Welcome to the Part II Zoology BBS course. This handbook provides information about the structure of the course, including timetables for lectures and special seminars, dissertations, examinations and resources available to you in the Department.

Key sources of information, and contacts

The **Part II Zoology Camtools** site is a key resource for the course, with course announcements, lecture handouts (generally posted after the relevant lectures), and past examination papers.

The **Department of Zoology website** at: http://www.zoo.cam.ac.uk has general information on the course, a copy of this handbook, lists of research seminars in the Department, and a telephone/e-mail directory.

The **noticeboard outside the Part II lecture theatre** hosts various announcements, including information on demonstrations/supervisions in particular modules.

Dr Nick Mundy is the course organizer and can be contacted regarding any academic or organizational issues by e-mail (nim21@cam.ac.uk), phone (36657) or in person (office F33 on the first floor).

Susan Rolfe organizes many practical aspects of the course, such as registration forms for Dissertations. Her office (F9) is just along from the Part II lecture theatre. e-mail: sr226@cam.ac.uk, phone: 36620.

Clair Castle (tel: 36648, e-mail: library@zoo.cam.ac.uk) is the senior librarian, and she or her assistant, **Jane Acred,** can help with any matters related to the library or online access to journals/books.

CONTENTS

SECTION A

GENERAL INFORMATION

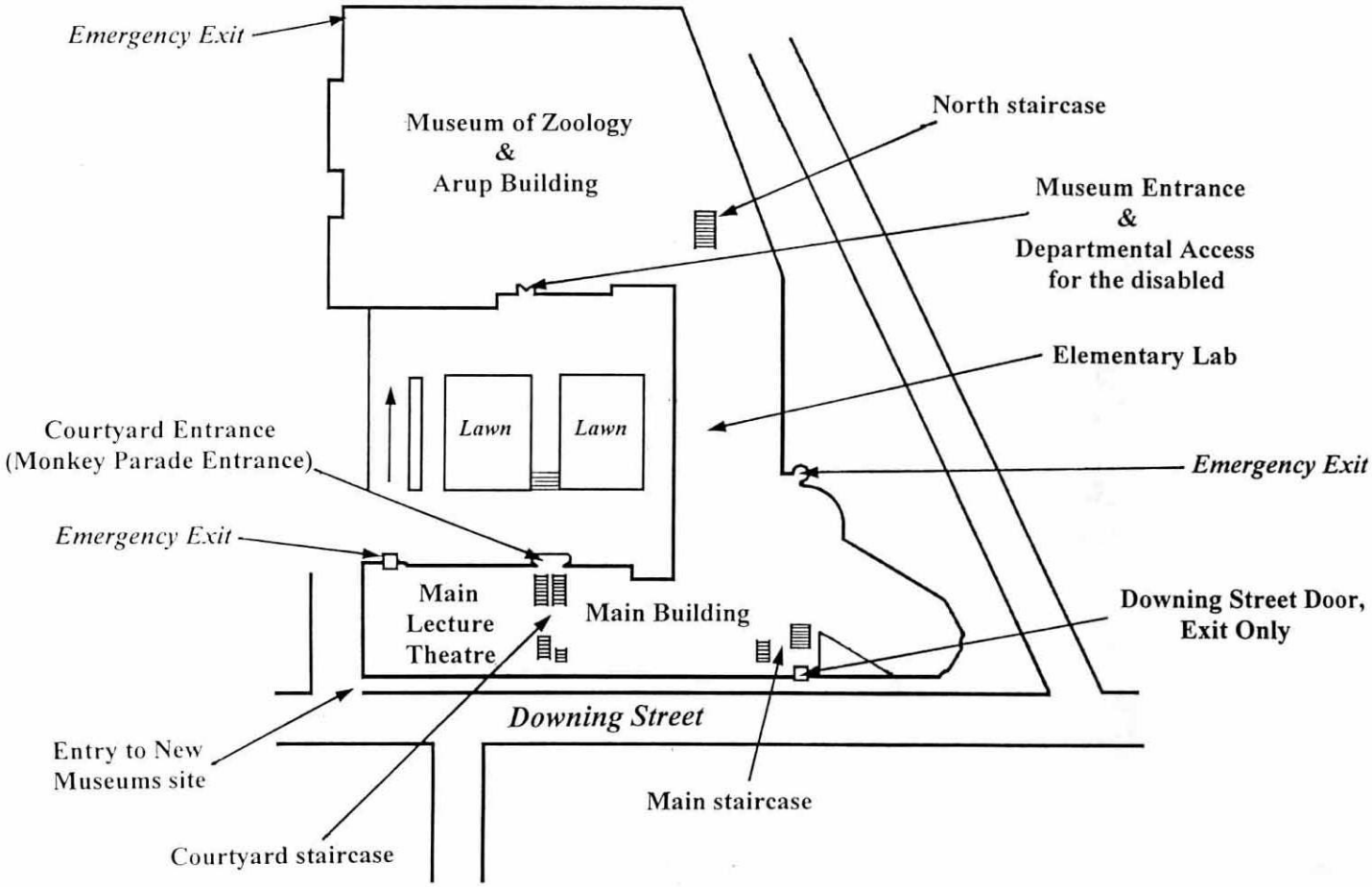
What to do in an emergency

You should familiarise yourself with:

1 The fire evacuation procedure

2 The location of fire exits (see map below) and emergency call points (break glass)

3 The location of first aid boxes and how to contact first-aiders. This information is posted with each first-aid box.



All BBS Part II students take six examined elements composed of a Dissertation and a combination of four Zoology Part II modules and one 'minor subject' from another Department with a total of five 3-hour examination papers. The dissertation may be set by any of the students' teaching departments. Zoology currently offers:

Table of Part II Modules offered through the Department of Zoology

Mich	**Module title**	**Lecture times**
M1	Topics in Vertebrate Evolution	M W F 10
M2	Aquatic Ecology	M W F 11
M3	Population Biology	M W F 5
M4	Neural Mechanisms of Behaviour	Tu Th Sa 11
M5	Behaviour	Tu Th 9 Sa 10
M6	Cell Assembly and Interactions	M W F 4
M7	Control of Cell Growth and Genome Stability	M W F 9
M8	Development: Patterning the Embryo	M 11, Tu 12, F 11
Lent		
L1	Mammalian Evolution and Faunal History	M W F 10
L2	Conservation Biology	M W F 4
L3	Behavioural Ecology	Tu Th Sa 10
L5	Genes, Genomes and Animal Evolution	M W F 11
L6	Development: Cell differentiation and organogenesis	M W F 5
L7	Control of Gene Expression	M W F 9
G Lent	Evolutionary Genetics (Genetics module 5, ends week 7)	Every day 9
P Mich	Dynamics, History & Future of Vegetation (Plant Sci. module M3)	M 9, Tu 10, F 9

There is also a voluntary course on 'Statistics for Biologists' in Michaelmas Term. This course may be of particular interest for those who may wish to continue into research (see section 5).

Table of Part II BBS Zoology Courses (combinations of modules) - Michaelmas Term & Lent Term & Lecture times.

	Modules	Course Title	MT	LT	Minor Subjects Possible**
418	**2 from M6, M7, M8 and 2 from L5, L6, L7,**	**Cell and Development**	M, 9, 11 & 4, Tu 12, W, 9 & 4, F, 9, 11 & 4	M W F, 9, 11 & 5	103, 105, 110, 111, 113, 114, 116, 118
419	**M4, M5, L2, L3**	**Behaviour**	Tu Th Sa, 10 & 11	M W F, 4 Tu Th Sa, 10	103, 104, 106, 108, 113, 114, 115, 116, 121
420	**2 from M1, M3, M5 and L1, L3**	**Vertebrate Biology***	M W F, 10 & 5 Tu Th, 9 & Sa 10	M W F, 10 Tu Th Sa, 10	101, 103, 104, 106, 107, 108, 110, 113, 114, 116, 119, 120, 121
421	**2 from M2, M3, M5 and L2, L3**	**Ecology & Conservation**	M W F, 11 & 5 Tu Th 9, Sa 10	M W F, 4 Tu Th Sa, 10	103, 104, 106, 108, 110, 113, 114, 115, 116, 117, 121
422	**2 from M2, M3, M5 and 2 from L2, L3, Genetics module M5**	**Ecology & Genetics**	M W F, 11 & 5 Tu Th 9, Sa 10	M W F, 4 Tu Th Sa, 10 Every day, 9	103, 104, 108, 110, 113, 114, 116
423	**2 from Zoology M2, M3 or Plant Sciences M3, and L2, L3**	**Ecology & Plant Sciences**	M W F, 10 M 9, Tu 10, F 9	M W F, 10 Tu 9, W 11, F 10	103, 104, 106, 108, 110, 113, 114, 115, 116, 117, 121

* Note that the vertebrate modules M1 & L1 ideally involve some practical work which is taken by Part II students after the lectures. Please consult with module organisers if the demonstrations are required at other times.

Important dates and deadlines

Michaelmas Term

Friday 7th November	4 pm Deadline for Dissertation Registration

Lent Term

Friday 13th March	Latest date to change title of Dissertation

Easter Term

Friday 24th April	4pm Deadline for submission of Dissertation
Weds 27th May - Sat 30th May	**Provisional** dates for Zoology Papers 1 to 4 Note: Times for Minor Papers vary

Learning Times for the BBS Part II courses in the Department of Zoology

These figures are a rough guide – you could expect to spend longer than this during some periods, such as before examinations, researching, Dissertation write-up etc.

	hrs/week/term
Lectures	**3**
Independent literature research (including for supervisions)	**7**
Directed reading (about 4 hrs per module)	**12**
Total	**22**
For 2 Modules	**44**
plus	
Dissertation	**8**
Statistics if taken	**1**
Grand total of hrs/week in each term	**53**

ALLOCATION OF MARKS IN THE ZOOLOGY BBS EXAM

Dissertation	**20%**
Major Subject	
Theory papers (four 3 hour papers)	**65%**
Minor Subject	**15%**
	100%

Special seminars

The times and locations of these seminars will be posted on Camtools.

Michaelmas term

Careers (Careers service and Prof. Simon Laughlin)

Reading a scientific paper (Prof. Simon Laughlin)

Providing Feedback

We take feedback from students on all aspects of the course seriously. There are two formal ways of providing feedback:

Modules
Feedback on lectures and other aspects of modules is provided online in the Ostrakon system via Camtools, twice a term. We strongly urge you to fill in and submit the Ostrakon forms for each module you are attending, which should only take a few minutes.

Student representatives
At the end of each term student reps meet with the course organizer and module representatives, and student reps also attend the Part II Zoology course committee. These are important for giving feedback on any aspect of the course.

10 good reasons to use the Department of Zoology's Balfour Library!

1. 24/7 access
Via your pre-validated University Card.

2. Access to online library catalogues
Search for books and journals throughout the university, and renew your books on loan from any library in the university, online via *Newton* at http://www.lib.cam.ac.uk/newton/

3. Great facilities
PCs, photocopiers, printer, A3 size scanner, and power for laptops. Wireless network available.

4. Friendly and knowledgeable staff
Two full time librarians offer a continuous service throughout the day.

5. Amazing Special Collections
You are welcome to consult any of the 6,000 volumes dating from the fifteenth to the mid-twentieth century. The Eltringham African Collection is of particular use for undergraduate projects in African mammals and related subjects.

6. Recommended texts in print and online
We purchase all your recommended textbooks, many of which are available as e-books at http://www.lib.cam.ac.uk/electronicresources/ebooks.php

7. Access to electronic journals and databases (including Web of Science)
To find your reading and do your research, at eresources@cambridge http://www.lib.cam.ac.uk/electronicresources/

8. Lovely studying environment
The historic main reading room with its domed ceiling offers a pleasant place to study.

9. Informative website
Please visit the Balfour Library website for more detailed information on library facilities and services at http://www.zoo.cam.ac.uk/library/index.html. There are also printed guides in the library, which are available online via CamTools.

10. Things you need to do at the beginning of the Michaelmas term
Please report to the Library Office between 10:30am-12:30pm, or 3:30pm-4:30pm, Monday to Friday to:

- Attend a tour (upon request, for groups of 5 or more people)
- Register your University Card so you can borrow books
- Buy a photocopying card and set up and credit your printing account

We look forward to seeing you in the Balfour Library soon!
Clair Castle, Librarian, and Jane Acred, Assistant Librarian

Lecture timetable, Part II Zoology 2008-2009

	9.00-10.00	10.00-11.00	11.00-12.00	12.00-1.00pm	4.00-5.00pm	5.00-6.00pm
Monday	**M7**	**M1**	**M2**		**M6**	**M3**
Mich			**M8+**			
Lent	**L7***	**L1**	**L5**		**L2°**	**L6**
Tuesday	**M5**		**M4**	**M8+**		
M						
L		**L3**				
Wednesday	**M7**	**M1**	**M2**		**M6**	**M3**
M						
L	**L7***	**L1**	**L5**		**L2°**	**L6**
Thursday	**M5**		**M4**			
M						
L		**L3**				
Friday	**M7**	**M1**	**M2**		**M6**	**M3**
M			**M8+**			
L	**L7***	**L1**	**L5**		**L2°**	**L6**
Saturday		**M5**	**M4**			
M						
L		**L3**				

Lectures in Part II Lecture Theatre, Zoology Department, with the following exceptions:

+M8 Lectures in the Anatomy Lecture Theatre. Journal Clubs in the Austin Building Lecture Theatre.
°L2 and L3 in the Main Lecture Theatre, Zoology.
***L7 in Old Lecture Theatre, Department of Biochemistry from February 6th.**

Dark shading - demonstration practicals for M1 and L1

There may be minor changes to this timetable at short notice during the Terms.

M1 Topics in vertebrate evolution
M2 Aquatic ecology
M3 Population biology
M4 Neural mechanisms of behaviour
M5 Behaviour
M6 Cell assembly and interactions
M7 Control of cell growth and genome stability
M8 Development: Patterning the Embryo

L1 Mammalian evolution and faunal history
L2 Conservation biology
L3 Behavioural ecology
L5 Genes, genomes and animal evolution
L6 Development: Cell differentiation and organogenesis
L7 Control of gene expression

(*voluntary attendance*)

Statistics for Part II Biologists
Dr Brian McCabe

tel: 41810, email b.j.mccabe@zoo.cam.ac.uk

Aims

- To help you to acquire the statistical skills necessary for research projects and evaluation of the literature.
- To provide practice in performing common statistical analyses using popular statistical packages.

Learning outcomes

- Detailed learning outcomes are given in the handout for each lecture. After each lecture, and the associated practical exercises and reading, you should be able to perform simple statistical analyses based on the ideas discussed in the lecture.
- At the end of the course, your understanding is expected to be sufficient for devising and analysing simple experimental designs independently. For more complex statistical problems, you should be able to design experiments and surveys, and analyse your data correctly, on the basis of specialist advice.

Learning time

It is suggested that, soon after each lecture, you spend one hour going over the material in it. The amount of subsequent private study will depend on your background and your field of interest.

Two hours' revision of the material in each practical is suggested. The practical exercises and computers are available throughout the year, so there is plenty of opportunity to acquire the biometrical skills that you need.

The course material should meet the requirements of most projects. Your supervisor will advise you if more specialised techniques are needed. For further advice, contact those who teach on this course, particularly Brian McCabe (e-mail bjm1@cam.ac.uk).

REMEMBER - DECIDE ON YOUR STATISTICAL PROCEDURES WHEN **DESIGNING** YOUR PROJECT, **BEFORE** YOU COLLECT THE DATA

Statistics for Part II Biologists, 2008/2009

Lectures
(Main Lecture Theatre, Department of Zoology)

Lecturer: Dr Brian McCabe

1. *Samples and populations; the normal distribution.* Monday 6th October, 9 am.

Measures of location and dispersion; samples and populations; unbiased estimators; the normal distribution; the standard normal curve; probability.

2. *The binomial distribution; testing hypotheses.* Monday 6th October, 2 pm.

The binomial distribution; testing hypotheses; the null hypothesis; statistical significance; one- and two-tailed tests; the effect of sample size.

3. *The t distribution.* Tuesday 7th October, 2 pm.

Standard error of the mean; comparison of a sample mean with a hypothetical population mean; tables of critical values of *t*; confidence limits; matched pairs *t*-test.

4. *Comparison of two independent, approximately normally distributed samples.* Wednesday 8th October, 2 pm.

Sums of squares; two-sample *t* test; confidence limits of the difference between two means; one- and two-tailed tests.

5. *One-way analysis of variance (ANOVA).* Thursday 9th October, 2 pm.

Reasons for using *ANOVA*; the basic idea of an *ANOVA*; assumptions of an *ANOVA*; partition of total sum of squares into between-groups and error sums of squares; calculation of *F*; tables of *F*; *t*-tests derived from an *ANOVA*.

6. *Analysis of variance (continued).* Friday 10th October, 2 pm.

Planned and unplanned comparisons; checking on the assumptions of an *ANOVA*; transformations; randomised blocks *ANOVA*.

7. *Association.* Monday 13th October, 2 pm.

Correlation as a measure of association; Pearson and Spearman correlation coefficients; the basic idea of linear regression; linear regression as an analysis of variance.

8. *Analysis of variance; models and factorial designs.* Tuesday 14th October, 2 pm.

The model of an analysis of variance; factorial analysis of variance; the idea of interaction.

9. *Techniques for non-normal data; non-parametric statistics.* Wednesday 15th October, 2 pm.

The three main levels of measurement; Wilcoxon test; Mann-Whitney *U* test; χ^2 goodness-of-fit test; contingency tables (χ^2 and Fisher exact probability tests).

10. *Further aspects of regression.* Thursday 16th October, 2 pm.

Prediction of the population regression line; prediction of an individual point; multiple regression; curvilinear regression; linear regression applied to grouped data; analysis of covariance.

Practicals
(Titan Teaching Rooms, New Museums Site)

1. *Introduction to the software.* Monday 6th October, 10-12 or 3-5.

2. *Distributions.* Wednesday 8th October, 10-12 or 3-5.

3. *Comparison of two samples.* Friday 10th October, 10-12 or 3-5.

4. *Analysis of variance.* Monday 13th October, 3-5.

5. *Association.* Wednesday 15th October, 3-5.

6. *Regression models.* Friday 17th October, 3-5.

7. *Factorial and nested analyses of variance.* Monday 20th October, 3-5.

Module Information

Module M1

Topics in Vertebrate Evolution
Module Organiser – Jenny Clack
tel: 336613, email: j.a.clack@zoo.cam.ac.uk

Aims

- To provide an introduction to the history and evolution of (non-mammalian) vertebrates
- To focus on areas of current controversy in the field of vertebrate palaeontology and related disciplines
- To introduce original research literature, and how to read it critically
- To provide an opportunity to examine first hand some of the most important fossil material that has provided the basis for many of the published ideas in the subject

Course structure

The first two lectures introduce cladistic methodology, its difficulties, and its applications to palaeontological problems.

Next, the problems of the anatomy and interrelationships of the earliest vertebrates are introduced, and then the story is continued by consideration of the earliest jawed vertebrates (gnathostomes), ideas about the origin of paired fins, and how gnathostomes might be related to the jawless vertebrates. The ray-finned fishes are treated as an exemplar to understand basic bony vertebrate structure. Then we meet the lobe-finned fishes, both extant and extinct, and their relationships to tetrapods.

A sequence of lectures follows the tetrapodomorph groups and the complexities of the 'fish-tetrapod' transition. They will cover the radiation of early tetrapods in the Palaeozoic, from the fish-like tetrapods of the Late Devonian to the appearance of lineages giving rise to modern tetrapods. We consider some of the problems that had to be met at the onset of terrestrialisation. We then look at the largest and longest-surviving clade of fossil amphibians, the temnospondyls, and examine evidence for the origin of modern amphibians.

The origin of amniotes as a whole is a controversial topic, considered next. Then, problems of relationship and character evolution in the lepidosaurs (the group that includes lizards and snakes) are introduced, followed by the marine reptiles of the Mesozoic, and problems of their biology and relationships.

The section on dinosaurs and related topics begins with an introduction to early archosaurs, from which crocodiles and dinosaurs evolved, followed by a look at the diversity and biology of the flying reptiles - the pterosaurs. The major groups of dinosaurs, the saurischians (such as theropods like *Velociraptor*) and ornithischians (herbivores such as *Iguanodon*) are dealt with, covering adapations of their skulls and skeletons, and behaviour as inferred from fossils. The final lecture is on the origin of birds and flight, the spectacular new material that represent this topic and some of the ideas that it has stimulated.

Learning outcomes

- An appreciation of the methods, aims, obsessions and interests of the science of vertebrate palaeontology and what are considered the important questions at present
- An appreciation of the important input that phylogenetic and evolutionary considerations can make to wider scientific endeavours
- An appreciation of the value and uniqueness of fossils and of the importance of studying original material first hand

Module M1
Mon, Wed, Fri, 10.00 am
Two lectures to take place on 17 Oct at 10 am and 12 noon
Demonstration Practicals M, W, F, 12.00 – 13.00

Rob Asher	**10, 13 Oct**
Introduction to Cladistics.	
Richard Sansom (University of Leicester)	
Problems of jawless vertebrates	**15, 17 Oct two lectures at 10am and 12 noon**
Jenny Clack	**20 Oct**
Optional lecture: Palaeontological localities, preservation and techniques	
Zerina Johanson (Natural History Museum, London)	
Early jawed vertebrates and the origin of paired fins	**22, 24 Oct**
Jenny Clack	**27, 29 Oct 3, 5, 7 Nov**
Introducing bony vertebrates – the ray-finned fishes	
Lobe finned fishes, living and extinct	
Tetrapodomorphs and the fish-tetrapod transition	
Early diversification of tetrapods	
Angela Milner (Natural History Museum, London)	**10, 12 Nov**
Temnospondyls – the most successful amphibians?	
Origin of modern amphibians	
Leslie Noè (Thinktank Museum, Birmingham)	**14, 17 Nov**
Problems of the origin of amniotes.	
Mesozoic marine reptiles	
Susan Evans (University College, London)	**21, 19 Nov**
Lepidosaur evolution	
The origin of snakes	
Leslie Noè (Thinktank Museum, Birmingham)	**24 Nov**
Early archosaurs and crocodilians	
David Unwin (University of Leicester)	**26 Nov**
Mesozoic flying reptiles - pterosaurs	
Richard Butler (Natural History Museum, London)	**28 Nov, 1, 3 Dec**
Saurischian dinosaurs	
Ornithischian dinosaurs	
Origin of birds and flight	

Module M2

Aquatic Ecology Module
Module Organiser – David Aldridge
tel: 34436/31769, email: d.aldridge@zoo.cam.ac.uk

Aims

- to illustrate and examine key ecological concepts and approaches with reference to certain fresh, brackish and marine waters
- to introduce key features of these ecosystems
- to identify important controversial issues and gaps in current knowledge and understanding
- to encourage a critical approach to published data, methodology and hypotheses
- to enable development and defence of a reasoned position in areas of current doubt and uncertainty

Course structure

After a short introduction to the global hydrological cycle and related features (3 lectures by Dr Mike Brooke), the main body of the course begins with 6 lectures on Deep Sea Ecology by Dr. Alex Rogers of the Institute of Zoology. Here we will learn about the constraints and challenges of living at depth, and the remarkable behaviours and ecology of organisms occupying such ecosystems. We then continue with lectures on Freshwaters (6 lectures by Dr. David Aldridge). After investigating how communities interact in river and lake ecosystems, these lectures will focus on how such communities can be perturbed either intentionally, by biomanipulation, or unintentionally, by invasion of non-native species. Microscope demonstrations will provide an opportunity to see many of the freshwater organisms discussed in the lectures.

Finally we come to Marine Macroecology, with lectures from by Prof. Andy Clarke and Dr. David Barnes of the British Antarctic Survey. These lectures examine the large-scale patterns exhibited by organisms throughout the ocean and discuss the processes that underpin these problems.

Learning outcomes

- development of understanding of key ecological concepts and approaches with reference to certain aquatic systems, and of the essential nature of ecological interactions within these important systems
- knowledge of certain important controversial issues and gaps in current knowledge and understanding, and of how these might be resolved
- development of a reasoned critical approach to published data, methodology and hypotheses, and the ability to transfer this skill to other areas of environmental biology
- development of an ability to evaluate different approaches to a single ecological question.

Module M2
Mon, Wed, Fri, 11 am

Mike Brooke	**10, 13, 15 Oct**
Ocean Movements: Causes and Consequences	
Alex Rogers (Institute of Zoology)	**17, 20, 22, 24, 27, 29 Oct**
Deep Sea Ecology	
David Aldridge	**31 Oct, 3, 5, 7, 10, 12 Nov**
Freshwater Ecology	
Andrew Clarke & David Barnes (British Antarctic Survey)	
Macroecology of the Marine Environment	**14, 17, 19, 21, 24, 26, 28 Nov, 1, 3 Dec**

Module M3

Population Biology
Interdepartmental course with Plant Sciences
Module Organiser – Andrea Manica
tel: 36627, email: am315@cam.ac.uk

Aims

This course aims to provide an integrated understanding of key issues in population biology, spanning population dynamics, population genetics and evolutionary dynamics.

Course structure

The course begins with 6 lectures outlining the basic concepts of population dynamics. In particular, Andrea Manica assesses how basic population processes such as competition, predation and parasitism influence the persistence and dynamics of real populations in time and space. Recent theoretical and empirical work on spatial heterogeneity is introduced. The focus of the last 2 lectures is on methods for explaining spatial processes at different scales (notably the metapopulation concept), the effects of spatial dynamics on population persistence and the tradeoff between competition and dispersal-colonization. The next three lectures, given by Colin Russell, further develop the concept of metapopulations with several applications to diseases.

The next 6 lectures explore two major groups (diseases and plants) that have been the subject of a large body of research in population biology. Derek Smith looks at the ecology and management of diseases in animals and humans. David Coomes provides an overview on plant population dynamics. Plants are a great study system to quantitatively test both simple and complex theories in population biology, and David highlights both successes and short-comings of the current framework.

The next 4 lectures introduce basic concepts of a new ecological discipline: molecular ecology. After a lecture on the use of genetic markers, Bill Amos describes the application of molecular ecology to analyse the interaction between population genetics and population dynamics in a range of systems.

The final 4 lectures explore the relationship between population dynamics and tradeoffs in life history traits. Rufus Johnstone introduces basic ideas of co-evolutionary ecology and in particular the application of game theory to explore evolutionary dynamics.

Learning outcomes

- A broad understanding of the modelling approaches used in population biology.
- An appreciation of how theoretical modelling can inform our understanding of biological phenomena, and how they need to be tested with data.
- A familiarity with those ideas in evolutionary biology and genetics that impinge significantly on population biology.
- An ability to think clearly about key issues in population biology, and potentially apply that thinking in a future career.

Module M3
Mon, Wed, Fri, 5 pm

Basic population dynamics

Andrea Manica **10 Oct**

Populations defined; observed patterns of stability and persistence. Population regulation and density-dependence.

Andrea Manica **13, 15, 17 Oct**

Population dynamics in theory and practice. Basic demographic processes: intra- and interspecific competition, predation and parasitism.

Andrea Manica **20, 22 Oct**

Spatial processes in ecology. Persistence and the metapopulation concept. Population interactions in space and time.

Applied Population Ecology: Case studies

Colin Russell **24, 27, 29 Oct**

Population Demography and dynamics of vertebrate populations.

Derek Smith **31 Oct, 3, 5 Nov**

The ecology and control of human and animal disease.

David Coomes (Plant Sciences) **7, 10, 12, 14 Nov**

Population biology of plants.

Genetical population biology

Bill Amos **17, 19, 21, 24 Nov**

Inferring population structure using genetic markers. Molecular ecology as a tool to analyse population size and population history.

Evolutionary population biology

Rufus Johnstone **26, 28 Nov, 1, 3 Dec**

Dynamics of evolutionary games at the population level. Evolution meets population dynamics.

Module M4

Neural Mechanisms of Behaviour
Module Organizer – Steve Rogers
tel: 331767, e-mail: smr34@cam.ac.uk

Aims

- To understand how adaptive behaviour requires many levels of neuronal organisation, drawing examples from a wide range of animals.
- To illustrate the mechanisms by which nervous systems operate.
- To foster a broad approach to biology that integrates different levels of analysis.
- To identify critical questions, gaps in current knowledge, and controversial issues

Course structure

The course considers a central problem in animal biology: How does the nervous system gather information about the environment, integrate it and then generate appropriate behavioural responses? Emphasis is placed on the biological context of neural mechanisms and relating neurophysiology to behavioural function. The lectures cover the following topics:

Sensory ecology relates an animal's sensory mechanisms and capabilities to its habitat and behaviour. Using examples from the visual system we will demonstrate how different levels of organisation, from molecule to cell, circuit and organ, have been adapted and organised to recognise patterns, expand behavioural repertoires and optimise performance.

The study of the mechanisms by which individual neurones and groups of interneurones interact underlies all of integrative neuroscience. We use invertebrate and lower vertebrate examples to identify and analyse circuits that generate patterned activity.

Communication is studied in insects, where acoustic signalling is a critical component of speciation. We show how signallers and receivers are adapted for specific roles through the development of specialised sensory and motor systems.

Neuronal plasticity allows animals to adapt behaviour in response to experience. We discuss the neural mechanisms of associative learning in invertebrates and vertebrates, and the mechanisms of neural plasticity underlying the generation of bird song, spatial learning and recognition.

We will show how powerful new gene technologies are being used to identify the role identified genes and genetic mechanisms have in controlling behaviour and in the evolution of the mammalian brain.

Finally we consider how genetically encoded information is used to construct the fully functional neural networks required to generate behaviour. We examine the special attributes of the developing nervous system that allow a network to tune its performance to match an animal's needs. Topics include the development of neural connections; the formation of maps in the central nervous system, and the role of neural activity in modulating connectivity.

Learning outcomes

- an understanding of the principles of neural organisation and operation, both cellular and molecular, within the context of adaptive behaviour.
- An appreciation of common organisational principles operating over a wide range of animals.
- The ability to evaluate different experimental approaches to a single problem and an appreciation of the need for a cross-disciplinary approach.
- Knowledge of the fundamental limitations and gaps in our understanding of major issues, and an understanding of the approaches that might resolve these problems.
- The development of a reasoned critical approach to the interpretation of published data, methodology and hypotheses that can be transferred to any discipline.

Module M4
Tues, Thurs, Sat 11 am

Malcolm Burrows	**9, 11, 14, 16 Oct**
The integrative action of neural circuits	
Simon Laughlin	**18, 21, 23, 25 Oct**
Sensation, behaviour and ecology	
Steve Rogers	**28, 30 Oct, 1, 4 Nov**
Neural mechanisms of acoustic communication	
Brian McCabe	**6, 8, 11, 13 Nov**
Plasticity, learning and memory	
Barry Keverne	**15, 18, 20, 22 Nov**
Brain evolution, genes and behaviour	
Mike Bate	**25, 27, 29 Nov, 2 Dec**
The development of neural networks	

Module M5

Behaviour
Module Organiser – Barry Keverne
tel: 41816, email: e.b.keverne@zoo.cam.ac.uk

Aims

- to illustrate the principles underlying the development of behaviour. These include genomics, sensitive periods, the importance of experience for "innate behaviour", sources of variation and individual differences in behaviour.
- to emphasise the adaptive plasticity in behaviour and how highly regulated learning processes may ensure successful adaptation of behaviour to the environment.
- to give an account of the current research on learning and memory, the nature of imprinting, social learning and its evolutionary significance.
- to understand mental representations in animals and how they use this information to form alliances, deceive one another and mend relationships when they fail.
- to consider behaviour as part of physiological homeostasis and how this adapts to motivational state communicated by hormones and brain evolution.

Course structure

The course aims to give a broad view of the major ideas, methods and empirical observations of ethology, in the biological study of behaviour. A second aim is to establish links between studying the behaviour of whole organisms and the neurobiological and hormonal analysis of mechanisms underlying behaviour.

A recurrent theme throughout the module is the functional approach of studying behaviour in terms of its design properties. The course covers four major issues raised by the study of behaviour – proximate causation (or control), function, evolution and development – and then deals with topics relating to the evolution of behaviour and the comparative approach.

Behavioural development and how inherited and environmental factors interact during the assembly of the adult behaviour system is considered, particularly in the context of imprinting. The course also deals with motivation as part of proximate mechanisms in the control of behaviour, especially in the context of reproductive and parental behaviour.

Learning outcomes

- develop an understanding of behavioural complexity, and the way both internal regulation (genetics) and external events combine to affect the development of behaviour in dynamic, non-addictive ways.
- gain knowledge of how appropriate experimental design and behavioural analysis can further our understanding of the neural basis of learning.
- to emphasis how the crossing of disciplines (ecology, physiology, genetics and neuroscience) is essential to comprehending the evolution of behaviour, and how behaviour can itself play an active role in evolution.
- a knowledge of how evolution has shaped the neural and endocrine mechanisms that underlie behaviour.

Module M5
Tues, Thurs, 9 am
Sat, 10 am

Patrick Bateson	**9, 11, 14, 16, 18 Oct**
Development of behaviour	
Brian McCabe	**21, 23, 25, 28, 30 Oct**
Imprinting and early learning	
Barry Keverne	**1, 4, 6, 8 Nov**
Mammalian maternal care	
Nathan Emery (Queen Mary College, London) and Nicky Clayton (Experimental Psychology)	**11, 13, 15, 18, 20, 22 Nov**
Animal Cognition	
Nick Mundy	**25, 27, 29 Nov, 2 Dec**
Evolution, behaviour and genetics	

Module M6

Cell assembly and interactions
Interdepartmental course with PDN
Module Organisers – Howard Baylis
(Zoology tel: 336630, email: h.baylis@zoo.cam.ac.uk) and
Nick Brown (PDN tel 34128, email: nb117@cam.ac.uk)

Aims
- To develop and expand your understanding of current research topics in cell biology.
- To provide an understanding of how the structure of the cell is established and maintained and, how cells interact with their environment to perform higher order activities.
- To introduce and discuss a range of experimental approaches to cell biology.
- To encourage a critical and focussed approach to literature.

Course structure
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. Our current knowledge of these vital topics will be presented in depth, with a focus on the molecular mechanisms that regulate cell behaviour. Once we have established basic cellular mechanisms, we will examine how cells use them in their complex activities within the organism, including cellular behaviour during development and how cellular activities provide key physiological functions in the adult.

The module begins with a discussion of the interplay between sub-cellular structures and cellular function. We will focus on the establishment of the different membrane compartments in the cell and the regulated transfer of molecules between them. We will then turn to how cells integrate and respond to the vast array of diverse information arriving at their surface. The emerging theme that the control of the location of signalling molecules has a profound influence on the nature of signalling will be presented. The first half of the course will culminate in exploring how trafficking of signalling molecules between membrane compartments is an essential element of signalling pathways.

In the second half of the module we describe the interplay between plasma membrane receptors and the cytoskeleton in a variety of processes: 1) the establishment of cell polarity, 2) mediation of adhesion between cells to form higher order multicellular assemblies, 3) specifying the shape of cells and 4) promoting cell and tissue movement.

Learning outcomes
- An ability to appreciate cell biological problems, to discuss possible solutions and to assess the validity of a hypothesis by assessing the available evidence.
- An understanding of the techniques used to study cell biology.
- Familiarity and understanding of the current knowledge in the fields of cell biology covered by the course.
- An ability to think independently, to critically evaluate published work and to devise experimental strategies to solve problems in cell biology.

Module M6
Mon, Wed, Fri, 4 pm
Journal clubs Thur for two hours between 2-4pm

Howard Baylis and Nick Brown (PDN)	**10 Oct**
Introduction	
Margaret Robinson (CIMR)	**13, 15, 17 Oct**
Coated vesicles & traffic through the Golgi	
Journal club	**23 Oct**
Paul Luzio (CIMR)	**20, 22, 24 Oct**
Post-Golgi traffic	
Rob White (PDN)	**27, 29 Oct**
Nuclear Architecture	
Journal club	**30 Oct**
Howard Baylis	**31 Oct, 3, 5, 7 Nov**
Cell signalling. G-proteins and second messengers	
Journal club	**6 Nov**
Jean Paul Vincent (NIMR, London)	**10, 12 Nov**
Vesicular trafficking and intercellular signalling	
Howard Baylis	**14, 17 Nov**
The polarised cell	
Journal club	**20 Nov**
Nick Brown (PDN)	**19, 21, 24 Nov**
Adhesion and junctions	
Journal club	**27 Nov**
Richard Adams (PDN)	**26, 28, Nov, 1 Dec**
Cytoskeleton and movement	
Journal club	**4 Dec**
Howard Baylis and Nick Brown (PDN)	**3 Dec**
Integrative finale	

Module M7

Control of Cell Growth and Genome Stability
Module organiser – Steve Jackson
tel: 34102, e-mail: s.jackson@gurdon.cam.ac.uk

Aims

- To provide a broad understanding of the intracellular factors that govern how and when a cell divides and how the genetic material is conserved through cell division
- To demonstrate the importance of these processes in the prevention of disease
- To illustrate the experimental approaches that are used to investigate these processes
- To highlight important questions that remain to be answered
- To encourage critical evaluation of the scientific literature

Course structure

The course begins by examining the molecular mechanisms that regulate the mitotic cell division cycle and the machinery of cell division in M phase.

Next, the course considers the molecular basis and regulation of DNA replication in S phase, how the genome is replicated once each cell cycle, and the importance of coupling this DNA replication to cell division. This part of the course also considers the importance of chromatin structure for DNA replication and transcription.

The third part of the course deals with the molecular mechanisms that repair various types of damaged DNA and the processes that arrest cell division when DNA is damaged in order to maintain genomic integrity. Finally in this section of the course, the maintenance of telomeres and the role of DNA repair factors in this important process is covered.

The final four lectures of the course describe how the cell cycle goes awry in cancer and how cell suicide (apoptosis or programmed cell death) contributes to the normal biological control of cancer cells and to regulating cell number during development.

Learning outcomes

Through this course, students should gain

- An understanding of the molecular mechanisms that control several related processes essential for cell division and how these controls help maintain the integrity of the genome as it is transmitted from one cell to its progeny
- An awareness of gaps and uncertainties in our current knowledge and how these may be addressed by future research
- An awareness of the techniques available to study these processes and their limitations
- A knowledge of the relevance of these processes to the generation and possible treatment of disease
- An ability to think critically about current molecular cell biological approaches

Module M7
Mon, Wed, Fri, 9 am
*** This lecture will take place on Thursday, 23 Oct. at 10 am**

Jon Pines	**Thursday 9 October**
Additional optional lecture Basics of the Cell cycle for those students who have not done Biochemistry Part IB	**10-11am**
Steve Jackson	**10 Oct**
Introduction to M7	
Kate Dry	**13 Oct**
How to read a paper	
Jon Pines	
The cell cycle and its regulation by cyclin-dependent kinases and proteolysis	**15 Oct**
Maintaining the order of cell-cycle events	**17 Oct**
Jordan Raff	
The mitotic spindle	**20 Oct**
The spindle assembly checkpoint	**22 Oct**
Mark Jackman	
Moving proteins in and out of the nucleus	***23 Oct at 10 am**
The dynamic localisation of proteins that regulate cell growth and division	**24 Oct**
Torsten Krude	
DNA topology and chromatin structure	**29 Oct**
Assembly and replication of chromatin	**31 Oct**
Chromatin remodelling	**3 Nov**
Guillermo de la Cueva Méndez	
DNA replication in eukaryotic systems	**5 Nov**
Control of DNA replication during the cell cycle	**7 Nov**
Regulation of S phase	**10 Nov**
Abdel Kaidi	
The biology of DNA double-strand breaks	**12 Nov**
Repair of DNA double-strand breaks by non-homologous end joining	**14 Nov**
Repair of DNA double-strand breaks by homologous recombination	**17 Nov**
Telomeres and genome stability	**19 Nov**
Sophie Polo	
DNA damage signalling pathways in yeast	**21 Nov**
DNA damaging signalling pathways in mammals	**24 Nov**
Trevor Littlewood (Addenbrooke's Centre for Clinical Investigation)	
Control of cell death	**26 Nov**
Tumour suppressor genes	**28 Nov**
Oncogenes and oncogenesis	**1 Dec**
Apoptosis and cancer	**3 Dec**

Module M8

Development: Patterning the embryo
Interdepartmental course with PDN
Module Organisers – Isa Palacios
(Zoology tel 767837, email: mip22@cam.ac.uk) and
Richard Adams (PDN tel 333782, email: rja46@cam.ac.uk)

Aims
The course is intended to provide an introduction to the mechanisms that underlie the establishment of cell fate and the early patterning of embryos, through discussion of different model systems and with an emphasis on comparisons between invertebrates and vertebrates. It also aims to familiarise students with ongoing research in these fields.

Course structure
The course will focus first on the molecular and cellular strategies adopted to generate differences between cells, taking examples from a wide range of organisms in order to establish the underlying principles. We shall then discuss how egg polarity is set up and how this leads to the establishment of the 3 embryonic axes. The patterning and execution of early embryonic movements, including gastrulation and segmentation, forms the final section of the course. Through comparison of a wide range of model organisms students will be able to appreciate the fundamental principles that guide embryonic development as well as the differences that lead to divergent morphologies. To provide a forum for discussion, we plan regular discussion groups focussing on one or two recent papers relating to each topic area covered by the course.

Learning outcomes
- An understanding of the techniques used in the study of early embryonic development, in particular genetics, imaging, molecular biology and genomics.
- A knowledge of the current state of understanding of cell fate determination and early embryonic patterning.
- Familiarity with the results of the latest research in the field of embryonic patterning.
- An ability to think independently and to critically evaluate published work and to devise experimental strategies to solve open questions in the field.

Module M8
Mon 11, Tues 12, Fri 11 am
Journal clubs Wed for one hour between 2-4pm (2 sessions)
Lectures will be held in the Anatomy Lecture Theatre
Journal Clubs in the Austin Building Lecture Theatre

Rob White (PDN) and Isa Palacios	**10 Oct**
Introduction: setting up the problems	
Journal club – Introduction to journal club	**15 Oct**
Isa Palacios and Richard Adams (PDN)	**13 Oct**
Model organisms and experimental approaches	
Nick Brown (PDN)	**14, 17, 20, 21 Oct**
How cells become different from one another	
Journal club	**22 Oct**
Isa Palacios and Howard Baylis and Magda Zernicka-Goetz (Genetics)	**24, 27, 28, 31 Oct, 3, 4 Nov**
Egg polarity and body axes	
Journal club	**29 Oct, 5 Nov**
Jim Smith, Richard Adams (PDN), Benedicte Sanson (PDN) and Magda Zernicka-Goetz (Genetics)	**7, 10, 11, 14, 17, 18 Nov**
Gastrulation	
Journal club	**12, 19 Nov**
Rob White (PDN), Matthieu Vermeren (PDN) and Benedicte Sanson (PDN)	**21, 24, 25, 28 Nov, 1, 2 Dec**
Dividing up the embryo (segmentation) and segment identity	
Journal club	**26 Nov**
Nick Brown (PDN), Isa Palacios and Richard Adams (PDN)	
Journal club	**2 Dec (fun finale)**

Module L1

Mammalian Evolution and Faunal History
Module Organiser – Rob Asher
tel: 36680, email: r.asher@zoo.cam.ac.uk

Aims

- to make students familiar with the comparative morphology and functional biology, modes of life and distribution, evolutionary relationships and basic systematics of mammals and their antecedents
- to emphasise the importance of a synthetic approach to the biology of mammals, by using evidence from both living and fossil groups
- to demonstrate the reciprocal illumination provided by a consideration of mammalian biology on one hand and of evolutionary processes on the other
- to illustrate and support the value of a critical attitude to published work

Course structure

In the first 4 lectures, attention is directed to the 'mammal-like reptiles', and to the evolutionary innovations leading to the origin of 'true mammals'.

The next 6 lectures deal with the diverse groups of so-called 'Mesozoic mammals' that occupy most of the evolutionary history of mammals.

6 lectures then consider the origins and biology of the three modern groups of mammals: the egg-laying monotremes (duck-bill platypus and spiny anteaters) and the marsupials and placentals, with an emphasis on their phylogenetic relationships, diversity and biogeography. Although the topics covered are set in a rigorous framework of evolutionary principles, the fascinating natural history of living mammals is not neglected.

The next 2 lectures consider aspects of the biology of Tertiary mammals.

Finally, 6 lectures are devoted to mammalian diversity and evolution in the Quaternary ('Ice Age mammals'). Two introductory lectures consider essential issues of dating, climate and stratigraphy. The following four lectures deal with the animals themselves, including a consideration of the possible consequences of human activity. Emphasis is put upon the correlation between measurable physical change in the mammals and climatic events.

Learning outcomes

- as the prime outcome of teaching in this module, students will acquire a synthetic and wide-ranging knowledge of the evolutionary biology of living mammals and their antecedents
- the module will enable students to think critically about the particular problems associated with learning about the biology of extinct mammals, in the light of the knowledge they will gain of living ones
- students will achieve the skills needed to take a critical approach to current controversies represented in the scientific literature, skills that are transferable to other areas of students' work within and beyond their university courses

Module L1
Mon, Wed, Fri, 10 am

Tom Kemp (University of Oxford)	**19 (two lectures 10 am and 12 noon), 21, 23, 26, 28 Jan**
Early radiation of the mammalian stem group	
Rob Asher	**30 Jan, 2, 4, 6, 9, 11, 13, 16 Feb**
Mesozoic mammals; diversity of modern mammal clades	
Eleanor Weston (Natural History Museum, London)	**18, 20 Feb**
Overview of Tertiary mammalian diversity and techniques used in palaeoecology	
Anjali Goswami (Natural History Museum, London)	**23, 25 Feb**
Diversity and evolution of ungulates and carnivorans	
Richard Preece	**27 Feb, 2, 4, 6, 9, 11 Mar**
Pleistocene mammals: life in the Ice Age.	

Module L2

Conservation Biology
Interdepartmental course with Plant Sciences
Module Organiser – Andrew Balmford
tel: 31770, email: apb12.cam.ac.uk

Aims
- To explain the importance and origins of biological diversity and examine the evidence that nature is currently in decline;
- To understand the immediate threats and underlying drivers causing this decline;
- To explore how biological, economic, political and social insights can be integrated to identify potential solutions;
- To help students appreciate that solving real-world practical conservation problems usually requires a multi-disciplinary approach

Course structure
This is an inter-departmental course taught by the Departments of Zoology and Plant Sciences, with additional input from outside experts on policy, economics, and conservation practice.

The module begins by addressing several fundamental issues – what the evidence is for an extinction crisis, why that might matter, what we mean by biological diversity, and where it is found.

The next block of lectures examines reasons for current declines in wild species and the places they live, including over-harvesting, habitat destruction and degradation, the introduction of exotic species, climate change, genetic factors, and underlying economic pressures. This section will also explore several key concepts in conservation biology, such as priority-setting, island biogeography theory, the idea that small populations of plants and animals are particularly vulnerable to extinction, and practical approaches to diagnosing causes of threat.

The final part of the module explores potential solutions to conservation problems. By combining socio-economic as well as biological insights, the lectures take a constructively critical look at *ex situ* conservation, ecosystem management and restoration, conservation treaties, agri-environment schemes, ecosystem services, nature-related tourism, and the sustainable exploitation of wild plants and animals.

Learning outcomes
- A broad understanding of the breadth of biological insights that can be brought to bear on questions in conservation biology;
- An appreciation of how successful conservation is based on high-quality science;
- A familiarity with those ideas from economics and policy that impinge significantly on conservation issues;
- An ability to think critically about key issues in conservation, and potentially to apply that thinking in a future career

Module L2
Mon, Wed, Fri, 4pm
*** except Lecture 12 which will be a field trip from ~1-6pm**

Introduction to biodiversity and its loss

Mike Brooke

Introduction to the module; what is the evidence for an extinction crisis?	**16 Jan**
Why conserve biodiversity?	**19 Jan**
What is biodiversity, and where is it found?	**21 Jan**

Understanding threats

Threats i – overkill, invasives and climate change	**23 Jan**

Ian Hodge (Land Economy)

Threats ii -an economic perspective	**26 Jan**

Alex Rogers (Institute of Zoology)

Threats iii – marine perspectives I	**28 Jan**
Threats iv - marine perspectives	**30 Jan**

Bill Sutherland

Threats v – habitat loss and deterioration	**2 Feb**

Mike Brooke

What and where to conserve; nature reserve design	**4 Feb**
Stochasticity and the small population paradigm	**6 Feb**

Bill Amos

Conservation genetics i	**9 Feb**
Conservation genetics ii	**11 Feb**

Bill Sutherland

Declining populations and threat diagnosis	**13 Feb**

Rhys Green

Threat diagnosis in practice: an example worked through by the class	**16 Feb**

Examining potential solutions

David Coomes (Plant Sciences)

Ecosystem management	**18 Feb**
Ecosystem restoration	**20 Feb**
The implications of global climate change	**23 Feb**
Excursion to Wicken Fen and Kingfisher Bridge reserves, to see management in action (**BRING WELLIES AND BINOCULARS)**	**25 Feb**

John O'Sullivan (RSPB)

The history and practice of conservation policy	**27 Feb**

Andrew Balmford

Ex situ conservation of animals and plants	**2 Mar**
Tropical forests – threats and opportunities	**4 Mar**
Conservation and agriculture	**6 Mar**
Patterns and problems of wildlife utilisation	**9 Mar**
Conservation and sustainable development	**11 Mar**

There will also be two **additional events**:

A discussion of career opportunities in conservation, in academia and beyond
An end-of-course discussion session at a nearby conservation agency

Module L3

Behavioural Ecology
Module Organiser – Rufus Johnstone
tel: 36685, email: r.a.johnstone@zoo.cam.ac.uk

Aims

This course aims to provide a functional interpretation of variation in animal life histories and behaviour.

Course structure

The underlying theme of the course is that individuals will behave in ways that promote their genetic contribution to future generations. The way in which they do so are constrained by their ecology and by social interactions with members of their own species.

Lecture blocks deal with social evolution, communication, family life, vertebrate and insect societies and selfish genes.

Learning outcomes

At the end of the course students should have an understanding of:

1) the framework of evolutionary theory that is used to explain variation animal behaviour;

2) the way in which ecology and social competition constrain and control evolutionary options;

3) the empirical evidence that supports functional interpretations of behaviour (including observation, comparative and experimental studies)

Module L3
Tu, Th, Sat 10 am

Nick Davies	**15, 17, 20, 22, 24 Jan**
Social Evolution	
Rufus Johnstone	**27, 29, 31 Jan**
Communication	
Rebecca Kilner	**3, 5, 7, 10 Feb**
Family Life	
Tim Clutton-Brock	**12, 14, 17, 19 Feb**
Vertebrate Societies	
William Foster	**21, 24, 26, 28 Feb, 3 Mar**
Insect Societies	
Rufus Johnstone	**5, 8, 11 Mar**
Selfish Genes	

Module L5

Genes, Genomes and Animal Evolution
Module Organiser – Michael Akam
tel: 336612, email: m.akam@zoo.cam.ac.uk

Aims
- To provide an understanding of how processes internal to the genome affect its evolution
- To show how information contained in genome structure and gene sequences can be used to infer phylogenetic relationships and patterns of character evolution
- To explore how the mechanisms of individual development have been molded, through evolution, to generate the diversity of form in the animal kingdom.

Course Structure
The first series of lectures examines strife within the genome and its consequences for genome and organismal evolution. There will be three main topics. First, a look at selfish DNA, DNA sequences such as transposable elements which appear to exist more because of their ability to reproduce within the genome than because they are useful to the organism. Second comes the battle of the sexes - how sex is determined and how this sets up a dynamic battle between the chromosomes within an individual. Finally, the concept of tension and competition within the genome will be broadened to embrace other forms of genomic conflict including that between competing offspring developing within a female, and between a female and her offspring. The series will end with a review of the importance of these internal conflicts to the process of organismal evolution.

The second group of lectures examines how the sequences of genes and genomes can be used to reconstruct the history of life on earth. They provide a brief, non-technical introduction to the various methods used, and the models of evolution that underly them, and then consider examples where molecular phylogenies have been used to study patterns of diversification, and to test hypotheses of character evolution.

The last two groups of lectures broadly cover evolutionary genomics and evolutionary developmental biology. First we use data from whole genome sequences to survey the genetic "tool kit" that guides metazoan development. We consider when the genetic mechanisms that control animal development arose, in relation to the origin and early diversification of animals. Then we examine the genetic and developmental basis of animal diversity, focussing on morphology and life history, using a series of case studies that range from the evolution of single cell lineages in nematodes to the evolution of pigment patterns in vertebrates. We explore such ideas as developmental constraints, gene recruitment and macromutation.

Learning Outcomes
- An understanding of the ways in which natural selection can act below the level of the individual to shape the structure and functioning of the genome
- An ability to interpret and assess molecular phylogenetic trees and the conclusions drawn from them.
- An appreciation of the ways in which molecular and developmental studies may enrich our understanding of evolution and animal diversity

Module L5
Mon, Wed, Fri, 11.00 am

Bill Amos — **16, 19, 21, 23, 26, 28, 30 Jan 2 Feb**

Mechanisms of Genome Evolution
Processes of genomic change (4)
Selfish DNA, Genome dynamics,
Transposable DNA, Intron Evolution
Evolution of sex chromosomes and sex determining mechanisms (2)
Genomic conflict, Imprinting and Genomic Piracy (2)

Giselle Walker and Nick Mundy — **4**, **6, 9, 11, 13, 16, 18 Feb**

Molecular Phylogenetics
Models for gene sequence evolution
Methods for making trees
Interpreting trees
Gene trees and species trees
Uses of molecular phylogenetics
Tests for selection
The origin and outcome of gene duplications

Michael Akam — **20, 23, 25 Feb**

Evolutionary Genomics
The metazoan toolkit: genome comparisons (2)
The evolution of gene regulation

Michael Akam, Nick Mundy and Chris Jiggins — **27 Feb 2, 4, 6, 9, 11 March**

Studies in the Evolution of Development
Hox genes and the evolution of body plans
Modelling development and evolution of teeth
Evolution of pigmentation in vertebrates
QTL analysis and gene effect size in adaptation
The molecular basis of mimicry in butterflies (2)

Module L6

Development: Cell differentiation and organogenesis
Interdepartmental course with PDN
Module organisers – Howard Baylis (Zoology tel 36630, email: hab@mole.bio.cam.ac.uk) and Nick Brown (PDN tel 334128, email: nb117@cam.ac.uk)

Aims
The course is intended to provide an introduction to the ways in which embryonic cells lose their pluripotency, becoming differentiated in patterned arrays to build specific structures. Examples will be drawn from a wide range of organisms to illustrate the regulatory mechanisms that produce cell polarity, cell migration, tubulogenesis and organogenesis. Students will be introduced to ongoing research in these fields.

Course structure
The course will consider first the nature of stem cells focussing on germ cells and sex determination. We then consider different cellular phenotypes (polarised cells; migratory cells) and the tissues that are built up from them, taking examples from a wide range of organisms in order to establish fundamental mechanisms. The principles of organogenesis will be introduced using different tissues each of which highlights particular developmental mechanisms. The course will finish with a consideration of regulated growth control and the consequences of its breakdown in cancer. To provide a forum for discussion, we plan regular journal club seminars focussing on one or two recent papers relating to each topic area covered by the course.

Learning outcomes
- An understanding of the techniques used in the study of early stem cell biology and organogenesis, in particular genetics, imaging and molecular biology.
- Knowledge of the current state of understanding of the stem cell state, cell differentiation and the regulation of patterned tissue generation.
- Familiarity with the results of the latest research in these fields.
- An ability to think independently and to critically evaluate published work and to devise experimental strategies to solve open questions in the field.

Module L6
Mon, Wed, Fri 5pm
Journal clubs Tues for one hour between 2-4pm (2 sessions)

Howard Baylis, Nick Brown (PDN) and Sarah Bray (PDN)	**16 Jan**
Introduction: setting out the questions	
Introduction to journal clubs	**20 Jan**
Azim Surani (PDN)	**19, 21, 23, 26 Jan**
Stem cells, germ cells and sex determination	
Journal club	**27 Jan**
Sarah Bray (PDN)	**28, 30 Jan, 2, 4 Feb**
Limb development	
Journal club	**3 Feb**
Howard Baylis and others	**6, 9, 11, 13 Feb**
Gene regulatory networks and differentiation	
Journal club	**17 Feb**
Nick Brown (PDN) and Katja Roeper (PDN)	**16, 18, 20, 23 Feb**
Epithelial polarity and tubulogenesis	
Journal club	**24 Feb**
Paul Schofield (PDN) and Barry Denholm	**25, 27 Feb, 2, 4 Mar**
Developmental of internal organs	
Journal club	**3 Mar**
Michael Agathocleous (PDN) and Bill Harris (PDN)	**6, 9, 11 Mar**
Growth control and cancer	
Journal club	**10 Mar**

Module L7

Control of Gene Expression
Module Organiser – Torsten Krude
tel: (3)30111, email tk1@mole.bio.cam.ac.uk

Aims

Control of gene expression is a topic that is invading many areas of contemporary biology. It is important for understanding the fundamental functions of cells, and for understanding how cells proliferate, how they respond to environmental stimuli and how they change their function during differentiation. Therefore, an understanding of gene expression becomes central for an understanding of developmental biology.

Recently, genome projects have been focusing more and more attention on patterns of gene expression in different cells, different tissues and different organisms. A new revolutionary experimental 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.

- This course aims to introduce and discuss a wide range of examples of how specific gene expression is regulated and to introduce students to the range of methodology that is used in such studies.

Course structure

The first 9 lectures are given in the Department of Zoology in the Part II Lecture Theatre. The subsequent 15 lectures are also taken by students reading Part II Biochemistry and these will be held in the Department of Biochemistry, Tennis Court Road. These lectures are given by members of the Departments of Zoology and Biochemistry.

Learning outcomes

- An understanding of the scope and range of examples of control of gene expression.

- An ability to approach and understand the rapidly growing literature on the control of gene expression.

- An ability to design and criticise experimental approaches for the study of the control of gene expression.

Module L7
Mon, Wed, Fri 9 am

Department of Zoology, Part II Lecture Theatre

Torsten Krude — **16 Jan**

Introduction and Overview

Antonis Kirmizis, Andy Bannister and Mark Dawson — **19, 21, 23, 26, 28, 30 Jan, 2, 4 Feb**

Mechanisms of transcriptional control
in vitro and *in vivo*

Department of Biochemistry, Old Lecture Theatre

Juan Mata (Biochemistry) — **6, 9 Feb**

Genome-wide studies of gene expression

Chris Smith (Biochemistry) — **11, 13, 16, 18 Feb**

Regulation by RNA splicing

Isa Palacios — **20, 23 Feb**

RNA localisation

Tuija Poyry (Biochemistry) — **25, 27 Feb, 2, 4 Mar**

Cytoplasmic regulation

Deidre Scadden (Biochemistry) — **6, 9 Mar**

RNA interference (RNAi)

Howard Baylis — **11 Mar**

RNAi in *C. elegans*

Some Advice on Supervisions

At Part II level, supervisions become optional and much less formally arranged. The initiative to arrange them lies with you and so it is up to you to decide whether you want them, when, and how many. Because of the flexible nature of Part II courses, it is not always possible to give the names of supervisors before the Module begins. To organise a session, speak first to the lecturer who gives that series of lectures. They should be able to provide names, telephone numbers and email addresses of capable persons in the field. Sometimes, the lecturer might prefer to provide supervisions himself or herself. Difficulties have on occasion arisen when a lecturer is from outside the University and/or when the audience is large but the number of possible supervisors is very small. In such circumstances you can request that the lecturer conduct an open meeting or seminar with those attending the lecture block (eg in the lecture theatre) at which your questions can be aired and discussed.

Something you can do for yourself is to look at past exam papers, held in the Balfour Library, and try to write an essay to answer previous questions. Check first with the Module Organiser to see if there have been changes to the course which make the old questions no longer so useful or relevant. The Module Organiser or other supervisor will be able to mark them and make comments on your answers.

Don't forget to tell your Director of Studies that you have had these supervisions, and give him/her the name and address of the supervisor. (Graduate students, for example, who supervise, appreciate the extra payment it brings!)

Some Tips on Examination Technique

A few VERY IMPORTANT principles can help you if you put them into practice.

- Read right through the exam sheet first, to decide which questions you can answer best. It is sometimes tempting to charge straight ahead with the first question you see on the sheet which you feel you can answer, but there may be more congenial ones further down the page.
- Read and then carefully think about the question you have chosen, and **answer the question** set! It is tempting to respond to key words in a question, and churn out all you know about that subject. Beware! You will not get extra marks for sheer volume of material, if what you write is not pertinent to the question. Think what the question actually means, and put your knowledge into that context, rather than answering what you **think** the question **ought** to be asking.
- Draw up an essay plan in note form to get your thoughts in order. If disaster strikes and you run out of time, the marker can use this plan as evidence of your knowledge. You can also, in dire straits, write the whole thing in note form, but this is not recommended generally.
- Budget your time! One hour per answer, whether you have finished all you want to say or not. You can almost never get more marks for two good answers than for three competent ones. Leaving your 'best' question till last is sometimes a good plan, so you don't get carried away with enthusiasm and leave yourself inadequate time for the others. Or, if you do the 'best' one first, leave it after an hour. If you have time left over after writing your third, least favourite question, you can go back to the first one and finish it later.

Location of teaching and departmental facilities

Facility	*Location*
Main lecture theatre	Ground floor, access via courtyard entrance
Part II lecture theatre	First floor, access via courtyard stairs
Elementary laboratory	Ground floor, access via courtyard or Museum entrance
Seminar room	First floor, room F11
Basement Conference Room	Basement
IT Facilities Room	Second floor, access via courtyard stairs
Library and student photocopy facilities	First floor, access via courtyard stairs
Tea room	Second floor, above Library
First-aid room	First floor, next to seminar room
Reception	Ground floor, courtyard entrance
Computing facilities	Elementary laboratory and IT Facilities Room
Drink dispensing machines	Museum entrance foyer and basement level from courtyard entrance
Purchasing office	First floor, room F6
Departmental Administrator	First floor, room F12
Head of Department	First floor, room F18
Austin building lecture room 2	Austin building, level 2
Wheelchair access	Via ramp at Museum entrance. Please use telephone in Museum foyer to contact Reception to arrange access.
Toilets for people with disabilities	Wheelchair access to toilets in Museum foyer, Museum basement and first floor of Downing Street building
Toilets	Basement of Downing Street building, downstairs from courtyard entrance First floor, opposite Purchasing office Second floor, between Arup and Downing Street building, near north staircase.

People and how to contact them

E-mail addresses and telephone numbers may be accessed via the departmental Web page http://www/zoo.cam.ac.uk/homepage.htm
or may be found in the University network directory. A number of key assistant staff may be paged via Reception.

Useful contacts:

Head of Department	Malcolm Burrows
Departmental Administrator	Julian Jacobs
BBS Part II Organiser	Nick Mundy
Principal Assistant	Susan Rolfe
Librarian	Clair Castle
Receptionist	Linda Blades
Computer Officer	Keith Griffin
Senior Computing Technician	David Clarke
First-aiders	To be contacted via Reception, tel. 36600 Outside office hours, tel. 101 Ambulance, tel. 1999

Who to see for what, on the technical staff:

Susan Rolfe	Part II general information
Neal Maskell	Part I teaching, Elementary laboratory facilities Biology of Cells course, Zoology section, histology
Bill Lee	Molecular Cell Biology course, Zoology section
Nigel Hall	Entry cards/keys
Laura Everitt	Purchasing
Nigel Hall	Insect cultures
Normal staff working hours	8.30 am to 1.00 pm and 2.00 to 5.00 pm Monday to Friday, inclusive
Tea room opening hours	10.00 to 11.15 am and 3.00 to 4.15 pm Monday to Friday inclusive
Access out of normal working hours	Out of hours access to the department is available using the University Card.
Balfour Library	See separate page on library

SECTION B: THE DISSERTATION

GUIDELINES FOR THE DISSERTATION
Part II Biological & Biomedical Sciences Tripos, 2008/9

The Dissertation set by the Department of Zoology

List of topics. Module organisers involved in the above courses will provide a list of topics suitable for student dissertations, but students may also suggest/discuss topics for approval by the organiser. *Titles are often better presented as questions* which allow the student to a) answer the question in the discussion section and b) provide scope for critical appraisal of the relevant literature. Topics may be discussed with a potential Supervisor as well as with the Module Organiser.

Length. Dissertations offered for the Part II BBS may reach up to 6000 words in length.

Deadlines. They have a deadline of the end of the Michalemas Term for submission of the title (supervisor signs a form to approve title specimen form on web). The completed dissertation must be handed in to Susan Rolfe, Department of Zoology (through the Receptionist), by the first day of the Easter Term.

Examining. Dissertations (if set for a Zoology module) will be double marked in the normal way and submitted to the Chair of Examiners of the BBS Part II as a mark out of 100 along with the examination marks for each candidate.

General Regulations for the Dissertation

All BBS Part II students should take note of the following regulations and guidelines for their dissertation. All dissertations must be prepared in accordance with these guidelines, issued by the Faculty Board. (See http.www.bio.cam.ac.uk/sbs/facbiol/bbs/dissertations.html).

Your dissertation must be on a topic associated with either your major or minor subject. You must, by notifying the module organiser for that course, obtain approval of the proposed title and subject of your dissertation. (The form for this is available by clicking the link from the above web site). This must be done not later than Division of Michaelmas term, that is **4.00 pm on Friday, 7 November, 2008**. **Note that the form must be signed by your Supervisor before submission to the Course Organiser at Zoology Reception.** You must notify the BBS course organiser of any subsequent changes to either the title or the subject of your dissertation. You can expect to receive a maximum of four supervisions with your Dissertation Supervisor.

Your dissertation must not exceed 6,000 words, excluding appendices, tables, figures, footnotes and bibliography.

Two copies of your dissertation must be submitted to Susan Rolfe, Department of Zoology, in its complete form, by the deadline of the first Friday of Full Easter Term, that is **4.00 pm on 24 April 2009. (In Zoology this is done through the Receptionist).**

You should **not** put your name and/or college on the dissertation itself.

In addition to the two typewritten or word-processed hard copies, the dissertation must be submitted in electronic form, via CamTools, **no later than 4.00 pm on Friday, 24 April 2009**.

The electronic version of your dissertation may be run through a plagiarism-detection software program.

Dissertations should be bound in uniform style. Your dissertation must be typewritten or word-processed, double spaced, on one side of A4 paper. All dissertations **must** have a binding margin of at least 2.5 cm on the left side of the printed page a font size no larger than 12pt and no smaller than 10pt. The Department will provide advice, resources and assistance with binding. Please consult Susan Rolfe about how to proceed: **you must do this well in advance of the relevant deadline** to be sure of submitting work on time.

Your dissertation must be accompanied by an A4 cover page (a sample form is available by clicking at: http://www.bio.cam.ac.uk/sbs/facbiol/bbs/coversheet.html)
which must **not** be bound to your dissertation, but **must** include:

1. the full title (as approved)
2. your name
3. your college
4. word count
5. a signed declaration that *it is your own original work, and that it does not contain material that has already been used to any substantial extent for a comparable purpose*.
6. a statement that *this is a dissertation submitted in partial fulfilment of the Regulations for Part II Biological and Biomedical Sciences Tripos*
7. the date

Examiners do have power to examine you *viva voce* on the subject of your dissertation. Copies of your dissertation may be needed for subject review and/or future reference. Please inform your supervisor if you do not wish your essay to be copied.

Please remember it is your responsibility to write and submit your dissertation on time. Queries concerning the administration of the Dissertation may be addressed to Dr Nick Mundy, BBS Organiser.

Advice on preparing the dissertation (as provided on the Faculty of Biology web pages at http://www.bio.cam.ac.uk/sbs/facbiol/bbs/dissertations.html):

The purpose of the dissertation is to give you an opportunity to produce a substantial piece of original work, which will form part of the assessment on which your class in the Tripos will be based. The advice that follows relates particularly to dissertations on scientific subjects; if you are doing a dissertation in a discipline which is not, in the narrow sense, scientific, you should listen particularly carefully to the advice of your supervisor and model your work on well-written reviews in the field in which you are working. Nevertheless, much of the advice that follows is applicable to all writing - scientific or otherwise.

The dissertation must not exceed 6,000 words. It is an extended account of a topic or question that lies broadly within the field of one of the courses you are taking. Before you begin, you should spend time defining your topic, discussing this with your supervisor, other members of staff and your colleagues. If you can define your objectives clearly, you will find that the rest of the process is much easier.

Beware of trying to do too much. You will find that you will need to refine your initial topic to make your dissertation manageable. Remember that, if you try to cover too wide a canvas you will not be able to do your topic justice in the space you are allowed. For example, "The role of genes in cancer" would be too wide, but "Is the xxx gene implicated in cancer of the lung?", would be manageable. Focussing on the essential question is a critical first step; be prepared to spend time on this and interact with your supervisor during this process.

The dissertation is a scholarly piece of work. That means that you should write it in the style of a scientific document. The exact form depends on what you do, but your dissertation should be divided into sections, reflecting the nature of the evidence that you are reviewing and the arguments should be backed by references, where appropriate. The overall objective is a critical assessment of a restricted topic. This means that part of your dissertation will be devoted to presenting the evidence or data which forms the topic (hence the need for references), and part will be your own assessment of what you have read or otherwise found out. You should make sure that a reader can distinguish which is which.

The sources of your material can be various. Reading the relevant literature is essential and, at the end of your text, you must provide a list of the references you have quoted. If you quote a reference, it will be assumed you have read it. If you have not, you should refer to the source in which it was cited. Your supervisor will help you with the literature and also point you in the direction of other people who have knowledge in the area you have chosen. The task of locating the relevant literature is made much easier these days by the use of computerised literature searches; if there is a particular key paper in your field of interest, a computer (using Web of Science, for example) can tell you all the more recent scientific papers that have cited it - a particularly useful method for tracking the development of a subject following a key contribution. Resist the temptation to include every paper you have seen or can think of. Most dissertations contain about 20 to 40 references. Do not exceed the latter figure without very careful thought.

The final product should look like an extended, balanced, informative critique. You should have assessed the various categories of evidence and weighed them. You should point to lack of recent references, gaps in current knowledge (see paragraph below), or to flaws in the evidence. You should say why your topic is important. Beware of starting the work for your dissertation with your mind already made up.

It will often be a good idea to include a separate section setting out promising lines of future research. This could, in some cases, represent a substantial part of your dissertation, and you might approach the writing of this section as if you were preparing a research proposal for a grant-giving body. It is an opportunity for you to display real originality and creativity. You may even lay the foundations for your future research career!

Short sentences are better than long sentences! Try to be entertaining without being either facetious or colloquial. Remember that a good critic justifies his/her criticism by careful argument. A good critical assessment is a creative process. Do not be afraid of uncertainty. Prune the first version of your dissertation mercilessly.

Supplementary information to assist in the preparation of dissertations

Students should be advised to provide **an abstract** which is different from a final summary (if present) in the discussion, a **table of contents,** and appropriate **illustrative material with captions** which should be included in the text and fully referenced.

Latin names of the genera and species in the text etc. should be underlined or written in italics. Where a generic name is the same as the last mentioned it may be abbreviated as the initial letter with full stop, eg *Agrostis canina* and *A. tenuis*. If in doubt, use the full generic name throughout. Vernacular names of organisms can be used without capital letters unless a proper name is involved eg 'bottle-nosed dolphins', but 'Mediterranean seals'. The Latin name should accompany the first mention of the vernacular name and subsequently either may be used. Anglicised names of higher taxa *should not* have initial capital letters eg 'carabids'; but the term 'Carabidae' is acceptable.

Figures and tables can be used to illustrate the essay, compiled or copied complete from original papers or books. Each should be numbered, eg Figure 1, and provided with a suitable caption and credits. They must be referred to in the text, eg 'Table 2 shows ...'. and have their citation in the references. References should be given in the text by using the

author's name with year of publication in brackets - Smith (1992). No comma is required between name and date when the whole reference is in brackets (Smith 1992), but use (Smith 1992; White 1971), (Black, 1972, 1975). If the reference has three or more authors use (Smith *et al* 1992) or (Smith et al 1992). Place the list of references at the end, in alphabetical order by first author and then date order, with the journal name in full, eg Smith, A., Black, B. & White, E.J. (1967). The ecology of natural communities. *Journal of Ecology,* **42,** 460-53. Or if a book: Smith, A. (1976) *Mountains and Moorlands.* Collins, London. (Italics for journal and book titles and bold for volume number may be excused for essay purposes). All the references should be accurate and cited by author and date in the text as above - be consistent in using (ed), pp, etc.

Notes on literature retrieval: literature retrieval is more of an art than a science and there are many ways of achieving your goal of finding all/most of the relevant literature on your chosen subject. Experts working in the same field often provide a helpful start, especially if approached in person!

Textbooks are usually out of date when published, but may provide a useful starting point (eg *The Handbook of British Mammals*). Look for authors or titles in *Books in Print*.

'Trends in', 'Advances in', 'Progress in', 'Annual Review of', etc, as well as symposium articles and recent reviews of your subject are also useful, but beware of imitation! The review journals mentioned above are useful as well as the review articles in many ecological journals such as *Oikos* and *Ecology.*

Computerised or printed indexing or abstracting services (including the Internet) may provide lists of references/abstracts from **recent** journals and earlier literature may be found from *Zoological Record* (ceased 198?) (Balfour), *Biological Abstracts* (1926-, Central Science Library (CSL), *Science Citation Index* (1964) - (CSL) - including papers referring to a particular author), *Excerpta Medica* (1947 - Medical Library), and bibliographies in papers, etc.

On line services in Cambridge are available via ISI Web of Science or ATHENS National authentication system, which provide access to MIMAS, EDINA and NISS. Information is available on the CSL web site and on the University Library web site.

Specialist abstracting services are also available in print such as *Key-word Index of Wildlife Research* (Swiss Information Service) and *Wildlife Review* (North American literature), but these are difficult to find outside personal subscriptions (ask your Supervisor).

Alerting systems such as *Current Contents* (CSL and available on the Internet) and even the index to *New Scientist* (CSL) may help in bringing the review right up to date.

The Internet gives summaries of research in progress and details of research workers' interests as well as much, much more.

Deadline dates for the Dissertation

a) **Registration:** You must, by notifying the BBS course organiser for that course, obtain approval of the proposed title and subject of your dissertation. The form for this is available by clicking the link in: http://www.bio.cam.ac.uk/sbs/facbiol/bbs/dissertations.html This must be done not later than Division of the Michaelmas term, that is **4.00 pm on Friday, 7 November, 2008.** You must notify the Course Organiser and the Faculty Office of any subsequent changes to either the title or the subject of your dissertation. You should also notify him/her of the name of your supervisor as soon as you have one. The latest date by which you can change the title of your dissertation is the last day of Lent term, that is **Friday, 13 March 2009**.

b) **Submission: Two** copies of your dissertation must be submitted to Susan Rolfe, in its complete form, by the deadline of the first Friday of full Easter term, that is **4.00 pm on 24 April 2009**. (This is done through the Receptionist, see 'Writing up/Binding' below) You should **not** put your name and/or college on the dissertation itself.

In addition to the two typewritten or word-processed hard copies, the dissertation must be submitted in electronic form, via CamTools, **no later than 4.00 pm on Friday, 24 April 2009**.

Writing up/binding

Your dissertation must be accompanied by a A4 cover page; a sample form is available by clicking at: http://www.bio.cam.ac.uk/sbs/facbiol/bbs/coversheet.html
This cover page must **not** be bound to your dissertation. (See previous 'General Regulations for the Dissertation for details)**.** The Department will provide advice on binding. Please consult Susan Rolfe if you are in doubt about how to proceed: **you must do this well in advance of the relevant deadline** to be sure of submitting work on time.

Late submissions

It is expected that dissertations will be submitted before the deadlines given above. The date of submission of work is recorded, and late submissions are likely to incur a penalty in terms of reduced marks. If there is good reason to suppose that work will be submitted late, a case should be made, **in advance of the deadline**, in writing to the examiners. The examiners will generally require that such a case be supported by a letter from the supervisor before an extension is granted. Any extension will be for a specific period.

The role of the Supervisor

The following guidelines are sent to supervisors:

Supervisors should keep these points in mind when assessing how students are progressing in their dissertations.

Providing frequent feedback on the progress of the dissertation. Roughly weekly meetings are desirable. If a supervisor is going to be away for more than a week, he/she should arrange for someone else to provide supervisions and **should tell the student this**.

Assessing student progress: The aim of the dissertation is to give you an opportunity to produce a substantial piece of original work, such as an extended account of a topic or question that lies broadly within the field of one of the courses you are taking.

Marks are awarded, not for the length of the reference list but for your critical assessment of a restricted topic. This means that part of your dissertation will be devoted to presenting the evidence or data which forms the topic (hence the need for references), and part will be your own assessment of what you have read or otherwise found out. You should make sure that a reader can distinguish which is which.

Time spent on Dissertations. The temptation to spend more than 120 hours gathering information and writing it up should be resisted because dissertations in total only count for one fifth of the examination. It is essential to tell the student to stop research work when they have optimised their chances of producing a dissertation which uses their time efficiently. **The research agenda of the supervisor is not the priority here**.

Supervising the dissertation write-up. The supervisor (or some other competent person nominated by the supervisor) should read a draft of the dissertation before the final version is produced. Comments should **be constructive** and not involve substantial reworking by

the supervisor. It is important for the student to start writing sufficiently before the dissertation deadline for a draft to be produced for comment.

Writing up (see also Guidelines for the Dissertation above)

Dissertation length
Dissertations must not exceed 6,000 words to exclude references and figure captions. They are adhered to strictly and dissertations that exceed these word limits will be returned for shortening. Please print the number of words in the text at the end of your dissertation. You will find examples of completed dissertations from past years that have been selected by the examiners and placed in the Balfour Library.

Originality
The cover page must have a signed declaration that *'it is your own original work, and that it does not contain material that has already been used to any substantial extent for a comparable purpose'.* See also Plagiarism below.

Binding the Dissertation
Dissertations should be bound in uniform style. The department will provide advice on binding (see p. 57). Please consult Susan Rolfe if you are in doubt about how to proceed: **you must do this well in advance of the relevant deadline** to be sure of submitting work on time.

Assessment
Your dissertations will be given to two 'Assessors', one of whom will be the module organiser, lecturer or dissertation supervisor. They will mark your project independently and agree upon a final mark. Dissertations and mark sheets will be returned to Susan Rolfe within two weeks. You will get back one copy of your dissertation. All your dissertation work will be looked at again in the Easter term by the examiners, including the external examiner. The examiners will ensure that the marks are fair and that different assessors have marked to a common scale.

Plagiarism
The Faculty Board of Biology has issued the following statement on Plagiarism in Tripos Examinations:

"The University regards plagiarism in examinations, in connection with essays, dissertations, project work and other such work, as a matter of great concern and will treat cases of plagiarism with the utmost seriousness and severity. Candidates who submit essays, dissertations, project work and other such work for examination must give full and proper acknowledgement to the work of others. Severe penalties may be imposed if plagiarism is detected."

Accordingly, every candidate submitting a dissertation will **be required to sign a declaration that the exercise submitted is his or her own work**, unaided except as may be specified in the declaration, and that it does not contain material that has already been used to any substantial extent for a comparable purpose; if two or more candidates have undertaken work in collaboration, they will each be required to indicate the extent of their contribution.

Examiners
The examiners for 2008/2009 are:
Nick Davies, First Floor Zology, Room F22, Tel (3)34405, e-mail nbd1000@cam.ac.uk
Jenny Clack, Museum, Room M29, Tel (3)36613, e-mail j.clack@zoo.cam.ac.uk
Professor Peter Holland (external examiner), University of Oxford.

SECTION C: EXAMINATIONS

Examination Regulations

Note that the Zoology Essay paper is NOT taken. The form and conduct regulations for the BBS examinations will be the same as for Part II Zoology.

Four-paper (4 module) exams. You will be asked to answer three questions in 3 hours from each of Part II Zoology Papers 1, 2, 3 & 4.

Minor subject exam. The minor subject exam is set and marked by the Department running the minor subject. Information on the format of the exam is available from the relevant Department.

NATURAL SCIENCES TRIPOS Part II Zoology
NATURAL SCIENCES TRIPOS Part II Biological and Biomedical Sciences (Zoology)

Wednesday 28 May 2008 1.30 to 4.30

PAPER 1

*Answer **three** questions; not more than **two** from any **one** Section.*

Restrictions apply to courses taught by the Departments of Plant Sciences and Genetics
Papers 1 and 2
Section I (Dynamics, History and Future of Vegetation)
Papers 3 and 4
Section G (Evolutionary Genetics)
Section H (Plant Responses to Environment)
*You may answer questions from only **one** of these **three** courses in the entire examination*

*Please tie up the answer to **each** question separately with its own cover-sheet*
*Write on **one** side of the paper only*

SECTION A Topics in Vertebrate Evolution

1 What is homology and when do you think you have it, in the context of cladistic analysis? Pay particular attention to character construction in your answer.

2 New vertebrate taxa from the Early Devonian MOTH locality in northern Canada are changing our understanding of the relationships of groups such as the Acanthodii and Chondrichthyes, and also changing our understanding of the evolution of major vertebrate features. Based on these new discoveries:

(a) List and discuss the validity of synapomorphies of the Acanthodii.
and
(b) Discuss the evolution and origins of the pectoral and pelvic fins in the Agnatha (jawless vertebrates).

3 What is an amniote and where did they come from? What are the problems associated with understanding the origin and early evolution of amniotes?

SECTION B Aquatic Ecology

4 'The cichlid fishes provide us with one of the best insights into the mechanisms of speciation.' Discuss.

5 To what extent are bottom-up and top-down processes central to our understanding of community structure in freshwater ecosystems?

6 Are typical life-history traits of any help in the determination of the processes characteristically structuring benthic populations in brackish-water habitats?

SECTION C Population Biology

7 Invasive species often take a while to get going. Discuss possible genetic reasons why this might be so, supporting your arguments with relevant examples.

8 Discuss the role of space in the maintenance of diversity.

9 Discuss the role of trade offs in promoting the coexistence of species.

SECTION D Neural Mechanisms of Behaviour

10 Discuss critically, giving examples, the degree to which the tangential neurons of the fly lobula plate typify sensory processing.

11 What different sorts of problems must a brain solve to generate ballistic and repetitive movements?

12 How did Sperry develop the chemospecificity theory of nerve connections? How far has his theory been justified by subsequent findings and to what extent does it provide us with a satisfactory explanation for the way in which nerve connections are actually formed?

SECTION E Behaviour

13 'Robustness and plasticity in behavioural development are complementary.' Discuss.

14 Evaluate the importance of the mammalian placenta and its hormonal secretions in the evolution of parental care strategies.

15 Why is there such a discrepancy between the ability of animals to use tools in the wild and to demonstrate an understanding of how tools work in the laboratory?

SECTION F Cell Dynamics and Communication

16 Describe (a) how Notch signalling allows equivalent cells to stochastically adopt different fates **and** (b) how signalling can be biased to specific cells.

17 Biological membranes have two sides, cytoplasmic and non-cytoplasmic. Discuss the events that take place on each of the two sides that enable proteins to traffic to different parts of the cell.

18 Discuss how signalling events at the cell surface can lead to changes in the behaviour of the cytoskeleton.

SECTION G Control of Cell Growth and Genome Stability

19 What are the **two** main problems that the cell cycle has to solve, and how does it do this?

20 Discuss the topological problems that arise during DNA replication and transcription, and molecular mechanisms that are used by the cell to solve them.

21 How are the regulators of cyclin-dependent kinase 1 (Cdk1) themselves regulated?

SECTION H Development: Patterning the embryo

22 Has the study of morphological movements during gastrulation in *Xenopus*, zebrafish and *Drosophila* revealed common cellular mechanisms?

23 Cell fate can be set by reading a morphogen gradient or by local cell-cell interactions. Why might one mechanism be used in preference to the other to generate a particular pattern of cell fates?

24 What do you understand by a 'segmentation clock'? How conserved do you think this is across the animal kingdom?

SECTION I Dynamics, History and Future of Vegetation

25 The evolution of C_4 (and CAM) pathways has been said to require 'anatomical preconditioning' (SAGE 2004) or 'pre-adaptation' by others. Are these phrases scientifically valid or useful, and what were the anatomical constraints and environmental influences which led to the development of **either** early land plants **or** C_4 and CAM pathways?

26 Why are chronosequences and sites affected by volcanoes so informative for the study of succession?

27 Illustrate the ways in which dispersal influences patterns of plant diversity.

END OF PAPER

NATURAL SCIENCES TRIPOS Part II Zoology
NATURAL SCIENCES TRIPOS Part II Biological and Biomedical Sciences (Zoology)

Thursday 29 May 2008 1.30 to 4.30

PAPER 2

*Answer **three** questions; not more than **two** from any **one** Section.*

Restrictions apply to courses taught by the Departments of Plant Sciences and Genetics
Papers 1 and 2
Section I (Dynamics, History and Future of Vegetation)
Papers 3 and 4
Section G (Evolutionary Genetics)
Section H (Plant Responses to Environment)
*You may answer questions from only **one** of these **three** courses in the entire examination*

*Please tie up the answer to **each** question separately with its own cover-sheet*
*Write on **one** side of the paper only*

SECTION A Topics in Vertebrate Evolution

1 Discuss the evolution of air-breathing adaptations in Devonian vertebrates, placing them in the context of environmental conditions of the Period.

2 Discuss the factors that facilitated the development of large body size in dinosaurs, and the potential biological advantages of large body size. Is bigger better?

3 Amongst living lepidosaurian reptiles, rhynchocephalians and squamates have sharply contrasting distributions. Discuss this disparity in terms of the anatomy and evolutionary history of the two groups.

SECTION B Aquatic Ecology

4 Describe the key features of the evolutionary increase in marine diversity since the Cambrian, and the role of mass extinctions in this pattern.

5 To what extent can we see historical **and** contemporary geographical patterns in competition amongst marine organisms?

6 Discuss, with examples, the way a marine organism's size affects its ecology **and** physiology.

SECTION C Population Biology

7 What is a metapopulation? How does the persistence of metapopulations differ from that of individual populations?

8 Imagine you are a mathematical biologist working on the population dynamics of measles epidemics. One day you are invited to a meeting at the World Health Organization to devise and implement a plan to eradicate measles virus from the planet. How could you, as a population biologist, help?

9 'Simple explanations are scarce in life history evolution.' (S.C. STEARNS) Discuss.

SECTION D Neural Mechanisms of Behaviour

10 Do we have to know how neurons work to understand how behaviour is produced?

11 Give an account of how genomic imprinting has shaped brain evolution and behaviour.

12 Review the evidence for the view that activity-dependent processes make a substantial contribution to the development of sensory systems. Do you think that similar mechanisms are required for the development of the circuitry underlying coordinated movement?

SECTION E Behaviour

13 Compare and contrast the current theories for the evolution of intelligence.

14 Discuss the ways that genes and the environment combine to affect behaviour. How is this relevant for the evolution of behaviour?

15 Discuss the characteristics of recognition memory.

SECTION F Cell Dynamics and Communication

16 How are the sorting, trafficking and targeting systems of non-polarised cells modified to establish and maintain apicobasal polarity? Are special features of these systems required in polarised cells? Give evidence for the statements you make.

17 Describe how the β2 adrenergic receptor is desensitised. Highlight how our understanding of this process has altered our view of signalling from G-protein coupled receptors.

18 Discuss the characteristics of **two** types of cell junction, including an example of a cell-cell and a cell-matrix junction. Show how their molecular composition serves their functional roles.

SECTION G Control of Cell Growth and Genome Stability

19 Discuss the role of the centrosome in the assembly of the mitotic spindle.

20 What are the functions of caspases and how are caspases activated during apoptosis?

21 Why do our cells have two systems (homologous recombination and non-homologous end-joining) for repairing DNA double-strand breaks?

SECTION H Development: Patterning the embryo

22 How do Hox genes specify segmental diversity?

23 You are examining the development of a new marine invertebrate and find that after the first three cleavage divisions two cells contain bright green cytoplasm. These cells make the gut. Describe experiments you would do to test whether the green colouring reflects the presence of a cytoplasmic determinant for gut cell fate.

24 Assess our current understanding of polarity establishment in the developing mouse embryo. How can our knowledge of polarity generation in other organisms guide further investigation in this area of mouse development?

SECTION I Dynamics, History and Future of Vegetation

25 Discuss the population dynamics of herbaceous plants and undershrubs (*Rubus* species) in woodland. How much difference does the size and management of an area of woodland make?

26 What factors control the processes of secondary succession?

27 Discuss the diversification of gymnosperms and angiosperms and how the distribution of ferns, and possibly bryophytes, may have been facilitated.

END OF PAPER

NATURAL SCIENCES TRIPOS Part II Zoology
NATURAL SCIENCES TRIPOS Part II Biological and Biomedical Sciences (Zoology)

Friday 30 May 2008 9 to 12

PAPER 3

*Answer **three** questions; not more than **two** from any **one** Section.*

Restrictions apply to courses taught by the Departments of Plant Sciences and Genetics
Papers 1 and 2
Section I (Dynamics, History and Future of Vegetation)
Papers 3 and 4
Section G (Evolutionary Genetics))
Section H (Plant Responses to Environment)
*You may answer questions from only **one** of these **three** courses in the entire examination*

*Please tie up the answer to **each** question separately with its own cover-sheet*
*Write on **one** side of the paper only*

SECTION A Mammalian Evolution and Faunal History

1 Discuss the functional significance of the differences in the vertebral column and limbs between a typical 'pelycosaur' and a primitive mammal.

2 What is the hard evidence for the first occurrence of lactation in a fossil mammaliaform and where in the mammaliaform Tree of Life is this evidence first apparent?

3 In the *Origin of Species*, Darwin predicted that 'in order to discover the early transitional grades through which the [structure] has passed, we should have to look to very ancient ancestral forms, long since become extinct'. Describe examples of extinct intermediates bridging a morphological gap between extant mammalian clades, using at least **one** from the Mesozoic and **one** from the Tertiary.

SECTION B Conservation Biology

4 Should conservationists attempt to manage ecosystems holistically, or focus attention on a few key species?

5 Protect nature for its own sake, harvest it sustainably, or try to put economic values on the services it provides – which approach to conservation would you adopt, and why?

6 Explain whether it is important for conservationists to understand the reasons for the latitudinal diversity gradient.

SECTION C Behavioural Ecology

7 Discuss the role of information in the resolution of evolutionary conflicts.

8 What affects an animal's reproductive value?

9 How do males constrain female choice?

SECTION D Genes, Genomes and Animal Evolution

10 To what extent can introns be thought of as selfish genetic elements?

11 What is the expected distribution of the size of phenotypic effect of different genes fixed during a bout of adaptation? How might one go about testing this theoretical prediction?

12 How does the organization of regulatory DNA both protect the organism against detrimental mutations and allow for fine-tuned and specific phenotypic change?

SECTION E Development: Cell differentiation and organogenesis

13 Communication between cells with different developmental fates is a common feature in organogenesis. Drawing examples from the developing kidney describe the nature and outcome of these molecular conversations.

14 To what extent is organ growth controlled by mechanisms operating intrinsically and extrinsically to the cell? Discuss the experimental evidence for these different modes of control.

15 Define pluripotency and describe how this state is generated during mammalian development. Discuss possible approaches for generating pluripotent cells *in vitro* and their potential for advances in human medicine.

SECTION F Control of Gene Expression

16 Discuss the mechanisms by which proteins that bind to exon splicing enhancers (ESEs) activate splicing.

17 Discuss how and where mRNA is degraded.

18 Discuss the role of RNA Pol II Carboxyl-terminal domain (CTD) in gene expression.

SECTION G Evolutionary Genetics

19 Is industrial melanism a convincing example of Darwinian evolution in action?

20 Describe, with examples, the diversity of ways in which new species are thought to evolve.

21 Discuss critically current approaches to detecting signals of selection in the human genome.

SECTION H Plant Responses to Environment

22 Why are sodium and aluminium major constraints on plant growth?

23 What kinds of characteristics might you want to modify in plants, for example in producing new varieties of crop plants, in order to increase their ability to acquire nitrogen and phosphorus?

24 To what extent are modifications in ‘unit leaf area’ and ‘leaf area ratio’ important in allowing plants to grow in the shade?

END OF PAPER

NATURAL SCIENCES TRIPOS Part II Zoology
NATURAL SCIENCES TRIPOS Part II Biological and Biomedical Sciences (Zoology)

Saturday 31 May 2008 1.30 to 4.30

PAPER 4

*Answer **three** questions; not more than **two** from any **one** Section.*

Restrictions apply to courses taught by the Departments of Plant Sciences and Genetics

Papers 1 and 2

Section I (Dynamics, History and Future of Vegetation)

Papers 3 and 4

Section G (Evolutionary Genetics)

Section H (Plant Responses to Environment)

*You may answer questions from only **one** of these **three** courses in the entire examination*

*Please tie up the answer to **each** question separately with its own cover-sheet*
*Write on **one** side of the paper only*

SECTION A Mammalian Evolution and Faunal History

1 How does the ‘cat-like’ ecomorph differ from the ‘dog-like’ ecomorph in anatomy, diet, and predation style? What other mammals have adopted the ‘cat-like’ ecomorph besides cats (Family Felidae)? Why is the ‘cat-like’ ecomorph more likely to become extinct than other types of carnivores?

2 Describe the diversity and distribution of Palaeogene mammals. Suggest why Neogene mammalian diversity is so different.

3 Describe some evolutionary trends exhibited by Quaternary mammals and offer explanations of their functional significance.

SECTION B Conservation Biology

4 Discuss how human activities can cause a cascade of changes in an ecosystem.

5 The genetic augmentation of Florida panthers can be thought a success, but the project is still young. Discuss the nature of possible downstream problems and construct an argument for which you consider the most important.

6 Describe, with examples, the various means of predicting the impact on biodiversity of environmental change.

SECTION C Behavioural Ecology

7 To what extent are ideas derived from the study of behavioural conflicts applicable to intra-genomic conflict?

8 What kinds of evidence are available to help us understand the evolution of reproductive altruism in animal societies?

9 Why is it useful to distinguish strategies from tactics?

SECTION D Genes, Genomes and Animal Evolution

10 You are interested in using a phylogenetic approach to studying the evolution of wing colour patterns in fruit flies. How much, and what kinds of data, would you use to generate a robust tree showing fruit fly evolution? How would you then reconstruct wing pattern evolution using this phylogeny?

11 What have studies of colouration in vertebrates revealed about the genetic basis of evolutionary change?

12 A comprehensive explanation for Haldane's rule continues to elude us. Discuss the possible reasons why this is so.

SECTION E Development: Cell differentiation and organogenesis

13 Discuss the relative importance of temporal and spatial patterning mechanisms in limb development.

14 You find a new molecular marker, NovelT, is expressed in a small group of cells (in the vertebrate embryo of your choice) in the olfactory epithelium at early stages, while at later stages it is expressed in a larger group of cells in the forebrain. How would you discover the relationship between these two groups of cells? Having done these experiments, you find that the larger group is derived from the initial small group. Using your understanding of embryonic cell migration, design experiments to discover how these cells find their new location.

15 Describe how the mechanisms of tubulogenesis permit remodelling in response to physiological stimuli.

SECTION F Control of Gene Expression

16 Discuss, with examples, the interplay between DNA methylation and histone modifications in the regulation of gene transcription in mammals.

17 Describe, with examples, how chromatin immunoprecipitation (ChIP) has been used to map factors and modifications to specific genomic loci.

18 MicroRNAs (miRNAs) are a large class of small RNAs that regulate gene expression in various ways. Discuss how the action of miRNAs results in the downregulation of gene expression.

SECTION G Evolutionary Genetics

19 Compare and contrast co-evolutionary arms races occurring between species and between individuals of the same species.

20 Explain the importance of frequency dependence in the evolution of various types of mimicry.

21 Discuss the role of chance in evolution.

SECTION H Plant Responses to Environment

22 For what sort of habitats are the various forms of C_4 photosynthesis adaptive, and why?

23 With examples, discuss the effects, in plant communities, of the symmetry of competition.

24 How do plants adapt to seasonal water deficits?

END OF PAPER

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ROUTINE CALLS - (3) 31818
EMERGENCY CALLS - 101

- Serious Incident/Emergency
- Anything suspicious
- Anyone acting suspiciously

CONTACT:

- **Departmental Supervisor**

and/or

- **University Security Control Centre**

Routine calls - **(3) 31818**

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