University of Glasgow | School of Chemistry

MSci with Industrial Placement/ European Placement Handbook

Class Handbook 2020-2021

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Contents

1.0 Guide for Students

The M.Sci. degrees with work/European placement include a nine-twelve month placement in the fourth year of the degree program.

1.1 The Benefits of a Placement

Spending a year working on a project in the chemical industry or in a foreign research laboratory has many benefits for students, which may be summarized as follows:

• It provides an opportunity to broaden your horizons. It is only possible to gain a limited view of what working in the chemical industry is like while at University.

• It provides an opportunity to improve your transferable skills, in: communication, report writing, information technology, presentation, team work.

•It increases your general confidence and maturity. These are often as important to prospective employers as academic qualifications and you will therefore improve your chances of securing a job following graduation.

•Many placement hosts seriously consider employing students who do well on placement.

•Much of what you will learn about how a large organisation operates will be equally applicable to a career in other areas of employment outside chemistry.

•It provides the opportunity to be involved with some interesting chemistry of real significance to the company.

•It provides the opportunity to live in a different part of the country or Europe for a year.

•It provides the opportunity to earn some money.

•It provides the opportunity to obtain a MChem degree *with* industrial/European experience.

•Students who have spent a year in industry gain many skills that are often of great benefit to the execution of final year projects.

•It enables you to make informed decisions about future career directions.

1.2 Progression from Chem-3 to Years 4/5

Students are required to obtain a *minimum of a C3 grade in third year* to progress onto years 4/5 (placement and then final year). It should also be noted that having agreed to join the MSci programme, transfer to another programme is not possible until the end of the academic year.

1.3 Recruitment and Interviews

Companies and organisations who have hosted students in recent years are listed below. Each of the companies organise their recruitment exercises differently. However, they all expect the submission of an application form and/or CV, and usually hold preliminary interviews in Glasgow. Successful candidates are then often invited to the company's site for a further interview and discussion of projects. Some companies also expect candidates to pass numeracy and/or psychometric tests.

Company/Organisation; Location

Astra-Zeneca; AlderleyPark, Macclesfield
Bayer Crop Science; Frankfurt
BASF; Ludwigshafen
Cadbury (Kraft); Reading
Charles River Laboratories; Edinburgh
Diageo; Menstrie
Eisai; Hatfield
F2G; Manchester
FujiFilm; Grangemouth
GlaxoSmithKline; Stevenage
Hoffmann La Roche; Basel, Switzerland
Ineos; Grangemouth
Infineum; Oxfordshire
Johnson Matthey; Teesside
LINK Technologies; Bellshill
MacFarlan Smith; Edinburgh
Novartis; Horsham, West Sussex
Proctor & Gamble; Egham, Newcastle
Reckitt Benckiser; Hull
RedX Oncology; Liverpool
Rutherford-Appleton Lab; Didcot (Oxford)
Sasol; St-Andrews
Syngenta; Jealott's Hill
Systagenix; Gargrave, North Yorkshire

The recruitment process starts at the beginning of the third year and it is therefore **important that students wishing to be considered for an industrial placement submit a copy of their CV (by e-mail as a Word attachment), and indications of the preferred area of chemistry (organic, pharmaceutical, biological, analytical, inorganic, physical etc.) and location to the *Placements Class Head* (Dr. Andrew Jamieson) by the end of the first week of the first semester.** Students will then be invited to discuss their options with the Placements Class Head and be provided with application forms for the companies that meet the requirements identified. Making applications, preparing for and attending interviews can be time consuming, particularly for those who are not initially successful, and securing a placement is largely in students' own hands. Students may seek advice from members of staff on interview technique and details of individual companies. Preparation is important and interviewers will be impressed by an ability to demonstrate some knowledge of the company and its activities as well as a solid knowledge of chemistry. Students who are not offered a placement as quickly as they had hoped should not despair, as the recruitment process usually continues until Easter. Once an offer has been accepted, an agreement/contract setting out the terms of your appointment will be signed. Students will not be able to withdraw from this agreement without **very good** reason.

1.4 European Placements

Opportunities exist for students currently studying at the University of Glasgow who would like to study at one of our partner Universities in Europe. We currently have agreements with around 250 Universities, some of which are listed below. The programme provides an opportunity to develop excellent research skills in an academic research laboratory.

The departmental coordinator for the programme is Dr Andrew Jamieson (Andrew.Jamieson.2@glasgow.ac.uk). Further information can be obtained from the GoAbroad team (GoAbroad@glasgow.ac.uk) in the GU international office. General information can be found on the GU international office website: http://www.gla.ac.uk/international/studyabroadexchange/.

The benefits of involvement in the exchange programme are:

- A challenging new experience
- The opportunity to live in another country and develop language skills
- Gain experience in fundamental research as well as develop a range of transferable skills
- The opportunity to travel throughout Europe
- The chance to form an international network of friends

Current European partners include:

Charles University, Prague, Czech Republic.
Humboldt University, Berlin, Germany.
Ruhr University, Bochum, Germany.
Clausthal University of Technology, Clausthal, Germany.
Ludwig-Maximillans University, Munich, Germany.
University of Utrecht, The Netherlands.
University of Barcelona, Barcelona, Spain.
Universidade de Santiago de Compostela, Santiago, Spain.
Universite d'Avignon, France.
Ecole Nationale Superieure de Chimie de Lille, France.
Universita degli Studi di Palermo, Italy.
University of Bergen, Norway.
University of Ljubljana, Slovenia.

International Academic Placements

A placement in an international academic research laboratory can be a very rewarding experience both in terms of practical chemical research and also experiencing a different culture. Students interested in international academic placements should contact Dr Andrew Jamieson (Andrew.jamieson.2@glasgow.ac.uk) in the first instance. University of Glasgow School of Chemistry students can apply to the Francis & Marta Johnson Travel Scholarship scheme (eligible countries: Canada and USA) for financial assistance. Placements have been available at the following institutions:

King Abdullah University of Science and Technology (KAUST), Saudi Arabia
University of Montreal, Canada
Indian Institutes of Science Education and Research (IISER), Pune, India

1.5 Starting the Placement

The start date of the placement is open to negotiation between the student and the company/European partner, but most start in July or August. Arrangements for accommodation should be established well ahead of the start date. It may be that the placement will be a continuation of a project following on from a student from the previous year, in which case it may be possible to arrange to take over their accommodation. Alternatively, the company may be able to offer temporary accommodation for the first few weeks to allow time to make arrangements. In any case, it is the student's responsibility to make the necessary contacts with the company and arrangements for accommodation. Advice should be sought from the academic supervisor if problems arise. Once the placement has started, students should contact their academic supervisor by e-mail to confirm the following details:

- Placement start date
- Work mail address
- Work e-mail address
- Work telephone
- Home address
- Home telephone number
- Placement Supervisor's name
- Placement Supervisor's e-mail address
- Placement Supervisor's telephone

1.6 Supervision

Each student is assigned an academic and a placement supervisor. The placement supervisor is responsible for overseeing the project, the day-to-day supervision of student's activities and training either directly or indirectly through another member of his/her team. She/he is also responsible, along with the academic supervisor, for the assessment of the placement.

The academic supervisor will visit at least once during the year. If the student's report can be sent to the department at the end of the placement, then the academic supervisor will visit at the beginning of the placement to ensure that student has settled into their placement satisfactorily. If the project report cannot leave the site, then the academic supervisor will visit the student near the end of their placement. If this is the case then the academic supervisor will keep in close contact with the student throughout the year by email. Any problems that have arisen can be discussed and resolved with the help of the placement supervisor if necessary. The assessment of the placement is described in detail below.

ERASMUS+ Placement Year Student Supervision Timeline

ERASMUS+ Placement	Pre-placement	Week 1	3 months	6 months	9 months	10 months	Final year week 1
Head of Placement Year	Intro Lecture (May)			Email brief on report	Email brief on presentation	Collect reports for external examiners	Organise presentations
UoG Supervisor	Email student to provide contact details	Skype meeting (Suitability of project, H&S, DL choices, pastoral care)	Visit (outline assessment components, pastoral care)	Skype meeting (establish report plan, pastoral care)	Skype meeting (final debrief, report Q&A, pastoral care)	Assess report	Attend student's presentation
Placement Supervisor	Provide project outline	H&S training, brief student on aims and objectives	Progress meeting	Progress meeting	Progress meeting	Assess practical & report	

Industrial Placement Year Student Supervision Timeline

Industrial Placement	Pre-placement	Week 1	3 months	6 months	9 months	12 months	13 months	Final year week 1
Head of Placement Year	Intro Lecture (May)			Email brief on report		Email brief on presentation	Collect reports for external examiners	Organize presentations
UoG Supervisor	Email student to provide contact details	Skype meeting (Suitability of project, H&S, Pastoral care, DL choices)	Skype meeting (Pastoral care)	Skype meeting (Pastoral care)	Skype meeting (establish report plan)	Visit (assess report and mediate practical grade)		Attend student's presentation
Placement Supervisor	Provide project outline	H&S training, Brief on aims and objectives	Progress meeting	Progress meeting	Progress meeting	Assess practical & report		

1.7 Returning to the Final Year

Most placements finish in July leaving over two months before the start of the final year. Although the placement components have been designed to maintain some familiarity with material from the Chem-3 course, it is inevitable that much will have been forgotten since the previous June. It is therefore essential that students devote some time over the summer to revision of material from earlier in the course. Students may access the departmental web pages. The website contains the course manuals for Chem-4 to enable revision topics to be targeted. It should be remembered however that the manuals available will be from the previous year, although differences should only be minor. Students who do not make an effort to prepare for the final year, will be placing themselves at a significant disadvantage. On the positive side, the experience and training received during the placement should enable rapid progress with the final year research project.

1.8 Components and Assessment of the Placement Year

The assessment of the placement year contributes **20%** to the final degree mark. We are aware that placements, and specifically the nature of research in different subject areas, differ considerably, and the following are intended as **general guidelines**.

The assessment will consist of:

1. An assessment of the work by the Placement supervisor.
2. A written report, which will be assessed by an academic staff member on the basis of content and presentation. The External Examiners will have access to the report unless it is subject to a confidentiality agreement.
3. An oral presentation of the work given to the Department on return to the University.
4. Distance Learning Courses.

	Year Contribution (170)	Final degree Contribution (20%)
Practical assessment (Placement Supervisor)	28 marks (16%)	3.2%
Report (Placement Supervisor)	22 marks (13%)	2.6%
Report (UoG Supervisor)	50 marks (29%)	5.8%
Distance learning	30 marks (18%)	3.6%
Presentation	40 marks (24%)	4.8%

2.0 General Information and Distance Learning Courses

2.1 Objectives of a Placement

•To give students an opportunity to undertake a period of chemistry-related work at a company or University away from Glasgow before graduating

•To gain first-hand experience of scientific research

•To broaden the students outlook and their approach to work in a professional environment

•To facilitate and accelerate the acquisition of transferable skills in a scientific and technical environment

•To enable the student to make a more informed choice regarding future career options

•To allow the students to take part in and observe the transfer of knowledge and techniques and scientific approaches from theory to practice

•To allow the student to form contacts that may enhance their career options

•To develop appropriate behaviour attitudes within the work environment

•To apply and further develop communication and decision making skills

2.2 Learning Outcomes

•Ability to undertake scientific and chemical research in an unfamiliar setting and an awareness of the frontiers of knowledge in that area **1**

•The ability to formulate questions in research and to appreciate how they can be addressed through experimentation and obtain practical skills in research **1, 2**

•To be able to design experiments and interpret them in the context of the question proposed and existing knowledge **1, 2**

•The ability to interact as a team member and be able to communicate effectively with other researchers, both in a group and on an individual basis **1**

•Develop an awareness of the timescale of research and develop an appreciation of the planning and management of research **1, 2**

•The ability to work towards specific goals and objectives **1, 2**

•The ability to undertake several courses of distance learning **3**

•The ability to adapt and acquire new skills appropriate to the research work being undertaken **1, 2**

•Develop an understanding of the organisation in which the placement was taken, for instance its origin, purpose, funding and management structure **1**

•The ability to utilise academic knowledge in a practical environment **1**

•The ability to write up research work, both at the bench and in a formal report **1, 2**

1= Assessed by the placement supervisor,
2= Assessed by the academic supervisor,
3= Assessed by the department via distance learning courses

2.3 Student Expectations

•To receive appropriate supervision and mentorship to allow the student integrate into the organisation and undertake research both individually and as a team member

•To receive training in the appropriate health and safety aspects and for these issues to be actively monitored throughout the placement

•To take part in a substantial and significant research programme that will challenge, stretch, motivate and enthuse the student as well as the student to produce a project report that describes a substantial and continuous piece of research; although this could include tasks of a routine nature it is expected that these will be balanced with the research programme

•For the students training needs to be identified such that they can adequately undertake the programme of work

•To receive a competitive salary during the placement period

2.4 Employer Expectations

•To receive adequate information from the University regarding the course requirements for the placement course

•That the University closely works with the employer to ensure that the student is being adequately mentored through two on-site visits by the academic supervisor

•For the University to fully comply with confidentiality agreements pertaining to the research of the student

•That the students will be both willing and capable of putting knowledge into practice and also both identifying knowledge gaps and training needs that will help the student met the employer expectations

•That the student behaves in a professional, well mannered and open minded way paying attention to line management and complying with all the local safety rules

2.5 University Expectations

•That the employer provides rich and rewarding projects that can stretch the academic, practical and interpersonal skills of the student

•That the employer maintains contact with the University reporting the progress of the student and reports any potential problems

•That the student receives appropriate supervision and mentorship to allow the student to integrate into the organisation and undertake research both individually and as a team member

•That the student receives training in the appropriate health and safety aspects and for these issues to be actively monitored throughout the placement

•That the student will take part in a substantial and significant research programme that will challenge, stretch, motivate and enthuse the student as well as the student to produce a project report that describes a substantial and continuous piece of research; although this could include tasks of a routine nature it is expected that these will be balanced with the research programme

•That the students training needs are identified such that they can adequately undertake the programme of work

•That the student will receive a competitive salary during the placement period

2.6 Sample of Recent Placements

Student 1 MSci Work Placement at ICI Paints in Slough

Project title: **Method Development of Free Monomer Analysis Using Headspace GC**

"During the year placement at ICI Paints a project was undertaken to improve and validate an existing method for free monomer analysis of lattices using GC techniques. This involved using a headspace, standard addition method to carry out multiple headspace extraction, progressive thermostatting and reproducibility work along with recovery rates and limit of determination tests to produce an acceptable method. The main aim was to establish an optimum headspace oven temperature and thermostat time which were found to be 120 degrees C and 10 minutes respectively. From this a standard operating method (SOM), see appendix 1, was written for the new method with the aim of gaining accreditation from the United Kingdom Accreditation Services (UKAS)."

Student 2 MSci Work Placement at Procter and Gamble in Surrey

Project title: **An Evaluation of the Current Method of Cysteic Acid Quantification by FTIR / ATR for Assessing Oxidative Hair Damage Dissertation Abstract**

"The use of FTIR/ATR spectroscopy as a means of measuring oxidative hair damage was investigated using 3 different FTIR/ATR arrangements. The investigation aimed to re-evaluate what was a well used method and determine the sources of variability that had affected the method throughout the past two years of its use. It was shown that the individual FTIR units all provided comparable spectra for the same sample, but using different ATR units on each machine changed the spectra and cross comparison was no longer possible. The source of variability was further proved to be the ATR units as it was shown that the differences found in readings were not as a result of energy throughput differences between FTIR/ATRs. The conclusion of this project led to a new method of hair sample measurement to improve the quality of results, and a more robust reference system being designed and installed."

Student 3 MSci Work Placement at Charles University (ERASMUS exchange)

Project title: **Co-Catalyzed Cyclotrimerization Reaction as a New Route to Axially Chiral Isoquinoline-Containing Phosphinamine Ligands Dissertation Abstract**

"Innovation of new and efficient methods as a means of obtaining chiral molecules is one of the principle challenges of the synthetic chemist. Described herein are steps towards the preparation of an axially chiral isoquinoline-containing phosphinamine ligand. Such axially chiral atropoisomeric aryl pyridines may be useful as ligands for transition metal complexes or as "organic catalysts" in asymmetric synthesis to induce enantioselective formation of products. The co-catalysed cyclotrimerization of 2-methoxy-1-octa-1,7-dinyl-naphthalene 29, with benzonitrile to give 46, is a new route in the preparation of biaryl linkage in non-C2-symmetric atropoisomerically chiral bidentate ligands. A brief background on non-symmetrically substituted 1,1'-binapthayls is provide as an introduction to this research area."

2.7 Industrial/European Academic Supervisor Guidelines

•Helping the student to be aware of the goals, expectations and job description for the work placement

•Liaising with the Department and reporting immediately on any major problems (poor timekeeping, unsatisfactory work, sickness etc.)

•Aiding the student in forming a learning plan which will help the formative and summative assessments

•Meeting regularly with the student

•Participating in visits by the academic tutor

•Completing forms to aid in the assessment of the student

2.8 Student Guidelines

•Ensure you understand your specific objectives and work programme

•Understand your line managers role

•Know who your day-to-day supervisor is, and to whom to go for advice if your supervisor is not available

•Ask to have information reconfirmed if you are not sure

•Define your boundaries and responsibilities with your supervisor

•Make sure you understand how your performance will be assessed

•Clarify if you are expected to work overtime

•Familiarise yourself with GLP, GMP, and COSHH; failure to adhere to these strict guidelines will probably invalidate anything that you do

•Be frank about the errors in your work; think about the accuracy, reliability and significance of your results

2.9 University Support for Placement Students

Each student is assigned an academic placement supervisor who acts as an immediate point of contact (should anything go wrong) with the University in order for the problem to be solved. The University and Companies realise that many issues that arise only become problems when left to develop unattended. The placement year head also keeps full details of the student and placement supervisor contact details and ensures that the academic supervisor makes contact with both the student and the placement supervisor at the outset. The academic supervisor will also visit the student during the placement year ensuring that everything is proceeding well. A general format for the visits is fixed around the following:

•Initial meeting with the student and placement supervisor for initial informal discussions to introduce the project and aims for the year.
•A small 15-20 minute talk is presented by the student on aims of the project and any literature review that has been done
•A private meeting between the academic supervisor and the student
•A private meeting between the academic supervisor and placement supervisor
•A tour of the working environment

2.10 Assessment Details

During the present year the placement course will be assessed using four components:
1. Participation in three distance learning courses.
2. Assessment by the placement supervisor.
3. Assessment of the final report by the academic supervisor.
4. Oral presentations given by the students during their final year.

Mark allocation for placements (subject to change due to implementation of 22 point University assessment Scale)
Out of 170:
Distance learning – out of 30 (10 marks per course)
Glasgow Academic assessment – out of 50
Placement assessment – out of 50
Oral assessment – out of 40

2.11 Distance Learning Courses

The distance learning courses will be implemented via a web-based system called Moodle, which is the University approved system. Students can use their Departmental user ID and password to log into the system at the following URL: http://physci.moodle.gla.ac.uk/course/category.php?id=27/

Assessment procedures will differ from course to course. During the current year, six courses will be offered and students will be required to complete three of these. The written component of each course must be submitted to the course organiser by the end of May during your placement year.

Course titles:

Molecular Symmetry

Quantum Chemistry

Frontiers of Inorganic Chemistry

Biophysical Methods

Advanced Structure Determination

Natural Products Chemistry

The aims and objectives of current distance learning courses are listed below:

1. Title: Molecular Symmetry

Facilitator: Dr Frances Docherty (Rm. A2-20, e-mail: Frances.Docherty@glasgow.ac.uk)

Aims: *To demonstrate by means of worked examples how molecular symmetry arguments in the context of the mathematical theory of groups can be exploited to deduce valuable information about molecular properties and behaviour and how they can greatly simplify many important chemical problems.*

Objectives:

1. Define the terms ***symmetry element***, ***symmetry operation*** and ***mathematical group***, and clarify their relationships.
2. Identify all the symmetry elements and symmetry operations of any given conformation of a molecule, correctly assign it to a particular point group employing the ***Schoenflies nomenclature***, and sketch the correct conformation of a molecule for any given point group.

3. Construct ***group multiplication tables***, determine ***matrix representations*** of group symmetry operations and their ***characters***, characterize ***character tables*** and apply them to the determination of ***permanent electric dipole moments*** and ***optical activity***, distinguish between ***reducible*** and ***irreducible representations***, and indicate ***totally symmetric*** and ***degenerate*** irreducible representations.
4. Reduce a general, reducible representation for any given point group using the ***reduction formula*** and the corresponding character table.
5. Specify the characters of ***direct product representations***, and determine whether or not ***quantum mechanical integrals*** will vanish identically as in the derivation of ***selection rules*** for ***electronic*** and ***vibrational spectra***.

Assessment: A set of nine problem solving exercises of increasing difficulty

Outline:
(8 information providing sessions, 4 problem solving sessions)
Symmetry arguments in the context of group theory provide a means of introducing mathematical rigour into many important qualitative chemical problems such as the interpretation of electronic and vibrational spectra, the simplification of quantum-mechanical calculations or the existence of molecular properties such as permanent electric dipole moments and optical activity.
Definitions of molecular ***symmetry elements*** and of the associated ***symmetry operations*** they generate.
Demonstration that the complete set of symmetry operations of a molecule forms a ***mathematical group*** (a ***point group***), ***Schoenflies nomenclature*** for molecular point groups, ***group multiplication tables***.
Representation of molecular symmetry operations by means of ***transformation matrices*** and the associated ***irreducible representations*** and ***character tables***, simple applications of character tables to the determination of molecular dipole moments and optical activity.
Development of the general recipe for ***reducing representations***.
Formula for characters of ***direct product representations***, vanishing integrals, applications to spectroscopic selection rules.
Determination of the ***symmetry species*** of ***normal modes of vibration***, ***infrared*** and ***Raman*** selection rules, ***stretching mode analysis*** to deduce the geometry of

large molecules from the number of infrared and Raman bands occurring in the appropriate stretching regions of the vibrational spectrum.

2. Title: Quantum Chemistry

Facilitator: Dr Hans Senn (Rm. A5-RA511, e-mail: Hans.Senn@glasgow.ac.uk)

Aims: *To demonstrate by means of worked examples how elementary quantum mechanical concepts are applied to deduce valuable information about spectroscopic behaviour, electronic structure and bonding schemes in simple molecules.*

Objectives:

1. Define the terms ***observables*** and ***operators***, ***wavefunction***, ***normalisation*** and ***probability***, as well as ***eigenfunctions***, ***eigenvalues*** and ***expectation values***.
2. Provide solutions of the ***Schrödinger equation*** for ***vibrating*** and ***rotating particles*** and ***hydrogen like atoms***.
3. Specify ***angular momemtum operators*** and derive ***atomic orbitals***.
4. Characterise ***valence bond*** and ***molecular orbital*** approaches employed in chemical bonding theory.
5. Formulate and rationalise ***hybridisation schemes*** using simple symmetry arguments.
6. Construct molecular orbitals from suitable ***linear combinations of atomic orbitals*** and create appropriate sets of ***symmetry adapted basis functions*** from raw basis sets (such as atomic orbitals) applying the ***projection operator*** method.
7. As demonstrated in the accompanying laboratory exercises, apply the ***Hückel molecular orbital*** approach to calculate ***orbital energies***, ***charge densities*** and ***bond orders*** in simple π-electron systems.

Assessment: A set of four problem solving exercises of increasing difficulty

Outline:

(8 information providing sessions, 4 problem solving sessions)

Quantitative quantum mechanical procedures and their underlying fundamental concepts provide a mathematically rigorous understanding of many important aspects in molecular spectroscopy and especially chemical bonding theory.

Definitions of ***observables*** and ***operators***, ***wavefunctions***, ***normalisation***, and ***probabilty***, ***eigenfunctions***, ***eigenvalues*** and ***expectation values***, applications to the particle-in-a-box problem.

Solutions of the ***Schrödinger equation*** for ***vibrating*** and ***rotating particles*** and ***hydrogen like atoms***, operation of ***angular momemtum operators***, derivation of ***atomic orbitals***.

Presentation of ***valence bond*** and ***molecular orbital*** approaches in chemical bonding theory, determination of ***hybridisation*** schemes, introduction to the concepts of ***linear combination of atomic orbitals*** and ***symmetry adapted functions***, application of the ***projection operator method*** to generate sets of symmetry adapted atomic orbitals for use as basis in molecular orbital calculations.

3. Title: Biophysical Methods

Facilitator: Dr Adrian Lapthorn (e-mail: Adrian.Lapthorn@glasgow.ac.uk)

Aims: *To explore the range of biophysical and related instrumental techniques currently used in the experimental study of the structure and function of biological macromolecules and their interactions, taking into account the theoretical background and the practical challenges facing the physical chemist working with materials of biological origin.*

Objectives:

1. To have a broad appreciation of the nature of biological molecules and their interactions.
2. To illustrate the underlying physics and chemistry of a range of instrumental techniques currently used in biomolecular research.
3. To be able to describe the basic layout of the various instruments used in the study of spectroscopic, hydrodynamic, thermodynamic, structural and kinetic properties of biological macromolecules.
4. To define the relative advantages and disadvantages of each technique in different circumstances.
5. To be able to make reasoned assessment of techniques that might be appropriate in the study of particular systems.

Assessment: Set of eight problem solving exercises. On-line test.

Outline:

(8 information providing sessions, 8 problem solving sessions)

There is nothing in principle special about biological macromolecules and the physical chemistry techniques that might be used to study them. However, unlike many of the materials used in much other chemistry, biological materials are the products of evolution and have emerged to take advantage of the aqueous environment and the weak non-covalent interactions that dominate their behaviour. This sets interesting experimental and interpretative challenges that will be addressed in this course.

Biological Molecules: Proteins and polypeptides; Polynucleotides; Polysaccharides; Fats, lipids and detergents; Water; Acids, bases, buffers and polyelectrolytes

Spectroscopy: Electromagnetic waves and their interactions; UV/visible spectroscopy; Circular dichroism; Fluorescence; Vibrational spectroscopy: IR and Raman; NMR (brief overview)

Mass Spectrometry

Hydrodynamics: Density and molecular volume; Analytical ultracentrifugation; Sedimentation equilibrium; Sedimentation rate; Diffusion/Brownian motion; Dynamic light scattering; Viscosity

Thermodynamics and Interactions: A bluffer's guide to molecular thermodynamics; Differential scanning calorimetry (DSC); Isothermal titration calorimetry (ITC); Binding equilibrium; General methods for determining thermodynamic properties; Equilibrium dialysis; Protein solubility and crystallisation

Kinetics: Basic kinetics; Rapid reaction techniques; Relaxation methods; Hydrogen exchange; Surface plasmon resonance; Enzyme kinetics

Chromatography & Electrophoresis: Chromatography; Electrophoresis

Single molecules: How many molecules can stand on the head of a pin?; Thermodynamic fluctuations and the ergodic hypothesis; Atomic force microscopy (AFM); Optical tweezers and traps; Single molecule fluorescence; Electron microscopy

Background reading:

Physical Biochemistry: principles and applications, David Sheehan, Wiley

Biophysical Chemistry, C R Cantor and P R Schimmel, W H Freeman & Co.

Physical Biochemistry, D Freifelder, W H Freeman & Co.

4. Title: The Frontiers of Inorganic Chemistry

Facilitator: Prof. Lee Cronin (Room A4-11b, e-mail: Lee.Cronin@glasgow.ac.uk)

Aims: *To develop by means of selected literature case studies, critical thinking and analysis of unseen 'inorganic' research articles that claim highly unusual results or paradigm shifts.*

Objectives:

1. To read original research papers published in the primary literature, and extract synopses of the work
2. To identify the paradigm shift, new understandings or breakthroughs discussed in the article.
3. To develop a logical and scientifically valid approach to evaluate the merits of the work.
4. To use the approach outlined in objective 3 to examine the work and decide if the results and conclusions are valid or invalid using a scientifically rigorous set of arguments.
5. To propose experimental or theoretical approaches that may allow further confirmation of the results and conclusions, or propose experimental or theoretical approaches that may suggest alternative interpretations.

Assessment: Each case study will be assessed by an essay that will address each of the 5 objectives. Once completed, and a copy sent to the lecturer, the students will then compare their evaluation with a further re-enforcing paper or a paper confirming the flaws as given in the literature. They will then write a further segment to complete their essay which will be fully assessed once completed.

Outline: Scientific progress is often first documented in the primary literature by research articles and communications of recent findings. However these findings are always examined anonymously by other scientific experts before the work is allowed to be published – a process called *peer re*view. This system normally works very well, but sometimes papers are published that are so astounding that they are questioned by the scientific community. In this course, a set of controversial findings from the Frontiers of Inorganic Chemistry will be examined, some correct, some totally wrong, some questionable. These will then be analysed and discussed in essay format, to be followed by an evaluation of the eventual outcome.

5. Title: Advanced Structure Determination

Facilitator: Dr. Götz Bucher (Rm. A4-14, e-mail: goetz.bucher@gla.ac.uk)

Aims: *To show how a combination of modern spectroscopic techniques can be used for the elucidation of complex structural problems.*

Objectives:

1. To define the basics of NMR spectroscopy and how pulse sequences can be designed to achieve a particular output from an NMR experiment.
2. To apply more advanced NMR spectroscopic and Mass Spectrometric techniques for the determination of molecular structure.
3. To select appropriate techniques to solve particular structural problems.
4. To deduce and assign complex structures using a combination of modern spectroscopic techniques.

Assessment: Set of problem solving exercises.

6. Title: **The Biosynthesis of Natural Products**

Facilitator: Dr Bob Hill (Rm. A5-19, e-mail: Bob.Hill@glasgow.ac.uk). **Aims:** *To develop an understanding of the range of natural products and how they are formed in nature.*

Objectives:

1. To describe the main groups of secondary natural products (terpenoids, alkaloids, polyketides and phenylpropanoids) and how they are biosynthesized in general.
2. To illustrate the common transformations that occur in biosynthetic processes.
3. To describe how labeling studies can be used to investigate biosynthetic pathways.
4. To develop a critical and scientifically valid approach to evaluate the results of labeling experiments.
5. To use the approach outlined in objective 4 to examine case studies of biosynthetic investigations to determine if the results and conclusions are valid or not.
6. To generate plausible biosynthetic pathways to natural products and experimental approaches that may allow these proposals to be tested.

Assessment: The student will be given the structures of two natural products and will be asked to propose biosynthetic pathways to these compounds and to provide details of experiments that could be performed to verify these proposals.