Unravelling and Exploiting the Complex Mechanisms Responsible for the Superior Tribological Behaviour of Natural Systems

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Nature-optimised soft matter has recently attracted a great deal of attention in the biotribology and biomimetics research communities. The study of plants, animals and humans has become more accessible thanks to the advent of new experimental and modelling tools, which have enabled the recent shift to mimic their very complex behavior. This presentation will provide an overview of the recent advances made for the development of a better understanding of natural systems and the man-made materials and solutions inspired from our attempt to learn from the wonders of evolutionary optimization.

Keywords: biotribology, modelling, characterisation, advanced functional materials, biomimetic solutions.

1. Introduction

In nature, living systems commonly evolve to produce functional solutions that achieve optimal behavior via a combination of improvements in terms of materials, surfaces and tuning of chemical reactions. Many examples exist in tribology, where *e.g.* switchable friction/adhesion mechanisms are used for climbing and locomotion. Other cases include the control of structural properties and molecular mechanisms to reduce and actively control friction and lubrication in articular joints, textured, anisotropic and pH-controlled surfaces.

Here the work recently performed as a collaborative effort with various groups around the world will be showcased to demonstrate how superior tribological behavior can be obtained by exploiting lessons learnt from nature (see *e.g.* Refs. [1-5]).

2. Results

Several results from studies conducted for both natural systems and synthetic materials derived to best mimic their living counterparts will be presented. The attention will be focused on the intertwined underlying physical, mechanical and chemical mechanisms, which are responsible for the superior frictional and adhesive behavior of these systems (see Fig. 1.)

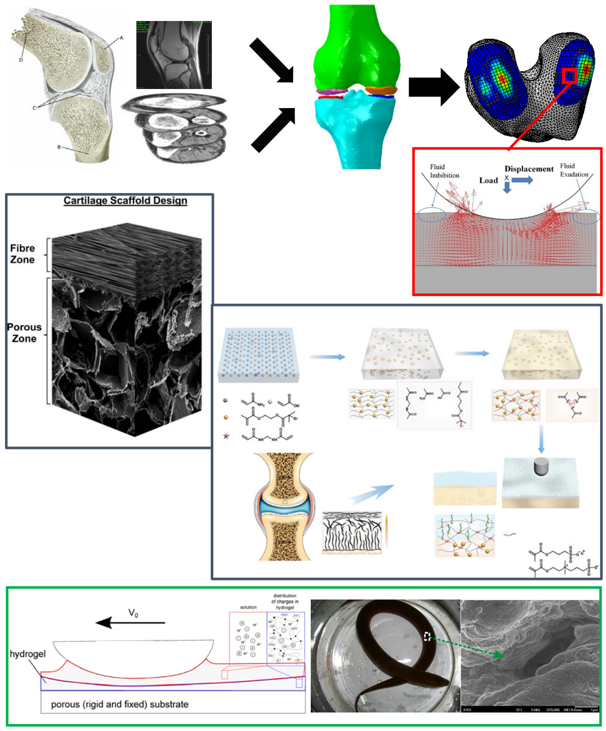

Figure 1: Examples of the use of combined experimental and modelling biotribology studies and biomimetic solutions obtained for various applications.

3. Discussion

Much of the development of new biomimetic tribological solutions depend on our ability to unravel and exploit the mechanisms that control friction in natural systems. For example, biomimicking cartilage with soft materials has been and remains a grand challenge in the fields of materials science and engineering. Inspired by the unique structural features of the articular cartilage, as well as by its remarkable lubrication mechanisms dictated by the properties of the superficial layers, a novel archetype of cartilage-mimicking bilayer material by robustly entangling thick hydrophilic polyelectrolyte brushes into the subsurface of a stiff hydrogel substrate has been recently developed. Different tissue engineering solutions as well as the design, synthesis, and testing of novel synthetic constructs that provide friction switching and locomotion will also be discussed.

4. References

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