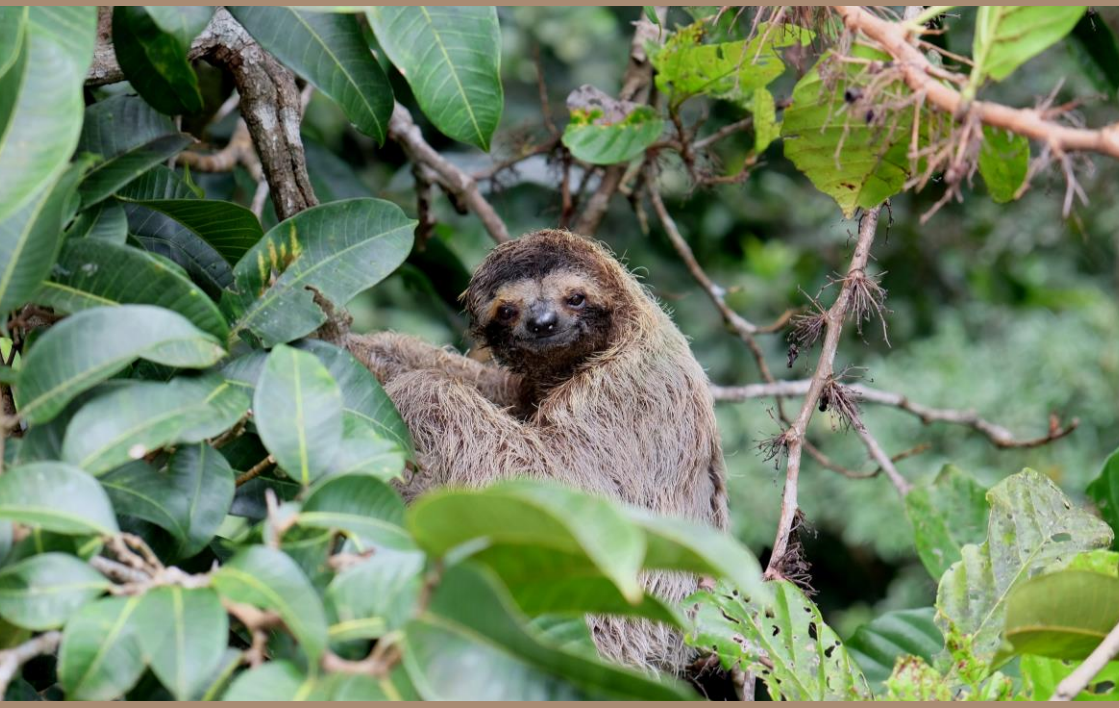
Part II Zoology

2019-20



UNIVERSITY OF CAMBRIDGE | ZOOLOGY 150 YEARS 1866–2016

Cover image: Brown-throated sloth (*Bradypus variegatus*), Panama
Photo courtesy of Matthew Lewis, Part II student on the
2018 Tropical field course

Why choose Part II Zoology or Part II BBS Zoology?

If you have enjoyed subjects that include **animal behaviour, conservation science, ecology** and **evolution** during your time at Cambridge, then you might well have already decided that Zoology is the Part II subject for you. But we also provide outstanding teaching in **cell and developmental biology** and each year we attract students that specialise in these subjects alone, and go on to study for a higher degree in these research areas. Our uniquely flexible course is also ideal for NST students that enjoy both cellular and organismal biology, because you can take a combination of our diverse modules.

If you are taking the MVST, then we can enhance your training in several ways: by showing you how healthy bodies develop and function; by teaching you more about the processes that trigger cancer; by explaining how evolutionary principles underpin the design of a new flu vaccine, and account for constraints on immune function; by revealing the evolutionary history of humans and their domesticated animals; and by highlighting how rapid man-made changes in our world have substantial implications for human and animal the health of living things and their environments.

We will provide a nurturing and stimulating environment for your Part II studies. Part II students are valued members of the Department, have their own dedicated computer facility, are invited to research seminars, and can join members of staff in the tea room and at our Happy Hour. We want you to excel in your third year at Cambridge, so we provide additional training in understanding the scientific process, essay-writing, reading a research paper, preparing a research project or dissertation, and giving a research talk. We also prepare you for the future with a careers session and advice on applying for postgraduate study.

For further information visit: www.zoo.cam.ac.uk. If you are unable to find the answer to your query please contact Part II Zoology and BBS Organiser, Professor Andrew Balmford ([3]31770, apb12@cam.ac.uk) or the Zoology Teaching Office (teaching@zoo.cam.ac.uk).

Dr Howard Baylis
Head of Department

Professor Andrew Balmford
Part II Organiser

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*(Please note that * starred sections above are **not** relevant to BBS Zoology students, but all others are)*

OVERVIEW OF THE PART II ZOOLOGY COURSE

An overview of the BBS Zoology course can be found on page 28.

The course is made up of:

Lecture modules in the Michaelmas and Lent terms. Students take two modules each term, but are free to attend lectures in any modules.

Project/demonstration practical work. Students must do either one **two-term** project, two **one-term** projects, or one **one-term project** and one **demonstration practical** associated with module ZL1. Project work can be started in the long vacation and extends over Michaelmas and Lent terms. At the beginning of Easter term, students give a compulsory **oral presentation** on one of their projects.

Research Project Proposal. Students will write a short research proposal on a topic from a module they are taking in Michaelmas or Lent term.

Statistics course in Michaelmas term. This optional course is designed to familiarise students with quantitative methods and computing and is not examined.

Long vacation field course
This year our Tropical Field Course is based at the Maliau Basin Field Centre, Sabah, Malaysia, which provides an excellent opportunity for students to learn about tropical rainforest ecology, evolution and conservation. Students attending the course will be able to use this research to form the basis of a Part II project.

Special seminars
In addition to these formal parts of the course, there are approximately 10 special seminars on a range of topics such as careers advice and how to give a research presentation.

AIMS, OBJECTIVES AND LEARNING OUTCOMES OF PART II ZOOLOGY

Aims

- To provide a broad multidisciplinary course in Zoology.
- To train students in a wide range of science-based skills that provide the learning base for future careers in disciplines such as health sciences, agriculture, environmental management, the emerging biotechnologies, publishing, teaching, research and management.

Objectives

- To offer a modular course of lectures, associated seminars and research projects, supported by supervisions where appropriate.
- To promote training in practical and conceptual skills in sub-disciplines ranging from molecular cell biology, through physiology and neurobiology, to the study of populations in both an ecological and evolutionary framework.
- To provide constructive feedback on students' work. During the course individual students will receive feedback on their project/s and written work for supervisions.
- To provide an optional Zoology-based course in statistics in the Michaelmas Term enabling students to apply quantitative methods to complex biological problems.
- To provide professional training in effective verbal and written communication skills.

Outcomes

At the end of the course students should be able to:

- Think critically in terms of their learning and research.
- Critically evaluate the published literature.
- Assess and implement the practical techniques necessary to solve a particular biological problem.
- Analyse and interpret data collected during a research project.
- Communicate with expert and non-expert audiences through seminar presentations, project reports and essays.

ASSESSMENT

Coursework comprises the research project proposal and either two project write-ups, one for each one-term project, or one longer write-up of a two-term project. At the end of the academic year are four 3 hour written examination papers, one for each module taken. On each of these four papers, candidates answer three questions.

PROJECT WORK

You may do two one-term projects, each amounting to about 80 hours of practical work and analysis, or one two-term project of about 160 hours in total. Student projects often lead to publications.

You may choose to start a one-term project during the summer vacation on the basis of either work done in a research laboratory or fieldwork done on the field course or elsewhere. If you wish to use vacation work in a project, you must discuss your summer plans **before** departure with a supervisor within the department, except for those of you who begin field projects on the field course, because you will be supervised by staff present on that course.

Modules ZM1 and ZL1 carry with them demonstration practicals following the lectures; the demonstration practicals for ZL1 may be used in place of one short project.

DEPARTMENTAL RESOURCES FOR PART II STUDENTS

During your Part II year, you will be treated as a full member of the Department, which is diverse in its research interests. There is a tradition of easy and informal access to members of the teaching staff and others, with whom students share the **Tea room** and other facilities and activities. The friendliness of the Department is often one of the first things a student will mention about the course.

Part II students have full use of the excellent and comprehensive facilities provided by the **Balfour Library**, including workstations. There is also a dedicated **Common Room** with full facilities.

You will also be welcome to attend **Happy Hour** in the Tea room on Friday afternoons. **Parties** for Part II students are held at the start of Michaelmas Term and after the exams.

EXPLORING YOUR INTERESTS WITHIN ZOOLOGY

We know from experience that your interests may not always fall tidily into the standard areas of biology such as "ecology", "evolution", "behaviour", and/or "cell biology". Many students wish to get experience of different aspects of animal biology, and Part II Zoology is organised with this in mind. **The only requirement is that you select two modules in each of the two teaching terms**. Often the interface between two conventional areas is a growing point in the subject, which is why we encourage this freedom of choice.

We encourage you to follow your interests as far as possible, even if you have not previously studied a particular area. All modules are taught in a way which is designed to maximise their accessibility to students taking the course. If you have any concerns about your ability to take a particular module you should contact the module organiser who will be very willing to advise you.

You need not decide on your modules until you have sampled what is available at the beginning of each term. This booklet outlines the contents of the modules in order to indicate what is available. Although the modules can be combined according to individual choice, the following

are examples of some of the more obvious combinations (modules lettered and numbered for convenience; M = Michaelmas Term module, L = Lent Term module).

- **An evolutionary biologist** might select two of ZM1, ZM2, ZM3, ZM4 and ZM5, and two out of ZL1, ZL3 and ZL5.
- **An ecologist or conservation biologist** might select two of ZM2, ZM3 and ZM5, followed by two out of ZL2, ZL3, ZL4 and Dynamics, History and PLM3 (see p. 24 for more details).
- **A cell or developmental biologist** might choose two from ZM6, ZM7 and ZM8 and two from ZL5, ZL6, ZL7 and Bioinformatics (see p. 25 for more details).
- Someone interested in **neurobiology and behaviour** might select ZM4 and ZM5, followed by ZL3 and ZL5.

These are simply examples to show ways in which the modules can be combined to meet individual interests. Members of the staff will be very happy to discuss other combinations, and to give you advice.

LONG VACATION FIELD COURSE

3 – 17 September 2019
Organiser: Dr Edgar Turner, ect23@cam.ac.uk

Based at Maliau Basin Field Centre, Sabah, Malaysia, the course will focus on tropical ecology, evolution and conservation. We will explore some of the diversity of habitat types found in Sabah and ongoing research programmes taking place there, including those investigating coral reef conservation and tropical forest fragmentation. In particular, the course will highlight what is distinct about tropical habitats, including aspects of the biology of species found there, the complex networks of interactions that tropical ecosystems can support, and the current and severe threats to biodiverse tropical systems from habitat change.

Students will gain a greater understanding of why tropical rainforests house such as extraordinary wealth of species and what management and conservation can do to protect tropical biodiversity.

Key features of the course will be the chance for students to interact with a wide range of tropical biologists and to carry out their own substantial project investigating a research topic of their choice.

MICHAELMAS TERM

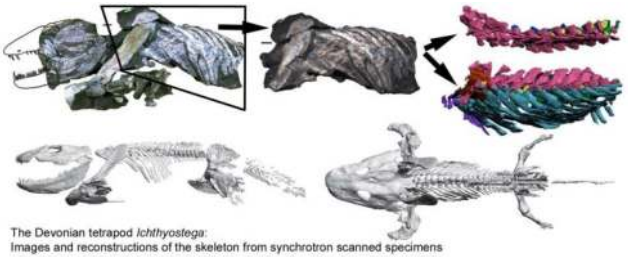
Module ZM1: Vertebrate Evolution

Also available as a BBS Minor subject

Module organiser: Dr Jason Head, jjh71@cam.ac.uk

This course introduces the history and evolution of non-mammalian vertebrates, emphasising questions that are the subject of current debate and controversy. We integrate studies of fossil and living vertebrates to examine major events in evolution. These variously include the relationships of gnathostomes to jawless fishes; the interrelationships of gnathostomes and the evolution of their distinguishing features, such as jaws and teeth; the early evolution of tetrapods and the transition to land–dwelling; the origin and radiation of stem tetrapods and amphibians; the diversification of amniotes and the subsequent evolution of the diapsids into lepidosaurs and archosaurs, including dinosaurs and birds. Building on the evolutionary relationships of these groups, we draw implications for their biology in several areas. These include topics such as the origin and development of fins and limbs, the evolutionary radiation and biogeography of lizards and rhyncocephalians, the mechanics of locomotion and feeding among dinosaurs, and the origins of avian biology. Case examples are used to highlight analytical approaches to interpreting fossil data such as morphometrics, and to explore controversial aspects of vertebrate phylogeny.

An important component of the course is the demonstration practicals, which give "hands-on" experience of actual fossil material, including some type and figured specimens. Practical and theoretical approaches to systematics including computer-based methods are dealt with.



The Devonian tetrapod *Ichthyostega*:
Images and reconstructions of the skeleton from synchrotron scanned specimens

Module ZM2: Conservation Science

(Inter-departmental course with Plant Sciences)
Also available as a BBS Minor subject
Module organiser: Dr David Aldridge, da113@cam.ac.uk

This interdepartmental course, taught by the Departments of Zoology and Plant Sciences, aims to provide an understanding of why wild nature is currently in decline, why this matters, and how biology coupled with other disciplines can be harnessed to identify potential solutions.

The course begins by explaining the distribution and importance of biodiversity, and the evidence that it is currently being lost. It then examines in detail the immediate threats to wild populations and their habitats, and the underlying drivers of those threats. The final section of lectures explores potential solutions, combining socio-economic as well as biological insights to take a constructively critical look at approaches ranging from sustainable harvesting and ecosystem restoration to agri-environment schemes and the marketing of ecosystem services.

Core lectures are supplemented by case studies given by outside experts on policy and conservation practice. There is also a field trip, a careers session, a class debate and a guided tour round various conservation organisations based in the David Attenborough Building.

Module ZM3: Human Evolutionary Ecology

Module organiser: Professor Andrea Manica, am315@cam.ac.uk

This course will take an evolutionary and ecological approach to understand how our own species interacts with its environment. Anatomically Modern Humans are arguably the most studied species on the planet, and provide a fascinating study system for which multiple lines of evidence (archaeology, physiology, genetics, and behaviour) can be blended to ask questions about its past and present. We will look at how our species evolved in its ancestral African homeland, how it responded to the challenges it faced when colonising new environments during the expansion out of Africa, and how it interacted with other species (other hominins as well as other animals). In these contexts, we will also pay attention to the possible role of culture and its effect on the structure of human societies.

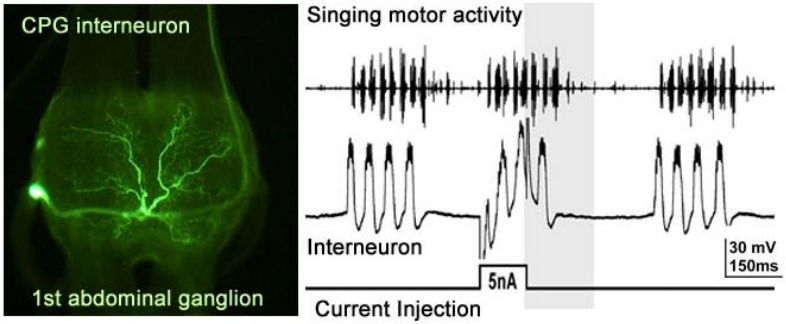
Module ZM4: Neuroethology: The Neural Basis of Adaptive Behaviour

Also available as a BBS Minor subject

Module organiser: Dr Berthold Hedwig, bh202@cam.ac.uk

These lectures place a strong emphasis on understanding the neural mechanisms underlying behaviour. Within this module we explore how nervous systems are organised, how animals gather and process information about the environment, and how they generate the motor activity underlying their behaviour.

The first lectures will give an introduction into the organisation and adaptations of brains and will show how an animal's neuronal capabilities are linked to energy, ecology and lifestyle. We then consider neural circuits and the control of motor patterns. We demonstrate how auditory and visual processing is adapted to the lifestyle in insects and other species. Larval and adult Drosophila will be discussed with an emphasis on genetic techniques to study their nervous system and behaviour. Finally, we will demonstrate the basis of plasticity and learning in neural networks und behaviour at a circuit and cellular level.



A central pattern generator interneuron in the cricket abdominal ganglion controls the insect's singing behaviour

Module ZM5: Evolution and Behaviour: Genes and Individuals

Module organiser: Dr Nick Mundy, nim21@cam.ac.uk

The classical way to study animal behaviour separates questions concerned with function (what is the adaptive value of the behaviour? what is its evolutionary history?) from those focused on causation (how is the behaviour controlled? how does it develop during a lifetime?). The aim of this course to show how recent research is sweeping aside these traditional distinctions in two different ways, yielding new insights into the way that evolution works. Specifically:

1) Animal behaviour, and the mechanisms by which it develops, can contribute to evolutionary change: by changing ecological conditions; by imposing selection on other parts of the phenotype and other individuals; by influencing patterns of inherited variation; and by facilitating reproductive isolation.

2) At the same time, the mechanisms controlling behaviour and its development are themselves subject to natural selection and are adaptations for the ecological conditions in which an animal lives. This means that we can predict the particular mechanisms involved in behavioural development, as well as an animal's immune function and its specific cognitive and sensory capacity, from aspects of its ecology.

The first half of the course focuses on the genetic foundations of behaviour and the consequences for evolutionary processes such as adaptation and speciation. In the second half of the course, the emphasis is on the adaptive value of cognitive, sensory and immune function and how they contribute to individual variation.

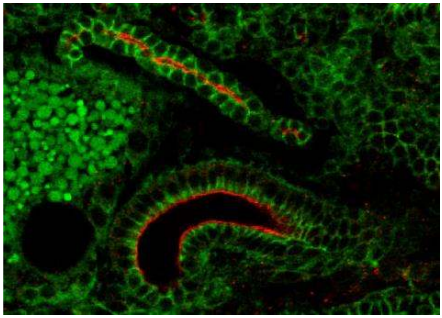
Module ZM6: Cell Assembly and Interactions

(Inter-departmental course with PDN)

Module organiser: Dr Tim Weil, tw419@cam.ac.uk

Cells are highly organised and dynamic structures. In this module we will explore how the architecture of the cell is constructed and how cells interact with each other and their environment in order to fulfil their myriad roles in animals. Our current knowledge of these vital topics will be presented in depth, with a focus on the molecular mechanisms that regulate cell behaviour. We will examine how cells use basic cell biological mechanisms in their complex activities within animals, including cellular behaviour during development and how cellular activities provide key physiological functions in the adult.

We will begin with a section of theories to explain how cells were first created and then evolved into the great diversity of cell morphologies and function observed today. We will then explore how membrane compartment are constructed, and the dynamics of transfer between them. Next we will discuss the key role of the cytoskeleton in cell shape, organization and movement. This is followed by an examination of how cells become polarized and adhere together to form higher order multicellular assemblies. We will then study how cells sense and respond to the mechanical properties of their surroundings. Finally, we look at long range signalling between cells by examining how cells integrate and respond to the diverse signals that arrive at their surface, exploring how the spatial organisation of intracellular signals has a profound influence on the nature of signalling.



This is an interdepartmental course (PDN and Zoology). In addition to lectures there are several interactive sessions (such as journal clubs) in which there will be discussions of key papers, experimental techniques and major concepts in the field.

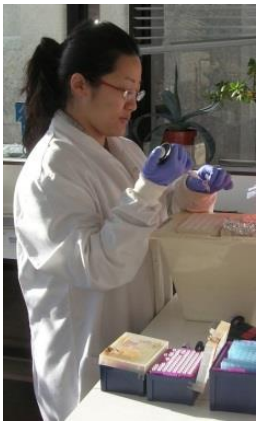
Module ZM7: From Genome to Proteome

(Inter-departmental course with Biochemistry)

Module organiser: Dr Torsten Krude, tk218@cam.ac.uk

This course aims to introduce and discuss the regulation of gene expression using a wide range of examples and different model organisms, and to introduce the range of methodology that is used in such studies. This course aims to take you from the level of familiarity with textbooks and reviews up to the level of reading, understanding and critically evaluating original research papers.

Control of gene expression is a topic that addresses the flow of information from the genome to the proteome. It includes the steps of gene transcription (i.e. mRNA synthesis), splicing, mRNA localization within the cell, and protein synthesis (i.e. mRNA translation). Understanding gene expression is important for understanding the fundamental functions of cells, how cells proliferate, how they respond to environmental stimuli, how they change their function during differentiation and how new complex patterns and structures emerge during development. An understanding of the molecular mechanisms that regulate gene expression is therefore an essential topic of contemporary cell and developmental biology. This module introduces and discusses the factors which catalyse and regulate transcription, RNA localization and translation. It also addresses newly emerging concepts, which provide additional levels of regulation and complexity. For instance, genome projects have focussed more and more attention on patterns of gene expression in different cells, different tissues and different organisms. The tool of RNA interference has been developed to knock-out the expression of any specific gene in living cells to study the function of that particular gene in vivo. Small non-coding RNAs have been identified as regulators for fine-tuning gene expression in many systems. Finally, the coordination of gene expression between the cell nucleus and organelles containing their own DNA will be discussed. This module is fully interdepartmental and the lectures are also taken by students reading Part II Biochemistry. The lectures are given in the Department of Biochemistry by members of the Departments of Zoology, Biochemistry and the Gurdon Institute.

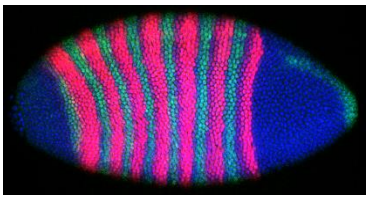


Module ZM8: Development: Patterning the Embryo

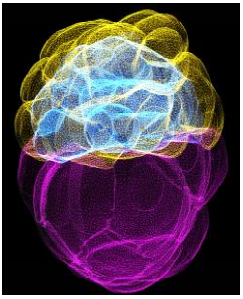
(Inter-departmental course with PDN)

Module organiser: Dr Howard Baylis, hab28@cam.ac.uk

This course is the first of two complementary modules (with L6), which can also be taken on their own. Our aim is to explore a fascinating biological question: how does a single cell, the fertilized egg, have all the information to make an animal? Our current knowledge of the underlying molecular mechanisms that create cell diversity and pattern in the early embryo will be examined in depth. We will discuss how the experimental advantages of different model organisms have aided the discovery of the principles of development, and the insights provided by comparing the developmental strategies of vertebrates and invertebrates. In this first module we will address key aspects of early development, including how development is regulated, how the patterning of spatial information is established and how morphogenetic mechanisms shape the embryo. At each stage we will discuss the cellular mechanisms required and the molecular networks that drive them. By comparing the development of different animals we aim to come to an understanding of conserved strategies of animal development.



These themes will be covered from the establishment of polarity in the egg, and its elaboration after fertilisation, to a consideration of how these events set the body axes. We will then see how axial patterning directs the morphogenetic movements of gastrulation and the grouping of cells into segments with differing identities.



This interdepartmental course (with PDN) will consist of three lectures per week including interactive sessions. Our aim is to provide a course that is accessible to anyone doing Part II Zoology and we hope that you will consider doing this course whatever your previous background.

Module ZL1: Mammalian Evolution and Faunal History

Also available as a BBS Minor subject

Module organiser: Dr Robert Asher, r.asher@zoo.cam.ac.uk

This course is similar in approach to the Michaelmas Term 'Vertebrate Evolution', but we make sure that it is possible to take 'Mammalian Evolution' without having done its Michaelmas Term relative. The course aims to familiarise you with the comparative morphology and functional biology, modes of life, distribution, evolutionary relationships and systematics of living and fossil mammals and their antecedents. Throughout, we attempt a synthesis of group-based and topic-based treatments.

The first block of lectures deals with the origin and radiation of the earliest synapsids, including such forms as sail-backed pelycosaurs, carnivorous gorgonopsids, and a variety of small and large cynodonts. We then explore the gradual evolution of the jaw, ear, braincase, limbs, and vertebral column in synapsids that, eventually, qualify as true mammals. The impressive diversity of Mesozoic mammals comprises the raw material for several lectures. Most of the course deals with the anatomy and evolutionary history of contemporary monotremes, marsupials, and placentals, along with their many extinct ancestors. The last three weeks of the course take up the themes of extinction and the Quaternary, or the biology of 'Ice Age' mammals. The mammals in question have particularly complete fossil records, which makes possible an examination of processes of evolutionary change.

Lectures are backed-up by demonstration practical classes, which reinforce and illustrate topics of central importance in the lectures. Students may additionally opt to be assessed on the material seen during these classes in an examined practical assessment in the Easter Term. The assessment counts as the equivalent of one short project.

Module ZL2: Responses to Global Change

(Inter-departmental course with Plant Sciences)

Module organisers: Dr David Aldridge, da113@cam.ac.uk (Zoology)
Professor Howard Griffiths, hg230@cam.ac.uk (Plant Sciences)

Temperatures are rising, rainfall patterns are changing, and species are on the move – we have never seen such changes in the history of humans.

Understanding what is happening, and why, will allow us to respond to these changes, potentially making a huge difference to what survives and how we humans live. This course explores changes in birds, plants, their physical environment, and then shows modelling approaches to predict the future . A range of experts with different perspectives deliver the course: James Pearce- Higgins, who works at the British Trust for Ornithology; Peter Carey, an environment consultant with much experience in evaluating biodiversity and assessing the impact of climate change; Ed Tanner (tropical forest dynamics); Howard Griffiths (impact of climatic extremes and drought tolerance); Andrew Tanentzap (global limits to growth and change), Mike Harfoot (biodiversity models) and Andrew Friend (earth-atmosphere dynamics models).

Module ZL3: Evolution and Behaviour: Populations and Societies

Module organiser: Prof Rufus Johnstone, r.a.johnstone@zoo.cam.ac.uk

This module aims to provide a functional interpretation of variation in animal social behaviour and inter-species interactions. The underlying theme is that individuals will behave in ways that promote their genetic contribution to future generations. The way in which they do so is constrained by their ecology and by social interactions with members of their own and other species.

The course aims to provide you with an understanding of:

1) the framework of evolutionary theory that is used to explain variation in animal social behaviour;
2) the way in which ecology and social competition constrain and control evolutionary options;
3) the empirical evidence that supports functional interpretations of social behaviour and life history (including observation, comparative and experimental studies).

Lecture blocks deal with social evolution, communication, family life, individuals and groups, coevolution (from mutualism to parasitism) and major transitions in social evolution.

Module ZL4 - Applied Ecology

Module Organiser: Dr Edgar Turner, ect23@cam.ac.uk

All too often, managers of natural resources make ill-informed decisions that can have devastating consequences upon ecosystems and the human populations who depend upon them. This module is about how a sound understanding of ecological processes can greatly improve our ability to manage ecosystems in a desirable way.

The course considers a diverse range of applied applications of ecological knowledge, from understanding disease epidemics, to predicting the future impacts of climate change. It also considers the role of applied ecology in a diverse range of environments, from the world's most remote island groups and Polar regions, to familiar agricultural landscapes.

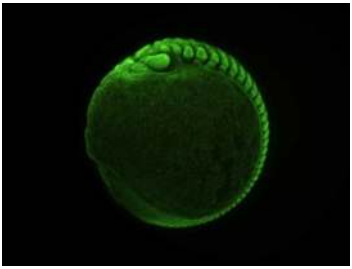
Different sections of the course include ecological approaches for the control of influenza, the control of invasive species on islands, the ecology of Antarctic ecosystems in the face on environmental change, applying lessons from palaeobiology to modern changes in species, and ecology in agricultural environments. As well as lectures, the course also includes sessions with applied ecologists from the David Attenborough Building and seminars that enable students to explore aspects of applied ecology in more detail.

Students taking this course will learn how a well-trained and enthusiastic ecologist can apply their scientific knowledge to make a real change to the world around them.

Module ZL5: Genetics, Development and Animal Diversity

Also available as a BBS Minor subject

Module organiser: Professor Chris Jiggins, c.jiggins@zoo.cam.ac.uk



This course lies at the interface of whole organism biology and molecular genetics. We look at how genomes themselves evolve, and also at how genome can inform whole organism biology. Recent advances in sequencing technology mean that genomic approaches are no longer limited to a few model species, but instead can be applied in many organisms of evolutionary or ecological interest.

How do genomes evolve? A large proportion of many genomes consists of repetitive DNA, which replicates itself at the expense of the organism – a form of genomic parasitism. Other sources of conflict occur between the sexes, and between parents and offspring. We will look at the genetic basis of sex determination and how this can lead to conflict between chromosomes. What is the genetic 'tool kit' that controls the great diversity of animal body plans?

How are species and populations related? We look at how we can reconstruct species relationships from DNA sequences, and how this can inform our understanding of traits such as human language.

What is the genetic basis of adaptation? Do we expect evolutionary change to involve few or many genes? What kinds of genes control recent evolutionary changes? Butterfly wing patterns and many other examples are used to illustrate these questions.

Module ZL6: Development: Cell Differentiation and Organogenesis

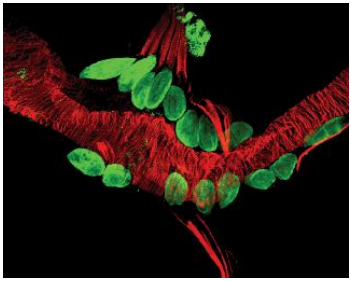
(Inter-departmental course with PDN)

Module organiser: Dr Tim Weil, tw419@cam.ac.uk

This course is the second of two complementary Developmental Biology modules (with M8) that can also be taken on their own. This module examines a second phase of embryonic development, following the initial steps of defining axes, major cell layers, and broad pattern domains that are covered in M8.

This interdepartmental course (with PDN) will consist of three lectures per week, and seven interactive sessions (such as journal clubs) in which we will aim to discuss key references and the concepts presented in the lectures.

A series of topics will be presented, each using particular tissues or organs to highlight individual developmental mechanisms. Thus, the generation of airways and vasculature addresses principles of tubulogenesis; vertebral column and lung illuminate mechanisms of cell allocation and morphogenesis; limb development illustrates how patterning mechanisms are coordinated with cell proliferation; the progressive determination of cell lineages and establishment of stem cells shows how organs are derived; and the development of pharyngeal arches, neural crest cells and craniofacial organizing centres demonstrates how epithelial-mesenchymal interactions instruct cell differentiation and patterning in the head.



A mixture of examples from simpler invertebrate models and vertebrates will show how developmental mechanisms have diversified with increasing cell number.

Module ZL7: Cell Cycle, Signalling and Cancer

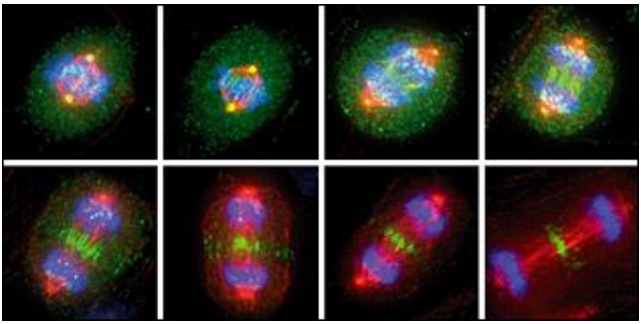
(Inter-departmental course with Biochemistry)

Module organiser: Dr Torsten Krude, tk218@cam.ac.uk

Precise control of cell proliferation is crucial to the normal development and homeostasis of multi-cellular organisms. Failure to accurately regulate these processes can lead to cancer. This course aims to provide a broad molecular understanding of the processes underlying cell proliferation in normal development and disease. It aims to explore experimental systems to study tumour biology, and to critically discuss therapeutic strategies against cancer.

This course will first concentrate on the molecular mechanisms underlying controlled cell proliferation, including cell cycle control, replication of DNA, repair of DNA damage and programmed cell death. It will then apply this fundamental understanding of cell proliferation and homeostasis to explore tumours as aberrantly proliferating tissues, including the interplay between oncogenes and tumour suppressors, and the specific topography of tumour microenvironments. Finally, this course will consider therapeutic anti-cancer strategies, including tumour virus vaccination, small molecule drugs and antibody-based therapies. It further aims to illustrate the experimental approaches used, to highlight important questions that remain to be answered, and to encourage critical evaluation of the scientific literature.

This module is fully interdepartmental and the lectures are also taken by students reading Part II Biochemistry. The lectures are given in the Department of Biochemistry by members of the Departments of Zoology, Biochemistry and the Gurdon Institute, as well as by several external experts.



Deconvolved images of Hela cells progressing through mitosis stained for Polo-like kinase 1 (green), tubulin (red) and DNA (blue)

Other available modules, which are organised by other departments (Plant Sciences and Genetics)

Part II students can take **one** of these three modules in place of a Zoology module.

Module PLM3: Evolution and Ecosystem Dynamics (Plant Sciences)

(Michaelmas term, 24 lectures)

Module Organiser: Professor Howard Griffiths (Plant Sciences), hg230@cam.ac.uk

For the first half of the module, we consider the origins and diversification of the land plant flora. As plants colonised the land, the phylogenetic progression is reflected in key physiological advances which provide a palaeohistorical framework. A workshop on practical aspects of measuring phylogeny then leads in to a more detailed comparison of factors leading to the evolution of three key groups, namely ferns, conifers and angiosperms. Aspects of generating ecological diversity are then developed through priority effects, with consideration then given to specific examples of factors regulating biodiversity in forest ecosystems, through co-existence, regeneration and dispersal. We also consider differences in diversity between primary and secondary tropical forests.

Module G1: Evolutionary Genetics (Genetics)

(Lent term, 24 lectures)

Module Organiser: Professor Frank Jiggins (Genetics), fmj1001@cam.ac.uk

Modern evolutionary biology 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 process of evolution, exploring the central topics of natural selection, adaptation and genetic drift, and combining a variety of empirical and theoretical approaches.

The course will begin with four lectures that 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. These will be followed by 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. There follows a series of lectures covering key areas of evolutionary genetics, including the formation of new species, the evolution of sex, and the origins of major features of our genome.

Module Bioinformatics (Genetics - also available as a BBS minor subject)

(Lent term, 15 lectures, 9 practical sessions)

Module Organiser: Dr Gabriella Rustici (Genetics), gr231@cam.ac.uk

This module will provide an introduction to the field of bioinformatics, focusing on applications related to the study of complex disease genetics and the recent advances made in this field since the introduction of next-generation sequencing (NGS) technologies.

It will consist of 15 lectures and 9 computer-based practical sessions. During the practical sessions, students will use the Unix command- line environment and the R project for statistical computing.

Aims:

- Learn bioinformatics approaches used in cutting-edge genomics and other biomedical sciences;
- Process, analyze and interpret HTS data;
- Learn basic computational skills crucial for modern research

CELL AND DEVELOPMENTAL BIOLOGY IN PART II ZOOLOGY

The Department of Zoology offers the choice of eight exciting Part II Cell and Developmental biology modules. Students can focus purely on these topics if they wish. However one of the advantages of studying these research areas in the Department of Zoology is that we offer a very wide range of other options with which cell, molecular and developmental biology can be combined. Indeed research and teaching in Zoology covers the range of animal biology from cells, molecules and embryos to nervous systems, ecology and evolution.

You should study two modules a term. The cell biology modules offered are:

Michaelmas Term

- **ZM4 Neuroethology: The Neural Basis of Adaptive Behaviour**
- **ZM6 Cell Assembly and Interactions**
- **ZM7 From Genome to Proteome**
- **ZM8 Development: Patterning the Embryo**

Lent Term

- **ZL5 Genetics, Development and Animal Diversity**
- **ZL6 Development: Cell Differentiation and Organogenesis**
- **ZL7 Cell Cycle, Signalling and Cancer**
- **Bioinformatics**

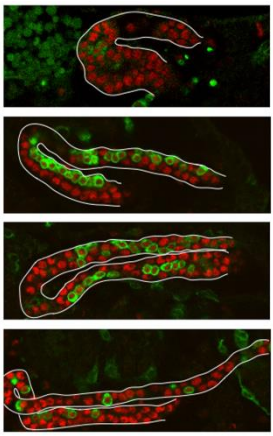


Photo by Kyra Campbell

ECOLOGY IN PART II ZOOLOGY

Many NST II Zoology students take what is in effect an ecology course at Part II level. There are six modules which may appeal to students interested in this route, and many students select four of these. However, it is also possible to combine a selection of these with some of the other modules on offer.

You should study two modules a term. The ecology modules offered are:

Michaelmas Term

- **ZM2 Conservation Science**
- **ZM3 Human Evolutionary Ecology**
- **ZM5 Evolution and Behaviour: Genes and Individuals Behaviour**

Lent Term

- **ZL2 Responses to Global Change**
- **ZL3 Evolution and Behaviour: Populations and Societies**
- **ZL4 Applied Ecology**

Photo by Nanna Evers

One module available to Zoology students is organised by the Plant Sciences Department:

- **PLM3: Evolution and Ecosystem Dynamics (24 lectures)**

PART II Biological & Biomedical Sciences (Zoology)

Course Structure

The BBS Zoology course is composed of a combination of four of the single modules listed on our website. They will be examined at the same time as Part II Zoology. Students also take another module for examination from the available minor subjects and submit a Dissertation supervised by Zoology or another Department.

BBS Zoology students are encouraged to attend the course on Statistics for Biologists provided by the Department of Zoology at the start of the Michaelmas Term.

BBS Zoology (major) students can take any two of the Michaelmas term modules and any two of the Lent term modules, provided the timetables do not clash with their minor subject. Timetables for the Zoology modules are available at:
https://www.zoo.cam.ac.uk/study/NST-II-Zoology/modules

and the minor subject timetables can be found at: www.biology.cam.ac.uk/undergrads/nst/bbs/Timetable

Note that the vertebrate modules ZM1 & ZL1 involve some practical work which is taken by Part II students after the lectures, which can potentially clash with lectures in your minor subject. Please consult with module organisers if these demonstrations are required at other times.

The following Zoology modules are available as a BBS minor subject:

- ZM1 Vertebrate Evolution
- ZM2 Conservation Science
- ZM4 Neuroethology: the neural basis of adaptive behaviour
- ZL1 Mammalian evolution and faunal history
- ZL5 Genetics, development and animal diversity

Therefore it is possible to take Biological and Biomedical Sciences entirely within the Department of Zoology (timetable permitting).

Aims of Part II BBS Zoology

Through guided reading, lectures, essays, seminars, and bibliographic reviews (dissertations) students will be educated and trained in a wide range of scientific skills which provide the learning base for future careers in disciplines such as behaviour, developmental biology, ecology, agriculture, environmental management, publishing, teaching and management.

Learning Outcomes for students

At the end of the lecture courses students should be able to:

- Think critically in terms of their learning and research.
- Critically evaluate the published literature.
- Be aware of the techniques needed to analyse and quantify data collected during a research project.
- Communicate with expert and non-expert audiences through seminar presentations, bibliographic project reports and essays.

ASSESSMENT

The Part II BBS Zoology course is assessed as follows:

Four 3 hour examination papers as set for Zoology Part II. Candidates are asked to answer three questions on each paper. Marks will be combined with those from the Dissertation and the fifth (minor subject) exam paper, to provide the six examination elements necessary to meet the requirements of the BBS Part II degree.

Back image: *Drosophila melanogaster* cuticle and muscle labelled for cytoskeletal proteins. Image acquired in the Zoology Imaging Facility on an Olympus FV3000 Confocal Laser Scanning Microscope. Weil Lab.