III European Conference on Computational Mechanics
Solids, Structures and Coupled Problems in Engineering
C.A. Mota Soares et al. (eds.)
Lisbon, Portugal, 5–8 June 2006

Computational Micromechanics of Biological Materials: Bone and Wood

Christian Hellmich*, **Karin Hofstetter***, **Cornelia Kober**†

*Vienna University of Technology (TU Wien), Institute for Mechanics of Materials and Structures
Karlsplatz 13/202, A-1040 Wien (Vienna), Austria
christian.hellmich@tuwien.ac.at, karin.hofstetter@tuwien.ac.at

†Osnabrück University of Applied Science, Faculty of Engineering and Computer Science
Albrechtsstraße 30, D-49009 Osnabrück, Germany
c.kober@fh-osnabrueck.de

ABSTRACT

Despite complex hierarchical organization of bone and wood, it was recently possible to identify a few elementary components at the micro and nanolevel of these material classes for the explanation of the diversity of macroscopic (poro-)elastic properties of different bones and woods [2, 3]. The mechanical properties (i.e. elasticity) of these elementary components are (up to experimental scattering) the same across a variety of different bones and woods, respectively; they are 'universal', i.e., independent of tissue-type, species, and anatomical location. The mechanical interaction between these elementary components (mechanical morphology) and the dosages of these components in different tissues determine the macroscopic material properties. Having in mind that, as regards bone, these dosages are dependent on complex biochemical control cycles (defining the metabolism of the organism), the purely mechanical theory can be linked to biology, biochemistry, and, on the applied side, to clinical practice. Drug-driven or genetically driven changes in metabolisms lead to changes in the dosages of elementary components. The effects of these metabolic changes on the mechanical behavior of skeletal (sub)systems under well-defined loading conditions (e.g., downfall of elderly persons with osteoporosis) can then be studied by feeding structural models (e.g., Finite Element models [4]) of whole bones with the aforementioned macroscopic material properties - the output of the micromechanical models. This is probably highly relevant for patient-specific non-invasive bone disease diagnosis and therapy. As regards wood, our nano-to-macro approach is expected to support optimization of technological processes, such as drying.

References

[1] L. Dormieux and F.-J. Ulm, editors. *CISM Vol.480 – Applied Micromechanics of Porous Media*. Springer, Wien - New York, 2005.

[2] Ch. Hellmich. *Microelasticity of bone*, pages 289 – 331. In Dormieux and Ulm [1], 2005.

[3] K. Hofstetter, C. Hellmich, and J. Eberhardsteiner. Development and experimental validation of a continuum micromechanics model for the elasticity of wood. *European Journal of Mechanics A - Solids*, 24:1030 – 1053, 2005.

[4] C. Kober, B. Erdmann, Ch. Hellmich, R. Sader, and H.-F. Zeilhofer. Validation of interdependency between inner structure visualization and structural mechanics simulation. *International Congress Series*, 1281:1373, 2005.