04-2 IUTAM Symposium on Mechanics of Biological Tissue Graz, Austria, June 27 - July 02, 2004

a) Scientific Committee

G.A. Holzapfel (Chair, Austria), R.W. Ogden (UK), S.C. Cowin (USA), J. Engelbrecht (Estonia), J.D. Humphrey (USA), J.M. Huyghe (The Netherlands), P.J. Prendergast (Ireland), A. Rachev (Bulgaria)

b) Short summary of scientific progress achieved

The mechanics of biological tissues, both soft and hard tissues, is a multidisciplinary and rapidly expanding area of research. Several prestigious universities have established new foci on this promising field, which brings together researchers in engineering, physics, biology, medicine and applied mathematics.
The IUTAM symposium provided important new directions and emphases on the need to combine these disciplines with the exciting new developments in biology. The symposium aimed to foster this interaction by including state-of-the-art presentations on the following topics.

- Mechanics of soft and hard tissues at the molecular, cellular, tissue and organ levels, with the aim of providing a deeper understanding of tissue structure and function.

- Mechanobiology, a new research area aimed at understanding better how mechanical information is processed and programmed by the cells. Of particular interest will be inter-relations between the mechanical and biological processes such as growth, remodelling, and repair.

- Experimental, microstructural, continuum mechanical and computational perspectives, with an emphasis on modelling the mechanical behaviour of tissues and simulating therapeutic and diagnostic procedures such as balloon angioplasty and stenting.

Because of the complexity of the material properties and the geometries encountered in applications, implementation of the biomechanical models in numerical codes is vital. An efficient numerical tool is one of the prerequisites for the design and development of soft and hard tissue prostheses. Thus, numerical aspects were also well represented.
A common goal for those working in the mechanics of biological tissue is to analyse and tabulate, to search for causal connections and to make predictions on the basis of abstraction and general principles. Therefore, we need to ask fundamental questions and we need to create new technologies for solving problems related to the mechanics of biological tissues; in other words, tissue biomechanics offers a positive heuristic. Hence, another aim of the IUTAM symposium was to provide a forum for discussion and comparison of different methods and approaches in the field and for the unification of

these approaches, to bring together young researchers and the world's leading scientists working in the field, and to stimulate the study of challenging new topics in the mechanics of biological tissue.

c) Countries represented and number of participants

We brought together an international pool of delegates actively working in the field of biomechanics and mechanobiology. Many are highly respected scientists with large numbers of rigorously reviewed journal articles; one participant has a two more than 10 publications in Science and Nature.

A total of 96 registered attendees from 19 countries participated in this Symposium: Austria (12), Brazil (1), Bulgaria (1), Canada (2), Czech Republic (4), Estonia (1), France (3), Germany (11), Ireland (4), Israel (1), Italy (9), Japan (4), New Zealand (2), The Netherlands (2), Spain (1), Sweden (1), Switzerland (7), UK (4), USA (26)

d) Publication of Proceedings of the Symposium

The proceedings of selected papers in the symposium will be published by Springer-Verlag, Heidelberg in 2005. This volume is being edited by G.A. Holzapfel and R.W. Ogden.

e) Financial supports

The organizers are deeply indebted for the following institutions and companies for their generous financial support in the preparation of the Symposium.

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- Springer-Verlag Heidelberg GmbH & Co.KG, Heidelberg, Germany
- Steiermärkische Bank und Sparkassen AG, Graz, Austria
- The Generics Group Ltd, Cambridge, United Kingdom

f) Scientific program

In addition to 42 oral presentations, 15 poster presentations were scheduled.

Day 1

Session 1:
G.A. Holzapfel, Chairman of the Scientific Committee, *What is Our Wish in Tissue Biomechanics?*
P.J. Hunter, J. Fernandez, H. Schmid, M. Tawhai, P. Nielsen, M. Nash , *(Keynote Lecture), Challenges in Modeling Soft Tissue Mechanics*

Session 2:
J.D. Humphrey, *(Keynote Lecture), Biomechanics of Arterial Growth and Remodeling*
M.A. Zulliger, A. Rachev, **N. Stergiopulos**, *A Constitutive Formulation of Arterial Mechanics Including Vascular Smooth Muscle Tone*
A. Rachev, *Solid Mechanics Approach to Some Remodeling-Related Problems in Arterial Grafting*

Session 3:
S.C. Cowin, *(Keynote Lecture) Reading Bones: Insights into the Modeling of Bone Morphogenesis, Growth and Adaptation*
Ph. K. Zysset, *Architecture Based Yield and Failure Criteria for Trabecular Bone*
M. Doblaré, J.M. García, M.J. Gómez-Benito, *Impact of Different Loading Conditions on Bone Fracture Healing*

Session 4:
R. Müller, *Time-Lapsed Microstructural Imaging of Bone Function*
M.S. Sacks, T. Lam, J. Stella, *A Structural Constitutive Model for the Native Pulmonary Valve*

Day 2:

Session 5:
W. Ehlers, B. Markert, A. Acartürk, N. Karajan, *A Coupled FE Analysis of the Intervertebral Disc Based on a Multiphasic TPM Formulation*
J.M. Huyghe, R.W. Roos, Y. Schroeder, *Coupling Finite Deformation, Electric Potentials and Chemical Potentials*
S.M. Klisch, *A Bimodular Second Order Constitutive Theory for Fiber-Reinforced Soft Biological Tissues*
Session 6:
R. Lakes, *(Keynote Lecture), Viscoelastic and Microelastic Behavior of Tissue*
D.P. Pioletti, *Viscoelastic Constitutive Law for Biological Tissue*
J.C. Criscione, *Semi-Inverse Solution to Extension and Inflation of a Thick-Walled Tube*

Poster Session:
M. Auer, R. Stollberger, P. Regitnig, F. Ebner, G.A. Holzapfel, *MRI-Based Morphological 3D Reconstruction of Atherosclerotic Lesions*

L.D. Blecha, P.Y. Zambelli, N.A. Ramaniraka, L.R. Rakotomanana, P.-E. Bourban, J.-A. Manson, D.P. Pioletti, *How Plate Positioning Impacts the Biomechanics of the Open Wedge Varus Osteotomy; A Finite Element Analysis*
F. Cacho, P.J. Elbischger, M. Doblaré, T.C. Gasser, G.A. Holzapfel, *From Image Data to Numerical Simulation: A Constitutive Model for Arterial Walls Considering Statistical Fiber Distribution*
S. Delorme, D. Laroche, R. DiRaddo, J. Buithieu, M. Stadler, G.A. Holzapfel, *Interaction of the Deployment System and Arterial Wall During Balloon Angioplasty*
E. Diouf, M. Cheref, M. Zidi, *Mechanical Study of a Prototype of Small Diameter Vascular Graft*
C. Gauvin, A.M. Yousefi, R. DiRaddo, J. Fernandes, *Biphasic Modelling of Functional Tissue Engineering Scaffolds Surrounded by Native Tissues*
R.L. Gleason Jr., J.D. Humphrey, *Mechanically-Induced Vascular Adaptations: A new Approach to Modeling and Experimentation*
K. Malakpoor, E.F. Kaasschieter, C.J. van Duijn, J.M.R.J. Huyghe, *Mixed Finite Element Modeling of Cartilaginous Tissues*
C.T. McCarthy, M.D. Gilchrist, M. Hussey, *Finite Element Modelling of Cutting Biomaterials with Surgical Instruments*
A.N. Mefti, B. Haussy, J.F. Ganghoffer, *Development of Red Blood Cell Adhesion With the Vein Walls: A Probabilistic Approach*
A. Menzel, G. Himpel, E. Kuhl, P. Steinmann, *Anisotropic Remodeling of Biological Tissues*
S.A. Riboldi, M. Sampaolesi, P. Neuenschwander, F.M. Montevecchi, G. Cossu, S. Mantero
Skeletal Muscle Tissue Engineering: Line Myoblasts and Primary Satellite Cells on Electrospun DegraPol® Scaffolds
H. Schmid, M.P. Nash, P. J. Hunter, *Sensitivity Analysis of Myocardial Material Parameters in Orthotropic Constitutive Laws*
J. Stålhand, *In-vivo Aorta Parameter Identification Using a Relaxed Force Constraint*
R. Wang, N. Katsube, R.R. Seghi, S.I. Rokhlin, *Statistical Failure Analysis of Ceramic/Dentin Layered Structures*

Session 7:
L.J. Gibson, *Contractile Response of Fibroblasts on a Collagen-GAG Scaffold*
B.P. Murphy, P. McGarry, B. Flaherty, **P.E. McHugh**, *Prediction of Changes in Cell Morphology and Adhesion Using a 3D Cohesive Zone Model*

Session 8:
K. Grosh, N. Deo, *Nonlinear Constitutive Models for Cochlear Outer Hair Cells*
F. Boschetti, M.T. Raimondi, **F. Migliavacca**, R. Pietrabissa, *Microfluid-Dynamics in Three Dimensional Engineered Cell Systems*

Day 3:

Session 9:
J.A. Weiss, A.I. Veress, G.T. Gullberg, N. Phatak, Q. Sun, D. Parker, R.D. Rabbitt, *Strain Measurement Using Deformable Image Registration*
S.J. Hollister, C.Y. Lin, C.Y. Lin, *Computational Analysis and Optimization of Tissue Engineering Scaffolds Using Image-Based Hierarchical Homogenization Approaches*
T. Yang, **R.L. Spilker**, *A Mixed Finite Element Formulation for Three-Dimensional Contact of Biphasic Soft Tissues*

Session 10:
K. Hayashi, *(Keynote Lecture), Tensile Properties and Local Stiffness of Cells*
H. Gao, *Mechanics of Flaw-Tolerant Nanostructures of Biological Systems*
M.C. Boyce, *Mechanics of Softening Biopolymers*

Day 4:

Session 11:
S.C. Calve, K. Garikipati, K. Grosh, K. Baar, H. Narayanan, **E.M. Arruda**, *Characterization and Modelling of Growth and Remodelling in Engineered Tendon Constructs*
E. Kuhl, G. Himpel, A. Menzel, P. Steinmann, *Modeling and Simulation of Isotropic and Anisotropic Growth in Hard and Soft Biological Tissues*
J. Engelbrecht, M. Vendelin, *Mathematical Modelling of Cardiac Mechanoenergetics*

Session 12:
P.D. Richardson, *(Keynote Lecture), Mechanical Properties of Atherosclerotic Tissues*
A.S. Khalil, T. Zhu, R. Chan, A. Chau, B. Bouma, R. Kamm, **M. Kaazempur-Mofrad**, *Characterization of Atherosclerotic Plaques using OCT-Based Elastography, Novel Parameter Estimation Techniques, and FEM*
K.B. Chandran, D.D. McPherson, *Material Property Alterations with Early Atheroma in an Animal Model*

Session 13:
P.B. Canham, R.M. Korol, R. Hammond, A.R. Lucas, *(Keynote Lecture), Human Brain Arteries and Aneurysms – Their Collagen Organization and Biomechanics*
M. Oshima, R. Torii, K. Takagi, *Image-Based Simulation of Blood Flow and Arterial Wall Interaction for Cerebral Aneurysms*
M.R. Moreno, J. Bedoya, C. Meyer, **J.E. Moore Jr**., *The Role of Biomechanics in the Restenosis of Stented Arteries*
Session 14:
P.J. Prendergast, C. Lally, *Simulation of In-stent Restenosis and its Relationship with Cardiovascular Stent Design*
A.D. Freed, D.R. Einstein, I. Vesely, *Invariant Theory for Dispersed Transverse Isotropy. An Efficient Means for Modeling Fiber Splay*

Day 5:

Session 15:
R.J. Clifton, M.S. Hahn, X. Jia, T. Jiao, *Viscoelastic Response of Vocal Fold Tissues and Scaffolds at High Frequencies*
E. Mazza, A. Nava, M. Bauer, R. Winter, G. A. Holzapfel, *In Vivo Experiments to Characterize the Mechanical Behavior of the Human Cervix*
S. Socrate, *Exploring the connections between Molecular Structure and Mechanical Function of the Extracellular Matrix*

Session 16:
T. Matsumoto, T. Furukawa, M. Taniguchi, K. Nagayama, *Microscopic Analysis of Residual Stress and Strain in the Aortic Wall*
R.W. Ogden, A. Guillou, *Residual Stress Development and Growth in Soft Tissue*
G.A. Holzapfel, M. Stadler, T.C. Gasser, M. Auer, *Challenges in Modeling Atherosclerotic Lesions Following Balloon Angioplasty and Stenting*

Report composed by Gerhard A. Holzapfel and Ray W. Ogden