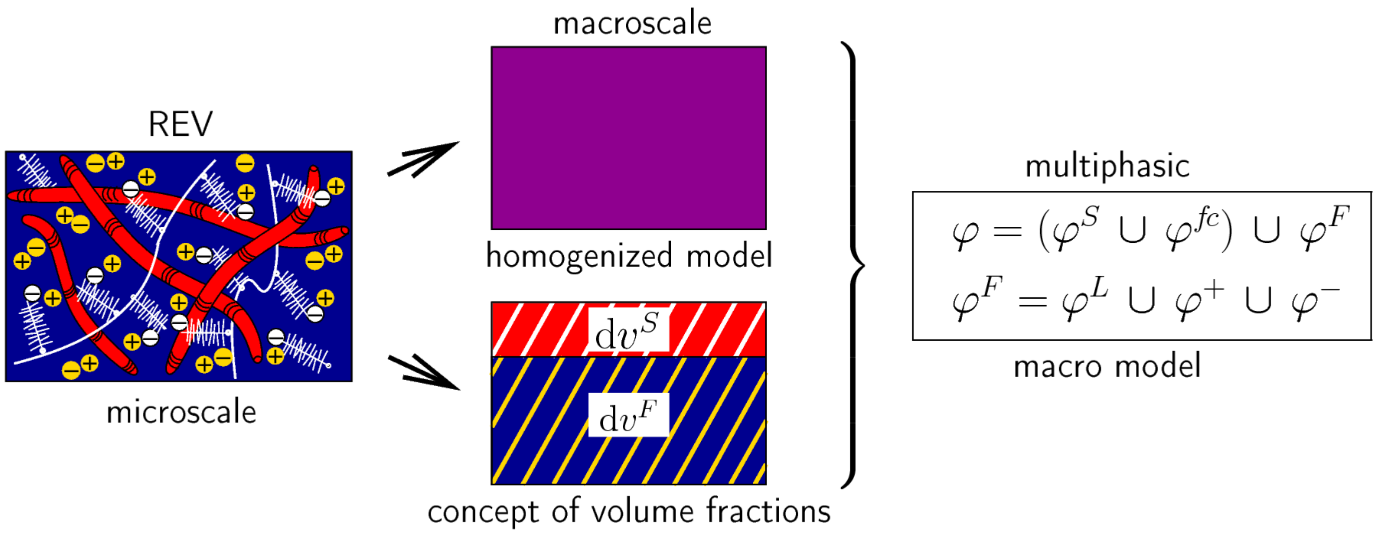
Healthcare industry BW

Biomechanics – a broad field

Biomechanics is a combination of the life sciences and the engineering sciences. Based on their knowledge and understanding of mechanics and the development of complex mathematical models and computer simulations, engineers, mathematicians and computer specialists help scientists gain new insights and give medical specialists access to new therapeutic options. In many cases, such as in the development of implants or in sports medicine, engineers also work closely with medical practitioners.

Biomechanics refers to the investigation of motion phenomena in biological systems. Methods from the field of mechanics are applied to the body's support and movement apparatus, organs, tissues and cells and can be used in a broad range of applications. One aspect of biomechanics is the investigation of how biological systems adapt to different mechanical requirements. These adaptations, i.e. biological optimisations, serve as models for many technical developments, which are applied in medicine as well as other areas where they are used to restore or maintain biological functions. Another aspect of biomechanics is the technical testing and optimisation of mathematical optimisation methods that are subsequently applied to biological systems.

Biomechanics is very much an interdisciplinary field of research and application. It represents a sea change in the world of science, moving away from disciplines that are clearly separated from each other to cross-disciplinary, methodologically linked approaches in which experts from completely different areas and completely different knowledge backgrounds work together synergistically. Biomechanics brings together a broad range of different disciplines: construction and aerospace engineers, biologists, physicists, medical practitioners, sports scientists, mathematicians and computer specialists. This huge range might be the reason why there are currently only a handful of biomechanics university chairs in Germany. Nevertheless, numerous research groups exist, which are either part of medical, engineering science, natural scientific or social sciences faculties, depending on their background and research priorities. One particular group that specifically focuses on basic research into biomechanical principles is part of the Department of Mechanics (construction engineering) at the University of Stuttgart. The group's construction engineers apply continuum mechanics methods in their work on biomechanical principles.



The microstructure of biological tissue is mathematically homogenised.

How does motion function? Biomechanics shows how.

Many biomechanics-related research themes arise in the fields of sports science and the science of motion. Examples include basic research-oriented movement analysis of athletes and applied research into the optimisation of training and sports equipment. Researchers use their knowledge about the biomechanics of standing, running and jumping to develop new sports shoes and floor surfaces for sports grounds and halls. The field of medicine benefits enormously from biomechanical insights from the field of sports science: orthopaedists, and physiotherapists and prosthesis developers alike benefit from sports science results. The article entitled "Sounding out human motion" deals with the key biomechanical principles of human motion and with the reasons why standing still is actually classified as movement.

The analysis and simulation of movement is also an interesting market in commercial terms. The Tübingen-based company Biomotion Solutions has developed marketable simulations for human motion, which have enabled the automotive industry, amongst others, to develop new and improved systems for accident prevention and driving comfort. Movement analyses are also interesting for the field of veterinary medicine enabling, amongst other things, the investigation of the biomechanics of lame horses and cattle.

However, movements are processes that can differ from one biological system to another. Environmental factors and disease can affect these processes as can overload and deterioration: In our ageing society, the bones, cartilage and joints, tendons and ligaments are subject to increasing wear and tear. Besides the stress involved for patients and their families, this phenomenon is also extremely costly. According to the German Federal Statistical Office, around 50% of the 26.6 million euro costs generated by musculoskeletal system diseases, are spent on treating the over 65s. In the 65 to 85 age group, the cost of treating such disorders is second only to the cost of cardiovascular disease treatment. Hip and upper thigh injuries are extremely costly, especially in the over 65 age group. Taking into account demographic trends, further cost increases can be expected in the coming years. It is therefore crucial to find efficient treatment methods, and biomechanics is well placed to make major contributions to this effort.

What kind of stress can bones and cartilage withstand? This is an important question for osteoporosis research as well as other areas. A group of biomechanics specialists at the University of Ulm is investigating fracture healing, particularly in osteoporotic bones. Biomechanics at the University of Constance are investigating the load on bones during everyday movements and sports activities. The Constance researchers are carrying out comparative biomechanical analyses on the load and demands made on human phalanges, in particular in professional musicians and sports climbers who are exposed to a particularly strong load.

External mechanical influences are important for body functions

The muscle-skeleton model of the cervical spine is used for the optimisation of car seats, amongst other things.
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Although too much strain is harmful, it is also known that the human body deteriorates if exposed to too little mechanical strain and as a result, is not able to maintain its normal functions. Something that is easily understood in terms of muscles, is also valid on the molecular level. Mechanical influences affect biochemical processes; they can stimulate or inhibit them. This is not a new finding. As far back as the end of the 19th century, the physician Julius Wolff from Berlin realised that external mechanical influences lead to tissue alterations. In 1892, Wolff published a theory according to which bone remodels itself over time to become stronger and more resistant to the loads it is placed under. This theory is known as Wolff's law.

Increasing knowledge about the metabolism and the molecular relationships have led to increasing insights into the details of what happens on the cellular level and below. In the 1990s, Swann et al. described how the mechanical properties of tissue change when placed under mechanical loads. Implants have been shown to have a huge influence on bone remodelling, i.e. on the continuous formation and degradation of bone material in the living body. Engineers at the Institute for Statics and Dynamics of Aerospace Structures at the University of Stuttgart are working on a mathematical description of these processes. In recent years, the influence of mechanical forces on the metabolic activity and on the differentiation and proliferation of cells has been described in detail (e.g., Vanwanseele et al. 2002 and Kelly et al. 2005). The "Molecular Biomechanics" group at the Heidelberg Institute for Theoretical Studies (HITS) is pursuing innovative approaches to investigate the mechanobiochemistry of blood coagulation and spider silk. The researchers are carrying out work that demonstrates and helps determine how gravity affects and leads to the creation of chemical bindings.

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