Science at Trinity

Faculty of Engineering, Mathematics and Science

TR061
Chemical Sciences
Senior Freshman Programme 2019 - 2020
This handbook applies to all students taking TR061: Chemical Sciences. It provides a guide to what is expected of you on this programme, and the academic and personal support available to you. Please retain for future reference.

The information provided in this handbook is accurate at time of preparation. Any necessary revisions will be notified to students via email and the Science Course Office website (http://www.tcd.ie/Science). Please note that, in the event of any conflict or inconsistency between the General Regulations published in the University Calendar and information contained in the course handbooks, the provisions of the General Regulations will apply.
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 four Moderatorships as exit routes, namely:

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

Senior Freshman 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 23 academic staff and 15 technical 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 recently refurbished 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), which was completed in 2000, provides ca. 1500 m² 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), which was formally opened in January 2008 and (ii) the Trinity Biomedical Sciences Institute (TBSI), which was inaugurated in July 2011.

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 800 and 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, a Rigaku Saturn 724 Diffractometer and Bruker SMART APEX single crystal and Siemens D500 powder diffractometers, Micromass LCTTM (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 Paula Colavita
Director, TR061: Chemical Sciences Course
TR061: Chemical Sciences overview and module selection

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

If you wish to change your mind before term begins in September 2019, you can resubmit the online form with a subject line of "change of module choice" and a note in the form specifying "change of module choice".

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

### Core Modules

<table>
<thead>
<tr>
<th>Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mandatory Core modules (30 ECTS)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHU22201</td>
<td>Chemistry 1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>CHU22202</td>
<td>Chemistry 2</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>MAU22S01</td>
<td>Multivariable Calculus for Science</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>PIU22992</td>
<td>History, Philosophy and Ethics of Science</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

Students must select from the following (10 ECTS)

- CHU22203: Introduction to Medicinal Chemistry*  
  - Or  
  - MAU22S03: Fourier analysis for Science *  
  - and  
  - CHU22204: Introduction to Environmental and Sustainable Chemistry **  
  - Or  
  - MAU22S02: Vector Calculus for Science **

* Students who take CHU22203 cannot take MAU22S03  
** Students who take CHU22204 cannot take MAU22S02  
*To select Physics as an approved module students must take MAU22S02 and MAU22S03
Students will choose 2 additional modules among those approved for the TR061 programme, for a total of 20 ECTS (10 ECTS per semester).

### Approved Modules

<table>
<thead>
<tr>
<th>Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYU22201</td>
<td>From Molecules to Cells</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>BYU22202</td>
<td>From Cells to Organisms</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>PYU22P10</td>
<td>Physics 1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>PYU22P20</td>
<td>Physics 2</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Or

It is important to note that approved 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

### Moderatorships

In the Junior and Senior Freshman years TR061 students complete a course of study which will qualify them to compete for a place in one of the following Moderatorships after the Senior Freshman year:

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

The curriculum in the four Moderatorships is tailored and balanced to offer a general Chemistry degree (C), a degree with greater emphasis on computational methods in chemistry (CMM), a degree focusing on the synthesis and applications of small drugs for medicinal purposes (MC) and a degree with emphasis on the chemistry and physics of advanced materials and nanomaterials (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:

<table>
<thead>
<tr>
<th>Pattern SF.1</th>
<th>Pattern SF.2-3</th>
<th>Pattern SF.4</th>
<th>Pattern SF.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 ECTS Chemistry</td>
<td>25 ECTS Chemistry</td>
<td>20 ECTS Chemistry</td>
<td>20 ECTS Chemistry</td>
</tr>
<tr>
<td>5 ECTS Maths</td>
<td>10 ECTS Maths</td>
<td>15 ECTS Maths</td>
<td>15 ECTS Maths</td>
</tr>
<tr>
<td>5 ECTS History, Philosophy and Ethics of Science</td>
<td>5 ECTS History, Philosophy and Ethics of Science</td>
<td>5 ECTS History, Philosophy and Ethics of Science</td>
<td>5 ECTS History, Philosophy and Ethics of Science</td>
</tr>
<tr>
<td>20 ECTS Biology</td>
<td>20 ECTS Biology</td>
<td>20 ECTS Biology</td>
<td>20 ECTS Physics</td>
</tr>
</tbody>
</table>
The Table below summarises which SF module patterns fulfil requisites to apply for each of the four Moderatorships.

### Moderatorship pre-requisites

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>Chemistry with Molecular Modelling</th>
<th>Medicinal Chemistry</th>
<th>Nanoscience</th>
</tr>
</thead>
<tbody>
<tr>
<td>All 5 patterns</td>
<td>All 5 patterns</td>
<td>Patterns SF.1-4</td>
<td>Pattern SF.5 only</td>
</tr>
</tbody>
</table>

### Semester structure

#### Semester One
9 September 2019 – 29 November 2019

<table>
<thead>
<tr>
<th>Module</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHU22201: Chemistry 1</td>
<td>10</td>
</tr>
<tr>
<td>CHU22203: Intro to Medicinal Chemistry *</td>
<td>5</td>
</tr>
<tr>
<td>MAU22S01: Multivariable Calculus for Science</td>
<td>5</td>
</tr>
<tr>
<td>MAU22S03: Fourier analysis for Science *</td>
<td>5</td>
</tr>
</tbody>
</table>

*Students who take CHU22203 cannot take MAU22S03

#### Semester two
20 January 2020 – 10 April 2020

<table>
<thead>
<tr>
<th>Module</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHU22202: Chemistry 2</td>
<td>10</td>
</tr>
<tr>
<td>CHU22204: Intro to Environmental and sustainable Chemistry *</td>
<td>5</td>
</tr>
<tr>
<td>MAU22S02: Vector Calculus for Science *</td>
<td>5</td>
</tr>
<tr>
<td>History, Philosophy and Ethics of Science</td>
<td>5</td>
</tr>
</tbody>
</table>

*Students who take CHU22204 cannot take MAU22S02

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

<table>
<thead>
<tr>
<th>Approved modules (optional)</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYU22201: From Molecules to Cells</td>
<td>10</td>
</tr>
<tr>
<td>BYU22202: From Cells to Organisms</td>
<td>10</td>
</tr>
</tbody>
</table>

Or

<table>
<thead>
<tr>
<th>Approved modules (optional)</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PYU22P10: Physics 1ª</td>
<td>10</td>
</tr>
<tr>
<td>PYU22P20: Physics 2ª</td>
<td>10</td>
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</tbody>
</table>

*To select Physics as an approved module students must take MAU22S02 and MAU22S03
## SENIOR FRESHMAN MODULES 2019/20

Please tick appropriate box

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Credits</th>
<th>Tick Box</th>
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</thead>
<tbody>
<tr>
<td>CHU22201</td>
<td>Chemistry 1</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>CHU22202</td>
<td>Chemistry 2</td>
<td>2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>MAU22S01</td>
<td>Multivariable calculus for Science</td>
<td>1</td>
<td>5</td>
<td>MANDATORY</td>
</tr>
<tr>
<td>PIU22992</td>
<td>History, Philosophy and Ethics of Science</td>
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</table>

And

**Pattern SF.1**

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHU22203</td>
<td>Introduction to Medicinal Chemistry</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>CHU22204</td>
<td>Introduction to Environmental and Sustainable Chemistry</td>
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</tr>
<tr>
<td>BYU22201</td>
<td>From Molecules to Cells</td>
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<td>BYU22202</td>
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<td>10</td>
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</tbody>
</table>

OR

**Pattern SF.2**

<table>
<thead>
<tr>
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<th>Module Title</th>
<th>Semester</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHU22203</td>
<td>Introduction to Medicinal Chemistry</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>MAU22S02</td>
<td>Vector Calculus for Science</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>BYU22201</td>
<td>From Molecules to Cells</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>BYU22202</td>
<td>From Cells to Organisms</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

OR

**Pattern SF.3**

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAU22S03</td>
<td>Fourier analysis for Science</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>CHU22204</td>
<td>Introduction to Environmental and Sustainable Chemistry</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>BYU22201</td>
<td>From Molecules to Cells</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>BYU22202</td>
<td>From Cells to Organisms</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

OR

**Pattern SF.4**

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAU22S03</td>
<td>Fourier analysis for Science</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>MAU22S02</td>
<td>Vector Calculus for Science</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>BYU22201</td>
<td>From Molecules to Cells</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>BYU22202</td>
<td>From Cells to Organisms</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Degree Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Total</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>MAU22S03</td>
<td>Fourier analysis for Science</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>MAU22S02</td>
<td>Vector Calculus for Science</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>PYU22P10</td>
<td>Physics</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>PYU22P20</td>
<td>Physics</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Signature of student: ____________________________________________

Date: ____________________________________________
The European Credit Transfer Accumulation System (ECTS)

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

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

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

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

Change of APPROVED modules
If, after a couple of weeks, a student feels that they have perhaps made the wrong choice of approved 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.

Change of modules forms are available from the Science Course Office. All change of module request must be submitted to the Science Course Office. Module change requests made via any other office will not be processed.

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 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**

<table>
<thead>
<tr>
<th>Teaching Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4 (14 L)</td>
<td><strong>Introduction to Molecular Orbital Theory</strong></td>
</tr>
<tr>
<td></td>
<td>• Atomic orbitals (s,p,d) as wave functions; their representation as enclosed boundary surfaces and as radial distribution functions. The relationship of these ideas to the Bohr model for atomic hydrogen. Relative energies of these orbitals; orbital angular momentum in non-hydrogen-like atoms; penetration and shielding.</td>
</tr>
<tr>
<td></td>
<td>• Hybridisation of atomic orbitals and the hybrids associated with various geometries; VSEPR treatment of molecular structures.</td>
</tr>
<tr>
<td></td>
<td>• Bonding as the linear combination of atomic orbitals, including non-bonding and anti-bonding interactions. Labelling of molecular orbitals as sigma, pi (g or u), molecular orbital diagrams of homonuclear diatomic molecules of the first and second row of the Periodic Table. Mixing of molecular orbitals and its effect on the relative energies of the resulting molecular orbital diagram. Molecular orbital approach for simple molecules including H₂O, BeH₂ and BCl₃. Reactivity of CO in terms of the molecular orbital energy diagram for this molecule. Appreciation of the Molecular Orbital basis of the spectrochemical series.</td>
</tr>
<tr>
<td></td>
<td><strong>Transition Metal Coordination Chemistry</strong></td>
</tr>
<tr>
<td></td>
<td>• Brief introduction - why study metal complexes?</td>
</tr>
<tr>
<td></td>
<td>• What is a metal complex? Overview of concepts and definitions: Lewis Acid-base concept.</td>
</tr>
<tr>
<td></td>
<td>• Formation and stability of metal complexes: Complex formation and dissociation; cumulative stability constants and trends; the 'chelate effect'; factors affecting stability.</td>
</tr>
<tr>
<td></td>
<td>• Classification of common ligands: Donor atoms and functional groups. Multidentate and chelating ligands; stereochemistry and formation of chelate rings.</td>
</tr>
<tr>
<td></td>
<td>• Stereochemistry of metal complexes. Coordination numbers 2-6 and geometry of metal complex; square planar, tetrahedral; trigonal bi-pyramid; square based pyramid; octahedral; distortion of geometries.</td>
</tr>
<tr>
<td></td>
<td>• Electronic structure and properties of transition metal complexes: Ionic vs. covalent bonding models; crystal field theory; energy level diagrams in tetrahedral - octahedral fields.</td>
</tr>
<tr>
<td></td>
<td>• Consequences and applications of orbital splitting: Electronic configurations of metal complexes; crystal field stabilization energies (CFSE); Factors</td>
</tr>
</tbody>
</table>
### 4-5 (SL) Molecular Spectroscopy

This course will focus on the major techniques employed in the identification of chemical entities (although some are not spectroscopic techniques).

- Why is spectroscopy important?
- Nuclear Magnetic Resonance Spectroscopy (NMR): Nuclear spin, chemical shift, shielding and spin-spin coupling. Both $^1$H and $^{13}$C NMR are covered. A brief consideration of MRI is included.
- Ultraviolet Spectroscopy: Effect of $\pi$-conjugation.
- Infra-red Spectroscopy: Molecular vibrations, detection of characteristic functional groups
- Mass spectrometry: Uses and application
- X-Ray Diffraction: How X-ray diffraction can be employed to aid structural elucidation.

### 6-9 (12 L) Introduction to Organic Synthesis

- Conformational analysis, including Newman projections diagrams. Conformation of cyclohexane including chair, boat, twist-boat. Concept of allylic strain.
- Introduction to carbohydrate chemistry and a discussion of common protecting groups in organic chemistry.
- Applications of radical reactions in Organic synthesis.
- In-depth discussion of aldol, carbonyl and beta-dicarbonyl chemistry for the formation of C-C bonds.
- Aldol and carbonyl chemistry.
- HSAB theory, the Michael addition reaction and Diels-Alder reaction.

### 10-12(9L) Aromatics

- Why is aromatic chemistry important? An overview of important drugs, dyestuffs and polymers that are based on aromatic compounds.
- Recap: An overview of JF Aromatic Chemistry I: The structure of benzene and a reminder of the mechanism of electrophilic aromatic substitution (EAS) reactions.
- How and why substituents on an aromatic ring influence the regiochemical outcome of EAS reactions: How do electron donating groups and electron withdrawing groups cause the substitution patterns that they do?
- Nucleophilic Aromatic Substitution: Introduction to NAS and the differences to EAS. The three different mechanisms of NAS and their use in synthesis.
- Organometallic chemistry: Introduction to metallation reactions, directed metallation as a method of controlled synthesis, metal catalysed coupling reactions.
- Synthetic considerations: How to plan successful synthetic strategies to prepare aromatic compounds.
- Other important aromatic systems: A brief look at some of the less common compounds and their chemistry.
- Aromatic chemistry in the body - a brief look at some important aspects including biosynthesis, hormones, drug metabolism and the production of toxic metabolites.
- Tying it all together: An overview of the synthesis of an important aromatic compound.

| 13 | Student Revision/Study week – tutorials only |
| 14 | Student Assessments |

**Reading list/Indicative Resources**
- Organic Chemistry, by Jonathan Clayden and Nick Greeves; Publisher: OUP Oxford; 2 ed.

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

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

**Learning Outcomes**
1. Discuss the trends in atomic orbitals and use these to explain trends in atomic properties
2. Generate a set of molecular orbitals and an energy level diagram based on the principles of molecular orbital theory
3. Classify ligands and explain transition metal complex geometries
4. Predict and explain the d-orbital splitting in transition metal complexes and its effects on the geometry and electronic properties.
5. Identify and explain stereochemical features of organic molecules
6. Describe strategies for controlled formation of stereochemical centres in organic synthesis
7. Formulate reasonable retrosynthetic pathways for the design of simple organic molecules.
8. Explain the principles of standard organic spectroscopy techniques
9. Determine information about the structure of unknown organic materials using spectroscopic data
10. Categorise and explain the principle reactions of aromatic molecules
CHU22202: Chemistry for the Chemical Sciences  
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

<table>
<thead>
<tr>
<th>Teaching Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4 (16 L)</td>
<td>Chemical Thermodynamics</td>
</tr>
<tr>
<td></td>
<td>• pV diagrams: isotherms and adiabatics, Carnot cycle, Engine efficiencies</td>
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<td></td>
<td>• 3rd Law: limiting values of Cv and Cp, Residual entropy, Free energy functions, Maxwell Relations</td>
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<td></td>
<td>• Chemical potentials and equilibria: The Chemical potential, activities, phase equilibria, Gibbs phase rule, Clausius Clapeyron, Homogeneous equilibria, Van’t Hoff isochore</td>
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<td>• Chemical potentials in ideal solutions: Liquid vapour equilibrium, Henry’s law, Raoult’s law, Liquid-solid equilibrium, ideal solubilities, colligative properties</td>
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<td>• Non-ideal systems: Non-ideal gases, Fugacity of a van der Waals’ gas, Mixture of gases</td>
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<tr>
<td>5-9 (14L) 7 study week</td>
<td>Chemical Kinetics</td>
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<tr>
<td></td>
<td>• Basic concepts: collisions and gas phase reactions, Boltzmann distribution, Rate constant and Arrhenius equation, factors control rate</td>
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<td></td>
<td>• Chemical bond breaking and making, Morse potentials, forces on atoms, potential energy surface, transition state, simple harmonic oscillator, quantisation</td>
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<tr>
<td></td>
<td>• Description of chemical reaction Definition of rate, initial rate, reaction order, rate constant, effect of concentration and temperature, experimental measurement</td>
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<td></td>
<td>• Derivation of integrated rate equations: zero, first and second order, graphical analysis to evaluate rate constant, half life</td>
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<td></td>
<td>• Activated processes, activation energy, Arrhenius equation, evaluation of activation energy, extension to other processes, diffusion, adsorption /desorption</td>
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<td>• 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</td>
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<tr>
<td></td>
<td>• Application of kinetics to catalysis (bio and surface), Langmuir-Hinshelwood, Michaelis-Menten, adduct formation, turnover frequency</td>
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<tr>
<td></td>
<td>• Unimolecular gas phase kinetics, reactions in solution, diffusion vs activation control.</td>
</tr>
</tbody>
</table>
### Structural Inorganic & Materials Chemistry

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

### Reading list/ Indicative Resources

- The elements of physical chemistry by P.W. Atkins J. de Paula, 6 ed. OUP (2013),

### Methods of Assessment

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

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

**Proposed practicals**

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

1. Analyse and apply chemical kinetic principles to simple, multi-step reactions and complex reactions.
2. Illustrate basic theory of chemical reaction rates.
3. Review and apply the laws of thermodynamics to the solution of problems in Physical Chemistry.
4. Define the concept of ideal and non-ideal systems and the use of chemical potentials.
5. Understanding of the structural principles of inorganic molecules and solids using traditional concepts, simple electron counting rules as well as modern approaches.
6. Understanding of systematic ordering of the recognized structure types, relationships among them, and the link between structure and properties.
7. Basic understanding of selected characterisation techniques for solid materials.

Module Coordinator:

Professor Eoin Scanlan
E-mail: eoin.scanlan@tcd.ie
Phone: 01 896 2514

Coordinator Freshman Teaching

Dr Noelle Scully
E-mail: pnscully@tcd.ie
Phone: 01 896 1972

Senior Executive Officer

Ms AnneMarie Farrell
E-mail: farrea25@tcd.ie
Phone: 01 896 1726
Introduction to Medicinal Chemistry and Bioinorganic 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 coordination chemistry of metals in biology and to the spectroscopic techniques employed to study metals in biology. A variety of metalloenzymes and their Chemistry will be discussed in detail. The course is descriptive, but also includes considerable focus on inorganic reaction mechanisms. This section of the module aims at exploring the coordination chemistry of metalloproteins while reinforcing fundamental topics explored in the core CHU22201 module.

Content Layout

<table>
<thead>
<tr>
<th>Teaching Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-6 (18 L)</td>
<td><strong>Introduction to Medicinal Chemistry:</strong></td>
</tr>
<tr>
<td></td>
<td>Lecture 1: History of medicinal chemistry. What is medicinal chemistry? What is a drug?</td>
</tr>
<tr>
<td></td>
<td>Tutorial 1: pKa in drug absorption</td>
</tr>
<tr>
<td></td>
<td>Lecture 5: Pharmacokinetic parameters: Lipinski rule of 5, clearance, bioavailability, volume of distribution, elimination rate.</td>
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<tr>
<td></td>
<td>Lecture 8: How drugs interact with all possible targets considered: phospholipids, protein receptors (agonism/antagonism).</td>
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<tr>
<td></td>
<td>Lecture 9: Protein as targets: enzymes. Different types of inhibition and inhibitors (reversible inhibition, irreversible inhibition, transition state inhibitors).</td>
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<tr>
<td></td>
<td>Tutorial 2: Targeting enzymes: dihydrofolate reductase.</td>
</tr>
<tr>
<td></td>
<td>Lecture 10: Nucleic acids as targets. DNA binding (intercalation, alkylation, minor groove binding). Guanine-quadruplexes.</td>
</tr>
</tbody>
</table>
### Tutorial 3: Biological evaluation: dose-response curves.
Lecture 12: Optimization process. Structural variations: pharmacophore and bioisosterism

### Tutorial 4: Pharmacophore and bioisosterism examples and salt forms.

Lecture 14: Drug development stages: Pre-clinical studies, Clinical phases (1, 2 and 3) and Post-marketing control.

<table>
<thead>
<tr>
<th>7</th>
<th>Study week</th>
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</thead>
<tbody>
<tr>
<td><strong>8-12 (12 L)</strong></td>
<td><strong>Bioinorganic Chemistry:</strong> Introduction to the natural roles metals play in Biology.</td>
</tr>
<tr>
<td>Lecture 1: Introduction to Bioinorganic Chemistry</td>
<td>Lecture 2: Spectroscopic Techniques in Bioinorganic Chemistry</td>
</tr>
<tr>
<td>Lecture 5: Dioxygen Activation – heme- and nonheme iron oxidase, and mono- and dicopper oxidases</td>
<td>Lecture 6: Electron Transfer - iron/sulfur clusters, ferrodoxins, cytochrome, aconitase, blue copper</td>
</tr>
<tr>
<td>Lecture 7: Hydrogenases - diiron, nickel/iron, mononuclear iron</td>
<td>Lecture 8: Nitrogen Fixation and Bioinorganic Organometallics – Nitrogenase, Cobalamin (Vitamin B12)</td>
</tr>
<tr>
<td>Lecture 9: Metals and Reactive Oxygen Species – Catalase, Superoxide reductase and Dismutases, Metals in Alzheimer’s Disease</td>
<td>Lecture 10: Synthetic models in Bioinorganic Chemistry – synthesis and characterization provide insights in enzyme function.</td>
</tr>
<tr>
<td>Tutorials will be held after lectures 5 and 10.</td>
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</tr>
<tr>
<td><strong>13</strong></td>
<td>Student Revision/Study week – tutorials only</td>
</tr>
<tr>
<td><strong>14</strong></td>
<td>Student Assessments</td>
</tr>
</tbody>
</table>

**Reading list/ Indicative Resources**

**Medicinal Chemistry:**
Bioinorganic Chemistry:

Proposed in course assessment/s:
A combination of paper assessment at the end of semester 1 (60%) and in course (40%) consisting of essay, group assignment and individual homework assignments.

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 pKa 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 amino acids and small molecules that are ligands for metals in biology.
9. Identify spectroscopic techniques suitable to probe metal sites in biology.
11. Have a deep understanding of Mn, Fe, Cu redox chemistry and be able to relate that to biological transformations.
12. Have a strong fundamental understanding of the natural roles trace metals play in biology.

Contact Details:

Module Coordinator:
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Phone: 01 896 2514

Coordinator Freshman Teaching
Dr Noelle Scully E-mail: pnscully@tcd.ie
Phone: 01 896 1972

Senior Executive Officer
Ms AnneMarie Farrell E-mail: farrea25@tcd.ie
Phone: 01 896 1726
CHU22204: Chemistry and Chemical Methods for the Environment
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

<table>
<thead>
<tr>
<th>Teaching Week</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1-3 (8 L)</td>
<td>Inorganic Environmental Chemistry and Green Chemistry</td>
</tr>
<tr>
<td></td>
<td>• Introduction to Environmental Chemistry</td>
</tr>
<tr>
<td></td>
<td>• The origin and distribution of the elements</td>
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<tr>
<td></td>
<td>• The Lithosphere: Important minerals and ores; soil and soil composition</td>
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<tr>
<td></td>
<td>• The Hydrosphere: Properties of water and speciation in aqueous systems</td>
</tr>
<tr>
<td></td>
<td>• Biogeochemical cycling: Nitrate, phosphate and carbon cycles</td>
</tr>
<tr>
<td></td>
<td>• Introduction to Green Chemistry</td>
</tr>
</tbody>
</table>

| 4-6 (9 L)     | Introduction to Nuclear and Toxic Elements Chemistry  |
|               | • Introduction to Nuclear Chemistry: the different kinds of nuclear decay, kinetics, mass loss and energy, half-life, effects of nuclear radiation on matter;  |
|               | • Applications of radioisotopes: radio-carbon dating, nuclear metals in medicine (diagnostics and radiation therapy).  |
|               | • Introduction to toxicity, HSAB principles and chelation therapy;  |
|               | • Toxic elements: general features, bioavailability, biomethylation;  |
|               | • Be, Al, Tl, Hg, Pb and Cd toxicity: sources, symptoms, mechanisms, treatment;  |
|               | • Nanotoxicology;  |
|               | • Therapeutic use of a toxic element: cisplatin for cancer treatment (DNA adducts, side effects, resistance), other metal based anti-cancer drugs.  |

<table>
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<tr>
<th>7</th>
<th>Study week</th>
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<tbody>
<tr>
<td>8-9 (6 L)</td>
<td>Instrumental Methods in Environmental Chemistry</td>
</tr>
<tr>
<td></td>
<td>• Analytical chemistry, quantitative vs. qualitative.</td>
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<td></td>
<td>• Fundamentals of spectroscopic methods.</td>
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<td></td>
<td>• Separation methods.</td>
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<td></td>
<td>• Electroanalytical methods for environmental chemistry.</td>
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</tbody>
</table>

| 10-12 (7 L)   | Introduction to Atmospheric Chemistry  |
|               | • Introduction to atmospheric chemistry.  |
|               | • Ozone layer chemistry.  |
|               | • Photochemistry and SMOG.  |
|               | • Aerosols/micro-particles.  |
|               | • Energy and climate change.  |

<table>
<thead>
<tr>
<th>13</th>
<th>Student Revision/Study week – tutorials only</th>
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<tbody>
<tr>
<td>14</td>
<td>Student Assessments</td>
</tr>
</tbody>
</table>
Reading list/ Indicative Resources


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

Proposed in course assessment/s:
A short (500-1000 word) essay and relevant problem based question on selected topics form the module will be assessed.

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:

Module Coordinator:
Professor Eoin Scanlan  E-mail: eoin.scanlan@tcd.ie
Phone: 01 896 2514

Coordinator Freshman Teaching
Dr Noelle Scully  E-mail: pnscully@tcd.ie
Phone: 01 896 1972

Senior Executive Officer
Ms AnneMarie Farrell  E-mail: farrea25@tcd.ie
Phone: 01 896 1726
PIU22992: History, Philosophy and Ethics of Science  
Semester 2, 5 credits

Contact Hours:  
20 hours of lectures + 6 hours of tutorials

Module Personnel: Dr. Keith Begley (Philosophy) & Prof. Linda Hogan (Ecumenics)

Learning Aims (Drawn from the Trinity Graduate Attributes)
- **Think independently:** Appreciates knowledge beyond chosen field. Thinks critically and creatively.
- **Communicate effectively:** Listens, persuades, and collaborates. Uses communication tools of discipline.
- **Develop continuously:** Learns and develops through reflection. Adapts to change.
- **Act responsibly:** Is ethically aware. Is effective in teams. Acts responsibly and on the basis of knowledge.

Module content:

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Topic</th>
<th>Lecturer</th>
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</thead>
<tbody>
<tr>
<td>22</td>
<td>Introduction and early History</td>
<td>Dr Begley</td>
</tr>
<tr>
<td>22</td>
<td>History of Science and Philosophy</td>
<td>Dr Begley</td>
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<tr>
<td>22</td>
<td>Tutorial: Essay Writing in Philosophy</td>
<td>Dr Begley</td>
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<tr>
<td>23</td>
<td>What is Knowledge?</td>
<td>Dr. Begley</td>
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<tr>
<td>23</td>
<td>Defining Knowledge</td>
<td>Dr. Begley</td>
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<tr>
<td>24</td>
<td>What is Scientific Justification?</td>
<td>Dr. Begley</td>
</tr>
<tr>
<td>24</td>
<td>Problems of Induction and Confirmation</td>
<td>Dr. Begley</td>
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<tr>
<td>24</td>
<td>Tutorial: Knowledge</td>
<td>Dr. Begley</td>
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<tr>
<td>25</td>
<td>What is Scientific Method?</td>
<td>Dr. Begley</td>
</tr>
<tr>
<td>25</td>
<td>Further views on Scientific Method</td>
<td>Dr. Begley</td>
</tr>
<tr>
<td>26</td>
<td>Trust in Science: Why Ethics Matters</td>
<td>Prof. Hogan</td>
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<tr>
<td>26</td>
<td>What Makes Something Ethical? Ends and Means</td>
<td>Prof. Hogan</td>
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<tr>
<td>26</td>
<td>Tutorial: Justification/Method</td>
<td>Prof. Hogan</td>
</tr>
<tr>
<td>27</td>
<td>What Makes Something Ethical? Duties and Virtues</td>
<td>Prof. Hogan</td>
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<tr>
<td>27</td>
<td>From Principle to Practice: Navigating the Ethics Ecosystem</td>
<td>Prof. Hogan</td>
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<tr>
<td>28</td>
<td>Reading Week</td>
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<tr>
<td>29</td>
<td>Does Science aim at Truth? (Scientific Realism)</td>
<td>Dr. Begley</td>
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<tr>
<td>29</td>
<td>Does Science aim at Truth? (Constructive Empiricism)</td>
<td>Dr. Begley</td>
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<tr>
<td>29</td>
<td>Tutorial: Ethics</td>
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<tr>
<td>30</td>
<td>Monday 17th March – St Patrick’s Day</td>
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<tr>
<td>30</td>
<td>What is Metaphysics?</td>
<td>Dr. Begley</td>
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<tr>
<td>30</td>
<td>Metaphysical theories (Realism and Nominalism)</td>
<td>Dr. Begley</td>
</tr>
<tr>
<td>31</td>
<td>Problems of Identity</td>
<td>Dr Begley</td>
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</tbody>
</table>
31 | Reduction and Emergence | Dr Begley
31 | Tutorial: Truth | Dr Begley
32 | What is Causation? | Dr. Begley
32 | What are Laws of Nature? | Dr. Begley
33 | Tutorial: Metaphysics | Dr. Begley
34 | Revision Week |
35 | Assessment Week |

**Note:** Some tutorials might have to be scheduled in the week following those indicated (excluding revision week).

**Detailed description of each Lecture**

The lectures follow a thematic progression that begins with the early history of science and philosophy and philosophical considerations about knowledge. This provides a context for discussion of scientific justification and method, and of science and truth. The lectures shift focus from epistemological considerations to ethical theories and their applications in science, and then again to metaphysical considerations regarding ontology, identity, emergence, causation and laws of nature.

**Week 22, Lecture 1: Introduction and early History**
This lecture is an introduction to the module. We will also begin to address the question: Where did our scientific and philosophical traditions come from?

**Week 22, Lecture 2: History of Science and Philosophy**
This lecture continues with the historical focus, by considering some key episodes in the genesis of science. We will also begin to consider in what way Science and Philosophy are investigations aimed at knowledge and wisdom.

**Week 23, Lecture 3: What is Knowledge?**
This lecture begins by distinguishing a number of different kinds and sources of knowledge, including the distinction between Knowledge-*how* and Knowledge-*that* and the distinction between *a priori* and *empirical* knowledge. We will also consider how these kinds manifest themselves in science.

**Week 23, Lecture 4: Defining Knowledge**
In this lecture we will discuss the philosophical project of defining or analysing knowledge, the traditional distinction between knowledge and mere true belief, and what is known as the ‘classical’ definition of knowledge as Justified True Belief. We will also begin to consider how science is distinguished from other practices aimed at knowledge, primarily by its manner of justification.

**Week 24, Lecture 5: What is Scientific Justification?**
In this lecture we will elucidate the distinctions between the main forms of inference, namely, deduction and induction/abduction, and the notions of argument, validity, fallacy, and soundness. We will see that induction, whatever else it may be, is not a logically valid form of inference. We will also consider a deeper issue, that of Hume’s problem of induction.

**Week 24, Lecture 6: Problems of Induction and Confirmation**
This lecture will introduce two further philosophical problems or paradoxes for the justification of inductive inference, which have been important in the philosophy of science, namely, Goodman’s new riddle of induction and Hempel’s paradox of ravens.
Week 25, Lecture 7: What is Scientific Method?
In this lecture we will consider one response to the problems of induction/confirmation, namely, Popper’s deductive scientific method (conjecture and refutation), which claims that science can do without induction and rely instead on deduction. We will also consider Popper’s claim that his criterion of falsification is what distinguishes science from non-science and pseudo-science, and whether or not there is such a thing as ‘scientific proof’ on this view.

Week 25, Lecture 8: Further views on Scientific Method
In this lecture we will consider a problem for naïve falsificationism, namely, the Duhem thesis. Further, we will consider some possible consequences of this for theory revision, such as Holism (Quine), and alternative views of (normal) science as operating within a certain paradigm (Kuhn).

Week 26, Lecture 9: 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.

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

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

Week 27, Lecture 12: From Principle to Practice: Navigating the Ethics Ecosystem
This lecture examines how institutional cultures affect individual decision-making, whether that be in the context of the university lab or the professional work environment. Topics for consideration will include ethical blind-spots, group-think, ethical fading and the question of whistle-blowing.

Week 28: Study Week

Week 29, Lecture 13: Does Science aim at Truth? (Scientific Realism)
In this lecture we will consider a number of views regarding the relation between science and truth, before considering some arguments for Scientific Realism, and the relevance of the (non-)distinction between observables and unobservables.

Week 29, Lecture 14: Does Science aim at Truth? (Constructive Empiricism)
This lecture will consider an anti-realist response to the argument for realism in the previous lecture, namely, and argument for the view known as Constructive Empiricism. This will take account of the relevance of the (vague) distinction between observables and unobservables, and the underdetermination of theory by evidence.

Week 30, Lecture 15: What is Metaphysics?
This lecture is an introduction to the philosophical area known as Metaphysics. We will consider in particular the main distinctions that are made in a main branch of metaphysics called ontology (the study of being): The object / property distinction (substantial / non-substantial) and the universal / particular distinction, and the ontological categories arising from these.
Week 30, Lecture 16: Metaphysical theories
This lecture builds upon the previous one by identifying kinds of metaphysical theory by the ontological categories that they accept. We will consider two such broad kinds of theory, Realism and Nominalism, and how principles and reasons, e.g., Occam’s Razor, might lead one to accept one view over another.

Week 31, Lecture 17: Problems of Identity
Having already prepared some basic notions in metaphysics in previous lectures, in this lecture we will begin to discuss some metaphysical problems. In particular, we will consider applications of metaphysics to problems of identity.

Week 31, Lecture 18: Reduction and Emergence
In this lecture we will consider applications of metaphysics to problems of reduction and emergence, and consider the question of whether and in what way the objects of the special sciences exist or are reducible to the fundamental posits of physics.

Week 32, Lecture 19: What is Causation?
In this lecture we will consider some traditional views of cause and explanation, as answers to why questions. We will then discuss an influential argument against real causation, which was put forward originally by Hume. Consideration will also be given to the notions of correlation and causation.

Week 32, Lecture 20: What is a Law of Nature?
In this lecture we will discuss the two main kinds of view regarding laws of nature. Following on from the previous lecture, we first discuss Regularity or ‘Humean’ views on laws of nature, before turning to Realist views. We will also consider some problems for these views.

Learning Outcomes:
At the end of this module students will be able to:
Think independently:
• demonstrate critical thinking and independence of judgement.
• investigate philosophical problems related to their discipline.
Communicate effectively:
• use valid argumentation and avoid fallacious reasoning.
• collaborate effectively regarding philosophical problems.
Develop continuously:
• appraise theory and practice through philosophical reflection.
• adapt to changing evidence and investigate new possibilities informed by philosophical approaches.
Act responsibly:
• demonstrate ethical awareness and recognise the place of science and philosophy in society.
• operate well both as part of a team and individually, recognising the role of the academic community in upholding standards.

Recommended Reading List:
Further reading: TBC
Assessment Details:

2 Written Essays of 1,000 words (2-3 pages) each (25%)
1. Essay (1,000 words) on scientific practice in light of one of the themes or problems regarding (i) Knowledge, (ii) Scientific Justification, (iii) Method
2. Essay (1,000 words) on an ethical problem in science (one question from three), applying approaches informed by normative ethical theories.

Questions will be published in weeks 22 & 27, respectively. Essays will be due in weeks 29 & 34. A 50–100 word abstract of the focus of each essay will be due two weeks prior to the essay deadline, in weeks 27 & 32.

Written Examination (1.5 hours, 50%) – two questions from five (excluding first essay topic).
Section A: (i) Knowledge, (ii) Scientific Justification, (iii) Method
Section B: (iv) Truth, (v) Metaphysics, (vi) Causation/Laws
1. One question from Section A (excluding first essay topic) OR one question from Section B. (25%)
A question from Section B. (25%)

Module Coordinator: PIU22992: History, Philosophy and Ethics of Science
Dr Keith Begley E-mail: kbegley@tcd.ie
Department of Philosophy Phone: 353 1 896 1671

Executive Officer: E-mail: philosophy@tcd.ie
Sarah Smullen Phone: 353 1 896 1529
Department of Philosophy

Module Website https://www.tcd.ie/Philosophy
MAU22S01: Multivariable calculus for science
Semester 1, 5 credits

Contact Hours
11 weeks, 3 lectures including tutorials per week

Lecturer
Prof Miriam Logan (t.b.c.)

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

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

Module Prerequisite
MAU11S01 & MAU11S02
Recommended Reading
*Calculus. Late transcendentals.* by H.Anton, I.Bivens, S. Davies

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

**Contact Details:**
Module Coordinator: MAU22S01

Professor Miriam Logan
E-mail: loganmi@tcd.ie  
Phone: 01 896 1211

Executive Officer:
Ms Emma Clancy
E-mail: clancyem@maths.tcd.ie  
Phone: 01 896 1949
Module MAU22S03: Fourier analysis for Science
Semester 1, 5 Credits

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

Lecturer
Prof Ruth Britto (t.b.c.)

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

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

Module Prerequisite
MAU11S01 & MAU11S02, co-requisite MAU22S01

Suggested Reference

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

Module Coordinator: MAU22S03: Fourier analysis for Science
Professor Ruth Britto  E-mail: britto@maths.tcd.ie
Phone: 01 896 3945

Executive Officer:  E-mail: clancyem@maths.tcd.ie
Ms Emma Clancy  Phone: 01 896 1949
Module MAU22S02: Vector calculus for science
Semester 2, 5 Credits

Contact Hours
11 weeks, 3 lectures including tutorials per week

Lecturer
Dr. Joe Ó hÓgáin (t.c.b.)

Learning Outcomes
On successful completion of this module, students will be able to:
• Manipulate vectors in $\mathbb{R}^3$ 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

Module Prerequisite
MAU22S01

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

Contact Details:
Module Coordinator: MAU22S02: Vector calculus for Science
Professor Joe Ó hÓgáin E-mail: johog@maths.tcd.ie
Phone: 01 896 1949

Executive Officer:
Ms Emma Clancy E-mail: clancyem@maths.tcd.ie
Phone: 01 896 1949
TR061: Chemical Sciences – APPROVED Modules

BYU22201: From Molecules to Cells
Semester 1, 10 credits

Contact Hours:
39 lectures. 8 x 3hr Practicals.

Module Personnel:

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. It also introduces students to the structure of viruses and how they enter cells and take over cellular processes during infection.

Module content: Programme of lectures and practicals

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Topic</th>
<th>Lecturer</th>
<th>Practical</th>
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<tbody>
<tr>
<td>3</td>
<td>Introduction to Module BYU22201 “from Molecules to Cells”</td>
<td>Prof Creagh</td>
<td></td>
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<tr>
<td>3</td>
<td>Cell structure &amp; intracellular transport</td>
<td>Prof Creagh</td>
<td>Solutions &amp; Dilutions</td>
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<tr>
<td>3</td>
<td>Cell cytoskeleton I</td>
<td>Prof Creagh</td>
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<td>3</td>
<td>Cell cytoskeleton II</td>
<td>Prof Creagh</td>
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<tr>
<td>4</td>
<td>Cellular Proliferation &amp; Death</td>
<td>Prof Creagh</td>
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<td>4</td>
<td>Proteins &amp; amino acids</td>
<td>Prof Mok</td>
<td>Chromatography</td>
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<td>4</td>
<td>Protein folding and purification</td>
<td>Prof Mok</td>
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<td>4</td>
<td>Oxygen binding proteins</td>
<td>Prof Mok</td>
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<tr>
<td>5</td>
<td>Enzymes, catalysis and assays</td>
<td>Prof Murray</td>
<td>Enzyme Kinetics</td>
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<tr>
<td>5</td>
<td>Enzyme kinetics, inhibition &amp; regulation</td>
<td>Prof Murray</td>
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<td>5</td>
<td>Lipids - Fatty acids &amp; Phospholipids</td>
<td>Prof Hayes</td>
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<td>5</td>
<td>Lipids – beta-oxidation &amp; fatty acid synthesis</td>
<td>Prof Hayes</td>
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<td>Topic</td>
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<tr>
<td>6</td>
<td>Powering Life: Energy transduction &amp; life</td>
<td>Prof Nolan</td>
<td>Spectrophotometry</td>
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<tr>
<td>6</td>
<td>Bioenergetics 1: Oxidative Phosphorylation</td>
<td>Prof Nolan</td>
<td>Oxidative Phosphorylation (1st half of class)</td>
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<tr>
<td>6</td>
<td>Bioenergetics 2: The university of chemiosmosis</td>
<td>Prof Nolan</td>
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<td>6</td>
<td>Harvesting the light: Photosynthesis</td>
<td>Prof Nolan</td>
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<td>7</td>
<td>Glycolysis</td>
<td>Prof Porter</td>
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<td>7</td>
<td>Gluconeogenesis</td>
<td>Prof Porter</td>
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<td>7</td>
<td>TCA cycle</td>
<td>Prof Porter</td>
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<td>7</td>
<td>Glycogen biosynthesis &amp; degradation</td>
<td>Prof Porter</td>
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<tr>
<td>8</td>
<td>Nitrogen metabolism &amp; Integration of Metabolism</td>
<td>Prof Nolan</td>
<td>Oxidative Phosphorylation (2nd half of class)</td>
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<tr>
<td>8</td>
<td>Summary Lecture – Cell Biology &amp; Metabolism</td>
<td>Prof Creagh and Prof Nolan</td>
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<td>8</td>
<td>DNA – Structure, Replication, Repair, Recombination I</td>
<td>Prof Ramaswami</td>
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<tr>
<td>8</td>
<td>DNA – Structure, Replication, Repair, Recombination II</td>
<td>Prof Ramaswami</td>
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<tr>
<td>9</td>
<td>Reading Week Open MCQ</td>
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<td>Monday 28th October 2019 – Bank Holiday</td>
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<tr>
<td>10</td>
<td>DNA – Structure, Replication, Repair, Recombination III</td>
<td>Prof Ramaswami</td>
<td>Genetic Variation in Humans PTC test and analysis I</td>
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<tr>
<td>10</td>
<td>Transcription – RNA types, mRNA processing</td>
<td>Prof Ramaswami</td>
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<tr>
<td>10</td>
<td>Transcription – RNA types, mRNA processing</td>
<td>Prof Ramaswami</td>
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<tr>
<td>11</td>
<td>Regulation of gene expression: general principles</td>
<td>Prof Martin</td>
<td>Genetic Variation in Humans PTC test and analysis II</td>
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<tr>
<td>11</td>
<td>Gene expression in prokaryotes and eukaryotes</td>
<td>Prof Martin</td>
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<td>11</td>
<td>Chromatin and epigenetic effects on gene expression</td>
<td>Prof Martin</td>
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<td>11</td>
<td>Alternative splicing and protein translation</td>
<td>Prof Martin</td>
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<tr>
<td>12</td>
<td>Mendelian Inheritance</td>
<td>Prof Campbell</td>
<td>Genetic Variation in Humans PTC test and analysis III</td>
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<td>12</td>
<td>Mapping Mendelian traits</td>
<td>Prof Campbell</td>
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<td>12</td>
<td>Quantitative traits and heritability</td>
<td>Prof Campbell</td>
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<tr>
<td>12</td>
<td>Genetics of common diseases</td>
<td>Prof Campbell</td>
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<tr>
<td>Week</td>
<td>Lecture Content</td>
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<tr>
<td>13</td>
<td>Virology: genetic diversity of viruses</td>
<td>Prof Roberts</td>
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<tr>
<td>13</td>
<td>Virology: Replication cycle 1- from entry to transcription</td>
<td>Prof Roberts</td>
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<tr>
<td>13</td>
<td>Virology: Replication cycle 2- from translation to virion formation &amp; release</td>
<td>Prof Roberts</td>
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<tr>
<td>13</td>
<td>Virology: Emerging viruses – mutation, adaptation &amp; transmission</td>
<td>Prof Robert</td>
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<td>14</td>
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</tbody>
</table>
| 15   | Revision Week  
Open MCQ | — |
| 16   | Assessment Week | — |

**Description of Lecture Content:**

**Week 3:**
- Introduction to to the BYU22201 Module ‘ from Molecules to Cells’
- Revision of Cell structure (Podcast), Membrane structure & Intracellular protein transport mechanisms. (Elements Flipped classroom)
- Cellular cytoskeleton I (Actin filaments, myosin motor protein) (combination of flipped classroom & traditional lectures material) - Principles of cellular movement & the process of muscle contraction.
- Cellular cytoskeleton II – Importance of Microtubules & Intermediate filaments for cellular function (combination of flipped classroom & traditional lectures material). Specialised microtubules involved in the motility of cilia/flagella will be discussed.

**Week 4:**
- 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.

**Week 5:**
- Enzyme substrate relationship, catalysis and the transition state. Physiochemical parameters of enzyme activities and assays.
- Michaelis-Menten kinetics, limiting velocity, rate/enzyme correlation (in class activity supported by podcasts). 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- β-oxidation and fatty acid synthesis. Energy production through the mobilisation of fatty acids from triacylglycerols and their oxidation in mitochondria. Energy storage through the synthesis of fatty acids and storage of triacylglycerols in adipocytes.

Week 6:
• 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 F1F0-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 C6C6-ATPase. A comparison of oxidative and photo phosphorylation.

Week 7:
• 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.

Week 8:
• Nitrogen metabolism & Integration of Metabolism
• Summary Lecture of Cell Biology and 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;

Week 9: Reading Week.

Week 10:
• 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.
Week 11:
- 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.

Week 12:
- Mendelian Inheritance. Mendel’s laws (recap from JF) 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 focuses 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.

Week 13:
- Virology: genetic diversity of viruses. The diversity of viral genomes and particle structures will be explored in this lecture.
- Virology: Replication cycle 1 – from entry to transcription. In this lecture we will compare how different viruses enter cells and a range of viral strategies for producing mRNA.
- Virology: Replication cycle 2 – from translation to virion formation and release. In this lecture we will explore how the location within the cell of viral genome replication and assembly of new virions is dependent on the cellular processes a virus needs to utilise during replication.
- Virology: Emerging viruses – mutation, adaptation and transmission. In this lecture we will discuss a range of viruses causing emerging infections and explore how their replication cycles changed to adapt to new hosts or cell types.

Description of Practical Content:

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

Practical 2 - Chromatography – During this practical highlights student’s will perform Gel filtration chromatography: oxidised sheep’s blood is used to observe the colour changes that occur as it is reduced (methaemoglobin-haemoglobin-oxyhaemoglobin); and Ion exchange chromatography: yeast extract is applied to a DEAE column, anionic enzymes Catalase & Glucose oxidase are eluted, collected in fractions and tested for the presence of both enzymes.
Practical 3 – Enzyme Kinetics - Students perform a stopped enzyme assay, using increasing substrate and inhibitor concentrations. They calculate the final concentrations in the assay, calculate Km and Vmax for uninhibited series, use Lineweaver-burk plots to demonstrate competitive inhibition, and determine the Ki.

Practical 4 - Spectrophotometry - Enzyme assays, using increasing Alcohol dehydrogenase (ADH) concentrations, will be performed - measuring the spectrophotometric production of NADH as the readout.

Practical 5 – Oxidative phosphorylation. Students will measure the P:O ratio of succinate and glutamate/malate; measure respiratory control ratios; inhibit Complexes I/III using rotenone/Antimycin A; uncouple mitochondria using DNP and inhibit ATP synthase using oligomycin.

Practicals 6 and 7: Genetic Variation in Humans
Variation in the ability to taste phenylthiocarbamide (PTC) in the population; DNA isolation from human cheek cells; detection of PTC taster and non-taster receptor alleles through PCR, restriction digest and agarose gel electrophoresis. Estimating allele frequencies in a population and Hardy-Weinberg equilibrium.

Practical 8: 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 understand fundamental concepts in the following cellular structures and processes: the structure and function of cells and organelles; structures and functions of nucleic acids, proteins carbohydrates and lipids; the fundamental concepts and regulation of metabolism; the composition, structure synthesis and function of DNA and RNA; regulation of gene expression in prokaryotes and eukaryotes; chromatin structure and epigenetic regulation of gene expression; the principles of genetic inheritance; genetic diseases and fundamental concepts in virology.

Recommended Reading List:
The topics and concepts presented in this module will be found in many general textbooks on Cell Biology. Biochemistry and Genetics. The following are recommended for your guidance:


Assessment Details:
(A) End of semester written examination: 50% total mark
Exam is comprised of:
• 25%: 10 short answer questions, testing understanding of concepts and deduction.
• 25%: 1 essay-type question from a choice of 3 questions on paper

(B) Two MCQ: 15% of total mark
• testing knowledge of subject

(C) Practical write-ups/assessments: 35% total mark.

Module coordinator - BYU22201 From Molecules to Cells
Dr Emma Creagh Ph: 01 896 2539
E-mail: ecreagh@tcd.ie

Executive Officer E-mail: BTC.Administrator@tcd.ie
Ms Diane Touzel Phone: 01 896 1117
BYU2202: From Cells to Organisms  
Semester 2, 10 credits

**Contact Hours**
39 lectures and 4 x 3 hour practical classes

**Module Personnel**

**Learning Aims**
This module aims to bring the student from the functioning of the most simple cell to the integrated functioning of perceiving, thinking and acting organisms. The module will give the students an appreciation of the highly specialised and dynamic communication between cells and tissues that brings about the functioning organism

**Module content:** Programme of lectures and practicals

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<tr>
<th>Week</th>
<th>Lecture Topic</th>
<th>Lecturer</th>
<th>Practical</th>
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<td>22</td>
<td>Introduction to BYU2202 “from Cells to Organisms”</td>
<td>Prof Cunningham</td>
<td>Bacterial motility</td>
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<td>Sugar utilisation And Cell communication</td>
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<td>22</td>
<td>The bacterial world: diversity &amp; unique extracellular structures</td>
<td>Prof Dorman</td>
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<tr>
<td>22</td>
<td>Energy, transport and scavenging in bacteria</td>
<td>Prof Dorman</td>
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<td>22</td>
<td>Motility and chemotaxis in bacteria</td>
<td>Prof Dorman</td>
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<td>23</td>
<td>Cell:cell communication &amp; bacterial development</td>
<td>Prof Geoghegan</td>
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<tr>
<td>23</td>
<td>Bacterial interactions with eukaryotic cells</td>
<td>Prof Geoghegan</td>
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<td>23</td>
<td>Fungal world</td>
<td>Prof Bond</td>
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<td>23</td>
<td>Autocrine, Juxtacrine, paracrine &amp; endocrine signaling</td>
<td>Prof Cunningham</td>
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<td>24</td>
<td>Cargo packaging for export (peptides vs non protein)</td>
<td>Prof Cunningham</td>
<td>cAMP synthesis</td>
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<td>24</td>
<td>Calcium-dependent exocytosis</td>
<td>Prof Cunningham</td>
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<td>24</td>
<td>Post-synaptic actions at ionotropic receptors</td>
<td>Prof Cunningham</td>
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<td>24</td>
<td>Conserved components of intracellular signal-transduction</td>
<td>Prof Zisterer</td>
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<td>25</td>
<td>G-protein coupled receptors, cAMP, PKA, integration</td>
<td>Prof Zisterer</td>
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<td>25</td>
<td>Receptor Tyrosine Kinases, MAP kinases</td>
<td>Prof Zisterer</td>
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<td>25</td>
<td>Crosstalk between pathways, conservation between organisms</td>
<td>Prof Zisterer</td>
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<td>25</td>
<td>Organising a body plan in multicellular organisms</td>
<td>Prof Rolfe</td>
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<td>26</td>
<td>Cell signaling/cell communication in the context of development</td>
<td>Prof Rolfe</td>
<td>Practical on</td>
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<td>Date</td>
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<tr>
<td>26</td>
<td>Elaboration of positional information/Progressive specification/cell lineage analysis</td>
<td>Prof Rolfe</td>
<td>Development</td>
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<tr>
<td>26</td>
<td>How a cell responds to positional information</td>
<td>Prof Rolfe</td>
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<tr>
<td>26</td>
<td>Evolution/Development – body plan changes through evolution</td>
<td>Prof Rolfe</td>
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<td>27</td>
<td>Organogenesis</td>
<td>Prof Rolfe</td>
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<td>Revision/integration lecture</td>
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<td>27</td>
<td>Nervous control of physiological function (CVS)</td>
<td>Prof Kelly</td>
<td>Cardiovascular Practical</td>
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<tr>
<td>27</td>
<td>Neuropharmacology of autonomic nervous system</td>
<td>Prof Kelly</td>
<td>(CVS physiology)</td>
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<td>28</td>
<td>Reading Week &amp; Open MCQ</td>
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<tr>
<td>29</td>
<td>Muscle function (cardiac, skeletal, pathophysiology)</td>
<td>Prof Kelly</td>
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<tr>
<td>29</td>
<td>Endocrine regulation of physiological function</td>
<td>Prof Kelly</td>
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<tr>
<td>29</td>
<td>Fundamentals of cardiovascular &amp; renal (altitude, exercise)</td>
<td>Prof Kelly</td>
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<td>29</td>
<td>Fundamentals of cardiovascular &amp; renal (acid/base, BP)</td>
<td>Prof Kelly</td>
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<td>30</td>
<td>Monday 17th March – St Patrick’s Day</td>
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<td>30</td>
<td>Pathophysiology and treatment of hypertension</td>
<td>Prof Kelly</td>
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<td>30</td>
<td>Digestion &amp; metabolism, metabolic syndrome, gut-brain axis</td>
<td>Prof Kelly</td>
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<td>The immune system and its influence on homeostasis</td>
<td>Prof Lynch</td>
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<td>31</td>
<td>Integration of Nervous, endocrine and immune regulation of physiology and pathophysiology of Neurodegenerative disease.</td>
<td>Prof Kelly</td>
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<td>31</td>
<td>Motor coordination and control</td>
<td>Prof Witney</td>
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<td>Pain, nociception, and interoception</td>
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<td>32</td>
<td>Emotion and motivation</td>
<td>Prof Ryan</td>
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<td>Learning and Memory</td>
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<td>Understanding brain function through pathology/disease</td>
<td>Prof Ryan</td>
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<td>Summary - Revision/integration lecture</td>
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<td>Revision Week &amp; Open MCQ</td>
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<td>Assessment Week</td>
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Description of Lecture Content:

**Unicellular to multicellular life**
- Examples of signaling 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 and their role in adaptation to the environment
- Mechanisms employed by bacteria to attach to and interact with eukaryotic cells
- The diversity of fungi & their life cycles

**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 (a mixture of flipped classroom and online resources)
- Neurotransmission as a specialized form of calcium-dependent exocytosis. Resting membrane potential and depolarization, the action potential, voltage-dependent calcium channels (a mixture of flipped classroom and online resources).
- Ionotropic receptors: neurotransmitter binding and gating of ion channels. Acetylcholine and plate potentials at the neuromuscular junction. Different functions at different receptors. Termination of signalling.
- 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.

**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. It will deal with molecular and biophysical mechanisms governing cellular behavior.
• **Cell signaling/cell communication in the context of development.** Cell communication is fundamental to building an organized body plan. The main developmental signaling pathways (Wnt, BMP, Hedgehog, FGF, YAP/hippo etc) will be introduced with examples of how they guide development. Pathway conservation and elaboration through evolution related to developmental complexity will be examined.

• **Elaboration of positional information over time.** Exploration of key concepts, moving from the “French flag model” to more sophisticated ways of thinking. The concept of gradients and graded influence across tissues. Progressive specification and how information builds over developmental time. Cell lineage analysis and tracing a cell through time. Stem cells and how stem cell niches are established during development

• **How a cell responds to positional information.** Transcriptional and post-transcriptional regulation leading to cellular differentiation. The integration of different types of information at the cellular level determining how a cell responds. The importance of the cellular context and epigenetics. Hox genes and how they relate to positional information – the concept of a positional code. Mutations that change the body plan.

• **Evolution & Development:** How body plans can change through evolution. The concept of “the Toolkit” for building an organism and “tinkering with the toolkit” – genetic changes that can lead to major body plan shifts such as loss of limbs or acquisition of specialised structures such as a turtle shell.

• **Organogenesis:** Development of organ and organ systems; e.g. heart, kidney, lung etc. building on the concepts and mechanisms involved in building complex structures, current knowledge on how specific organs are established will be presented and explained.

**Human physiology**

• Nervous control of physiological function: sensory and autonomic nerves. CVS as model system.

• Muscle function and its nervous control. Disorders of skeletal muscle, cardiac hypertrophy (physiological via exercise & pregnancy; pathophysiological via hypertension)

• Neuropharmacology, with specific emphasis on pharmacology of the autonomic nervous system; effect of toxins on neuromuscular junction

• Endocrine regulation of physiological function, highlighting endocrine disorders.

• Fundamentals of cardiovascular and respiratory physiology and their interaction (homeostatic responses to altitude, exercise)

• Fundamentals of cardiovascular and renal physiology and their interaction (regulation of blood pressure and volume, acid-base balance)

• Pathophysiology and treatment of hypertension (pharmacology of ANS, role of exercise in prevention and treatment)

• Digestion and metabolism, metabolic syndrome, the gut-brain axis.

• Immune regulation of physiological function (innate vs adaptive, role of inflammation in infection and cancer. Regulation of tissue homeostasis and role in food allergy, obesity, and diabetes.

• Pathophysiology of diseases of the nervous system (MS, AD, PD, encompassing nervous, endocrine and immune regulation of physiology).
Neuroscience and Behaviour

- 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.
- Sensation and perception. Students will gain an understanding of how the brain makes sense of sensory input. They will be aware of and able to explain fundamental discoveries (e.g. Hubel & Wiesel). They will be able to describe neuronal circuitry that enables us to distinguish between sensory input from the external world and that which is internally generated (sensory cancellation and efference copy mechanisms).
- Pain, nociception, and interoception. Students will attain and understanding of the internal awareness of the animal body to states such as pain.
- 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.

Description of Practical Content:

Practical 1
Title: Studying bacterial signalling molecules using a transcriptional fusion reporter gene.

Summary:
Bacteria release and detect signalling molecules to control gene expression as their population grows. This phenomenon is called quorum sensing. This practical will illustrate the principles of quorum sensing in bacteria by studying the effect of quorum sensing molecules on gene expression in real-time. Supernatants from different bacteria grown under a variety of conditions will be examined for their ability to activate the promoter of a gene normally activated in response to a specific-signalling molecule. The promoter has been fused to a gene encoding green fluorescent protein (GFP). The production of GFP protein, which makes the bacteria fluoresce when exposed to light of the appropriate wavelength, will be examined using fluorescence microscope.

Learning Outcomes: Upon successful completion of this practical students will be able to:
- Appreciate the specificity of quorum sensing signalling molecules in bacteria
- Understand the use of transcriptional fusions for studying cell-cell communication in bacteria

Practical 2
Title: Analysis of the Degradation of a Second Messenger by Thin-layer Chromatography
Summary: Cyclic adenosine monophosphate (cAMP) is a second messenger important in many biological processes. cAMP is hydrolysed to 5’ adenosine monophosphate (5’AMP) by the enzyme phosphodiesterase in a reaction inhibited by theophylline. Given that both substrate and product fluoresce when exposed to ultra violet light the degradation and the inhibition of degradation of cAMP can be conveniently analysed by thin-layer chromatography.
Learning Outcomes: Upon successful completion of this practical and the associated exercises, students should be able to:

- Demonstrate that they can evaluate and optimize experimental conditions
- Demonstrate that they can keep complete and reliable records of experiments
- Perform a thin-layer chromatography analysis
- Demonstrate a knowledge of some important second messenger molecules

Practical 3
Title: 3D Imaging and database research of Embryonic Development

Summary: Visualising and interpreting dynamic complex changes that take place during vertebrate embryonic development. Using online 3D databases of developing embryos, students will 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.

Learning Outcomes: Upon successful completion of this practical and the associated exercises, students should be able to:

- Utilise online tools and databases to explore specific questions related to embryonic development including an appreciation of the power of using shared data in research

Practical 4
Title: Cardiovascular and respiratory physiology

Summary: 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: Upon successful completion of this practical and the associated exercises, students should be able to:

- Measure and understand fundamental cardiovascular and respiratory variables in human subjects

Learning Outcomes:
Unicellular to multicellular life:

On successful completion students will be able to:

- Demonstrate an understanding of how bacteria form communities and the role of signalling in bacterial communication.
- Describe the regulatory and physiological adaptations that bacteria undergo to acquire nutrients and respond to stress.
- Appreciate the structure, function and importance of bacterial extracellular structures and their roles in modulating cell-cell interactions
- Describe the mechanisms used by bacteria to interact with eukaryotic cells
- Appreciate the diversity of fungi, their developmental processes and multicellular lifestyles
**Cell signalling:**

After completing the cell-cell communication & cell signalling lectures, students should be able to demonstrate an understanding of how biological signals are prepared for export, are temporally and spatially controlled, are sent, amplified, and received in the cellular context (signal transduction), and provide examples as to how this is achieved in cells. Students should be able to:

- Understand the different mechanisms by which cells communicate with each other and how these shape the spatial extent of signalling.
- Appreciate and be able to articulate the ways in which molecules must be packaged, in order to be released.
- Give an account of how neurotransmitters are released by Calcium-dependent exocytosis, including demonstrating understanding of the ionic and energetic basis of depolarisation and release (Action potential and voltage-dependent calcium channels).
- Understand how neurotransmitters act on post-synaptic ionotropic receptors on muscle cells or neurons, to bring about activation or inhibition.
- Understand the basic principles of signal transduction mechanisms, in particular the concepts of response specificity, signal amplitude and duration, and how signals are integrated within a cell to give a specific functional response
- Give examples of different types of extracellular signals and receptors, and explain their functional significance
- Describe the mechanisms by which different receptors may be activated by their respective ligands
- Describe and give examples of the structure and properties of the major components of signal transduction pathways
- Understand the importance of signal termination and give examples of how signal transduction pathways can be terminated
- Understand and give examples of how defects in certain signalling molecules can give rise to disease states

**Development:**

- Articulate the concepts of how biological complexity is established as the body plan of multicellular organisms emerge.
- Integrate these concepts in the context of how body plans have evolved.

**Human Physiology**

- After completing these lectures students will be able to:
- Describe the contribution of the nervous, endocrine and immune systems to regulation of physiological homeostasis in humans
- Describe the gross and microscopic structures of the cardiovascular, respiratory, immune, renal and digestive systems
- Discuss how the functions of physiological systems are integrated to ensure cell, tissue, organ and whole-body homeostasis
- 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

**Neuroscience & Behaviour**

- The students will be able to use examples from invertebrate & vertebrate neurobiology to articulate how the brain achieves basic functions for the animal.
- Students will be encouraged to think integratively about how the fundamental physiology of neural circuits can be used to explain behavioural function in both vertebrates and invertebrates.
• Students will be able to give explanatory accounts of movement and motor control, sensation, and interoception.
• Students will be able to give explanatory accounts of emotion/motivation, memory, and how brain injury in human patients can inform us about brain function.

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


**Assessment Details:**
(A) **End of semester written examination**: 50% total mark
Exam comprised of:
• 25%: 10 short answer questions, testing understanding of concepts and deduction
• 25%: 1 essay-type question from a choice of 3 questions on paper
(B) **Two MCQ**: 15% of total mark
• testing knowledge of subject
(C) **Practical write-ups/assessments**: 35% total mark.

**Contacts:**

Module coordinator - BYU22202: From Cells to Organisms
Professor Colm Cunningham E-mail: colm.cunningham@tcd.ie
Phone: 896 3964

Executive Officer E-mail: BTC.Administrator@tcd.ie
Phone: 01 896 1117
PYU22P10: Physics 1  
Semester 1, 10 Credits

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

This module combines four elements of classical physics as follows:

**Thermodynamics** – 15 lectures  
**Electricity and Magnetism II** – 14 lectures  
**Oscillations** – 12 lectures  
**Materials** – 12 lectures

**Syllabus:**

- **Thermodynamics: - 15 lectures**

- **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**

- **Materials 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
- Relate the concept of oscillations to optical properties of matter and AC circuits
- Describe elementary crystal structures and the response of materials to external forces
- Describe how the laws of thermodynamics react to properties of matter
- Employ web-based research techniques in a small group project and present the results in the form of a poster
- Either prepare an extensive report detailing methodology, data gathering and interpretation of a physical experiment and obtain, pre-process, display and analyse experimental data using software packages such as Origin or analyse, modify and run Python language programs to perform computer experiments

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

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

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

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<tr>
<td>Examination</td>
<td>60%</td>
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<tr>
<td>Experimental / Computational labs</td>
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<td>Project</td>
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<td>Tutorials</td>
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**Examination**
Information about examinations will be made available on the Examination Office’s website. Each module, PYU22P10 and PYU22P20, is examined in a separate 2-hour examination paper during the relevant end of semester exam session.

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

**Contact Details:**

**Module Coordinator:**
Professor Martin Hegner  E-mail: hegnerm@tcd.ie  Phone: 01 896 2285

**Executive Officer:**
Ms Helen O’Holloran      E-mail: hollorn@tcd.ie  Phone: 01 896 4141
PYU22P20 – Physics
Semester 2, 10 Credits

PYU22P20 Physics
(C Patterson, M Stamenova, A Vidotto, D McCloskey: Co-ordinator: Prof Martin Hegner)

This module combines four elements of modern physics as follows:

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

**Syllabus:**

- **Special relativity: - 12 lectures**

- **Nuclear & Particle Physics: - 14 lectures**

- **Astrophysics: - 12 lectures**

- **Waves & Optics II: - 14 lectures**
  Maxwell equations in differential form. Coulomb’s and Gauss’ Laws; Biot-Savart and Ampere’s Laws; absence of magnetic monopoles; Faraday’s Law and magnetic induction. Electric dipoles, dielectric polarisation and dielectric susceptibility; magnetic dipoles, magnetisation and diamagnetic susceptibility; continuity equation, displacement current and Maxwell’s generalisation of Ampere’s Law. Electromagnetic waves in vacuum and isotropic matter.
Energy density in time-varying electromagnetic fields and Poynting vector. Reflection, refraction, plane, circular and elliptic polarisation of light; dichroism, birefringence; interference, interferometers, coherence, Young’s slits, near and far field diffraction.

**PYU22P20 Learning Outcomes:**
On successful completion of this module, the students will be able to:

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

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

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

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

**Contact Details:**

**Module Coordinator:**
Professor Martin Hegner  
E-mail: hegnerm@tcd.ie  
Phone: 01 896 2285

**Executive Officer:**
Ms Helen O’Holloran  
E-mail: hollorn@tcd.ie  
Phone: 01 896 4141
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.
Academic Year Structure 2019/20

Key Dates:

Study/Review Week:

Revision Week Semester 1: Monday 21 to Friday 25 October inclusive

Foundation Scholarship

Application Dates for Foundation Scholarship Examinations: Wednesday 16 October to Wednesday 30 October inclusive

Exam Dates: Monday 6 January to Friday 10 January inclusive

Study/Review Week:

Revision Week Semester 2: Monday 13 April to Friday 17 April 2020

Trinity week: Monday 20 April to Friday 23 April 2019

Announcement of Scholarship Monday 20 April 2020 at 10 am outside the Examination Hall, Front Square

Formal Assessment weeks:

Semester 1 examinations Monday 9 December 2019 to Friday 13 December 2019 inclusive

Semester 2 examinations Monday 27 April 2020 to Friday 1 May 2020 inclusive

Closing Dates for Course Transfer

If you decide to transfer out of your course altogether, you must submit an application for transfer of course to the Academic Registry, following discussion with your tutor. Decisions are based on a) the availability of places, and b) the entry qualifications of the transfer applicant. It may not be possible to permit transfers to subjects which already have a full complement of students. Further details are available on the following link:

http://www.tcd.ie/study/apply/making-an-application/undergraduate/index.php

Students may not register or attend a course until their application to transfer has been formally approved by the Senior Lecturer
Progression and Awards

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

Attendance

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

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

The requirements for attendance at lectures and tutorials vary between the different faculties, schools and departments. Attendance is compulsory for Junior Freshman in all subjects. 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.
Absence from College – Medical and Absence Certificates

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

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

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

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

Other Absences
Students who require to be absent from a laboratory practical classes or tutorials (with or without an associated assessment) for any other reason, such as a sporting or social event, should inform the Science Course Office well in advance of the event (preferably a week beforehand).

- Science Absence from College Form, Sport or Other – Available from the Science Course Office

Where possible they will be assigned to an alternative laboratory practical session, but if that is not possible, and the justification for the absence is considered legitimate, they may be treated in the same manner as students submitting medical certificates (i.e. assigned an alternative assessment for one missed or awarded a pro-rata/pass mark). This is decided by the individual Disciplines concerned (i.e. Biology, Chemistry, Physics etc.) not the Science Course Office.

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).

Non-satisfactory attendance and course work
All students must fulfil the 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. Further information on non-satisfactory attendance and course work may be found via the following webpage:

https://www.tcd.ie/undergraduate-studies/academic-progress/attendance-course-work.php
Plagiarism

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

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

A general set of guidelines for students on avoiding plagiarism is available on: https://libguides.tcd.ie/friendly.php?s=plagiarism

The Calendar entry outlines the process through which a suspected case of plagiarism should be dealt with https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf

Trinity Tutorial Service

The Tutorial Service is unique, confidential and available to all undergraduate students offering student support in all aspects of College life. The Tutorial Service is supported and co-ordinated by the Senior Tutor’s Office which is located on the ground floor in House 27.

Opening Hours
The Senior Tutors Office is open Monday - Friday from 9am - 5.30pm. Closed for lunch from 1-2pm.

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

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

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

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

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

Further information on the support available may be found via the following link: https://www.tcd.ie/disability/services/

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

Student Counselling

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

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

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

Useful College Websites:

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

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

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

Student Accommodation
The Accommodation Office is open Monday to Friday from 8.30am to 1pm and 2pm-5pm each day. Queries can be emailed to residences@tcd.ie, or you can telephone 8961177 during office hours. https://www.tcd.ie/accommodation/
Sample timetables

Please note that the following SAMPLE timetables may change before term commences on 9 September 2019. Once registered students can view their timetable via my.tcd.ie in real time. Do not take and save snapshots as they will not reflect the most up-to-date information

Semester One Sample Timetable
(please insert semester one timetable here)
SAMPLE SEMESTER TWO TIMETABLE

(Please insert sample semester two timetable here)
TR061: Chemical Sciences

Contact details:

Course Director TR061: Chemical Sciences
Professor Paula Colavita  
E-mail: colavitp@tcd.ie  
Ph: 01 896 3562

Coordinator Freshman Teaching
Dr Noelle Scully  
E-mail: pnscully@tcd.ie  
Ph: 01 896 1972

Senior Executive Officer
E-mail: farrea25@tcd.ie  
Ph: 01 896 1726

Science Course Office

Professor Áine Kelly  
Associate Dean of Undergraduate Science Education  
Ph: 01 896 2025

Ms Anne O’Reilly  
Science Course Administrator  
E-mail: science@tcd.ie  
Ph: 01 896 2023

Ms Ann Marie Brady  
Senior Executive Officer  
E-mail: sfSCO@tcd.ie  
Ph: 01 896 2829

Ms Lucy Martin  
Executive Officer  
E-mail: martInl@tcd.ie  
Ph: 01 896 2829

Ms Eva Page  
Global Officer, Life and Geosciences  
E-mail: eva.page@tcd.ie  
Ph: 01 896 2799
## Teaching Term Dates 2019-20

### Michaelmas Term
**Monday 09 Sept 2019 - Friday 29 Nov 2019**

<table>
<thead>
<tr>
<th>Teaching wk</th>
<th>Week 03</th>
<th>09 Sept - 13 Sept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching wk 1</td>
<td>Week 04</td>
<td>16 Sept - 20 Sept</td>
</tr>
<tr>
<td>Teaching wk 2</td>
<td>Week 05</td>
<td>23 Sept - 27 Sept</td>
</tr>
<tr>
<td>Teaching wk 3</td>
<td>Week 06</td>
<td>30 Sept - 04 Oct</td>
</tr>
<tr>
<td>Teaching wk 4</td>
<td>Week 07</td>
<td>07 Oct - 11 Oct</td>
</tr>
<tr>
<td>Teaching wk 5</td>
<td>Week 08</td>
<td>14 Oct - 18 Oct</td>
</tr>
<tr>
<td>Study week</td>
<td>Week 09</td>
<td>21 Oct - 25 Oct</td>
</tr>
<tr>
<td>Teaching wk 8</td>
<td>Week 10</td>
<td>* 28 Oct - 01 Nov</td>
</tr>
<tr>
<td>Teaching wk 9</td>
<td>Week 11</td>
<td>04 Nov - 08 Nov</td>
</tr>
<tr>
<td>Teaching wk 10</td>
<td>Week 12</td>
<td>11 Nov - 15 Nov</td>
</tr>
<tr>
<td>Teaching wk 11</td>
<td>Week 13</td>
<td>18 Nov - 22 Nov</td>
</tr>
<tr>
<td>Teaching wk 12</td>
<td>Week 14</td>
<td>25 Nov - 29 Nov</td>
</tr>
</tbody>
</table>

### Hilary Term
**Monday 20 January 2020 - Friday 10 April 2020**

<table>
<thead>
<tr>
<th>Teaching wk</th>
<th>Week 22</th>
<th>20 Jan - 24 Jan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching wk 1</td>
<td>Week 23</td>
<td>27 Jan - 31 Jan</td>
</tr>
<tr>
<td>Teaching wk 2</td>
<td>Week 24</td>
<td>03 Feb - 07 Feb</td>
</tr>
<tr>
<td>Teaching wk 3</td>
<td>Week 25</td>
<td>10 Feb - 14 Feb</td>
</tr>
<tr>
<td>Teaching wk 4</td>
<td>Week 26</td>
<td>17 Feb - 21 Feb</td>
</tr>
<tr>
<td>Teaching wk 5</td>
<td>Week 27</td>
<td>24 Feb - 28 Feb</td>
</tr>
<tr>
<td>Study week</td>
<td>Week 28</td>
<td>02 Mar - 06 Mar</td>
</tr>
<tr>
<td>Teaching wk 8</td>
<td>Week 29</td>
<td>09 Mar - 13 Mar</td>
</tr>
<tr>
<td>Teaching wk 9</td>
<td>Week 30</td>
<td>* 16 Mar - 20 Mar</td>
</tr>
<tr>
<td>Teaching wk 10</td>
<td>Week 31</td>
<td>23 Mar - 27 Mar</td>
</tr>
<tr>
<td>Teaching wk 11</td>
<td>Week 32</td>
<td>30 Mar - 03 Apr</td>
</tr>
<tr>
<td>Teaching wk 12</td>
<td>Week 33</td>
<td>06 Apr - 10 Apr</td>
</tr>
</tbody>
</table>

* Monday 28th October 2019 Bank Holiday - College closed
* Tuesday 17th March 2020 St Patricks Day - College closed
<table>
<thead>
<tr>
<th>Appendix 1: General Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ITEM</strong></td>
</tr>
<tr>
<td>--------</td>
</tr>
</tbody>
</table>
| General Regulations | Calendar, Part II - General Regulations and Information, Section II, Item 12: <https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf>  
Calendar, Part III, General Regulations, Section 1.20  
<https://www.tcd.ie/calendar/graduate-studies-higher-degrees/complete-part-III.pdf>  
Attendance Requirements:  
Calendar, Part II, General Regulations and Information, Section II, Items 17-23  
Calendar, Part III, General Regulations and Information, Sections 1.23; 2.11; and 3.2  
Absence from Examinations  
Calendar, Part II, General Regulations and Information, Section II, Item 35  
Calendar, Part III, Section 3.5  
| General Information | Timetable are available via my.tcd.ie portal: <https://my.tcd.ie/urd/sits.urd/run/siw_lgn>  
Blackboard: <https://tcd.blackboard.com/webapps/login/>  
Academic Registry: <https://www.tcd.ie/academicregistry/>  
Science Foundation Scholarship information sheet: <https://www.tcd.ie/Science/assets/documents/PDF/Foundation-Scholarship-Information%202018-19.pdf> |
| Teaching and Learning | Academic Policies:  
https://www.tcd.ie/teaching-learning/academic-policies/  
Student Learning and Development:  
https://www.tcd.ie/Student_Counselling/student-learning/  
Student Complaints Procedure:  
https://www.tcd.ie/about/policies/160722_Student%20Complaints%20Procedure_PUB.pdf  
Dignity & Respect Policy  
https://www.tcd.ie/equality/policy/dignity-respect-policy/  
Student Evaluation and Feedback:  
Avoiding Plagiarism:  
https://libguides.tcd.ie/friendly.php?s=plagiarism/about  
National Framework for Qualifications:  
http://www.nfq-qqi.com/index.html |
|---|---|
| Student support | Student Support Services:  
https://www.tcd.ie/students/supports-services/  
Student Services Booklet:  
www.tcd.ie/students/assets/pdf/Student%20Services%20Booklet%20(web%20version).pdf  
Senior Tutor & Tutorial Service  
www.tcd.ie/students/assets/pdf/Student%20Services%20Booklet%20(web%20version).pdf  
Graduate Studies  
https://www.tcd.ie/graduatestudies/  
Mature Student Office  
https://www.tcd.ie/maturestudents/ |
| Co-curricular activities | Central Societies Committee:  
https://www.tcd.ie/calendar/general-information/students-unions-societies-and-clubs.pdf  
DUCAC:  
https://www.tcd.ie/Sport/student-sport/ducac/?nodeId=94&title=Sports_Clubs |
| Information on TCDSU and GSU, Including student | TCDSU  
https://www.tcdsu.org/  
TCDSU Student Representation Overview |
representative structures

TCD GSU
https://www.tcdgsu.ie/

GSU - Student Representation Overview
https://www.tcdgsu.ie/becomearep/

Emergency Procedure

In the event of an emergency, **dial Security Services on extension 1999**
Security Services provide a 24-hour service to the college community, 365 days a year. They are the liaison to the Fire, Garda and Ambulance services and all staff and students are advised to always telephone extension 1999 (+353 1 896 1999) in case of an emergency.

Should you require any emergency or rescue services on campus, you must contact Security Services. This includes chemical spills, personal injury or first aid assistance.

It is recommended that all students save at least one emergency contact in their phone under ICE (In Case of Emergency).

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