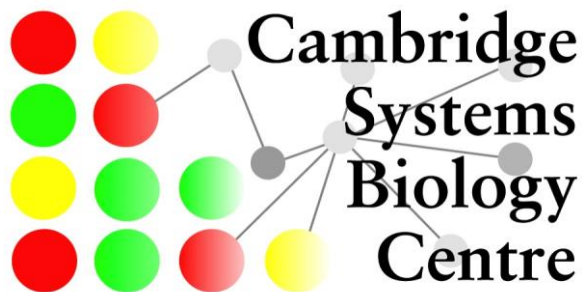




UNIVERSITY OF  
CAMBRIDGE

**Part III**  
**Systems Biology**  
**Course Handbook**  
**2020-21**



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## Contact details at a glance

**NB: please use your [@cam.ac.uk](mailto:gen.cam.ac.uk) email address for emails sent to the organisers, lecturers and each other**

Course organiser	Prof Steve Russell	<a href="mailto:s.russell@gen.cam.ac.uk">s.russell@gen.cam.ac.uk</a>
Course secretary	Mrs Helen Schwarz	<a href="mailto:hs593@cam.ac.uk">hs593@cam.ac.uk</a>
INT organiser	Prof Steve Russell	<a href="mailto:s.russell@gen.cam.ac.uk">s.russell@gen.cam.ac.uk</a>
DAH organiser	Dr Juan Mata	<a href="mailto:jm593@cam.ac.uk">jm593@cam.ac.uk</a>
MAN organiser	Dr David Huen	<a href="mailto:david.s.huen@gmail.com">david.s.huen@gmail.com</a>
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	Dr Karen Lipkow	<a href="mailto:kl280@cam.ac.uk">kl280@cam.ac.uk</a>
	Dr Ben Hall	<a href="mailto:bh418@mrc-cu.cam.ac.uk">bh418@mrc-cu.cam.ac.uk</a>
Systems biology	General email	<a href="mailto:sysbiol-admin@gen.cam.ac.uk">sysbiol-admin@gen.cam.ac.uk</a>

Cambridge Systems Biology Centre website [www.sysbiol.cam.ac.uk](http://www.sysbiol.cam.ac.uk)

# Key Dates

## Michaelmas

**Mon 28<sup>th</sup> Sept 2020**  
**Fri 4<sup>th</sup> Dec 2020**

**Course starts**  
**Term ends**

## Lent

**Tue 12<sup>th</sup> Jan 2021**  
**Fri 22<sup>nd</sup> Jan 2021**  
**Mon 8<sup>th</sup> – Fri 12<sup>th</sup> Mar 2021**  
**Thu 18<sup>th</sup> Mar 2021**  
**Fri 19<sup>th</sup> Mar 2021**

**Lent term modules start**  
**Interim project report submission**  
**Group miniprojects**  
**Mini-project assessment**  
**Term ends**

## Easter

**Wed 28<sup>th</sup> Apr 2021**

**Project Report Submission**

# Introduction

Welcome to the Part III Systems Biology course, this is a Masters-level undergraduate course and you will be working towards an MSci degree. In line with this, we expect far more independence than in your previous three years of study. You will be expected to take far more responsibility for your learning: you will not be spoon-fed! You will need to read original research papers and you should try to write regular “revision essays” to consolidate your knowledge. No one will be leaning over your shoulder forcing you to do these things, so please be prepared to take the initiative – it’s your degree.

Clearly, the methods for delivering teaching during the current COVID-19 situation are going to be very different from anything you have experienced as students and we have experienced as teachers. We are working hard to provide the very best experience we can but inevitably there may be problems and we ask you to work with us and help deliver the high-quality course we have provided in previous years. You may also find the taught elements of the course more intensive than you have been used to and recognising that back to back video presentations can be mentally fatiguing we have elected to spread Michaelmas teaching across the term rather than compress it into October as we have traditionally done. The following page will overview our approach to delivering the course.

Systems Biology is an integrated approach to the study of living systems. It is quintessentially interdisciplinary with participation of biological, physical, mathematical, engineering and computational sciences. One strand of Systems Biology is fuelled by the acquisition and handling of large and comprehensive sets of data, using high-throughput ‘omics technologies; its integration, development, and comprehension depends on recursive mathematical modelling and experimentation. The discipline is concerned as much with the links that connect components of a network as with the components themselves. A major focus here is the determination of how the properties of networks arise from all their constituent links. A second strand focuses on the collection of detailed highly quantitative data from smaller systems with the goal of developing predictive mathematical descriptions of systems behaviour. Ultimately, these strands will converge to provide accurate mathematical models of biological processes

Interdisciplinary research starts small amongst far-sighted and broad-minded enthusiasts and, if success and momentum build, burgeons into Institutes propelled by waves of funding initiatives. With growth comes demand for practitioners and a need for underpinning with education to provide both individual specialist expertise but, arguably more important, to develop understanding of the power and use of all the disciplines that progress in systems biology will require. The cultures and characteristic skills of broadly biological and broadly physical scientists present a range of challenges to cross-disciplinary awareness. It is easier for a typical “physicist” to gain a sophisticated understanding of the processes of gene structure and expression, protein structure and function, and of metabolism and its control than for a typical “biologist” to appreciate and use relatively advanced mathematical structures and methods. This is obviously a challenge, but Part III of the NST is a ready-made arena in which this may be achieved.

After several years running the course, it is now our firm opinion that progress on the course and good examination results are best achieved by interacting and cooperating with your classmates. Those with a mathematical or physical sciences background will benefit from interactions and discussions with biologists to learn key concepts in biology, while the reverse can help biologists better understand some of the maths and statistics. With social distancing this will be challenging and we are organising Teams channels for you to interact. We hope you enjoy the course and find it rewarding, Enjoy!

# COVID-19

The current University position regarding in person teaching is that it should only take place under social distancing guidelines in a safe environment. We need to take account of individuals who may be vulnerable or need to self-isolate in thinking about how we deliver lectures, computational practicals, journal and whole class supervisions. Consequently, we have elected to deliver teaching in the ways described below. Please bear in mind that all arrangements, especially where in-person teaching is planned, are subject to change depending upon Government and University guidance.

**Lectures:** these will be prerecorded using the Panopto system and made available via the course Moodle site. On the timetables an indicative date recommending when these should be viewed will be given – these should be viewed as “watch before” times and to help structure your learning you should try to adhere to these.

Each block of lectures from an individual will be followed up with a Zoom-based Q&A session of 30-60mins. These will be timetabled and you should join these to ask questions to clarify things you are unclear about and engage in discussion with the class. A small number of these may be delivered in person. The Zoom sessions may be recorded and be available for ~1 week on the Moodle site

**Computational Practical:** there are 14 computer-based practical sessions in the Michaelmas term and these will be delivered as live sessions where you log in to a virtual environment hosted in the Biological Science Bioinformatics Teaching Facility. Essentially, your web browser will act as a window to the software and infrastructure in the facility – it is strongly recommended you use a laptop or desktop machine for these sessions, your smartphone or keyboardless tablet will not be up to the job! The instructor will lead the session live, which may include breakout rooms with demonstrators. These sessions will NOT be recorded.

**Supervisions:** unlike in previous years, “supervisions” are run as whole class sessions that provide an opportunity to dig deeper into a particular area and resolve any general or specific questions you have. These will have an element of structure, where specific topics will be posted in advance on the Moodle site. The sessions will generally be run live via Zoom though there is the possibility that a small number are delivered in person. The Zoom sessions may be recorded and be available for ~1 week on the Moodle site.

**Journal sessions:** again, these are whole class sessions looking at 1 or 2 research papers in depth. The papers will be provided to you in advance on the Moodle site along with some guidance/specific questions. In some cases the class may be divided into groups with each taking a particular paper or aspect of a paper. Students will be expected to contribute during these sessions according the guidance provided for each session. In most cases these sessions will be delivered via Zoom though there is the possibility that a small number are delivered in person. The Zoom sessions may be recorded and be available for ~1 week on the Moodle site.

**Seminars:** we have arranged some research seminars across each term where world class Cambridge researchers will present aspects of their work to you. These sessions will be delivered live via Zoom and will not be recorded.

**Project Intros:** we started these sessions a couple of years ago and they have proved popular, they will run in November and consist of 3 Zoom sessions where students present a 3-slide introduction to their research project. Details will follow.

# Tools & Resources

In these unprecedented circumstances the University is reliant on a variety of digital platforms for delivering high quality teaching. Below we summarise the main platforms we will employ during the course.

**Moodle.** The course Moodle site will be your primary port of call for all course material. Copies of lecture slides, material for computational practicals, journal club papers and supervision guidance, along with the course handbook and other administrative documents will all be available on the site. **If you cannot access the site please let Helen Schwarz [sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk) know immediately.**

**Zoom.** The Zoom video conferencing software will be used to deliver various live sessions, including Q&A, journal, supervision and seminars. It is recommended that you sign up for a free Zoom account and provide Helen Schwarz [sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk) with your account name.

**Microsoft Teams.** You will all be enrolled in the class Teams group and this may be used as an alternative to Zoom for delivery of live sessions.

**SLACK.** As an alternative to using the chat function in Zoom or Teams, we will pilot the use of SLACK for live interactions. SLACK may also be useful for interactions between students. It is recommended that each student signs up for a free SLACK account and send the account details to Helen Schwarz [sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk).

An alternative that you may be more familiar with is WhatsApp and we leave it to you as to whether or not you start up a class WhatsApp group.

# Modules

## Michaelmas

**Introductory module (INT):** This module starts with an introduction that deals with the concepts, history, and future aspirations of systems biology. The module develops three interweaving sub-themes. You will have lectures that deal with the nature of modern biological science in relation to the concepts, approaches, methods and tools of Systems Biology. Following this, the teaching focuses on a contextualised mathematical and computer modelling toolkit comprising lectures and classes. The module runs in the first half of term and comprises **28 lectures, 8 computer-based practicals, 3 journal clubs, 3 group supervisions and 2 seminars.**

**Data Acquisition and Handling (DAH):** Systems biology relies on the ability to obtain a 'global' view of the physiology of a cell by the simultaneous identification and quantification of thousands of different molecules (such as proteins, nucleic acids and metabolites). This module will present the techniques used to acquire data in the various 'omics' approaches (transcriptomics, proteomics and metabolomics), as well as in high-throughput genetics. Because of their size and experimental limitations, the handling of these datasets presents unique challenges. Therefore, the module will emphasise the practical aspects of dealing with these types of data. Large-scale approaches are generally applied to cell populations, and often lack spatial and temporal resolution. The module will introduce how they are complemented by *in vivo* analysis of single cells using advanced microscopy, which can provide information on cell-to-cell variation and spatial control. The module consists of **17 lectures, 6 computer-based practicals, 7 journal clubs, 7 group supervision sessions.**

## Lent

**Modelling and Analysis of networks (MAN):** The module focuses on mathematical and statistical methods used to evaluate and analyse large-scale data sets and use them for the reconstruction of biological networks. Methods for the analysis of metabolic, gene-regulatory, and large-scale networks will also be introduced. The module comprises **16 lectures, 11 computer-based practicals, 3 journal clubs, 3 group supervision sessions, 1 seminar.**

**Modelling in Biology (MIB):** This module aims to introduce students to the *de novo* design of biological systems using the techniques of Synthetic Biology and computational simulation. The theory and practice of Synthetic Biology is introduced both in the context of designing exemplar biological systems to test our understanding of natural systems and in that of systems design and fabrication to produce novel devices of commercial or medical utility. The design, simulation, and analysis of biological models using some of the main computational techniques in Executable Biology are then introduced. Finally, the two strands of the module are integrated by a group mini-project in which students design a system and test its feasibility by computer simulation, or build an executable model of a particular biological process and analyse its behaviour. The module consists of **13 lectures and 5 computer-based practical sessions, plus a 5-day computer-based group mini-project that is examined.**



## Lectures

Lecture locations and timing are detailed in the timetable, as indicated all lectures will be delivered via pre-recorded Panopto sessions available from the Moodle site and you should view these by the recommended date. Lectures will be followed up with live Zoom-based Q&A sessions. Experts in each of the topics will teach and you can expect a diversity of lecturing styles across the course. Viewing at all lectures and attending the Q&A sessions is expected since all material presented in the lectures is examinable and all lecturers are asked to contribute questions for consideration in the final examination papers. Lecturers have been asked to deposit their slides on the course Moodle site, as well as the recordings please let us know immediately ([sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk)) if content is missing or you have any difficulties accessing these.

## Practicals

The computer-based practical sessions will all held remotely via web-based access to the Bioinformatics teaching facility. Mr Paul Judge will be on hand to help with any hardware problems. The practical sessions form a critical part of the course since familiarity with statistics, mathematical and computational modelling, along with the handling of large-scale datasets, is integral to the discipline. As with the lectures, you may be examined on any of the concepts or methods presented in practical sessions.

## Seminars

Each term there will be 3 or 4 research seminars, delivered by experts in the field. The purpose of these is to put some of the concepts and approaches you learn about in the context of a research question. Seminar speakers are not asked to provide examination questions, but lecturers on the course will expect you to have attended the seminars and may hope to find material from them in exam answers. Please take the opportunity to ask questions, all the seminar speakers are very approachable!

## Supervisions

Each module has supervision sessions timetabled; these are not the very small group sessions to which you have been used to in previous years since they involve the whole class. They provide an opportunity to clarify any immediate problems you have with the lecture material. Each is different: in some cases, you may focus on a particular paper in a journal club style; in others, there may be group discussion on a particular theme or topic. Make the most of these, discussion and debate are key to the development of scientific ideas and provide an excellent opportunity for learning. If you have problems understanding aspects of the course or particular lectures that are not answered in the lectures, you are encouraged to contact lecturers or those running supervisions for a follow-up session.

## Journal Clubs

These sessions are designed to develop your skills in dealing with the literature. You will be given a research paper a few days in advance of each session and you will be expected to have read it! In some cases, you may be provided with a series of questions to consider.

# Research Project

The research Project contributes 30% towards your final degree and we therefore expect a high standard. You will be provided with a list of project titles and supervisors as soon as possible: you are advised to contact the supervisors whose projects interest you to discuss possibilities. You are also permitted to organise your own project if you have identified a supervisor who is willing to host you, providing that the subject is acceptable to the management committee. If you are thinking of organising your own project, please contact Steve Russell ([s.russell@gen.cam.ac.uk](mailto:s.russell@gen.cam.ac.uk)) as soon as possible. Projects commence at the start of term and full details of what we expect are laid out below. For some of you, this will be your first experience of working on a project, and even those who have carried our Part II projects should find that the Part III projects are more intensive and hopefully more rewarding. Remember, experimental science, be it wet or dry, can be exciting and frustrating in equal measure. Don't get too down when, as is inevitable at times, things don't go well and try to enjoy the experience. You will be examined on how well you present and discuss the results of your project work not on the volume of results you generate, so even when ideas don't pan out and you have to go back to square one, do not despair.

## Intro sessions

Last year we introduced a set of project introduction sessions in the second half of the Michaelmas term which appeared to be successful. These will run on three early evenings (probably Thursdays from 17:00-18:30) where 6 or 7 students each present a **5 min** introduction to what the research projects are about and the methods that will be used. A maximum of 4 slides and **NO DATA** are presented in an "elevator pitch" style: i.e. what's it about, why is it important and here's what I plan to do. There will of course be time for a few questions after each presentation. We found these sessions useful since it helps you all keep in touch when you are spread about for your projects and can help make connections between different projects or share methods.

## Notes for Supervisors and Students

While some of the following is likely to be irrelevant since we anticipate that projects will be entirely computer-based, should there be an opportunity for wet-lab work in the Lent term there are general issues to which you should pay attention.

**1. Legal Obligations.** The most important responsibility of supervisors is to ensure that projects are carried out in a safe environment. It is also a clear responsibility of the student to work within the relevant safety rules and be mindful of the safety of others in the lab. Before any wet lab work starts, supervisors should discuss safety aspects with students and it is expected that all relevant safety documentation is complete prior to commencing work.

**2. Student supervision.** Supervisors are requested to nominate a **day-to-day or deputy supervisor** from within their group and **to ensure that the deputy receives a copy of these notes**. Please send the name and email address of the day-to-day supervisor to ([sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk)). This ensures that adequate supervision is available at all times. As part of their supervision, it is expected that the student will meet regularly, usually weekly, with their supervisor to discuss progress and future work. Such discussions are facilitated if students have a written summary of the preceding week's work.

Supervisors should note that students are expected to integrate into their research group for

the duration of the project and, for example, participate in group seminars/journal clubs. Please remember that students need to achieve a reasonable balance between project work and other components of the course.

Supervisors should bear in mind that projects are part of a Tripos examination and that they should be designed to obtain a reasonable amount of data for the write-up. Projects that are too ambitious for a two-term undergraduate project (more akin to 1st year PhD project) may limit the scope the student has to demonstrate their capacity to critically evaluate data.

**3. Duration.** Projects can begin as soon as possible after the start of term and will run until the end of Lent term. All the projects this year will be dry, with little or no opportunity for wet lab experiments. Arrangements for each project are highly dependent upon the rules and working practices for each lab/building and it is important students and project supervisors establish how the projects will be managed at the outset. Interactions with day-to-day project supervisors and research groups may be entirely remotely or involve an element of face-to-face interaction.

It is important to remember that some students or project supervisors may not be able to undertake face-to-face interactions during the current pandemic and individuals should be respectful of each other's needs at this challenging time.

While projects are generally limited to term time, it is possible for project work to continue past the end of term (Fri 4<sup>th</sup> Dec) with the agreement of student and supervisor. Supervisors, should not put pressure on students to stay in Cambridge or work remotely beyond the end of term since they may face accommodation or connectivity difficulties. Projects formally recommence on Mon 13<sup>th</sup> Jan, please note that students have course work across both terms, some of which involves live sessions. Project work from 8<sup>th</sup> to 12<sup>th</sup> of March inclusive is not possible due to team project work. Final project reports must be submitted by **Wednesday 28<sup>th</sup> April 2021**. Students are strongly encouraged to commence the write-up of their dissertation before the end of the Lent Term and to organise writing so that they can obtain feedback from their supervisor.

**4. Project write-up:** 6000 words – due **Wednesday 28<sup>th</sup> April 2021**

**5. Budget allocated per project:** £250 per project is available to supervisors to cover any costs for 'dry' projects, if any wet lab work is planned please contact [sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk) for advice and for budget claims.

**6. Supervision payment.** The payment for Part III project supervision has changed. As agreed by the Senior Tutors Committee, Colleges will pay for a notional total of 9 hours of supervision per term for Part III project supervisors. Claims can be made by the lab head or by the day-to-day supervisor(s) through CamCORS supervision reporting system at <http://www.camcors.cam.ac.uk> at the end of each term. Part III project supervisors are required to write reports for *both* Michaelmas and Lent term to ensure Colleges get supervision reports on the project work of their students, which is important for writing references and in the event of a student having problems in the examinations due to illness or other causes.

**7. Interim Progress Report.** Supervisors and students should provide a short progress report on the provided form to the Course Coordinator at the end of the Michaelmas Term. This is simply to ensure that there are no problems that require action on our part. **Please return the completed form by Friday 22<sup>nd</sup> Jan 2021** [sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk)

## MIB Mini-Project

### DETAILS OF HOW THIS ELEMENT OF THE COURSE WILL RUN ARE BEING DEVELOPED AND WILL DEPEND ON THE COVID SITUATION

Available if needed by email:

Smoldyn & biological systems - Karen Lipkow [kl280@cam.ac.uk](mailto:kl280@cam.ac.uk)

Biological systems - Gos Micklem [gm263@cam.ac.uk](mailto:gm263@cam.ac.uk)

BMA & executable modelling - Ben Hall [bh418@mrc-cu.cam.ac.uk](mailto:bh418@mrc-cu.cam.ac.uk)

**Task:** The aim is to work in groups of three to generate a model of a biological system and use it to investigate the system's properties. You may do a project of your choice, with a modelling method of your choice, but it should be different from primary methods being used in the main projects of the team members. This restriction only applies to the modelling part, you may use MATLAB or R for data analysis, even if you use these in your main project. You may pick a project that has been modelled in the iGEM competition (<https://igem.org>) and approach it with a different modelling method.

You will be assigned to a group of three students with mixed backgrounds: these will be listed on the Moodle site in Michaelmas. Please use the earlier weeks of the MIB module to search for and discuss project ideas. The best projects address new biological questions. Think about the feasibility of your project using your simulation methods of choice and the availability of quantitative data to inform your models.

The MIB module (15% of final mark) is assessed by jointly designing a poster and giving an oral poster presentation, with a short demonstration of the model, to the examiners (e.g. explain structure/parameterisation and demonstration run of the code). A **maximum of 30 min** is allocated for your presentation. In our experience, the best presentations involve everyone from the group explaining parts of the project.

The poster should be in the style of a conference poster, including title, authors, affiliations, abstract, introduction, methods, results, discussion, summary and references. In addition to the poster and demonstration. Each student independently produces a short report on the project: **maximum two pages A4**; minimum font 11 pt Arial; margins no less than 2 cm all round. This write-up should briefly introduce the project, describe your contribution to the work and briefly summarise the overall conclusions of the work. **DO NOT WASTE SPACE BY REPRODUCING FIGURES FROM THE POSTER.** Each report should be an individual piece of work from each student. PDF files of an A4 version of the poster along with individual reports must be sent to [sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk) by noon on **Wed 17<sup>th</sup> March** before the assessment session on **Thur 18<sup>th</sup> Mar**. As will be obvious, this is a tight deadline and it is deliberately set this way. You are being examined on your ability to work quickly in a team to a deadline. You would be advised to think about elements of your poster during the week of the miniproject and use the weekend to put it together. Posters from previous years will be available from the Moodle site. We recommend the examples from the previous years to guide you. You all know how to use Google, but here a couple of useful links for preparing scientific posters:

<http://guides.nyu.edu/posters>

<https://www.the-scientist.com/careers/poster-perfect-42000>

**Poster production:** Unlaminated A0 posters will be printed by the Department of Biochemistry Photography & Graphics Service, which is located downstairs in the Sanger Building, outside the entrance to the lecture theatre. 2-3 days notice is required for printing, and an extra day if an A3 proof is required. Contact: Chris Green, <photo@bioc.cam.ac.uk>. N.B. Each group will only be allowed to print one version of your A0 poster, though it will be possible to check an A3 proof version first.

**Assessment:** The poster, demonstration and individual reports will count towards the 15% overall mark awarded for the MIB module. This is NOT broken down into individual components for design/poster/write-up. After seeing all your design/model demonstrations and poster presentations, the examiners evaluate these along with each write-up to allocate individual marks. The external examiner looks at the posters and the individual reports and has, in the past, asked students about the posters during oral exams.

## Examinations

Examinations are expected to be held around the first week in June, though concrete information cannot be given until the Examination timetables are published. There will be 3 written papers and a computer-based practical:

**Paper 1:** of two hours' duration, is a general paper in which candidates write integrative essays in response to questions covering the whole of the course. It is divided into two sections of equal weight. Candidates answer one question, chosen from three, in Section I (a biologically oriented essay), and one question, chosen from three, in Section II (a physical/computational science oriented essay).

**Paper 2:** of three hours' duration. Candidates answer three questions out of six from the DAH, 'Data acquisition and handling' module.

**Paper 4:** of three and a quarter hours' duration, with the first quarter of an hour solely for reading the paper. There will be two questions, and candidates answer both questions. One question will be a data-handling question, based on the analysis and interpretation of a short research article. The second question require candidates to write an outline grant proposal for one of three specified investigations.

**Paper 3:** of 3 hr duration and comprises a computer-based examination covering aspects of the Mathematical modelling and analysis of networks module. Candidates answer all questions in the paper.

Copies of past examinations papers (with solutions for Paper 3 and Paper 4 Question 1 are available from the course Moodle site.

**Viva:** approximately 1 week after the last examination, students will be informed if they are required to attend a *viva*. Candidates for *viva*'s will be informed the evening before at the latest. Please note that the external examiner may choose to invite a range of candidates for *viva* and nothing regarding your final mark should be inferred from a *viva* invitation.

**Assessment.** Exam marking and assessment is carried out according to the criteria below. Please familiarise yourself with these. There will be a presentation on examination matters at the beginning of the Easter Term by the Senior Examiner.

Part III SYSTEMS BIOLOGY Criteria for Marking Essay Questions in Tripos			
Mark out of 100	Class	Description	
70-100	I	<p>Work, which is excellent both in the range and command of the material covered and in the argument and analysis. Work that is excellent in its understanding of the subject; that has engaged closely with the question; that has shown some originality and treated the evidence critically; that brings in relevant material from an appropriate range of sources; and that is well-planned and complete.</p> <p>A first class mark may be awarded on more than one set of criteria: there may be a great deal of relevant information, displaying substantial knowledge and understanding; the arguments and presentation may be stylish: the approach may be original, critical or unorthodox. An upper first would be an outstanding performance, meeting all, or virtually all, of these criteria. A low first would meet at least some of these criteria.</p>	
60-69	II.I	<p>Work that shows a good broad-based knowledge of the topic and the lecture material; that is presented in an organised way; and clearly argued and focused on the set question.</p> <p>Answers at the top end of this class would often include material from outside the taught material and where relevant, from different lecture courses and would include some attempt to treat the evidence critically and to synthesise arguments. Answers at the lower end of this class would be competent, accurate in reproducing lecture material and show evidence of reading of the principal sources of published work on the subject.</p>	
50-59	II.2	<p>Work that overall shows a reasonable competence in the understanding and presentation of the relevant material.</p> <p>Answers at the top end of this class would show competent understanding of the basic lecture material or reasonable organisation and focus; an answer at the lower end would show gaps in understanding and coverage together with poor organisation and focus.</p> <p>Certain types of uneven work would fall into this class; detailed factually-correct work that did not relate a broad knowledge of the topic to the specific question asked, or work with clear organisation and some insight but with serious omissions of factual knowledge.</p>	
40-49	III	<p>At the upper end of the class, work that just shows competent knowledge of the basic, core material.</p> <p>At the lower end of the class, work that shows some knowledge of the material but with serious deficiencies in understanding, coverage and organisation. This will include work that is unduly brief or largely misses the point of the question.</p>	
0-39	Fail	Work that is irrelevant shows a considerable degree of ignorance or is short and superficial. Where the question is barely attempted.	



# Data Retention Policy (Examinations)

This policy applies to: **Natural Sciences Tripos Part III, Systems Biology**

The following data are retained by the Department of Genetics, University of Cambridge

Data on individual candidates available routinely		
<i>Data type</i>	<i>Retention period</i>	<i>Access route</i>
<b>Final University Grade Roster (Mark Book)</b> containing classes awarded, rank, total percentage marks, percentage marks for each paper or element of the examination.	Indefinitely	College DoS or Tutor, CamSIS.
<b>Minutes of Examiners' meetings</b>	Indefinitely	Department of Genetics Teaching Administrator
<b>Senior Examiner's report</b> including feedback on candidates' performance on individual questions.	Indefinitely	Faculty of Biology web site

The marks contained in the final University Grade Roster and routinely released are those that the Examiners have determined as being meaningful or helpful as indicators of examination performance.

Data on individual candidates with limited availability		
<i>Data type</i>	<i>Retention period</i>	<i>Access route</i>
Interim marks held by examiners	Destroyed immediately after the Final Examiners' meeting.	Not accessible
Examiners' comments on individual candidate's questions or components of the exam.	Destroyed immediately after the Final Examiners' meeting.	Not accessible
Marks for individual questions	Destroyed immediately after the Final Examiners' meeting.	Not accessible

At the end of the retention period, data are either destroyed or anonymised and retained in anonymous form for use in statistical analysis. Examination scripts are retained for six months but are not released to students.

Examiners and assessors are expressly instructed not to write comments on scripts.

In the case of a formal appeal, ALL data on the individual concerned that is held at the time of the formal appeal will be retained until the appeal process is complete. Data on marks and individual coursework may be retained in the case of students degrading.

Release of data under this policy does not constitute a formal subject access request under data protection legislation. Formal requests for access to all other personal data should be directed to the University's Information Compliance Office (<https://www.information-compliance.admin.cam.ac.uk/data-protection/subject-access-request>).

# Essay Writing

## Advice for writing essays on biological topics

To reiterate, the Part III is a masters-level course and you are expected to take responsibility for your learning. This includes approaching lecturers and asking for essay titles. You can also consult the past exam papers available from the course Moodle site. Some of you may have little experience in writing essays and you are strongly advised to practice! There are two types of Part III essay: those written for exam practice and in exams, and essays written to assist comprehension and revision. The guidelines below apply to both, with some comments at the end that relate specifically to revision essays.

**Starting.** Read the question carefully so that **you are sure you understand what it is asking** (beware of making a reflex response to key words). Considerable thought goes into structuring Part III essay titles so be sure you are clear at the outset about the precise areas you are asked to cover. **If the question clearly has more than one facet, ensure that your answer reflects this** and that you do not write extensively about an area that you are particularly interested in at the expense of other aspects, because you will probably be penalized.

**Plans.** There is no unique, ideal form for an essay on a given topic. However, one rule that will stand you in very good stead when writing anything is: **start by making a plan.**

- Begin with headings that indicate the major components of the story.
- Amplify these with sub-headings that reflect the specific topics you wish to cover under each major category.
- Consider the best sequence - which may change as you complete the overall design.
- Under each sub-heading note what you might use as specific examples and how best to convey the information: that is, use sketches/diagrams/graphs/tables, ANYTHING that helps to get facts and concepts across as clearly and succinctly as possible.

This process will really help you to focus on the question, decide what is to be included and, (equally important given the huge amount of information that is usually available), what to leave out, and give you a logical theme and progression to the story (any story). While there is a great temptation to stick down everything you can think of that seems vaguely relevant, it is often the case that rather than producing a structured story engaging the reader, you compile a disparate agglomeration of facts that ends up being confusing. The key thing is to convey understanding and 'feel' for the subject, not to catalogue every molecule/pathway/model.

**Writing rules.** Whilst it is more satisfying to produce polished prose, in Tripos exams in particular the dominant requirement is to convey relevant information and **your** scientific arguments.

- Don't tell the reader what you're going to do: just do it.
- Use the headings and sub-headings from your plan to introduce new topics (so you do not start each section with a bit of waffle).
- If it seems appropriate, use bullet points.



- Use generally accepted definitions and abbreviations (if you are unsure, write in full the first time and then use your abbreviation).
- Sketches/diagrams/graphs/tables are very useful, they can both save you time and improve the reader's comprehension.
- However, do not repeat in prose what is in the sketches/diagrams/graphs/tables: just use the text to expand any points arising.

The aim is to tell the reader a factual story in as clear and selectively comprehensive a manner as possible. If you can do this in an exam answer you will appear knowledgeable, critical and thoughtful. It is a well-informed mind at work that the examiners are looking for!

All of the above will have been learned in IA & IB for the biological scientists, however, these practices often seem to have been forgotten by Part III. One result of following the above strategies is that what would have been a good basic account in a IB essay can be condensed into the first page or less of a good Part III answer (using sketches, etc. to help). This permits the bulk of the essay to be devoted to the science covered in the Part III lectures and in your reading and to discussion, for example, of the current position, the critical questions and controversies and where the field is going.

### **Common problems:**

1. *How knowledgeable can I assume the reader to be?*  
Don't think about this problem. Just make the first heading the most direct point of entry to the core of the subject. For example, if the topic is 'The action of the X family of membrane receptors' a first heading of 'The Superfamily of X ligands' might be fine. Don't feel you always have to start with Watson and Crick. Even if you omit minor points, as a good essay proceeds it will become evident that this was a rational decision, not ignorance.
2. *Separate sections/sub-headings for everything?*  
The advice above to have lots of sub-headings sometimes raises the problem of 'should something go in its own section or be intercalated with other parts of the story?' You have to decide which works best for the particular question. For example, this might arise when trying to relate transgenic mouse studies to *in vitro* biochemical data and studies of human disease. One basis for decision could be 'do I just want passing references to transgenics?' or 'are they such a major part of the story that they need their own section(s)?'
3. *Experimental evidence and methods*  
Usually the intention is that you grasp the principle of a method, not memorise the molarity of every buffer. In essays this might manifest itself in discussing sets of seemingly conflicting data: why does A bind to B in an immunoprecipitate in one study but not in another? Possible answers include different cell lines used, antibodies of differing specificity, etc., which are only evident if you are aware of the experimental procedures at the relevant level of detail.
4. *How to deal with apparent contradictions in experimental evidence and arising from consideration of the literature*  
Possible explanations are that comparisons have been made between experimental procedures or systems that are not identical: these differences may be identifiable from scrutiny of the published methods (as in the example above). However, that may not be possible and significant differences may have to be inferred pending further (possible collaborative) experiments. Experimental procedures may be directly

comparable but the methods of data analysis may differ – an increasing problem with the expansion of ‘omics methods. A different problem may arise when data sets that are perfectly valid in themselves are forced into a general model that may have little physiological relevance (a particular hazard in the cell signalling field). Regardless of the specific nature of the problem, a succinct summary followed by some basic suggestions for its resolution will accrue credit.

5. *Where is the field going?*

Often the final and most difficult part of an essay. You’re unlikely to win a Nobel prize on the basis of a Part III essay but you can identify problems and even rather simple suggestions will bring you credit. For example, would an attempt at an exact replication of an experiment in a second lab be sensible? How relevant are the animal models for human disease and could they be improved?

6. *References: include or omit?*

Including ‘(Bloggs *et al.*, 2007)’ or ‘the work of Bloggs and his group...’ can help the reader and it does make the point that you’ve actually looked at papers. Don’t include the full reference: if the reader doesn’t know it they can look it up. However, if you include the appropriate information, thoroughly digested, the extent of your knowledge will be very clear, referenced or not. But don’t bluff: if the examiner doesn’t recognise the reference, they will check!

**Write or type?** It’s up to you. You have to write in the exam so practising that is obviously useful. However, you can readily amend an electronic version to produce something that is finally very polished. One problem with typing is that folk either assume that sketches/diagrams/graphs/tables are unnecessary or download them: both a mistake. *Either* leave gaps into which you can insert by hand *or* include captions and have sketches/diagrams/graphs/tables as separate pages. If you produce it electronically remember that formatting, figures and symbols may be altered when opened on someone else’s computer. Resist the temptation to paste directly: aside from the risk of your plagiarism being detected, you should practise thinking the story through and then formulating it in your own words. If you do generally type, make sure you don’t forget how to write **legibly** by hand for three hours.

**Revision essays.** A fairly comprehensive review of a subject will be very useful as the exams approach and, bearing in mind that you do not know what the exam questions are going to be, it should make you better equipped to deal with anything on that topic. However, an alternative is to assemble an integrated version of your notes and the lecture handouts together with additional reading. Whichever of the above strategies you follow, write also as many timed essays on specific exam questions as you can and get at least some of these assessed.

# Preparation of Research Project Reports

**1. Format and style of presentations, number of copies.** Project reports should generally conform to the style of a scientific journal i.e. PLoS Biology or *EMBO Journal*, except that they should include:

- a) a Table of Contents;
- b) a list of *Abbreviations*;
- c) a Summary of approximately 250 words; and
- d) an Introduction that may be slightly longer than the *EMBO Journal* model, may be divided into subsections, and may include figures or tables.

The different sections should be in the following sequence, with each section starting on a new page, however, we recognise that it is sometimes better for the presentation to describe methods before results: Title/Cover Page; Summary; Table of Contents; List of Abbreviations; Introduction; Results; Discussion; Materials and Methods; Acknowledgements; References.

We recognise that PartIII Sys Biol projects cover a wide range of subjects and techniques and may necessitate different approaches to presenting the results. **As long as each of the sections is included there will be no penalties for the order they are presented.**

**The dissertation should not exceed 6,000 words. This total excludes:** references, figures, figure legends, tables, table headings, abbreviations, acknowledgements and tables of contents. Students who overstep this limit significantly are likely to be penalized. Extensive appendices are not permitted but you may, for example, have supplementary material with code you have written, gene lists, etc. You should not include large amounts of text in the excluded items as a way of circumventing the overall word count. Normally, a good project report would have at least 25 references.

The dissertation should be typed. The text should be in 1.5 spacing or double-spacing, except for the figure legends and the reference list, which should be single-spaced. Times New Roman or Ariel, 12 pt, are the recommended fonts. The pages should be serially numbered.

You must submit a PDF of the complete dissertation on deadline day to [sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk).

**2. Declaration. You are strongly advised to read the statements on plagiarism from the University and the Faculty of Biology and at the end of this handbook:**

<http://www.admin.cam.ac.uk/univ/plagiarism/students/statement.html>  
<https://www.biology.cam.ac.uk/exams/AllExams/plagiarism>

The University's regulations: Ordinances, Chapter II Section 17, regulation 6 <http://www.admin.cam.ac.uk/univ/so/2010/chapter02-section17.html#heading2-15> require you to abide by the statements on plagiarism and include a signed declaration about the work. The following form of words should be used:

*I understand the University's definition of plagiarism. I declare that, in accordance with Discipline regulation 6, this dissertation is entirely my own work except where otherwise*

*stated, either in the form of citation of published work, or acknowledgement of the source of any unpublished material.*

**You should insert into your dissertation a page containing your name, your College, the title of the dissertation and the above declaration, which you must sign and date, this should be included immediately after the Cover Page (see next section).**

You must also include a note on this page explicitly stating if any experiments have been done on your behalf. For example, this might be where an experiment involved the use of complex equipment requiring special training and a postdoctoral researcher did the experiment for you to save time. This is a standard requirement for PhD and similar dissertations.

### **3. Cover page** See below

**4. Help from your supervisor** You are actively encouraged to show an early draft to your supervisor for their comments, and then, if need be, to show your supervisor a near-final version at a later date. Some supervisors may prefer to see drafts section by section, whereas others may prefer to see the work as a whole - please make appropriate arrangements with your supervisor ahead of time. If you do present your draft in sections, remember that you cannot expect to get informed criticism of the Results section unless it is accompanied by at least a rough version (e.g. a photocopy of an autoradiograph, or a sketch of a graph) of the data you intend to show plus a draft of the accompanying legend. Please also remember that supervisors have other duties and commitments, and may not necessarily be able to read your work at the drop of a hat.

The role of your supervisor is to advise, but **not** to act as a proof-reader. Use a spell-check programme before you present the draft to them. If you are consistently making the same mistake, don't expect your supervisor to mark **every** instance of this error; if one or two instances are identified, it is up to you to find and correct all the others.

Supervisors will be asked to state how much help they have given with the write-up. This should **not discourage** you from seeking their advice, but please do ensure that you provide them with a decent first draft. If it is full of mistakes or spelling errors, requiring a lot of attention, the supervisor is required to notify the Examiners of this in their report and the Examiners may take it into consideration.

**5. Project Assessment** Your supervisor will be requested to give a report and offer a mark on your report and on your performance in the laboratory. Your dissertation will also be read separately by an Examiner, who will provide an independent mark.

**6. Submission deadline** A draft of the project write up should be provided to supervisors by **Fri, 8<sup>th</sup> April 2021**. Two copies of research project dissertation **must** be handed to the course administrator [sysbiol-admin@gen.cam.ac.uk](mailto:sysbiol-admin@gen.cam.ac.uk) by **12.00 noon Wednesday 28<sup>th</sup> April 2021**.

Any leave for extension can only be granted by the University Council, via its Applications Committee, in response to an application made by a student's Tutor. You are therefore strongly advised to allow a safety margin for technical problems such as computer or printer malfunction which might lead you to overrun the deadline. Contact your College Tutor immediately if it appears that late submission may be inevitable.

# Guidance on individual sections

**1. General advice.** The order in which you write up the various sections is, of course, up to you but we recommend that you think of adopting the following order of priority:

*Results, Figures and figure legends; Discussion; Summary; Materials and methods; Introduction; References; the remainder.* It is often a good idea to have more than one section "on the go" at any one time, so that if you get "writer's block" on, say, the Results section, you can at least be getting on with the more mundane Materials and Methods in the meantime.

**2. Cover (title) page** The cover page should only include:

- a) your **Name**;
- b) the **title of the project**, which need not necessarily be the same as the title under which you started the project
- c) the **name of the official supervisor** of your project, and the name of the person who did most of the day-to-day supervision if this is different;
- d) a **statement confirming the number of words** contained in the thesis, which must not exceed 6,000 (excluding references, figures, figure legends, tables, table headings, abbreviations, acknowledgements and tables of contents).

**3. Summary** This should give a concise account of the problem you studied, what approaches (in outline) you took, and what your major findings were. Avoid superfluous minor details, but do try to make the main points absolutely clear. Aim at a limit of ~250 words, a little more than the *EMBO Journal* normally allows. Be careful that the Summary does not claim that more was achieved than actually was! Examiners are more likely to understand a shortfall in attainment than to respond favourably to exaggerated and unjustified claims. A Summary must be a 'stand-alone' section, fully comprehensible even if the reader doesn't have the rest of the work to hand. Thus, non-standard abbreviations should not be used unless they are defined within the Summary, and references must not be included unless they are also cited in full (authors, year, journal name, volume and pagination) in the text of the Summary.

**4. Table of contents.** This is a brief index to help readers orient themselves. It should give page numbers and is therefore best prepared when the rest of the dissertation has been completed. A useful convention is to number the first pages - covering the Summary, Table of contents itself, and Abbreviations - as (i), (ii), (iii) etc, and to start the Arabic numerals with the first page of the Introduction. Be careful about consistency in the use of upper and lower case for the titles of subsections, and therefore also in the Table of contents. You will see that in the *EMBO Journal*, the titles of subsections are in lower case.

**5. Abbreviations** The list should not include widely accepted abbreviations such as ATP, DNA, RNA, etc. It is also not strictly necessary to include commonly accepted abbreviations such as EDTA, EGTA, Tris, HEPES, etc. On the other hand, do not forget to include abbreviations which, even though they may be in very common use in the particular laboratory where you did your project, are not standard, generally recognised, abbreviations. It is a good idea to consult your supervisor if in doubt and to look at some recent published papers on the same topic.

Abbreviations should ideally be defined twice: once in the abbreviation list, and again at the point they first appear in the text. Please ask yourself whether any abbreviation you

use is really necessary. If used only two or three times in the whole dissertation, it is probably better spelled out in full each time.

**6. Introduction** When writing the Introduction, and indeed the whole dissertation, bear in mind the readership at which you are aiming. As a general principle you should assume that the reader is: (a) intelligent; (b) has a broad general knowledge of systems/molecular biology; (c) is at least vaguely aware of the problem you have been investigating; but (d) may lack any detailed appreciation of the topic. Thus, the Introduction should **not** be a comprehensive review of the whole field of research in which your project fits. It should cover: the background to the problem you studied; how this relates to other major questions in the field; what was known before you started; why the particular problem was considered to be worth investigating; how you decided to set about it and why you chose that approach. Above all the reader must be left in no doubt as to the aims of your project. Given the constraints of the word-limit, you cannot afford to make this too long; certainly no more than about 20% overall, with perhaps up to about 2 figures or tables.

The Introduction to *EMBO Journal* papers usually ends with a couple of sentences that briefly state what was studied and what was discovered. Remember that the reader will already have read the Summary, so these closing remarks should be no more than a succinct reminder. You may find it useful and reader-friendly to divide your Introduction into sub-sections with separate sub-headings. Likewise, a diagram or two, or a table, can be included if this would be helpful to the reader.

**7. Results** It is often best to present the results in chronological order, but this need not necessarily be the case. The overriding consideration is that they should be scientifically logical and, if hindsight indicates that you should have done the experiments in a different sequence, present them in the more logical sequence.

Beware of presenting too many negative results. On the other hand, semi-failures or unexpected results, which caused you to modify the protocol in a way that eventually lead to success, should be shown. As much credit will be awarded for showing logical scientific reasoning in your efforts to overcome technical problems as for getting the perfect result on the very first attempt.

If a given experiment/analysis was repeated a few times, with more or less the same outcome on each occasion, there is no point in showing the results of every such experiment. Just show the "typical" result, but mention in the text that you had obtained essentially the same result in, say, four different experiments (otherwise the sceptical reader may have doubts about whether you did it only once and whether the result is reproducible). Remember that you don't need to show every single result. Sometimes it is appropriate simply to state a result in the text, accompanied by "(data not shown)", provided this isn't used too often (otherwise suspicions are aroused!). Obviously it must **not** be used in respect of a result that is absolutely pivotal to your final conclusions!

Assuming that you have a separate Discussion section you should avoid extensive discussion and speculation within the body of the Results section. On the other hand, do not go to the other extreme of a bald presentation of the results with no "interpretation" whatsoever. In general, the most reader-friendly style is to have a couple of sentences explaining why the results of the experiment you have just described prompted you to try the experiment that you are going to describe next.

If and when the logical sequence of presenting your results takes you in a new direction, it is helpful to have a separate sub-heading. This alerts the reader that you about to go into new territory, which may well be related to what has gone before, but is not simply a continuation or more of the same. Again, a glance at the *EMBO Journal* will show you that in almost every paper, the Results section is divided by sub-headings and is not presented as a continuous block.

For purely computational projects, by and large you should adhere to the same model when presenting your result, rather than PCR assays you will have modelling simulations or particular pieces of computational/bioinformatics analysis.

**Presentation of data** All Figures and Tables **must** have a legend. The legend may start with a sentence which is really a title - and thus can be ungrammatical in not having a verb, e.g. "The influence of RNA concentration on the efficiency of translation dependent on the poliovirus IRES"; or it can be a statement, e.g. "The fidelity of mRNA translation decreases with increasing RNA concentration". What follows the title should be a **brief** description of the experimental conditions/model/computational analysis for the particular experiment, such that when read in conjunction with the Materials and Methods section, the reader is left in no doubt as to what was actually done. The legend should also make quite clear what is being shown – gel photograph, model output, etc

The legend should preferably be placed immediately below - and on the same page as - the figure itself. If a figure occupies a whole page, the legend should be on the facing page opposite. Figures collected together at the end of the report **ARE NOT** a good idea and, with modern word processors or typesetters such as LaTeX, there is no excuse for not embedding Figures and Tables in the results section.

For **line graphs**, make sure that the **axes are labelled** to show not only what parameter is being varied, but also the units in use. For example, the x-axis might be labelled: "Enzyme concentration ( $\mu\text{g/ml}$ )", or "Time (min or h or days)"; and the y-axis might be labelled: "[ $^{35}\text{S}$ ]methionine incorporation (cpm or nmol)"; "Product concentration (nM)", and so on. Another reader-friendly virtue is to make the symbols consistent from one graph to another. For example, if you use open circles (o) for the control, and filled (blackened-in) circles for the experimental ("something added") curves in Figure 1, don't switch to blackened-in triangles for the control and open triangles for the experimental in Figure 2 unless there is a compelling reason to do so.

Again there are two ways of "labelling" different plots on the same graph. It can be done entirely within the legend by a succinct description of which symbols refer to what conditions. Or the curves can be labelled on the graph itself, provided this can be done neatly and unambiguously. Again, both methods of identifying each curve can often usefully be used in a single figure. The same principles apply for labelling **histograms**. For **micrographs**, make sure that the scale is indicated (usually by a scale-bar), and that important features are highlighted by labelled arrows.

If you are unfamiliar with any of the various computer drawing or graphics program packages available, hand-drawn graphs and diagrams annotated by hand are perfectly acceptable provided that they are clear and legible.

**8. Discussion.** What your reader wants here is a very brief recapitulation of your major conclusions and the evidence that supports them. A common mistake is to reiterate, at too great length, points you have already made in the Results section.

You should discuss how your results relate to previously published work, and to the ideas and models currently favoured in the field. Beware of over-interpreting your results, and claiming that you have established more than is in fact the case (see remarks under 'Summary' above). Speculation is permissible, provided it is modest, and provided you make it quite clear to the reader that you are speculating. You may also make suggestions as to how your experiments might be improved and refined. And it is a good idea to explain what further work you would have done if you had had more time. (In this respect a project dissertation **can legitimately differ from a published paper**, since your project had an arbitrary cut-off point, whereas papers are published only when the time and data are ripe.)

**9. Materials and methods** A common mistake is to make this section unnecessarily long and detailed. It **must** contain the minimum information necessary for someone (your successor, perhaps) to repeat the experiments or computational analyses. Thus if you followed exactly the supplier's recommendations (e.g., for restriction enzymes, or Qiagen columns), a standard published method, or default settings on a software tool then it suffices to say just this and to cite the reference. However, if you modified the published method or used custom settings in a software tool, you should briefly describe these modifications. When citing published standard methods, it is useful and reader-friendly to drop a hint as to the nature of the method. For example, instead of "Protein concentration was estimated by the method of Jones (1980)", it is better to say "Protein concentration was estimated from the A<sub>280</sub> as described by Jones (1980)" or "ClustalW was used for protein alignments with the default parameters (Thompson et al 1994)"

Unless you are following a published protocol to the absolute letter, you should list the compositions of the reagents you used, since these do vary slightly between different practitioners. Common mistakes include:

- use of 10ml and 50mM: it should be 10 ml and 50 mM
- use of sec. or mins: it should be sec or min or h (no plurals and no full stops)
- the use of jargon, such as "kinasing the oligos" ("to kinase" is not a recognised verb, and "oligo" is likewise jargon).

If in doubt, leaf through the pages of *EMBO Journal* for appropriate models and examples.

**10. References** The style of citation of references in the text, and the presentation of the reference list at the end, should conform either to the Author-Date style exemplified by *EMBO Journal* OR the numerical system used by PLoS journals (i.e. PLoS Biology). Study some papers in that journal to see what is expected.

**11. Permissible Variations** It is sometimes better to amalgamate the Results and Discussion sections. It is difficult to make hard and fast rules about when and if this would be an advantage. The deciding factor is whether it would make the dissertation easier to follow. We advise starting out with the intention of having separate Results and Discussion sections. If the first draft shows that the outcome would be more "comfortable" if the two were amalgamated, then you can copy-paste various parts of the Discussion into the appropriate different places of the Results.

In scientific writing, the passive is more conventional than the active voice (e.g. "...the reaction temperature was increased..." rather than "...I increased the reaction temperature..."). However, there is an argument that the active voice provides more information, as it makes clear who did the experiment. Either is acceptable in your dissertation, but in any case you must ensure you are consistent throughout.

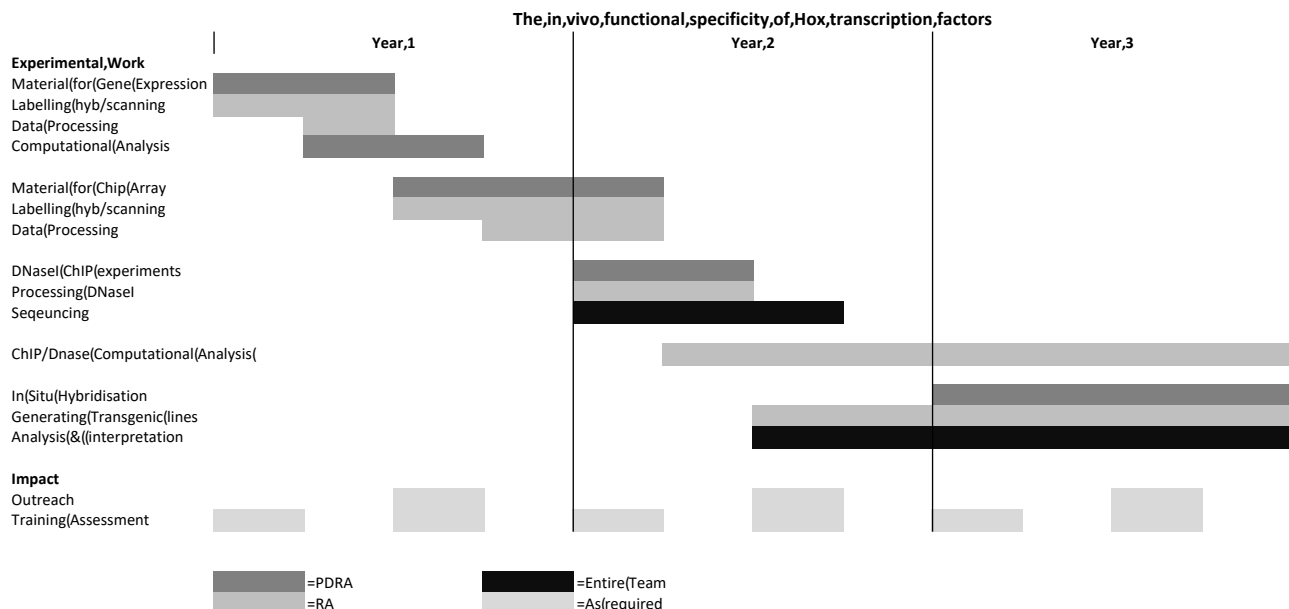


# Writing an outline grant proposal

In paper 4 of the examination you will be asked to write an outline grant application on one of three suggested topics, many students are daunted by this prospect and we will give you a short lecture on what is expected in the Easter term. In brief, this is like a structured essay question aimed at testing your knowledge of the methods and approaches you have been taught during the course, bringing them together to design a set of experiments to address the biological question. You are encouraged to be imaginative! In terms of structure we expect to see something along the following lines:

- Background
  - This is an important problem because.... this is what we already know and we now need to know the following.....
- Objectives
  - To address this problem we will ask the following questions: a), b), c).....
- Plan of Investigation
  - To answer these questions/tackle the objectives, we will do the following experiments: a), b), c)...and learn X, Y and Z
- Outcome
  - A brief summary of what the work hopes to achieve to advance the field
- Resources
  - To perform the experiments/analyse the data need this many people, this bit of specialised equipment and these consumables/costs.
- Gantt Chart
  - A graphical plan of how the objectives will be progressed over the course of the grant.

A Gantt chart (named after Henry Gantt).



NB: there are some successful grant application written by your lecturers on the Moodle for you to familiarise yourselves to what grant writing is all about.

# Course Management

There is a management committee that monitors the progress of the course and provides an avenue for students to raise any concerns they have. The committee meets once per term, towards the end of term, and an agenda is circulated in advance.

Two student reps represent the Part III class and volunteers will be sought at the start of the course. We do listen to student feedback and respond to all issues raised. At the end of the course we collect feedback and the students also have the opportunity to meet with the External examiner in private to voice any concerns they have about the course. Such concerns are raised in the External Examiners independent report.

Any student who has issues or difficulties with the course may contact the Course Organiser at any time.

## Management Committee

Dr Pietro Cicuta	Physics
Dr David Huen	MAN Module Organiser
Dr Gos Micklem	MIB Module Organiser
Dr Juan Mata	DAH Module Organiser
Prof Steve Russell (Chair)	Course Organiser & INT representative
2 Student Reps	

# Syllabus

## Module INT: Induction Course

The aim of the INT module is to introduce a group of students from a range of backgrounds (biological and physical sciences, mathematics, computer science and engineering) to the basic concepts and theories along with the modelling and experimental techniques underpinning Systems Biology. Students from all backgrounds will be taught together, rather than separating the biological scientists from the rest. This will enable students with complementary expertise to help one another and will expose all students to the full range of viewpoints concerning how the study of living systems may be approached.

### **Learning outcomes**

- An understanding of the differences between biological and physical systems
- Knowledge of the different kinds of large-scale data sets generated in Systems Biology and of the approaches used to handle them
- A familiarity with the kinds of biological and mathematical tools employed in Systems Biology
- To ensure a common standard of maths knowledge for the rest of the Part III course. It will not be possible to educate all students to the same level in such a short course but this will provide a basis of common knowledge that the lecturers can assume for future courses.
- To introduce computer programming and provide practice with key software (Matlab and R).

### **The Nature of Biological Sciences**

**INT1.1- 1.4**

The unity and diversity of life; Macromolecules of life  
How do we study biology? Observation & experimentation  
Genetics; Manipulating genes & genomes; Molecular biology & Molecular machines; Model organisms

### **What is Systems Biology ?**

**INT1.5-1.6**

The virtuous cycle & prediction; Technology; Complexity & non-linearity; Modelling; Synthetic biology

### **The Nature of Biological Sciences & Biological Data**

**INT1.7**

Structural Biology; From protein sequence to structure; Sequence similarity and conservation; Methods in structural biology

### **Genomics**

**INT1.8**

'Omes & 'Omics; Transcriptome analysis; Functional analysis of the genome

### **Proteomics**

**INT1.9**

Proteomics concepts & definitions; Proteins & the proteome; Proteomics tools  
Mass spectrometry; Fractionation; Databases & software

### **Metabolomics**

**INT1.10-1.11**

Flow of energy & matter; Thermodynamics & living systems; Entropy & Gibbs free energy; Metabolic networks and pathways; Reduction & Oxidation; Catalysis & enzyme kinetics; Control

**Big data & multivariate statistics****INT1.12-1.13 & 1.16**

Data &amp; normalisation; Standards &amp; integration; Machine learning; The Cloud

**Regulatory Networks****INT1.14-1.15**

Structure evolution and dynamics of regulatory networks; Transcriptional regulatory networks motifs and scale-free structures; Hierarchy and node-dynamics; Alternate networks and multi-dimensionality

**Modelling & Networks****INT1.17 & 1.18**

Molecular interactions; Capturing and predicting physical interactions; Interaction databases; Epistasis; Experimental analysis of interaction networks; Graph theory &amp; graphical representations of molecular interactions

**Metabolic control analysis****INT1.19 – 1.20**

Pathways, systems and their properties; Flux; Empirical &amp; mechanistic models; Exploiting metabolism

**Modelling in biology****INT1.21 – 1.22**

What is a model; Types and scale of model; Dynamic, Boolean, Quantitative ODEs; Parameterisation

**Basic Maths****INT1.23, 1.26, 1.30, 1.33**

Introductory and advanced R

**INT1.29**

Introduction to MATLAB

**INT1.24, 1.25, 1.27 & 1.28**

Linear Algebra; Vectors; Matrices; Systems of linear equations; Eigenvalues and eigenvectors

**INT1.31 & 1.36**

Functions: Drawing, differentiation and integration

**INT1.32 & 1.37**

Differential equations: Simple rates of reaction; Directly solvable equations; Fitting to solve complex equations

**INT1.34 1.35**

Elementary probability; Exponential and Poisson distributions.

## Module DAH: Data Acquisition and Handling

Systems biology relies on the ability to obtain a 'global' view of the physiology of a cell by the simultaneous identification and quantification of thousands of different molecules (such as proteins, nucleic acids and metabolites). This module will present the techniques used to acquire data in the various 'omics' approaches (transcriptomics, proteomics and metabolomics), as well as in high-throughput genetics. Because of their size and experimental limitations, the handling of these datasets presents unique challenges. Therefore, the module will emphasise the practical aspects of dealing with this type of data. Large-scale approaches are generally applied to cell populations, and often lack spatial and temporal resolution. The module will introduce how they are complemented by single-cell genomics, and by *in vivo* analysis of single cells using advanced microscopy, which can provide information on cell-to-cell variation.

### Learning outcomes:

- Knowledge of methods used to acquire large scale 'omics' data
- Ability to retrieve, handle and process large-scale datasets
- Understanding of basic approaches for the analysis of systems biology datasets
- Familiarity with single-cell approaches used in systems biology

### ❖ DAH1, Genomes

- **DAH1.1 Genome sequencing**
  - Sequencing technologies & strategies
  - Sanger (Shotgun v clone based)
  - Ultra-High Throughput (Illumina/Nanopore/PacBio)
  - Advantages and disadvantages of each approach
  - Data quality, Processing and evaluating raw sequence data
  - Naïve and reference genomes
  - Data management
  - Assembly of traditional & UHT sequence data
- **DAH1.2 Genome annotation and curation**
  - Importance of biocuration for systems biology
  - Creating and accessing "parts-lists"
    - Identifying biological sequence features
    - Feature description and data exchange
      - Building ontologies
      - Databases & sequence display
  - Applying ontologies
    - Functional curation using GO (Basic and extended)
    - Analyses using curated data
      - Enrichments
      - Ontology subsets (e.g. Slims)
      - Building curated networks
- **DAH1.3: Handling multiple genomes**
  - Multiple sequence alignment
  - Tools and resources
  - Comparative genomics
- **DAH1.4: Practical - Tools and resources**

## ❖ DAH2, Gene regulation

- **DAH2.1 Gene expression**
  - Principles of gene expression profiling
  - Sample treatment and labelling
  - Experimental designs
  - Basics of variance statistics, loops, linear & reference design
  - Expression databases, data extraction & deposition
- **DAH2.2 Practical - Normalisation principles and methods**
- **DAH2.3 Chromatin**
  - ChIP/DamID/ChIP-Seq
  - Experimental designs
  - Extracting data & peak-finding
  - Visualising ChIP data
- **DAH2.4 Practical - Meta analysis**
  - Assessing significant changes
  - Statistical power
  - Unsupervised analysis
  - Supervised methods
- **DAH2.5 Post-transcriptional regulation**
  - RNA-binding proteins and posttranscriptional networks
  - Genome-wide translational control
  - RNA turnover and localisation

## ❖ DAH3, Proteome

- **DAH3.1 Mass Spectrometry**
  - Basic principles of protein analysis
  - Types of mass spectrometers
  - Proteomics workflows
  - Database searching
  - Analysis of post translational modifications
- **DAH3.2, Practical Evaluating MS data, identification, quantitation and post translational modifications**
- **DAH3.3 High throughput quantitative proteomics**
  - Shotgun proteomics
  - Label free quantitation
  - In vivo and in vitro stable isotopic labelling
  - Absolute quantification and targeted methods
- **DAH3.4 Protein Interactions, spatial proteomics and function**
  - Protein interactions using genetic approaches
  - Protein interactions using mass spectrometry methods
  - Sub cellular localisation via microscopy or proteomics
  - Protein arrays, antibody arrays, functional assay arrays
- **DAH3.5 Multiscale molecular dynamics simulations of proteins and biomolecular complexes**
- **DAH3.6 Molecular dynamics simulation of a protein in solution**

## ❖ DAH4 Metabolome (2 Lectures + 1 practical)

- **DAH4.1 NMR & Mass Spec**
- **DAH4.2 Data acquisition and processing**

- **DAH4.3 Practical Meta analysis**
  - Multivariate statistics
  - Validation
  - Biological and clinical applications of MALDI imaging
- ❖ **DAH5 Genetics**
  - **DAH5.1 RNAi**
    - Genome wide RNAi in metazoans: principles & problems
    - Off target effects
    - RNAi v siRNA
    - *C. elegans*, *Drosophila*, mammalian cell culture
    - HTTP screening methods
    - Evaluating reliability
  - **DAH5.2 – 5.3 Single-cell studies**
    - Why single-cell biology
    - Single-cell RNA-seq
    - Human Cell Atlas
- ❖ **DAH6 Imaging**
  - **DAH6.1-6.2 Imaging techniques**
    - Confocal microscopy
    - Real-time acquisition
    - Visualising biomolecules

# Module MAN: Mathematical modelling and analysis of networks

The module will focus on mathematical and statistical methods for the analysis of metabolic networks, gene-regulatory networks, and large-scale networks.

## **Learning outcomes:**

- Knowledge of statistical methods used to stratify large data sets & divide them into classes.
- Ability to model dynamic biological systems using ordinary differential equations
- Knowledge of basic network theory
- Ability to reconstruct biological networks from primary data

### **❖ MAN1 – Tools for data analysis**

- 1.1/1.2 – Linear algebra
- 1.3-1.6 – Data analysis
- 1.7/1.8 – Further probability
- 1.9-1.13 – Bayesian analysis

### **❖ MAN2 – Network approaches to biology**

- 2.1/2.2 – Flux balance analysis
- 2.3 – Graphical models
- 2.4 – Biological networks

### **❖ MAN3 – System modelling**

- 3.1-3.5 – Deterministic modelling
- 3.6-3.9 – Stochastic modelling



# Module MIB: Modelling in Biology

This module aims to introduce students to the *de novo* design of biological systems using techniques of Synthetic Biology, as well as modelling and analysis of biological phenomena using techniques such as Executable Biology. The theory and practice of Synthetic Biology is introduced both in the context of designing exemplar biological systems to test our understanding of natural systems and in that of systems design and fabrication to produce novel devices of commercial or medical utility. The design and analysis of executable biological models using computational techniques is then introduced in order to gain new insights into the molecular mechanisms operating inside cells and test system dynamics. Finally, the two strands of the module are integrated by an exercise in which students either design a system and test its feasibility by computer simulations or build a model describing a biological process and analyse its behaviour.

## **Learning outcomes:**

- Understanding of the design principles involved in Synthetic Biology.
- Familiarity with “bio-bricks” and other systems components.
- Understanding of basic approaches to the design and execution of computer models to simulate biological systems.
- Ability to design a biological system using standard components, build a computational model of that system, simulate and analyse the behaviour of the system computationally.

## ❖ **MIB1: Synthetic Biology**

- MIB1.1: *Introduction to Synthetic Biology.*
- MIB1.2: *Parts and assembly*
- MIB1.3: *Examples and applications I: repressilator, intrinsic vs extrinsic noise, photographic bacteria.*
- MIB1.4: *Examples and applications II*

## ❖ **MIB2: Particle-based simulations**

- **MIB2.1 Particle-based simulations**
  - Spatial vs. non-spatial simulations
  - Stochastic vs. deterministic simulations
  - Methods for spatial, stochastic simulations: Spatial Gillespie, microscopic lattice, particle-based
  - Particle-based algorithms
  - Introduction to the design and use of the particle-based simulator Smoldyn
- **MIB2.2 Practical: Smoldyn I**
  - Building a model of an *E. coli* cell and its chemotaxis signalling pathway in Smoldyn.
- **MIB2.3 Smoldyn II**
  - Examples of scientific studies using Smoldyn models, focusing on bacterial chemotaxis and the yeast nucleus.
- **MIB2.4 Practical: Smoldyn III**
  - Advanced applications of the Smoldyn chemotaxis model: quantification of experimental data; in-simulation responses.

### ❖ **MIB3: Executable Biology**

- MIB3.1 *Introduction to Executable Biology*
- MIB3.2 *Boolean Networks*
- MIB3.3 *Practical: BioModelAnalyzer tool*
- MIB3.4 *State-based models*
- MIB3.5 *Visualisation of executable models*
- MIB3.6 *Pi Calculus models*
- MIB3.7 *Hybrid models*
- MIB3.8 *Practical: Introductory Unix*
- MIB3.9 *Programming executable models*
- MIB3.10 *Practical: Programming executable models*

### **MIB4: Design and Simulation Mini-Project**

# University of Cambridge Part III Systems Biology

## Interim Progress report on Part III Research Project

Name of student:

Name of supervisor:

Name of day-to-day/deputy supervisor:

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Please briefly summarise the students' progress and indicate any major difficulties:

Signed:

Date:

Please return the completed form by Friday 22<sup>nd</sup> Jan 2021 to Helen at  
[sysbiol@gen.cam.ac.uk](mailto:sysbiol@gen.cam.ac.uk)

# Plagiarism

## Summary guidelines for Part III Systems Biology students

*"Plagiarism is defined as submitting as one's own work, irrespective of intent to deceive, that which derives in part or in its entirety from the work of others without due acknowledgement; or, in the case of self-plagiarism, unless explicitly permitted by regulation, submitting one's own work that has already been submitted for assessment to satisfy the requirements of any other academic qualification, or submitted for publication without due acknowledgement. It is both poor scholarship and a breach of academic integrity."*

Please view the following brief description of plagiarism and how to avoid it at:

<https://www.biology.cam.ac.uk/exams/AllExams/plagiarism>

General University of Cambridge guidelines can be found at:

<http://www.admin.cam.ac.uk/univ/plagiarism/students/statement.html> with further details at <http://www.admin.cam.ac.uk/univ/plagiarism/students/>

It is an essential part of your scientific training that, in your supervision work and any other writings, you ensure you follow best practice regarding avoiding plagiarism. It is an important aspect of academic integrity to cite all sources on which you base your work (even if it is not copied directly from them), be they published in hard copy or web based. Please note that the use of essays purchased from any source or copied from other students is unacceptable regardless of whether the source is acknowledged.

## Coursework

Guidelines for citation are provided with the instructions for writing your Part III project dissertation. The Board of Examinations has issued guidelines on plagiarism and can be found at <http://www.admin.cam.ac.uk/univ/plagiarism/>

## Unseen written examinations

Full citation is not expected in written unseen examinations such as those taken at the end of the Part III Course. If you still have questions, you should talk to your supervisors and/or Director of Studies and/or your course organiser.

## Use of Turnitin in Part III Systems Biology

The Systems Biology Course Management Committee have agreed that the following procedure agreed by the Biological Sciences Committee of the NST will be applied to submitted work in Part III.

*"If, during marking by an examiner, plagiarism is suspected in a piece of submitted work, the work will be marked as normal and then turned over to the Senior Examiner. The electronic version will then be passed on to the Scrutiny Officer within the*

*Department/course for checking with Turnitin. If analysis by Turnitin supports initial suspicions of plagiarism, the Chair of Examiners will be informed, who will proceed as per the advice given by*

<http://www.admin.cam.ac.uk/univ/plagiarism/examiners/detection.html> ”

The Course Management Committee also agreed that a Senior Examiner may, for the Project report “*submit all students work for analysis by Turnitin this will be done automatically on any piece of work once it is submitted. If this option is chosen, there will be an academic appointed as a ‘Scrutiny Officer’, whose role will be to analyse the reports resulting from the Turnitin analysis. **This Officer will not be involved in the academic assessment of the work in question.** If analysis by Turnitin reveals suspicions of plagiarism, the Chair of Examiners will be informed, who will proceed as per the advice given at:*

<http://www.admin.cam.ac.uk/univ/plagiarism/examiners/detection.html> ”

Updated guidance is now available and this will be followed

<http://www.admin.cam.ac.uk/univ/plagiarism/examiners/investigative.pdf>

You will also be required to submit an electronic copy on the course Moodle site of each item of course work, as well as the hard copies that are required. At the time of submission, you will be asked to sign a declaration, “which confirms that the electronic version is indeed the file that is printed out in the hard copy.” Full details of how to submit the electronic copy will be distributed along with coursework guidelines.

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**Please note that consent forms are no longer required (since 1<sup>st</sup> October 2016)**

<http://www.admin.cam.ac.uk/univ/plagiarism/examiners/detection.html>

Queries about plagiarism or the Faculty’s use of Turnitin UK should be addressed in the first instance to your Director of Studies or College Tutor.

**Timetables will be uploaded separately**