Mathematisches Forschungsinstitut Oberwolfach

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Mini-Workshop: Mathematical Methods and Models of Continuum Biomechanics

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Abstract. The workshop *Mathematical Methods and Models of Continuum Biomechanics* focused on skills and tools providing a rational approach for integrating data that reductionist and molecular approaches in modern biological and medical science has recently provided. The workshop has provided contributions that brought together experts from the (bio-)mechanics and applied mathematics communities in order to highlight the mathematical needs and challenges especially in the fields of soft tissues and DNA mechanics.

Mathematics Subject Classification (2000): 74L15, 76Z05, 92C10, 92C35, 92D20.

Introduction by the Organisers

It is well known that biomechanics is rapidly becoming a classical field of application of mathematics. Several recently established societies and journals are devoted to this subject and increasingly many conferences are being organized with biomechanics as the central theme. However, continuum biomechanics remains to attract the attentions of significant numbers of mathematicians. Biomechanics has contributed much to understanding of human health and to disease and injury and their treatment, but has yet to reach its full potential as a consistent contributor to the improvement of health-care delivery. Because of the inherent complexities of the microstructure and biomechanical behaviour of biological cells and tissues, there is a need for new theoretical frameworks to guide the design and interpretation of new classes of experiments. Because of continued advances in experimental technology and the associated rapid increase in information on molecular and cellular contributions to the behaviour at tissue and organ levels, there is a pressing need for mathematical models to synthesize and predict observations across multiple length and time scales. And because of the complex geometries and loading conditions, there is a need for new computational approaches for the solution of

boundary- and initial-value problems of clinical, industrial and academic importance.

The investigations of particular interest in this framework are those that quantify the mechanical environment in which cells and matrix function in health, disease or injury, identify and quantify mechano-sensitive responses and their mechanisms, detail interrelations between the mechanical and biological processes such as growth, remodelling, adaptation and repair, and report discoveries that advance therapeutic and diagnostic procedures. For these investigations to be successful there is need for a strong mathematical background that differs from that in classical biomathematics.

First of all because, as noted in the 1998 Bioengineering Consortium (BECON) Report of the US National Institutes of Health,

The success of reductionist and molecular approaches in modern medical science has led to an explosion of information, but progress in integrating information has lagged. Mathematical models provide a rational approach for integrating this ocean of data, as well as providing deep insight into biological processes.

Second, because there are new challenges for such mathematical models that require review and revision of the axiomatic framework underpinning the usual analytical and computational models based on solid mechanics, fluid mechanics and thermo-mechanics, and their interactions. This means that there is a need to develop also new mathematical models.

The workshop *Mathematical Methods and Models of Continuum Biomechanics*, organized by Ray W. Ogden (Glasgow) and Giuseppe Saccomandi (Lecce) and held February 21st–26th, 2005, focused on this timely subject with contributions that brought together experts from the (bio-)mechanics and applied mathematics communities in order to highlight the mathematical needs and challenges in the field.

The topics addressed were:

mathematical modelling and computational issues in soft tissue mechanics with particular reference to growth and remodelling – this is a fundamental topic where there is the need for a new generation of mathematical tools for describing deformation as the mass and material properties change;

mathematical models and methods in cardiovascular systems – here the computational effort is striking, mainly for the study of blood flow in large arteries and in fluid-structure interaction problems; interesting mathematical problems come from associated multi-scale analysis and optimal control;

mathematical issues on the modelling of DNA - here the aim is to apply rigorous mathematical approaches and efficient computational algorithms in the development and application of models in order to understand the basic physical properties of DNA as a function of its base sequence; these properties are generally believed to be key to the biological function of DNA, but the mechanisms are not well understood.

The meeting was attended by 14 participants, a nice blend of researchers with various backgrounds. The program consisted of 14 talks and several informal discussions that benefited enormously from the unique academic atmosphere at the Oberwolfach Institute.