Suggested title of dissertation:

Mathematical modelling of tumour growth

Dissertation supervisor:

Prof Helen Byrne

Description of the proposal:

Multiple biophysical processes influence the growth and response to treatment of solid tumours. For example, oxygen levels regulate rates of cell division and tumour responses to radiotherapy. Additionally, the mechanical properties of the healthy tissue in which the tumour is growing may affect its ability to invade, with stiffer tissues offering more resistance to tumour invasion. Many mathematical models of solid tumour growth have been developed to investigate these and other processes. The models are typically formulated either as coupled systems of partial differential equations or as hybrid multiscale models that couple subcellular, cellular and tissue scale processes. While these models have generated useful insight into tumour growth, many questions remain to be answered.

Possible avenues of investigation:

1. Model how one goes from a discrete to a continuum description of nutrient-limited tumour growth
2. Investigate how the mechanical properties of the tissue in which a tumour is embedded affect its pattern of invasion
3. Model how the mechanical properties of the tissue in which a tumour is embedded affect its response to radiotherapy

Pre-requisite knowledge:

B5.5 Further Mathematical Biology (essential) (`https://courses.maths.ox.ac.uk/node/36417`)
B5.2 Applied Partial Differential Equations (essential) (`https://courses.maths.ox.ac.uk/node/36395`)

B6.1 Numerical Solution of Differential Equations I (useful) (https://courses.maths.ox.ac.uk/node/36448)
B5.1 Stochastic Modelling of Biological Processes (useful) (https://courses.maths.ox.ac.uk/node/36382)
B6.2 Numerical Solution of Differential Equations II (useful) (https://courses.maths.ox.ac.uk/node/36456)

Useful reading:

J.D. Murray, Mathematical Biology, II: Spatial Models and Biomedical Applications, Springer, Chapters 1, 5 (2003)

HP Greenspan (1972). Models for the growth of a solid tumour by diffusion. Studies in Applied Maths 51(4): 317-340.

TD Lewin, PK Maini, EG Moros, H Enderling and HM Byrne (2018). The evolution of tumour composition during fractionated radiotherapy: implications for outcome. Bull Math Biol 80(5): 1207-1235.

ARA Anderson (2005). A hybrid mathematical model of solid tumour invasion: the importance of cell adhesion. Math Med Biol 22(2): 163-186.

Further references:

H Byrne and L Preziosi (2003). Modelling solid tumour growth using the theory of mixtures. Math Med Biol 20(4): 341-366.

CY Chen, HM Byrne and JR King (2001). The influence of growth-induced stress from the surrounding medium on the development of multicell spheroids. J Math Biol 43(3): 191-220.

JT Oden, A Hawkins and S Prudhomme (2010). General diffuse-interface theories and an approach to predictive tumour growth modelling. Math Models Methods Appl Sci 20: 477.