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MATHEMATICAL MODELS IN BIOMECHANICS ACROSS THE SCALES: FROM CELLS TO BIOLOGICAL TISSUES

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MINI-SYMPOSIUM PROPOSAL

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1 BACKGROUND

In recent years a vibrant scientific community has shown a grown interest for closely understanding and predicting the mechanical and multi-physics behavior of biological tissues. This is done by providing more refined, realistic and reliable multiscale coarsening procedures which incorporate the refinements of the constituents at smaller length-scales. For instance, among many other things, this turns out to be crucial for estimating the load capacity in mammaliam organisms. In this regard understanding the mechanical behavior of bones, tendons, ligaments and other highly functionalized tissues is very important per-se but also to the extent of conceiving bioinspired artificial structures with enhanced structural performances. These features involve similar stiffness, strength and toughness among in vivo and artificial devices. Another example is that it is of high priority to aim to design tools helping the early diagnosis and control of aneurysms. More and more the recent strategy is to treat only those aneurysms that are at high risk of rupture and avoid unnecessary interventions for low risk ones that could safely be followed non-invasively. This requires a reliable discrimination between high and low risk illnesses. In all of the cases mentioned above, new generations of multiscale models require more refined information at the smaller scales, starting from the constituents of the cells, from the lipid membrane to the cytoskeleton, the cells themselves and their organization in tissue aggregates.

2 MOTIVATION

In recent years mechanical scientists worldwide have devoted strong research efforts toward predictive models of the mechanical behavior of biomechanical materials and systems. Indeed, since the beginning of the nineties several mathematical models have been reported to capture the non-linear elastic [1], hereditary [2], and the submacroscopic effects [3] that are involved in biological structures. In this regard no uniform paradigms have been released to deal with such systems and further efforts are still needed either to capture the mechanical behavior of biological tissues and to describe different aspects of cells biomechanics. For instance, multiphysics phenomena determining the mechanical behavior of tissues are starting to be incorporated in some of the new generations models [4], thereby indicating the need of much more detailed information at the smaller length scales of the constituents.

3 FOCUS OF THE MINI-SYMPOSYUM

The purpose of this mini-symposium is to bring together researchers in mathematical models of biological structures with the focus on the modeling of vascular tissues, bones, ligaments, cardiac muscles, valvular tissue, lipid bilayers, on chemo-bio-mechanical coupling [5] and electromechanical activation.

The goal is to provide a picture of the current knowledge in this field of the multiscale mathematical models governing the mechanics and multiphysics of biological in the field structures, describe current research efforts, and discuss the role of different spatial and time scales in the mathematical prediction of the observable behavior of tissues and cells. Topics to be considered include: the role of internal structures from the nano to the microscale, the role of fluid transport, effects the role of configurational changes in tissue geometry, the role of the chemo-bio-mechanical coupling in receptor-mediated mechanism, the role of the electromechanical coupling in cells, the role of material dissipation in biomechanical structures, microgravity effects on biological systems, etc.

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