Mathematical Biology

MATH3104

Dr Christine Beveridge
Prof Hugh Possingham
Dr Geoff Goodhill
Mathematical Biology is a relatively new and growing branch of mathematics with applications in medicine, neuroscience, physiology, ecology and genetics. Unlike many mathematics courses where much time is spent finding solutions to problems, we will spend about a third of our time on constructing models of biological systems and another third on learning how to interpret the solutions of these new sorts of models.

Staff
Lecturers

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Guest Lecturers

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Dr Kate O’Brien
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Email: k.obrien@mailbox.uq.edu.au
Consultation hours or Office hours: various by appointment (send an email)

Tutor
To be advised

Web Page
The course profile and course material can be found on the web at the following address:
http://www.cpai.uq.edu.au/Math3104/
This also contains up-to-date news about the course material and announcements for students.
Please check this regularly during the semester.

Class contact hours:
This varies during semester although is always 4 hours per week. At first it is 2 lectures and 2
hours computer lab/tutorial, then later it is 3 lectures and 1 hour tutorial. The computer labs
and tutorials are very important to attend – if you have a clash, make this known to your
lecturer such that so that a solution can be reached early in semester.

Assumed background:
There are no formal prerequisites for this course, but you should have an appreciation and
basic knowledge of calculus, probability and algebra. Lecture notes are handed out during
lectures.
Course goals/rationale:

On completing this course students will be able to:

- transfer a biological hypothesis into a mathematical representation;
- translate mathematical statements into computational statements and models;
- create simple models of a biological processes;
- create models that can be used for understanding complex systems or for prediction;
- interpret the solutions of models;
- understand the advantages and disadvantages of different types of models;
- use rule-based systems such as Matlab and L-studio;
- use ODEs, difference equations and Markov Chain models;
- create population models for ecology, epidemiology and bioeconomics;
- create models of neural computation.

Graduate Attributes:

The following graduate attributes will be developed in the course –

In-Depth Knowledge of the Field of Study

- A comprehensive and well-founded knowledge of the field of study.
- An understanding of how other disciplines relate to the field of study.

Effective Communication

- The ability to collect, analyse, and organise information and ideas, and to convey those ideas clearly and fluently, in written and/or spoken forms.
- The ability to interact effectively with others in order to work towards a common outcome.
- The ability to select and use the appropriate level, style and means of communication.

Independence and Creativity

- The ability to work and learn independently.
- The ability to generate ideas and adapt innovatively to changing concepts.
- The ability to identify problems, create solutions, innovate and improve.

Critical Judgement

- The ability to define and analyse problems.
- The ability to apply critical reasoning to issues through independent thought and informed judgement.
- The ability to evaluate opinions, make decisions and to reflect critically on the
Ethical And Social Understanding

- An appreciation of the philosophical and social contexts of a discipline

For more information on the University policy on development of graduate attributes in courses, refer to the web

Teaching and Learning Methods

The course is divided into three major parts.

**Part I  Introduction to Modelling**  
Weeks 1-4  
**Jim Hanan and Christine Beveridge; Guest Lectures by Kate O’Brien.**  
- How can mathematics help biological researchers?  
- Understanding biological research from a mathematical viewpoint  
- Why is computation important?  
- Problem solving in mathematical biology, particularly in systems of several unknown components  
- How to transfer a biological hypothesis into a mathematical representation  
- Concepts of complex systems and emergent properties; cellular automata and fractals  
- Introduction to modelling using rule-based systems: L-systems and Matlab  
- Importance of levels of detail and abstraction in models  
- Genetic regulatory network modeling: rule-based models

**Part II  Population modelling**  
Weeks 5-8  
**Hugh Possingham**  
- Modelling single species population dynamics: Single species population models: ODE models, time lag differential equations, difference equations and Markov Chain models.  
- Two species population dynamics and epidemiology: Simultaneous differential equation models for two or more species, stability analysis and phase planes. Predator-prey cycles and epidemics will be explored in detail. Epidemics will be considered from the applied perspective of immunisation programs.  
- Bioeconomics: Population models will be combined to some economic modelling to explore problems in optimal harvesting of populations, eg fish and forests.

**PART III  Mathematical Neuroscience - How does the brain work?**  
Weeks 9-12  
**Geoff Goodhill**
• Introduction to the brain and neural computation
• Encoding and decoding of information in the brain
• Modelling individual neurons
• Neural development, plasticity and learning

The first part of the course, weeks 1 to 4, will have a computer based learning module that will require the course delivery via two lectures, one tutorial/lecture and one computer lab per week. Often your lectures will be delivered in a very open format with many opportunities for questions and interaction.
The second part, weeks 5 to 8 will be 3 lectures and one tutorial, and the third part, weeks 9-12 will be similar to the first part in structure. The last week will be guest lectures and a tutorial in preparation for the exam.

ASSESSMENT

Required assessment tasks:

There will be six assignments during semester. Assignments for Parts I and III will be worth 7.5% each, whereas those in Part II will be worth 5% each. The emphasis on the exam will be 15, 25 and 20% respectively for the three parts.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Part I</th>
<th>Part II</th>
<th>Part III</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Assignment (%)</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>Exam (%)</td>
<td>15</td>
<td>25</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>No. of assignments</td>
<td>2</td>
<td>2</td>
<td>2</td>
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</tbody>
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Your lecturers will advise you when the assignments are due, however they are likely to be due every second week starting with the first one due on the Tuesday of the third week. Your lecturers will advise you where to hand in your assignment and of any penalties for late assignments.

Assessment criteria

Answers to written examination questions, tutorial exercises, and assignments will be assessed in terms of the extent to which they demonstrate the ability of the student to:

• Interpret and understand the question and to state possible different interpretations of the question;
• Use initiative in interpreting the meaning of questions;
• Acknowledge the advantages of different approaches to solve problems;
• Reduce the complexity of the problem before attempting a solution;
• Define the problem with a simple set of hypotheses or rules;
• Translate written hypotheses or rules into mathematical equations;
• To implement mathematical solutions in Matlab or L-studio to formulate a logical model that represents the biological system;
• Define, explain and interrelate the key concepts involved in the course.
• Recognise the regime of applicability of the modelling approach.
• Use the basic theory to apply to a range of biological problems.
• Utilise the appropriate mathematical and other techniques to derive predictive relationships.

Criteria for the award of grades

Your grade for this course will be determined by which of the following levels of achievement that you consistently display in the items of summative assessment.

• To earn a Grade of 7, you must achieve a final mark between 85-100% by demonstrating an excellent understanding of the course material. This includes clear expression of nearly all deductions and explanations, the use of appropriate and efficient mathematical techniques, and accurate answers to nearly all questions and tasks with appropriate justification. You will be able to apply mathematical techniques to completely solve both theoretical and practical problems.
• To earn a Grade of 6, you must achieve a final mark between 75-84% by demonstrating a comprehensive understanding of the course material. This includes clear expression of most deductions and explanations, the general use of appropriate and efficient mathematical techniques, and accurate answers to most questions and tasks with appropriate justification. You will be able to apply mathematical techniques to partially solve both theoretical and practical problems.
• To earn a Grade of 5, you must achieve a final mark between 65-74% by demonstrating an adequate understanding of the course material. This includes clear expression of some deductions and explanations, the use of appropriate and efficient mathematical techniques in some situations, and accurate answers to some questions and tasks with appropriate justification. You will be able to apply mathematical techniques to solve fundamental problems.
• To earn a Grade of 4, you must achieve a final mark between 50-64% by demonstrating an understanding of the basic concepts of the course. This includes occasionally expressing deductions and explanations clearly, the occasional use of appropriate and efficient mathematical techniques, and accurate answers to a few questions and tasks with appropriate justification. You will have demonstrated knowledge of techniques used to solve problems and have applied this knowledge in some cases.
• To earn a Grade of 3, you must achieve a final mark between 45-49% by demonstrating some knowledge of the basic concepts of the course. This includes occasional expression of deductions and explanations, the use of a few appropriate and efficient mathematical techniques, and attempts to answer a few questions accurately and with appropriate justification. You will have demonstrated knowledge of techniques used to solve problems.
• To earn a Grade of 2, you must achieve a final mark between 20-44% by demonstrating some knowledge of the basic concepts of the course. This includes attempts at expressing their deductions and explanations, and attempts to answer a few questions accurately.
• To earn a Grade of 1, you must achieve a final mark between 0-19%. This includes attempts at answering some questions but showing an extremely poor understanding of the key concepts.
Assessment policy

There are no word limits on assignments. Each question will be marked individually and given the proportion of marks as indicated on the question sheet. Late assignments will have one percentage point (or a total of 100% for the course) deducted per week day unless the Lecturer warrants an extension based on a medical or other certificate.

In case of illness (or bereavement) you may be exempted from an assignment if a medical certificate (or other documentation) is received by your tutor or lecturer within one week of the due date of the assignment. If you are exempted from any assignment, then an average for the other assignments is taken. Please note that ad hoc excuses (car trouble and the like!) will not be accepted: only documentation in connection with illness or bereavement. If you enrolled late, then exemption will automatically be granted for anything missed before the date of enrolment.

Students should be familiar with the rules which relate to assessment in their degrees as well as general university policy such as found in the General Award Rules. These are all set out on the myAdvisor page on the UQ website


Plagiarism:

Students are encouraged to discuss the assignments in class from the point of view of identifying the problem and the approaches to implement a solution. Such discussions can be deemed equivalent to asking tutors and lecturer’s questions or seeking advice from textbooks or the web and are among the best possible methods of learning.

The University has adopted the following definition of plagiarism:

“Plagiarism is the action or practice of taking and using as one’s own the thoughts or writings of another, without acknowledgment. The following practices constitute acts of plagiarism and are a major infringement of the University's academic values:

- Where paragraphs, sentences, a single sentence or significant parts of a sentence are copied directly, and are not enclosed in quotation marks and appropriately footnoted;

- Where direct quotations are not used, but are paraphrased or summarised, and the source of the material is not acknowledged either by footnoting or other simple reference within the text of the paper; and

- Where an idea which appears elsewhere in printed, electronic or audio-visual material is used or developed without reference being made to the author or the source of that material.”

When a student knowingly plagiarises someone’s work, there is intent to gain an advantage and this may constitute misconduct.

Students are encouraged to study together and to discuss ideas, but this should not result in students handing in the same or similar assessment work. Do not allow another student to
copy your work. While students may discuss approaches to tackling a tutorial problem, care
must be taken to submit individual and different answers to the problem. Submitting the
same or largely similar answers to an assignment or tutorial problem may constitute
misconduct.

Should an incident of plagiarism be suspected, the tutor or lecturer will take up the matter
through appropriate administrative channels and may result in the tutorial or lab assessment
being annulled.

For more information on the University policy on plagiarism, please refer to

**Supplementary examinations**

A supplementary examination may be awarded in one course to students who obtain a grade
of 2 or 3 in the final semester of their program and require this course to finish their degree.
You should check the rules for your degree program for information on the possible award
of supplementary examinations. Applications for supplementary examinations must be made to
the Director of Studies in the Faculty.

EPSA Faculty policy on the award of supplementary exams may be found via the Faculty
Guidelines on Examinations from the EPSA student page

**Special examinations**

If a student is unable to sit a scheduled examination for medical or other adverse reasons,
she/he can and should apply for a special examination. Applications made on medical grounds
should be accompanied by a medical certificate; those on other grounds must be supported by
a personal declaration stating the facts on which the application relies.

Applications for special examinations for central and end-of-semester exams must be made
through the Student Centre. Applications for special examinations in school exams are made
to the course coordinator.

More information on the University’s assessment policy may be found

EPSA Faculty policy on the award of special exams may be found via the Faculty Guidelines
on Examinations from the EPSA student page

**Feedback on assessment:**

You may request feedback on assessment in this course progressively throughout the semester
from the lecturer or tutor. In most cases you will be given individual feedback automatically
within 1-2 weeks of assignment assessment. Other feedback on assessment may include
discussion, written comments on work, model answers, lists of common mistakes and the like.

Students may peruse examinations scripts and obtain feedback on performance in a final
examination provided that the request is made within six months of the release of final course
results. After a period of six months following the release of results, examination scripts may be destroyed.

Information on the University’s policy on access to feedback on assessment may be found at http://www.uq.edu.au/hupp/index.html?page=25114&pid=25075

EPSA Faculty policy on assessment feedback and re-marking may be found at http://www.epsa.uq.edu.au/index.html?page=7674&pid=7564

Textbook and references

None relevant.

Library contact:

The liaison librarian for the physical sciences disciplines is located in the Physical Sciences and Engineering Library in the Hawken Building and may be consulted for assistance in the course:

Leith Woodall
Email: l.woodall@library.uq.edu.au
Extension: 52367

Students with disabilities:

Any student with a disability who may require alternative academic arrangements in the course is encouraged to seek advice at the commencement of the semester from a Disability Adviser at Student Support Services.

Assistance for Students:

Students with English language difficulties should contact the course coordinator or tutors for the course.

Students with English language difficulties who require development of their English skills should contact the Institute for Continuing and TESOL Education on extension 56565.

The Learning Assistance Unit located in the Relaxation Block in Student Support Services. You may consult learning advisers in the unit to provide assistance with study skills, writing assignments and the like. Individual sessions are available. Student Support Services also offers workshops to assist students. For more information, phone 51704 or on the web http://www.sss.uq.edu.au/index.html.

Student Liaison Officer:

The School of Physical Sciences has a Student Liaison Officer as an independent source of advice to assist students with resolving academic difficulties.
The Student Liaison officer during 2005 will be Dr Peter Adams, Room 547 Priestley building, (email pa@maths.uq.edu.au)