning of perceiving, thinking and acting multicellular organisms. The module will give the students an appreciation of the highly specialised and dynamic communication between cells and tissues that brings about the functioning organism.

Module content:
Programme of lectures and practicals, four lectures a week, Monday at 9:00, Tuesday at 9:00 and 13:00, Wednesday at 17:00, practicals on alternate Wednesday

Lecture Topic	Lecturer	Practical
Introduction to BYU22202 "from Cells to Organisms"	Prof Cunningham	**Practical 1.** Adherence & the induction of bacterial gene expression Carsten Kroger
The bacterial world: diversity & unique extracellular structures	Prof Martins	
Energy, transport and scavenging in bacteria	Prof Dorman	
Motility and chemotaxis in bacteria	Prof Dorman	
Cell:cell communication & bacterial development	Prof Dorman	
How bacteria 'stand still'. Bacterial attachment	Prof Martins	
Bacterial interactions with eukaryotic cells	Prof Martins	
Cell:cell communication; autocrine, juxtacrine, paracrine & endocrine signalling	Prof Cunningham	
Cargo packaging for export	Prof Cunningham	**Practical 2.** Resting membrane and action potential Colm Cunningham
Calcium-dependent exocytosis for signal release	Prof Cunningham	
Signalling at ligand-gated ion channels	Prof Cunningham	
Conserved components of intracellular signal-transduction	Prof Zisterer	
G-protein coupled receptors, cAMP, PKA, integration	Prof Zisterer	

Receptor Tyrosine Kinases, MAP kinases	Prof Zisterer	
Crosstalk between pathways, conservation between organisms	Prof Zisterer	
Organising a body plan in multicellular organisms	Prof Rolfe	
Cell signaling/cell communication in the context of development	Prof Rolfe	Practical 3. Development Rebecca Rolfe
Elaboration of positional information/progressive specification/cell lineage analysis	Prof Rolfe	
How a cell responds to positional information	Prof Rolfe	
Evolution/Development –body plan changes through evolution	Prof Rolfe	
Organogenesis	Prof Rolfe	
Revision/integration lecture		
Nervous control of physiological function	Prof Kelly	
Neuropharmacology	Prof Kelly	
Reading Week Lecture MCQ 1		
Muscle physiology	Prof Kelly	Practical 4. Cardiovascular physiology Áine Kelly
Endocrine regulation of physiological function	Prof Kelly	
Fundamentals of cardiovascular & respiratory physiology	Prof Kelly	
Fundamentals of cardiovascular & renal physiology	Prof Kelly	
Pathophysiology and treatment of hypertension	Prof Kelly	
Digestion & metabolism, metabolic syndrome, gut-brain axis	Prof Kelly	
The immune system and its influence on homeostasis	TBA	
Integration of nervous, endocrine and immune regulation of Physiology; Importance in pathophysiology.	Prof Kelly	
Sensation and perception	Prof Witney	
Nociception and pain	Prof Witney	
Motor control	Prof Witney	
Emotion and motivation	Prof Ryan	

Learning and memory	Prof Ryan	
Understanding brain function through pathology/disease	Prof Ryan	
Summary - Revision/integration lecture **Lecture MCQ 2**	Prof Cunningham	

Lecture Content:

Unicellular to multicellular life

- Examples of signalling molecules released by bacteria and their effects on individual cells and populations
- Quorum sensing as a method of communication between bacteria within a population
- Regulatory and physiological adaptations to stress in bacteria
- ATP synthesis and the generation of proton motive force in bacteria
- Nutrient uptake mechanisms and transporters in bacteria
- Motility and chemotaxis in bacteria
- Extracellular structures such as fimbriae, capsules and S-layers and their role in adaptation to the environment
- Mechanisms employed by bacteria to attach to and interact with eukaryotic cells

Cell-cell communication & Signal Transduction

- The basic mechanisms of cell-cell communication including juxtacrine, autocrine, paracrine & endocrine signaling. From gap junctions and plasmodesmata (metabolic or electrical coupling), to contact-dependent signaling, neurotransmitter release at short range to hormone release at long range
- Packaging of cargo for export: protein synthesis and export via the trans-golgi network and the secretory pathway versus vesicular transporter-mediated packaging of synaptic vesicles (with provision of online resources)
- Neurotransmission as a specialized form of calcium-dependent exocytosis. Resting membrane potential and depolarization, the action potential, voltage-dependent calcium channels (with provision of online resources).
- Signalling via ligand-gated ion channels: neurotransmitter binding and gating of ion channels. Acetylcholine and end plate potentials at the neuromuscular junction. Glutamate and GABA receptors, excitation and inhibition.
- Highly conserved components of intracellular signal-transduction pathways-G proteins used as on/off molecular switches; protein kinases/phosphatases employed in virtually all signalling pathways; second messengers carry and amplify signals from many receptors. Concept of crosstalk between signalling pathways. Signal termination.
- General elements of G protein coupled receptor systems. GPCRs that activate or inhibit adenylyl cyclase. GPCRs that activate phospholipase C. Mechanisms that downregulate signalling from GPCRs. Integrating responses of cells to environmental influences.
- Receptor tyrosine kinases (e.g. EGF). Activation of ras and MAPK pathways. The role of protein binding domains in the specific interactions between signalling molecules. Pathways that involve signal-induced protein cleavage (e.g. Notch/Delta signalling).
- Signalling networks that respond to changes in nutrient and energy status of cell (e.g. SnRK1 and TOR kinases in plants). Signalling pathway conservation between organisms. Defects in signalling pathways leading to disease with emphasis on cancer.

Development

- **Organising a body plan in multicellular organisms:** The concepts of multicellular life and how an organized body plan, composed of different cell types and tissues, is established. Examples of relatively simple (hydra) organisms to the most complex (examples of drosophila, mouse, human and others) will be used. Fundamental similarities and differences in the organisation of animals and plants will be covered. Molecular and biophysical mechanisms governing cellular behaviour will be discussed.
- **Cell signalling/cell communication in the context of development**. Cell communication is fundamental to building an organized body plan. The main developmental signalling pathways (Wnt, BMP, Hedgehog, FGF, YAP/hippo etc) will be introduced with examples of how they guide development. Pathway conservation and elaboration through evolution related to developmental complexity will be examined.
- **Elaboration of positional information over time.** Exploration of key concepts, moving from the "French flag model" to more sophisticated ways of thinking. The concept of gradients and graded influence across tissues. Progressive specification and how information builds over developmental time. Cell lineage analysis and tracing a cell through time. Stem cells and how stem cell niches are established during development
- **How a cell responds to positional information**. Transcriptional and post-transcriptional regulation leading to cellular differentiation. The integration of different types of information at the cellular level determining how a cell responds. The importance of the cellular context and epigenetics. Hox genes and how they relate to positional information – the concept of a positional code. Mutations that change the body plan.
- **Evolution & Development**: How body plans can change through evolution. The concept of "the Toolkit" for building an organism and "tinkering with the toolkit" – genetic changes that can lead to major body plan shifts such as loss of limbs or acquisition of specialised structures such as a turtle shell.
- **Organogenesis**: Development of organ and organ systems; e.g. heart, kidney, lung etc. building on the concepts and mechanisms involved in building complex structures, current knowledge on how specific organs are established will be presented and explained.

Human physiology

- Nervous control of physiological function: sensory and autonomic nerves. CVS as model system.
- Muscle function and its nervous control. Disorders of skeletal muscle, cardiac hypertrophy (physiological via exercise & pregnancy; pathophysiological via hypertension)
- Neuropharmacology, with specific emphasis on pharmacology of the autonomic nervous system; effect of toxins on neuromuscular junction
- Endocrine regulation of physiological function, highlighting endocrine disorders.
- Fundamentals of cardiovascular and respiratory physiology and their interaction (homeostatic responses to altitude, exercise)
- Fundamentals of cardiovascular and renal physiology and their interaction (regulation of blood pressure and volume, acid-base balance)
- Pathophysiology and treatment of hypertension (pharmacology of ANS, role of exercise in prevention and treatment)
- Digestion and metabolism, metabolic syndrome, the gut-brain axis.
- Immune regulation of physiological function (innate vs adaptive, role of inflammation in infection and cancer. Regulation of tissue homeostasis and role in food allergy, obesity, and diabetes.
- Pathophysiology of diseases of the nervous system (MS, AD, PD, encompassing nervous, endocrine and immune regulation of physiology).

Neuroscience and Behaviour

- Sensation and perception. Students will gain an understanding of how the brain makes sense of sensory input. They will be aware of and able to explain fundamental discoveries (e.g. Hubel & Wiesel). They will be able to describe neuronal circuitry that enables us to distinguish between sensory input from the external world and that which is internally generated (sensory cancellation and efference copy mechanisms).
- Pain, nociception, and interoception. Students will attain and understanding of the internal awareness of the animal body to states such as pain.
- Motor coordination and control. Students will learn how the complexity of an animal's movement is constrained by the underlying neural circuitry. Simple behaviours in simpler animals and their underlying neural control (e.g. CPGs) through to complex voluntary action and manipulative tasks.
- Emotion and motivation. Students will develop an understanding of how we empirically study animal behaviours that can be attributed to motivational drives and emotional states and will attain knowledge of how environment experience and genetic background can alter these behaviours.
- Learning and memory. Students will be able to describe the basic learning theory models in the context of Pavlovian and operant conditioning, and basic invertebrate and vertebrate experimental models of learning-induced brain plasticity and memory storage.
- Understanding brain function through pathology/disease. Students will gain an understanding of how clinical studies of humans with brain damage and disease, when combined with careful behavioural and psychiatric analysis, and give us new insights into brain function at a systems level. An introduction to the use of animal disease models and a few highlights of how animal models have been used to develop an understanding of disease processes.

Practical Content:
Practical 1
Bacterial Adherence to Eukaryotic Cells & the Induction of Bacterial Gene Expression during Infection
Examination of buccal epithelial cells to observe adherence of resident microbial flora to cells. Determination of the induction speed of the acid-responsive *asr* gene of *Salmonella enterica* in the human stomach using Green Fluorescent Protein as a biosensor.
Practical 2
Simulation of resting membrane potential and action potential using Metaneuron.
Students will use a downloadable application to simulate neuronal behaviour. This will be used to examine the contribution of sodium and potassium ions to the resting membrane potential; contribution of sodium flux and alteration of membrane potential in induction of the action potential; relationship between stimulus intensity and stimulus delay in the refractory period
Practical 3
3D Imaging and database research of embryonic development
Students will use online 3D databases of developing embryos, to investigate and describe changes in anatomical features during the formation of a 3D body plan and begin to explore the molecular changes that underpin morphological change.
Practical 4
Cardiovascular and respiratory physiology. In this class, fundamental cardiovascular and respiratory physiology parameters will be measured. Students will be trained in the use of standard physiological equipment and will explore regulation of heart rate, blood pressure and blood flow, along with respiratory volumes and control of breathing.

Learning Outcomes:
On successful completion of this module students will be able to:

- Describe the regulatory and physiological adaptations that bacteria undergo to acquire nutrients and respond to stress and describe the structure, function and importance of bacterial extracellular structures and their roles in modulating cell-cell interactions
- Demonstrate an understanding of the role of signalling in bacterial communication in forming communities and the mechanisms used by bacteria to interact with eukaryotic cells
- Describe the multiple ways in which cells communicate with each other over short and long distances.
- Demonstrate an understanding of how biological signals are prepared for export, are temporally and spatially controlled, are sent, amplified, and received in the cellular context (signal transduction), and provide examples as to how this is achieved in cells.
- Articulate the concepts of how biological complexity is established as the body plan of multicellular organisms emerge and integrate these concepts in the context of how body plans have evolved.
- Describe the contribution of the nervous, endocrine and immune systems to regulation of whole body physiological homeostasis in humans and detail cell, tissue and organ integration in the cardiovascular, respiratory, immune, renal and digestive systems.
- Describe how alterations in physiological variables as a result of exercise, changes in barometric pressure or pathophysiological processes impact on homeostasis in different organ systems
- Articulate how the brain achieves basic functions for the animal using examples from invertebrate & vertebrate neurobiology.
- Provide explanatory accounts of movement and motor control; sensation and interoception; emotion and memory, and how brain injury in human patients can inform us about brain function
- Describe, integratively, how the fundamental physiology of neural circuits can be used to explain behavioural function in both vertebrates and invertebrates.
- Utilise online tools and databases to explore fundamental concepts relating to neurotransmission and to answer specific questions related to embryonic development including an appreciation of the power of using shared data in research.
- Measure and understand fundamental cardiovascular and respiratory variables in human subjects.

Recommended Reading List:

The topics and concepts presented in this module can be found in selected chapters of the following textbooks:

- Biology, A global Approach. Campbell *et al.* 11TH Edition. Pearson.
- Prescott's Microbiology 10th edition. McGraw Hill.
- Biochemistry. Berg, Tymoczko, Gatto, Stryer 8th edition. Macmillan International.
- Molecular Cell Biology. Lodish *et al*.., 8th edition. Macmillan International.
- Principles of Development. Wolpert, Tickle, Martinez-Arias. 5th Edition Oxford University Press.
- Developmental Biology. Gilbert, Barresi, 11th Edition. Sinauer, Oxford University Press
- Human Physiology from Cells to Systems. Sherwood. 9th Edition. Cengage Learning.
- Principles of Neurobiology. Liqun Luo. 1st edition. Garland Science.

Assessment Details:
End of semester written examination: 50% of module mark
Exam format: Part A, one essay question from a choice of three. Part B, 10 compulsory short questions, 2 hour duration, Part A and Part B equally weighted

Continuous assessment of course work: 50% of module mark
Two on-line open assessments of lecture material, 7.5% each
Practicals assessment 35%

Contacts:
Module Coordinator: Colm Cunningham**,** colm.cunningham@tcd.ie, Phone: 01 8963964
Biology Course Coordinator: Glynis Robinson, **robinsog@tcd.ie,** Phone: 01 8962895
Laboratory Manager: Siobhan McBennett, smcbnntt@tcd.ie, Phone: 01 8961049
Executive Officer: Helen Sherwin-Murray btcadmin@tcd.ie, Phone: 01 8961117

CHU22201: Chemistry 1

Semester 1, 10 Credits

Contact Hours: **50 hours lectures and tutorials and 27 Labs hours**

Rationale and Aims: To provide core Inorganic and Organic Chemistry topics at an intermediate level, which further develop the material covered in the JF year and are the basis for further detailed studies in the Sophister years.

Content Layout

Teaching Week	Topic
1-4 (14 L)	**Introduction to Molecular Orbital Theory** • Atomic orbitals (s,p,d) as wave functions; their representation as enclosed boundary surfaces and as radial distribution functions. The relationship of these ideas to the Bohr model for atomic hydrogen. Relative energies of these orbitals; orbital angular momentum in non-hydrogen-like atoms; penetration and shielding. • Hybridisation of atomic orbitals and the hybrids associated with various geometries; VSEPR treatment of molecular structures. • Bonding as the linear combination of atomic orbitals, including non-bonding and anti-bonding interactions. Labelling of molecular orbitals as sigma, pi (g or u), molecular orbital diagrams of homonuclear diatomic molecules of the first and second row of the Periodic Table. Mixing of molecular orbitals and its effect on the relative energies of the resulting molecular orbital diagram. Molecular orbital approach for simple molecules including H_2O, BeH_2 and BCl_3. Reactivity of CO in terms of the molecular orbital energy diagram for this molecule. Appreciation of the Molecular Orbital basis of the spectrochemical series. **Transition Metal Coordination Chemistry** • Brief introduction - why study metal complexes? • What is a metal complex? Overview of concepts and definitions: Lewis Acid-base concept. • Formation and stability of metal complexes: Complex formation and dissociation; cumulative stability constants and trends; the 'chelate effect'; factors affecting stability. • Classification of common ligands: Donor atoms and functional groups. Multidentate and chelating ligands; stereochemistry and formation of chelate rings. • Stereochemistry of metal complexes. Coordination numbers 2-6 and geometry of metal complex; square planar, tetrahedral; trigonal bi-pyramid; square based pyramid; octahedral; distortion of geometries. • Electronic structure and properties of transition metal complexes: Ionic vs. covalent bonding models; crystal field theory; energy level diagrams in tetrahedral - octahedral fields. • Consequences and applications of orbital splitting: Electronic configurations of metal complexes; crystal filed stabilization energies (CFSE); Factors effecting Delta; spectrochemical series; HS and LS configurations; magnetic properties and the spin-only formula.

	• Electronic spectra of metal complexes: UV-vis. Spectra; interpretation of data; Laporte and spin selection rules; extinction coefficients and wavelength; Jahn-Teller effect.
4-5 (5L)	**Molecular Spectroscopy** • This course will focus on the major techniques employed in the identification of chemical entities (although some are not spectroscopic techniques). • Why is spectroscopy important? • Nuclear Magnetic Resonance Spectroscopy (NMR): Nuclear spin, chemical shift, shielding and spin-spin coupling. Both ^{1}H and ^{13}C NMR are covered. A brief consideration of MRI is included. • Ultraviolet Spectroscopy: Effect of π-conjugation. • Infra-red Spectroscopy: Molecular vibrations, detection of characteristic functional groups • Mass spectrometry: Uses and application • X-Ray Diffraction: How X-ray diffraction can be employed to aid structural elucidation.
6-9 (12 L) Week 7 Study week	**Introduction to Organic Synthesis** • In-depth discussion of stereochemistry including definition of chemo-, region- and stereoselectivity. Identification of stereoisomers and assignment of absolute configuration. Resolution of racemic mixtures. Biological relevance of stereochemistry. • Conformational analysis, including Newman projections diagrams. Conformation of cyclohexane including chair, boat, twist-boat. Concept of allylic strain. • Introduction to carbohydrate chemistry and a discussion of common protecting groups in organic chemistry. • Applications of radical reactions in Organic synthesis. • In-depth discussion of aldol, carbonyl and beta-dicarbonyl chemistry for the formation of C-C bonds. • Aldol and carbonyl chemistry. • HSAB theory, the Michael addition reaction and Diels-Alder reaction.
10-12(9L)	**Aromatics** • Why is aromatic chemistry important? An overview of important drugs, dyestuffs and polymers that are based on aromatic compounds. • Recap: An overview of JF Aromatic Chemistry I: The structure of benzene and a reminder of the mechanism of electrophilic aromatic substitution (EAS) reactions. • How and why substituents on an aromatic ring influence the regiochemical outcome of EAS reactions: How do electron donating groups and electron withdrawing groups cause the substitution patterns that they do? • Nucleophilic Aromatic Substitution: Introduction to NAS and the differences to EAS. The three different mechanisms of NAS and their use in synthesis. • Organometallic chemistry: Introduction to metallation reactions, directed metallation as a method of controlled synthesis, metal catalysed coupling reactions.

	• Synthetic considerations: How to plan successful synthetic strategies to prepare aromatic compounds. • Other important aromatic systems: A brief look at some of the less common compounds and their chemistry. • Aromatic chemistry in the body - a brief look at some important aspects including biosynthesis, hormones, drug metabolism and the production of toxic metabolites. • Tying it all together: An overview of the synthesis of an important aromatic compound.
13	Student Revision/Study week – tutorials only
14	Student Assessments

Reading list/ Indicative Resources

- Organic Chemistry, by Jonathan Clayden and Nick Greeves; Publisher: OUP Oxford; 2 ed.
- Inorganic Chemistry, by C. E. Housecroft and A. G. Sharpe, PrenticeHall, 1 ed, 2001

Methods of Assessment
In-course assessment: 25% of Final Grade
Written Examination: 75% of Final Grade

Lab Hours = 9 x 3 hours = 27 hours. Organic Chemistry (6 experiments), Inorganic (3 experiments)

Learning Outcomes

1. Discuss the trends in atomic orbitals and use these to explain trends in atomic properties
2. Generate a set of molecular orbitals and an energy level diagram based on the principles of molecular orbital theory
3. Classify ligands and explain transition metal complex geometries
4. Predict and explain the d-orbital splitting in transition metal complexes and its effects on the geometry and electronic properties.
5. Identify and explain stereochemical features of organic molecules
6. Describe strategies for controlled formation of stereochemical centres in organic synthesis
7. Formulate reasonable retrosynthetic pathways for the design of simple organic molecules.
8. Explain the principles of standard organic spectroscopy techniques
9. Determine information about the structure of unknown organic materials using spectroscopic data
10. Categorise and explain the principle reactions of aromatic molecules

CHU22202: Chemistry 2

Semester 2, 10 credits

Contact Hours: **52 hours lectures and tutorials and 27 lab hours**

Rationale and Aims: Chemistry 2 module consists of core Physical and Inorganic Chemistry topics at an intermediate level, which further develop the material covered in the JF year and are the basis for further detailed studies in the Sophister years.

Content Layout

Teaching Week	Topic
1-4 (16 L)	**Chemical Thermodynamics** • Review (calculus based) of: First Law, Internal Energy and Enthalpy, Enthalpy as a function of temperature: use of differentials, 2nd Law: entropy, entropy as a function of temperature. • pV diagrams: isotherms and adiabatics, Carnot cycle, Engine efficiencies • 3rd Law: limiting values of Cv and Cp, Residual entropy, Free energy functions, Maxwell Relations • Chemical potentials and equilibria: The Chemical potential, activities, phase equilibria, Gibbs phase rule, Clausius Clapeyron, Homogeneous equilibria, Van't Hoff isochore • Chemical potentials in ideal solutions: Liquid vapour equilibrium, Henry's law, Raoult's law, Liquid-solid equilibrium, ideal solubilities, colligative properties • Non-ideal systems: Non-ideal gases, Fugacity of a van der Waals' gas, Mixture of gases
5-9 (14L) 7 study week	**Chemical Kinetics** • Basic concepts: collisions and gas phase reactions, Boltzmann distribution, Rate constant and Arrhenius equation, factors control rate • Chemical bond breaking and making, Morse potentials, forces on atoms, potential energy surface, transition state, simple harmonic oscillator, quantisation • Description of chemical reaction Definition of rate, initial rate, reaction order, rate constant, effect of concentration and temperature, experimental measurement • Derivation of integrated rate equations: zero, first and second order, graphical analysis to evaluate rate constant, half life • Activated processes, activation energy, Arrhenius equation, evaluation of activation energy, extension to other processes, diffusion, adsorption /desorption • Multistep reactions, rate determining step, reactive intermediates, reaction mechanism, consecutive and competitive reactions, Simple reversible reactions, quasi-equilibrium, quasi steady state, thermodynamic vs kinetic control, yield • Application of kinetics to catalysis (bio and surface), Langmuir-Hinshelwood, Michaelis-Menten, adduct formation, turnover frequency • Unimolecular gas phase kinetics, reactions in solution, diffusion vs activation control. • Collision theory, mean free path, collision frequency, activated complex theory, Eyring equation, activation parameters, relationship to Arrhenius, interpretation of pre-factor. • Kinetic isotope effect
9-12 (12L)	• Structural Inorganic & Materials Chemistry

	• Introduction, Classification of solids, Degree of order in solids; Definition of terms: Crystal structure, unit cell and lattice; Crystal systems; Structure of Metals and close packing of atoms: hpc, fcc, bcc, primitive packing (alpha-Po), deviations from ideal structures; phase transitions, Goldschmidt rule; • Alloys and solid solutions, Interstitial phases (Hägg-Phases), Phase diagrams, Carbides, nitrides and hydrides; Frank-Kasper and Laves phases. • 8-N Rule and Elemental Modifications; Examples of this concept form Group 17, 16, 15 and 14 of the Periodic Table (I2, S, P, As Bi, Po, C); Principle of maximum connectivity, pressure homologue rule and examples (i.e. Sn); pressure distance paradoxon; Binary diamond-type compounds with ZnS structure; Properties of these materials (semiconductors); Temperature-dependences; • Concept of interstices in close packings; AB, AB2, AB3-type structures; A2B3 oxides; structures of normal and inverse spinels; • Synthetic concepts to hybrid organic-inorganic materials that replicate the topologies of purely inorganic default structures (reticular synthesis concept); properties of the resulting solid state materials; zeolite-type materials; • Extended 8-N concept (Bussmann-Klemm concept); Zintl Phases and Zintl clusters; concepts to deduce the structures of these materials; clusters and electron counting. • Physicochemical properties of solids (examples can include magnetic, ferro/piezo-electric and mechanical properties) • Introduction to nanostructured and nanocrystalline materials ; • Characterisation and synthetic techniques for solid materials;
13	Student Revision/Study week – tutorials only
14	Student Assessments

Reading list/ Indicative Resources

- The elements of physical chemistry by P.W. Atkins J. de Paula, 6 ed. OUP (2013),
- Inorganic Chemistry', C.E. Housecroft, A.G. Sharpe, 4th Ed, Pearson; 2012
- 'Inorganic Structural Chemistry', Ulrich Muller; 2nd Edition, Wiley, Weinheim, ISBN: 978-0-470-01864-4 ''

Methods of Assessment

In-course assessment: 25% of Final Grade.
Written Examination: 75% of Final Grade.
Lab Hours = 9 x 3 hours = 27 hours

Proposed practicals

Inorganic (3 experiments), Physical Chemistry (6 experiments)

Learning Outcomes

1. Analyse and apply chemical kinetic principles to simple, multi-step reactions and complex reactions.
2. Illustrate basic theory of chemical reaction rates.
3. Review and apply the laws of thermodynamics to the solution of problems in Physical Chemistry.
4. Define the concept of ideal and non-ideal systems and the use of chemical potentials.
5. Understanding of the structural principles of inorganic molecules and solids using traditional concepts, simple electron counting rules as well as modern approaches.

6. Understanding of systematic ordering of the recognized structure types, relationships among them, and the link between structure and properties.
7. Basic understanding of selected characterisation techniques for solid materials.

Module Coordinator:		
Professor Yurii Gun'ko		E-mail: igounko@tcd.ie
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Coordinator Freshman Teaching		
Dr Noelle Scully		E-mail: pnscully@tcd.ie
		Phone: 01 896 1972
Senior Executive Officer		
Ms AnneMarie Farrell		E-mail: farrea25@tcd.ie
		Phone: 01 896 1726

GSU22201: From Atoms to Rocks: Introduction to Geochemistry

Semester 1, 5 credits

Contact Hours

2 x 1 hour lectures / week for 10 weeks = 20 hours

1 x 2 hour laboratory / week for 10 weeks = 20 hours

Module Personnel

Dr. Michael Stock and Dr Juan Diego Rodriguez-Blanco

Module Outline

Geochemistry is a branch of Earth Sciences that uses chemical principles to study how the geosphere, hydrosphere, atmosphere and biosphere interact to process and distribute elements. This module will introduce fundamental chemical concepts, using geological examples to demonstrate their importance in Earth Science. The module provides an overview of high- and low-temperature geochemistry, outlining both how elements are processed in the Earth's crust/mantle, and providing an overview of the interaction between dissolved elements in natural waters and the rocks which they come in contact.

Module Learning Outcomes

On successful completion of this module, students should be able to:

- Illustrate the importance of geochemistry in Earth Sciences and the relationship between geochemistry and geology, environmental chemistry, oceanography, soil sciences and biology.
- Describe the electronic structure of atoms and ions, as well as the periodic table and the arrangement of atoms to form solids.
- Describe the main geochemical reservoirs Earth and the processes responsible for distributing elements within the crust and mantle.
- Outline the most relevant physicochemical phenomena occurring when minerals are dissolved in melts and aqueous solutions.
- Illustrate the most important processes occurring during the interaction of minerals/rocks with water and their relevance to environmental quality and therefore to humans.
- Define radiogenic and non-radiogenic isotope systematics and their importance in Earth Science.
- Relate the relevance of the carbon cycle and carbonate minerals with life, ocean evolution, climate and availability of elements.

Method of assessment

Theory examination (70%; 2 hrs) and in-course practical assessment (30%)

Recommended reading lists

Ryan, P. (2014) Environmental and Low Temperature Geochemistry. Wiley-Blackwell.

White, W. M. (2013) Geochemistry. Wiley-Blackwell.

Contacts:

Module Coordinator: GSU22201: From Atoms to Rocks: Introduction to Geochemistry

Dr Michael Stock	E-mail: MICHAEL.STOCK@tcd.ie
	Phone: 01 896 2957
Executive Officer:	E-mail: TR062Admin@tcd.ie
Ms Sarah Guerin	Phone: 01 896 1074

GSU22202: Sedimentary Processes & Environments

Semester 1, 5 credits

Contact Hours
Lectures = 20 hrs
Lab Practicals = 8 hrs

Module Personnel
Dr Micha Ruhl, Prof Jerry Dickens, Dr Robin Edwards

Module Aims
Sediments and sedimentary rocks hold a rich history of how physical, chemical, and biological processes have changed over space and time. This module is designed to give basic information, so that the evolution of Earth's surface can be understood. We will share how one can take sediments and sedimentary rocks and reconstruct the past and appreciate the processes that led to what we can see today. This module will provide the fundamentals of sediments and sedimentary rocks, and how to think about Earth evolution.
The module will develop understanding of:

- Geological time
- Basic sedimentary rock-analyses: from observation, to interpretation
- How sediments are generated transported, deposited & preserved
- Different sedimentary depositional environments across the Earth system (past & present; continental & marine)
- How sedimentary archives provide records of (changes in) the past Earth system and past environmental & climate change processes

Module Content

Earth's climate and environments have changed on multiple temporal and spatial scales throughout its history, which significantly impacted on physical, chemical and biological processes across Earth's surface. Information on past climates and environments, stored in sedimentary archives, informs our understanding on present-day conditions at Earth's surface and provides constraints on future changes. Sedimentary materials storing such information can be found across most of the Earth's crust, both on land and in the oceans, and much of our understanding of Earth history comes from their examination.
This Module will introduce key physical, chemical, biological and sedimentary processes, deposits and examples of contemporary sedimentary depositional environments. It will analyse and explain the generation, transport and preservation of sediments, as diagnostic tools to link surface processes with the geological records of Earth history, as well as modern environmental change.
To achieve the module learning aims, the module will introduce examples of environmental change, and their impact on the sedimentary depositional environment at that time, such as Snowball Earth, Oceanic Anoxic Events, Hyperthermals, the Messinian Salinity Crisis, and Quaternary Glacial-Interglacial Cycles.
The above described module will prepare the student for related modules in Stratigraphy, Climate Change, Oceanography, as well as fieldwork, in Junior and Senior Sophister.

Learning Outcomes

On successful completion of this module students will be able to:

- Classify sediments and sedimentary rocks
- Provide technical descriptions of common sedimentary rock types and textures from hand samples and thin sections

- Explain the basic concept of “source-to-sink”, and how this links weathering of mountains, and transport and deposition of sediments
- Describe changes in sedimentary archives from outcrop observations, stratigraphic logs and/or petrological evidence
- Describe (changes in) in sedimentary archives, and interpret these in regards to changes in physical, geochemical and biological Earth surface processes, and changing environments
- Distinguish and describe temporal and spatial variability in Earth surface processses and how this links to sediment deposition locally
- Illustrate how Global Change processes (physical/ geochemical/biological) (have) shape(d) Earth’s surface, in the past, present, and future

Method of assessment

Laboratory practicals (50%); In-course problem solving exercises and tests (50%)

Module Coordinator: GSU22202: Sedimentary Processes & Environments

Dr Micha Ruhl E-mail: MICHA.RUHL@tcd.ie
Phone: 01 896 1165

Executive Officer: E-mail: TR062Admin@tcd.ie
Ms Sarah Guerin Phone: 01 896 1074

GSU22006: Physical Geography: Dynamic Earth

Semester 2, 10 credits

Contact Hours
4 x 1 hr lectures / week for 10 weeks = 40 hrs

Module Personnel
Dr Mary Bourke, Dr John Connolly, Dr Margaret Jackson, Prof Iris Möller, Dr Matt Saunders

Module Content:
Physical geography is an exciting scientific discipline that examines the Earth and how it functions. Geographers have already contributed substantially to scientific efforts to understand the emergence of truly globally significant human– environmental linkages. Physical Geography has thus been fundamental to investigating and modelling long-term changes to Earth surface process and dynamics. This type of knowledge is critical in allowing humans to live sustainably on planet Earth. In this module you study a wide variety of environmental systems, ranging from climate and weather to soils, beaches and rivers, to name just a few. The focus is to understand the location and character of landscape features such as mountain ranges and river valleys, and to explain why they came to be and how and why they vary depending on their geographic context. An underlying theme is to examine how aspects of physical geography affect human lives and, in turn, how people impact the dynamics of the physical landscape. This module will give students an understanding of key physical geography concepts. You will build on keys areas of Geography from the JF Spaceship Earth and Anthropocene modules. Elements of the module are designed to prepare students for Sophister geography modules.

Module learning outcomes:
On successful completion of this module, students should be able to:

- Critically evaluate the influence of climate, topography and humans on the variability of landforms.
- Explain the theories underlying how and why specific landforms vary over space and time.
- Draw on specific example of landforms and landscapes to demonstrate the influence of climate, topography, and humans.
- Evaluate the complex and reciprocal relationships between physical and human aspects of environments and landscapes.
- Assess the relative importance of infrequent/extreme versus frequent/moderate events in driving landform change.
- Discuss the potential application of geographical concepts, techniques and expertise as a means of addressing a range of issues facing the Earth and its people at a global and local scale.
- Explain the importance and relevance of physical systems and landforms to the future of human society.

Assessment Details:
In course tests and assessment (100%)

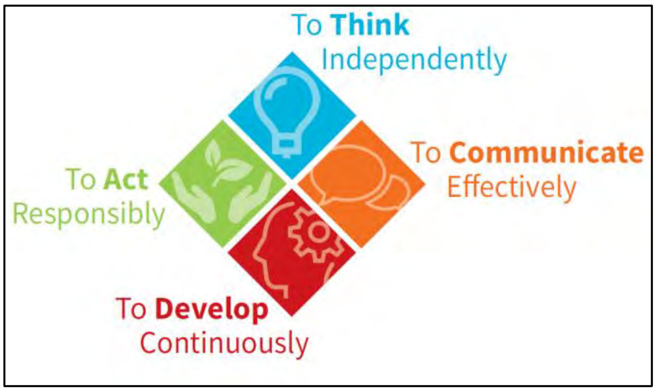
Module coordinator - GSU22006: Physical Geography: Dynamic Earth	
Dr Mary Bourke	E-mail: bourkem4@tcd.ie Phone: 01 896 1888
Executive Officer Ms Sarah Guerin	E-mail: TR062Admin@tcd.ie Phone: 01 896 1074

Graduate Attributes

The Trinity Graduate Attributes represent the qualities, skills and behaviours that you will have the opportunity to develop as a Trinity student over your entire university experience, in other words, not only in the classroom, but also through engagement in co- and extra-curricular activities (such as summer work placements, internships, or volunteering).

The four Trinity Graduate Attributes are:

- To Think Independently
- To Act Responsibly
- To Develop Continuously
- To Communicate Effectively



Why are the Graduate Attributes important?

The Trinity Graduate Attributes will enhance your personal, professional and intellectual development. They will also help to prepare you for lifelong learning and for the challenges of living and working in an increasingly complex and changing world.

The Graduate Attributes will enhance your employability. Whilst your degree remains fundamental, also being able to demonstrate these Graduate Attributes will help you to differentiate yourself as they encapsulate the kinds of transversal skills and abilities, which employers are looking for.

How will I develop these Graduate Attributes?

Many of the Graduate Attributes are 'slow learned', in other words, you will develop them over the four or five years of your programme of study.

They are embedded in the curriculum and in assessments, for example, through undertaking independent research for your final year project, giving presentations and engaging in group work. You will also develop them through the co-curricular and extra-curricular activities. If you help to run a club or society you will be improving your leadership skills, or if you play a sport you are building your communication and team-work skills.

Important information

Closing Dates for Course Transfer
If you decide to transfer out of your course altogether, you must submit an application for **transfer of course** to the Academic Registry, following discussion with your tutor. Decisions are based on **a)** the availability of places, and **b)** the entry qualifications of the transfer applicant. It may not be possible to permit transfers to subjects which already have a full complement of students. Further details are available on the following link:
http://www.tcd.ie/study/apply/making-an-application/undergraduate/index.php
Students may not register or attend a course until their application to transfer has been formally approved by the Senior Lecturer

Progression and Awards
Information on progression and awards can be found via the following webpage:
https://www.tcd.ie/TEP/assets/Docs/factsheet_students_progression_awards.pdf

Attendance
All students should enter into residence in or near Dublin and must begin attendance at the College not later than the first day of teaching term, and may not go out of residence before the last day of teaching term, **unless they have previously obtained permission from the Senior Lecturer through their tutor.**

Students must attend College during the teaching term. They must take part fully in the academic work of their class throughout the period of their course. Lecture timetables are published through my.tcd.ie and on school or department notice-boards before the beginning of Michaelmas teaching term. The onus lies on students to inform themselves of the dates, times and venues of their lectures and other forms of teaching by consulting these timetables.

The requirements for attendance at lectures and tutorials vary between the different faculties, schools and departments. The school, department or course office, whichever is relevant, publishes its requirements for attendance at lectures and tutorials on notice-boards, and/or in handbooks and elsewhere, as appropriate.

Non-attendance regulations
https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf

Plagiarism
Plagiarism is interpreted by the University as the act of presenting the work of others as one's own work, without acknowledgement.

Plagiarism is considered as academically fraudulent, and an offence against University discipline. The University considers plagiarism to be a major offence, and subject to the disciplinary procedures of the University.

A general set of guidelines for students on avoiding plagiarism is available on:
https://libguides.tcd.ie/friendly.php?s=plagiarism. The Calendar entry outlines the process through which a suspected case of plagiarism should be dealt with
https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf

Absence from College – Medical and Absence Certificates

Medical Certificates/Absence due to Illness

Where a student misses an assigned laboratory practical class through illness, they should **(a)** submit a Medical Certificate to the Science Course office **on the day of their return to College** and **(b)** inform the laboratory practical supervisor of their absence at the next session.

Science **Medical Certificate** Form (**use with med cert from doctor**) – Available from Science Course Office

Self-Certification/Absence due to illness - three days or less

For periods of illness of **three days or less** (but **no more than seven days in any year**) a student may 'self-certify' their illness on the forms supplied, again to the Science Course Office on the day of their return to College.

Science Medical **Self Certification** Form (**use for 3 days med not covered by doctor**) – Available from the Science Course Office

Other Absences

Students who require to be absent from a laboratory practical classes or tutorials (with or without an associated assessment) for any other reason, such as a sporting event or other situation, should inform the Science Course Office well in advance of the event (preferably a week beforehand). Science Absence from College Form, **Sport or Other** – Available from the Science Course Office Please note that filling in this form is **not a guarantee** that you will be afforded any accommodations with regard to marks or assignment of an alternative lab or tutorial session. In such cases decisions on what action/accommodations will be given is purely at the discretion of the individual disciplines concerned. The Science Course Office do not have any jurisdiction in this situation.

Students who will not be in attendance for any extended duration during term time must have permission from Senior Lecturer via their tutor to be absent from College. Please refer to the absence regulations noted in the previous page.

Excuses for absence, presented after the event, **will not be entertained.** Students who anticipate that their sporting commitments may necessitate more than the occasional absence from College (e.g. Sport Scholars, etc.) should discuss their situation with their tutor and the Associate Dean of Undergraduate Science Education (ADUSE).

NOTE:

Please note that these regulations do not apply to absence from examinations. Students who are absent from examinations must contact their tutor as a matter of urgency and present any medical information/documentation to them.

Student Services

Trinity Tutorial Service
The Tutorial Service is unique, confidential and available to all undergraduate students offering student support in all aspects of College life. The Tutorial Service is supported and co-ordinated by the Senior Tutor's Office which is located on the ground floor in House 27.
Opening Hours
The Senior Tutors Office is open Monday - Friday from 9am - 5.30pm. Closed for lunch from 1-2pm.

Appointments
If you require specific advice or would like a confidential meeting with the Senior Tutor, you can make an appointment by telephoning +353 1 896 2551 or by emailing stosec@tcd.ie

What is a Tutor?
A Tutor is a member of the academic staff who is appointed to look after the general welfare and development of the students in his/her care. Whilst the Tutor may be one of your lecturers, this is not always the case as the role of the College Tutor is quite separate from the teaching role.

When should I go to see my Tutor?
Whenever you are worried or concerned about any aspect of College life or your personal life, in particular if it is affecting your academic work. Everything you say to your Tutor is in strict confidence. Unless you give him/her permission to do so, s/he will not give any information to anybody else, whether inside College or outside (to your parents/family for example). Your Tutor can only help you if s/he knows you are facing difficulties, so if you are worried about anything go and see your Tutor before things get out of hand.

Further information on the Senior Tutors Office and College Tutors may be found via the following webpage: **Senior Tutor's Office -** https://www.tcd.ie/seniortutor/students/undergraduate/

Disability Services
The Disability Service aims to provide appropriate advice, support and information to help students and staff with disabilities. The Disability Service has in place a range of supports to ensure that students with disabilities have full access to the same facilities for study and recreation as their peers. Most students registering with the Disability Service request access to a range of supports that help the student reach their full potential while studying. Most students' needs are accommodated through these supports. The student decides what level of support they require.

For contact information or to make an appointment please contact the Disability Services – contact details are available via the following webpage:
https://www.tcd.ie/disability/contact/

Student Counselling
The Student Counselling Service is here to help you to manage any difficulties you are experiencing so you can enjoy and fully participate in your time here at College.

If you wish to make an appointment with the Student Counselling Service, please consider one of the options below. If you have any other queries you can call into reception on the 3rd floor of 7-9 South Leinster Street or contact us on:
Phone: (01) 8961407
Email: student-counselling@tcd.ie

For further information visit the following webpage:
https://www.tcd.ie/Student_Counselling/

Useful College Websites:

Student Life
Student life offers information on Supports and Services, Clubs and Societies, Student Unions etc., https://www.tcd.ie/students/

Academic Registry
The Academic Registry is responsible for services that support the complete student lifecycle of Trinity College Dublin – from application to graduation.

For information on Registration, Fees, Grants, ID Cards etc. visit the Academic Registry (AR) in the Watts Building or the visit the AR website: https://www.tcd.ie/academicregistry/

Student Accommodation
The Accommodation Office is open Monday to Friday from 8.30am to 1pm and 2pm-5pm each day. Queries can be emailed to residences@tcd.ie, or you can telephone 8961177 during office hours. After hours you can contact Front Gate at 8963978 in case of difficulties or key problems. In Goldsmith Hall attendants are on duty in the residential area at weekends and overnight and they will assist with local problems. In the event of a serious emergency, particularly where you require the attendance of ambulance, fire or police services please telephone College Security at 8961999 (internal 1999). To ensure a co-ordinated response please do not call these services directly. We recommend that you programme these numbers into your mobile phone using the prefix “01” before the number. https://www.tcd.ie/accommodation/

Academic Year Structure 2021/22

Key Dates:

Semester 1 teaching term begins:	Monday 13 September 2021
Study/revision week Semester 1:	Monday 25 October - 29 October 2021
Semester 1 teaching term ends:	Friday 03 December 2021
Semester one examinations:	Monday 15 November – Friday 19 November 2021
Semester 2 teaching term begins:	Monday 24 January 2022
Study/Revision week Semester 2	Monday 7 March to Friday 11 March 2022
Semester 2 teaching term ends:	Friday 15 April 2022
Revision week	Monday 18 April to Friday 22 April 2022

Teaching Term Dates 2021-2022

Teaching Term Dates 2021-2022					
Michaelmas Term Monday 13 Sept 2021 - Friday 03 Dec 2021			**Hilary Term Monday 24 January 2022 - Friday 15 April 2022**		
Teaching wk. 1	Week 03	13 Sept – 17 Sept	Teaching wk. 1	Week 22	24 Jan - 28 Jan
Teaching wk. 2	Week 04	22 Sept - 24 Sept	Teaching wk. 2	Week 23	31 Jan – 04 Feb
Teaching wk. 3	Week 05	27 Sept - 01 Oct	Teaching wk. 3	Week 24	07 Feb - 11 Feb
Teaching wk. 4	Week 06	04 Sept - 07 Oct	Teaching wk. 4	Week 25	14 Feb - 18 Feb
Teaching wk. 5	Week 07	11 Oct - 15 Oct	Teaching wk. 5	Week 26	21 Feb - 25 Feb
Teaching wk. 6	Week 08	18 Oct - 22Oct	Teaching wk. 6	Week 27	28 Feb – 04 Mar
Study week	**Week 09**	*** 25 Oct - 29 Oct**	**Study week**	**Week 28**	**07 Mar - 11 Mar**
Teaching wk. 8	Week 10	01 Nov - 05 Nov	Teaching wk. 8	Week 29	*14 Mar - 18 Mar
Teaching wk. 9	Week 11	08 Nov - 12 Nov	Teaching wk. 9	Week 30	21 Mar - 25 Mar
Teaching wk. 10	Week 12	15 Nov - 19 Nov	Teaching wk. 10	Week 31	28 Mar - 01 Apr
Teaching wk. 11	Week 13	22 Nov - 26 Nov	Teaching wk. 11	Week 32	04 Mar - 08 Apr
Teaching wk. 12	Week 14	29 Nov – 03 Dec	Teaching wk. 12	Week 33	*11 Apr - 15 Apr

* Monday 25th October 2021 Bank Holiday - College closed
* Thursday 17th March 2022 St Patricks Day - College closed
* Friday 15th April 2022 – College closed

NOTE: All the information contained in this booklet is accurate at time of publication. However, the Science Course Office reserves the right to modify information, dates and times as necessary. Students will be notified of any changes via e-mail and the Science webpage.

TR063: Physical Sciences contact details

Course Director TR063: Physical Sciences		
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Appendix 1: General Information

ITEM	REFERENCE/Source
General Regulations	Calendar, Part II - General Regulations and Information, Section II, Item 12: https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf Attendance Requirements: Calendar, Part II, General Regulations and Information, Section II, Items 17-23 Absence from Examinations Calendar, Part II, General Regulations and Information, Section II, Item 35 Plagiarism Policy and information: https://www.tcd.ie/teaching-learning/UG_regulations/Plagiarism.php https://libguides.tcd.ie/friendly.php?s=plagiarism
General Information	Timetables are available via my.tcd.ie portal: https://my.tcd.ie/urd/sits.urd/run/siw_lgn Blackboard: https://tcd.blackboard.com/webapps/login/ Academic Registry: https://www.tcd.ie/academicregistry/ Data Protection: https://www.tcd.ie/info_compliance/data-protection/student-data/ Dignity & Respect Policy https://www.tcd.ie/equality/policy/dignity-respect-policy/
Foundation Scholarship	Foundation and Non Foundation Scholarship: Calendar, Part II www.tcd.ie/calendar/undergraduate-studies/foundation-and-non-foundation-scholarships.pdf Science Foundation Scholarship information sheet: https: https://www.tcd.ie/Science/assets/documents/PDF/foundation-scholarship/TR063/TR063-foundation-scholarship-information-20-21.pdf
Teaching and Learning	Academic Policies: https://www.tcd.ie/teaching-learning/academic-policies/ Student Learning Development: https://www.tcd.ie/Student_Counselling/student-learning/ Student Complaints Procedure: https://www.tcd.ie/about/policies/160722_Student%20Complaints%20Procedure_PUB.pdf

	Student Evaluation and Feedback: https://www.tcd.ie/teaching-learning/quality/quality-assurance/evaluation.php National Framework of Qualifications: https://nfq.qqi.ie/
Student support	Student Support Services: https://www.tcd.ie/students/supports-services/ Student Services Booklet: https://www.tcd.ie/students/assets/pdf/Student%20Services%20Handbook.pdf Senior Tutor & Tutorial Service www.tcd.ie/students/assets/pdf/Student%20Services%20Booklet%20(web%20version).pdf Mature Student Office https://www.tcd.ie/maturestudents/
Co-curricular activities	Central Societies Committee: https://www.tcd.ie/calendar/general-information/students-unions-societies-and-clubs.pdf DUCAC: https://www.tcd.ie/Sport/student-sport/ducac/?nodeId=94&title=Sports_Clubs
Information on TCDSU Including student representative structures	TCDSU https://www.tcdsu.org/
Emergency Procedure	In the event of an emergency, **dial Security Services on extension 1999** Security Services provide a 24-hour service to the college community, 365 days a year. They are the liaison to the Fire, Garda and Ambulance services and all staff and students are advised to always telephone extension 1999 (+353 1 896 1999) in case of an emergency. Should you require any emergency or rescue services on campus, you must contact Security Services. This includes chemical spills, personal injury or first aid assistance. It is recommended that all students save at least one emergency contact in their phone under ICE (In Case of Emergency).

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Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Science Course Office

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Oifig na gCúrsaí Éolaíochta Dámh na hinne-altóireachta, na Matamaitce agus na hÉolaíochta Ollscoil Átha Clíath, Coláiste na Tríonóide Baile Átha Cliath 2. Éire.

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