All but diamonds – Biological materials are not foreve

Abstract

Diamonds are known for their perfection and durability. Low flexibility and a lack of adaptation capability are the price to pay for such permanence. Over the course of evolution many different biological materials have appeared which adapt their physical properties to the environmental conditions. To allow for such flexibility biological materials such as bone, silk, shell, skin, plant stem and insect cuticle have complex, often hierarchical, structures. They contain defects, interfaces, structural and chemical gradients and are generally built to be either defect-tolerant in their behavior or to have the capability of self-repair. This complexity makes biological materials difficult to study and to understand. However, over the last hundred years materials engineers have developed metal alloys and other materials with increasing complexity, recognizing that imperfections are not always detrimental but can be useful to tune mechanical, electrical or optical properties. A wide range of models and concepts has been developed to understand the influence of microstructure and defects on the properties of engineering materials. This review reports a few examples where concepts borrowed from physical met- allurgy were successful in describing the structure and (mostly mechanical) behavior of biological materials. Approaches of this kind, judiciously combined with biochemical and biological knowledge, may increasingly influence our thinking about tissues and organs. Conversely, the design principles learnt from nature may also help us to develop new types of materials with unexpected property combinations.