Programme for LMS/EPSRC Short Instructional Course in Mathematical Biology
January 9–14, 2005

School of Mathematics, University of Manchester

Organiser: Dr. Matthias Heil

Over the past decades, mathematics has increasingly (and successfully) been applied to the modelling and analysis of many biological and physiological problems. Mathematical Biology has thus developed into an active, varied and inherently interdisciplinary field of research. Major advances have been made (e.g.) in the modelling of disease spreading and tumour growth, in the analysis of biological pattern formation and in physiological fluid mechanics. The complexity of biological and physiological systems makes them a rich source of challenging problems whose analysis often stimulates the development of novel mathematical techniques.

Many mathematics departments in the UK now offer courses in Mathematical Biology but typically the syllabi of these courses only cover a small subset of the entire field, reflecting the research interests within each department. This problem persists at PhD level and especially first year PhD students often fail to appreciate the breadth of the field. The aim of the course is to provide first and second year mathematics PhD students with an overview of four main research areas in Mathematical Biology. The course will start with an opening lecture on 'Bioconvection'. This will be followed by three eight-hour courses on 'Modelling Biological Pattern Formation', 'Biological Fluid Mechanics' and 'Tumour Modelling'.

Programme

The course will open with a formal welcome on Sunday afternoon, followed by Prof. Nick Hill's opening lecture. Courses 1–3 will start on Monday morning. Each course will consist of eight one-hour sessions which will comprise of formal lectures and tutorials in the form of examples classes and group work sessions. Five to six of the eight sessions will be given as lectures and the lecturers will distribute their tutorials flexibly within their programme. Printed course notes and example sheets will be provided for all courses.

Course Overview

1. Biological fluid mechanics (Dr. Matthias Heil, University of Manchester)

The course will start with a general overview of biological fluid mechanics and will give a short review of the relevant fluid and solid mechanics. Following this, four problems in the area of physiological fluid mechanics will be studied in greater detail: **(i)** pulse

wave propagation and flow patterns in the arteries; **(ii)** collapsible tube models for blood flow in the veins; **(iii)** flow patterns in the lung; Taylor dispersion; **(iv)** airway closure; surface-tension-driven instabilities of the lung's liquid lining. We will develop simple mathematical models of these physiological systems and use the models to analyse the system's behaviour. Finally, an overview of current research problems will be given.

2. Modelling biological pattern formation (Prof. Philip Maini, University of Oxford)

This course considers the phenomenon of spatiotemporal pattern formation in developing biological systems. Although genetics plays a key role in development, a study of genetics alone cannot inform us of the mechanisms that give rise to the spectacular variety of patterns we see in nature. We will explore a number of models that have been proposed to account for spatial patterning, ranging from simple gradient models, through to more complex models in which patterning is hypothesized to occur via the process of self-organisation. We will focus on reaction-diffusion models, for example, Turing models and cell-chemotactic models, and explore mathematically, the phenomena of excitability and diffusion-driven instability. The applications of the models and the insight they give to biological patterning will be discussed.

3. Modelling solid tumour growth (Dr. Helen Byrne, University of Nottingham)

The main aim of this course is to show how mathematical techniques can be used to investigate and provide insight into the mechanisms that regulate different aspects of solid tumour growth. The models we study will include: systems of coupled differential equations that describe vascular tumour growth (when the tumour is connected by the host's blood supply and has an effectively limitless supply of nutrients); moving boundary problems that describe avascular tumour growth (when the tumour lacks its own blood supply and relies on nutrient diffusion to sustain its growth); and, probabilistic models of angiogenesis (the process by which an avascular tumour becomes vascularised by stimulating the formation of a new blood supply from neighbouring vessels). Whilst the models and analytical techniques employed will apply to tumours, the methods are sufficiently general in nature that they will be applicable in other areas of mathematical biology and applied mathematics.

Timetable

Sunday	
16.00-17.00	Registration
17.00-17.30	Welcome
17.30-18.30	Opening Lecture
18.30	Dinner (for residents)

Time	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
7.30-9.00	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
9.00-10.00	Course 1	Course 1	Course 1	Course 1	Course 1
10.00-11.00	Course 2	Course 2	Course 2	Course 2	Course 3
11.00-11.30	Coffee	Coffee	Coffee	Coffee	Coffee
11.30-12.30	Course 3	Course 3	Course 3	Course 3	Course 3
12.30-14.00	Lunch	Lunch	Lunch	Lunch	Lunch
14.00-15.00	Course 3	Course 3		Course 2	
15.00-16.00	Course 2	Course 2	Free afternoon	Course 1	
16.00-16.30	Tea	Tea		Tea	
16.30-17.30	Course 1	Course 1		Course 2	
18.30	Dinner	Dinner	Dinner	Dinner	

Meals

Breakfast, lunch and dinner are served for the residents. Lunch is provided for all local (non-resident) participants.

Registration and directions to Chancellors

Registration will be on Sunday, January 9th from 4-5pm at the reception of Chancellors Hotel & Conference Centre (Chancellors Way, Moseley Road, Fallowfield, Manchester M14 6NN). If you arrive early, please report to the reception and identify yourself as a participant of the course – you should then be able to get your room keys straight away.

Chancellors is number 4 on the enclosed map. This and other maps which might be helpful in finding your way can be found on the WWW at:

`http://www.conference.manchester.ac.uk/chancellorshotelconferencecentre/`

`http://www.manchester.ac.uk/aboutus/howtofindus/`

and at

`http://www.streetmap.co.uk/`

(enter the postcode M14 6NN).

The nearest train station is Manchester Oxford Road. Buses 41-46 (and many others) take you down Oxford Road/Wilmslow Road; the nearest stops are near "Owens Park".

Lecture Theatre

All lectures will take place in the 'Marquis Room' at Chancellors.

Email/Computer Access

Chancellors provides a wireless network system for anyone wanting to access the internet. You'll need to have a network card installed on your laptop.

Things to do/places to visit on Wednesday afternoon

- The City Centre for some light (or even heavy) retail therapy
- Whitworth Art Gallery
- University Museum (opposite the Maths Tower)
- Manchester City Centre: take (pretty much) any bus going up Oxford Road
- Museum of Science and Technology
- The Lowry Museum
- The Imperial War Museum North
- Manchester United Stadium Tour

Get to know each other:

- This course provides an excellent opportunity to meet PhD students with similar research (and other?) interests. $\Longrightarrow$ Make an effort to find out what people are working on.

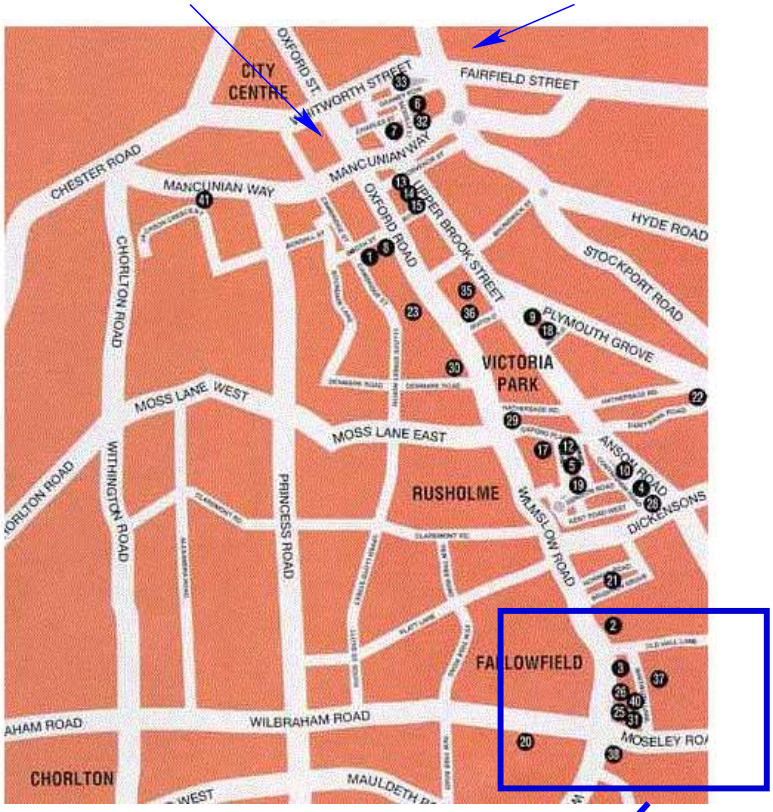
To facilitate scientific (and non-scientific!) discussions, the bar will be open every night...

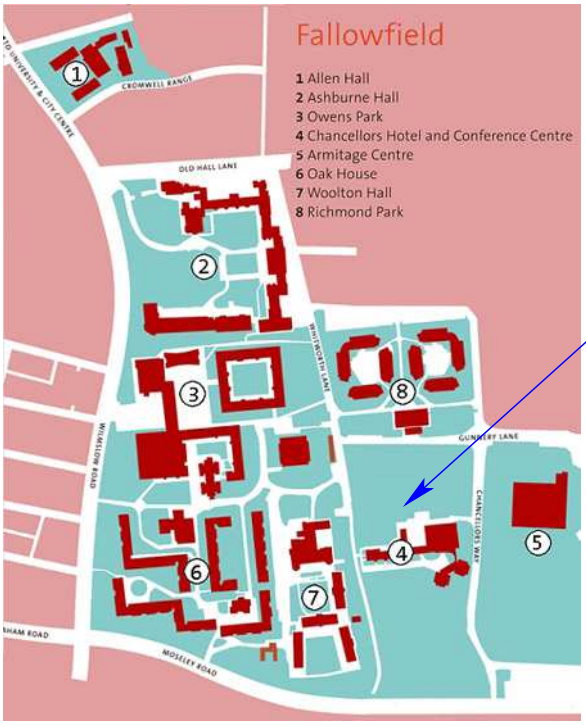
Help

- If you require any further information before the start of the course, please contact the course organiser, Dr. Matthias Heil (Room 18.07; School of Mathematics, Univ. of Manchester, Oxford Road, Manchester M13 9PL; M.Heil@maths.man.ac.uk; Tel. & Voicemail: 0161 275 5808; Fax: 0161 275 5819).
- If there are any problems during your stay, please contact the reception.

Oxford Road
railway station

Manchester Piccadilly
railway station





Chancellors