Department of genetics

Part II Genetics

Contents

What is Genetics?

Genetics is the most fundamental of the biological sciences – it underpins all of biology and all biomedical research. It is the core discipline for understanding that grandest of phenomena – evolution - and, as the famous evolutionist Dobzhansky once said, 'Nothing in biology makes sense except in the context of evolution'

Just before you were born, the Head of the Medical Research Council Laboratory of Molecular Biology in Cambridge, Sydney Brenner, predicted 'Genetics will disappear as a separate science because, in the 21st century, everything in biology will become gene-based, and every biologist will become a geneticist' [*Trends in Genetics* 9:104, 1993].

Modern genetics encompasses an enormous diversity of topics. These can be divided into two broad categories: function, how the genetic blueprint operates during the lifetime of an organism; and evolution, how the genetic systems we see today have come about.

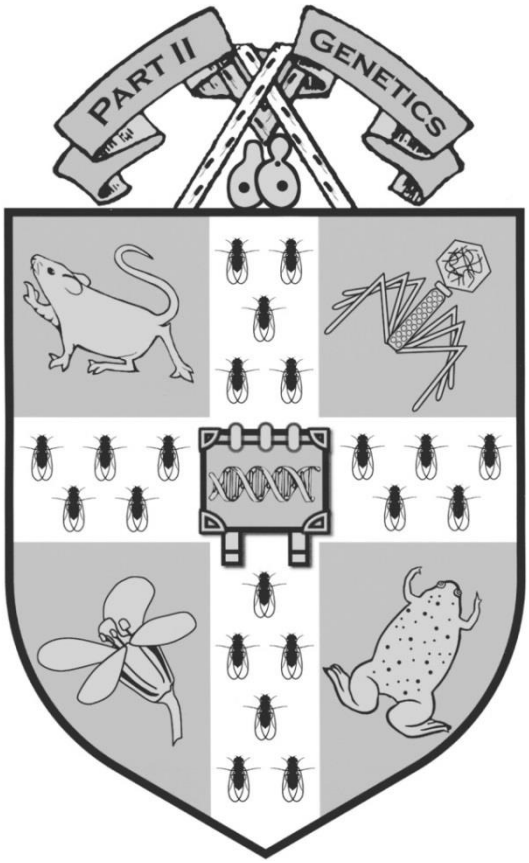
Function can be studied at many levels. At the level of the genome, we are interested in how DNA is copied, transcribed and repaired, how genes work and how chromosomes are organised. During development, we would like to know how groups of genes work together to orchestrate cell division and differentiation. The end-product is an adult organism whose behaviour, physiology, morphology and ecology are determined by a complex interaction between the environment and the genes it carries. Disentangling the effects of genes and environment is a further area of interest.

All organisms are the product of **evolution**. To understand the overall biology of an organism we must appreciate both the evolutionary steps that shaped it and the forces that are acting to change or maintain it now.

Sydney Brenner's prediction has proved to be largely correct, with genetics one of the most important disciplines in both the basic and biomedical sciences today. Several other Part II courses cover some aspects of Genetics, but we offer a broad grounding in the subject, which will equip you for a wide range of careers, both in and outside science.

'Genetics is the most exciting subject to study. It was so 40 years ago when I started, and it is even more so now, a time when the complete genomic sequences of organisms for bacteria to humans are being made available' *Professor Michael Ashburner FRS*

The Genetics Department and the Part II Class



As a Department, Genetics is small, friendly and has a much less formal atmosphere than many larger Departments. Final year students become integrated into the life and work of the Department and interact daily with the academic staff. Our Part II class has averaged about 30 students for the past few years - small enough for the entire class to know each other and to be known to the staff, but large enough to make an impact on the Department and not disappear between the cracks.

The familiar atmosphere of the Department gives students easy access to staff and arranging supervisions, or more informal meetings, is straightforward.

A large recently-refurbished seminar room is set aside for the use of the Part II course, and an in-house library is shared among all members of the Department - although the majority of users at any one time are usually Part II students. The library has a wide range of books and journals, and computer links to the necessary e-resources.

These facilities allow students to ensconce themselves in the Department during the day. The departmental tea room is shared by all members of the department, including of course Part II students, and this encourages a sense of belonging and familiarity.

Despite its small size, the Department of Genetics has been rated highly by stringent external reviewers, both for its research and teaching. The Department houses a wide spectrum of interests, with a common theme being the application of genetic tools to the understanding of biological problems. Areas of interest include cell and chromosome biology, mammalian developmental biology, insect and worm development and neurobiology, plant development, microbial genetics and various aspects of evolutionary biology. The breadth of interests of the Department means that it is possible to obtain tips and contacts in a wide range of research areas, which could help with your career planning. For more details, please see 'Research in the Department of Genetics' on page 16, or: http://www.gen.cam.ac.uk/research-groups

Genetics Part II logo above designed by Luke Cahill (Part II 2011/12)

Course aims and objectives

The Genetics Part II course aims to provide both a **broad overview** of the subject, and to give you an opportunity to study some selected areas **in depth**.

During the year, we aim to give you:

- A thorough grounding in the theoretical and practical foundations of basic genetics.
- An appreciation of the breadth of genetics; how genetics is applied in other disciplines.
- Detailed knowledge of selected areas.
- The chance to discuss and think about moral and ethical questions arising out of the applications of genetics to modern life, e.g. genetic counselling and GMOs.
- Experience of research through a term-long project working within a research group.
- The ability to muster information about a topic, to critically assess it, and to communicate this information effectively in speech and writing.

What does the course entail?

The course is organised into **5 modules**, each being made up of 20-24 lectures, accompanied by one or two seminars or discussion sessions. These modules aim to cover the range of genetics from cellular to organism level, and will show how the latest developments, in the areas such as genome sequencing and microarray technology, are being applied to the problems of how genes in different species are organised, expressed and interact, to give the final phenotype.

There is no option system; instead you are encouraged to attend all the lectures, to ensure that you acquire the necessary breadth of background in the subject. Lectures generally take place at 9 am and 11 am, Monday to Friday, with 'extras' usually in the afternoons.

Teaching in the Department takes a variety of forms. Apart from lectures, we provide interactive seminars, examples and data handling classes, and journal clubs. We offer supervisions with teaching staff around the time of their lectures. You will also be assigned an Adviser within the Department, with whom you meet regularly, to support your progress during the year.

Teaching in the Department takes a variety of forms

In the Michaelmas term, you are offered sessions to help you make the transition to Part II, for example: sessions on essay writing, study skills, and introductions to the online resources available via the UL and to bioinformatics [see page 10 – Extras]

You have an opportunity to show your individual worth through your research project, and the project oral presentation [see page 12]. You are also encouraged to submit regular essays or specimen answers throughout the year, on which you receive feedback. This practice is vital preparation for the exams.

NST Part II and Part II BBS

You can take Genetics as a single subject in Part II of the Natural Sciences Tripos. This route will automatically involve a research project. Alternatively, you can take Genetics as your major subject in Part II Biological and Biomedical Sciences, or you can take a single Genetics module as a Part II BBS minor subject:

Single subject Genetics in Part II NST

You will do **all five modules** plus the problem solving and journal sessions, and undertake a **research project.**

Four paper subject in Part II BBS (414)

You can choose any **four out of the five Genetics modules**, together with another one paper subject, and complete a **dissertation**. In addition to your four Genetics modules you will also be expected to attend the Social Aspects of Genetics discussions, and the journal and problem solving sessions for your modules. You may opt to take the fifth Genetics module as your minor subject, or you can select one from the list of permissible options available. The Department also oversees the BBS Bioinformatics minor option. Students choosing the BBS route will have Genetics as their 'home' department, and have access to exactly the same facilities as single subject NST students.

One Genetics module taken as a Part II BBS Minor subject

Modules 2 (119), 4 (120) and 5 (121) are offered as Minor subjects to Part II BBS students who are not taking Major subject Genetics. In addition to the lectures you will be expected to attend relevant journal and problem solving sessions for that module.

The Department also offers a stand-alone module in Bioinformatics (128) that is available as a minor subject to BBS students (contact details: Dr G. Rustici gr231@cam.ac.uk).

BBS information can be found at : http://www.biology.cam.ac.uk/undergrads/nst/bbs

There is also a separate brochure for Part II BBS as a whole, from the Faculty of Biology.

MVST - Are you a Medic or a Vet?

In recent years 20-50% of the class has comprised Medical and Veterinary students, so if you are concerned about your relative lack of subject background, there will be plenty of others in a similar situation. Access to appropriate Moodle Part I course sites is provided, and background reading is advised, prior to the course, to help you catch up.

See page 21 - 'Preparation and previous courses of study'.

Genetics in IA and IB

Lecturers from the Department of Genetics contribute to a variety of IA and IB courses, so you will probably have already encountered many of us at some stage in your degree course.

For example, in the following NST courses:

Biology of Cells (IA)

Lectures from: Dr David Summers (Hunting the Gene; Lent Term) and Dr Christine Farr (The Genetic Revolution; Lent Term).
Lent Term Practicals on fungal, bacterial and *Drosophila* genetics (introduced by Marco Geymonat).

Evolution & Behaviour (IA)

Lectures & practical from: Dr John Welch (Evolutionary Genetics & Adaptive Evolution in Populations; Michaelmas term)

Mathematical Biology (IA)

Lectures from: Dr Aylwyn Scally (Probability, genome sequencing and population genetics; Michaelmas Term).

Cell & Developmental Biology (IB)

Lectures from: Dr David Summers (Prokaryotic strategies; Michaelmas Term), Prof Alfonso Martinez Arias (Gene expression and cell decisions; Michaelmas Term), Dr Cahir O'Kane (Genome organisation and genomics; Michaelmas Term), Dr Marisa Segal (The eukaryotic cytoskeleton and mitotic cell division; Lent Term), Prof Eric Miska (Molecular biology of the nucleus; Michaelmas Term).
Practicals on stem cells from Dr David Turner, on mobile elements in *Drosophila* from Dr O'Kane (both in the Michaelmas Term) and on the cytoskeleton from Dr Marisa Segal (Lent Term).

Ecology (IB)

Professor Frank Jiggins lectures on Ecological Genetics during the Lent term.

Or in the following MVST courses:

Molecules in Medical Science (MIMS) (IA)

Lectures from Professor Erik Miska (Transcription, translation and control; Lent Term) and Professor Anne Ferguson-Smith (Genetics in human and animal medicine; Lent Term)

Human Reproduction (IB)

Lectures from Dr Aylwyn Scally (Human genetics and whole genome association studies; Lent Term)

The Modules

Michaelmas Term

- Module 1: The Cell Cycle and Cancer
- Module 2: Plant & Microbial Genetics
- Module 3 (part 1): Developmental Genetics
- Module 4 (part 1): Human Genetics, Genomics & Systems Biology

Lent Term

- Module 3 (part 2): Developmental Genetics
- Module 4 (part 2): Human Genetics, Genomics & Systems Biology
- Module 5: Evolutionary Genetics

MODULE 1 – The Cell Cycle and Cancer

This module will focus on the mechanisms promoting the accurate segregation of genes and chromosomes into daughter cells at cell division and what happens when this goes wrong. We will also consider the special case of cells dividing asymmetrically and the mechanisms accounting for spatial and temporal coupling. We will explore the underlying eukaryotic cell cycle controls centred on cyclin-dependent kinases, protein phosphatases, ubiquitin-mediated proteolysis and checkpoints. This will be followed by a review of the key molecular themes linking cell cycle disruption and oncogenesis.
[Taught by : Marco Geymonat, Marisa Segal, David Glover]

MODULE 2 - Plant and Microbial Genetics

Paradoxically, while bacteria species show extraordinary stability they also respond to evolutionary challenges with dizzying rapidity. Their expertise in evolution is due to the "floating genome" comprised of mobile elements including plasmids, transposable elements, integrons and conjugative transposons. The concerted action of these elements (with the help of international air travel) means that bacterial genes cross species and geographical boundaries with ease. We will explore the mechanisms of movement of these elements and their contributions to evolution, asking whether they really deserve to be considered as independent parasitic entities, rather than as integral parts of the bacterial genome. The course will also provide an introduction to microbial pathogenesis. Topics will include a description of approaches used to identify virulence factors, discussion of bacterial genome dynamics (including horizontal gene transfer and the evolution of pathogenic mechanisms) and classification of the virulence factors of pathogenic bacteria with appropriate examples of factors required for entry and adherence, invasion of host cells, establishment and dissemination. The module will then move on to the genetics of higher plants including conventional, molecular and developmental plant genetics, illustrating the impact of transgenesis and genomics on pure and applied aspects of plant biology.

[Taught by : David Summers, Ian Furner, Andrew Grant, Alexander Jones]

MODULE 3 - Developmental Genetics

This module will cover the field of Developmental Genetics with an emphasis on how genetics is used to uncover cellular and molecular mechanisms of development. The determination of early cell fates in different animal model organisms will illustrate mechanistic similarities and differences and the genetic technologies used for addressing biological questions. The properties and uses of stem cells and other cultured cells will also be presented. Topics will include the establishment of body axes and early cell fates in development, roles of small RNAs in development, early mouse development, organ development and maintenance, properties of embryonic and adult stem cells, advanced genetic tools to study development in mouse and human, signalling mechanisms and their functions in diverse biological events, transcription regulation in cell fate determination, and gene networks in development.
[Taught by : Julie Ahringer, Daniel St Johnston, Alfonso Martinez Arias, Erik Miska, Jenny Nichols, Ed Ryder, Michaela Frye]

MODULE 4 - Human Genetics, Genomics & Systems Biology

Humans are a problem for the geneticist, because for all sorts of good reasons, we don't do experiments on ourselves, but also because the variation available for study is limited to that occurring naturally in the population. Human genetics has always needed to exploit technology to obtain answers to the problems it poses. In this module we will explore how the information from the human genome project has improved both our understanding of the organisation of the human genome and of the genetic causes of human phenotypes. DNA microarrays, proteomics and other methods for analysing gene expression and function at the whole-genome scale provide new ways to explore the causes and treatment of disease. A major goal of Systems Biology is to describe biological networks and processes in the form of quantitative models, and the course will cover how progress with model organisms are paving the way for such system wide approaches to human biology.
[Taught by : Steve Russell, Gos Micklem, Anne Ferguson-Smith, Michael Imbeault, John Perry, Robert Scott & Sudhakaran Prabakaran]

MODULE 5 - Evolutionary Genetics

Modern evolutionary theory has its roots in the union of Mendelian genetics with Darwin's theory of evolution, two of the great unifying themes of biology. This course will consider the process of evolution, exploring the central topics of natural selection, adaptation and genetic drift, and combining a variety of empirical and theoretical approaches. We will introduce evolutionary genetics, explaining how signatures in genome sequences allow us to infer the past action of natural selection, and to reconstruct the evolutionary histories of living things, from infectious viruses to extinct mammals. The first lectures cover general principals in evolutionary genetics, and key topics such as speciation and the evolution of gene expression. These will be a series of lectures on the evolutionary genetics of humans, exploring our species' origins, our spread around the globe, and examples of adaptive and non-adaptive changes in our genes. The course will also consider the evolution of sex and how experimental evolution can be used to understand the evolution and function of genomes and look at the exceptionally rapid evolution of viruses, which can sometimes adapt to their host in the course of a single infection.
[Taught by : Frank Jiggins, Aylwyn Scally, John Welch, Chris Illingworth, Simon Frost, Lucy Weinert, Toomas Kivisild, Richard Durbin]

'Extras'

Social Aspects of Genetics

A series of interactive seminars and discussions, with invited speakers from industry, the media, and other sources. Topics include plant GMOs, scientific fraud, medical ethics (e.g. issues surrounding gene therapy approaches and genome sequencing) and bioethics (e.g. genome editing technologies), as well as careers in science. Sessions on other important topics, such as applying for a PhD, and on careers in genetics, are also provided.

Journal sessions

A session is held for each Module, in which students learn to read, understand and criticise papers from the primary scientific literature.

Problem-solving/ Data-handling sessions

In these sessions, students work in groups solving genetics problems. This forms vital practice for the exams, and indeed for any future career in a lab. A session is held for each Module.

Computational practical sessions

In recognition of the need for more training in programming and bioinformatics, Modules 4 and 5 now include practical sessions.

Meetings with your Adviser

During the Michaelmas term you are encouraged to arrange weekly meetings with your assigned Adviser, who will answer any queries you have about the course and its organisation and will help sort out any problems that arise during the year.

Seminars

The Department runs two main seminar series, which Part IIs are encouraged to attend. One series is given by external speakers; and in the other series current Postgraduate students give a brief lunchtime presentation on their research, with snacks provided.

Supervisions

Supervisions on the lecture material are provided by the lecturers themselves. Each lecturer will provide a list of times when they are available to give supervisions, together with possible essay titles and topics for discussion. We encourage you to submit essays to lecturers, who will provide you with feedback.

Reading Breaks

In the middle of the Michaelmas Term there is a brief break to allow you to catch up with reading. Then in the Lent Term a week is set aside without lectures or other formal teaching, which gives you the chance to catch up on your reading, writing, and/or immerse yourself in your research project. During this week, each student will have a meeting with their Adviser to discuss their progress on the course, and their career plans.

Revision seminars

There is no formal teaching in the Easter Term, but revision seminars are organised for each Module, to allow you to ask questions about the aspects you don't feel you have understood, and to help with your preparation for the exams.

The Part II Examination

The examination for Genetics Part II consists of a number of written papers, and a research project. There is also a brief oral examination, although this does not make a numerical contribution to the final mark.

Each module in the course will be examined by a separate paper in the final examination, so you can expect questions on Module 1 to be in Paper 1 and so on. Each paper will also include questions designed to assess the skills acquired in the problem-solving component of the course and the journal sessions.

If you are taking **NST Part II Genetics**, the current weightings of each part of the examination are:

Papers 1-5 (16% each)	80%
Research Project (a literature review and project report)	20%

See the following pages for information about the project

If you are taking Genetics as **BBS Part II** the current weightings of each part of the examination are:

Four of Genetics Papers 1-5	65%
Minor Subject	15%
Dissertation	20%

See page 14 for information about the dissertation

The Research Project

In the Lent Term each Part II Genetics student carries out an individual research project. This forms an important part of the course, and allows you to engage in your own research work within an established group in the Department. It gives you an opportunity to work alongside graduate students and post-doctoral scientists who are carrying out up-to-date work in the field, and to become familiar with the atmosphere of an experimental laboratory.

Each student selects a project from a list suggested by members of staff. Projects are chosen during October/ November, which gives plenty of time to plan them before the beginning of Lent Term. Breeding experiments can be set up before the Christmas vacation if necessary, but no substantial commitment of time on the actual research is required before the New Year. Over the Christmas vacation you will be asked to write a review of the scientific literature in your chosen field. Then your actual research will start at the beginning of the Lent term. Your findings are written up and the report handed in by the beginning of the Easter vacation.

As well as providing an exciting opportunity for you to demonstrate initiative and ability, the project gives you some idea of what research is really like.

In the time available, exciting results can emerge:
Some projects have evolved into PhDs for the student concerned,
and others have contributed to published scientific papers.

For example, Tim Freeman [Part II 2014/5] contributed to:

Shaw C , Lonchamp J, Downing T, Imamura H, Freeman T M, Cotton J A, Sanders M, Blackburn G, Dujardin J C, Rijal S, Khanal B, Illingworth C J, Coombs G H, Carter K C. : In vitro selection of miltefosine resistance in promastigotes of Leishmania donovani from Nepal: Genomic and metabolomic characterization. Molecular Microbiology (2016) 99(6) 1134-48. doi: 10.1111/mmi.13291

… and Jessica Patel [Part II 2010/11; Part III 2011/12] contributed to:

Corrigan et al: Automated tracking of mitotic spindle pole positions shows that LGN is required for spindle rotation but not orientation maintenance. Cell Cycle (2013) 12: 2643-2655

Project presentations

All students give a short oral presentation on their research project to the rest of the class, and a few of the lecturers. A chance to try to lecture better than the lecturers!

Examples of projects offered

- Deterministic and stochastic models for inferring fitness effects in viral populations
- A connectomics approach to study the role of novel neurons in sensory discrimination
- Bioinformatic identification and characterisation of KRAB-ZPPs transcripts and their isoforms in purified ex vivo mammalian cells
- Dissecting the C-terminal region of human Topoisomerase IIα
- Determining the function of long non-coding NAs using Cas9/CRISPR genome editing
- In vivo assessment of the anti-tumour capacity of the inhibition of the mitotic APC/C activator Fzy/cdc20
- Heat responsive transposon and its possible role in acclimation to heat stress
- Genomics of Drosophila Sox100B transcription factor
- Visualising single neurons that monitor activity in mushroom bosies (memory centre) of larval Drosophila – a Brainbow approach
- The role of Par-1 in polarising the cortex
- Genome reduction and pathogenicity in bacteria
- Indole signalling and antibiotic resistance
- Polarising the epithelial microtubule cytoskeleton
- Manipulating mother-daughter controls for asymmetric expression and age-sensitive protein mobility
- Comparing recombination maps in Pan genome sequence data
- Characterisation of cellular immune response in resistant and susceptible Drosophila lines to the parasitoid wasp Leptopilina boulardi
- Drosophila in vivo proteomics
- Using micro-injection to down-regulate genes involving retro-element suppression in maize endosperm
- Viewing the axonal ER network in live Drosophila that are mutant for hereditary spastic paraplegia genes
- Optogenetic activation of modulatory neurons to test behavioural odour discrimination in Drosophila larvae
- Analysis of cell behaviour and gene expression during mouse ES cell differentiation
- Characterisation of Tem1 phosphorylation in the control of mitotic exit network and the spindle orientation checkpoint in yeast
- Molecular evolution of rotavirus
- Investigating the molecular mechanism behind gene repression via a Retinoblastoma-like protein in *C. elegans*
- Identification of mammalian metastable epialleles

BBS Dissertation

BBS students will have the chance to select a dissertation topic from a list circulated early in the Michaelmas term. Past topics have included:

- Bacterial persisters: molecular mechanisms and clinical management
- Can we assign a function to 80% of the DNA in the human genome?
- The biology of CRISPR/CAS systems and their uses in eukaryotic genome engineering
- How can genomic data be used to understand cancer evolution and to assist with cancer therapy?
- How does a cell make a decision to divide – or stop dividing?
- How have bdelloid rotifers avoided sex for so long?
- Discuss the concepts presented in C H Waddington's 1942 paper in *Nature* 'Canalisation of development and the inheritance of acquired characteristics'
- Transgenerational epigenetic inheritance in mammals - fact or fiction?
- Many human cancers are aneuploid. Yet aneuploidy has detrimental effects on human development and has been shown to reduce cellular fitness : Consider this conundrum
- Why do endosymbiotic bacteria have small genomes?
- Cell and gene therapy – the future of human monogenic disorders
- Have regulatory changes been more important for the evolution and divergence of species than changes in protein coding sequence?
- Discuss recent developments in the mechanistic understanding of cell size control

Social Aspects of life in the Department

Research in Genetics Day

This one-day review of research in the Genetics Department takes place at the end of the Michaelmas Term. This informal meeting is an excellent way to appreciate who does what within the Department. Part II students are encouraged to attend.

The Christmas Party and the Traditional Pantomime

At the end of the Michaelmas Term there is a Christmas Happy Hour, which traditionally includes a Panto, performed by the Part IIs. This could be your chance to not only demonstrate your thespian skills, but also to exact revenge on the academic staff who have tortured you in lectures! This Department can, shall we say, boast several members of staff who can easily be represented as compelling pantomime characters – and they love it! Old-timers maintain that the jibes have become more barbed since exam scripts have become anonymous.

Happy Hour

On Friday evenings the Happy Hour Team invite everyone along for drinks and snacks.

The Garden Party

On the day the exam results are announced, we hold a Garden Party, a chance to relax once the year's hard work is over, with champagne and strawberries.

A tour of the European Bioinformatics Institute and Sanger Institute

We organise a visit to this internationally renowned research campus for you, at the end of the Michaelmas Term.

Research in the Department of Genetics

The range of research subjects in the Genetics Department is very broad, but it can be roughly divided into the 'themes' below. Of course, many Groups fit more than one 'theme'. This breadth benefits students in several ways. First, it means that the Department is well balanced between whole-organism and molecular approaches. Second, for those wishing to go on to research, there will almost certainly be someone with useful contacts, to help you get into almost any branch of genetic research. Each research group has its own web page, with more details about their work, accessed from: http://www.gen.cam.ac.uk/research-groups.

*An * indicates a Group which is based outside the main Department building. Most are sited just across Tennis Court Road*

Functional Genomics and Systems Biology

Professor Steve Russell. Steve's group is studying the function of the Sox family of transcriptional regulators during *Drosophila* embryonic development with a particular focus on the role the proteins play in the formation of the CNS. Along with classical genetics and developmental biology approaches, they are utilising modern functional genomics approaches such as microarray-based gene expression analysis and mapping of DNA-binding proteins.

Dr Gos Micklem. Gos is interested in using computational approaches to model biological systems, in particular using data from high throughput methods - such as gene expression microarrays - for functional and also comparative genomics. Wet lab work is directed towards generating data for building and testing models, together with development of technology to enrich mRNA from specific cell populations of interest within *Drosophila*.

Dr Sudhakaran Prabakaran. Sudhakaran is interested in how human genetic variants affect normal biological processes and cause diseases of the nervous system and cancer. Computational and systems biology-based approaches are being used to study non-exonic regions of the genome and disordered regions of proteins.

Developmental Biology

Professor Alfonso Martinez-Arias. Alfonso's group is studying how different signalling pathways interact with each other during development. They are using mouse embryonic stem cells to study how cells generate organs and tissues. They have a special interest in notch and wingless signalling.

Professor Julie Ahringer *. Julie's group is interested in how the right type of cell forms in the right place in embryonic development, using the nematode *Caenorhabditis elegans* as a model system. Her group uses a wide range of techniques to study the genes involved (genetics, microscopy, molecular biology, transgenesis, RNAi etc) and is aided by the worm's short life cycle (3 days) and the availability of the complete genome sequence. Another reason that Julie and her colleagues study *C. elegans* is because it's beautiful!

Professor Daniel St Johnston FRS *. Daniel makes fruitfly larvae with no heads or no abdomens, or in some cases, two heads or two abdomens. He studies the mechanisms involved in localisation in the egg of maternal determinants such as bicoid RNA, which control embryonic pattern formation. He uses *Drosophila* as a model system to investigate intracellular transport and the origin of anterior-posterior polarity. Daniel himself has a normal complement of body parts.

Dr Michaela Frye. Michaela's group aims to identify key factors regulating stem cell differentiation in adult tissues. How the balance between self-renewal and differentiation is regulated is not fully understood, but highly relevant to an understanding of cell biology and human diseases. They have a particular interest in RNA methylation.

Dr Ben Steventon. Ben's research interest is in comparative developmental dynamics. He is studying how self-renewal and differentiation, precisely balanced within stem cell populations, generates well-proportioned tissues during development and growth.

Dr Felipe Karam Teixeira. Felipe's interest is the development of the germline, the 'immortal' cell lineage that provides the continuity of life. In particular, he is interested in the genetic and molecular mechanisms controlling germline stem cell behavior and protecting totipotency, using the *Drosophila* ovary as a model system.

Cell Biology

Professor David Glover FRS. David's laboratory studies the structure of the mitotic apparatus and the regulation of its function. Their work into mitotic mutants in *Drosophila* has identified genes encoding a number of conserved regulatory molecules. Abnormal function of the mammalian counterparts of several of these proteins appears to play a role in the generation of chromosome instability in human tumours.

Dr Christine Farr. Christine's research focuses on centromeres and telomeres. Her lab has created vertebrate cell lines mutated for various chromosomally-associated proteins, as well as a series of human mini-chromosomes. These reagents are being used to study chromosome behaviour in mitosis.

Dr Cahir O'Kane. Cahir studies how neurons work and how they go wrong during neurodegeneration in *Drosophila*. Of particular interest are the processes that organise and traffic membranes, both pre-and post-synaptically. At this level, flies are about as smart as we are.

Dr Liria Masuda-Kakagawa. Liria is interested in brains and is using *Drosophila* to investigate the circuitry of odour discrimination and olfactory memory formation.

Dr Hansong Ma *. Hansong is intressted in that other genome – the one packed inside the mitochrondrion. She is using *Drosophila* to study how mtDNA mutations are inherited and how different mutations contribute to longevity and fertility.

Epigenetic Inheritance

Professor Anne Ferguson-Smith FRS. Using mouse genetic models, the Ferguson-Smith lab studies the genetic and epigenetic control of developmental processes including stem cells, and the epigenetic control of genome function. The research combines both experimental and bioinformatics approaches to understand the link between genome and epigenome and the impact that this has on normal and abnormal development and physiology in tissues and in the whole organism.

Professor Eric Miska *. The Miska group studies microRNAs (miRNAs) and other short RNA species, using *C.elegans* as their model organism. Approximately 3% of all known human genes encode miRNAs and important functions in animal development and physiology are emerging, with some directly implicated in human disease.

Dr Ian Furner. Ian's group combines traditional approaches, such as mutant isolation and genetics, with more modern ones, such as transgenesis, gene tagging, RNAi and genomics, in

order to try to understand how plants silence expression of genes, transgenes and transposons.

Dr Michael Imbeault. Michael is interested in the impact of transposable elements on mammalian genomes. Using a mix of bioinformatic and molecular biology approaches his group is delving into how TEs, and DNA binding proteins that interact with them, contribute to disease risk factors and other complex traits.

Microbial Genetics

Dr David Summers. Bacterial plasmids are sophisticated parasites. David's group studies two aspects of their life story: multimer resolution and bacterial cell cycle control. Multimers cause the loss of plasmids from growing cells but plasmid ColE1 uses site-specific recombination to eradicate them. The lab has discovered that ColE1 controls *E. coli* cell division so that the cell cannot divide until the plasmid is ready. It achieves this by stimulating production of a signalling molecule (indole) whose mechanism of action is the subject of current research. Finally the group has an interest in the expression of foreign proteins and metabolites in bacterial cell factories and has developed a novel expression system where proteins are made in non-growing "quiescent" *E. coli*.

Dr Marisa Segal. Marisa's group uses the yeast *S. cerevisiae* to explore the mechanisms coupling mitotic spindle orientation with cell polarity, processes critical for the fidelity of chromosomal segregation and cell division. The principles emerging from these studies can be extended to learn how spindle orientation is controlled throughout metazoan development to generate cell diversity.

Dr Marco Geymonat. Marco is also a big fan of yeast and is using genetics, biochemistry and microscopy in budding yeast to study the mitotic exit network.

Evolution and Population Genetics

Professor Frank Jiggins. Using insects as a model system, Frank's Lab is studying the evolution of hosts and parasites. A combination of population, quantitative and molecular genetics is being used to address the genes that cause variation in susceptibility to infection, the evolutionary processes that maintain this variation in populations and how coevolution with parasites has shaped the insect immune system.

Dr John Welch. John's research focuses on the processes that shape DNA sequence variation within and between populations. Ongoing research projects involve quantifying the contribution of natural selection to genomic change, inferring specific selection pressures that were faced by natural populations, and identifying the general conditions that promote or hinder an adaptive response.

Dr Aylwyn Scally. Aylwyn's research focuses on the evolution of populations and species, using computational analyses of large-scale genome sequence data. His particular interest is in human and primate evolution, but the methods and approaches involved in evolutionary genomics are applicable to organisms across the tree of life.

Dr Chris Illingworth. Chris's group develops theoretical and computational approaches for analysing rapid evolutionary processes using genome sequence data. A particular focus of the group is the role of evolution in pathogenic organisms, including parasites, viruses, and bacteria.

Professor Richard Durbin. The focus of the Durbin group is sequence-based analysis of genetic variation and genome evolution. Their computational research projects encompass a broad range of organisms, including ancient and moden human DNA samples, induced pluripotent stem cells and cichlid fishes.

Beyond Part II

Part II Genetics offers a challenging, rewarding and socially enjoyable course, which combines whole organism biology and molecular studies effectively to provide a step towards a successful career.

Many in the Part II class will progress to PhD positions in Cambridge and elsewhere. This is normally the best option for an eventual career in either pure research (e.g. in a university or research institute), or industrial research (e.g. in a biotechnology or pharmaceutical company). There are prospects for research positions in both 'pure' areas such as cell biology, genome analysis, evolutionary and population biology, and more 'applied' areas such as agricultural and medical genetics, biotechnology, and genetic applications to environmental problems. Where funding is tight a background in genetics may give prospective candidates an edge. A PhD might for example lead on to a career in bench science, academic or industrial research, science administration and management, working in an advisory capacity, or publishing and disseminating scientific information.

Employment prospects are good for Cambridge graduates in general. Part II Genetics provides an excellent training also for those not wishing to continue in 'front-line' science. Many employers are realising that they require people with a good background knowledge of genetics and a broad scientific training, even for jobs that do not involve bench science. Therefore, there are Part II geneticists doing well in traditional publishing, in the City, in the law, even accountancy!

Genetics is a booming subject that offers a wider range of job opportunities than many other areas of biology

Former Part II and PhD students from this department now hold significant scientific positions in the UK and world-wide : Oxford, Cambridge, the USA (Yale, California), and the Pacific rim (Singapore and Papua New Guinea). They often work as research group leaders for companies such as Unilever, AstraZeneca, Novartis and GlaxoSmithKline. Some have joined Cambridge area 'Start Ups'. Other science-related destinations have included publishing (e.g. Benjamin Lewin, who founded the important journal, *'Cell'*) and venture capital consultancy.

Part III Systems Biology

For those interested in the Part III Systems Biology course, Part II Genetics offers an ideal platform by providing a comprehensive grounding in the basic methods underpinning genomics as well as an introduction to modelling approaches from a developmental biology perspective.

Consumer feedback from former Part II students

Kane Toh [...still in the Department, working on his PhD]
The part II genetics course gave me a thorough and critical knowledge of genetics. This is excellent as students of genetics are particularly well-equipped to enter different sub-disciplines in biology, since all fields in biology must intersect with the fundamental study of genetics. In terms of its atmosphere, the Genetics Department is really welcoming towards its small cohort of Part II students, and our unique pantomime tradition brings the class and the research community together. With the thorough syllabus, excellent teaching and vibrant atmosphere, I am proud to have chosen genetics as my Part II subject!

Katherine White
The small class size means that everyone knows each other and there's a feeling of belonging to a department that you don't get in Part I. The course itself is broad enough that you'll find something that you really love and goes into enough depth so that it's interesting. If that isn't enough for you then there's the fact that tea breaks are scheduled into the timetable and the fun of putting on a pantomime for Christmas!

Marianne Quigley
Part II Genetics definitely made my third year the most enjoyable of the three. The five modules divide up the different aspects of Genetics in a really comprehensive way … We also had problem solving classes (useful for exams) and ethics classes, which helped put the information learnt in the course into a social context. The small class sizes really helped and meant that the lecturers could learn our names and faces and we felt like a valued group to the Department. The project in Lent term was definitely the highlight for me – it sounds a lot of work (and it is) but it allowed 'proper' scientific investigation with an active research group and the production of a report that could potentially be useful, in a small way, to scientific progress, which was really rewarding.

Sarah Jones
There is no denying that the Genetics course is extremely hectic, especially when you have to undertake a research project as well as keep up with all the lecture material, and it often feels as though there aren't enough hours in the day. However, due to the helpful atmosphere of the Department and the structure of the course, there is always enough support to help you through. Even if you do not want a career in science, the Genetics Department is a fantastic place to spend a year, and will hopefully provide you with some great memories!

Joe Laycock
Imagine yourself surrounded by desert with neither water nor sustenance. Hungry and thirsty you espy an oasis surrounded by a banquet of magnificent proportion. A mirage? Why no, this is Part II Genetics. An overflowing cornucopia awaits, ready to cater for every taste with a bounteous panoply of succour. Classical versus modern, genomics, cell cycle, development, evolution, plants; even the most ravenous of desires will be sated. Extended essays, projects and bio-informatics provide appetising introductions to some of the delicacies of modern genetics. Rich, succulent, alluring; come, eat, for none shall go hungry.

How to apply

All students are required to register their Departmental preferences on-line through CamSIS.

This booklet, together with our website, should provide the necessary background information about the Department of Genetics and our Part II course.

You are also invited to visit the Department to meet members of staff, discuss the Part II course and learn more about our research on **Thursday 15 March from 2.30 p.m.** There will be plenty of opportunities to have informal chats with teaching staff, and to quiz current Part II students on their experiences of the course. There will be talks about the course and about the research being undertaken in the department (from 2:45 pm). Refreshments will be available. All this will take place in our recently refurbished Part II teaching room.

The Department will also have representatives for you to chat to at the Faculty of Biology Subjects Fair on Friday 16 March.

Preparation and previous courses of study

There are no compulsory prior courses or prerequisites for admission to Part II Genetics; we are looking above all for students with a genuine interest in genetics, who will get the most out of our stimulating course.

Part II Genetics students from the Natural Science Tripos will typically have taken courses such as Part IA Biology of Cells, IA Evolution & Behaviour, Part IB Cell & Developmental Biology, IB Ecology, or IB Biochemistry & Molecular Biology. Medical and veterinary students may also elect to take this course before proceeding to their clinical studies, and often form a significant proportion of the class. Students with a background in the physical sciences or mathematics have also done well in Part II Genetics in the past, and we welcome applications from such students.

For all incoming Part IIs who have not taken IA Biology of Cells, IA E&B and/or IB CDB, access is granted during the long vacation to the previous year's version of the Moodle sites for these courses, so that they can consult lecture notes and other posted material. The Department can also suggest material for directed reading prior to the course.

Vacation Research

Hands-on experience is an invaluable bonus when it comes to getting a foot in the door in research. There are many sources of opportunities and financial support to allow students who have completed 1B to work on research projects during the summer vacation before embarking on their Part II course. More information on all of these sources of funding and on how to apply can be found on our website at:
http://www.gen.cam.ac.uk/undergraduate/vacation-research

Genetics-specific bursaries - the Department of Genetics offers two sources of vacation research funding, which are reserved for IB students intending to read Part II Genetics:

- **Stephen P. Johnson Research Bursaries:** these provide a stipend of £200 p.w. for a maximum of 10 weeks, plus some research costs for the host laboratory. The research must be carried out under the supervision of a Principal Investigator who is a member of the Department (see next page for further information on this scheme).

- **J.R.S. Fincham Bursary:** provides limited support (up to £500) for a student undertaking summer vacation research, either within the Department or elsewhere (see next page).

- **Richard Wilson Bursary:** funds student exchanges between the Universities of Glasgow and Cambridge (see next page).

General bursaries – open to all students

- **Wellcome Trust Vacation Scholarships**
  http://www.wellcome.ac.uk/Funding/Biomedical-science/Funding-schemes/PhD-funding-and-undergraduate-opportunities/WTD004448.htm
- **Amgen Scholars' Programme**
  http://www.biomed.cam.ac.uk/amgenscholars/index.html
- **Colleges:** Many colleges provide funds to support students wishing to broaden their experience by conducting research over the summer period.

Interested students should approach staff members directly to find out if they have vacation research opportunities and space available http://www.gen.cam.ac.uk/research-groups

The earlier you apply the better - some closing dates are as early as February.

Collated information about Undergrad funding can be found at :
https://www.biology.cam.ac.uk/undergrads/InfoCurrentStudent/undergrad-fund

Stephen P. Johnson Research Bursaries

The Department of Genetics offers two undergraduate research bursaries, through the generosity of Stephen P. Johnson, a former Part II student. They are awarded to second year students in either NST or MVST who intend to read Part II Genetics as their final year option.

The research must be carried out under the supervision of a Principal Investigator who is a member of the Department of Genetics. A list of research groups and their fields of research can be found on our web site: http://www.gen.cam.ac.uk/research-groups Each bursary will provide a stipend of £200 per week for a maximum of ten weeks, plus some research costs for the host laboratory.

Applications must be made using the form available from our web site: http://www.gen.cam.ac.uk/undergraduate/vacation-research and should include a brief description of the proposed project, which must have been discussed with the head of the host laboratory.

Completed applications should be returned to the Secretary to the Head of Department at: hodsec@gen.cam.ac.uk. **The deadline for applications is Tuesday 8 May 2018**, and successful applicants will be informed as soon as possible after this.

J.R.S. Fincham Bursary for Summer Vacation Research

The Genetics Department offers a bursary of up to £500, to help provide financial support to a Part IB student wishing to carry out vacation project work in biological science. The work, which should have particular relevance to genetics, may be undertaken within the Department or elsewhere. To be eligible for support, applicants should intend to read Part II Genetics in their final year. Applications should include:

a) a curriculum vitae, with the name of a referee
b) a brief description of the work proposed (~200 words)
c) a letter of support from the head of the host laboratory

The closing date for applications is Tuesday 8 May 2018.

Applications (paper or electronic) should be submitted to the Secretary to the Head of Dept, Department of Genetics, Downing Street, Cambridge CB2 3EH or hodsec@gen.cam.ac.uk. Successful applicants will be informed in early June.

Richard Wilson Bursary

The Department of Genetics now offers a new Bursary to encourage research exchange in genetics between Cambridge and Glasgow Universities. Funds are available due to the generosity of the late Dr Richard Wilson, who spent 40 years conveying his enthusiasm of genetics and evolutionary biology to students and research colleagues alike. This opportunity will allow a student (of any stage) from either Glasgow University or Cambridge University to study at the opposite University. Cambridge University students wishing to spend a summer in a lab at the University of Glasgow should contact cg663@cam.ac.uk etc for further details.

Completed applications for all summer awards should be returned to the Secretary to the Head of Department at: hodsec@gen.cam.ac.uk

The deadline for applications is **midday on Tuesday 8 May 2018**, and successful applicants will be informed in late May.

For further information on the Part II Course:

- Visit our website : http://www.gen.cam.ac.uk/undergraduate/genetics-for-pt1
- Use the QR code below
- For general information about the course e-mail : partII.info@gen.cam.ac.uk
- To contact the course organisers : ptIIorganisers@gen.cam.ac.uk

Several members of this Department lecture in IA and IB NST and MVST :

Prof Anne Ferguson-Smith, Prof Alfonso Martinez Arias, Prof Eric Miska, Dr Cahir O'Kane, Dr Christine Farr, Dr Aylwyn Scally, Dr Marisa Segal, Dr David Summers, Dr Marco Geymonat, and Prof Frank Jiggins.

They can supply further information about the Department and the Part II course. All can be contacted by email at the generic address: first initial.surname@gen.cam.ac.uk (no spaces or apostrophes).