Modelling biological pattern formation

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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 acccount 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.

LECTURE 1: *Spatiotemporal patterns in the Life Sciences.* Introduction to the vast array of spatiotemporal patterning phenomena that occur across the Life Sciences. Motivation for modelling. Simple gradient models.

LECTURE 2: *Turing reaction-diffusion model I.* Derivation of Turing's model, a coupled pair of nonlinear parabolic differential equations. Linear stability analysis and spatial pattern formation.

LECTURE 3: *Turing reaction-diffusion model II.* Properties of Turing's model and biological applications.

LECTURE 4: *Cell-chemotactic models:* Derivation of cell-chemotaxis models, analysis, and application to slime mold aggregation in an excitable medium.

LECTURE 5: *Summary and future directions:* The state of the art and future applications.

Reading:

P. Ball, The self-made tapestry: Pattern formation in nature, OUP, 1999

J.D. Murray, Mathematical biology (2nd edition). Springer-Verlag: Berlin, 1993

L.A. Segel, Modeling dynamic phenomena in molecular and cellular biology. CUP, 1989