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Biological Physics of the Developing Embryo, by Gabor Forgacs and Stuart A. Newman, Cambridge University Press, Cambridge, 2005, pp vii + 337. Scope: textbook. Level: undergraduate and postgraduate.

Physicists usually take it as an article of faith that, at least in principle, all science must ultimately be explicable in terms of the laws of physics. Chemists, understandably irritated by the condescension inherent in this world picture are apt to retort: "Yes, maybe, and in that case the useful parts of physics are called chemistry". The reality, as usual, is far more complex, especially in the case of the connections between physics and biology. Even the simplest living system is so complicated that the application of physics seems at first sight unlikely to be helpful. Even knowing that only electromagnetic forces are involved, with some effect from gravity in particular cases, the sheer complexity of life seems at first sight overwhelming. Physicists usually work with simplified models of reality. They are unaccustomed to matter that displays goal-directed behaviour, for example, although it is absolutely normal and to be expected in living systems that have evolved with an ability and drive to reproduce. It is now understood, however, there are many cases where physics can in fact be applied directly to gain deeper understanding. This is still so, even at much higher levels of modelling than that of atoms and molecules where physics and chemistry and biology are well understood to meet together in their common discussion of DNA. The importance of physics in accounting for e.g. the operation of molecular motors, the architecture of biological individual cells, and the biomechanical properties of tissues is now widely appreciated by biologists.

Gabor Forgacs and Stuart Newman – respectively professors of biological physics and of cell biology and anatomy – have joined forces to produce a book about how physics can usefully be applied to biology, intended to be accessible to both biologists and physicists. It is an ambitious enterprise. As their exemplar they take the developing embryo, starting from a single cell, because it undergoes such an extraordinary series of changes with, correspondingly, many different stages where physics is of importance. As the authors point out, the role of physics is especially obvious in constraining and influencing the outcome during early development.

The book opens by introducing the eukaryotic cell (with a nucleus, the kind of cell of which plants and animals are made) in simple terms, but in sufficient detail to bring out its huge complexity. Relevant physical concepts and processes within the cell are then described, including free diffusion, directed diffusion, osmosis, viscosity, transport, elasticity, and viscoelasticity. The overdamped nature of the internal cell dynamics is emphasised, showing that inertial effects are essentially absent: net motion ceases almost instantly when the force is removed. This introduction sets the scene for most of what follows.

The second chapter describes the processes through which an embryo develops from a single cell to a multicellular aggregate or *blastula*. In the course of this description, many important concepts and definitions are introduced including e.g. DNA, chromosomes, microtubules, mitosis and cytokinesis. Another physical concept, surface tension, is introduced and deployed in modelling the first cleavage.

There follow eight chapters treating different aspects of the physics of the developing embryo including, to mention only a few examples, gene expression, oscillatory processes in cells, diversification, adhesion, cell sorting, gastrulation, neurulation, pattern formation, segmentation, development of the cardiovascular system, branching morphogenesis, vertebrate limb development, fertilization, calcium waves, and an example of an evolutionary transition: segmentation in insects.

There are numerous beautiful coloured illustrations to illuminate the structures and ideas discussed in the text, and are enormously helpful in clarifying some difficult concepts and sequences of events. Detailed material is confined to boxes so as not to break the flow of the narrative. Each chapter closes with a perspective paragraph to summarise what has been said and set it in context. There is a very substantial glossary of technical terms, which is indeed essential in a book of this kind, together with an extensive bibliography and a detailed and seemingly inclusive index.

Have the authors succeeded in their ambitious aim of being comprehensible to both physicists and biologists? I believe that they have. The average physicist will have to work quite hard, but everything he or she needs is there and the illustrations and glossary are a great help. Of course, the book only covers particular examples of the application of physics to biology, but the topics included are both interesting and remarkably diverse. I cannot speak for biologists, but physicists who read to the end will learn a lot. They will enjoy doing so, and they will gain an appreciation of the way in which quite simple physics often underlies the extraordinarily complex behaviour exhibited by living systems.

Peter V. E. McClintock
Lancaster University.