MEETING REPORT

Pattern formation*

A discussion meeting on the 'Mechanisms of Pattern Formation' was held at Coorg last year. Pattern formation is a multidisciplinary area of enquiry that braces physical, life and engineering sciences. While a biologist may be looking at generation of complex organizations of cell fates in space and time, a physicist or an engineer may be interested in studying the evolution of patterns in space and time in the flow of fluids, microstructures of materials, snowflakes or geological formations.

The goal of the meeting was to connect a group of experimentalists and theoretical scientists from diverse research fields such as physics, biology, chemical engineering, and mathematics, to discuss the critical issues that confront the description of pattern at the systemic level in biology, and identify the core mechanisms that direct patterning in functional multicellular structures. In all, 24 participants (largely national and few international) working on pattern formation came together to find out the commonalities and differences among the systems and methods.

The emergence of understanding the similarity in fundamental mechanisms of pattern formation in biological, chemical and physical systems makes the study of pattern formation a truly interdisciplinary science. Even though pattern specification is genetically controlled in living systems, it is seemingly clear that non-genetic mechanisms such as stochasticity in gene expression, biophysical properties (such as adhesion) and their heterogeneity, matrix-mediated interactions and environmental perturbations can be strong determinants of the final pattern. Different concepts and modelling methodologies from statistical physics and nonlinear dynamical systems used to describe the pattern-forming processes have also been applied with fair success on biological systems. This amalgamation led to a fruitful dialogue among diverse researchers in the field of pattern formation.

In an introductory presentation, Somdatta Sinha (CCMB, Hyderabad) highlighted the ubiquitous presence of spatial, temporal and spatio-temporal patterns and their functional roles in biological and natural physical systems. It was observed that disturbance in the normal pattern could give rise to pathology and disease. The programme consisted of nine overview talks by experimentalists and theorists reviewing specifics of pattern-forming systems and experimental and theoretical methodologies to study them. Herbert Levine (University of California, San Diego, USA), Philip Maini (University of Oxford, UK), Sitabhra Sinha (Institute of Mathematical Sciences, Chennai), and Anand Asthagiri (California Institute of Technology, USA) reviewed theoretical methods and their application to specific pattern-forming systems in biology. They also discussed the nature of questions relevant to theoreticians in the analysis of pattern formation. The discussion on Turing mechanism and other activator–inhibitor models for pattern formation elicited exciting debate among the theoreticians. L. S. Shashidhara (Indian Institute of Science Education and Research, Pune and CCMB), Maithreyi Narasimha (Tata Institute of Fundamental Research, Mumbai), and Amitabha Bandopadhyay (Indian Institute of Technology, Kanpur) reviewed pattern formation during development in different organisms, such as during embryogenesis in the fruit fly *Drosophila*, and specification and morphogenesis in vertebrate limb. Images of cell movement during dorsal closure in normal and laser-perturbed tissues gave a clear picture of the role of biophysical mechanisms, such as cell adhesion and division during tissue organization. John Reinitz (Stony Brook University, USA) and Gabor Forgacs (University of Missouri-Columbia, USA) discussed examples where both modelling and biophysical mechanisms have been implicated to describe and predict pattern-forming mechanisms.

Other participants made fascinating projections on the diversity of physical approaches and experimental techniques to elucidate the formation of pattern in a variety of physical and biological systems. The gamut of subjects ranged from patterning in *Dictyostelium*, *Hydra* and *Drosophila*, to pattern formation in physical systems such as sand-particle avalanches, kinetics of phase ordering, and non-equilibrium dynamics and glassy behaviour. These topics were functional in placing into context the approaches undertaken by the physicists to deal with biological/biomedical problems, with a certain measure of success and limitations. These limitations were particularly apparent in the presentations on developmental biology. The work dealing with patterns which arise in purely physical and/or chemical contexts (such as granular patterns and patterns during phase separation) illustrated the success of the basic physics approach of looking at complex processes by starting with relatively simple models to explain the generic behaviour of the systems.

It was a successful attempt to bring together researchers from two different cultures through extensive discussions by trying to understand each others' vocabulary and restructuring the definitions. Several participants observed that such meetings could bring about possibilities of collaborative research and unanimously felt the need to have more such discussion forums.

*A report on the discussion meeting on the 'Mechanisms of Pattern Formation' held at the Orange County Resort, Coorg, during 6–9 December 2007. The meeting was organized under the aegis of the Indian Academy of Sciences, Bangalore and coordinated by the Centre for Cellular and Molecular Biology, Hyderabad.

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