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Introductory Remarks

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Introductory remarks

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Perhaps I should give my view of why this meeting on Theories of biological pattern formation is being held now. By the mid-1970s mathematical biology or modelling (or whatever it should be called) was a well established area of research, welcomed or not. This was particularly so in North America, continental Europe and Japan. I sympathize with the lack of grateful acceptance of this panacea for biology since much of the work had (and still has) little relevance to the real biological problems that it purported to study. At several 'interdisciplinary' meetings it was clear that communication between the various groups was non-existant and, after some of the answers to questions, perhaps it was not even wanted. A reply such as, 'It's probably a secondary Hopf bifurcation in the p.d.e. parameter space' does not have biologists on the edge of their seats – unless to leave.

Genuine interdisciplinary research and the use of models in general can often produce spectacular and exciting results: regeneration models and positional information theories are just two dramatic model examples. It seems that the increasing use of models in biology is inevitable. It is now less common to hear a bioscientist dismiss their use, although they may still privately do so. For those souls who are promoting the field in the face of vocal pre-prejudiced opposition and criticism there is the apt north African proverb: 'The dogs may bark but the camel train goes on'.

There are many reasons for the increased involvement of mathematicians and physical scientists in the biomedical sciences – other than the increased number of jobs and grants available (at least in America). For example, there is on the one hand the genuine scientific interest and excitement of people becoming involved in new fields, and on the other, a realization that some of the traditional areas, in applied mathematics at least, are becoming moribund. Certainly from my experience in the U.S.A. and Europe, when mathematics courses are offered that discuss bio/ecological/medical modelling, students (and some of the faculty) give them substantial support. Biotechnology, of course, is not unrelated. I find that the strongest interest comes when the problems discussed are practical and real.

This meeting, therefore, arose out of a desire to try to get people together from a variety of areas who have a common interest in developmental biology and who might give an understandable interdisciplinary description of current thinking and extant problems. The organizers have tried to get an even balance between theory and experiment in the hope that it will help to promote interdisciplinary endeavour. As a by-product I hope that the uncommitted will take away with them the view that not all mathematicians or theoreticians are out of it, unrealistic, etc., and not all biologists are unsympathetic to modelling. There is certainly still a wide gap in general but it is not unbridgeable with good will and patience.

Mathematics–biology research, to be useful and interesting, must be relevant biologically and *not obvious*. Real parameter values, for example, have to be put in or assigned by real

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people. The best models should show how a process works and then what may follow. An acceptable first step is a model that phenomenologically describes the biology. Suggestions as to how a process works may evolve from it. Questions of model sensitivity and robustness are important. Usually in a model we require a stability of development after it has been initiated. What is neither wanted nor appreciated are models whose aims are to show to mathematical colleagues how clever the mathematics is. Nor are trite phrases that do not explain or enlighten the mechanism studied; for example, 'the system is far from thermodynamic equilibrium' does not explain anything, nor does 'it is an elliptical umbilical catastrophe' – that sounds more like a complicated birth by an incompetent physician.

From a *mathematical* point of view I feel that the art of good model building relies on (i) a sound appreciation and understanding of the biological problem (not necessarily the intricate details, at least initially); (ii) a realistic mathematical representation of the important phenomena; (iii) finding the solution, quantitative if possible, of the resulting mathematical problem; and, finally and very importantly, (iv) a biological interpretation of the results with, ideally, biological insight and predictions. The mathematics is dictated by biology, not vice versa. If the mathematics is trivial, so be it. The research is not judged by mathematical standards but by different and no less demanding ones.

Turning now to the area of *pattern formation theories*, there is now a wealth of mechanisms. Turing's seminal reaction–diffusion model of morphogenesis, although the basis of many, is just one example. Although it and its successors are rich in structure, it does not mean that reaction–diffusion is the only mechanism in developmental biology, as has been claimed. The time has come (and realized by many, years ago) for more of the theoreticians interested in pattern formation in development to try to apply more of their mechanisms and theories to real problems and experiment to try to unravel the underlying mechanisms. Part of the resurgence of interest in development is a reflection of the current optimism that major breakthroughs are possible, perhaps even imminent. Mathematical modelling can certainly play a part and I am in no doubt as to the exciting research that can result from such interdisciplinary endeavour.

I should like to conclude by replying to those few bioscientists who still sympathize with St Augustine, who said, 'Beware of mathematicians and all those who make false prophecies', with a quotation from the philosopher George Berkeley's (1685–1753) private notebooks (he was combating the new mathematical physics in the first half of the eighteenth century):

MEM. Upon all occasions to use the utmost modesty – to confute the mathematicians with the utmost civility and respect, not to style them rather Nihilarians ....

N.B. To rein in ye satirical nature.

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