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PREFACE

Biomechanics in "Sino-Italian Joint"

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As originally proposed by professor Alberto Corigliano of Politecnico di Milano and professor Jizeng Wang of Lanzhou University, the Chinese Society of Theoretical and Applied Mechanics (CSTAM) and the Italian Association for Theoretical and Applied Mechanics (AIMETA) signed a memorandum of understanding on strengthening exchange and cooperation between mechanics scholars of the two countries in January, 2018, officially opening the activities of bilateral academic exchange. Following the plan, exchange activity in 2019 was determined to be organized by the AIMETA, with the topic of biomechanics, aiming to gather researchers from different backgrounds for enhancing communications and creating cooperation opportunities for jointly solving challenging biomechanical problems.

Mechanics plays a prominent role in the study of biological systems and processes. Mechanical research has proven to be a powerful tool to advance our understanding of physiological and pathological mechanisms of cells and tissues, and provide insights into the interaction between medical devices and biological materials. Although to some extent traditional mechanical concepts are directly applicable to solve biomechanical problems, multiple spatial and temporal scales are typically involved in biological processes, and structural, fluidic, chemical and electrical fields are often tightly coupled. These issues bring unprecedented challenges towards the fundamental understanding of molecular, cellular, tissue, and organ mechanics, which may also benefit the fields of biomaterials and biomimetics. These challenges create great opportunities to experimental, theoretical, and computational researchers, and call for close collaborations among scientists from different fields.

From July 1 to 3, 2019, the exchange activity in the form of an academic workshop on biomechanics was successfully held in Rome, Italy, as hosted by the University of Rome Tor Vergata. Nearly fifty people from twenty-seven universities and research institutes were invited to attend the workshop. Professor Xiqiao Feng of Tsinghua University and Professor Paolo Bisegna of the University of Rome Tor Vergata jointly served as the workshop chairs. To celebrate and witness the success of this first joint workshop on biomechanics, we organized this thematic issue, which includes twelve invited papers. In this special issue, we presented studies of selected topics to the research community of biomechanics, aiming to report the most recent representative developments of this field in both countries. Together, they addressed several well-established and emerging topical areas, advanced the state-of-the-art, and offered some interesting directions for future research. Works in this collection reflected not only the similarities but also differences of biomechanical problems focused by researchers in the two countries, providing an important reference for further strengthening the exchanges and cooperation in this field between the two countries. We believe that this collection will provide a valuable reference source and a useful view of the present state of development in the field of biomechanics. Further papers stemming from the activities of the workshop will be published in future issues of Acta Mechanica Sinica.

Many biological structures, such as eukaryotic flagella and cilia, can be viewed as tubular assemblies of helical rods with programmable deformation ability. This enables them to adapt to changing functional requirements by altering conformations and specific properties. To understand the underlying mechanism, Quaglierini et al. [1] analyzed the

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mechanical response of tubular assemblies composed of 8 helical Kirchhoff rods under compression and tension, and revealed the relation between individual rod interactions and favored stable configurations of tubular assemblies.

Understanding the mechanism of genetic information decoding is the key to the development of advanced gene therapy and cancer diagnosis technology, among which detection of RNA in living cells by using molecular-beacons has emerged as a promising tool for live-cell interrogation. Gong and Shi [2] established a theoretical model based on continuum mechanics to study the interaction between the molecular-beacon and target system, and revealed that the hybridization between the target and stem is energetically favorable compared with that between the target and loop, implying a new detection strategy.

Cytoplasm, occupying the largest volume of a cell, has been found to be poroelastic. Determination of the poroelasticity of the cytoplasm is challenging, as its material behaviors are usually rate- and size-dependent, mainly caused by diffusion of free molecules and deformation of cytoskeleton. Based on the theory of the translation of a rigid spherical inclusion, Sun et al. [3] proposed a new method for the characterization of the poroelasticity, providing a powerful tool for in situ measurement of material properties of cytoplasm via optical/magnetic tweezers.

Liver sinusoidal endothelial cells (LSECs) play an important role in maintaining the stability of liver internal environment and are mechanically sensitive to various microenvironments, where main mechanical stimulation comes from the shear stress and mechanical stretch caused by blood perfusion and the increase of matrix stiffness due to extracellular matrix deposition. Shu et al. [4] made a systematic and in-depth review on how LSECs respond to external forces in physiology and pathology, how LSECs interact with other hepatocytes, and what are the molecular mechanisms that enhance LSEC mechanotransduction.

Cancer is one of the major public health problems in the world. One of the main causes of death of cancer patients is that cancer cells are prone to metastasis, for which blood vessels are important "pathways". Cancer cells can penetrate into and out of blood vessel through vascular endothelial cell barrier. To understand how the endothelial cells involve in tumor progression, Wei et al. [5] systematically summarized the regulatory role of endothelial cells on the mechanics microenvironment in tumor progression. Information in this review may help to find new therapeutic targets for tumor therapy.

Understanding the adhesion between cells and extracellular matrix is a crucial issue in many basic physiological and pathological processes. To quantitatively understand the cellular adhesion mediated by stochastic dissociation/association reactions of adhesion molecules, Lin et al. [6] proposed a theoretical model by considering the coupling between mechanical deformation of the system, stochastic dissociation/association of ligand-receptor bonds and stochastic unfolding/folding events of internal structures of adhesion molecules. Through Monte Carlo simulation, they found that molecular unfolding can have a profound influence on the binding energy of the adhesion interface, and controls the failure mode transition between the uniform decay and the catastrophic cleavage.

A growing tumor can be theoretically modeled as a poroelastic solid subjecting to potential competition dynamics of cells for available space and public resources. However, due to the strong nonlinear interweaving between poroelasticity and biochemical factors, to obtain useful qualitative law will be difficult if a nonlinearly coupled method is adopted to describe such growth process. By using linear mechanics theory to reduce the complexity, Carotenuto et al. [7] successfully derived the Lyapunov stability criterion, and analyzed the stability process of mechanical cell competition during the process of cancer invasion.

During heartbeat, the synchronous contraction of the ventricle is caused by the timely electrical activation of myocardial cells integrated in a complex and robust electrical network. Biomechanics models on cardiac electrical activation involves the epistemic uncertainty of the input parameters, which include the bundles and chambers geometry, electrical conductivities and cell parameters. Del Corso et al. [8] proposed an uncertainty quantification approach for the evaluation of the fast conductivity structures of the atria, and pointed out that the main factor affecting the propagation of the depolarization front is the electrical conductivity.

In recent years, endovascular treatment of femoral popliteal artery has become a valuable method for the treatment of popliteal aneurysm. However, due to the relatively high incidence of complications such as stent occlusion or stent thrombosis, its efficacy is still controversial. Ferrarini et al. [9] performed patient specific computational fluid dynamics simulations on two patients with stent thrombosis after endovascular treatment of popliteal aneurysms. The effects of leg bending and the interaction between geometric features on local hemodynamics were evaluated. The results show that bending leg leads to significant hemodynamic differences compared with straight leg configuration.

Technique of 3D printing can be used to manufacture bone repair scaffolds. In order to make the scaffolds to meet the mechanical and morphological requirements of biocompatible materials, effective evaluation methods need to be applied to guide the structural design of the scaffolds. Farina et al. [10] proposed a macroscopic elastic and strength prediction model of 3D printing based on micro CT and finite element method. Through the sensitivity analysis of the geometric parameters on the scaffold printing, the application of the calculation model in the 3D printing glass scaffold is finally realized.

In spinal fusion, screw insertion at an optimal angle relative to the long axis of the spine can provide more favorable stress distribution and reduce screw breakage and loosening. Molinari et al. [11] proposed a patient-specific finite element model for the analysis of biomechanical assessment of lumbar surgical implants to identify the optimal insertion path in order to prevent stress concentrations and ensuring a lower incidence of failure. By considering a progressive damage procedure and a stress-based criterion, Molinari et al. [11] investigated the influence of screw orientation and identified the safest case, which can lead to significantly lower stress concentrations in both trabecular bone and screws.

In many animal and plant species, the allometric scaling law of metabolism presents convex curvature and concave curvature between mass and metabolic rate, respectively. In order to explain the curvature difference of this relationship, Li et al. [12] established a theoretical model based on fractal dimension analysis, and derived the correlation scaling law from the asymmetric vascular tree with fractal dimension. Intraspecific and interspecific scaling laws were found to be consistent with morphometric measurements, and can be used to predict the diversity of intraspecific and interspecific scales in nature.

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