MATH0117 Spatial Mathematical Biology

Year:	2025–2026
Code:	MATH0117
Level:	7 (UG and PG)
Normal student group(s):	UG: Year 3 or Year 4 Mathematics degrees PG: (2026-27) MSc Mathematics (level 7)
Value:	15 credits (= 7.5 ECTS credits)
Term:	2
Assessment:	90% examination, 10% coursework
Normal Pre-requisites:	MATH0030 Mathematical Ecology MATH0016 Mathematical Methods 3
Lecturer:	Dr B Walker

Course Description and Objectives

This module is an introduction to the mathematical modelling of biological phenomena that have a distinct spatial component, such as the interactions of populations in space and the emergence of patterns. Spatial mathematical biology is an area of intense research activity at the interface between mathematics and biology, and this module will develop some of the tools and understanding needed to approach a range of interdisciplinary research problems.
In this module, we will derive and explore the diffusion equation and its generalisation (to systems of reaction-diffusion equations) in 1 and 2 dimensions, before exploring a range of biologically motivated problems that fall into this broad class of models. We will introduce the notion of travelling waves in biology, with reference to applications in populations dynamics and epidemiology, and consider what it means for a solution of a partial differential equation to be stable. Finally, we will explore the celebrated Turing mechanism of patterning, exploring interactive solutions and deriving broad and interpretable conditions for pattern formation.
Throughout, we will focus on predicting and understanding emergent, interpretable behaviours rather than results of existence and uniqueness of solutions. As such, only a basic familiarity with partial differential equations is assumed, along with methods for assessing the linear stability of ordinary differential equations.

Recommended Texts

Murray, J. D. (2002) Mathematical biology. 3rd ed. New York: Springer. ISBN: 0387952284

Detailed Syllabus

An indicative list of topics is as follows:

- Derivation of the reaction-diffusion equations. Discrete dynamics and Fick's law.
- The diffusion equation in multiple dimensions. A review of separable solutions. Eigenfunctions of the Laplacian.
- Moving boundary problems in biology. Spatial modelling of cancer.
- Travelling waves. Scalar systems (the Fisher-KPP equation). SIR models. Lotka-Volterra population dynamics in space.

– Linear stability of partial differential equations. Deriving stability criteria. Critical domain sizes. Impacts of boundary conditions.

– Diffusion as a stabiliser or destabiliser. Absence of patterns in scalar systems. Destabilising effects in Swift-Hohenberg.

– Turing patterns. Derivation and interpretation of the Turing instability conditions. Domain dependence of patterns. Example dynamics: Schnakenberg; Gierer-Meinhardt; Gray-Scott; Keller-Segel.

– Patterns on complex and discrete domains. Links between continuum and discrete theories.