MRes in Systems and Synthetic Biology

Institute of Systems and Synthetic Biology
Imperial College London, London

Academic Year: 2018 - 2019
Welcome to the College

Congratulations on joining Imperial College London, the only university in the UK to focus exclusively on science, medicine, engineering and business.

From Fleming’s discovery of Penicillin to Gabor’s invention of holography, Imperial has been changing the world for well over 100 years. You’re now part of this prestigious community of discovery and we hope you will take this opportunity to make your own unique contribution.

We’re committed to providing you with the very best academic resources to enrich your experience. We also provide a dedicated support network and a range of specialist support services to make sure you have access to the appropriate help, whether that’s further training in an academic skill like note taking or simply having someone to talk to.

You’ll have access to an innovative range of professional development courses within our Graduate School throughout your time here, as well as opportunities to meet students from across the College at academic and social events.

We actively encourage you to seek out help when you need it and try to maintain a healthy work-life balance. Our choice of over 340 clubs, societies and projects is one of the largest of any UK university, making it easy to do something different with your downtime. You also have free access to gym (following a one-off orientation fee of £40 in 2017-18) and swimming facilities across our campuses.

As one of the best universities in the world, we are committed to inspiring the next generation of scientists, engineers, clinicians and business leaders by continuing to share the wonder of what we do through public engagement events. Postgraduate students, alongside our academics and undergraduate students, make a significant contribution to events such as our annual Imperial Festival and our term-time Imperial Fringe events – if you’re interested in getting involved then there will be opportunities for you to do so.
Our Principles

In 2012 the College and Imperial College Union agreed ‘Our Principles’ a series of commitments made between students and the College. The Principles are reviewed annually by the Quality Assurance and Enhancement Committee and changes recommended for Senate approval.

Imperial will provide through its staff:

• A world class education embedded in a research environment
• Advice, guidance and support
• The opportunity for students to contribute to the evaluation and development of programmes and services

Imperial will provide students with:

• Clear programme information and assessment criteria
• Clear and fair academic regulations, policies and procedures
• Details of full programme costs and financial support
• An appropriate and inclusive framework for study, learning and research

Imperial students should:

• Take responsibility for managing their own learning
• Engage with the College to review and enhance provision
• Respect, and contribute to, the Imperial community

The Imperial College Students’ Union will:

• Support all students through the provision of independent academic and welfare assistance
• Encourage student participation in all aspects of the College
• Provide a range of clubs, societies, student-led projects and social activities throughout the year
• Represent the interests of students at local, national and international level
Welcome from the Graduate School

Professor Sue Gibson,
Director of the Graduate School

The Graduate School has several roles but our main functions are to provide a broad, effective and innovative range of professional development workshops and to facilitate interdisciplinary interactions by providing opportunity for students to meet at academic and social events. Whether you wish to pursue a career in academia, industry or something else, professional skills development training will improve your personal impact and will help you to become a productive and successful researcher.

Professional development courses for Master’s students are called “Masterclasses” and they cover a range of themes, for example, presentation skills, academic writing and leadership skills (http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/masters/). All Masterclasses are free of charge to Imperial Master’s students and I would encourage you to take as many as you can to supplement your academic training. The Graduate School works closely with the Graduate Students’ Union (GSU) and is keen to respond to student needs so if there is an area of development training, or an activity that you would like us to offer, but which is not currently provided, please do get in touch (graduate.school@imperial.ac.uk).

The Graduate School also runs a number of exciting social events throughout the year which are an opportunity to broaden your knowledge as well as to meet other students and have fun. You should regularly check the Graduate School’s website and e-Newsletters to keep up to date with all the events and development opportunities available to you.

Finally, I hope that you enjoy your studies here at Imperial, and I wish you well.

Dr Janet De Wilde,
Head of Postgraduate Professional Development

I would like to welcome you to the Graduate School programme for postgraduate professional development.

Our team of tutors come from a wide variety of experiences and we understand just how important it is to develop professional skills whilst undertaking postgraduate studies and research. Not only will this development improve success during your time at Imperial College, but it will also prepare you for your future careers. We are continually working to develop the courses we offer and over this year you will see a range of new courses including face-to-face workshops, interactive webinars and online self-paced courses. I encourage you to explore and engage with the diverse range of opportunities on offer from graduate school and I wish you well in your studies.

Janet De Wilde
The Graduate School

You automatically become a member of the Graduate School when you register as a postgraduate student at Imperial.

The Graduate School has been set up to support all postgraduate students at the College through:

- Training and development courses
- Networking activities, social and academic events to encourage cross-disciplinary interactions
- Forums to represent the views of postgraduate students throughout the College

‘Masterclass’ professional skills courses

You can see the full range of free professional skills courses for postgraduate students on the Graduate School website:

www.imperial.ac.uk/study/pg/graduate-school/professional-skills/masters

All courses can be booked online.

Contact us

Level 3, Sherfield Building, South Kensington Campus
020 7594 1383
graduate.school@imperial.ac.uk
www.imperial.ac.uk/graduate-school
Welcome from the Graduate Students’ Union (GSU)

I am delighted to welcome you to Imperial College! Let me introduce you to the Graduate Students’ Union (GSU). We are the representative body defending your interests as a postgraduate student in major decisions taken by the College. Beyond that, we work towards building a thriving post-graduate community that spans faculties and where students effectively communicate in an interdisciplinary way. Our committee is comprised by motivated post-graduate students like yourself, who have been appointed in university-wide elections and volunteer to make your experience at Imperial as fulfilling and enjoyable as possible.

So, what are we up to for this coming year 2018/19? We are going to focus on three major areas of action:

- Continue improving post-graduate well-being by increasing the quality of supervision and by creating strategies to tackle common mental health challenges in higher education.
- Develop the GSU to become central to the post-graduate community by improving the two-way flow of information, between the GSU and you.
- Organise exciting events around the topics of well-being, interdisciplinary research, and entrepreneurship.

As the GSU president, I would like to emphasise that Imperial College London is relying on its post-graduate students to maintain its position as a front-runner in world-class research and teaching. For us, the GSU, to be successful we need to receive as much of your input as possible. We want to work with you, for you!

Finally, I hope that you have a fantastic time here at Imperial and take advantage of the richness of opportunities that awaits you. If ever you have questions or ideas to share with us, please do not hesitate to get in touch with us and we are looking forward to seeing you at our events!

Ute Thiermann, GSU President 2018/19

gsu.president@imperial.ac.uk
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Communication and Course Management

Once you have registered at College you will be provided with access to College teaching computers via your IC login. This will also provide you with an Imperial College email account. It is imperative that you use your Imperial College email as we will always communicate to you via this account and it is your responsibility to check it on a daily basis.

Course Management

A management team chaired by the Course Directors will oversee the course. Individual team members will take responsibility for different aspects of course management (see below).

The members of the management team are:

<table>
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<tr>
<th>Role</th>
<th>Name</th>
<th>Department</th>
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<tr>
<td>Course Directors</td>
<td>Dr. James Murray</td>
<td>Dept. of Life Sciences</td>
</tr>
<tr>
<td></td>
<td>Dr. Nikolai Windbichler</td>
<td>Dept. of Life Sciences</td>
</tr>
<tr>
<td>Postgraduate Administrator</td>
<td>Ms Annie Murphy</td>
<td>Dept of Life Sciences</td>
</tr>
<tr>
<td>Safety</td>
<td>Mr Stefan Hoyle</td>
<td>Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Chair of Exam Board:</td>
<td>Dr Geoff Baldwin</td>
<td>Dept. of Life Sciences</td>
</tr>
</tbody>
</table>

The Exam Board will comprise Dr Murray, Dr Windbichler, Dr Baldwin and the External Examiners.

Important websites and links:

- Blackboard (booklet, timetable, course material): [https://bb.imperial.ac.uk/webapps/login/](https://bb.imperial.ac.uk/webapps/login/)
- CISBIO: [http://www.imperial.ac.uk/integrative-systems-biology](http://www.imperial.ac.uk/integrative-systems-biology)
- Synthetic Biology Hub: [https://www.imperial.ac.uk/synthetic-biology/](https://www.imperial.ac.uk/synthetic-biology/)
- Institute of Systems and Synthetic Biology: [http://www.imperial.ac.uk/systems-biology](http://www.imperial.ac.uk/systems-biology)
- The full programme specification can be found online: [https://www.ulcts.cv.imperial.ac.uk/media/imperial-college/study/programme-specifications/life-sciences/1718/ProgSpec(C1U1)-2017-18.pdf](https://www.ulcts.cv.imperial.ac.uk/media/imperial-college/study/programme-specifications/life-sciences/1718/ProgSpec(C1U1)-2017-18.pdf)
Course Overview

Course synopsis

Systems biology aims to quantitatively describe and predict the behaviour of biological processes at the molecular, network, and organ level, whereas synthetic biology aims to apply such understanding to the development of biotechnology and molecular medicine. Advances in understanding biomolecular processes have often depended on the collaborative efforts of biochemists, chemists and physicists. To foster collaborative work, the Centre for Integrative Systems Biology and Bioinformatics (CISBIO) and the Centre for Synthetic Biology and Innovation (CSynBI) were established. To better connect the College’s activities in these highly interdisciplinary research areas with industry and medicine, the Institute of Systems and Synthetic Biology at Imperial College was launched as a college-wide enterprise. This course, run by the Department of Life Sciences and the Department of Bioengineering, enables students to bridge the gap that can exist between the physical and life sciences because of differences in ‘language’, perspective and methodology. The course consists of an 8-month multidisciplinary research project, as well as taught modules in advanced molecular biology, genetics, biophysics, systems biology, physiological systems, advanced imaging technology, data analysis, bioengineering, and synthetic biology. Specialist lectures in transferable skills and group discussion sessions complete the comprehensive curriculum.

Introduction

Biological systems are made up of huge numbers of different components (molecules, cells, organisms) interacting at different scales. In the past, measurements of these were expensive and time consuming, so that most scientists could only study a handful of such components at a time. This led to an approach where a single event was assumed to result in a single effect, which in turn initiated a further effect, and so on in a simple chain of cause and effect. In reality, however, most genes, proteins and other components carry out their functions within a complex network of interactions. Typical networks have positive and negative feedback loops that regulate their operation. Consequently, a single component (such as a gene) rarely controls any particular biological function or disease, and conversely any given component may influence many different functions.

Such a simple cause and effect framework imposes a severe handicap as we try to understand, manipulate and design increasingly complex biological systems. Systems and Synthetic Biology are emerging fields of research that are revolutionizing our approach to many of the most challenging problems in the life sciences today. Systems Biology tightly couples state-of-the-art biological measurements with sophisticated mathematical and computational modelling in order to understand and predict how networks of interactions between components of a biological system give rise to its observed properties. Synthetic Biology builds on this foundation to provide tools for the rational engineering design and synthesis of biological devices and systems that display predictable functional behaviour.

Synthetic and Systems Biology are most powerful in combination. While Systems Biology aims for a quantitative and predictive understanding of biological networks, its full potential is only achieved when this understanding is applied to redesign and combine pathways in a modular fashion to build something new. This new application may be a microbe, which produces more hydrogen, hunts down cancer cells in the human body, or produces a drug. Hence, the results of these fields of research are expected to have significant impacts not only in fundamental bioscience, but also in medicine and biotechnology.

To strategically place Imperial College into the emerging field of Systems Biology, the Centre for Integrative Systems Biology and Bioinformatics (CISBIO) was established in 2005, mainly
funded by BBSRC and EPSRC with a £6.5M award. A recent BBSRC Systems Approaches to Biological Research (SABR) £5.6M grant jointly with Aberdeen has further strengthened this theme. Several new Faculty have successfully been recruited and an active Imperial network of multidisciplinary research combining theory, computer modelling, and experiments are underway. CISBIO’s efforts mainly deal with understanding and predicting cellular and sub-cellular processes. However, it was recognised that the Systems Biology approach also applies at higher levels including tissue, organs, and whole organisms, and that systems biology can provide solutions to biotechnological and biomedical problems. In response, the Centre for Synthetic Biology and Innovation (CSynBI) was recently opened with a £4.9M award from EPSRC. This centre places Imperial College in the emerging field of Synthetic Biology and to capitalise on both industrial and research council funding opportunities.

To better connect the College’s activities in these highly interdisciplinary research areas with industry and medicine, the Institute of Systems and Synthetic Biology at Imperial College was launched as a college-wide enterprise. The Institute covers all four Faculties – Natural Sciences, Medicine, Engineering and the Business School. The Institute is made up of a number of centres and groups, with the Institute acting as a coordinating body to bring these groups together to enhance interaction and promote new training programs. The new Institute provides the College with an excellent focus for college-wide research and training as well as funding opportunities with industry and granting agencies. Although the MRes will be administered within the Department of Life Sciences, it will constitute one of the main teaching and training platforms of the Institute involving associates of the Institute from all four Faculties.

As Systems and Synthetic Biology are emerging fields that require a different type of trained researcher, i.e. interdisciplinary with basic skills and fundamental understandings of biosciences and the application of engineering and mathematical modelling, it is now timely to establish novel training programs that will equip the next generation of scientists with these necessary skills. The MRes in Systems and Synthetic Biology is an exciting and timely postgraduate training course, bringing together expertise from all over the College. This course produces highly trained and motivated scientists who are ideal candidates for research positions in both industrial and academic settings; indeed we have an excellent track record of placement for our graduates.

**Aims and Objectives**

The aim of the proposed MRes is to provide graduate students from the Life Sciences, Engineering and Physical Sciences with a platform to overcome traditional barriers and collaboratively work on the ‘big problems’ and applications in Systems and Synthetic Biology. The MRes students gain intensive hands-on experience in a combination of experimental biology and modelling to understand, predict, and redesign biological pathways. In addition to a minimum set of conventional lectures, these objectives are achieved through active engagement by the students in the programme, i.e. through practicals, coursework, presentations, written proposals, group work and feedback sessions, seminars, and an 8-month long interdisciplinary research project. Assessment will be through a combination of assessed coursework assignments; presentations; reports and projects. Only these activities will be marked; there will not be any formal written exams. For further enrichment of the programme, connections to broader research will be provided through additional seminars and meetings.

**Specifically the course will:**

Provide knowledge in a wide range of modern scientific fields including genetics, imaging, data analysis, engineering design and modelling, biophysics, systems biology, physiological systems, bioengineering, and synthetic biology.

Provide hands-on experience through project work, computer practical, literature research, and oral presentations.
Offer a rich research training experience through multiple project supervisors with different expertise and disciplines.
Provide research training within cutting edge academic research groups.

Show how to succeed in modern interdisciplinary research, as well as prepare for future research employment.

Individuals who successfully complete the course will have:

Developed experience in communicating across traditional scientific borders, e.g. by appreciating different scientific cultures with their own styles and terminology.

Acquired solid research experience through one long project instead of several shorter projects.

Demonstrated flexibility through facilitating research between different supervisors and scientific cultures.

Performed cutting-edge research in the modern areas of Systems and Synthetic biology.

Acquired crucial transferable skills in writing, presenting, discussing scientific material.

**Entrance requirement**

The minimum qualification for admission is normally at least an Upper Second Class Honours degree in a Physical, Engineering, Mathematical, or Life/Biomedical Sciences-based subject from a UK academic institution or an equivalent overseas qualification. A-level mathematics or equivalent will generally be required for entry. Offers will be made to students by the Course Directors.

**Curriculum**

The programme is only offered as a **full-time**, one-year course and leads to the MRes degree. All students will be required to attend an introduction process during their first week, which will include registration; general orientation and guide to the main Imperial campuses; welcoming party (opportunity to meet with faculty, postdoctoral scientists and postgraduate students); essential briefings on health and safety and library skills. The taught course will start with a welcome meeting to introduce Systems and Synthetic biology, along with an overview of the course, the participating Departments and faculty members.

**Term 1 (Oct-Dec):**

During weeks 1-11, all students will attend all Modules 1-5. The first module includes introductory courses in physical sciences/programming and in molecular/cell biology. These are taken by all students, but tailored toward biological and physical scientists, respectively. The remaining modules include lectures covering functional genetics, biophysics, systems biology, physiological systems, advanced technologies, data analysis, bioengineering, and synthetic biology. Each module will be assessed, either in case studies, computer problem solving, literature searches, written reports, or oral presentations. All these aspects require the students to actively engage in the programme, either working individually or in groups depending on the type of assessment.

**Terms 2 (Jan - April) and 3 (May - September):**

Student will choose one research project and at least two supervisors of different disciplines and expertise (see section “Project Selection”). The supervisors are most likely to be from within the College but could also involve a supervisor from industry. During their first 4 weeks of their research project, the students will undertake a literature review on their chosen project topic, and write a research proposal for examination (see section “Research Proposal”). These research proposals will be “evaluated” by a mock panel for early feedback.
prior to submission to the supervisors. The research projects will form the most important part of the MRes course and will be carried out in researchers’ laboratories, and along with enabling a taste of ‘cutting-edge’ research, these would highlight transferable skills such as oral presentations (frequent progress reports in lab meetings and student research meetings). It is expected that industrial collaborators will contribute to these research projects and students with such projects will also spend time in industrial labs and experience ‘real’ working environments. However, the majority of the project should be carried out within laboratories within the College. This will allow the students to remain in contact and meet regularly, maintain the communal spirit of the cohort engendered from the time of the taught modules, and to ensure that no one feels disengaged.

We also have contacts with social scientists working in the BIOS Centre at Kings College and there may be the opportunity to interact with students from this centre. Students must attend any extra events such as these which are timetabled as part of the MRes.

Early in the summer term (May), there will be a mini-conference with presentations (about 15 min) from students. This is to ensure students are making progress and to provide for the opportunity for feedback and input into the project. Towards the end of August the project reports will be submitted for marking. Following this there will be viva voce (oral examinations) with internal examiners to assess the projects. There will also be vivas with our external examiners which must be attended by all students.

**Modules**

There are five course modules. These modules constitute the common part of the course where students from diverse backgrounds come together and learn how to communicate across traditional scientific barriers, e.g. by working in mixed teams during the practicals. In particular Module 1 is designed to bring students from diverse backgrounds up to a comfort level where they start communicating and collaborating with each other. This transition will be eased by its two introductory courses taken by all students: Essentials for Life Scientists and Essentials for Physical Scientists. Specifically, Module 1 also contains a computer practical (using language Matlab), as well as a wet-lab practical. Although for some students the introductory courses will largely be repetition of already known material, the above mentioned interdisciplinary aspects will make the introductory courses beneficial to all students. It will also foster inter-student learning with all students attending the same introductory course but with very different backgrounds. The remaining modules will centre around systems and synthetic biology, augmented by the last module on advanced technologies and biotechnology.

**Coursework**

Each module will be assessed by coursework, which may require solving problems on a computer, conducting a literature search, writing a report, or presenting findings in an oral presentation. The type of assessment will be supervised by the module convenor. A tutorial or Q&A session may guide the students further towards completing the requested tasks. Students can generally discuss work in groups but need to present their findings orally or in writing individually for marking.

All coursework must be submitted both in hard copy and electronically by the deadline to the Course Administrator (202, Sir Ernst Chain/Biochemistry Building). Coursework will be checked for plagiarism.

**Project selection**

During the Autumn term students will receive a list of potential projects. These will be of multidisciplinary character, and will fall either into the area of systems biology or into the area of synthetic biology. Multidisciplinary character of the project could mean that a theoretical project includes modelling of real data or explain how model predictions can be tested experimentally. The latter requires feedback from experimentalists approached by the student. For an experimental project, the report needs to outline potential modelling or analysis
approaches. These need to be based on discussion with theorists to assess feasibility. Students will rank projects in order of preference. Finally, projects will be assigned to students by the course committee. We assign projects to minimise unhappiness, i.e. better to give two second choices than one first and one third choice, and will try to assign projects evenly between supervisors. We note that in the past most students have had very successful and rewarding projects. The course committee’s decision is final. Supervisors are reminded that the final report will also need to demonstrate multidisciplinary character.

**Research Proposal**

The research proposal is written in BBSRC proposal style (6 pages plus project plan). The research proposal should describe the background to the project, make a scientific case for carrying it out, and state the goals against which the project will be assessed. Students should not forget that supervisors’ time is a resource, and that supervisors may be at conferences during part of the summer.

**Research Report**

The report should be at a postgraduate level. The length of the reports should not exceed 50 word-processed pages, written in strictly enforced format. The content of the report should include an abstract, introduction and literature survey, aims consistent with the research proposal, results, multidisciplinary components, methods, and bibliography.

**Overview**

<table>
<thead>
<tr>
<th>October</th>
<th>January</th>
<th>April</th>
<th>July</th>
<th>September</th>
</tr>
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<tbody>
<tr>
<td>Teaching</td>
<td>Practicals and case studies</td>
<td>Literature review</td>
<td>Research projects</td>
<td>Student mock panel</td>
</tr>
<tr>
<td>Research proposal</td>
<td>Research meetings, journal clubs, and mini conference</td>
<td>Research reports, Vivas</td>
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Term breaks must be used by students for private study. Specifically, the Christmas break is intended for literature reading and project preparations.

**Important Course Deadlines**

Dates of the deadlines will be provided to students with the detailed timetable.

**Project Supervisors**

Each research project requires at least two supervisors with different expertise to maintain the interdisciplinary character during the full length of the project. Preference will be given to project proposers from the CISBIO and CSynBI centres. The research project can be a mixture of experiment and theory, only theory, or only experiment. One supervisor may also stem from industry.
Representative Projects

The following list shows example project titles and supervisors. Some of the examples are based on on-going or planned research, but there will be many other new projects featuring new collaborations.

1. Building a synthetic gene circuit for *in vivo* transcriptional profiling in *Drosophila melanogaster*
   Supervisors: Dr. Nikolai Windbichler, Dr. Tony Southall

2. A novel system for the automatic regulation and tuning of protein degradation rates
   Supervisors: Dr. Guy-Bart Stan, Dr. Tom Ellis

3. Engineering Turing patterns in bacterial systems
   Supervisors: Prof. Mark Isalan, Dr. J. Krishnan

4. Remapping metabolism of *E. coli* for optimal fatty acid synthesis
   Supervisors: Dr. Patrik Jones, Dr. Diego Oyarzún

5. Constructing protein-protein interaction and gene expression networks for the antibiotics-induced Rtc RNA repair system of *Escherichia coli*
   Supervisors: Prof. Martin Buck, Prof. Michael Stumpf

6. Developing a nitrogenase selection system
   Supervisors: Dr. James Murray, Prof. Mark Isalan

7. Design and characterisation of new to nature inducible and repressor promoter bioparts
   Supervisors: Prof. Richard Kitney, Dr. Geoff Baldwin

8. Adding functionality to macrophages to tackle atherosclerosis
   Supervisors: Prof. Rob Krams, Dr. James Pease

9. Metabolic engineering of industrial *Clostridium* with foreign / synthetic product pathways
   Supervisors: Dr. John Heap, Dr. Diego Oyarzún

10. Population control of co-cultured microorganisms using RNA regulation
    Supervisors: Dr. Karen Polizzi, Dr. Guy-Bart Stan, Prof. Paul Freemont, Prof. Richard Kitney

Additional educational events

Although not required to pass the course, we highly recommend you attend extracurricular events and courses at Imperial College. Imperial provides a rich and stimulating environment, and we expect you to make the most of it. We recommend at least two Graduate School courses, ideally on writing and presentation skills, and the Synthetic Biology Symposium in November. There are a large number of talks and seminars around Imperial. Please make sure to be part of relevant email lists.

Research seminars and colloquia

Regular research seminars given by leaders in particular fields and include the CISBIO and Molecular Biosciences seminars, the bioinformatics seminar, as well as various divisional and departmental seminars. Students are expected to attend the CSynBI lab meetings which take place throughout the year. Other journal clubs also take place such as the, CISBIO and bioengineering-neuroscience journal club. Students may be asked to present at these events, which are ideal opportunities to develop presentation skills, whilst encouraging scientific debate, and providing the opportunity to broaden scientific knowledge. Students are requested to get feedback on their ability to organise the presentation in a logical manner, the use of clear slides, the clarity of the presentation and its scientific content from the organisers.
**Professional Skills**

Students will be trained in a wide range of transferable skills following exposure to the various teaching and learning aspects of the MRes course. Additionally, MRes students are recommended to take additional professional skills courses, offered by the Graduate School at Imperial College London. The online plagiarism awareness course is compulsory, and should be completed during the first term.

For more information on the courses available please see:

[http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/](http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/)

A list of potential skills developed is as follows:

1. **Communicate effectively through oral presentations, computer processing and presentations, written reports and scientific publications** – via coursework and developed through feedback on assessed reports and oral presentations. A short workshop on scientific writing is planned. To practise oral presentations, students present one case study orally, as well as participate in weekly lab meetings and student journal clubs. In the latter, students can present papers related to their research project or deliver progress reports to obtain feedback from their fellow students. Towards the end of term 3, students will organize a mini conference where they can present posters and talks on their work.

2. **Management skills: decision processes, objective criteria, problem definition, project design and evaluation, risk management, teamwork and coordination** – via the group projects and the research project and regular meetings with research teams.

3. **Integrate and evaluate information from a variety of sources** – via literature reviews as part of their case studies, research proposal, journal clubs, and research project.

4. **Transfer techniques and solutions from one discipline to another** – is a core activity of the research projects and is additionally taught in lectures.

5. **Use information and communications technology** – taught in lectures, developed through project work and individual learning.

6. **Manage resources and time.**

7. **Learn independently with open-mindedness and critical enquiry.**
## Course Modules

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<tr>
<th>Module</th>
<th>Description</th>
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<tbody>
<tr>
<td>M 1a Essentials for life scientists</td>
<td>Introduction to modelling in biology; Matlab computer practical</td>
</tr>
<tr>
<td>M 1b Essentials for physical scientists</td>
<td>Introduction to molecular and cell biology; wet-lab practical</td>
</tr>
<tr>
<td>M 2 Experimental systems biology</td>
<td>Signalling pathways and cellular programmes in bacteria, mammalian cells, and plants.</td>
</tr>
<tr>
<td>M 3 Theoretical systems biology</td>
<td>Modelling of dynamical systems and networks using deterministic and stochastic approaches, control theory, cell mechanics, and statistics.</td>
</tr>
<tr>
<td>M 4 Synthetic biology</td>
<td>Engineering design strategies to biological systems for application in health and industry, engineering blocks, standardisation, 'biobricks' and parts; social, ethical and policy issues</td>
</tr>
<tr>
<td>M 5 Advanced technology</td>
<td>Imaging and high-throughput techniques, and their analysis. Miscellaneous techniques.</td>
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**Description of Module 1a – Essentials for life scientists**

This short lecture course introduces the basics of modelling and theoretical analysis, tailored towards students from the life sciences with limited theoretical background. In particular, lectures will cover differential equations and stochastic simulations.

**Computer practical** - the programming Matlab package will be introduced. Emphasis will be put on learning by examples. Students will learn how to read data files, analyse data, fit models to data, plot graphs, print to output files, and how to implement simple dynamical models. The latter will focus on ordinary differential equations.

**Description of Module 1b – Essentials for physical scientists**

This short lecture/tutorial course will provide an introduction to life sciences, tailored towards students from the physical sciences. Lectures will discuss aspects of molecular biology and information flow within a biological context (DNA, RNA, proteins, transcription and translation). An overview of some experimental techniques (cloning, PCR) will be provided. In addition to the basic introduction to biology some insight will be provided into up-to-date DNA assembly methods which have applications in synthetic biology and will be of interest to students with life science backgrounds.

Hand-on experience in basic experimental techniques will be provided. The practical will explore new techniques in DNA assembly.

**Description of Module 2 – Experimental systems biology**

Lectures will cover signalling and gene regulatory pathways and programmes in bacteria, mammalian cells and plants. Further topics of the lectures will include structural and
functional genomics, and experimental techniques. Molecular medicine and genetic aspects of health and disease will be mentioned as well.

**Description of Module 3 – Theoretical systems biology**
This lecture course will cover various modelling techniques. Specifically, lectures will cover dynamical systems, networks, deterministic differential equations, stochastic simulations, control theory, biophysics and cell mechanics, as well as statistical approaches, such as Bayesian inference.

**Description of Module 4 – Synthetic Biology**
Topics of module range from biological building blocks and their characterization as, e.g. input/output relations, filters, amplifiers, robustness, as well as control theory, metabolic flux analysis, and genetic engineering. Additionally, this module will address social, ethical and policy issues, such as how is science linked to society, biology in the political context, social challenges, governance and regulation.

**Description of Module 5 – Advanced Technology & Biotechnology**
This short lecture course will cover imaging and high-throughput technologies. Imaging techniques include various forms of fluorescence microscopy, and high-throughput techniques such as RNAi screens, microarrays, and microfluidic devices.

**Student responsibilities**

The MRes course is a postgraduate assignment and does not follow undergraduate timing. There is no free time during term in this course. Students should be aware that bursaries are paid for a full-time employment up to the end of September 2019. Any holidays or sick leave will have to be taken at the discretion of the supervisors, but should under no circumstances be taken in the examination period of September 2019.

It is mandatory to attend all scheduled lectures, practicals, and exemplar case studies. Missing such events without any support of documented mitigating circumstances for the day of the event can lead to disqualification from the course. Any illness occurring in the preparation time towards examination times and deadlines cannot be taken into account. It is the responsibility of the student to ensure that sufficient time is allocated for write-up preparation. If illness prevents a student from attending courses or performing their project then it is their responsibility to inform the module convener, project supervisor and course Directors as soon as possible.

First contact in case of problems with the project supervisors are the course Directors. The course administrators will be the point of contact for all administrative or logistic issues.

Students are expected to organise, conduct and present their research project in an independent fashion. The supervisory role is to guide and advise the student intellectually as well as technically, but it is not the supervisor’s responsibility to do the thinking or the work for the student. All projects will have at least two supervisors of different expertise, ideally one with biological and one with physical/mathematical/computational expertise. Both supervisors should be approached for guidance. It is the students’ responsibility to make an effort and seek contact with their supervisors on a regular basis.

In order to pass the course successfully students have to pass all assessed components of the course. This includes the combine coursework mark for the modules and proposal as well as the final project report and the viva. Failing in one of the components could lead to a failure of the whole course.

At the end of the course an external examiner will assess the examination process. All students have to be present for this day, as they will need to attend a moderation viva with the external examiners. Students that are either at boundaries between marks (i.e. pass/failure or pass/distinction) or have failed one or more components of the course may
have their mark moderated upwards as an outcome of the viva with the external examiners to determine their final mark.

Students should seek guidance with respect to their write-up of reports from their corresponding supervisors, since they will be involved in the marking. Specifically, after a first draft is written, they should seek feedback from their corresponding supervisors (biological and physical) to foster the improvement of their final report.

Students are required to submit an electronic version of the final report to their supervisors. Additionally, they must hand over all notes, lab-books, results, computer programmes etc. to their supervisors.

A general Regulations-for-Students document can be found on the Registry website http://www.imperial.ac.uk/students/terms-and-conditions/student-regulations/ and students are expected to familiarise themselves with it.

In case of sickness, students are required to inform their supervisors (or the administrator or course directors) if they are absent from College for more than three days and to produce a medical certificate after 7 days if absence is due to illness. If illness prevents attendance for more than 7 days then it is the student's responsibility to inform their supervisor and the course director immediately. If there is reason to believe that a student's state of health makes him/her unable to pursue his/her studies, or causes disruption to other members of the College, that he/she may be required to be assessed by the College Health Service. This regulation can be read in full in the above mentioned document.

**Late submissions:**

Material to be submitted must be typewritten, correctly formatted, bound, and provided in the correct number by the specified deadlines. An electronic version must also be submitted as well and this will be subject to plagiarism checks.

All coursework and project reports, must be submitted by the designated deadlines. You must inform the Course Director and Administrator without delay if illness or other mitigating circumstances will prevent you from handing coursework in on time. Failure to do so will result in deduction of marks, normally 10% of the awarded mark per day.

**Vivas:**

Students are responsible for contacting their two examiners end at the end of August to arrange a viva date after the project report has been handed in. Students are not allowed to take holiday during the viva period without written permission from the course director.

**Guidelines for preparing marked elements**

**Guidelines for module coursework**

Each of the five modules will be assessed by a piece of coursework with details depending on the module convenor. Students can generally discuss work in progress with their fellow students but need to individually present their findings for marking. For orally presented work, students generally need to prepare a short powerpoint-style presentation, explaining their findings and putting them in the correct context with background, methods and results. Presentations will be marked by a committee attending the presentations using proforma and assessment criteria for orally presented work, keeping to time is an important criteria. Written work will similarly require reviewing relevant literature, presentation of results, and the student’s own critical assessment of the findings. Such reports will generally be first and second marked using assessment criteria for written work. Reports must be submitted by hard copy and electronic copy. Reports may be screened for plagiarism.
Guidelines for Research Proposal

The purpose of the proposal is largely to test the student's ability to work independently. The proposal should be at a postgraduate level, and consist of a 6-page document (including figures and up to 30 references) in BBSRC-proposal style (part 2 of Case of Support without the Previous research track record; minimum font size 11pt Arial, Helvetica or Verdana and margin 2 cm, single line spacing, https://je-s.rcuk.ac.uk/Handbook/Index.htm). You should also include an additional 1 page **Diagrammatic workplan**, which should be a Gantt chart (https://en.wikipedia.org/wiki/Gantt_chart) describing the timeline of the proposed work. So the final document should be 7 pages total.

The proposal should include an abstract, background and literature survey, and a proposal for the work to be carried out during the research project, contingency plans, and work organization and time planning, and a bibliography. Importantly, include estimates of the times required to fulfill the work packages or aims. Figures need to have proper captions, legends, and axis labelling with physical units.

**When preparing your proposal you should bear in mind the following:**

**Written style/Presentation**
- Is the proposal well-written and presented (typewritten, bound, organisational figures, formatting etc) and clearly explained?
- The report should be concise and complete (thorough and informative)
- Are the references listed actually referred to or discussed in the text? Is the abstract an accurate description of the contents?
- Is the proposal written in your own words?
- Is the format up to publication standard?

**Literature survey**
- Is the literature survey thorough and complete?
- Are important references missing?
- Are all relevant subjects (biological context and physical/technical aspects) sufficiently covered?
- A recitation of published material is not acceptable

**Analysis of literature**
- The student should show ability to compare and contrast the relevant literature in all subject areas.
- The student should present a coherent “story” throughout the report.
- Has the student made a good selection of material where choices exist or where the sources are voluminous?
- For a first class proposal, original input is expected

**Rationale of proposal**
- Is the proposed work’s relationship to other work in the literature clear?
- Aims and objectives should be clearly justified.
- Is the choice of methodology clear and is it justified?
- Do the two (or more) supervisors have clear relevance and oversight tasks?
- Are the expertise of the supervisors sufficiently different?
- Is the proposed work sufficiently multidisciplinary?
- **IS THE WORK REALISTIC IN AVAILABLE TIME?** Many proposals, including actual grant applications (!) are far too optimistic on this point.

Two paper copies and an electronic version need to be submitted to the Course Administrator before the deadline. The Research proposals will be marked by the individual
supervisors (see criteria for assessment of written work). Reports will be screened for plagiarism.

Guidelines for MRes Research Report

The thesis should be at a postgraduate level and the length of the report should not exceed 50 word-processed pages including figures and references and must conform to the following formatting guidelines. Figures need to have proper captions, legends, and axis labelling with physical units. The thesis sections must follow the following order and address the bullet point items.

Table of Contents
List of abbreviations
Abstract
Introduction
  • Background
  • Aims
Results
  • Experimental Strategy
  • Results
Discussion/Conclusion
  • Discussion
  • Conclusion
  • Future work
Methods and Materials
  • Include details necessary to reproduce experiments (e.g. tables of primer sequences used)
  • DO NOT INCLUDE EXPERIMENTAL STRATEGY IN THIS SECTION
Bibliography
  • References should be in author-date (Harvard) format. We recommend you use a citation manager such as Endnote or Mendeley, available on College PCs. Students have also used LaTeX and BibTeX successfully in the past.

NO APPENDICES ALLOWED! You can submit additional data or computer code electronically, but it is up to the examiners to consider this extra material.

FORMAT

Font: Arial/Helvetica (11 point minimum)
Line spacing: 1.5
Margins: minimum 2.5 cm all round
References: author-date (Harvard)

FAILURE TO CONFORM TO FORMAT SPECIFICATIONS WILL RESULT IN THE STUDENTS BEING REQUIRED TO RESUBMIT WITHIN 24h AND WILL INCUR A 5% DEDUCTION IN MARKS.

Three copies in comb bound form and an electronic version need to be submitted to the course administrator before the deadline (date to be confirmed). The Research Reports will be marked by the individual supervisors and by the viva examiners (see criteria for assessment of written work). Reports will be submitted for plagiarism screening. Students are reminded that the written report comprises 35% of the final mark for the MRes, and should allocate enough time to the writing of the report.
Assessment

Scheme of Examination:

The course will not have any formal written exams. However, each of the five modules will individually be assessed via coursework (see above) with students' results either presented orally or by a written report. Modules 1a and 1b each contribute 2.5% to overall course mark, while all other modules contribute 5%. The Research Proposal will also be written up and contributes 15% to overall mark. Taken together the modules and research proposal are 40% of overall course mark. In September, the course ends with an oral examination of each student in the area of his/her research project (viva). The report, research conduct, and viva contribute 60% to the overall mark.

The first supervisor will mark the research project and also assess the research conduct during terms 2 and 3, e.g. by creative thinking, lab work, and various presentations at lab meetings. A 30-50 minute viva voce will generally be conducted by the first internal examiner with a second supervisor sitting in. Both together will contribute agreed marks for the report and the viva. Marks will be reviewed by the internal board of examiners and may be moderated.

The course itself will come under the scrutiny of two external examiners with different backgrounds, who will comment on the content, its delivery and conduct. The external examiners will viva all students. Marks may be moderated by the board of examiners taking account of recommendations from the external examiners before the award of the final mark to students.

Minimum standards (i.e. 50%) in each of the two assessed elements (assessed coursework and research project) will be required with an overall pass mark of 50%.

To achieve pass with merit a minimum of 59.5%, is required in each of the two elements. To achieve pass with merit an aggregate mark of 59.5% is required, with at least 55% in both elements. To achieve pass with distinction an aggregate mark of 69.5% is required, with at least 65% in both elements.

To qualify for the award of MRes, students must complete all the course requirements, including the participation in mandatory extra-curricular events, and must achieve an overall pass mark in the combined examinations including coursework, research report, lab performance/conduct, and viva.
Occupational Health Information for PG Students

The College Occupational Health (OH) Service provides the same clinical services to taught and research postgraduates as we do to staff. However students do not go through pre-employment health screening so we are unaware of students who need vaccinations, health clearance or health surveillance unless they contact us. Course organisers or supervisors need to instruct new students needing these services to contact the College OH service. More specific information is below.

Health and safety information (OH requirements, vaccinations, use of equipment, training etc.): http://www.imperial.ac.uk/occupational-health

LONE WORKING AND SUPERVISION

Students must be appropriately supervised and monitored when working in a laboratory area or in a computer office.

Masters Students must not be left to work alone in the lab or in a computer office. Masters Students cannot supervise each other, an experienced competent member of the group must be available. Except with permission from their formal academic supervisor (and not a PhD or postdoctoral researcher), Masters students can only work between 9.00 am and 7.00 pm Monday to Friday (and not on public holidays).

Fieldwork activities must be planned so that Masters Students are not working alone.

General Health and Safety

The College wishes to ensure that the health, safety and welfare of its students are not jeopardised through misuse of alcohol or substances in College. Please refer to the College policy: http://www.imperial.ac.uk/media/imperial-college/current-students/public/Student-Alcohol-and-Substance-misuse-policy.pdf

Health clearance for work with pathogens, GMOs or unfixed human tissue

Postgraduate students who will be handling human pathogens, GMOs of class 2 or higher or unfixed human tissue, including blood, in a laboratory environment must be health cleared for this activity.

Students requiring clearance should be instructed to complete a Biological Agents Health Questionnaire and to send this to the College OH Service at South Kensington. Most will be cleared through submission of the questionnaire. We will only call them in for a clinic attendance if they need a vaccination or they declare a health problem that requires a further assessment.

After the student is cleared they will be sent an e-mail confirming this. This is copied to whoever is named as the Principal Investigator on the questionnaire and to the College Biological Safety Officer.

Students who will not be directly handling and screened blood do not need health clearance or vaccination.

Health surveillance enrolment for work with laboratory animals

Any student who will be working with live laboratory animals must enrol for health surveillance with the College OH Service before commencing their research programme.
Enrolment is not required prior to licensee training.

Students who require it should be instructed to complete a health surveillance enrolment questionnaire and to arrange an appointment with the College OH Service for a mask fit test and lung function testing. They should only arrange the appointment when they are within 2 to 3 weeks of commencing their research work. Once student has completed enrolment an e-mail confirming this will be sent to the student and copied to the manager of the CBS facility in which it will be working and their Principal Investigator.

The College wishes to ensure that the health, safety and welfare of its students are not jeopardised through misuse of alcohol or substances in College. Please refer to the College policy: [http://www.imperial.ac.uk/media/imperial-college/current-students/public/Student-Alcohol-and-Substance-misuse-policy.pdf](http://www.imperial.ac.uk/media/imperial-college/current-students/public/Student-Alcohol-and-Substance-misuse-policy.pdf)

### NHS health clearance

All postgraduate students who will have contact with patients in a clinical environment have to complete NHS infection control clearance. This health clearance is carried out by the College OH Service. Students should be instructed to complete a Postgraduate Health Clearance Form and arrange an appointment with an OH Adviser at the College OH clinic at South Kensington. They should bring copies of any of vaccination records and relevant serology tests to the appointment. When the student complete health clearance the certificate on page 2 of the questionnaire will be stamped and given to the student to pass on to their course organiser or principal investigator.

### Health clearance for travel

Postgraduate students travelling abroad for study or research have the same health clearance requirements as for staff. Clearance is compulsory for any travel to a tropical country. If any vaccinations are required for the destination country then an appointment with the OH Service should be sought at least four weeks in advance of travel. Students will need to provide evidence that their trip is directly related to their study or research activity. Clearance will be notified to the Principal Investigator/supervisor named on the health clearance questionnaire.

### Emergency assessment and treatment of laboratory accidents

Postgraduate students based on hospital campuses can attend the hospital OH clinic for emergency assessment and treatment of inoculation accidents involving human blood or unfixed tissues. Any other emergency assessment will be carried out by the College OH Service at South Kensington. For information on the urgency and form for assessment consult the laboratory accident guide issued by the OH Service last year. If you would like to receive some copies contact occhealth@imperial.ac.uk


**Occupational Health**

Level 4, Sherfield Building
Imperial College London
Exhibition Road
London SW7 2AZ

Opening hours:
Monday to Friday 09.00-17.00