Bio-inspired materials: learning from nature and applying the lesson

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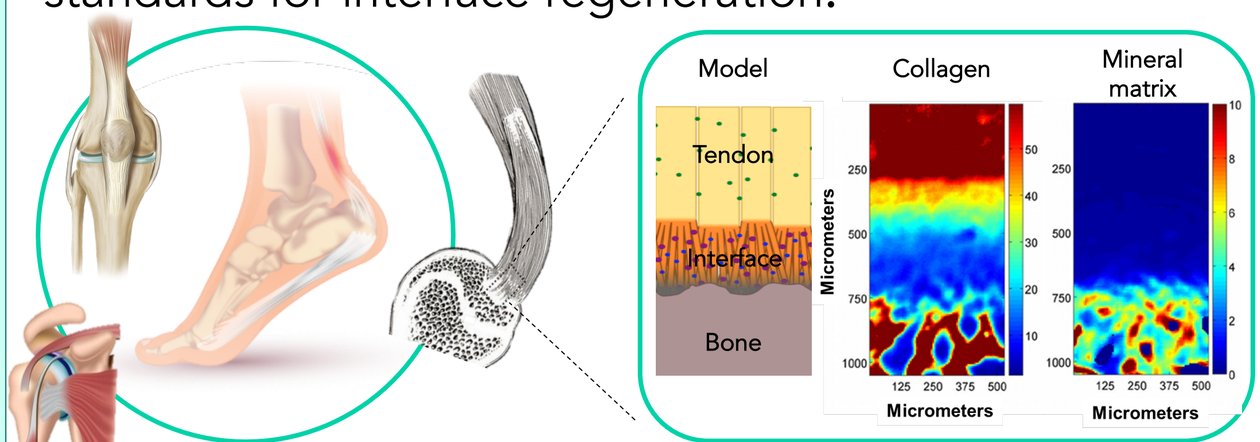
AIM OF THE RESEARCH GROUP

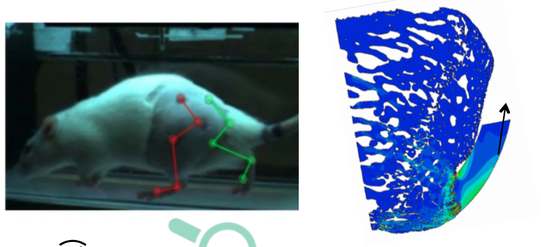
We investigate **mechanical properties** of biological and bio-inspired materials. The main biological tissue considered is **bone** and **its interface with ligaments and tendons**, which is a rather unexplored topic yet of paramount importance in the clinical context. We combine **experimental tools** with **computer simulations** to quantify and predicts tissue changes during **aging**, **diseases** and **treatments** as well as to establish new standards for the **regeneration of soft tissue-to-bone interfaces**. We also prototype novel bio-inspired material designs based on the mechanical construction principles identified in biological materials with the final mission of developing **high-performance and multifunctional composite materials** at the centimeter length scale.

Biological materials: the lesson

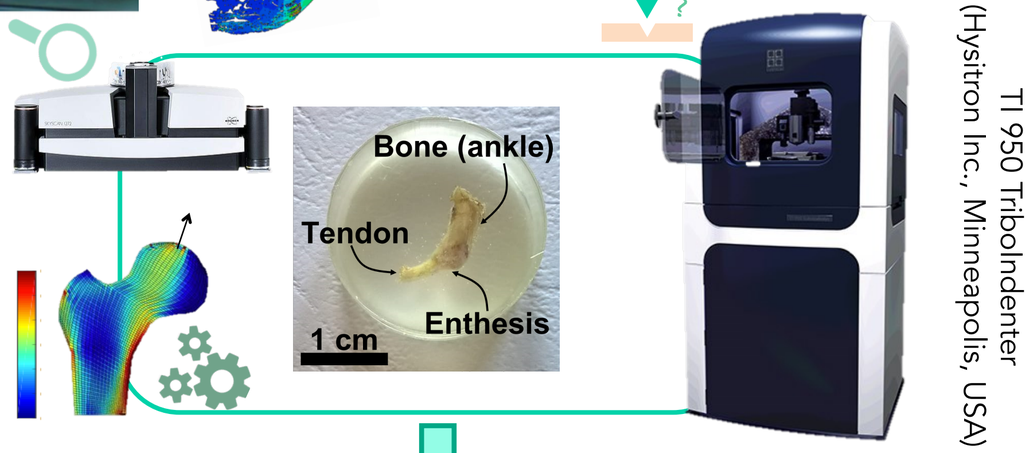
Strategy: Micro-computed tomography and dynamic nanoindentation to characterize microstructure and nanoscale mechanical properties as well as finite element simulations to study local stresses and strains at the **bone tendon/ligament interface** in heathy and aged scenarios, with the final aim to establish new standards for interface regeneration.



Adapted from Rosstti et al., Nature materials, 2017
Spalazzi et al., PlosOne, 2013



Microstructure
Mechanical properties
Stress transmission



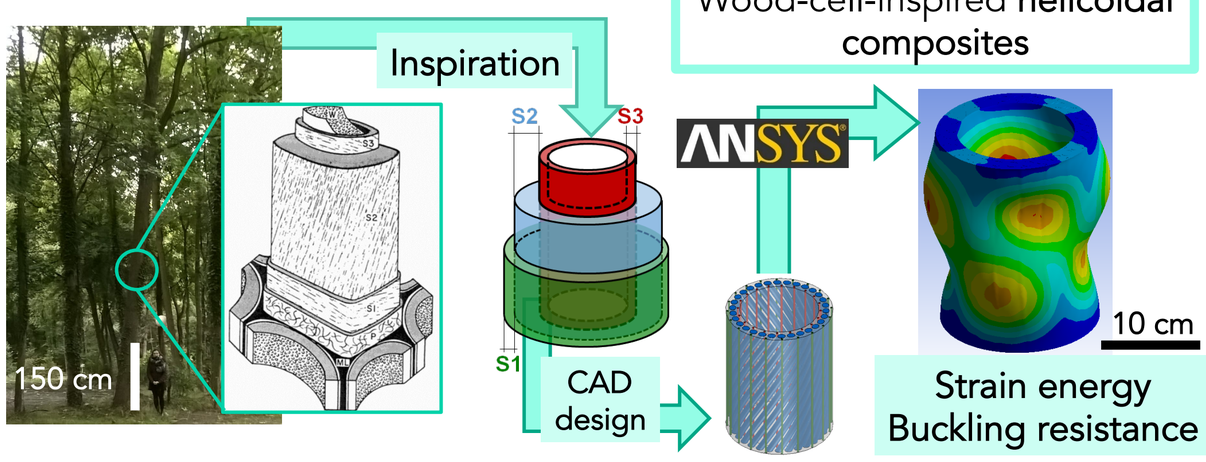
- **Image analysis:** Link between attachment of tendon and bone structure adaptation.
- **NanoDMA:** Link between local mechanical properties and tissue composition/organization.
- **FE simulations**: Local mechanical environment to better understand inflammation and aged-related modifications.

Synthesis of strategies providing natural interfaces their efficiency.

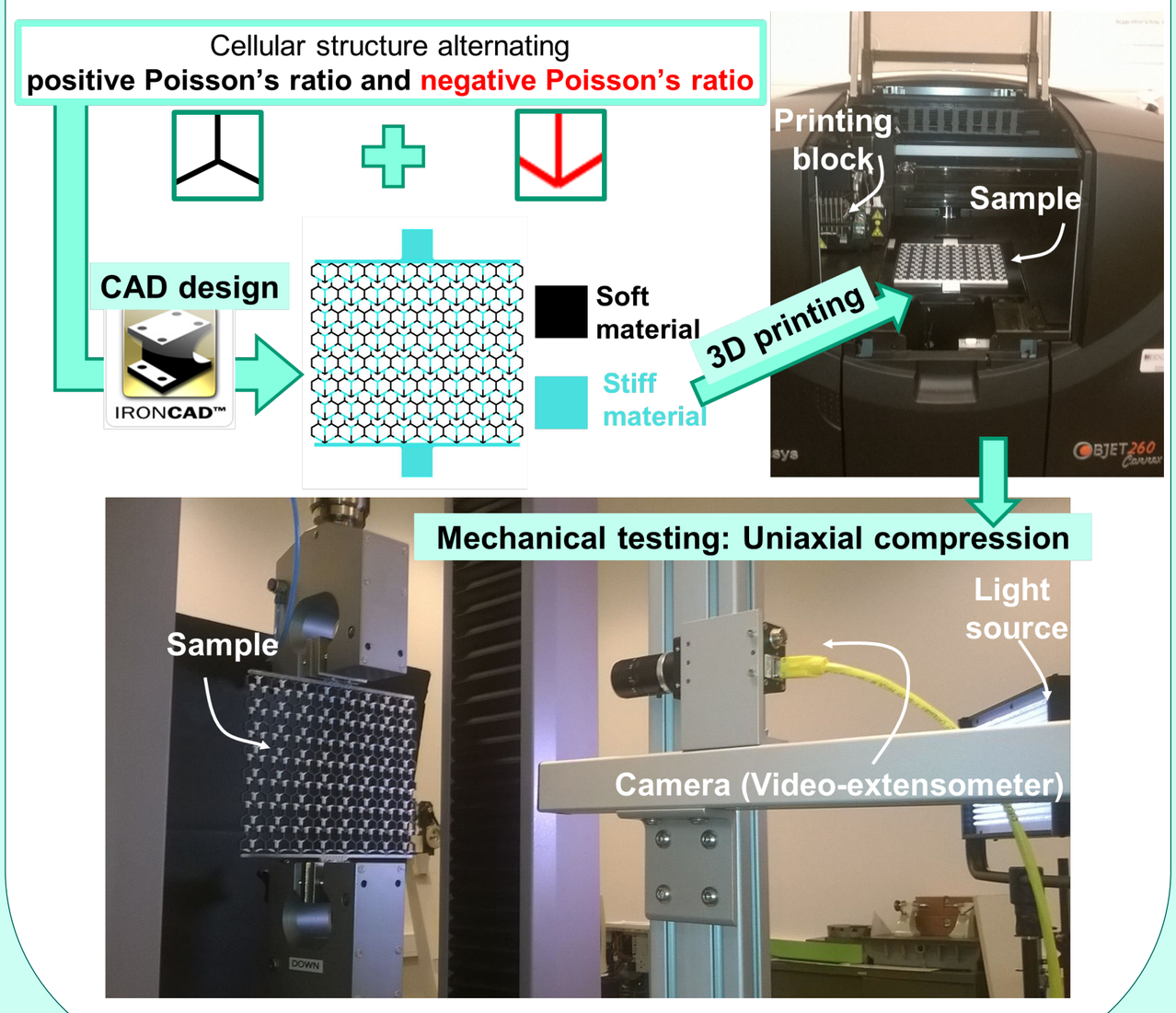
Bio-inspired materials: the replication

Strategy: replicate into synthetic materials building principles observed in biological structures such as embedding **stiff fiber-like elements into a soft matrix**, **hierarchical structuring** and **cellular architectures**.

- *In silico* characterization:



- Prototyping by multimaterial 3-dimensional polymer printing & mechanical testing



Adapted from Zorzetto and Ruffoni, Composite Structures, 2017

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