Supervisor Expression of Interest
MSCA-IF Marie Sklodowska Curie Action-Individual Fellowship

Supervisor name:	Anna Pandolfi
Email address:	anna.pandolfi@polimi.it
Department Name: Research topic: (https://www.polimi.it/en/scientific-research/research-structures/departments/)	DICA Models of passive and active biological tissues with embedded multi-scale microstructure
MSCA-IF Research Area Panels	☐ CHE_Chemistry ☐ ECO_Economic Sciences X ENG_Information Science and Engineering ☐ ENV_Environmental and Geosciences ☐ LIF_Life Sciences ☐ MAT_Mathematics ☐ PHY_Physics ☐ SOC_Social Sciences and Humanities
Politecnico di Milano Areas:	☐ Cultural Heritage ☐ Smart Cities ☐ Territorial Fragilities X Health ☐ Industry 4.0
Brief description of the Department and Research Group (including URL if applicable):	Researchers activities in DICA concern the more classical areas of applied mechanics and engineering. Key topics are the characterization and the modelling of materials and the analysis and design of structures at several length scales. The expertize of the department is transversal among the more general disciplines of diverse engineering branches. In particular, the competencies on material modelling provide the ability to extend the typical methods of applied science to the analysis of the behavior of biological material and structures, characterized by internal microstructure. www.dica.polimi.it/en/ricerca/materiali/. The proponent has experience as Adviser of 10 PhD students (Polimi and Caltech, CA USA) and Supervisor of 2 Post-Docs (Polimi).

Brief project description: (max 1 page)	The theoretical and numerical modeling of the behavior of soft biological tissues in physiological or pathological conditions plays a key role in the modern computational mechanics. Numerical analysis is used to predict the behavior of organs or biological ensembles, to design and improve diagnostic tools and surgical instruments that interact with biological tissues, and to design and produce new materials mimicking peculiar features observed in natural tissues. Most soft biological tissues are characterized by anisotropy, necessary because the organ must provide a general multi-direction confinement and, at the same time, it must resist to localized and strongly oriented actions. We refer, e.g., to artery walls, cornea, intestine walls, heart walls, bladder membranes and others. Mechanical anisotropy in soft tissues is achieved by means of complex and specialized architectures of cable-like fibrils and fibers, made of the most diffused protein in nature, i.e., the collagen. It follows that material models commonly employed for biological tissues account for different kinds of anisotropy induced by the collagen reinforcement. Moreover, biological tissues are characterized ineluctably by a spatial distribution of the collagen reinforcement whereas unique strong alignments of fibers are in contrast with the function of the organ. In many practical applications the physiological behavior of biological tissues is described sufficiently well by hyperelastic models that have been conceived for rubber materials, suitably adapted to account for the presence of distributed collagen by means of average or higher order statistics. Behaviors become more complex when biological tissues are in pathological conditions. In particular, we are addressing pathologies directly connected to the altering of the microstructure of the biological tissues, e.g, ectasia or aneurism which may appear in the cornea or the artery walls. In these cases, the expected mechanical behavior is compromised by the lack of one or more components or by the failure of the collagen microstructure. By disregarding the chemical aspects of the material degeneration, the interest here focuses on the mechanical interpretation of the behavior of the pathologic tissue. This implies the definition of a micromechanical model of the collagen structure that is able to describe healthy and pathological behaviors, that may be related to the attainment of the strength of the components. The application of the model to the simulation of real clinical case in clearly subordinated to the viability of a numerical implementation of the model, which therefore should be characterized by a moderate number of parameters.