Václav Klika
FNSPE, Czech Technical University in Prague and Institute of Thermomechanics, AS CR
e-mail: klika@it.cas.cz
František Maršík
Institute of Thermomechanics, AS CR
e-mail: marsik@it.cas.cz

Tissue adaptation driven by chemo-mechanical coupling with application to bone

Based on the current knowledge of bone remodelling process, a biochemical model is proposed which describes the essential interactions that governs the whole bone remodelling process. Further, the influence of mechanical stimulation on bone tissue is well known. Considerations from non-equilibrium thermodynamics are used to quantify this effect and moreover to stress the importance of dynamic character of the loading. Particularly, the question of what constitutes a mechanical stimulation of biochemical reactions in general will be addressed and further to compare the importance of the two possible mechanical stimulations: shear rate and the rate of volume variation. Consequently, a modified form of the Law of Mass Action is derived which includes also the mechano-chemical coupling and not only the affinity of interaction based on the difference in chemical potentials. This rather different approach from the classical ones can predict bone density distribution as will be shown on some examples including the effect of stem insertion or osteoporosis.

Acknowledgement. This research has been supported by the Czech Science Foundation project no. 106/08/0557.

References

[1] Klika, V., Maršík, F., 2009. *Coupling effect between mechanical loading and chemical reactions.* Journal of Physical Chemistry B **113**, 14689–14697.

[2] Klika, V., 2010. *Comparison of the Effects of Possible Mechanical Stimuli on the Rate of Biochemical Reactions.* Journal of Physical Chemistry B **114**(32), 10567—10572.

[3] Klika, V., Maršík, F., 2010. *A Thermodynamic Model of Bone Remodelling: The Influence of Dynamic Loading Together with Biochemical Control.* Journal of Musculoskeletal and Neuronal Interactions **10**(3), 210–220.