LONDON MATHEMATICAL SOCIETY
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Naylor Prize and Lectureship: citation for Helen Byrne

Short citation:

Professor Helen Byrne of the University of Oxford is awarded the Naylor Prize and Lectureship for her profound contributions using mathematical, computational and statistical modelling to understand the mechanisms that drive tumour growth, their escape from immune system control, and response to treatment.

Long citation:

Professor Helen Byrne, University of Oxford, is awarded the Naylor Prize and Lectureship for her pioneering and sustained contributions to the development and application of mathematical, computational, and statistical modelling techniques to understand the mechanisms that drive tumour growth, immune evasion and treatment response.

Cancer progression is a highly nonlinear problem, in which tumour characteristics and behaviours emerge from complex interactions components across a wide range of temporal and spatial scales and the tumour characteristics and behaviours are emergent. To tackle these problems, Professor Byrne has developed a suite of powerful multiphase and multiscale modelling techniques. For example, Byrne led the development an elegant mathematical theory to accurately and efficiently model the internal sub-cell dynamics of many cells simultaneously within an evolving microenvironment using large deviation theory to coarse-grain the system. In a particular case where the cells are subject to lateral inhibition by their neighbours, Byrne was able to relate the patterns that emerge at long time scales with the detailed subcellular dynamical processes. This is an example of how sophisticated mathematical tools can be used to provide insights into the biology.

Recognising that advances in biology often demand new mathematics, Professor Byrne has also been instrumental in developing and applying topological and statistical approaches to analyse spatial structure and phenotypic heterogeneity in tumours. She has led the use of topological data analysis, particularly persistent homology via Dowker and Witness complexes, to characterise spatial organisation in heterogeneous tumour microenvironments. These techniques, applied to both simulated and experimental data, have revealed novel quantitative relationships between tumour architecture and immune or stromal cell infiltration, and offer tools that can be applied directly to multiplexed imaging data. In parallel, she has developed statistical tools for quantifying correlations and heterogeneity in spatial data, integrating them with mechanistic models to support inference and parameter estimation.

In addition to her original contributions, Professor Byrne has authored a series of authoritative review articles that have helped define the landscape of mathematical oncology. These works convey the state-of-the-art in mathematical modelling of tumour growth and complex biological systems in a clear and well-organised way, which makes them accessible to both specialist and non-specialist audiences.