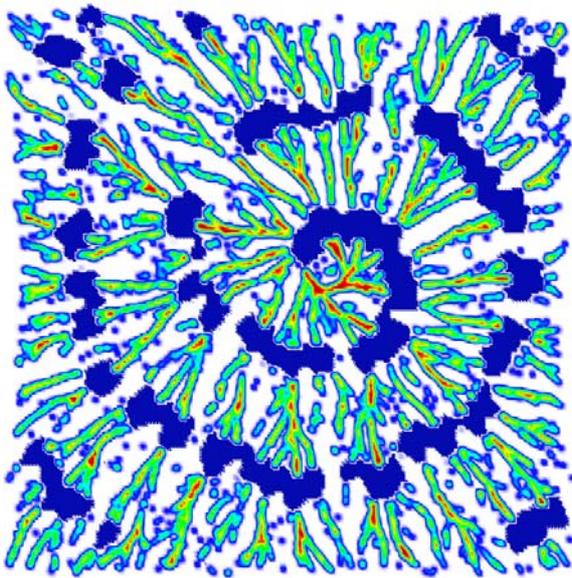


From Individual to Collective Behaviour in Biological Systems

10 September – 19 December 2001

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In recent years there has been an explosive growth in our knowledge of biological processes, especially at the molecular and cellular level. However, understanding the behaviour of individual enzymes, cells or organisms in isolation is only a first step in understanding the collective behaviour of a population of such individuals. Incorporating individual aspects of behaviour into macroscopic descriptions of population behaviour is a challenging problem, even if only deterministic aspects are considered. In addition, stochastic effects are often important, whether at the level of switching on genes or at the level of spatial variability in ecology. However, random noise can produce undesirable effects, and one may expect to find mechanisms for buffering the effects of noise in development and ecology. Therefore probabilistic methods play an important role in deriving a population-level description from models of individual behaviour, though it is unlikely that the same mathematical approach will be applicable at all levels of organization.



Cellular aggregation in response to a spiral wave of cyclic AMP (dark blue) in the cellular slime mold *Dictyostelium discoideum*

Four major biological areas in which these mathematical questions are central and in which the biological questions can guide the mathematical developments have been chosen for this programme:

(1) *Physiology*. Here the emphasis will be on bringing together those who have established detailed descriptions of individual cells and study their interactions in a computational framework, and those who try to establish average or continuum models, based on the same microscopic data, in advance of computation.

(2) *Developmental biology*. This topic covers all aspects of pattern-formation in populations of cells. The interaction between signalling, gene expression, genetic regulatory networks, cell movement and differentiation at the single-cell and population level will be stressed.

(3) *Stochastic spatial ecology*. In this time of unprecedented environmental change it is crucial for scientists to formulate and analyze stochastic mechanistic descriptions of the change based on underlying ecological processes: examples include, the evolution and maintenance of biodiversity, extinction thresholds, the spatial spread of introduced pests; the shift of species ranges as a result of environmental change (climatic or directly manmade), etc.

(4) *Theoretical immunology*. New techniques have led to an increasing stream of kinetic data on the populations of various types of immune cells. Mathematical approaches are required to integrate this data to gain insights into the dynamics of the immune cell response, the homeostatic regulation of immune cells and immune memory, and mechanisms of cytopathicity and resistance.

The specific program in each of the four major areas is formulated with the advice and assistance of a leading biologist:

- Physiology - Dennis Noble (Oxford)
- Developmental biology - Michael Akam (Cambridge)
- Stochastic spatial ecology - Charles Godfray (Imperial)
- Theoretical immunology - Martin Nowak (Princeton).

Each month of the programme will be devoted to one of the topics, beginning with a workshop on both the biological problems and those mathematical approaches which might be expected to be fruitful.

