



UNIVERSITY OF  
CAMBRIDGE

# Part IA Evolution and Behaviour

## Course Handbook 2017 – 2018



[www.plantsci.cam.ac.uk/teaching/eandb/](http://www.plantsci.cam.ac.uk/teaching/eandb/)

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For further information on the course, please contact either the Course Organiser, Prof Frank Jiggins ([f.jiggins@gen.cam.ac.uk](mailto:f.jiggins@gen.cam.ac.uk)) or the Undergraduate Teaching Administrator [ugadmin@plantsci.cam.ac.uk](mailto:ugadmin@plantsci.cam.ac.uk)

## Natural Sciences Tripos Part IA

### Evolution and Behaviour

Evolution and Behaviour is a first-year Natural Sciences course on evolutionary biology and behaviour. It is taught jointly by the Departments of Biochemistry, Psychology, Genetics, Plant Sciences and Zoology, and the Division of Biological Anthropology, Dept. of Archaeology and Anthropology. The course consists of five half-term sections:

- evolutionary theory;
- the origins of cells and the evolution of plants;
- the evolution and diversity of animals;
- the evolution of behaviour;
- primate and human evolution and behaviour.

## 1. Aims, objectives, and learning outcomes of the course

### Aims

To provide a course on evolutionary biology that introduces you to the major principles of evolutionary theory, and ranges from the origins of life, through the evolution of plants and animals to the evolution of behaviour. To prepare you for subsequent biology courses that require an understanding of evolution and behaviour.

### Objectives

- To show how natural selection ultimately underpins all biological processes and how evolution has generated biological diversity;
- To outline the major transitions in evolution, from the origin of life and of sex, to hominid evolution;
- To investigate the evolutionary basis of behaviour in animals, including humans and other primates;
- To develop your practical biological skills.

### Learning outcomes

At the end of the course you should

- Have an enhanced knowledge and appreciation of evolutionary biology and behaviour;
- Be able to develop cogent and critical arguments based on the course material.
- Be able to perform, analyse and report on experiments and observations in whole-organism biology;
- Be able to integrate related topics from separate parts of the course.

## 2. What kinds of students should consider doing this course?

Evolution and Behaviour provides a broad base for further studies across the whole spectrum of biology, and should be considered by all biologists, whether their primary interests lie in molecular and cellular disciplines, physiology, psychology, or in ecology and evolution. The course is also appropriate for physical scientists with an interest in evolutionary biology or psychology. It will be of particular relevance to those with an interest in Genetics.

## 3. What previous experience is required?

An A level in Biology is not an essential requirement for this course, but some sixth-form level experience of Biology (e.g. AS level, IB, Scottish Higher) is definitely useful background. Students with no previous knowledge of genetics will probably need one or two extra supervisions.

## 4. With which other courses is Evolution and Behaviour compatible?

The course can be most usefully combined with Biology of Cells, Physiology of Organisms or Geology, but in fact it can be taken with any of the other 1st-year Natural Sciences courses. It is an excellent background for all the second-year biological courses, including cellular courses, but is particularly relevant to Animal Biology, Cell & Developmental Biology, Ecology, Psychology and Plant & Microbial Sciences. It is considered useful preparation for Part II Genetics in particular.

## 5. Structure of the course

**Lectures:** There are three lectures per week, held in the Main Lecture Theatre of the Department of Zoology on the New Museums Site. Synopses of these lectures are given in Section 16.

**Practicals:** Biology is an experimental subject: The course therefore provides hands-on experience of basic techniques and experimental approaches and an opportunity to see a wide range of organisms. The practicals are an integral part of the course and it is essential that you attend them. They are held in the Elementary Laboratory of the Department of Zoology.

You will do a four-hour practical every other week either on a Monday or a Tuesday. Both practicals run from 12 – 5, with a break for lunch. You will have been registered for either the odd or even weeks of term. Please ensure you sign the register for each practical class you attend. The register, along with other information, will be posted on the Evolution and Behaviour noticeboard in the Elementary Lab. If for some reason you cannot attend your assigned practical time please email [practicals@zoo.cam.ac.uk](mailto:practicals@zoo.cam.ac.uk) with details. It may be possible to accommodate you in another session. You are expected to write up each practical. One practical from each half-term section will be formally assessed and form part

of your total mark in this subject for the year as a whole. This assessed practical must be written up and handed in during the practical session. Once the practical write-up is marked, you may collect it from the 'pigeon holes' at the front of the Zoology Elementary Laboratory. If you are unable to attend an assessed practical for good reason, please let us know without delay. **Please ask your Director of Studies or Tutor to contact the Course Organiser, Professor Frank Jiggins [f.jiggins@gen.cam.ac.uk](mailto:f.jiggins@gen.cam.ac.uk), to confirm the reason.** In cases of illness, etc., an average mark can be given for that session.

**Ethical reservations:** If you have any reservations concerning any part of the practical course, please raise these in advance of the practical concerned. A solution can normally be found by negotiation with the organiser of that particular practical in consultation with the examiners.

**Field Course:** You have the opportunity to attend one of the one-week field courses held away from Cambridge in the Easter Vacation (details in Section 17).

## 6. Supervisions

Your College Director of Studies will organise supervisions on your behalf. Supervisions are one-hour sessions with a lecturer or post-graduate/post-doctorate research worker. They offer the opportunity to discuss course work and iron out problems and will help you to develop your ability to present material orally and in writing. You will be set written work on aspects of the course, which your supervisor will read and return to you with feedback. Remember also that the lecturers and practical organisers involved in this course are willing to discuss questions or problems you may have.

## 7. Student feedback and representation on the Management Committee

Evolution and Behaviour is run jointly by the Departments of Biochemistry, Psychology, Genetics, Plant Sciences and Zoology, and the Division of Biological Anthropology, Dept. of Archaeology and Anthropology. Responsibility for what is taught on the course rests with the Management Committee, consisting of staff members from the Departments teaching the course and four undergraduates. This Committee decides, broadly speaking, on the content of the lectures and practicals. In order to help it reach decisions, it seeks feedback about the course from the students who take it. There are two ways of achieving this:

- replies to questionnaires
- collation of student views by the student representatives on the Management Committee

**Questionnaires:** As the course progresses, you will be asked to fill in an electronic questionnaire about the current part of the course. It is VITAL to fill in these questionnaires. It is very important that we know understand your experience of the course.

**Management Committee:** You will be asked to elect your own representatives during one of the practical sessions in the Michaelmas Term. There will be four from NST/CST and two

from PBST. It is important that you participate in the nomination and election of your representatives and use them to make your views known to the Management Committee, who meet towards the end of each term.

You may of course direct comments directly to the Course Organiser, Undergraduate Teaching Administrator or to other members of staff whenever you wish.

## 8. Assessment of the course

The course is assessed by one 3-hour theory examination in the Easter Term (worth 75% of the final mark) and by continuous assessment of the practicals (worth 25% of the final mark). The marks of five practicals (each worth 5%) will count towards this final assessment: one in each half of the Michaelmas Term, one in each half of the Lent Term, and one in the Easter Term. Assessed practicals are flagged with an asterisk in the practical timetable (see Section 15). Copies of examination papers from previous years are provided elsewhere on this site. The theory paper is based on the lecture course and is divided into five sections, one for each half-term section of the course. There will be two questions in each section and you will be required to answer five questions, one from each section. Some of the questions may require consideration of material from more than one part of the course. Section A will consist of material covered in the first half of the Michaelmas Term, Section B of material covered in the second half of the Michaelmas Term, Section C of material covered in the first half of the Lent Term, Section D of material covered in the second half of the Lent Term, and Section E of material covered in the Easter Term. There are five examiners for the course (one each from Biological Anthropology, Psychology, Genetics, Plant Sciences and Zoology), and the Senior Examiner rotates among them. The Senior Examiner for 2017-18 is Prof Nicky Clayton, Dept of Experimental Psychology. Lecturers on the course generally set and mark questions in consultation with the Senior Examiner.

## 9. Marking criteria

The Faculty of Biology criteria that will be applied when assessing your theory and practical answers are available at the following webpage:

<http://www.bio.cam.ac.uk/sbs/facbiol/camonly/exam-marking.html> and are briefly summarised below. Note that in the subjects in NST Part IA the second class is not divided.

**First:** Work that is excellent in the range and command of the material covered. Work that is excellent in its understanding of the subject; that has engaged closely with the question; and that is well planned and complete. A first class mark may be awarded on more than one set of criteria: there may be a great deal of relevant information, displaying substantial knowledge and understanding; the arguments and presentation may be stylish; the approach may be original, critical or unorthodox. An upper first would be an outstanding performance, meeting all, or virtually all, of these criteria; a low first would meet at least some of these criteria.

**Second:** Work that shows a good knowledge of the topic and the material covered in lectures; that is presented in an organised way; and clearly argued and focused on the set question. Work that overall shows a reasonable competence in the understanding and

presentation of the relevant material. Certain types of uneven work would fall into this class: detailed factually-correct work that did not relate a broad knowledge of the topic to the specific question asked, or work with clear organisation and some insight but with serious omissions of factual knowledge.

**Third:** At the upper end of the class, work that just shows competent knowledge of the basic, core material. At the lower end of the class, work that shows some knowledge of the material but with serious deficiencies in understanding, coverage and organisation; this will include work that is unduly brief or largely misses the point of the question.

**Fail:** Work that is irrelevant, shows a considerable degree of ignorance, or is short and superficial. Where the question is barely attempted. Guidance on Examination Skills can be found at: <http://www.biology.cam.ac.uk/exams/skills>

## 10. Libraries

**College Libraries:** These should cover most of your needs for books on the subject. Use your College Library as your first resource.

**Departmental Libraries:** The Departments that contribute to this course have libraries that you may use, as follows:

### ***Zoology (Balfour Library)***

The Balfour Library is located on the first floor of the Department of Zoology. The library has a collection of Overnight Loan books for Part I students, which are those in heavy demand due to being recommended for reading by lecturers. They are borrowable literally overnight, from 4.00 pm – 11.00 am the following day, or if borrowed after 3.30 pm on a Friday, they should be returned by 11.00 am the following Monday. There are extra copies of some of these books on the Open shelves that can be borrowed for two weeks. Vacation borrowing of all books is available at Christmas and Easter. Journals cannot be borrowed.

If you wish to use the Balfour Library you must firstly present your University Card to the Receptionist who will release the first floor door to allow access to the library via that corridor. You should register to borrow books by presenting your University Card to the Senior Library Assistant in the Library Office during opening hours.

Library staff can be contacted by email at [library@zoo.cam.ac.uk](mailto:library@zoo.cam.ac.uk) or by tel. on 01223 (3)36648. See also the library's website at <http://www.zoo.cam.ac.uk/department/library>

### ***Plant Sciences***

You may use the Plant Sciences Library on a walk-in basis, either to study, or to borrow books, provided you show your University ID card. Reception can let you into the library – see opening hours below. Since the recent refurbishment, there's plenty of study space, including a quiet study room, and an area where you can work in groups. There is a water cooler, and we are happy for you to eat your lunch whilst working.

This library keeps a special 'Reserve' collection of books cited on reading lists, provided lecturers ask us to keep them. These are for use in the Plant Sciences Library only, and cannot be borrowed, to ensure they are always available. They are kept in the corridor, between the staff desk and the first computer bay. They can be identified by their yellow stickers. You may borrow any other item in the library except these books. Books are signed out in the loans book, which is kept on the staff desk. The three computers on the right-hand side of the Bay furthest from the main door are publicly-accessible. Please e-mail [library@plantsci.cam.ac.uk](mailto:library@plantsci.cam.ac.uk) if you have any problems with, or questions about, the Plant Sciences Library.

### ***Genetics***

You may use the Genetics Library on a walk-in basis, either to study, or to borrow books, provided you show your University ID card. Reception will let you into the building – see opening hours below.

The library keeps a special 'Reserve' collection of books cited on reading lists, and key texts.

These are for use in the Genetics Library only, and cannot be borrowed, to ensure they are always available. You will see them on the first book-stack facing you, with the shelves labelled. They can be identified by their red stickers. Any other books may be borrowed. Unfortunately the library computers have a departmental password, so you would not be able to use them. Please e-mail [library@gen.cam.ac.uk](mailto:library@gen.cam.ac.uk) if you have any problems with, or questions about, the Genetics Library.

***Biological Anthropology (Haddon Library)***

You may borrow books but not journals. Photocopier available. Please register with the Librarian before you use the library. For latest information about opening times, borrowing rules etc. see the library's webpages: <http://bit.ly/8WWyRQ>

***Psychology***

The Psychology Library is situated on the first floor of the Psychological Laboratory (Downing Site), and is open 9am-5pm, Monday to Friday. Please register with the Librarian on your first visit. Books may be borrowed, but not journals. Books from the Special Reference collection may be borrowed as overnight loans. There are scanning and photocopying (black & white) facilities, and a ring-binding service.

Further information can be found on the Library website:

<http://www.library.psychol.cam.ac.uk>

[library@psychol.cam.ac.uk](mailto:library@psychol.cam.ac.uk)

01223 333554

**Opening hours of the libraries in Full Term are as follows:**

<i>Zoology</i>	8.30 am - 5.00 pm (Mon - Thur) 8.30 am – 4.30 pm (Fri)
<i>Plant Sciences</i>	9.00 am – 4.30 pm (Mon - Fri)
<i>Genetics</i>	9.00 am - 4.30 pm (Mon-Fri).
<i>Biological Anthropology</i>	8.45 am - 5.15 pm (Mon - Thurs) (Michaelmas and Lent) 9.15 am – 5.15 pm (Fri) (Michaelmas and Lent) 8.45 am - 7.00 pm (Mon - Thurs) (Easter) 9.15 am – 7.00 pm (Fri) (Easter) 9.00 am - 1.00 pm & 2.00 pm – 5.00 pm (Sat)
<i>Psychology</i>	9.00 am – 5.00 pm (Mon – Fri)

Note also that some of the recommended texts are available as eBooks. Departmental or College library staff will be able to advise you on finding these resources.

## 11. Suggested background reading

- Archibald, J. (2016)  
*One Plus One Equals One* (Oxford University Press)
- Carroll, S.B. (2011)  
*Endless forms most beautiful: The New Science of Evo Devo and the Making of the Animal Kingdom* (Quercus)
- Coyne, J. (2009)  
*Why Evolution is True* (OUP)
- Dawkins, Marian Stamp (1998)  
*Through Our Eyes Only?* (OUP)
- Dawkins, R (1990)  
*The Blind Watchmaker* (Penguin)
- Dawkins, R. (2004)  
*The Ancestor's Tale: a pilgrimage to the dawn of life* (Weidenfeld & Nicholson)
- de Waal, F. (2001)  
*The Ape and the Sushi Master* (Basic Books)
- Fortey, R. (1998)  
*Life: an unauthorized biography* (Flamingo Press)
- Jones, S. (1997)  
*In The Blood* (Harper/Collins)
- Lewin, R. & Foley, R. (2004)  
*Principles of Human Evolution. 2nd edit.* (Blackwell)
- Margulis, L. (1998)  
*The Symbiotic Planet: A new look at evolution* (Weidenfeld & Nicholson)
- Maynard Smith, J. and Szathmary, E. (1999)  
*The Origins of Life*
- Ridley, M. (2003)  
*Nature via Nurture* (Fourth Estate)

## 12. Safety in the Practical Class

- Follow safety instructions carefully, in particular the safety sheet issued for each practical class.
- Do not eat, drink or smoke in the laboratory.
- If you suffer from an allergy or other medical condition that you think might place you at risk during practicals, or on the field course, inform the teaching officer in charge of your practical class.
- Keep water away from mains-powered equipment.
- Ensure that you know where the fire exits are located. The fire signal is a continuous sound from a klaxon or bell. On hearing this sound, leave the classroom immediately under the guidance of the person in charge of the class.
- When in the practical class, cover all wounds, even minor cuts and abrasions.
- If an accident occurs, no matter how minor, inform a demonstrator or technician immediately.
- On the field course, follow all safety instructions given by your teaching staff and the staff of the field study centre.

### 13. Online Resources

Online resources are provided through Moodle. You will be subscribed to this site automatically as part of the NST IA subject choice procedures. Your Raven ID and password will allow you to access Moodle from outside Cambridge during the vacations

The following websites provide information about the course and related topics:

<a href="http://www.plantsci.cam.ac.uk/teaching/eandb/">http://www.plantsci.cam.ac.uk/teaching/eandb/</a>	Course web site
<a href="http://www.zoo.cam.ac.uk">http://www.zoo.cam.ac.uk</a>	Zoology
<a href="http://www.plantsci.cam.ac.uk">http://www.plantsci.cam.ac.uk</a>	Plant Sciences
<a href="http://www.gen.cam.ac.uk">http://www.gen.cam.ac.uk</a>	Genetics
<a href="http://www.bioc.cam.ac.uk/">http://www.bioc.cam.ac.uk/</a>	Biochemistry
<a href="http://www.bioanth.cam.ac.uk">http://www.bioanth.cam.ac.uk</a>	Biological Anthropology
<a href="http://www.psychol.cam.ac.uk">http://www.psychol.cam.ac.uk</a>	Psychology
<a href="http://www.bio.cam.ac.uk">http://www.bio.cam.ac.uk</a>	Faculty of Biology

## 14. Lecture Timetable

Lectures are on Thursdays, Saturdays and Tuesdays at 11 - 12, in the Main Lecture Theatre, Department of Zoology.

**NB** The following dates were correct at the time of publishing; please refer to your electronic diaries [www.timetable.cam.ac.uk](http://www.timetable.cam.ac.uk) . We advise you to set up the automatic export to calendar function for the latest timetabling information.

<b>MICHAELMAS TERM</b>			
<b>Lecture</b>	<b>Date</b>	<b>Lecture</b>	<b>Lecturer</b>
<b>1-4</b>	5,7,10,12 Oct	Introduction to evolutionary biology	<b>Dr Edgar Turner</b>
<b>5-12</b>	14,17,19,21,24,26,28,31 Oct	Evolutionary genetics	<b>Prof Frank Jiggins</b>
<b>13-15</b>	2,4,7 Nov	Early events in cellular evolution	<b>Prof Chris Howe</b>
<b>16-20</b>	9,11,14,16,18 Nov	The origin and evolution of plants	<b>Prof Beverley Glover</b>
<b>21-24</b>	21,23,25,28 Nov	Diversification of angiosperms	<b>Prof Beverley Glover</b>
<b>LENT TERM</b>			
<b>1-6</b>	18,20,23,25,27,30 Jan	The Evolution of Animal Diversity I: Towards a robust tree of animal relationships	<b>Prof Michael Akam</b>
<b>7-12</b>	1,3,6,8,10,13 Feb	The Evolution of Animal Diversity II: Adaptive radiation and exploring morphospace	<b>Prof Paul Brakefield</b>
<b>13-15</b>	15,17,20 Feb	Evolution of Behaviour I	<b>Dr Stephen Montgomery</b>
<b>16-18</b>	22,24,27 Feb	Evolution of Behaviour II	<b>Dr Ljerka Ostojić</b>
<b>19-24</b>	1,3,6,8,10,13 March	Evolution of Behaviour III	<b>Prof Tony Dickinson</b>
<b>EASTER TERM</b>			
<b>1&amp;2</b>	26,28 April	Primate and human evolution and behaviour I	<b>Dr Jake Dunn</b>
<b>3-5</b>	1,3,5 May	Primate and human evolution and behaviour II	<b>Dr Edward Legg</b>
<b>6-10</b>	8,10,12,15,17 May	Primate and human evolution and behaviour III	<b>Dr Alison Macintosh</b>
<b>11</b>	19 May	4 billion years in 1 hour	<b>Dr Edgar Turner</b>

## 15. Practical Timetable

You will do one practical class every two weeks: either Mondays 12 - 5 or Tuesdays 12 – 5.

Practicals will be held in the [Elementary Laboratory, Department of Zoology](#), unless otherwise stated.

MICHAELMAS TERM			
WK	Dates	Practical	
1&2	9,10,16,17 Oct	Adaptive evolution in populations	Dr Jane Charlesworth
3&4	23,24,30,31 Oct	The reconstruction of phylogeny*	Dr Edgar Turner
5&6	6,7,13,14 Nov	Plant Evolution through polyploidy*	Dr Sam Brockington
7&8	20,21,27,28 Nov	Plant Evolution through polyploidy*	Dr Sam Brockington
LENT TERM			
1&2	22,23,29,30 Jan	Animal diversity and evolution	Prof Michael Akam
3&4	5,6,12,13 Feb	Evolution of phenotypic plasticity*	Prof Paul Brakefield
5&6	19,20,26,27 Feb	Designing behavioural experiments and testing hypotheses* A case study: Bird song. <b>From 12:00-14:00</b> <a href="#">Teaching Classroom, Department of Psychology</a> (all groups) and then <b>from 15:00-17:00</b> in the following locations: Mill Lane, Lecture room 7 (Monday groups) Mill Lane, Lecture room 1 (Tuesday groups)	Dr Ljerka Ostojić
7&8	5,6,12,13 March	Comparative studies of learning and memory. <b>The first session between 12.00-13.00 of this practical will be held in the <a href="#">Teaching Classroom, Department of Psychology</a></b>	Dr Edward Legg & Prof Tony Dickinson
EASTER TERM			
1&2	30 Apr 1,7,8 May	Primate features and behaviour <b>This practical will be held in the <a href="#">Henry Wellcome Building, Fitzwilliam St.</a></b>	Dr Jake Dunn, Dr Ljerka Ostojić & Dr Edward Legg
3&4	14,15,21,22 May	Hominid evolution* <b>This practical will be held in the <a href="#">Henry Wellcome Building, Fitzwilliam St.</a></b>	Dr Alison Macintosh

\* Practicals to be assessed

## 16. Course Details

### MICHAELMAS TERM

#### Introduction to evolutionary biology

Dr Edgar Turner [ect23@cam.ac.uk](mailto:ect23@cam.ac.uk) (Zoology)

1. Introduction to course. Natural selection and the origin of adaptation
2. Sex and sexual selection.
3. Kin selection. The levels of selection
4. The origin of diversity. Evolution as a historical process

The aim is to give a general introduction to the broad principles of evolutionary biology and to provide an understanding of how natural selection provides the only explanation for the origin of adaptation in living organisms. The lectures will explore how selection acts on the processes of sex and of mating. We will discuss the revolution that has taken place in recent years in our thinking about the level at which selection acts and consider, for example, the importance of kin selection.

#### Evolutionary genetics

Professor Frank Jiggins [f.jiggins@gen.cam.ac.uk](mailto:f.jiggins@gen.cam.ac.uk) (Genetics)

1. Introducing evolutionary genetics
2. Genetic changes in populations: selection and drift
3. Natural selection in context
4. The genetics and evolution of quantitative traits
5. Adaptation and apparent design
6. Some ongoing debates in evolutionary genetics
7. On the origin of species
8. Phylogenies and lineages over time

Genetics and evolution are two of the great unifying themes in biology. These lectures will introduce the major methods and tools that are used by evolutionary geneticists to understand earth's biodiversity. The aim is to provide you with the means to think clearly about evolution, and to answer your own questions about the natural world. The lectures will move from mutation – the ultimate origin of genetic variation – via the processes of random genetic drift, and natural selection, to the formation of new species, and macroevolutionary patterns.

### Early events in cellular evolution

Prof Chris Howe [ch26@cam.ac.uk](mailto:ch26@cam.ac.uk) (Biochemistry)

1. The earliest "life" - how replicating macromolecules originated.
2. Living together - the origin of mitochondria.
3. Living together - the origin of chloroplasts.

The lectures will review the macromolecules and cellular structures that are important for life today and discuss how macromolecules might have evolved and what the earliest self-replicating macromolecules might have been. We will discuss the origin of cells, concentrating particularly on the origin of structures like mitochondria and chloroplasts in eukaryotic cells. We will look at the evidence that they have an endosymbiotic origin, and what the consequences of these endosymbioses have been.

### The origin and evolution of plants

Prof Beverley Glover [bjg26@cam.ac.uk](mailto:bjg26@cam.ac.uk) (Plant Sciences)

1. The invasion of land and air.
2. Herbs, trees and water.
3. Embryophytes, heterospory and seeds.
4. Adaptive walks through the terrestrial landscape.
5. Hybridisation and polyploidy.

The lectures will review the key features that have enabled the green plants to colonise the hostile terrestrial environment. We will consider how the availability of water for growth and reproduction has been a key selective factor in their evolution. The evolution of green plant life histories and the genetic consequences of their reproductive strategies will be discussed and the evolutionary impetus provided to plants by hybridisation and chromosome doubling will be considered. Finally the genetic opportunities provided by female mate choice in flowering plants will be explored.

### Diversification of angiosperms

Prof Beverley Glover [bjg26@cam.ac.uk](mailto:bjg26@cam.ac.uk) (Plant Sciences)

1. Exploitation of animals: evolution of flowers.
2. From moss to mirror orchids: the DNA story.
3. Divergence and convergence through gene duplication.
4. Selection in action

These lectures will look at the diversification of the flowering plants, taking a molecular perspective where possible. We begin by discussing the exploitation of animals as flowers evolved, and the impact this had on plant diversity. The genes controlling flower development and their roles during plant evolution are analysed, and we explore how the duplication of genes, particularly regulatory genes, influences divergence. We also discuss current examples of selection in action on alleles of plant genes.

## LENT TERM

### **The Evolution of Animal Diversity I: Towards a robust tree of animal relationships**

Prof Michael Akam [m.akam@zoo.cam.ac.uk](mailto:m.akam@zoo.cam.ac.uk) (Zoology)

1. Animal origins: From protists to multicellular forms
- 2&3. An overview of animal evolution: The diversity of phyla
4. Arthropods: Evolution within constraints
5. Our own phylum: The chordates
6. Vertebrates: Clades and grades

These lectures focus on the range of different animal forms, and the pattern of animal relationships. I aim to link this diversity with our growing knowledge of genome evolution, and of how genes are used to build animal bodies. We begin by looking at the origin of the animals and the genetic innovations that accompanied multicellularity. We move on to survey the diversity of invertebrate animals, and consider to what extent the relationships of these hugely varied forms are understood.

Next we look at the arthropods – an immensely species-rich group, and a good place to explore links between the diversity of form and function, and underlying genetic changes. The final two lectures focus on the phylum to which we ourselves belong, the chordates. We explore the conserved characteristics that define the unity of this group, which includes both the familiar vertebrates and the less familiar invertebrate chordates. We survey the key transitions and innovations that led to the appearance of the major groups within vertebrates, and discuss issues of clades and grades.

### **The Evolution of Animal Diversity II: Adaptive radiations and exploring morphospace**

Prof. Paul Brakefield [pb499@cam.ac.uk](mailto:pb499@cam.ac.uk) (Zoology)

1. Natural selection and adaptive evolution
2. Evolution of phenotypic plasticity
3. Adaptive radiations: Ecology and evolution
4. Adaptive radiations: “Evo-devo”
5. Morphospace
6. Evolutionary trajectories: Constraints and bias

These lectures focus on the processes that shape the evolution of patterns of diversification in animals. We begin by revisiting the process of adaptive evolution and discussing the crucial role of natural selection and the importance of genetic variation underlying variation in form and other traits. The evolution of phenotypic plasticity will then be described in the context of how organisms can adapt to environmental heterogeneity, both in time and space.

Ecological and evolutionary research on several case studies of adaptive radiations will be covered before examining how ‘evo-devo’ is contributing to understanding the

diversification of animal form. Radiations will also be viewed in relation to how they explore morphospace. Finally we will ask 'how all-powerful natural selection is' and examine the extent to which observed patterns of evolution may be dependent on properties of constraint or bias that emerge from the processes involved in the generation of phenotypic variation.

### Evolution of behaviour

Dr Stephen Montgomery [shm37@cam.ac.uk](mailto:shm37@cam.ac.uk) (Zoology)

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1. Behavioural evolution and the phenotypic gambit (SM)
2. Proximate causes of behavioural evolution (SM)
3. Behavioural drive (SM)
4. Mate choice (LO)
5. Mating systems: ecological factors (LO)
6. Conflict and co-operation: kin selection and altruism (LO)
7. General principles of learning: Pavlovian and instrumental conditioning (AD)
8. Laws of associative learning (AD)
9. Learning in sensitive periods: imprinting and song learning (AD)
10. Flexibility and updating of learning: food caching and brood parasitism (AD)
11. Discrimination learning and search images (AD)
12. Mental time travel (AD)

Evolution has shaped not only animals' bodies, but also their behaviour. Yet the detailed genetic mechanisms that cause variation in behaviour remain to be elucidated. To understand the evolution of behaviour, we must focus instead on the phenotype. In this way, we can explain variation in life history strategies as well as patterns of mate choice, parental behaviour, social organization, co-operation and conflict. To understand very detailed variation in individual vertebrate behaviour we also have to account for an individual animal's past experience. Understanding vertebrate behaviour therefore requires analysis of what and how animals learn from their environment, which in turn requires understanding of the psychological mechanisms involved in animal learning.

## EASTER TERM

### Primate and human evolution and behaviour

Dr Jacob Dunn ([jcd54@cam.ac.uk](mailto:jcd54@cam.ac.uk)) (Biological Anthropology)

Dr Edward Legg ([ewl24@cam.ac.uk](mailto:ewl24@cam.ac.uk)) (Psychology)

Dr Alison Macintosh ([am2028@cam.ac.uk](mailto:am2028@cam.ac.uk)) (Biological Anthropology)

1. Primate origins and evolution (JD)
2. Primate sociality (JD)
3. Physical intelligence in non-human animals (EL)
4. Social intelligence in non-human animals (EL)
5. Communication and language in non-human animals (EL)
6. Hominin evolution: The earliest fossils (JS)
7. The genus *Homo* (JS)
8. The evolution of modern behaviour (JS)
9. Modern human dispersals and adaptation (JS)
10. Are humans still evolving? (JS)

Humans belong to the order of primates, and although we may like to see ourselves as unique, it is important to see how far the principles of evolutionary biology apply to our species. We start with the evolution of primates and the study of their behaviour in the wild and in the laboratory. The story of human evolution is told both in the fossil record and by anthropological studies of existing populations. According to evolutionary psychologists, many aspects of human behaviour can best be understood from an evolutionary perspective, and these claims are critically examined.

### Wrap-up Lecture

Dr Edgar Turner ([ect23@cam.ac.uk](mailto:ect23@cam.ac.uk)) (Zoology)

1. 4 billion years in 1 hour

This lecture will take a long-term view to summarise aspects of the course and highlight key step changes in complexity that have marked the evolutionary history of life on Earth. This lecture is non-examinable.

## 17. Evolution and Behaviour Field Courses

Students have the opportunity of attending one of the one-week field courses held away from Cambridge in the Easter Vacation. These represent an unparalleled opportunity to get up close and personal with some of the extraordinary diversity of life that shares the planet with us. Field courses are often the highlight of undergraduate courses in Cambridge, and offer one of the first opportunities for students to carry out their own independent projects. If you have been to either of the field stations before as part of a school trip, do not think that you have done this already – ours will be a very different experience! Students will be required to contribute £50 towards subsistence. We strongly recommend you attend one of these courses.

**Aim:** To provide an introduction to the biology, ecology and diversity of organisms in natural habitats. To enable students to study, in their natural habitats, some of the organisms discussed during the lectures, and to illustrate some of the concepts, such as adaptive morphology and behaviour covered in the rest of the course. Students will be given the opportunity to carry out research on their own, or in small groups, which they will present in short talks at the end of the course.

**Applying for a course:** Both field courses were found to be very valuable and enjoyable by those who attended over the last two years (see below), and all students are encouraged to attend one of the courses. Information on how to apply and advice to help you decide which course will best suit your interests will be available in practical sessions in the second half of the Michaelmas term. Applications will be online, and the closing date will be the first Friday of the Lent term. As there are a limited number of places on the courses, places will be allocated on a lottery basis, if oversubscribed.

### Easter Vacation Field Courses 2018

Location	Dates	Field Trip Leaders
Orielton, Pembrokeshire	14th to the 21st April 2018	Dr David Aldridge and Dr S Brockington
Slapton Ley, Devon	16 <sup>th</sup> to 23 <sup>rd</sup> March 2018	Dr Ed Turner and Prof D Coomes

**Student comments on last year's courses:** *"Learnt more from this one week about the diversity of animals than I did from all the lectures" -- "Lots of fun! Definitely worthwhile and a really useful/helpful experience re preparing for exams and consolidating material. Thanks!" "We all are really amazed by how much the demonstrators know. Like living encyclopaedias. Thank you!" -- "It was really good having access to the lab just to be able to observe the organisms." -- "If you are in a dilemma to go to the trip or not because you'll miss revision time you should definitely go! Lots of fun, an awesome way to get to know people and the food is really awesome and unlimited amounts of sandwiches for lunch!" -- "Very glad I came on the field trip. It was a great experience and I learnt a lot. Thank you!"*

## 18. Location of teaching and other facilities

<b>Zoology</b>	
Main Lecture Theatre	Ground floor, access via main entrance
Elementary Laboratory	Ground floor, access via main entrance, practical classes in the "short arm" of the lab
Library	First floor, access via courtyard stairs
First-aid room	First floor, next to Seminar Room
Museum Display Galleries	These facilities will be unavailable for three years during renovation works
Drink dispensing machines	Basement; access from the main entrance
Reception	Ground floor
Toilets	Basement of Downing Street building, downstairs from courtyard entrance
<b>Plant Sciences</b>	
Teaching Laboratory	Ground floor, access via front entrance
Library	Ground floor, access via front entrance
Toilets	On landing between ground and first floors on the two main staircases; also on ground floor, immediately west of the library
Drink dispensing machine	Library, and Tea Room on first floor
Reception	Entrance foyer, ground floor
<b>Genetics</b>	
Library	First floor, west end of building
Reception	Ground floor, by the main entrance
Tea room	Ground floor, west end of building
<b>Biological Anthropology</b>	
Library	Haddon Library. First floor, Downing Site; access via Dept. of Archaeology
Reception	Entrance Foyer, Ground Floor, Henry Wellcome Building, Fitzwilliam St.
Practical Classroom	Seminar Room, Henry Wellcome Building
Toilets	Ground Floor, Henry Wellcome Building
Wheelchair access	Main (front) entrance, Henry Wellcome Building
<b>Psychology</b>	
Reception	Ground floor, Main Entrance
Library	First floor, Main Entrance
Toilets	Ground floor
Wheelchair Access	Back entrance via ramp
Drink Dispensing machine	First floor, in student common room

## 19. Example examination paper

NST0  
NATURAL SCIENCES TRIPOS Part IA

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Date: 13 June 2017

Time: 13.30–16.30

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**Paper EAB/1**

**EVOLUTION AND BEHAVIOUR**

Answer **five** questions, **one** from **each** Section.

Write on **ONE SIDE** of paper only.

Answers from each Section must be tied up in separate bundles, each with a blue cover sheet.

On the cover sheet of each Section write your candidate number (not your name) and the letter of the Section.

Fill out one yellow cover sheet giving the numbers of all questions you attempted.

Where appropriate, candidates are encouraged to incorporate material from different elements of the Evolution and Behaviour course in their answers .

**STATIONERY REQUIREMENTS**

*Script paper*

*Five blue cover sheets*

*One yellow cover sheet*

*Tags*

**SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAMINATION**

*Calculator – students are permitted to bring an approved calculator.*

**You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.**

**SECTION A**

1. Male organisms commonly have elaborate features and bright colours that make them more prone to predation. How can such traits be explained by the theory of natural selection?
2. Discuss which is more important: natural selection, or genetic drift.

**SECTION B**

3. Discuss the role of polyploidy in the evolutionary history of plants.
4. How have studies of anaerobic eukaryotes helped our understanding of the origin of eukaryotes and the origin and subsequent evolution of mitochondria?

**SECTION C**

5. Summarise current views on the pattern of relationships of major groups within the chordates. What characters do all chordates share, and what characteristics distinguish major clades within the vertebrates?
6. Describe with the help of examples how adaptive radiation happens.

**SECTION D**

7. What difficulties might researchers encounter when investigating reciprocity in non-human animals?
8. Describe and discuss the psychology of food caching and recovery.

**SECTION E**

9. To what extent is primate social organisation driven by ecology?
10. Critically assess the evidence that primates possess a "Theory of Mind".

**END OF PAPER**