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

Science at Trinity

Faculty of Engineering, Mathematics and Science

TR061
Chemical Sciences
Sophister Booklet 2022-2023

tcd.ie/science

TR061 Chemical Sciences Sophister Booklet 2022-2023

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Welcome

Dear Students

Congratulations – you are nearing the end of the Freshman years of your degree and are ready to make the important decision about which chemical sciences Moderatorship you wish to pursue. The Freshman course structure has given you an excellent grounding in your core subject to prepare you for the advanced material you will cover in your Sophister years. You have also had opportunities to take open modules in other science subjects that have given breadth and context to your science education.

Development of educational breadth continues in the Sophister years via the opportunity to take further open modules and also Trinity Electives. Trinity Electives are stand-alone, College-wide modules that enable you to broaden your knowledge outside of your chosen subject. There is a wide range of choice available to you that encompasses languages and cultures, key societal challenges and Trinity's ground-breaking research activities.

A list of the modules can be found at this link (https://www.tcd.ie/trinity-electives/apply/).

Having the opportunity to develop these broader skills, particularly in communication and presentation, will allow you to derive the greatest benefits from your particular choice of Moderatorship subject and will give you important insights into other subjects and modes of scholarship outside of the sciences.

I wish you the very best in your Sophister years and look forward to seeing your future successes and achievements.

Prof Áine Kelly
Associate Dean of Undergraduate Science Education

Foreword from the Course Director/Director of Teaching and Learning, Undergraduate

Together with the Associate Dean of Undergraduate Science Education I, as Course Director of the Chemical Sciences, wish all of the soon-to-be Sophister students well in the final two years of their degree. This handbook reflects the structure of each of the Sophister years in all four of the Moderatorships available within the Chemical Sciences course. These four are of course the **Chemistry** Moderatorship, the **Medicinal Chemistry** Moderatorship, the **Chemistry with Molecular Modelling Moderatorship, Chemistry with Biosciences** Moderatorship and the **Nanoscience** Moderatorship. The structures, core modules, practical elements, progression, capstone research projects, and the choices available (Junior Sophister Open, Junior Sophister Trinity Elective) are listed in this handbook.

As the Chemical Sciences Moderatorships have been rapidly evolving in light of the Trinity Education project, all of the information presented here is as accurate as possible at the time of compilation of this document. However, module codes, the module content, the choice or breadth, or timing of available Core, Mandatory, Open or Optional modules and details of examinations are subject to change between this academic year and the beginning of the next when the first rising Senior Sophister students will embark on the final year of the Moderatorships within Chemical Sciences. We are very happy for you to be with us on this exciting journey where these four Moderatorships are now presented in a way not possible before now with Core components and Open modules in Junior Sophister and a new range of Optional modules in the Senior Sophister year.

Specifically, there are opportunities within each Moderatorship to tailor your degree through your parallel choice of Trinity Electives; by subsequent choices within the Junior Sophister year of Junior Sophister Open modules; your preference for your Senior Sophister capstone project, and your selection from among the Senior Sophister Optional modules. Whatever your pathway and whatever the Moderatorship ultimately chosen each of our chemistry degrees offers you a wide range of transferable skills that will be of value in research, industry or business.

Best wishes to all,

Prof Iouri Gounko
Director of Teaching and Learning, Undergraduate
School of Chemistry

Introduction

Sophister courses in **Chemical Sciences** are organised so that students follow a continuous programme of work over two years leading to a Moderatorship in a particular subject. Each module (comprising lectures, tutorials, seminars and/or practicals) has a specified credit value, which is an approximate measure of the workload associated with the module and is in turn reflected in its proportional weighting towards module assessment. One credit is normally considered to represent a minimum of 20 hours of work on the part of a student. Students take modules to the value of 60 credits in each of the Sophister years.

The Chemical Sciences (TR061) Sophister Course Booklet is intended as a detailed and comprehensive guide to all Moderatorships within the Chemical Sciences.

While every effort will be made to give due notice of major changes, the School of Chemistry and the Science Course Office reserve the right to suspend, alter or initiate courses, timetables, examinations and regulations at any time.

Course Advisors

Chemical Sciences Course Director Chemistry	Prof Iouri Gounko	igounko@tcd.ie
Associate Course Director	Prof Valeria Nicolosi	NICOLOV@tcd.ie
Chemistry with Molecular Modelling	Prof Graeme Watson	WATSONG@tcd.ie
Medicinal Chemistry	Prof Mathias Senge	Mathias.Senge@tcd.ie
Nanoscience	Prof Peter Dunne	P.W.Dunne@tcd.ie
Chemistry with Biosciences	Prof. Joanna McGouran	jmcgoura@tcd.ie

Moderatorship Courses and Quotas

To be qualified for a Moderatorship, students must have successfully completed both Freshman years and must have taken the stated prerequisite modules for any Moderatorship for which they wish to be considered. All students in Chemical Sciences who have completed both Freshman years are eligible to proceed into the **Chemistry** or the **Chemistry with Molecular Modelling** Moderatorships. The three Moderatorships with a prerequisite are **Nanoscience** (where a student must have taken in the two Freshman years, all of the Physics modules), **Chemistry with Biosciences** (where a student must have taken in the two Freshman years, all of the Biology modules) and **Medicinal Chemistry** (where a student must have taken in the two Freshman years, all of the Biology modules).
While every effort will be made to give due notice of major changes in the quotas, the Chemical Sciences Course Director reserves the right to alter prerequisites and quotas, if necessary. In the case of the Nanoscience Moderatorship this will be in conjunction and in consultation with the Physical Sciences Course Director and the Nanoscience Moderatorship Course Director.

Moderatorship	**Quotas**
Chemistry	30
Medicinal Chemistry	35
Chemistry with Molecular Modelling	8
Nanoscience	10 + 6*
Chemistry with Biosciences	10

***Note regarding Nanoscience quota.** Nanoscience is a shared course between the Schools of Physics and Chemistry and is accessible through both Physical Sciences (TR063) and Chemical Sciences (TR061) for students with the appropriate 120 credits of Freshman modules in Physics, Chemistry and Mathematics. Thus the 10 highest ranked students from both Physical Sciences and Chemical Sciences are allocated places in the Nanoscience Moderatorship. Six additional places are available to the highest ranked qualified students from either Physical or Chemical Sciences who have not already been allocated a place in the Moderatorship.

TR061: Moderatorships and Approved Module Choice Diagram

In the Junior and Senior Freshman years TR061 students complete a course of study that 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)
- Chemistry with Biosciences (CB)

The curriculum in the five Moderatorships is tailored to offer a general chemistry degree (C), a chemistry degree with an emphasis on molecular modelling (CMM), a degree focusing on the synthesis and applications of small drugs for medicinal purposes (MC), a degree with emphasis on the chemistry and physics of advanced materials and nanomaterials (N), and a degree focusing on the application of chemical techniques and investigation of chemical processes in biological systems (C.B.). 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 depend on module pattern choice and are outlined below:

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

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

Chemistry	**Chemistry with Molecular Modelling**	**Medicinal Chemistry**	**Chemistry with Biosciences**	**Nanoscience**
All 5 patterns	All 5 patterns	Patterns SF.1-4	Patterns SF.1-4	Pattern SF.5 only

Trinity Electives

Trinity Electives are a unique feature of your Trinity Education. They are stand-alone, College-wide 5-credit modules. They cover a broad range of topics in the arts, humanities, sciences, health and social science, and technology. They are designed to allow students to study topics outside of their core discipline and thus to develop breadth within their education. Science students take a minimum of one and a maximum of two Trinity Electives in the Junior Sophister year. Depending on your moderatorship, you will choose a combination of Trinity Electives and Open Modules as described in this handbook.

Choosing your Trinity Elective

The choice of Trinity Elective is student driven. Almost all Trinity Electives are open to all students; some exceptions may apply to your moderatorship that are outlined in the Trinity Electives webpage (e.g., From Planets to the Cosmos is not available to TR063 Physical Sciences students, for obvious reasons).

Selection will be made through online enrolment, which will be in early July 2022, after publication of results and allocation of moderatorships. You will be asked to list your choice(s) of Trinity Elective in order of preference. Places are allocated according to a computer algorithm and are based on student preference and places available in the Trinity Elective. Exam results are not factored into this algorithm.

The Trinity Electives website provides full details of each of the Trinity Electives. A list of the Trinity Electives can be found at https://www.tcd.ie/trinity-electives/

You will need to think carefully about your choice of Trinity Elective as the semester in which you take the module (Semester 1, Semester 2 or both) will affect the Open Modules that you can take – refer carefully to the tables in this handbook.

Please note that you CANNOT change your Trinity Elective so choose carefully!!!

Summary of Process

May: Results are published.

June: Moderatorships are allocated.

Students apply for Trinity Electives through an online portal on the Trinity Electives website. Trinity Electives are allocated by computer algorithm.

Students are informed of their Trinity Elective allocation. **THERE IS NO CHANGE OF MIND.**

Following this process, students will select their Open Modules.

Non-Satisfactory Attendance and Coursework

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

At the end of the teaching term, students who have not satisfied the school or department requirements may be reported as non-satisfactory for that term. Students reported as non-satisfactory for the Michaelmas and Hilary terms of a given year may be refused permission to take their semester two assessment/examinations and may be required by the Senior Lecturer to repeat the year.
Please refer to your department/discipline handbook for moderatorship regulations.

Junior Sophister Examination Information

Modules are assessed by continuous assessment and/or by examination. The Junior Sophister year carries a total of 60 credits. The scheme of distribution of marks between papers and practical work at the Sophister examinations will be published by individual schools or departments/disciplines.

Calculation of Moderatorship results
The final moderatorship results are calculated as a weighted average of the overall result for the Junior and Senior Sophister examination results, as follows:
Junior Sophister 30%, Senior Sophister 70%.

Reassessment Regulations
Reassessment is available in all years.
The right to reassessment will be automatic for those students who achieve a fail grade in any of their modules.
Students may not present for reassessment in a module they have passed.
Capping of marks will not be applied for reassessment.

Repeat-Year regulations
Students who fail to satisfy the requirements of their year at the Reassessment session are required to repeat the year in full (i.e., all modules and all assessment components).
Students are permitted to repeat any year of an undergraduate programme subject to not repeating the same year more than once and not repeating more than two academic years within a degree course, except by special permission of the University Council (see Calendar, https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf).
The option to repeat a year on 'off-books' basis will be at the discretion of the Senior Lecturer.

Junior Sophister Chemistry/MedChem/CMM Course Structure Diagram

The Junior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="4">Junior Sophister TR061 - Chem/CMM/MedChem</th></tr>
<tr><td colspan="4">40 ECTS Core</td></tr>
<tr><td colspan="2">Semester 1</td><td colspan="2">Semester 2</td></tr>
<tr><td>CHU33209 (Org Lab; 5 ECTS)</td><td>CHU33409 (ACM Workshop; 5 ECTS)</td><td>CHU33109 (Inorg Lab; 5 ECTS)</td><td>CHU33309 (PhysChem Lab; 5 ECTS)</td></tr>
<tr><td>CHU33405 (5 ECTS) Interdisciplinary Methods</td><td>CHU33207 (5 ECTS) Organic Chemistry</td><td>CHU33107 (5 ECTS) Inorganic Chemistry</td><td></td></tr>
<tr><td>CHU33303 (5 ECTS) Physical Chemistry</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">20 ECTS Open Modules/Elective</td></tr>
<tr><td colspan="2">Elective 1 (5 ECTS)
Mandatory</td><td colspan="2">Elective 2 (5 ECTS)
Optional</td></tr>
<tr><td colspan="2"></td><td colspan="2">Open Modules (5 ECTS each)</td></tr>
<tr><td colspan="2"></td><td colspan="2">Organic/Inorganic/Physical/MedChem*
*Only available as an option for the MedChem moderatorship</td></tr>
</table>

Details for each individual moderatorship and brief descriptor for each module are outlined in the next section.

Senior Sophister Chemistry/MedChem/CMM Course Structure Diagram

The Senior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><td colspan="3">Senior Sophister TR061 – Chem/CMM/MedChem</td></tr>
<tr><td colspan="3">40 ECTS Core</td></tr>
<tr><td>Semester 1</td><td colspan="2">Semester 2</td></tr>
<tr><td rowspan="2">CHU44120/CHU44420/CHU44720 Capstone Project
(20 ECTS)</td><td>CHU44304 (5 ECTS)
Physical Chemistry</td><td>CHU44204 (5 ECTS)
Organic Chemistry</td></tr>
<tr><td>CHU44004 (5 ECTS)
Inorganic Chemistry</td><td></td></tr>
<tr><td>CHU44123 Problems Module (5 ECTS)</td><td colspan="2"></td></tr>
<tr><td colspan="3">20 ECTS Options</td></tr>
<tr><td></td><td colspan="2">Option Modules (10 ECTS each)</td></tr>
<tr><td></td><td colspan="2">OChem*/IChem/PChem Option/CMM**
MedChem Option (only available for MedChem Moderatorship; compulsory)
*Ochem option is compulsory for MedChem
**CMM option is compulsory for CMM</td></tr>
</table>

Details for each individual moderatorship and brief descriptor for each module are outlined in the next section.

Chemistry

The Chemistry moderatorship affords access to a wide range of careers in industry, academia and the professions. By choice of practical project and of lecture options in the final year, a student may specialise in Organic, Physical or Inorganic Chemistry.

Junior Sophisters:
The JS year consists of lectures, tutorials and practicals delivered in modules, as listed below. Within the Junior Sophister year in Chemistry there are 40 credits of Core modules, with the remaining 20 credits comprising either Open or Elective modules. **All students are required to take a Trinity Elective in the first semester.**

Mandatory: In order to reinforce and extend a student's laboratory skills in Chemistry, rising Junior Sophister students **are required** to attend a day-long workshop on Safety, which is held in Freshers' Week (i.e., the week before lectures start) of Michaelmas Term. Attendance at all workshops **is compulsory**.

Assessment and Examination Procedures:
The lecture material in Chemistry will be examined in module examination papers taken during the relevant examination period. Practical work is assessed in-course. Further information relating to the assessed components and composition of written papers will be given in the Sophister Chemistry Booklet issued to rising Junior Sophisters. The JS Chemistry mark will contribute 30% of the final degree mark.

Senior Sophisters:
In SS year, students attend a series of core modules (in Physical, Organic and Inorganic Chemistry), four specialised open modules of their choice and associated tutorials. In addition, students are required to attend research seminars and undertake a Capstone project in a research lab.

Assessment and Examination Procedures:
Core and open modules detailing advanced topics in Organic, Inorganic and Physical Chemistry will be examined during the Annual Examination periods. The Research Project is assessed in-course. The SS Chemistry mark will contribute 70% to the final degree mark. All modules are weighted according to their respective credit rating. Further information relating to the assessed components, composition of written papers and credit weightings will be given in the Sophister Chemistry Booklet .

Junior Sophister Core Modules 40 credits

(CHU33405) Analytical and Computational Methods (S1) 5 credits
This module introduces the student to instrumental methods in analytical chemistry and to modern computational tools to understand chemical structure and interpret spectroscopic results.

(CHU33207) Synthetic Organic Chemistry (S1) 5 credits
This module is aimed at achieving an understanding of fundamental reaction mechanisms of transition metal-catalysed reactions, introducing the student to the different reactivities of organoheteroatom compounds and at providing the student with a grounding in the advanced selective oxidative and reductive transformations necessary to apply retrosynthetic analysis effectively.

(CHU33303) Quantum Mechanical Concepts in Physical Chemistry (S1) 5 credits
This module seeks to introduce the student to the fundamental aspects of quantum mechanics and the use of Schrödinger's equations to describe particle systems in chemistry.

(CHU33107) Organometallic and Coordination Chemistry (S2) 5 credits
The aim of this module is to develop an understanding of the main methods of synthetic organometallic chemistry, fundamental structure-reactivity relationships, and concepts of bonding and structure, functional group chemistry, thermodynamics and kinetics.

CHU33409 Analytical and Computational Methods Labs/Workshops (S1) 5 credits
CHU33209 Practical in Organic Chemistry (S1) 5 credits
CHU33109 Practical in Inorganic Chemistry (S2) 5 credits
CHU33309 Practical in Physical Chemistry (S2) 5 credits
These practical laboratory modules introduce the student to instrumental methods in analytical chemistry and to modern computational tools to understand chemical structure and interpret spectroscopic results. Practical modules in Organic, Inorganic and Physical Chemistry will enable the student to gain practical experience of techniques and methods in traditional and modern chemistry.

Junior Sophister Open Modules and Trinity Electives 20 credits

(CHU33205) Advanced Organic Transformations (S2) 5 credits
This module is aimed at achieving an advanced understanding of the reactivity of heterocyclic compounds, introducing the student to applications of molecular orbital theory for organic reactivity, and integrating physical chemistry principles into their understanding of organic chemistry reactions.

(CHU33105) Chemistry of Polymers and Macromolecules (S2) 5 credits
This module introduces the student to polymer and macromolecular chemistry. Polymer based materials are an important component of many devices and products.

(CHU33307) Solid State Materials and Modelling (S2) **5 credits**

This module introduces the student to the fundamental aspects of solid-state materials and their modelling of them. It will focus on the electronic structure and defects and how these can be used to influence the properties of materials and hence create functional materials.

Trinity Elective (S1) :(compulsory) and (S2):(optional) **5 credits**

Details on Trinity Electives can be found at https://www.tcd.ie/trinity-electives/electives/

Senior Sophister Core Modules **40 credits**

(CHU44120) Capstone Project (S1) **20 credits**

The Capstone project will be carried out during S1 under the supervision of a member of staff in the School of Chemistry or in an overseas institute and must be completed and assessed by the end of the semester. Details of start dates, thesis submission dates and assessments will be provided at the beginning of S1 and can be found in the SS handbook.

(CHU44123) Problems Module (S1) **5 credits**

A set of long problems based on material covered in Organic, Inorganic and Physical Chemistry modules will be completed and submitted by all students during S1. In addition to the continuous assessment element of this module, students will be asked about a problem in an oral examination. The remainder of the module will be assessed in written exam format and will consist of short problems based on material covered in the Core chemistry modules. Tutorials on problem-solving will be provided during S1.

(CHU44204) Organic Chemistry (S2) **5 credits**

This module is aimed at achieving an understanding of advanced aspects of organic chemistry including retrosynthesis, reactive intermediates including synthetic radical and carbene chemistry and planning of total synthesis.

(CHU44004) Inorganic Chemistry (S2) **5 credits**

The student will be introduced to advanced synthetic methods in materials chemistry. The module focuses on an understanding of the fundamental concepts of structure-property relationships to design materials for specific applications (*e.g.* alloys, ceramics, glasses, inorganic polymers and various composite materials). The second part of the module will introduce the students to the molecular chemistry of the f-block elements (lanthanides and actinides).

(CHU44304) Physical Chemistry (S2) **5 credits**

The student will be introduced to statistical thermodynamics and its applications in chemistry, integrating this topic with the kinetics, classical thermodynamics and quantum chemistry covered in previous years. The second part of the module will cover elements of soft matter and macromolecular and colloid chemistry.

Senior Sophister Option Modules **20 credits**

(CHU44205) Advanced Organic Chemistry (S2) 10 credits
This module is aimed at achieving an understanding of advanced aspects of organic chemistry including photochemistry, supramolecular chemistry, chemical biology, asymmetric synthesis and advanced topics in organic synthesis.

(CHU44005) Advanced Inorganic Chemistry (S2) 10 credits

This module covers aspects of advanced coordination, organometallic and bioinorganic chemistry. It focuses on structure-property relationships and outlines characterisation techniques for bioinorganic systems. In addition, the module will cover the synthesis, structural chemistry, and physicochemical properties of (I) molecular crystals and (II) copper oxide superconductors, emphasizing the interplay between composition, structure and properties.

(CHU44167) Advanced Physical Chemistry (S2) 10 credits
The student will be introduced to advanced topics in physical chemistry that integrate and build on the core concepts of kinetics, thermodynamics and quantum chemistry covered in core physical chemistry modules. Topics will include: (a) electrochemistry and its applications to energy devices for sustainability, (b) photochemistry and spectroscopy, and (c) surface and interfacial chemistry, including catalysis for the environment.

(CHU44705) Advanced Computational Chemistry (S2) 10 credits
This module will cover the main computational quantum chemistry methods and computational techniques, including optimisation and molecular dynamics, used in the modelling of structure, chemical reactivity and electronic properties of molecular systems and solid crystals. The performance and suitability of these methods for different applications will also be analysed and discussed. In addition, lectures will be complemented with computational practicals so that students can see a direct application of these methods to specific scientific questions.

Chemistry Moderatorship Learning Outcomes

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

- Articulate in written and oral form a foundation level of knowledge and understanding of the biological, physical and quantitative sciences underpinning Chemistry.

- Apply key concepts in the major chemical sub-disciplines of Physical, Inorganic and Organic Chemistry.

- Design, perform, and analyse the results obtained from experiments in physical, inorganic and organic chemistry, using modern chemical experimental methodology and instrumentation.

- Demonstrate skills in problem-solving, critical thinking and analytical reasoning, and be able to effectively communicate the results of their work to chemists and non-chemists, both verbally and in writing.

- Use modern library searching and retrieval methods to obtain information pertinent to the identification and solution of chemical problems and the exploration of new research areas.

- Work effectively and safely in a laboratory environment operating within the proper procedures and regulations for safe handling and use of chemicals.

- Update their knowledge and to undertake further study with a high degree of autonomy.

Chemistry with Molecular Modelling

Course Advisor: Prof. Graeme Watson

A degree in Chemistry with Molecular Modelling allows access to a wide range of careers in industry, academia and the professions.

Junior Sophisters:
The JS year consists of lectures, tutorials and practicals with Molecular Modelling, delivered in modules, as listed below. Within the Junior Sophister year in Chemistry there are 40 credits of Core modules, with the remaining 20 credits being either Open or Trinity Elective modules. **All students are required to take a Trinity Elective in the first semester.**

Mandatory Courses: In order to reinforce and extend the laboratory skills of students, rising Junior Sophister students **are required** to attend a day-long workshop on Safety, which is held in Freshers' Week (i.e. the week before lectures start) of Michaelmas Term. Attendance at all workshops **is compulsory**.

Assessment and Examination Procedures:
The lecture material in Chemistry and Molecular Modelling will be examined in module examination papers taken during the relevant examination period. Practical work is assessed in-course. Further information relating to the assessed components and composition of written papers will be given in the Junior Sophister Chemistry Booklet issued to rising Junior Sophisters. The JS Chemistry mark will contribute 30% of the final degree mark.

Senior Sophisters:
In SS year, students attend a series of core modules (in Physical, Organic and Inorganic Chemistry), two specialised option topics and associated tutorials. In addition, students are required to attend research seminars and undertake a Capstone project in a research lab.

Assessment and Examination Procedures:
Core and option lecture modules detailing advanced topics in Organic, Inorganic and Physical Chemistry will be examined during the relevant examination period. The Research Project is assessed in-course. The SS Chemistry mark will contribute to 70% of the final degree mark. All modules are weighted according to their respective credit rating. Further information relating to the assessed components, composition of written papers and credit weightings will be given in the Senior Sophister Chemistry Booklet that will be issued to rising Senior Sophisters.

Junior Sophister Core Modules 40 credits

(CHU33405) Analytical and Computational Methods (S1) 5 credits
This module introduces the student to instrumental methods in analytical chemistry and to modern computational tools to understand chemical structure and interpret spectroscopic results.

(CHU33207) Synthetic Organic Chemistry (S1) 5 credits
This module is aimed at achieving an understanding of fundamental reaction mechanisms of transition metal-catalysed reactions, introducing the student to the different reactivities of organoheteroatom compounds and at providing the student with a grounding in the advanced selective oxidative and reductive transformations necessary to apply retrosynthetic analysis effectively.

(CHU33303) Quantum Mechanical Concepts in Physical Chemistry (S1) 5 credits
This module introduces the student to the fundamental aspects of quantum mechanics and the use of Schrödinger's equations to describe particle systems in chemistry.

(CHU33107) Organometallic and Coordination Chemistry (S2) 5 credits
The aim of this module is to develop an understanding of the main methods of synthetic organometallic chemistry, fundamental structure-reactivity relationships, and concepts of bonding and structure, functional group chemistry, thermodynamics and kinetics.

CHU33409 Analytical and Computational Methods Labs/Workshops (S1) 5 credits
CHU33209 Practical in Organic Chemistry (S1) 5 credits
CHU33109 Practical in Inorganic Chemistry (S2) 5 credits
CHU33309 Practical in Physical Chemistry (S2) 5 credits
These practical laboratory modules introduce the student to instrumental methods in analytical chemistry and to modern computational tools to understand chemical structure and interpret spectroscopic results. Practical modules in Organic, Inorganic and Physical Chemistry will enable the student to gain practical experience of techniques and methods in traditional and modern chemistry.

Junior Sophister Open Modules and Trinity Electives 20 credits

(CHU33205) Advanced Organic Transformations (S2) 5 credits
This module is aimed at achieving an advanced understanding of the reactivity of heterocyclic compounds, introducing the student to applications of molecular orbital theory for organic reactivity, and integrating physical chemistry principles into their understanding of organic chemistry reactions.

(CHU33105) Chemistry of Polymers and Macromolecules (S2) 5 credits
This module introduces the student to polymer and macromolecular chemistry. Polymer based materials provide important component of many devices and products.

(CHU33307) Solid State Materials and Modelling (S2): Mandatory 5 credits
This model introduces the student to the fundamental aspects of solid-state materials and their modelling of them. It will focus on the electronic structure and defects and how these can be used to influence the properties of materials and hence create functional materials.

Trinity Elective (S1) :(compulsory) and (S2):(optional) 5 credits
Details on Trinity Electives are found at: https://www.tcd.ie/trinity_electives/electives.

Senior Sophister Core Modules 40 credits

(CHU44720) Capstone Project (S1) 20 credits
The Capstone project will be carried out during S1 under the supervision of a member of staff in the School of Chemistry or in an overseas institute and must be completed and assessed by the end of the semester. Details of start dates, thesis submission dates and assessments will be provided at the beginning of S1 and can be found in the SS handbook.

(CHU44123) Problems Module (S1) 5 credits
A set of long problems based on material covered in Organic, Inorganic and Physical Chemistry modules will be completed and submitted by all students during S1. In addition to the continuous assessment element of this module, students will be asked about a problem in an oral examination. The remainder of the module will be assessed in written exam format and will consist of short problems based on material covered in the Core chemistry modules. Tutorials on problem-solving will be provided during S1.

(CHU44204) Organic Chemistry (S2) 5 credits
This module is aimed at achieving an understanding of advanced aspects of organic chemistry including retrosynthesis, reactive intermediates including synthetic radical and carbene chemistry and planning of total synthesis.

(CHU44004) Inorganic Chemistry (S2) 5 credits
The student will be introduced to advanced synthetic methods in materials chemistry. The module focuses on an understanding of the fundamental concepts of structure-property relationships to design materials for specific applications (e.g., alloys, ceramics, glasses,

inorganic polymers and various composite materials). The second part of the module will introduce the students to the molecular chemistry of the f-block elements (lanthanides and actinides).

(CHU44304) Physical Chemistry (S2) 5 credits

The student will be introduced to statistical thermodynamics and its applications in chemistry, integrating this topic with the kinetics, classical thermodynamics and quantum chemistry covered in previous years. The second part of the module will cover elements of soft matter and macromolecular and colloid chemistry.

Senior Sophister Option Modules 20 credits

(CHU44205) Advanced Organic Chemistry (S2) 10 credits

This module is aimed at achieving an understanding of advanced aspects of organic chemistry including photochemistry, supramolecular chemistry, chemical biology, asymmetric synthesis and advanced topics in organic synthesis.

(CHU44005) Advanced Inorganic Chemistry (S2) 10 credits

This module covers aspects of advanced coordination, organometallic and bioinorganic chemistry. It focuses on structure-property relationships and outlines characterisation techniques for bioinorganic systems. In addition, the module will cover the synthesis, structural chemistry and physicochemical properties of (i) molecular crystals and (ii) copper oxide superconductors, emphasizing the interplay between composition, structure and properties.

(CHU44167) Advanced Physical Chemistry (S2) 10 credits

The student will be introduced to advanced topics in physical chemistry that integrate and build on the core concepts of kinetics, thermodynamics and quantum chemistry covered in core physical chemistry modules. Topics will include: (a) electrochemistry and its applications to energy devices for sustainability, (b) photochemistry and spectroscopy, and (c) surface and interfacial chemistry, including catalysis for the environment.

(CHU44705) Advanced Computational Chemistry (S2) * 10 credits

This module will cover the main computational quantum chemistry methods and computational techniques, including optimisation and molecular dynamics, used in the modelling of structure, chemical reactivity and electronic properties of molecular systems and solid crystals. The performance and suitability of these methods for different applications will also be analysed and discussed. In addition, lectures will be complemented with computational practicals so that students can see a direct application of these methods to specific scientific questions.

*Compulsory for CMM moderatorship

Chemistry with Molecular Modelling Moderatorship Learning Outcomes

On the successful completion of this programme, a student should be able to

- Articulate in written and oral form a foundation level of knowledge and understanding of the biological, physical and quantitative sciences underpinning Chemistry.

- Apply key concepts in the major chemical sub-disciplines of Physical, Inorganic and Organic Chemistry.

- Design, perform, and analyse the results obtained from experiments in physical, inorganic, and organic chemistry, using modern chemical experimental methodology and instrumentation.

- Demonstrate skills in problem solving, critical thinking and analytical reasoning, and is able to effectively communicate the results of their work to chemists and non-chemists both verbally and in writing.

- Use modern library searching and retrieval methods to obtain information pertinent to the identification and solution of chemical problems and the exploration of new research areas.

- Work effectively and safely in a laboratory environment operating within the proper procedures and regulations for safe handling and use of chemicals.

- Demonstrate knowledge of molecular modelling techniques and their implementation.

- Design and perform appropriate theoretical calculations to solve chemical problems and analyse the results.

- Update their knowledge and to undertake further study with a high degree of autonomy.

Medicinal Chemistry

Course Advisor: Prof. Dr. Mathias Senge.

Medicinal Chemistry is the area of chemistry that bridges chemistry, pharmacy and medicine and specialises in drug discovery, development and translational chemistry. The specialisation really begins in the Sophister years, building upon the fundamental principles covered in the Freshman years. From a chemistry perspective the focus is on both Organic and Medicinal Chemistry. Graduates will receive a degree in Medicinal Chemistry, which affords access to a wide range of careers in industry, academia and the professions.

Junior Sophisters:
The JS year consists of lectures, tutorials and practicals delivered in modules, as listed below. Within the Junior Sophister year in Chemistry there are 40 credits of Core modules, with the remaining 20 credits comprising either Open or Trinity Elective modules. **All students are required to take a Trinity Elective in the first semester.**

Mandatory Courses: In order to reinforce and extend a student's laboratory skills in Chemistry, rising Junior Sophister students **are required** to attend a day-long workshop on Safety, which is held in Fresher's Week (i.e., the week before lectures start) of Michaelmas Term. Attendance at all workshops **is compulsory**.

Assessment and Examination Procedures:
The lecture material will be examined in module examination papers taken during the examination periods. Practical work is assessed in-course. Further information relating to the assessed components and composition of written papers will be given in the Junior Sophister Chemistry Booklet issued to rising Junior Sophisters. The JS Chemistry mark will contribute 30% of the final degree mark.

Senior Sophisters:
In SS year, students attend a series of core modules (in Physical, Organic and Inorganic Chemistry), take two specialised option topics and associated tutorials. In addition, students are required to attend research seminars and undertake a Capstone project in a research lab.

Assessment and Examination Procedures:
Core and option lecture modules detailing advanced topics in Organic, Inorganic and Physical Chemistry will be examined during the relevant examination period. The Research Project is assessed in-course. The SS mark will contribute 70% of the final degree mark. All modules are weighted according to their respective credit rating. Further information relating to the assessed components, composition of written papers and credit weightings will be given in the Senior Sophister Chemistry Booklet that will be issued to rising Senior Sophisters.

Junior Sophister Core Modules 40 credits

(CHU33405) Analytical and Computational Methods (S1) 5 credits
This module introduces the student to instrumental methods in analytical chemistry and to modern computational tools to understand chemical structure and interpret spectroscopic results.

(CHU33207) Synthetic Organic Chemistry (S1) 5 credits
This module is aimed at achieving an understanding of fundamental reaction mechanisms of transition metal-catalysed reactions, introducing the student to the different reactivities of organoheteroatom compounds and at providing the student with a grounding in the advanced selective oxidative and reductive transformations necessary to apply retrosynthetic analysis effectively.

(CHU33303) Quantum Mechanical Concepts in Physical Chemistry (S1) 5 credits
This module seeks to introduce the student to the fundamental aspects of quantum mechanics and the use of Schrödinger's equations to describe particle systems in chemistry.

(CHU33107) Organometallic and Coordination Chemistry (S2) 5 credits
The aim of this module is to develop an understanding of main methods of synthetic organometallic chemistry, fundamental structure-reactivity relationships, and concepts of bonding and structure, functional group chemistry, thermodynamics and kinetics.

CHU33409 Analytical and Computational Methods Labs/Workshops (S1) 5 credits
CHU33209 Practical in Organic Chemistry (S1) 5 credits
CHU33109 Practical in Inorganic Chemistry (S2) 5 credits
CHU33309 Practical in Physical Chemistry (S2) 5 credits
These practical laboratory modules introduce the student to instrumental methods in analytical chemistry and to modern computational tools to understand chemical structure and interpret spectroscopic results. Practical modules in Organic, Inorganic and Physical Chemistry will enable the student to gain practical experience of techniques and methods in traditional and modern chemistry.

Junior Sophister Open Modules and Trinity Electives 20 credits

(CHU33205) Advanced Organic Transformations (S2) :(compulsory) 5 credits
This module is aimed at achieving an advanced understanding of the reactivity of heterocyclic compounds, key rearrangement reactions of reactive intermediates, introducing the student to applications of molecular orbital theory for organic reactivity, and integrating physical chemistry principles into their understanding of organic chemistry reactions.

(CHU33105) Chemistry of Polymers and Macromolecules (S2) 5 credits
This module introduces the student to polymer and macromolecular chemistry. Polymer based materials provide important component of many devices and products.

(CHU33307) Solid State Materials and Modelling (S2) 5 credits
This model introduces the student to the fundamental aspects of solid-state materials and their modelling of them. It will focus on the electronic structure and defects and how these can be used to influence the properties of materials and hence create functional materials.

(CHU33442) Drug Design and Development (S2): (compulsory) 5 credits
This module is aimed at introducing the student to drug design and development with special focus on antivirals, antibiotics and therapeutics in cancer treatment. The student will also be introduced to the principles of QSAR in drug design.

Trinity Elective (S1) :(compulsory) and (S2) :(optional) 5 credits
Details on Trinity Electives can be found at https://www.tcd.ie/trinity-electives/electives/

Senior Sophister Core Modules 40 credits

(CHU44420) Capstone Project (S1) 20 credits
The Capstone project will be carried out during S1 under the supervision of a member of staff in the School of Chemistry or in an overseas institute and must be completed and assessed by the end of the semester. Details of start dates, thesis submission dates and assessments will be provided at the beginning of S1.

(CHU44123) Problems Module (S1) 5 credits
A set of long problems based on material covered in Organic/Inorganic and Physical Chemistry modules will be completed and submitted by all students during S1. In addition to the continuous assessment element of this module, students will be asked about a problem in an oral examination. The remainder of the module will be assessed in written exam format and will consist of short problems based on material covered in the Core chemistry modules. Tutorials on problem solving will be provided during S1.

(CHU44204) Organic Chemistry (S2) 5 credits
This module is aimed at achieving an understanding of advanced aspects of organic chemistry including retrosynthesis, reactive intermediates including synthetic radical and carbene chemistry and planning of total synthesis.

(CHU44004) Inorganic Chemistry (S2) **5 credits**

The student will be introduced to advanced synthetic methods in materials chemistry. The module focuses on an understanding of the fundamental concepts of structure-property relationships to design materials for specific applications (*e.g.,* alloys, ceramics, glasses, inorganic polymers and various composite materials). The second part of the module will introduce the students to the molecular chemistry of the f-block elements (lanthanides and actinides).

(CHU44304) Physical Chemistry (S2) **5 credits**

The student will be introduced to statistical thermodynamics and its applications in chemistry, integrating this topic with the kinetics, classical thermodynamics and quantum chemistry covered in previous years. The second part of the module will cover elements of soft matter and macromolecular and colloid chemistry.

Senior Sophister Option Modules* **20 credits**

(CHU44205) Advanced Organic Chemistry (S2) **10 credits**

This module is aimed at achieving an understanding of advanced aspects of organic chemistry including, photochemistry, supramolecular chemistry, chemical biology, asymmetric synthesis and advanced topics in organic synthesis.

(CHU44405) Advanced Medicinal Chemistry (S2) **10 credits**

This module is aimed at achieving an understanding of advanced aspects of medicinal chemistry including concepts and targets in medicinal chemistry, the cardiovascular system, the central nervous system, computational medicinal chemistry, drug discovery and combinatorial chemistry.

*Both Advanced Organic Chemistry and Advanced Medicinal Chemistry modules are mandatory for the Med Chem moderatorship.

Medicinal Chemistry Moderatorship Learning Outcomes

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

- Articulate in written and oral form a foundation level of knowledge and understanding of the biological, chemical and quantitative sciences underpinning Medicinal Chemistry.
- Apply key concepts in the major chemical sub-disciplines of Physical, Inorganic and Organic Chemistry with particular reference to Medicinal Chemistry.
- Design, perform, and analyse the results obtained from experiments in physical, inorganic and organic chemistry, using modern chemical experimental methodology and instrumentation.
- Demonstrate skills in problem solving, critical thinking and analytical reasoning, and be able to effectively communicate the results of their work to chemists, biologists, clinicians and others both verbally and in writing.
- Use modern library searching and retrieval methods to obtain information pertinent to the identification and solution of chemical problems and the exploration of new research areas.
- Work effectively and safely in a laboratory environment operating within the proper procedures and regulations for safe handling and use of chemicals and instrumentation.
- Demonstrate knowledge of medicinal chemistry techniques and their implementation.
- Combine accrued knowledge to design and prepare drug candidates.
- Update their knowledge and to undertake further study with a high degree of autonomy and in an ethically considered manner.

Chemistry with Biosciences

Course Advisor: Prof. Joanna McGouran

Chemistry with Biosciences is the area of chemistry that bridges chemistry, biochemistry, immunology and biosciences while maintaining a solid foundation in chemistry. The specialisation really begins in the Sophister years, expanding upon the biological topics covered in the Freshman years alongside core and optional chemistry modules. Graduates will receive a degree in Chemistry with Biosciences, which affords access to a wide range of careers in industry, academia and the professions. This degree is particularly suited to interdisciplinary careers such as medical writing, patent law and biologics research and manufacturing.

Junior Sophisters:
The JS year consists of lectures, tutorials and practical laboratory sessions delivered in modules, as listed below. Within the Junior Sophister year in Chemistry there are 30 credits of Core Chemistry modules, 10 credits of Core Biosciences with the remaining 20 credits comprising either Open or Trinity Elective modules. **All students are required to take a Trinity Elective in the first semester.**

Mandatory Courses: In order to reinforce and extend a student's laboratory skills in Chemistry, rising Junior Sophister students **are required** to attend a day-long workshop on Safety, which is held in Freshers' Week (i.e., the week before lectures start) of Michaelmas Term. Attendance at all workshops **is compulsory**.

Assessment and Examination Procedures:
The lecture material will be examined in module examination papers taken during the examination periods. Practical work is assessed in-course. Further information relating to the assessed components and composition of written papers will be given in the Junior Sophister Chemistry Booklet issued to rising Junior Sophisters. The JS Chemistry mark will contribute 30% of the final degree mark.

Senior Sophisters:
In SS year, students attend a series of core modules (in Physical, Organic and Inorganic Chemistry), take three specialised biosciences topics and associated tutorials. In addition, students are required to attend research seminars and undertake a Capstone project in a research lab.

Assessment and Examination Procedures:
Core and Open lecture modules detailing advanced topics in Organic, Inorganic and Physical Chemistry will be examined during the relevant examination period. The Research Project is assessed in-course. The SS mark will contribute 70% of the final degree mark. All modules are weighted according to their respective credit rating. Further information relating to the assessed components, composition of written papers and credit weightings will be given in the Senior Sophister Chemistry Booklet that will be issued to rising Senior Sophisters.

The Junior Sophister course structure is diagrammatically illustrated below:

Junior Sophister TR061 – Chemistry with Biosciences			
40 ECTS Core			
Semester 1		Semester 2	
CHU33209 (Org Lab; 5 ECTS)	CHU33409 (ACM Workshop; 5 ECTS)	CHUXXX (Inorg& Phys Labs; 5 ECTS)	
CHU33403 (5 ECTS) Interdisciplinary Methods	CHU33207 (5 ECTS) Organic Chemistry I	CHU33107 (5 ECTS) Inorganic Chemistry	
CHU33303 (5 ECTS) Physical Chemistry		BYU22207 (5 ECTS) Genomes, Disease and Diversity Lect & Lab*	BYU22206 (5 ECTS) Microbes, Immune Systems & their Interaction Lect & Lab*
5 ECTS Electives/Options		10 ECTS Open	
Elective 1		Chem option from JS	Elective 2/chem option

* Provisional modules, subject to timetabling

Details for each individual moderatorship and brief descriptor for each module are outlined below.

Junior Sophister Core Modules (provisional) 45 credits

(CHU33405) Analytical and Computational Methods (S1) 5 credits
This module introduces the student to instrumental methods in analytical chemistry and to modern computational tools to understand chemical structure and interpret spectroscopic results.

(CHU33207) Synthetic Organic Chemistry (S1) 5 credits
This module is aimed at achieving an understanding of fundamental reaction mechanisms of transition metal-catalysed reactions, introducing the student to the different reactivities of organoheteroatom compounds and at providing the student with a grounding in the advanced selective oxidative and reductive transformations necessary to apply retrosynthetic analysis effectively.

(CHU33303) Quantum Mechanical Concepts in Physical Chemistry (S1) 5 credits
This module seeks to introduce the student to the fundamental aspects of quantum mechanics and the use of Schrödinger's equations to describe particle systems in chemistry.

(CHU33107) Organometallic and Coordination Chemistry (S2) 5 credits
The aim of this module is to develop an understanding of main methods of synthetic organometallic chemistry, fundamental structure-reactivity relationships, and concepts of bonding and structure, functional group chemistry, thermodynamics and kinetics.

CHU33409 Analytical and Computational Methods Labs/Workshops (S1) 5 credits
CHU33209 Practical in Organic Chemistry (S1) 5 credits
CHU33XXX Combined Practical in Inorganic and Physical Chemistry (S2) 5 credits

These practical laboratory modules introduce the student to instrumental methods in analytical chemistry and to modern computational tools to understand chemical structure and interpret spectroscopic results. Practical modules in Organic, Inorganic and Physical Chemistry will enable the student to gain practical experience of techniques and methods in traditional and modern chemistry.

(BYU22207) Genomes, Disease and Diversity (S2) 5 credits
Through lectures (content delivery, explanation) practicals (practice in techniques and problem solving) we will provide students with a broad overview of the genomics and the impact of new approaches across the biosciences. We will introduce the basics of new technologies and show the application of these to study of a) inherited traits, including Mendelian and complex human diseases; b) the non-inherited somatic genome with particular focus on cancer; c) human kinship and origins; d) the microbiome; and e) the genomics of ecology.

(BYU22206) Microbes, Immune Systems and their Interaction (S2) 5 credits
The microbial world existed successfully for 1.5 billion years before multicellular organisms began to appear. During that time, microbes evolved multiple defence mechanisms against potential competitors. Even when multicellular organisms evolved, microbes continued to exist successfully, often in harmony. Many of these mechanisms are conserved in multicellular organisms and used in defence against potential pathogens. In this module, students will learn about immune systems that have evolved over billions of years and about the complex interactions between microbes and their hosts which can lead to significant disease but which are also required for health. Students will learn about the molecular and cellular biology of key pathogens (viral, prokaryotic and eukaryotic) which currently threaten human populations; they will learn about immune systems and the diverse mechanisms used by immune molecules and cells to detect and respond to these microbes.

Junior Sophister Open Modules and Trinity Electives (Provisional) 15 credits

(CHU33205) Advanced Organic Transformations (S2): 5 credits
This module is aimed at achieving an advanced understanding of the reactivity of heterocyclic compounds, key rearrangement reactions of reactive intermediates, introducing the student to applications of molecular orbital theory for organic reactivity, and integrating physical chemistry principles into their understanding of organic chemistry reactions.

(CHU33105) Chemistry of Polymers and Macromolecules (S2) 5 credits
This module introduces the student to polymer and macromolecular chemistry. Polymer based materials provide important component of many devices and products.

(CHU33307) Solid State Materials and Modelling (S2) 5 credits
This model introduces the student to the fundamental aspects of solid-state materials and

the modelling of them. It will focus on the electronic structure and defects and how these can be used to influence the properties of materials and hence create functional materials.

(CHU33442) Drug Design and Development (S2): 5 credits
This module is aimed at introducing the student to drug design and development with special focus on antivirals, antibiotics and therapeutics in cancer treatment. The student will also be introduced to the principles of QSAR in drug design.

Trinity Elective (S1) :(compulsory) and (S2):(optional) 5 credits
Details on Trinity Electives can be found at https://www.tcd.ie/trinity-electives/electives/

Senior Sophister Core Modules

The Senior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="4">Senior Sophister TR061 – Chemistry with Biosciences</th></tr>
<tr><th colspan="4">60 ECTS Total</th></tr>
<tr><th colspan="2">Semester 1</th><th colspan="2">Semester 2</th></tr>
<tr><td colspan="2">Capstone Project</td><td>CHU44004 Inorganic Chemistry</td><td>CHU44204 Organic Chemistry</td></tr>
<tr><td>CHU44123 Synoptic Problem solving</td><td>BIU3350 Molecular Basis of Disease* (Planned online)</td><td>CHU44304 Physical Chemistry</td><td>BIU33250 Introduction to Immuno/metabolism (Planned online)*</td></tr>
<tr><td colspan="2"></td><td colspan="2">BIU33010-Nucleic acids 10 credits. Lect & Labs*</td></tr>
</table>

*Provisional modules-subject to timetabling

Details for each individual moderatorship and brief descriptor for each module are outlined in the next section.

(CHU44220) Capstone Project (S1) 20 credits
The Capstone project will be carried out during S1 under the supervision of a member of staff in the School of Chemistry/Biochemistry or in an overseas institute and must be completed and assessed by the end of the semester. Details of start dates, thesis submission dates and assessments will be provided at the beginning of S1.

(CHU44123) Problems Module (S1) 5 credits
A set of long problems based on material covered in Organic/Inorganic and Physical Chemistry modules will be completed and submitted by all students during S1. In addition to the continuous assessment element of this module, students will be asked about a problem in an

oral examination. The remainder of the module will be assessed in written exam format and will consist of short problems based on material covered in the Core chemistry modules. Tutorials on problem solving will be provided during S1.

(BIU33350) Molecular Basis of Disease (S1) 5 credits

This module is to provide students with the grounding in cell signalling and disease biology and how modern therapeutics are designed, developed and deployed for the treatment of human diseases. The topics covered will include cell signalling, drug design and delivery, and will focus on the molecular basis of cancer, pro-inflammatory disease, and metabolic disorders.

(CHU44204) Organic Chemistry (S2) 5 credits

This module is aimed at achieving an understanding of advanced aspects of organic chemistry including retrosynthesis, reactive intermediates including synthetic radical and carbene chemistry and planning of total synthesis.

(CHU44004) Inorganic Chemistry (S2) 5 credits

The student will be introduced to advanced synthetic methods in materials chemistry. The module focuses on an understanding of the fundamental concepts of structure-property relationships to design materials for specific applications (*e.g.,* alloys, ceramics, glasses, inorganic polymers and various composite materials). The second part of the module will introduce the students to the molecular chemistry of the f-block elements (lanthanides and actinides).

(CHU44304) Physical Chemistry (S2) 5 credits

The student will be introduced to statistical thermodynamics and its applications in chemistry, integrating this topic with the kinetics, classical thermodynamics and quantum chemistry covered in previous years. The second part of the module will cover elements of soft matter and macromolecular and colloid chemistry.

Senior Sophister Open Modules* **15 credits**

(BIU33250) Introduction to Immunology & Immunometabolism (S2) 5 credits
This module introduces to the basic components and function of the immune system – the molecules, cells, tissues and organs that make up the immune system. It will illustrate the immune responses to infection. Additionally, it will introduce students to the importance of central energy and intermediary metabolic pathways or bioenergetics before considering how they are dysregulated in diseases like cancer and also how we can harness this knowledge for new immunotherapies.

(BIU33010) Nucleic Acids (S2) 10 credits
This module covers the structure and function of nucleic acids in a eukaryotic context. The basis of gene transcriptional regulation and mRNA translation are described at a mechanistic and structural level in addition to the processes involved in DNA replication and repair. The lectures of this module are accompanied by a set of practical sessions (15 contact hours) that include:
(i) analysis of plasmid DNA, digestion and cloning, transformation and selection of bacteria; laboratory and tutorial sessions.
(ii) PCR and qRT-PCR, analysis and tutorial.

*For Chemistry with Biosciences these modules are compulsory

Chemistry with Biosciences Moderatorship Learning Outcomes

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

- Articulate in written and oral form a foundation level of knowledge and understanding of the biological, chemical and quantitative sciences.
- Apply key concepts in the major chemical sub-disciplines of Physical, Inorganic and Organic Chemistry.
- Apply key concepts in biosciences sub-disciplines including genetics, biochemistry and immunology.
- Design, perform, and analyse the results obtained from, experiments in physical, inorganic and organic chemistry, using modern chemical experimental methodology and instrumentation.
- Design, perform, and analyse the results obtained from, biochemical and molecular biology protocols, using modern biochemical experimental techniques and instrumentation.
- Demonstrate skills in problem solving, critical thinking and analytical reasoning, and be able to effectively communicate the results of their work to chemists, biologists and others both verbally and in writing.
- Use modern library searching and retrieval methods to obtain information pertinent to the identification and solution of chemical and biological problems and the exploration of new research areas.
- Work effectively and safely in a laboratory environment operating within the proper procedures and regulations for safe handling and use of chemicals, biological samples and instrumentation.
- Update their knowledge and to undertake further study with a high degree of autonomy and in an ethically considered manner.

Nanoscience

Course Advisor: Prof. Peter Dunne

Nanoscience is a moderatorship taught jointly by the Schools of Physics and Chemistry. Building on the foundation courses taken in the Freshman years, students follow in-depth courses across the spectrum of modern physics, physical chemistry, materials science and nanoscience while reflecting the strength of Trinity's research expertise in these areas.

Junior Sophister:
The Junior Sophister year consists of lectures, tutorials and practicals delivered in modules, as listed below. Within the Junior Sophister year in Nanoscience there are 40 credits of Core modules, with the remaining 20 credits comprising either Open or Elective modules. **All students are required to take a Trinity Elective in the first semester.** Students receive training in communication skills within the practical modules.

Safety:
To reinforce and extend laboratory skills rising Junior Sophister students are required to attend a day-long workshop on Chemical and Laboratory Safety to be held in Freshers' Week (i.e. the week before lectures start). Attendance at this workshop is compulsory.

Core Modules: The Core modules, one Trinity Elective and two Open modules specified below are mandatory. In the second semester, students have the choice of taking a second Trinity Elective or one of the specified Chemistry or Physics Open modules**.**

Assessment and Examination Procedures:
Modules may be assessed by end-of-semester examination and/or continuous assessment. Further information relating to the assessed components and composition of written papers will be given in the Junior Sophister Nanoscience Booklets issued to rising Junior Sophisters. Examined modules may include continuous assessment components. Junior Sophister marks contribute 30% of the final degree Moderatorship mark.

Senior Sophisters:
The Senior Sophister year consists of lectures, tutorials and a capstone research project, as listed below. The independent research capstone project is carried out during the first nine weeks of the first semester in an internationally recognised laboratory that specialises in aspects of nanoscience, physics, chemistry or advanced materials, either on campus or in a facility off-campus. Projects external to Trinity College are either hosted by cognate universities or research institutes. Projects are also hosted by the Schools of Chemistry and Physics and by CRANN.

Mandatory Modules: The research project and several other modules are designated as core modules. These mandatory modules total 45 credits, but the remaining 15 credits of the Senior Sophister year in Nanoscience are made up from among several Optional modules of either 5 or 10 credits in size.

Assessment and Examination Procedures:
Modules may be assessed by end-of-semester examination and/or continuous assessment. Further information relating to the assessed components and composition of written papers will be given in the Senior Sophister Nanoscience Booklets issued to rising Senior Sophisters. Assessment of the full-time research project (PYU44NP2) will be performed in Semester 2. Problem Solving in Nanoscience (PYU44NP5) will be examined at the end of Semester 1. Examined modules may include continuous-assessment components. Senior Sophister marks contribute 70% of the final degree Moderatorship mark.

Junior Sophister Core Modules 40 credits

PYU33P01 Quantum Mechanics (S1) 5 credits
This module covers solution of the Schrödinger Equation in specific topics, such as angular momentum and the hydrogen atom.

CHU33405 Analytical and Computational Methods (S1) 5 credits
This module deals with both the fundamental principles and application of spectroscopic and other characterisation techniques. Topics such as analytical chemistry, organic spectroscopy and structural methods in inorganic chemistry will be covered.

PYU33P03 Condensed Matter I (S2) 5 credits
This module introduces condensed matter concepts such as crystal structure and thermal and electronic properties of matter.

CHU33307 Solid State Materials and Modelling (S2) Mandatory 5 credits
This model introduces the student to the fundamental aspects of solid-state materials and the modelling of them. It will focus on the electronic structure and defects and how these can be used to influence the properties of materials and hence create functional materials**.**

CHU33609 Analytical and Computational Methods Workshops (S1) 5 credits
In this module students complete a range of experiments in advanced chemical analysis, spectroscopic and other characterisation techniques which are applied to nanoscience.

CHU33603 Practical in Physical Chemistry and Nanoscience (S2) 5 credits
In this module students complete several nanoscience and physical chemistry experiments.

PYU33NP3 Practical in Nanoscience (S1 & S2) 10 credits
In this module students complete several advanced experiments in Nanoscience and Physics together with a practical training in Advanced Nanoscience. It also includes components involving training in communication skills, personal and career development, and requires attendance at Nanoscience related School Seminars in the Schools of Physics and Chemistry.

Junior Sophister Open Modules and Trinity Electives 20 credits

PYU33P02 Electromagnetic Interactions I (S1) **5 credits**
This module covers the fundamentals of electromagnetic theory together with quantum optics and lasers. (This module is mandatory for Institute of Physics accreditation.)

Trinity Elective (S1)/also delivered in (S2) **5 credits**
Details on Trinity Electives are found at: https://www.tcd.ie/trinity-electives/electives/. Nanoscience students **must** take a TE in S1. If taking a second TE in S2 it is taken with CHU33107.

CHU33107 Organometallic and Coordination Chemistry (S2) **5 credits**
The aim of this module is to develop an understanding of the main methods of synthetic organometallic chemistry, fundamental structure-reactivity relationships, and concepts of bonding and structure, functional group chemistry, thermodynamics and kinetics. (This module is mandatory as a prerequisite for SS Nanoscience modules.)

PYU33P04 Semiconductor Physics (S2) **5 credits**
This module covers the physics of semiconductors and the construction, fabrication and application of semiconductor devices.
OR
CHU33105 Chemistry of Polymers and Macromolecules (S2) **5 credits**
This module introduces the student to polymer and macromolecular chemistry. Polymer-based materials are an important component of many devices and products.

Junior Sophister Nanoscience Course Structure Diagram

The Junior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="3">Junior Sophister TR061 – NANOSCIENCE</th></tr>
<tr><th colspan="3">40 ECTS core + 20 ECTS Open modules or Trinity Elective modules</th></tr>
<tr><td rowspan="5">Core Modules (40 ECTS)</td><td>Semester 1: Core</td><td>Semester 2: Core</td></tr>
<tr><td>PYU33P01: Quantum Mechanics I
(5 ECTS)</td><td>PYU33P03: Condensed Matter I
(5 ECTS)</td></tr>
<tr><td>CHU33405: Analytical and Computational Methods / Interdisciplinary Chemistry (5 ECTS)</td><td>CHU33307: Solid State Materials and Modelling (5 ECTS)</td></tr>
<tr><td colspan="2">PYU33NP3: Nanoscience Physics Laboratory (10 ECTS)</td></tr>
<tr><td>CHU33609: Interdisciplinary Chemistry Lab for Nanoscience
(5 ECTS)</td><td>CHU33603: Physical & Inorganic Chemistry Lab for Nanoscience
(5 ECTS)</td></tr>
<tr><td rowspan="5">Open or Trinity Elective Modules (20 ECTS)</td><td>Semester 1: Open modules both mandatory</td><td>Semester 2: Open – first is mandatory then choose 1 of 3</td></tr>
<tr><td>* Trinity Elective 1 (Mandatory)
(Nanoscience students obliged to take a TE in S1)</td><td>* CHU33107: Organometallic and Coordination Chemistry (Mandatory)</td></tr>
<tr><td>* PYU33P02: Electromagnetic Interactions I
(5 ECTS)</td><td>PYU33P04: Semiconductor Physics
(5 ECTS)</td></tr>
<tr><td></td><td>CHU33105: Chemistry of Polymers and Macromolecules
(5 ECTS)</td></tr>
<tr><td></td><td>Trinity Elective 2
(5 ECTS)</td></tr>
</table>

A Nanoscience student must take their one required Trinity Elective in Semester 1 along with the Mandatory module PYU33P02. Of the Open modules in Semester 2 the CHU33107 module is also Mandatory. If taking only one Trinity Elective, the only choice between Open modules is between PYU33P04 (Semiconductor Physics) and CHU33105 (Chemistry of Polymers and Macromolecules). If a Nanoscience student chooses to take a second Trinity Elective, they must take the Mandatory Open modules in each semester. Taking two Trinity Electives reduces the Physics and Chemistry content in the degree, and may impact on later career choices, or on the choice of Capstone research project.

Nanoscience

Senior Sophisters:
The Senior Sophister year consists of lectures, tutorials and a research project delivered in modules, as listed below. The independent research project is pursued during the first nine weeks of the first semester contributing 20 credits, in an internationally recognised laboratory that specialises in aspects of nanoscience, physics, chemistry or advanced materials, which may be a facility off-campus. In exceptional circumstances and with the agreement of the Course Director, projects in College may extend to 12 weeks duration. Projects external to Trinity College are either hosted by cognate universities or research institutes. Projects are also hosted by the Schools of Chemistry and Physics and by CRANN and PIs within AMBER.

Core Modules: The research project and several other modules are designated as core modules. These core modules total 45 credits, but the remaining 15 credits of the Senior Sophister year in Nanoscience are selected from among several Open modules of either 5 or 10 credits in size.

Assessment and Examination Procedures:
Modules may be assessed by end-of-semester examination and/or continuous assessment. Further information relating to the assessed components and composition of written papers will be given in the Senior Sophister Nanoscience Booklets issued to rising Senior Sophisters. Assessment of the full-time research project (PYU44NP2) will be performed in Semester 2. Problem Solving in Nanoscience (PYU44NP5) will be examined at the end of Semester 1. Examined modules may include continuous-assessment components. Senior Sophister marks contribute 70% of the final degree Moderatorship mark.

Senior Sophister

Senior Sophister Course Structure Diagram (subject to change for AY22/23)

The Senior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="5">Senior Sophister TR063 – Nanoscience</th></tr>
<tr><th colspan="5">45 Credits Core modules + 15 Credits Open modules (AY 21/22)</th></tr>
<tr><td rowspan="5">Core Modules (45 credits)</td><td colspan="2">Semester 1: Core</td><td colspan="2">Semester 2 Core</td></tr>
<tr><td colspan="3">PYU44NP2: Project (20 credits) – Assessment in Semester 2</td><td></td></tr>
<tr><td rowspan="3">Project in first 9 - 12 weeks of semester 1</td><td>PYU44NP5: Problem solving (5 credits)</td><td colspan="2">CHU44304: Physical Chemistry (5 credits)</td></tr>
<tr><td colspan="3">PYU44N02: Nanoscience, complex fluids and polymers (10 credits)</td></tr>
<tr><td colspan="2"></td><td colspan="2">CHU44004: Inorganic chemistry (5 credits)</td></tr>
<tr><td rowspan="8">Open Modules (10 credits)</td><td colspan="2">Semester 1: Open modules</td><td colspan="2">Semester 2: Open modules</td></tr>
<tr><td colspan="2" rowspan="7">Take 2 or 3 Open modules which total 15 credits</td><td colspan="2">PYU44P13: Magnetism & Superconductivity (5 credits)</td></tr>
<tr><td colspan="2">PYU44P06: Modern Optics (5 credits)</td></tr>
<tr><td colspan="2">PYU44P05: Electromagnetic Interactions II (5 credits)</td></tr>
<tr><td colspan="2">PYU44P17: Energy Science (5 credits)</td></tr>
<tr><td colspan="2">CHU44167: Advanced Physical Chemistry (10 credits)</td></tr>
<tr><td colspan="2">CHU44005: Advanced Inorganic Chemistry (10 credits)</td></tr>
<tr><td colspan="2">CHU44705: Advanced Computational Chemistry (10 credits)</td></tr>
</table>

The PYU44NP2 capstone research project takes place in the first nine weeks of Semester 1. This may be extended to 12 weeks in some circumstances, pending approval by the course director. The assessment of the research project is in Semester 2. The remaining three weeks of Semester 1 has tutorials associated with the PYU44NP5 Problem Solving module which is examined at the end of Semester 1. Lectures associated with the core PYU44N02 module begin in the first three weeks of Semester 1, but examinations for this module is at the end of Semester 2. All other modules, whether mandatory or optional, occur wholly within Semester 2 and are examined at the end of Semester 2.

Senior Sophister Core Modules **45 credits**

PYU44NP2 Nanoscience Research Project (S1 and S2) **20 credits**

This module consists of a 9–12-week independent research project. The project is pursued in an internationally recognised laboratory that specialises in aspects of nanoscience, advanced materials or semiconductor processing. The project may be hosted within the School of Chemistry, School of Physics, CRANN, or at an approved international host institution. Submission of report and presentation of results is in Semester 2.

PYU44NP5 Problem Solving in Nanoscience (S1) **5 credits**

This module involves general problem-solving and scientific comprehension in nanoscience, advanced materials, materials chemistry or semiconductor processing.

PYU44N02 Nanoscience, Complex Fluids and Polymers (S1&S2) **10 credits**

This module covers nanoscience and the modified properties of nanoscale matter, its fabrication and potential applications together with the rheology and behaviour of liquids as applied to microfluidic systems and a detailed overview of polymer physics.

CHU44304: Physical Chemistry (S2) **5 credits**

The student will be introduced to statistical thermodynamics and its applications in chemistry, integrating this topic with the kinetics, classical thermodynamics and quantum chemistry covered in previous years. The second part of the module will cover elements of soft matter and macromolecular and colloid chemistry.

CHU44004: Inorganic Chemistry (S2) **5 credits**

The student will be introduced to advanced synthetic methods in materials chemistry. The module focuses on the understanding of the fundamental concepts of structure-property relationships to design materials for specific applications (e.g., alloys, ceramics, glasses, inorganic polymers and various composite materials). The second part of the module will introduce the students to the molecular chemistry of the f-block elements (lanthanides and actinides).

Senior Sophister Open Modules **Options must total 15 credits**

PYU44P13 Magnetism and Superconductivity (S2) **5 credits**
This module covers magnetism, magnetic materials, and introduces superconductivity.

PYU44P06 Modern Optics (S2) **5 credits**
This module covers optical communications and nonlinear optics involving lasers.

PYU44P05 Electromagnetic Interactions II (S2) **5 credits**
This module covers electromagnetic wave phenomena together with the optical properties of materials.

PYU44P17 Energy Science (S2) **5 credits**
This module consists of the physics behind key technologies for energy generation.

CHU44167 Advanced Physical Chemistry (S2) **10 credits**
The student will be introduced to advanced topics in physical chemistry that integrate and build on the core concepts of kinetics, thermodynamics and quantum chemistry covered in core physical chemistry modules. Topics will include: (a) electrochemistry and its applications to energy devices for sustainability, (b) photochemistry and spectroscopy, and (c) surface and interfacial chemistry, including catalysis for the environment.

CHU44005 Advanced Inorganic Chemistry (S2) **10 credits**
This module covers aspects of advanced coordination, organometallic and bioinorganic chemistry. It focuses on structure-property relationships and outlines characterisation techniques for bioinorganic systems. In addition, the module will cover the synthesis, structural chemistry and physicochemical properties of (i) molecular crystals and (ii) copper oxide superconductors, emphasizing the interplay between composition, structure and properties.

CHU44705 Advanced Computational Chemistry (S2) **10 credits**
This module will cover the main computational quantum chemistry methods and computational techniques, including optimisation and molecular dynamics, used in the modelling of structure, chemical reactivity and electronic properties of molecular systems and solid crystals. The performance and suitability of these methods for different applications will also be analysed and discussed. In addition, lectures will be complemented with computational practicals so that students can see a direct application of these methods to specific scientific questions.

Nanoscience Moderatorship Learning Outcomes

On successful completion of this programme students should be able to:

- Articulate in written and oral form a foundation level of knowledge and understanding of Physics, Chemistry and Mathematics.

- Apply key concepts in Physics and Chemistry of Nanomaterials.

- Design, perform and analyse the results obtained from experiments in materials physics and chemistry, using modern physical and chemical experimental methodologies and instrumentation, with particular reference to materials and nanomaterials.

- Demonstrate skills in problem-solving, critical thinking and analytical reasoning, and be able to effectively communicate the results of their work to chemists, physicists, material scientists and others, both verbally and in writing.

- Use modern library searching and retrieval methods to obtain information pertinent to the identification and solution of problems in the physics and chemistry of materials, and the exploration of new research areas.

- Work effectively and safely in a laboratory environment operating within the proper procedures and regulations for safe handling and use of chemicals and instruments.

- Design and perform appropriate experiments to address materials physics, chemistry and nanoscience problems and analyse the results.

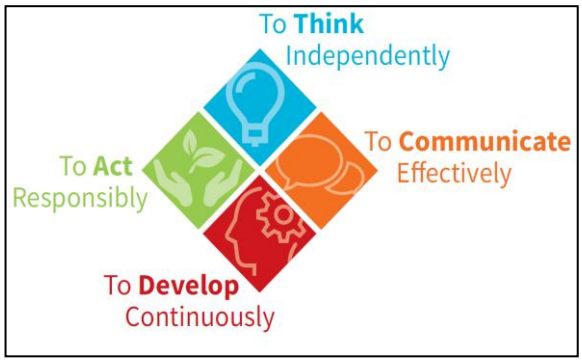
- Update their knowledge and be able to undertake further study with a high degree of autonomy.

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.

Appendix 1

Item	Reference/Source
General Regulations	Calendar, Part II, General Regulations and Information, Section II, Item 12 Calendar, Part III, General Regulations, Section 1.20
Student Support	Student Supports & Services Student Services Booklet Senior Tutor & Tutorial Service Graduate Studies Mature Student Office
Co-curricular Activities	Central Societies Committee DUCAC
Information on the TCDSU & GSU, including Student Representation Structures	TCDSU TCDSU Student Representation Overview TCD GSU GSU - Student Representation Overview
Emergency Procedure	**Standard Text:** 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).
Data Protection	Data Protection for Student Data

Item	Reference/Source
Research Ethics	Provided by School/Discipline Handbook
Key Dates	Provided by School/Discipline Handbook
Timetable	My TCD
Key Locations	Blackboard Academic Registry
Internships/ Placements for Credit	Provided by School/Discipline Handbook
Health and Safety Statements	Provided by School/Discipline Handbook
Item	**Reference/Source**
Programme Architecture	Science Course Office website https://www.tcd.ie/Science/#menu and in School/Discipline Handbook
Plagiarism & Referencing Guidance	Calendar, Part II, General Regulations and Information, Section II, Item 82 Plagiarism Policy Library Guides - Avoiding Plagiarism Plagiarism Declaration
Explanation of ECTS Weighting	Description of ECTS for use in Course Handbooks
Programme Structure & Workload	Policy on Trinity Virtual Learning Environment
Study Abroad	Provided by School/Discipline Handbook
Registration (UG only)	Students in TR060, TR061, TR062 & TR063 will find handbooks and information on the Science Course Website https://www.tcd.ie/Science/#menu and School/Discipline Handbook.
Coursework Requirements	Student Learning Development
Marking Scale	Calendar, Part II, General Regulations & Information, Section II, Item 30

Item	**Reference/Source**
Progression Regulations	Calendar, Part II, General Regulations & Information Calendar, Part II, Part C Calendar, Part III, Section 3.8
Awards	National Framework for Qualifications
Professional and Statutory Body Accreditation	Provided by School/Discipline Handbook
Careers Information & events	Provided by School/Discipline Handbook
External Examiner	Procedure for the transfer of students assessed work to external examiners
Learning Outcomes	Provided in JF, SF & JS Handbooks on the Science Course Website https://www.tcd.ie/Science/#menu. Also available in School/Discipline Handbooks.
Graduate Attributes	Trinity Education Project website https://www.tcd.ie/TEP/
Capstone (UG Programmes)	Capstone website Policy on Good Research Practice
Attendance Requirements	Calendar, Part II, General Regulations and Information, Section II, Items 17-23 Calendar, Part III, General Regulation sand 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

Reference to Relevant University Regulations	Academic Policies Student Complaints Procedure Dignity & Respect Policy
Item	**Reference/Source**
Feedback and Evaluation	Student Evaluation and Feedback Student Partnership Policy Procedure for the conduct of Focus Groups
Foundation Scholarships Prizes, medals and other scholarships	Calendar, Part II, Foundation and Non- Foundation Scholarships