**Statistical inference for mathematical models of tumour spheroid growth**

During avascular growth tumour cells are fuelled by nutrients that diffuse from blood vessels near the tumour’s boundary to its centre. Early on during tumour growth, the nutrients required for growth are in abundance, and exponential growth ensues. As the tumour grows the amount of nutrient reaching the central part of the tumour declines, until it is insufficient to sustain live, proliferating cells. As a result a necrotic core composed of dead tumour cells forms, which is surrounded by an outer shell of proliferating cells. At the onset of the necrotic core tumour growth typically slows *in vivo*. As the tumour grows in size further competition for nutrients and space eventually arrests growth altogether and a maximum tumour volume is reached (Folkman and Hochberg 1973). Tumour spheroids represent a model system whose growth and behaviour has been shown to be in accordance with that of *in vivo* tumours (Hirschhaeuser, et al. 2010). The aim of this project is to investigate different mathematical models for tumour growth, by fitting the parameters of these models to time series data from laboratory experiments of tumour spheroids. An often-used model is logistic or gompertzian growth which allows for competition of nutrient resources. A more flexible approach that is more amenable to experimental data is to use a modified version of the logistic model (Byrne 2009),

where allows a faster/slower approach to the carrying capacity than in the simpler model.

The aim of this project is explore the various frameworks (Maximum Likelihood, Approximate Bayesian Computation, non-hierarchical/hierarchical Bayesian) that can be used to estimate the parameters (with their uncertainty) of the aforementioned models from the data, and learn how the results from each method of estimation relates to the others. In doing so, you should implement any MCMC algorithms yourself. At the end of the project you should conclude which model represents the best fit to the data, using an appropriate metric. Extensions to this work include exploring the conditions under which the parameters of the aforementioned/other models can be identified. For example, by generating fake data by simulating from a model of spheroid growth, determine how much data is required to reliably estimate the model parameters.

# References and recommended texts

Byrne, Helen M. "Mathematical modelling of solid tumour growth: from avascular to vascular, via angiogenesis." Biol 14 (2009).

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Gelman,Andrew, Carlin, John B., Stern, Hal S., Dunson, David B., Vehtari, Aki, and Rubin, Donald B. “Bayesian data analysis”. 3rd Edition, (2013).

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