

# Science at Trinity

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

TR061 Chemical Sciences

Senior Fresh Handbook 2026-2027



This programme booklet applies to all students taking TR061 Chemical Sciences. It is a guide to what is expected of you on the programme and the supports available to you. Please retain for future reference.

The information provided is correct at the time of publication. Any necessary revisions will be notified to students via email and the TR061 Chemical Sciences web address here:

<https://www.tcd.ie/science/undergraduate/tr061-chemical-sciences/senior-fresh/>

In the event of any conflict or inconsistency between the General Regulations published in the University Calendar and the information provided in this course programme, the general college regulations will prevail: <https://www.tcd.ie/calendar/general-information/>

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## TR061: Chemical Sciences Introduction

Welcome to the Chemical Sciences course in Trinity College.

Chemistry is a dynamic discipline that interfaces constantly with other disciplines. Chemists enjoy analysing, synthesising, and designing new compounds and materials to solve modern societal, medical, and environmental challenges. Chemists also engage in the creative process of developing new models and theories to explain the workings of our natural world. As part of your degree, you will learn core foundational principles of the chemical sciences but will also be introduced to new areas of chemistry at the frontiers with biology, physics, medicine, and computer sciences. Importantly, we will help you acquire proficiency in technical methodologies while supporting the development of effective professional communication skills that are essential for your future career, whether you aspire to becoming a practicing chemist in industry or academia, or to working in business, consultancy, or social enterprises.

Formal Chemistry teaching in TCD commenced in August 1711 as part of the new School of Medicine and is now delivered by the staff in the School of Chemistry. The TR061 Chemical Sciences is a new and highly flexible 4-year degree programme that allows you to tailor the focus of your degree through selection of module combinations over the course of your entire undergraduate education. Entry into TR061 gives you the option to choose among five Moderatorships as exit routes, namely:

- Chemistry (C)
- Chemistry with Biosciences (CB)
- Chemistry with Molecular Modelling (CMM)
- Medicinal Chemistry (MC)
- Nanoscience (N).

Second year module choices recommended and/or required for completing each of the above Moderatorships are discussed in this handbook.

### **Staff, Research and Facilities in the School of Chemistry**

The School of Chemistry currently has 26 academic staff, 10 technical and attendant staff and 4 administrative staff. The School has an active research programme, with approximately 100 postgraduate students and postdoctoral researchers. They study a range of subjects such as organic, inorganic, organometallic, physical, theoretical, medicinal, analytical, material, polymer, environmental, and supramolecular chemistry. Research income is earned from national, international, and commercial sources and the School has held grants in all relevant research programmes funded by the EU. The College also fosters an interdisciplinary approach to research, with members of the School having strong links with colleagues in the physical, technological, and biological sciences both within College, nationally and internationally.

The main building includes two lecture theatres and four research laboratories. A suite of teaching laboratories (the Cocker laboratories) provides facilities for the teaching of preparative inorganic and organic chemistry. The Sami Nasr Institute for Advanced Materials (SNIAM) provides ca. 1500 m<sup>2</sup> of accommodation for the School of Chemistry. This includes a Physical Chemistry teaching laboratory and six research laboratories to house ca. 40 researchers. Computational Chemistry research is housed in the Lloyd Institute on a multidisciplinary computational-science floor comprising researchers from Mathematics, Physics, Chemistry and High-Performance Computing. In addition, chemists play an important role in interdisciplinary research taking place in TCD's research institutes: (i) the Nanoscience Institute – The Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), and (ii) the Trinity Biomedical Sciences Institute (TBSI).

As part of your degree, you will gain exposure to open ended research thanks to the support of academic staff who work at the cutting-edge of science and through access to state-of-the-art instrumentation. The school is well equipped for its research activities, having Agilent 400 MHz, and Bruker 600 and 400 MHz high-field multi-nuclear NMR, FTIR, dispersive IR and UV-visible spectrometers, high performance liquid (HPLC) and gas (GC) chromatography equipment, X-Ray crystallography facilities with two single crystal small molecule X-Ray -diffractometers (scXRDs) and a powder XRD (pXRD), Micromass LCTM (TOF) mass spectrometer, thermogravimetric analysis and differential scanning calorimetry, dynamic light scattering, several spectrofluorimeters for steady-state and time-resolved fluorescence measurements, circular and linear dichroism, and a large range of wave generators and potentiostats for cyclic voltammetry.

Professor Mike Southern

Director, TR061: Chemical Sciences Course

## TR061: Chemical Sciences Overview and Module Selection

The second year will build on the material covered in first year, which will help students decide on which career path to follow. The second 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.

In their SF year, all students must take core modules for a total of 40 ECTS (20 ECTS per semester) as follows:

### Core Modules

Code	Module Title		Semester	ECTS
<b>Mandatory Core modules (30 ECTS)</b>				
CHU22201	Chemistry 1		1	10
CHU22202	Chemistry 2		2	10
MAU22S01	Multivariable Calculus for Science		1	5
PIU22992	History, Philosophy and Ethics of Science		2	5
<b>Students must select from the following (10 ECTS) #</b>				
CHU22M03	Introduction to Medicinal Chemistry*		1	5
<b>Or</b>				
MAU22S03	Fourier analysis for Science*		1	5
<b>and</b>				
CHU22204	Introduction to Environmental and Sustainable Chemistry**		2	5
<b>Or</b>				
MAU22S02	Vector Calculus for Science**		2	5

\* Students who take CHU22M03 cannot take MAU22S03 \*\* Students who take CHU22204 cannot take MAU22S02

# To select Physics as an open module student must take MAU22S02 and MAU22S03

Students will choose 2 additional modules among those open for the TR061 programme, for a total of 20 ECTS (10 ECTS per semester).

### Open Modules

Code	Module Title	Semester	ECTS
BYU22C01	From Molecules to Cells	1	10
BYU22202	From Cells to Organisms	2	10
<b>Or</b>			
PYU22P10	Physics 1	1	10
PYU22P20	Physics 2	2	10

It is important to note that open SF modules will require the student to have completed the corresponding pre-requisites:

- **BYU11101 module is a pre-requisite to Biology modules in SF year**
- **PYU11P10/P20 modules are pre-requisites to Physics modules in SF year**

## SENIOR FRESH MODULE CHOICES

Module Code	Module Title	Semester	Credits	
CHU22201	Chemistry 1	1	10	MANDATORY
CHU22202	Chemistry 2	2	10	
MAU22S01	Multivariable calculus for Science	1	5	
PIU22992	History, Philosophy and Ethics of Science	2	5	
<b>And Pattern SF.1</b>				
CHU22M03	Introduction to Medicinal Chemistry	1	5	
CHU22204	Introduction to Environmental and Sustainable Chemistry	2	5	
BYU22C01	From Molecules to Cells II	1	10	
BYU22202	From Cells to Organisms	2	10	
<b>OR Pattern SF.2</b>				
CHU22M03	Introduction to Medicinal Chemistry	1	5	
MAU22S02	Vector Calculus for Science	2	5	
BYU22C01	From Molecules to Cells II	1	10	
BYU22202	From Cells to Organisms	2	10	
<b>OR Pattern SF.3</b>				
MAU22S03	Fourier analysis for Science	1	5	
CHU22204	Introduction to Environmental and Sustainable Chemistry	2	5	
BYU22C01	From Molecules to Cells II	1	10	
BYU22202	From Cells to Organisms	2	10	
<b>OR Pattern SF.4</b>				
MAU22S03	Fourier analysis for Science	1	5	
MAU22S02	Vector Calculus for Science	2	5	
BYU22C01	From Molecules to Cells II	1	10	
BYU22202	From Cells to Organisms	2	10	
<b>OR Pattern SF.5</b>				
MAU22S03	Fourier analysis for Science	1	5	
MAU22S02	Vector Calculus for Science	2	5	
PYU22P10	Physics	1	10	
PYU22P20	Physics	2	10	

## Moderatorships

In the first and second year TR061 students complete a course of study which will qualify them to compete for a place in one of the following Moderatorships after their second year:

- Chemistry (C)
- Chemistry with Biosciences (CB)
- Chemistry with Molecular Modelling (CMM)
- Medicinal Chemistry (MC)
- Nanoscience (N)

The curriculum in the five Moderatorships is tailored and balanced to offer a general Chemistry degree (C), a degree focusing on the application of chemical techniques and investigation of chemical processes in biological systems (CB), a degree with greater emphasis on computational methods in chemistry (CMM), a degree focusing on the synthesis and applications of drug molecules for medicinal purposes (MC) and a degree with emphasis on the nanoscience and chemistry and physics of advanced materials(N). Importantly, students should ensure that module choices over JF and SF years fulfil the requisites to apply for a place in the preferred Moderatorship/s. The credits dedicated to each discipline depending on module pattern choice are outlined below:

<b>Pattern SF.1</b> fulfils requisites for Moderatorships in C, CB CMM, MC	<b>Patterns SF.2-3</b> fulfils requisites for Moderatorships in C, CB, CMM, MC	<b>Patterns SF.4</b> fulfils requisites for Moderatorships in C, CB, CMM, MC	<b>Pattern SF.5</b> fulfils requisites for Moderatorships in C, CMM, N
30 ECTS Chemistry	25 ECTS Chemistry	20 ECTS Chemistry	20 ECTS Chemistry
5 ECTS Maths	10 ECTS Maths	15 ECTS Maths	15 ECTS Maths
5 ECTS History, Philosophy and Ethics of Science	5 ECTS History, Philosophy and Ethics of Science	5 ECTS History, Philosophy and Ethics of Science	5 ECTS History, Philosophy and Ethics of Science
20 ECTS Biology	20 ECTS Biology	20 ECTS Biology	20 ECTS Physics

The Table below summarises which SF module patterns fulfil requisites to apply for each of the five Moderatorships.

### Moderatorship pre-requisites

<b>Chemistry</b>	<b>Chemistry with Biosciences</b>	<b>Chemistry with Molecular Modelling</b>	<b>Medicinal Chemistry</b>	<b>Nanoscience</b>
All 5 patterns	Patterns SF.1-4	All 5 patterns	Patterns SF.1-4	Pattern SF.5 only

**TR061: Chemical Sciences**

SEMESTER 1 – Michaelmas term 14 September 2026 – 04 December 2026		SEMESTER 2 – Hilary Term 18 January 2027 – 09 April 2027	
<b>CORE MODULES (Mandatory) – 20 per semester</b>			
CHU22201: Chemistry 1	10	CHU22202: Chemistry 2	10
CHU22M03: Intro to Medicinal Chemistry *	5	CHU22204: Intro to Environmental and sustainable Chemistry *	5
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

\*Students who take CHU22M03 cannot take MAU22S03

\*Students who take CHU22204 cannot take MAU22S02

**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
<b>Or</b>			
PYU22P10: Physics 1 <sup>#</sup>	10	PYU22P20: Physics 2 <sup>#</sup>	10

**#To select Physics as an open module students must take MAU22S02 and MAU22S03**

### Open Module Choice Form

The module choice form is available in the following link: <https://forms.office.com/e/jSsTDFdRNr>

The deadline for completing the form is **5pm on Friday 17<sup>th</sup> April 2026**.

## Change of Open Modules

If, after a couple of weeks, a student feels that they have perhaps made the wrong choice of open module combination, they should seek **advice immediately** from a Tutor, Course Director, or the Science Course Office. It may be possible to change from one module to another within your course, subject to permission from the Associate Dean of Undergraduate Science Education. Once a decision has been made to change modules, it should be done **quickly** - it can be difficult to try to catch up with work in a new module when more than two or three weeks of lectures have been missed.

If you wish to change your mind before term begins in September, you may resubmit the online form with a subject line of "change of module choice" and a note in the form specifying "change of module choice".

Online forms can be found via the following link: <https://forms.office.com/e/jSsTDFdRNr>  
All change of module requests must be submitted via the online module form **by Monday 28<sup>th</sup> September 2026**.

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

## College Registration

The Academic Registry issue an **'Invite to Register'** email to all continuing students eligible to register for the forthcoming academic year. This communication is issued via the [my.tcd.ie](https://my.tcd.ie) portal and your institutional (TCD issued) email address.

On receipt of the emailed invitation, you should log in to the my.tcd.ie to complete the registration steps. All information regarding College registration is available at the following links:

<https://www.tcd.ie/academicregistry/>

<https://www.tcd.ie/academicregistry/student-registration/>

## TR061: Chemical Sciences - CORE Modules

### 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

No of Lectures	Topic
14 L	<p><b>Inorganic Course Title: Introduction to Inorganic Chemistry 2</b></p> <p>The aim of this module is to introduce molecular symmetry and cover aspects of group theory in order to help develop an understanding of electronic spectroscopy of transition metal complexes. The student will learn basic concepts in electronic spectroscopy to develop an understanding of the UV/Vis spectra of transition metal complexes, the influence of the metal and its oxidation state, the nature of the ligand and the coordination number and geometry of the complex on its electronic properties. The application of UV-visible absorption spectroscopy to the characterisation of metal complexes and the effective interpretation of spectra is also discussed in detail developing skills in the manipulation of data and in spectral analysis.</p> <p><b>Electronic Spectroscopy of Transition Metal Compounds:</b></p> <p>Lecture 1: An introduction to molecular symmetry. Symmetry operations and symmetry elements</p> <p>Lecture 2: Point groups; Determining the point group of a molecule or molecular ion</p> <p>Lecture 3: An introduction to character tables</p> <p>Lecture 4: Why do we need to recognize symmetry elements?</p> <p>Lecture 5: Introduction to electronic spectroscopy. Absorption of light by transition metal complexes. Review of ligand field splitting for octahedral, tetrahedral and square planar geometries, factors affecting the magnitude of splitting. Limitations of ligand field theory – interelectron repulsion.</p> <p>Lecture 6: Coupling of orbital and spin angular momenta, Russell-Saunders coupling, application to first row transition metal ions. Formation of microstates in metal ions and generation of term symbols</p> <p>Lecture 7: Use of Hund's first and second rules to identify the ground term</p>

	<p>Lecture 8: Crystal field splitting of free ion terms; Orgel diagrams for the weak-field limit (D and F ground term diagrams), the hole formalism. Interpretation of weak field spectra using Orgel diagrams.</p> <p><i>Tutorial 1 &amp; 2: Point group assignments. Determination of ground term. Assignment of UV-Vis spectra of transition metal complexes.</i></p> <p>Lecture 9: Quantum mixing. Calculation of quantum mixing term <math>x</math> and Racah parameter <math>B</math></p> <p>Lecture 10: Selection rules for electronic transitions.</p> <p><math>d^5</math> spectra. Understanding and reasons for the broadening of electronic transitions. Molecular vibrations, Franck-Condon Principle. Spin-orbit coupling, Jahn-Teller distortion</p> <p>Lecture 11: Tanabe-Sugano diagrams, the high-spin/low spin transition, calculation of octahedral splitting, <math>E</math> and <math>B</math>, use of Tanabe-Sugano diagrams to predict the positions of missing bands.</p> <p>Lecture 12: Origins and consequences of the nephelauxetic effect. Spectra of pseudooctahedral complexes e.g. <math>D_3</math> complexes such as <math>\text{Cr}(\text{en})_3^{3+}</math> – analysis as a small perturbation from the octahedral case, limitations. Continuation of problem-based exercises using Tanabe Sugano Diagrams</p> <p>Lecture 13: Ligand-to-metal and metal-to-ligand charge transfer transitions</p> <p>Lecture 14: Excited state complexes and their resulting emissive properties.</p> <p><i>Tutorial 3&amp;4: Assignment of UV-Vis spectra of transition metal complexes. Charge transfer transitions.</i></p>
5 L	<p>Molecular Spectroscopy</p> <ul style="list-style-type: none"> <li>• This course will focus on the major techniques employed in the identification of chemical entities (although some are not spectroscopic techniques).</li> <li>• Why is spectroscopy important?</li> <li>• Nuclear Magnetic Resonance Spectroscopy (NMR): Nuclear spin, chemical shift, shielding and spin-spin coupling. Both <math>^1\text{H}</math> and <math>^{13}\text{C}</math> NMR are covered. A brief consideration of MRI is included.</li> <li>• Ultraviolet Spectroscopy: Effect of <math>\pi</math>-conjugation.</li> <li>• Infra-red Spectroscopy: Molecular vibrations, detection of characteristic functional groups</li> <li>• Mass spectrometry: Uses and application</li> <li>• X-Ray Diffraction: How X-ray diffraction can be employed to aid structural elucidation.</li> </ul>
12 L	<p>Introduction to Organic Synthesis</p> <ul style="list-style-type: none"> <li>• In-depth discussion of stereochemistry including definition of chemo-, regio- and stereoselectivity. Identification of stereoisomers and assignment of absolute configuration. Resolution of racemic mixtures. Biological relevance of stereochemistry.</li> </ul>

	<ul style="list-style-type: none"> <li>• Conformational analysis, including Newman projections diagrams. Conformation of cyclohexane including chair, boat, twist-boat. Concept of allylic strain.</li> <li>• Introduction to carbohydrate chemistry and a discussion of common protecting groups in organic chemistry.</li> <li>• Applications of radical reactions in Organic synthesis.</li> <li>• In-depth discussion of aldol, carbonyl and beta-dicarbonyl chemistry for the formation of C-C bonds.</li> <li>• Aldol and carbonyl chemistry.</li> <li>• HSAB theory, the Michael addition reaction and Diels-Alder reaction.</li> </ul>
9 L	<ul style="list-style-type: none"> <li>• Aromatics</li> <li>• Why is aromatic chemistry important? An overview of important drugs, dyestuffs and polymers that are based on aromatic compounds.</li> <li>• Recap: An overview of JF Aromatic Chemistry I: The structure of benzene and a reminder of the mechanism of electrophilic aromatic substitution (EAS) reactions.</li> <li>• 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?</li> <li>• Nucleophilic Aromatic Substitution: Introduction to NAS and the differences to EAS. The three different mechanisms of NAS and their use in synthesis.</li> <li>• Organometallic chemistry: Introduction to metallation reactions, directed metallation as a method of controlled synthesis, metal catalysed coupling reactions.</li> <li>• Synthetic considerations: How to plan successful synthetic strategies to prepare aromatic compounds.</li> <li>• Other important aromatic systems: A brief look at some of the less common compounds and their chemistry.</li> <li>• Aromatic chemistry in the body - a brief look at some important aspects including biosynthesis, hormones, drug metabolism and the production of toxic metabolites.</li> <li>• Tying it all together: An overview of the synthesis of an important aromatic compound.</li> </ul>

#### Reading list/ Indicative Resources

- Organic Chemistry, by Jonathan Clayden and Nick Greeves; Publisher: OUP Oxford; 2 ed.
- Inorganic Chemistry, Catherine E. Housecroft and Alan G. Sharpe, Pearson Education Limited 2005 (An introduction to molecular symmetry - Chapter 3; d-Block chemistry: coordination complexes – Chapter 20)
- Characterisation Methods in Inorganic Chemistry, M. T. Weller, N. A. Young, Oxford University Press, 2017. (Electronic Spectroscopy – Chapter 5)
- Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Keiter, R. L. Keiter, HarperCollins, 1997, 4<sup>th</sup> Ed. (Electronic Spectroscopy – Chapter 11)
- Inorganic Chemistry, M. Weller, T. Overton, J. Rourke, F. Armstrong, Oxford University Press, 2018, 7<sup>th</sup> Ed. (Electronic Spectroscopy – Chapter 20)

## 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)

## Important Note on Examinations, Assessments and Reassessments in the School of Chemistry:

- There is a minimum mark requirement of **35%** in the **Examination** component and the **40% Laboratory** component, in order for a Pass or Qualified Pass mark in this module to be granted. Other components making up fewer marks are not included in this requirement. A mark of less than 35% in the Examination or 40% Laboratory components leads to a Qualified Fail and requires reassessment examination or a repeat of the year.
- There is a maximum mark or cap of 40% on any reassessed component in this module if reassessment is required. The final module mark is calculated based on the reassessed component mark and any already achieved marks for components that did not need to be reassessed, according to the published weightings of these components.
- Re-assessment capping does not apply to deferred 1st attempts at assessment.
- These requirements apply to all students in this module.
- For more details see the section on 'Progression Regulations applying to Chemistry modules' under the 'Progression and Awards' within this booklet.

## Learning Outcomes

1. Explain the basics of symmetry operators and symmetry elements
2. Explain the basics of group theory
3. Be able to show how one given molecule belongs to a specific point group.
4. Summarize the process for the absorption of light and the mechanism by which this leads to electronic rearrangement in a transition metal complex
5. Explain the implications that absorption has for the origin of the wide-ranging and characteristic optical properties of coordination complexes.
6. State the importance of both the wavelength and intensity of the light absorbed in determining the nature of the transitions between electronic energy levels involving the metal centre.
7. Describe the influence of the metal and its oxidation state, the nature of the ligand and the coordination number and geometry of the complex on its electronic properties.
8. Describe the application of UV-visible absorption spectroscopy in the characterisation of metal complexes and the effective interpretation of spectra.
9. Illustrate the skills required to manipulate relevant data sets and in analyzing spectra.
10. Illustrate the main principles of homogeneous catalysis by transition metals complexes, mechanisms and catalytic cycles.
11. Identify and explain stereochemical features of organic molecules.
12. Describe strategies for controlled formation of stereochemical centres in organic synthesis.
13. Formulate reasonable retrosynthetic pathways for the design of simple organic molecules.
14. Explain the principles of standard organic spectroscopy techniques.
15. Determine information about the structure of unknown organic materials using spectroscopic data.
16. 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

No of Lectures	Topic
16 L	<b>Chemical Thermodynamics</b> <ul style="list-style-type: none"><li>• 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.</li><li>• P-V diagrams: isotherms and adiabatics, Carnot cycle, Engine efficiencies</li><li>• 3rd Law: limiting values of <math>C_v</math> and <math>C_p</math>, Residual entropy, Free energy functions, Maxwell Relations</li><li>• Chemical potentials and equilibria: The Chemical potential, activities, phase equilibria, Gibbs phase rule, Clausius Clapeyron, Homogeneous equilibria, Van't Hoff isochore</li><li>• Chemical potentials in ideal solutions: Liquid vapour equilibrium, Henry's law, Raoult's law, Liquid-solid equilibrium, ideal solubilities, colligative properties</li><li>• Non-ideal systems: Non-ideal gases, Fugacity of a van der Waals' gas, Mixture of gases</li></ul>
14 L	<b>Chemical Kinetics</b> <ul style="list-style-type: none"><li>• Basic concepts: collisions and gas phase reactions, Boltzmann distribution, Rate constant and Arrhenius equation, factors control rate</li><li>• Chemical bond breaking and making, Morse potentials, forces on atoms, potential energy surface, transition state, simple harmonic oscillator, quantisation</li><li>• Description of chemical reaction Definition of rate, initial rate, reaction order, rate constant, effect of concentration and temperature, experimental measurement</li><li>• Derivation of integrated rate equations: zero, first and second order, graphical analysis to evaluate rate constant, half life</li><li>• Activated processes, activation energy, Arrhenius equation, evaluation of activation energy, extension to other processes, diffusion, adsorption /desorption</li><li>• 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</li><li>• Application of kinetics to catalysis (bio and surface), Langmuir-Hinshelwood, Michaelis-Menten, adduct formation, turnover frequency</li><li>• Unimolecular gas phase kinetics, reactions in solution, diffusion vs activation control.</li><li>• Collision theory means free path, collision frequency, activated complex theory, Eyring equation, activation parameters, relationship to Arrhenius, interpretation of pre-factor.</li><li>• Kinetic isotope effect</li></ul>
12 L	<b>Introduction to Main Group Chemistry</b>

- This module serves as the foundation for the Main Group Elements Chemistry. It focuses on the fundamental concepts and principles that underpin the chemistry of main group elements, which comprise the s- and p-block elements of the periodic table. Main group elements are essential components of various chemical compounds and play a critical role in diverse fields, including materials science, biology, and environmental science.
- Periodic trends on main group elements: The organization of the periodic table and the significance of main group elements in the table. Discussion how periodic trends (e.g., atomic radius, ionization energy, and electron affinity) are related to their position in the periodic table. Discussion of the reactivity patterns of main group elements, including their tendency to gain or lose electrons in chemical reactions.
- Representative Main Group Elements: Studies of specific main group elements (in detail, including their properties, and the compounds they form).
- Hydrogen: Industrial hydrogen production, hydrogen storage, ortho- and para-hydrogen, isotopes of hydrogen and isotope effects, general features of hydrogen chemistry, metal hydrides and their application.
- Main group 1 and 2: Representative features of alkali metal chemistry, liquid ammonia solutions of alkali metals, lithium chemistry and Li-Mg diagonal extension of lithium, Grignard reagents, general features of alkaline earth metals and their reactivities.
- Main groups group 13 elements: Unique features of boron chemistry, electron deficiency in diborane, B – Al contrast in halides, main features of Al, Ga, In, Tl chemistry, complexes of Al and Ga, stability of Tl(I) state and inert pair effect. Main group 14 elements: Main trends of the group 14, general features of carbon chemistry, allotropes of carbon, carbon oxides, chemistry of Si, Ge, Sn and Pb.
- Main groups 15 elements: Main trends of the group 15, Hydrogen compounds  $\text{EH}_3$ , oxygen compounds, halogen compounds, applications.
- Main groups 16 elements: general trends of the group 16, dioxygen species and ozone, sulfur allotropes, hydrogen compounds, chalcogenide polyanions and
- Polycations, applications
- Main group 17 elements: main trends of the group 17, reactivity of elements, hydrogen halides, interhalogens, polyhalogen compounds, oxides and oxoacids, applications.

#### **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.

- |  |   |
|--|---|
|  | <ul style="list-style-type: none"> <li>• Concept of interstices in close packings; AB, AB<sub>2</sub>, AB<sub>3</sub>-type structures; A<sub>2</sub>B<sub>3</sub> oxides; structures of normal and inverse spinels.</li> <li>• 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.</li> </ul> |
|--|---|

### Reading list/ Indicative Resources

- The elements of physical chemistry by P.W. Atkins J. de Paula, 6 ed. OUP (2013),
- C.E. Housecroft, A.G. Sharpe, "Inorganic Chemistry", 4<sup>th</sup> and 5<sup>th</sup> Edition.
- 'Inorganic Structural Chemistry', Ulrich Muller; 2nd Edition, Wiley, Weinheim, ISBN: 978-0-470-01864-4 "
- Shriver & Atkins, "Inorganic Chemistry", 5th edition.
- N. N. Greenwood and A.E. Earnshaw, Chemistry of the Elements, 2<sup>nd</sup> edition.
- A.G. Massey, "Main Group Chemistry", 2nd edition, Wiley, 2000.

### Proposed practical's

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

### Methods of Assessment

In-course assessment: 25% of Final Grade.

Written Examination: 75% of Final Grade

**Lab Hours** = 9 x 3 hours = 27 hours

### Important Note on Examinations, Assessments and Reassessments in the School of Chemistry:

- There is a minimum mark requirement of **35%** in the **Examination** component and the **40% Laboratory** component, in order for a Pass or Qualified Pass mark in this module to be granted. Other components making up fewer marks are not included in this requirement. A mark of less than 35% in the Examination or 40% Laboratory components leads to a Qualified Fail and requires reassessment examination or a repeat of the year.
- There is a maximum mark or cap of 40% on any reassessed component in this module if reassessment is required. The final module mark is calculated based on the reassessed component mark and any already achieved marks for components that did not need to be reassessed, according to the published weightings of these components.
- Re-assessment capping does not apply to deferred 1st attempts at assessment.
- These requirements apply to all students in this module.
- For more details see the section on 'Progression Regulations applying to Chemistry modules' under the 'Progression and Awards' within this booklet.

### 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. Understand the periodic table and its organization, including trends in atomic size, ionization energy, and electron affinity within the main group elements.
8. Explain the bonding behaviour of main group elements, including covalent, ionic, and metallic bonds.
9. Explain the reactivity patterns of main group elements, focusing on their ability to form compounds and participate in chemical reactions.
10. Discuss specific representative main group elements in detail, including their chemical properties, and common compounds.
11. Discuss the reactivity patterns of main group elements, focusing on their ability to form compounds and participate in chemical reactions.

### Contacts for Modules CHU22201 and CHU22202:

**Module Coordinator:** E-mail: [southerj@tcd.ie](mailto:southerj@tcd.ie)  
Professor Mike Southern Phone: 01 896 3411

**Coordinator Fresh Teaching** E-mail: [pnscurly@tcd.ie](mailto:pnscurly@tcd.ie)  
Dr Noelle Scully Phone: 01 896 1972

**Administrative Officer** E-mail: [farrea25@tcd.ie](mailto:farrea25@tcd.ie)  
Ms AnneMarie Farrell Phone: 01 896 1726

## CHU22M03: Introduction to Medicinal Chemistry

Semester 1, 5 credits

Contact Hours: 30 hours lectures and tutorials

**Rationale and Aims:** To provide an introduction to aspects of medicinal chemistry and bioinorganic chemistry that are essential to an understanding of the chemistry of therapeutic compounds and metalloenzyme function in living systems. The student will learn basic concepts in medicinal/pharmaceutical chemistry, how a drug exerts its action, how it can be optimised and the different steps in the development of a drug. The student will also be introduced to the concept of metals in medicine, to cover both diagnostic and therapeutic agents. A variety of non-invasive imaging techniques will be discussed, with a focus on metal-based contrast agents. Specific examples of coordination compounds as therapeutic agents will also be covered to illustrate their applications and show how they link with our basic concepts of coordination chemistry. The course is descriptive, but also includes considerable focus on in-vivo reaction pathways of different metallodrugs. This section of the module aims at exploring the coordination chemistry of metallodrugs while reinforcing fundamental topics explored in the core CHU22201 module.

### Content Layout

No of Lectures	Topic
18 L	<p><b>Introduction to Medicinal Chemistry:</b></p> <p>Lecture 1: History of medicinal chemistry. What is medicinal chemistry? What is a drug?</p> <p>Lecture 2: Drug safety. The therapeutic index. How a drug exerts its activity? Main phases of drug activity.</p> <p>Lecture 3: Pharmaceutical Phase. Pharmacokinetic phase: ADME properties (Absorption, Distribution, Metabolism and Elimination) of a drug. Absorption: types of absorption and the role of the <math>pK_a</math> and <math>\log P</math> of a drug in its absorption.</p> <p><i>Tutorial 1: <math>pK_a</math> in drug absorption</i></p> <p>Lecture 4: Pharmacokinetic phase, continuation. Distribution. Metabolism. Elimination</p> <p>Lecture 5: Pharmacokinetic parameters: Lipinski rule of 5, clearance, bioavailability, volume of distribution, elimination rate.</p> <p>Lecture 6: Drug Toxicity. Pharmacodynamic phase. Targets: (phospho)lipids, proteins, glyco-lipids/-proteins, nucleic acids.</p> <p>Lecture 7: Drug-target theories. Drug-Target interactions (covalent bonds, electrostatic, dipole-dipole, charge transfer, van der Waals, hydrogen bonds, hydrophobic).</p> <p>Lecture 8: How drugs interact with all possible targets considered: phospholipids, protein receptors (agonism/antagonism).</p> <p>Lecture 9: Protein as targets: enzymes. Different types of inhibition and inhibitors (reversible inhibition, irreversible inhibition, transition state inhibitors).</p> <p><i>Tutorial 2: Targeting enzymes: dihydrofolate reductase.</i></p> <p>Lecture 10: Nucleic acids as targets. DNA binding (intercalation, alkylation, minor groove binding). Guanine-quadruplexes.</p> <p>Lecture 11: Drug discovery process: Design and synthesis steps. Identification of a target. Finding a hit/lead compound: serendipity, high-throughput screening (combinatorial chemistry, natural products).</p> <p><i>Tutorial 3: Biological evaluation: dose-response curves.</i></p>

	<p>Lecture 12: Optimization process. Structural variations: pharmacophore and bioisosterism</p> <p><i>Tutorial 4: Pharmacophore and bioisosterism examples and salt forms.</i></p> <p>Lecture 13: Computer assisted drug design. Molecular modelling: computational methods (ab initio, DFT, molecular dynamics). QSAR: 2D and 3D. "Me-too" drugs.</p> <p>Lecture 14: Drug development stages: Pre-clinical studies, Clinical phases (1, 2 and 3) and Post-marketing control.</p>
12 L	<p><b>Metals in Medicine:</b> Introduction to the role's metals play in medicine.</p> <ul style="list-style-type: none"> <li>• Introduction to the role of metals and inorganic compounds in medicine <ul style="list-style-type: none"> <li>○ History</li> <li>○ Inorganic medicines and imaging agents in use today</li> </ul> </li> <li>• Metal-based diagnostic (imaging) agents in medicine <ul style="list-style-type: none"> <li>○ Non-invasive imaging techniques</li> <li>○ Contrast agents for MRI, in particular Gd-based contrast agents for MRI</li> <li>○ Metal-based probes for optical imaging</li> <li>○ Other Examples</li> </ul> </li> <li>• Therapeutic metal-based drugs <ul style="list-style-type: none"> <li>○ Platinum-based drugs in cancer chemotherapy</li> <li>○ Therapeutic gold drugs</li> <li>○ Other Metallodrugs based on Titanium, Ruthenium and Vanadium complexes</li> <li>○ Chelation therapy for metal poisoning</li> <li>○ Metallodrug delivery systems</li> <li>○ Recent developments</li> </ul> </li> </ul> <p>Tutorials will be held after lectures 5 and 10.</p>

### Reading list/ Indicative Resources

#### Medicinal Chemistry:

- Lehninger principles of biochemistry. David L. Nelson and Michael M. Cox, 6<sup>th</sup> Edition, 2013. McMillan Learning.
- Pharmacology. H.P Rang, MM Dael JM Ritter PK Moore, 5<sup>th</sup> edition, Churchill 2003, Livingstone editors
- Fundamentals of General, Organic and Biological Chemistry. McMurry, Ballantine, Hoeger, Peterson, 8<sup>th</sup> edition, Pearson 2017.
- The Organic Chemistry of Drug Design and Drug Action. Richard B. Silverman, 2014 (3<sup>rd</sup> Edition). Academic Press
- An Introduction to Medicinal Chemistry, 5<sup>th</sup> edition. Graham L. Patrick, 2012. Oxford University Press

#### Metals in Medicine:

- Introduction to modern inorganic chemistry. K.M. Mackay, R.A. Mackay, H. Henderson, Nelson Thornes | 2002 | 6<sup>th</sup> ed
- Introduction to coordination chemistry. Geoffrey A. Lawrance, Wiley-Blackwell | 2010
- Metals in medicine. James C. Dabrowiak, Wiley-Blackwell | 200

#### Methods of Assessment:

A combination of paper assessment at the end of semester 1 (60%) and in course assessments (40%) consisting of a group assignment, individual homework assignments and in-class assessments.

## Learning outcomes:

On completion of this module the student should be able to:

1. Identify what is a drug and how to assess its safety.
2. Identify the three main phases of drug activity: pharmaceutical, pharmacokinetic (ADME- Absorption, Distribution, Metabolism and Elimination) and pharmacodynamics phases.
3. Predict drug absorption based on its  $pK_a$  value.
4. Understand how a drug exerts its activity by identifying the interactions with its target.
5. Identify the different possibilities in the drug discovery process.
6. Have a good understanding of the different drug optimization processes/tools available.
7. Identify the drug development stages.
8. Identify common non-invasive medical imaging methods and suitable contrast agents
9. Identify in-vivo reaction pathways for common metallodrugs
10. Identify chelating agents for heavy metal toxicity and have a deep understanding of chelation therapy
11. Have a deep understanding of cytotoxic, optical and electronic of metal complexes and be able to relate that to their role in medicine.
12. Be able to discuss advancements in metallodrug delivery systems for improved drug stability, controlled release, and targeted delivery.

## Contact Details:

**Module Coordinator**  
TBC

E-mail: TBC  
Phone: 01 896 3731

**Coordinator Fresh Teaching**  
Dr Noelle Scully

E-mail: pnsully@tcd.ie  
Phone: 01 896 1972

**Administrative Officer**  
Ms AnneMarie Farrell

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## CHU22204: Introduction to Environmental and Sustainable Chemistry

Semester 2, 5 credits

**Contact Hours:** 30 hours lectures and tutorials

### Rationale and Aims:

To provide an introduction to aspects of environmental and green chemistry that are essential to an understanding of chemical processes in environmental compartments and their impact on ecosystems and/or animal and human health. The module will also introduce the student to experimental methods of analysis and frontier methods for mitigating environmental impacts.

### Content Layout

No of Lectures	Topic
8 L	<b>Inorganic Environmental Chemistry and Green Chemistry</b> <ul style="list-style-type: none"><li>• Introduction to Environmental Chemistry</li><li>• The origin and distribution of the elements</li><li>• The Lithosphere: Important minerals and ores; soil and soil composition</li><li>• The Hydrosphere: Properties of water and speciation in aqueous systems</li><li>• Biogeochemical cycling: Nitrate, phosphate and carbon cycles</li><li>• Introduction to Green Chemistry</li></ul>
9 L	<b>Introduction to Nuclear and Toxic Elements Chemistry</b> <ul style="list-style-type: none"><li>• Introduction to Nuclear Chemistry: the different kinds of nuclear decay, kinetics, mass loss and energy, half-life, effects of nuclear radiation on matter</li><li>• Applications of radioisotopes: radio-carbon dating, nuclear metals in medicine (diagnostics and radiation therapy)</li><li>• Introduction to toxicity, HSAB principles and chelation therapy</li><li>• Toxic elements: general features, bioavailability, biomethylation</li><li>• Be, Al, Tl, Hg, Pb and Cd toxicity: sources, symptoms, mechanisms, treatment</li><li>• Nanotoxicology</li><li>• Therapeutic use of a toxic element: cisplatin for cancer treatment (DNA adducts, side effects, resistance), other metal based anti-cancer drugs</li></ul>
6 L	<b>Instrumental Methods in Environmental Chemistry</b> <ul style="list-style-type: none"><li>• Analytical chemistry, quantitative vs. qualitative</li><li>• Fundamentals of spectroscopic methods</li><li>• Separation methods</li><li>• Electroanalytical methods for environmental chemistry</li></ul>
7 L	<b>Introduction to Atmospheric Chemistry</b> <ul style="list-style-type: none"><li>• Introduction to atmospheric chemistry</li><li>• Ozone layer chemistry</li><li>• Photochemistry and SMOG</li><li>• Aerosols/micro-particles</li><li>• Energy and climate change</li></ul>

### Reading list/ Indicative Resources

- C.E. Housecroft and A.G. Sharpe, "Inorganic Chemistry", Prentice Hall, 2001
- G.W. vanLoon and S.J. Duffy, "Environmental Chemistry: A Global Perspective", Oxford Press, 2000
- M.S. Silberberg, 'Chemistry....', McGraw-Hill, 2nd Ed., 2000, Chapter 24 for Nuclear Chemistry.
- J. McMurry and R.C. Fay, 'Chemistry', Pearson, 4th Ed. 2004. Chapter 22 for Nuclear Chemistry.
- W. Kaim, B. Schwederski and A. Klein, "Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introduction and Guide", 2nd Edition, Wiley, 2013. Chap. 18 for Radionuclides; Chap. 17 for Toxic Metals; Chap. 19 for Chemotherapy with cis-platin.
- Colin Baird and Michael Cann, "Environmental Chemistry", W. H. Freeman; Fifth edition, 2012.

### Methods of Assessment

In course assessment: 25%

Written Examination: 75%

### Proposed in course assessment/s:

A short (500-1000 word) essay, problem-based questions on selected topics and in-class assessments.

### Learning outcomes:

On completion of this module the student should be able to:

- Explain the origin, distribution, and availability of elements in the environment.
- Appreciate the impact of human activity on natural biogeochemical cycles and be aware of measures to limit this impact.
- Understand the main concepts of nuclear chemistry and discuss applications of nuclear materials.
- Discuss the bioavailability, toxic effects of poisonous metals and appropriate treatments.
- Explain principles of chemotherapy and discuss the use of Pt complexes for cancer treatment.
- Explain and apply statistical tools used in the analysis of experimental data.
- Describe physical principles and process behind common analytical techniques.
- Understand the advantages and disadvantages of specific analytical techniques.
- Understand the basic principles of atmospheric chemical processes such as those involved in the ozone layer, photochemistry, SMOG, aerosols/micro-particles.

### Contact Details:

<b>Module Coordinator:</b>	E-mail: <a href="mailto:dunnep13@tcd.ie">dunnep13@tcd.ie</a>
Professor Peter Dunne	Phone: 01 896 4449
<b>Coordinator Fresh Teaching</b>	E-mail: <a href="mailto:pnscully@tcd.ie">pnscully@tcd.ie</a>
Dr Noelle Scully	Phone: 01 896 1972
<b>Administrative Officer</b>	E-mail: <a href="mailto:farrea25@tcd.ie">farrea25@tcd.ie</a>

## PIU22992: History, Philosophy and Ethics of Science

**Semester 2, 5 credits**

**Contact Hours:**

22 hours of lectures + 10 hours of tutorials

**Module Personnel:** TBC (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? Insofar as science is successful, can we rely on it to solve our problems? This course will examine the workings of science through four core topics: what is science and the scientific method, the unity of science, ethical conduct in science and ethical issues that arise in addressing climate change.

### Module Learning Outcomes:

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

- Think critically about the historical, philosophical and ethical dimensions of science.
- Reflect on the aims and methods of science, in ways that facilitate ongoing exploration of scientific practice.
- Demonstrate awareness of competing ethical demands that arise in scientific practice and of the role of scientists, individuals and communities in promoting ethical standards.
- Communicate their ideas effectively to others in writing using clear and precise language.
- Engage in reasoned debate in classroom and lecture settings.

**Module content:** Programme of Lectures and Tutorials

Week	Lecture Topic	Lecturer
1	Module Introduction	
	What is Science? The Demarcation Problem	
2	The Scientific Revolution	
	Other Scientific Revolutions	
	Tutorial: What is Science?	
3	Scientific Method: The Problem of Induction	
	Popper's Falsificationism	
	Tutorial: Scientific Revolutions	
4	Scientific Method: How are Theories Confirmed?	
	Kuhn on Scientific Method and Revolutions	
	Tutorial: Induction and Falsificationism	
5	The Unity of Science: Reduction and Emergence	
	Why was Vitalism Discarded?	
	Tutorial: Kuhn on Scientific Method and Revolutions	
6	The Problem of the Direction of Time	
	What is Causation?	
	Tutorial: Unity at Work: Why was Vitalism Discarded?	
7	<b>Reading Week</b>	
8	Trust in Science: Why Ethics Matters	Prof Hogan
	What Makes Something Ethical? Ends and Means	Prof Hogan

	Tutorial: Finding the Direction of Time and Causation in Physics	
9	What Makes Something Ethical? Duties and Virtues	Prof Hogan
	From Principle to Practice: Navigating the Ethics Ecosystem	Prof Hogan
	Tutorial: Trust in Science and Ethical Principles	
10	Sustainability: The Climate Change Consensus	
	Climate Responsibility and Energy	
	Tutorial: Applied Ethics in Science	
11	Ethical Decision Making and Values	
	Decision-making and Disagreement: Eating Animals	
	Tutorial: Climate Responsibility and Energy	
12	Distraction Tactics: Waste and Fast Fashion	
	Review Lecture	
	Tutorial: Ethical Decision-making	
13	<b>Revision Week</b> <b>Open MCQ</b>	
14	<b>Assessment Week</b>	

## Lecture Content and Assessment Schedule

### *Component 1: What is Science and its Method?*

#### **W1L1: Module Introduction**

Introduction to the module. What is it to approach science historically, philosophically and ethically?

#### **W1L2: What is Science? The Demarcation Problem**

What is Science? How is science different from other disciplines and activities? Contemporary attempts to demarcate science from non-science using its aims or methods.

#### **W2L1: 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: Other Scientific Revolutions**

To what extent do sciences like chemistry and the geosciences also have revolutions? Is there a clear demarcation between science and non-science?

#### **W3L1: Scientific Method: The Problem of Induction**

What is it to follow the scientific method? The distinction between two forms of inference: deduction and induction. Do observations of the past constrain our predictions of the future? Can induction be justified? Hume's 'Problem of Induction'.

#### **W3L2: Popper's Falsificationism**

Can scientific theories be refuted? Is there no more to scientific method than choosing unrefuted (but refutable) theories? Popper's deductive scientific method—avoiding the problem of induction. Are specific scientific claims or theories refutable? Criticisms of Popper from Quine and Duhem.

#### **W4L1: Scientific Method: How are Theories Confirmed?**

What is it for evidence to count in favour of a theory? Can probabilities be used to give a complete account of theory confirmation? Bayesian approaches to theory confirmation.

#### **W4L2: Kuhn on Scientific Method and Revolutions**

Is science a rational enterprise? To what extent do sciences at all times follow the same rules? To what extent are scientists led by paradigms of good science? Kuhn's account of science: science as a historical process that goes through periods of normal and revolutionary change.

#### **Component 2: The Unity of Science**

##### **W5L1: The Unity of Science: Reduction and Emergence**

To what extent is science a unified enterprise? Do all sciences have to agree? What is the relation between more 'fundamental' and 'higher-level' sciences? How do sciences depend on each other?

##### **W5L2: Why was Vitalism Discarded?**

The historical case of Vitalism. Why did scientists used to believe in a distinctive force possessed by only living things? What led to the demise of vitalism? What, if anything, do we learn about the relation between biology and other sciences?

##### **W6L1: The Problem of the Direction of Time**

Is there a direction of time? Is there a direction of time in (relatively) fundamental physics? How might a direction of time emerge from dynamics that are temporally symmetric? The role of entropy.

##### **W6L2: What is Causation?**

What is it for one thing to cause another? How do causal relations relate to laws? Are there causal relations in fundamental physics? If not, where are they? What are causal relations *for*?

#### **Component 3: The Ethics of Scientific Practice**

##### **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, Duties, and Virtues, and assesses their relevance and persuasiveness in the context of a range of examples from science.

##### **W9L1: From Principle to Practice: Navigating the Ethics Ecosystem (I)**

These lectures examine critical contemporary ethical issues that arise in the different scientific fields, focusing on bioethics, animal ethics, geoethics and information ethics.

##### **W9L2: From Principle to Practice: Navigating the Ethics Ecosystem (II)**

These lectures examine critical contemporary ethical issues that arise in the different scientific fields, focusing on bioethics, animal ethics, geoethics and information ethics.

#### **Component 4: Sustainability and Climate Change**

##### **W10L1: Sustainability: The Climate Change Consensus**

What was the role of science and scientists in establishing global consensus on climate change?  
What is the state of climate change and our attempts to address it?

**W10L2: Climate Responsibility and Energy**

Who is responsible for historical climate change? Who is responsible for addressing climate change now? Climate change and equality. What is the role of the energy sector? Is new technology enough? What is the role of economic policy? What role (if any) do arguments about 'personal responsibility' have? The idea of your 'carbon footprint'.

**W11L1: Ethical Decision Making and Values**

How should we decide what to do? What should we value? How should the needs of the present be weighed against the needs of the future? What psychological biases might impede ethical decision-making about the climate?

**W11L2: Decision-making and Disagreement: Eating Animals**

What is the role of food production and land use in climate change? What values and interests shape choices about food? Who is responsible for what we eat? Is there value to eating meat? How can we disagree productively?

**W12L1: Distraction Tactics: Waste and Fast Fashion**

What happens to waste? What role does the fashion industry play in climate change? How have companies addressed (or not addressed) climate change? Are carbon offsets a reasonable way to reduce emissions? What about carbon capture or geo-engineering?

**W12L2: Review**

Review lecture, in preparation for final in person exam.

**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:**

2 Written assignments of 500 words (1–2 pages) (30% total; 15% each)

1 hr end of term in person exam (50%)

7 Discussion posts (10%)

Attendance at tutorials (10%)

**Module Website:** (See Blackboard)

<b>Module Coordinator: PIU22991: History, Philosophy and Ethics of Science</b>	
(Prof Alison Fernandes)	(E-mail: asfernan@tcd.ie)
Department of Philosophy	(Phone: 353 1 896 1174)
<b>Executive Officer:</b>	E-mail: philosophy@tcd.ie
Carly Forde	Phone: 353 1 896 1529

## TR061: Chemical Sciences – OPEN Modules

### BYU22C01: From Molecules to Cells II

**Semester 1, 10 credits**

**Prerequisite:** BYU11101

**Module coordinator:** Prof Mohammed Hankir

**Contact Hours:** 34 hours lectures, 21 hours practicals

**Module Personnel:** E. Creagh, K. Mok, A. Khan, M. Hankir, D. Nolan, J. Hayes, 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 afternoons.

#### **Lecture Content:**

- Introduction to the BYU22C01 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. Sick 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. Reversible inhibition and allosteric regulation.
- 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-  $\beta$ -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.
- 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.
- 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.
- 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 I: genetic diversity of viruses.** The diversity of viral genomes and particle structures will be explored in this lecture. Introduction to viral replication - how different viruses enter cells and an example of viral strategies for producing mRNA.
- **Virology II: Replication continued–** we will explore how replication and assembly of new virions is dependent on location within the cell and also the cellular processes a virus needs to utilise during replication. In this lecture we will touch on viruses causing emerging infections and how their replication cycles have changed to adapt to new hosts/cell types.

### **Practical Content:**

**Practical 1 Solutions & dilutions** - This numerical skills activity will prepare students for numerical calculations relevant for lab work (eg. calculating molarities, how to make up buffers, dilution factors, etc.).

**Practical 2 Chromatography & spectrophotometry** - During this practical students will perform (1) **ion exchange Chromatography** and (2) **a spectrophotometric 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  $K_m$  and  $V_{max}$  for uninhibited series, use Lineweaver-Burk plots to demonstrate competitive inhibition, and determine the  $K_i$ .

### **Practical 4 Oxidative Phosphorylation**

### **Practical's 5 and 6: Differential Gene Expression**

### **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.
- Students should be able to demonstrate practical, numerical and analytical skills appropriate to modern biochemistry, genetics and microbiology.
- Students should be able to collate, synthesise and present information in written reports and essays.

### 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<sup>th</sup> / 5<sup>th</sup> Editions). W. W. Norton & Company.

**Biochemistry.** Berg, Tymoczko, Gatto, Stryer (8<sup>th</sup> edition). Macmillan International.

**Introduction to Genetic Analysis.** Griffiths, Wessler, Carroll, Doebley (11<sup>th</sup> edition). W.H. Freeman and Co.

### Assessment Details:

#### (A) End of semester written examination: 50% of module mark

The examination paper is divided into two sections, equally weighted.

- **Section 1: Essay** One essay from a choice of three.
- **Section 2** Ten short answer questions from across the module.

#### (B) Course Work: 50% of module mark

1. Practical assignments 20% of module mark
2. End of Module practical exam, 15% of module
3. MCQ test of lecture material, 15% of module

**To pass the module a student must obtain an overall module mark of 40%**

### Contacts:

<b>Module Coordinator:</b>	Mohammed Hankir	<a href="mailto:HANKIRM@tcd.ie">HANKIRM@tcd.ie</a>	
<b>Biology Teaching Manager:</b>	Mirela Dardac	<a href="mailto:mdardac@tcd.ie">mdardac@tcd.ie</a>	Ph: 01 8962895
<b>Chief Technical Officer:</b>	Audrey Carroll	<a href="mailto:aucarrol@tcd.ie">aucarrol@tcd.ie</a>	Ph: 01 8961620
<b>Executive Officer:</b>	TBC	<a href="mailto:btcadmin@tcd.ie">btcadmin@tcd.ie</a>	Ph: 01 8961117

## BYU22202: From Cells to Organisms

**Semester 2, 10 credits**

**Prerequisite:** BYU11101

**Module coordinator:** Prof Colm Cunningham

**Contact Hours:** 37 hours lectures, 15 hours practicals.

**Module Personnel:** C. Cunningham, S. O'Brien, D. Zisterer, P. Murphy, Á. Kelly, T. Ryan, A. Witney, Mathew Dorman

### **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, laboratory practical's and writing skills exercise. Four lectures a week, Monday at 9:00, Tuesday at 9:00 and 13:00, Wednesday at 17:00, practicals on alternate Wednesdays. There will be two in-course assessments of Lecture material (multiple choice format). The first will be immediately after reading week, the second in the last week of semester.

### **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 obesity, diabetes and brain injury/neurodegenerative disease.
- 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 an 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: Writing Skills Activity:** A topic from the lecture series will be selected and students are given approximately two weeks to prepare a first draft essay. Students will bring their drafts to a supervised session where they will peer review the drafts in small groups (under supervision) and attend a masterclass on writing skills. Final essays will be submitted a few days later.

**Practical 5: 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, respond to stress, and describe the structure, function and importance of bacterial extracellular structures and their roles in modulating cell-cell interactions. Utilise phenotypic tests and microscopy to characterise bacteria in the laboratory (Practical).
- 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, received, transduced and amplified in the cellular context (signal transduction), and provide examples as to how this is achieved in cells.
- 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 (Practical's).
- 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
- Measure and understand fundamental cardiovascular and respiratory variables in human subjects (Practical).
- 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.
- Demonstrate good practice in essay writing: including planning, drafting, responding to constructive review and timely submission of a final draft (Practical, graded for continuous assessment).

### 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.* 12<sup>TH</sup> Edition. Pearson.
- Prescott's Microbiology 10<sup>th</sup> edition. McGraw Hill.
- Biochemistry. Berg, Tymoczko, Gatto, Stryer 8<sup>th</sup> 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. 9<sup>th</sup> Edition. Cengage Learning.
- Principles of Neurobiology. Liqun Luo. 1<sup>st</sup> edition. Garland Science.

### Assessment Details:

Marks are allocated across two components, course work (50% of module mark) and end-of-module examination (50% of module mark). The end-of module examination will be two hours duration. Students must answer three out of five questions. **To pass the module a student must obtain an overall module mark of 40%.**

### Contacts:

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<b>Biology Teaching Manager:</b>	Mirela Dardac	<a href="mailto:mdardac@tcd.ie">mdardac@tcd.ie</a>	Ph: 01 8962895
<b>Chief Technical Officer:</b>	Audrey Carroll	<a href="mailto:aucarrol@tcd.ie">aucarrol@tcd.ie</a>	Ph: 01 8961620
<b>Executive Officer:</b>	To be confirmed	<a href="mailto:btadmin@tcd.ie">btadmin@tcd.ie</a>	Ph: 01 8961117

## MAU22S01: Multivariable Calculus for Science

### Semester 1, 5 ECTS credits

**Contact Hours:** 11 weeks, 3 lectures and 1 tutorial per week

**Lecturer:** Prof Manya Sahni (msahni@tcd.ie)

**Module Prerequisite:** MAU11S01 & MAU11S02

### Learning Outcomes

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

- Calculate limits and partial derivatives of functions of several variables
- Compute directional derivatives of functions of many variables and determine the direction of maximal growth of a function using its gradient vector; write equation of the plane tangent to its graph at a given point;
- Compute the divergence and curl of a vector function;
- Use the method of Lagrange multipliers to find local maxima and minima of a function;
- Develop polar, spherical and cylindrical coordinates;
- 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)
- Compute line and surface integrals

### Module Content

- Polar, Cylindrical and Spherical Coordinates;
- Functions of Several Variables, Partial Derivatives;
- Tangent Planes and Linear Approximations;
- Directional Derivatives and the Gradient Vector;
- Vector functions, Divergence and Curl;
- 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
- Line integrals and Surface integrals

### Recommended Reading

*Calculus, Late transcendentals* 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 Michaelmas term. **Continuous assessment** will contribute 20% to the final grade for the module at the annual examination.

### Contact Details:

<b>Module Coordinator: MAU22S01</b>	E-mail: msahni@tcd.ie
Professor Manya Sahni	Phone:
<b>Administrative Officer</b>	E-mail: mathdep@maths.tcd.ie
Ms Jennifer Murray	Phone: 01 896 2423

## MAU22S02: Vector Calculus for Science

### Semester 2, 5 ECTS credits

**Contact Hours:** 11 weeks, 3 lectures and 1 tutorial per week

**Lecturer:** Prof. Nicholas Aidoo ([naidoo@tcd.ie](mailto:naidoo@tcd.ie))

**Module Prerequisite:** MAU22S01

### Learning Outcomes

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

- Manipulate vectors in  $\mathbb{R}^3$  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  $\mathbb{R}^3$ ;
- Find the equation of normal lines and tangent planes to surfaces in  $\mathbb{R}^3$ ;
- 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  $\mathbb{R}^3$ . Vector fields, curves and surfaces in  $\mathbb{R}^3$ .
- Theorems of Green, Stokes and Gauss.
- PDEs of first and second order

### 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:

MAU22S02: Vector calculus for Science		
<b>Module Coordinator</b>	Prof. Nicholas Aidoo	E-mail: <a href="mailto:naidoo@tcd.ie">naidoo@tcd.ie</a>
<b>Administrative Officer</b>	Jennifer Murray	E-mail: <a href="mailto:mathdep@maths.tcd.ie">mathdep@maths.tcd.ie</a>
	Phone: 01 896 2423	Phone: 01 896 2423

## MAU22S03: Fourier Analysis for Science

### Semester 1, 5 ECTS credits

**Contact Hours** : The term lasts for 11 weeks, there are three 1-hour lectures and one 1-hour tutorial per week.

**Lecturer** : Dr Anthony Brown ([browna2@tcd.ie](mailto:browna2@tcd.ie)).

**Module Prerequisites** : MAU11S01 & MAU11S02, co-requisite MAU22S01.

### Learning Outcomes

- Find the real and complex Fourier series of periodic functions,
- Obtain the Fourier transforms of non-periodic functions,
- Evaluate integrals containing the Dirac delta function,
- Calculate the Fast Fourier Transform using the Cooley–Tukey algorithm,
- Solve first order ordinary differential equations using separation of variables, the integrating factor method, and by using substitution,
- Solve second order ordinary differential equations with constant coefficients, both homogeneous and non-homogeneous,
- Obtain series solutions (including using the Frobenius method) of ordinary differential equations.

### Module Content

- Vector spaces and inner products,
- Fourier series,
- Fourier transforms,
- Discrete Fourier transforms,
- First order ordinary differential equations,
- Second order ordinary differential equations,
- Series solutions of ordinary differential equations.

### Suggested Reference

There are many large and comprehensive methods books that cover (either some or all of) the material in this course. Examples are:

- Advanced Engineering Mathematics by Erwin Kreyszig,
- Mathematical Methods for Physicists by George Arfken,
- Advanced Modern Engineering Mathematics by Glyn James.

### Assessment Detail

This module will be examined by a 2-hour examination in Michaelmas term. Continuous Assessment consisting of three written assignments throughout the term will contribute 20% to the final grade, with the examination counting for the remaining 80%.

### Contact Details:

MAU22S03: Fourier analysis for Science		
Module Coordinator	Dr Anthony Brown	E-mail: <a href="mailto:browna2@tcd.ie">browna2@tcd.ie</a>
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## PYU22P10: Physics 1

Semester 1, 10 Credits

### PYU22P10 Physics

(E. Keane, H. Zhang, M. Hegner, P. Eastham; Co-ordinator: Prof H. Zhang)

This module combines four elements of classical physics as follows:

**Observing The Universe** – 15 lectures

**Electricity and Magnetism II** – 14 lectures

**Oscillations** – 12 lectures

**Quantum Physics** – 12 lectures

#### Syllabus:

- **Observing the Universe: - 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.
- **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.
- **Quantum Physics: - 12 lectures**

## **PYU22P10 Learning Outcomes:**

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

- Solve basic problems in relation to harmonic oscillators
- Describe elementary crystal structures and the response of materials to external forces
- Describe how the laws of thermodynamics react to properties of matter
- Explain a broad variety of astrophysical phenomena with simple physics
- 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.

<b>Assessment</b>	<b>Weighting</b>
Examination	60%
Experimental / Computational laboratories	25%
Project	5%
Tutorials	10%

### **Important Note on Examinations, Assessments and Reassessments in Fresher years**

- There is a minimum mark requirement of 30% separately in the Examination component and the Laboratory component, in order for a Pass or Qualified Pass mark in the module to be granted. Other components making up fewer marks are not included in this requirement. A mark of less than 30% in either of these Examination or Laboratory components leads to a Qualified Fail, and requires reassessment examination or a repeat of the year.
- There is a maximum mark or cap of 60% on any reassessed component in this module if reassessment is required. The final module mark is calculated based on the reassessed component mark and any already achieved marks for components that did not need to be reassessed, according to the published weightings of these components.
- Re-assessment capping does not apply to deferred 1st attempts at assessment.
- These apply to all students in this module.
- For more details please see the section in the School of Physics Undergraduate Handbook on “Progression regulations applying to Physics modules and accredited Physics programmes” available in full at: <https://www.tcd.ie/physics/study/current/undergraduate/handbook/> or see a summary at: <https://www.tcd.ie/physics/study/current/undergraduate/progression>

**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 and a half-hour examination paper during the relevant end of semester exam session.

**Web:** <https://www.tcd.ie/physics/>

**Contact Details:**

<b>Module Coordinator:</b>		
Professor Hongzhou Zhang		E-mail: <a href="mailto:Hongzhou.Zhang@tcd.ie">Hongzhou.Zhang@tcd.ie</a>
		Phone: 01 896 4655
<b>Administrative Officer:</b>		
Ms. Una Dowling		E-mail: <a href="mailto:dowlingu@tcd.ie">dowlingu@tcd.ie</a>
		Phone: 01 896 1675

## PYU22P20: Physics 2

Semester 2, 10 Credits

### PYU22P20 Physics

(J Vos, M Stamenova, G. Cross, D McCloskey: Co-ordinator: Prof Hongzhou Zhang)

This module combines four elements of modern physics as follows:

**Special Relativity** – 12 lectures

**Nuclear and Particle Physics** – 14 lectures

**Thermodynamics** – 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.
- **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.
- **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
- Relate the concept of oscillations to optical properties of matter and AC circuits
- 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.

<b>Assessment</b>	<b>Weighting</b>
Examination	60%
Experimental / Computational laboratories	30%
Tutorials	10%

### **Important Note on Examinations, Assessments and Reassessments in Fresher years**

- There is a minimum mark requirement of 30% separately in the Examination component and the Laboratory component, in order for a Pass or Qualified Pass mark in the module to be granted. Other components making up fewer marks are not included in this requirement. A mark of less than 30% in either of these Examination or Laboratory components leads to a Qualified Fail and requires a reassessment examination or a repeat of the year.
- There is a maximum mark or cap of 60% on any reassessed component in this module if reassessment is required. The final module mark is calculated based on the reassessed component mark and any already achieved marks for components that did not need to be reassessed, according to the published weightings of these components.
- Re-assessment capping does not apply to deferred 1st attempts at assessment.
- These apply to all students in this module.
- For more details please see the section in the School of Physics Undergraduate Handbook on "Progression regulations applying to Physics modules and accredited Physics programmes" available in full at: <https://www.tcd.ie/physics/study/current/undergraduate/handbook/> or see a summary at: <https://www.tcd.ie/physics/study/current/undergraduate/progression>

**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 and a half-hour examination paper during the relevant end of semester exam session.

**Web:** <https://www.tcd.ie/physics/>

**Contact Details:**

<b>Module Coordinator:</b>		
Professor Hongzhou Zhang		E-mail: <a href="mailto:Hongzhou.Zhang@tcd.ie">Hongzhou.Zhang@tcd.ie</a>
		Phone: 01 896 4655
<b>Administrative Officer:</b>		
Ms Una Dowling		E-mail: <a href="mailto:dowlingu@tcd.ie">dowlingu@tcd.ie</a>
		Phone: 01 896 1675

## 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/teaching-learning/academic-affairs/ug-prog-award-regs/index.php>

### Progression regulations applying to Chemistry modules.

An overview of the progression regulations within the Chemical Sciences programme is detailed here.

#### (a) Minimum mark requirement and Qualified Fails in Fresher years

The progression and regulations rules for chemistry modules are different to modules associated to different Schools. In modules with a practical component (CHU11101, CHU11102, CHU22201 and CHU22202) a minimum mark requirement applies to the examination and practical separately as outlined below:

- (i) These regulations apply to the Fresher JF and SF 10 credit modules that are core to Chemical Sciences (TR061), and which are available as Open modules to JF and SF Physical Sciences (TR063) and Geosciences (TR062) students.  
These modules are JF: CHU11101 and CHU11102; and in SF: CHU22201 and CHU22202. (*This does not include CHU22M03 and CHU22204*).
- (ii) In these Fresher modules there is a **minimum mark requirement of 35%** in the Examination component and **40%** the Laboratory component, in order for either a Pass or a Qualified Pass mark in the module to be granted. The Progression threshold is not simply an overall module mark of 40% or higher but requires minimum marks in these components.
- (iii) A mark of less than 35% in the Examination or less than 40% in the Laboratory components leads to a Qualified Fail. A Qualified Fail requires reassessment in that component before progression to the next year can occur. Reassessment of the exam component is in the reassessment examination period; reassessment of the laboratory component occurs before the beginning of the reassessment examination period.
- (iv) If a mark of less than 35% occurs or recurs in the examination or less than 40% in the laboratory component following the reassessment period, the student cannot progress and must repeat the year. This necessarily applies to students who had deferred their first attempt at examinations to the reassessment period.
- (v) Students who fail a module with a module mark of <40%, but  $\geq 35\%$  are not eligible for Pass by Compensation, or a Qualified Pass, if the examination is less than 35% or laboratory components is less than 40%.

## **(b) Capping of reassessed components in the reassessment session in Fresher years**

In all chemistry related reassessments (with or without a practical component), a cap (maximum mark) of 40% will apply as outlined below:

- (i) All the reassessed components for Junior Fresh and Senior Fresh Chemistry modules delivered as part of the Chemical Sciences (and available to students in the Physical Sciences and Geosciences courses as Open modules). These modules are JF: CHU11101 and CHU11102; and in SF: CHU22201, CHU22202, CHU22M03 and CHU22204.
- (ii) Re-assessment capping does not apply to deferred 1<sup>st</sup> attempts at assessment.

The full text of these derogations from the College Progression and Award rules can be found at: <https://www.tcd.ie/academic-affairs/academic-regulations/-undergraduate-progression-and-awards/>

### **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](http://my.tcd.ie) and on school or department noticeboards 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.

Attendance at chemistry practical classes is compulsory for all students in all years of Chemical Sciences TR061, and for students in other science streams (Physical Sciences TR063 and Geosciences TR062) that may take chemistry modules as open modules in JF and SF years.

### **Assessment: Procedures for Non-Submission of Coursework and Absence from Exams**

All students must fulfil the course requirements of the school or department, as appropriate, with regard to attendance and course work. Where specific requirements are not stated, students may be deemed non-satisfactory if they miss more than a third of their course of study or fail to submit a third of the required course work in any term.

Full regulations on Attendance/Non-attendance Regulations for Junior and Senior Fresh Students can be found via the following:

<https://www.tcd.ie/media/tcd/science/pdfs/Science-ABSENCE-NON-SATISFACTORY-regulations---TSPMC-August-2024.pdf>

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

## Guidelines on Marking for Junior and Senior Fresh Courses

Class	Mark Range	Criteria
I	90-100	<b>EXCEPTIONAL ANSWER:</b> This answer will show original thought and a sophisticated insight into the subject, and mastery of the available information on the subject. It should make compelling arguments for any case it is putting forward and show a rounded view of all sides of the argument. In exam questions important examples will be supported by attribution to relevant authors and while not necessary giving the exact date, should show an awareness of the approximate period. In essays the references will be comprehensive and accurate
	80-89	<b>OUTSTANDING ANSWER:</b> This answer will show frequent originality of thought and make new connections between pieces of evidence beyond those presented in lectures. There will be evidence of awareness of the background behind the subject area discussed, with evidence of deep understanding of more than one view on any debatable points. It will be written clearly in a style which is easy to follow. In exams authors of important examples may be provided. In essays all important examples will be referenced accurately.
	70-79	<b>INSIGHTFUL ANSWER:</b> Showing a grasp of the full relevance of all course material discussed and will include one or two examples from wider reading to extend the arguments presented. It should show some original connections of concepts. There will be only minor errors in examples given. All arguments will be entirely logical and well written. Referencing in exams will be sporadic but referencing should be presented and accurate in essays.
II-1	65-69	<b>VERY COMPREHENSIVE ANSWER:</b> Good understanding of the concepts supported by broad knowledge of the subject. Notable for synthesis of information rather than originality. Evidence of relevant reading outside lecture notes and coursework. Mostly accurate and logical with appropriate examples. Occasional lapse in detail.
	60-64	<b>LESS COMPREHENSIVE ANSWER:</b> Mostly confined to good recall of coursework. Some synthesis of information or ideas. Accurate and logical within a limited scope. Some lapses in detail tolerated. Evidence of reading the assigned course literature.
Class	Mark Range	Criteria

II-2	50-59	<b>SOUND BUT INCOMPLETE ANSWER:</b> Based on coursework alone but suffers from significant omission, error or misunderstanding. Usually lacks synthesis of information or ideas. Mainly logical and accurate within its limited scope with lapses in detail
	50-54	<b>INCOMPLETE ANSWER:</b> Suffers from significant omissions, errors and misunderstandings, but still understanding of main concepts and showing sound knowledge. Several lapses in detail.
III	45-49	<b>WEAK ANSWER:</b> Limited understanding and knowledge of subject. Serious omissions, errors and misunderstandings, so the answer is no more than adequate
	40-44	<b>VERY WEAK ANSWER:</b> A poor answer, lacking substance but giving some relevant information. Information given may not be in context or well explained, but will contain passages and words, which indicate a marginally adequate understanding.
Fail	35-39	<b>MARGINAL FAIL:</b> Inadequate answer with no substance or understanding but with a vague knowledge relevant to the question.
	30-34	<b>CLEAR FAILURE:</b> Some attempt made to write something relevant to the question. Errors serious but not absurd. Could also be a sound answer to the misinterpretation of a question.
	0-29	<b>UTTER FAILURE:</b> With little hint of knowledge. Errors serious and absurd. Could also be a trivial response to the misinterpretation of a question.

## Academic Integrity Policy

Trinity College Dublin, the University of Dublin, is committed to upholding academic integrity, and recognises that it underpins all aspects of university life, including all activities relating to research, learning, assessment, and scholarship.

Trinity therefore considers academic misconduct to be serious and academically fraudulent and an offence against academic integrity that is subject to the Trinity procedures in cases of suspected misconduct.

The Academic Integrity Policy

(<https://www.tcd.ie/media/tcd/about/policies/pdfs/academic/Academic-Integrity-Policy.pdf>) should be read in conjunction with (and is subject to) the University Calendar, Part II on Academic Integrity (This policy replaces the Plagiarism Policy).

Other sources of information are available:

<https://www.tcd.ie/calendar/undergraduate-studies/>

<https://libguides.tcd.ie/academic-integrity>

<https://www.tcd.ie/teaching-learning/academic-affairs/academic-integrity/>

<https://www.tcd.ie/teaching-learning/academic-affairs/academic-integrity/mandatory-academic-integrity-training/>

## Guidance on the use of AI and Generative-AI in College

The advent of commonly available artificial intelligence tools is disruptive in both positive and negative ways. Before using them in your studies it is important that you familiarise yourself with College policies on their use. Unless otherwise instructed for particular modules or assessments, **the default expectation would be that you do not submit AI-generated content as an attempt at an assessment.**

Below is some basic overview of the College policy on AI and GenAI. This has been taken from the more detailed policy, which is informative and wide ranging. You are expected to have read and familiarised yourself with this policy.

[https://www.tcd.ie/academicpractice/resources/generative\\_ai/](https://www.tcd.ie/academicpractice/resources/generative_ai/)

### Artificial Intelligence (AI)

Artificial intelligence is generally understood to be a set of technologies that enable computers to perform a variety of functions usually perceived as requiring human intelligence – for example, understanding speech, recognising objects in images, composing written answers and problem reasoning. A more formal definition of an AI system from the European Union AI Act (2024) is: **...a machine-based system designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments[.] (EU AI Act 2024)**

## **Generative Artificial Intelligence (GenAI)**

Generative AI is the sub-area of AI, involving AI systems which generate content — for example, human dialogue, speech, images and video. GenAI systems are capable of generating such content based on a user’s request or instruction. More formally, GenAI is defined by UNESCO as **“an artificial intelligence (AI) technology that automatically generates content in response to prompts written in natural-language conversational interfaces” (UNESCO 2023).**

### **AI and GenAI in Trinity**

As Ireland’s leading university and as a world leader in AI research, Trinity recognises that AI and GenAI offer new opportunities for teaching, learning, assessment and research. We also recognise that these technologies present challenges and risks, including to academic integrity, ethics, privacy, impartiality, intellectual property and sustainability.

Acknowledging these opportunities and challenges, Trinity commits to supporting the opportunity for students and staff to become AI literate and fluent, thereby helping them to navigate and respond to the challenges and risks of AI and GenAI in order to harness the potential of (Gen)AI to enhance teaching, learning, assessment and research – and to be prepared for future challenges as these technologies evolve. We also commit to providing ongoing resources and guidance to support students and staff to use AI and GenAI in ways that are appropriate, responsible and ethical – and to ensure that academic integrity is maintained in its usage.

College aspires to develop best practice guidelines in this area. In addition to the resources and supports that College provides and recognising that appropriate uses of AI and GenAI tools vary across academic disciplines, Schools will have some flexibility to customise their own discipline-specific practices in line with this institutional statement, other institutional policies as they develop, and national and international regulation. The College goal is to enable overall consistency in the regulation of GenAI usage, while also respecting where disciplines or degree programmes require specific restrictions in GenAI usage in assessment preparation and execution. Thus, where disciplines or degree programmes wish to refine specific regulations on student use of GenAI for learning, general as well as programme-specific regulations should be communicated in the relevant discipline/degree programme handbook.

Such regulation could range from how student GenAI usage is acknowledged or cited within student assessment submissions, to prohibition of GenAI usage in the production of student assessment submissions.

### **AI and GenAI in The School of Chemistry**

Students must compose laboratory reports and assignments themselves. The reports/assignments must be an original individual intellectual effort. Students take sole responsibility for the accuracy of the content of the reports. Staff will assess the reports for originality, and additional or alternative forms of assessment may be used to validate the originality of reports.

From an academic integrity perspective, if a student generates content from a GenAI tool and submits it as his/her/their own work, it is considered plagiarism, which is defined as academic misconduct in accordance with College Academic Integrity Policy.

Link: <https://www.tcd.ie/media/tcd/academic-practice/pdfs/college-statement-on-genai.pdf>

## Absence from College – Medical and Absence Certificates

**The online SCIENCE ABSENCE FORM must be completed for all types of absences.**

You can specify what type of absence once you start completing the form.

You will find the link to the form on the following page [Science Absence Form](#)

### **Absence from Laboratories, Continuous Assessments Tests and Non-Submission of Lab Reports (must read)**

The online absence form covers the following...

#### **1. Medical Certificates/Absence due to Illness**

Where a student misses an assigned laboratory practical class through illness, they should...

- (a) fill in the online absence form.
- (b) upload supporting documentation from a Doctor/ GP or hospital.
- (c) If your absence is going to be longer than three days, you should inform your Course Organiser

#### **2. Other Absences**

Students who have sports commitments to the College should supply confirmation from the appropriate committee to the Module Coordinator/Course Director well in advance of any event.

Students who anticipate that their sporting commitments may necessitate more than an occasional absence from College (e.g., Sports Scholars etc.) should discuss their situation with their tutor and the Associate Dean of Undergraduate Science Education (ADUSE).

Excuses for absence presented after the event, will not be accepted.

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.

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](mailto: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](mailto:student-counselling@tcd.ie)

For further information visit the following webpage: [https://www.tcd.ie/Student\\_Counselling/](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 on the first floor, 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](mailto:residences@tcd.ie) or you can telephone 01 8961177 during office hours. After hours you can contact Front Gate at 01 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 and 2026-27

### Key Dates:

Semester 1 teaching term begins:	Monday 14 September 2026
<b>Study/revision week Semester 1:</b>	Monday 26 October to 30 October 2026
Semester 1 teaching term ends:	Friday 04 December 2026
<b>Semester 1 Examinations:</b>	Monday 14 December to 22 December 2026
Semester 2 teaching term begins:	Monday 18 January 2027
<b>Study/Revision week Semester 2</b>	Monday 01 March to Friday 05 March 2027
Semester 2 teaching term ends:	Friday 09 April 2027
Revision Week	Monday 12 April to Friday 16 April 2027

### Teaching Term Dates 2026-27

Michaelmas Term Monday 15 September - Friday 04 Dec 2026			Hilary Term Monday 18 January 2027 - Friday 09 April 2027		
Teaching wk. 1	Week 04	14 Sept - 18 Sept	Teaching wk. 1	Week 22	18 Jan - 22 Jan
Teaching wk. 2	Week 05	21 Sept - 25 Sept	Teaching wk. 2	Week 23	25 Jan – 29 Jan
Teaching wk. 3	Week 06	28 Sept - 02 Oct	Teaching wk. 3	Week 24	01 Feb - 05 Feb
Teaching wk. 4	Week 07	05 Oct - 09 Oct	Teaching wk. 4	Week 25	08 Feb – 12 Feb
Teaching wk. 5	Week 08	12 Oct - 16 Oct	Teaching wk. 5	Week 26	15 Feb – 19 Feb
Teaching wk. 6	Week 09	19 Oct - 23 Oct	Teaching wk. 6	Week 27	22 Feb – 26 Feb
<b>Study week</b>	<b>Week 10</b>	<b>26 Oct - 30 Oct</b>	<b>Study week</b>	<b>Week 28</b>	<b>01 Mar – 05 Mar</b>
Teaching wk. 8	Week 11	02 Nov - 06 Nov	Teaching wk. 8	Week 29	08 Mar – 12 Mar
Teaching wk. 9	Week 12	09 Nov - 13 Nov	Teaching wk. 9	Week 30	15 Mar – 19 Mar
Teaching wk. 10	Week 13	16 Nov - 20 Nov	Teaching wk. 10	Week 31	22 Mar - 26 Mar
Teaching wk. 11	Week 14	23 Nov - 27 Nov	Teaching wk. 11	Week 32	29 Mar – 02 Apr
Teaching wk. 12	Week 15	30 Nov to 4 Dec	Teaching wk. 12	Week 33	05 Apr – 09 Apr

- Orientation week - 21<sup>st</sup> to 25<sup>th</sup> September 2026
- October bank holiday – Monday 26<sup>th</sup> October 2026
- February bank holiday – Monday 1<sup>st</sup> February 2027
- St Patrick’s Day – Wednesday 17<sup>th</sup> March 2027
- Good Friday – 26<sup>th</sup> March 2027
- Easter Monday – 29<sup>th</sup> March 2027

The information provided is correct at the time of publication. Any necessary revisions will be notified to students via email and/ or the TR061: Chemical Sciences webpage <https://www.tcd.ie/science/undergraduate/tr061-chemical-sciences/senior-fresh/>

In the event of any conflict or inconsistency between the General Regulations published in the University Calendar and the information provided in this course programme, the general college regulations will prevail: <https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/general-regulations-and-information.pdf>

## TR061: Chemical Sciences - Contact Details

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## Appendix 1

Item	Reference/Source
General College Regulations	<a href="https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf">https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf</a>
Emergency Procedures	<p>In the event of an emergency, <b>dial Security Service on extension 1999</b></p> <p>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.</p> <p>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.</p> <p>It is recommended that all students save at least one emergency contact in their phone under ICE (In Case of Emergency).</p>
Health and Safety	<p>Faculty of Science, Technology, Engineering and Mathematics website - <a href="https://www.tcd.ie/stem/undergraduate/health-safety.php">https://www.tcd.ie/stem/undergraduate/health-safety.php</a></p> <p>School Handbooks will have School/Discipline information on Health and Safety.</p>
Data Protection	<a href="https://www.tcd.ie/dataprotection/">https://www.tcd.ie/dataprotection/</a> <a href="https://www.tcd.ie/dataprotection/assets/docs/dataprotectionhandbook/DP_Handbook_15042021.pdf">https://www.tcd.ie/dataprotection/assets/docs/dataprotectionhandbook/DP_Handbook_15042021.pdf</a>
Academic Integrity	<a href="https://www.tcd.ie/teaching-learning/academic-integrity/">https://www.tcd.ie/teaching-learning/academic-integrity/</a>
Research Ethics	<a href="https://www.tcd.ie/research/support/ethics-integrity.php">https://www.tcd.ie/research/support/ethics-integrity.php</a>
Blackboard	<a href="#">Blackboard</a>
Explanation of Weightings	<a href="https://www.tcd.ie/academic-affairs/academic-regulations/ug-module-sizes-and-capstone/">https://www.tcd.ie/academic-affairs/academic-regulations/ug-module-sizes-and-capstone/</a>
Assessment and Progression Regulations	<a href="https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf">https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf</a> <a href="https://www.tcd.ie/teaching-learning/academic-policies/">https://www.tcd.ie/teaching-learning/academic-policies/</a>
Academic Awards	<a href="https://www.tcd.ie/academic-affairs/academic-regulations/">https://www.tcd.ie/academic-affairs/academic-regulations/</a>

Item	Reference/Source
Equality, Diversity, and Inclusion	<a href="https://www.tcd.ie/equality/">https://www.tcd.ie/equality/</a>
Prizes, medals, and other scholarships	<a href="https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/prizes-and-other-awards.pdf">https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/prizes-and-other-awards.pdf</a>
Teaching and Learning Study Abroad	<a href="https://www.tcd.ie/global/mobility/study-abroad/">https://www.tcd.ie/global/mobility/study-abroad/</a>
Marking Scales	<a href="https://www.tcd.ie/media/tcd/science/pdfs/Trinity-Science-Guidelines-on-Marking---TSPMC-2024.pdf">https://www.tcd.ie/media/tcd/science/pdfs/Trinity-Science-Guidelines-on-Marking---TSPMC-2024.pdf</a>
Framework of qualifications Trinity Pathways	<a href="https://www.qqi.ie/national-framework-of-qualifications">https://www.qqi.ie/national-framework-of-qualifications</a> <a href="#">Trinity Pathways Trinity Courses</a>
Capstone (UG Programmes)	<a href="https://www.tcd.ie/academic-affairs/academic-regulations/ug-module-sizes-and-capstone/">https://www.tcd.ie/academic-affairs/academic-regulations/ug-module-sizes-and-capstone/</a>
Careers Information & events	<a href="https://www.tcd.ie/Science/careers/">https://www.tcd.ie/Science/careers/</a> For further information refer to School/Discipline Handbooks.
Attendance Requirements	<a href="https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf">https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf</a>
Student Cases	<a href="https://www.tcd.ie/academicregistry/student-cases/">https://www.tcd.ie/academicregistry/student-cases/</a>
Student complaints procedures	<a href="https://www.tcd.ie/media/tcd/about/policies/pdfs/Student-Complaints-Procedure-21.07.22.pdf">https://www.tcd.ie/media/tcd/about/policies/pdfs/Student-Complaints-Procedure-21.07.22.pdf</a>
General Examination Guidelines	<a href="#">Exam Guidelines - Academic Registry - Trinity College Dublin</a>
Feedback and Evaluation	<a href="#">Student Evaluation and Feedback Procedure for the conduct of Focus Groups</a>
Academic Policies and Procedures	<a href="https://www.tcd.ie/teaching-learning/academic-policies/">https://www.tcd.ie/teaching-learning/academic-policies/</a>
Registration (UG only) – Academic Registry	<a href="https://www.tcd.ie/academicregistry/student-registration/">https://www.tcd.ie/academicregistry/student-registration/</a>
Student supports	<a href="https://www.tcd.ie/students/">https://www.tcd.ie/students/</a>
STEM Schools and Disciplines	<a href="https://www.tcd.ie/structure/faculties-and-schools/#d.en.2024679">https://www.tcd.ie/structure/faculties-and-schools/#d.en.2024679</a>
GradIreland Career advice, graduate jobs and internships	<a href="https://gradireland.com/">https://gradireland.com/</a>

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



**Science Course Office**

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