# Growth Patterns in Physical Sciences and Biology

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## PREFACE

During the past decade interest in the formation of complex disorderly patterns far from equilibrium has grown rapidly. This interest has been stimulated by the development of new approaches (based primarily on fractal geometry) to the quantitative description of complex structures, increased understanding of non-linear phenomena and the introduction of a variety of models (such as the diffusion-limited aggregation model) that provide paradigms for non-equilibrium growth phenomena. Advances in computer technology have played a crucial role in both the experimental and theoretical aspects of this enterprise. Substantial progress has been made towards the development of comprehensive understanding of non-equilibrium growth phenomena but most of our current understanding is based on simple computer models.

Pattern formation processes are important in almost all areas of science and technology, and, clearly, pattern growth pervades biology. Very often remarkably similar patterns are found in quite diverse systems. In some case (dielectric breakdown, electrodeposition, fluid-fluid displacement in porous media, dissolution patterns and random dendritic growth for example) the underlying causes of this similarity is quite well understood. In other cases (vascular trees, nerve cells and river networks for example) we do not yet know if a fundamental relationship exists between the mechanisms leading the formation of these structures.

This NATO Advanced Research Workshop was organized with the objective of bringing together physicists and biologists with a common interest in pattern growth and in applying new tools across the areas of their disciplines to explore the similarities and differences in their subjects. In general, the community of physicists is interested in the most simple pattern formation processes and focuses its attention on the similarities (universalities) that are associated with different processes. Biologists, on the other hand, must necessarily work with extremely complex systems and are primarily concerned with the development of a detailed (but generally qualitative) understanding of specific systems (organisms). Nevertheless there is a large “common ground” between these divergent approaches. For example, theoretical biologists have long studied simple growth models that are quite similar to those developed by physicists for quite different purposes. It was apparent to us that both communities should benefit substantially from an exchange of ideas and techniques.

The theory of pattern formation is still under development, and part of our task was to review the advances made. In some cases (such as the Eden model for the growth of cell colonies) the relationship between the growth algorithm and the pattern generated by the model is now quite will understood. In other cases (such as the diffusion-limited aggregation model) we are still quite far from developing a comprehensive analytical understanding. In this case a quite wide range of phenomena can nevertheless be understood in terms of this model. At present there is a growing acceptance of the idea that physical phenomena can be understood equally well in terms of simple algorithms or continuum equations.

Both the Eden model and diffusion-limited aggregation played a large role in many of the discussions in the workshop. Despite their simplicities both seem to seize some of the essential aspects of biological growth for some systems. However much remains to be learned about generalizations and more realistic (but more complicated) models.

The workshop was held in Granada Spain during the period 7-11 October, 1991. Despite the rather large fraction of physicists the main objectives of the workshop were achieved. In some cases, as the contributions to this volume attest, the confrontation between the point of view of physics and biology was very fruitful indeed. In other cases a large gaps remain, but a start was made. We think that substantial progress was made towards establishing a common language. The beautiful city of Granada provided a delightful environment for the workshop that was conducive to informal exchange of ideas.

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The Editors