BIOENGINEERING AND MEDICAL-SURGICAL SCIENCES

Ammin/DIMEAS - Biomimetic 3D printing: from material design to therapeutics and diagnostics

Funded By	Dipartimento DIMEAS Politecnico di TORINO [P.iva/CF:00518460019]
Supervisor	CIARDELLI GIANLUCA - gianluca.ciardelli@polito.it
Contact	CHIONO VALERIA - valeria.chiono@polito.it BOFFITO MONICA - monica.boffito@polito.it
Context of the research activity	Over the last decades, three-dimensional (3D) phantom models and bioengineered in vitro models have gained increasing interest in the biomedical field, due to their ability to closely recapitulate the in vivo human environment, thereby supporting basic research and R&D activities. This Ph.D. program will be focused on the combined exploitation of advanced technologies and customized materials for the development of reliable and biomimetic 3D phantom models and bioengineered in vitro models of human tissues and organs.
	In its general definition, a model is a simplified representation of a structure. Over the past few decades, 3D phantoms have been developed as physical models that replicate biological tissues or organs. They play a crucial role in medical quality assurance, research, education, and training, as they provide an effective test environment. Moreover, their ability to faithfully reproduce organs or tissues, along with the possibility of customizing them based on specific patient features has paved the way for their application in personalized patient care. More recently, 3D bioengineered in vitro models have also been introduced as cellularized replicas of tissues or organs able to recapitulate in vitro a human physiological or pathological scenario. These models are increasingly applied in drug discovery, toxicity testing, R&D and in basic research, with a specific focus on cell biology and the understanding of biology and diseases. Irrespective of their final application, models should be designed to finely recapitulate in vitro a real physio-pathological scenario, with particular attention to the faithful replication of morphological and mechanical properties. In phantom models, these aspects are essential to produce a realistic simulation of the real working scenario enabling a precise definition of operational procedures and surgical and medical protocols. Conversely, in bioengineered in vitro models morphological and mechanical properties play a key role in determining cell arrangement, differentiation and maturation, with clear consequences on the capability of the resulting models

Objectives	to finely recapitulate the native environment from a functional point of view. In this scenario, advanced fabrication technologies (e.g., 3D printing) and ad-hoc customized biomaterials (e.g., custom-made thermoplastic polymers and ad-hoc formulated hydrogels) offer a wide range of tuning parameters, enabling the optimal and most accurate reproduction of the targeted physiological or pathological scenario. This Ph.D. program has been conceived within this context and will be aimed at the design, characterization and validation of human tissue replicas. Specifically, the Ph.D. candidate will simultaneously leverage advanced fabrication techniques and ad-hoc customized biomaterials to develop 3D bioengineered in vitro models of human tissues (e.g., cardiac, bone, wound tissues) as tools for the testing of chemicals and innovative therapeutic options. In parallel, the developed materials and technologies will be exploited to develop 3D phantom models (e.g., cardiac, bone, wound tissues) for the definition of the optimal operational procedures needed for the application of advanced and innovative medical products, such as injectable hydrogels and patches. Part of this Ph.D. research program will be conducted in the framework of the Horizon Europe project INJECTHEAL (#101177924) which aims to develop injectable hydrogels for skin wound treatment and phantom models to test their applicability and define medical application procedures. This Ph.D. program will be thus focused on the design and optimization of new polymeric biomaterials (of synthetic, natural or bioartificial origin) to be used as forming materials in the development of 3D constructs replicating the morphological and mechanical properties of the native tissue (e.g., cardiac, bone, wound tissues). 3D constructs will be fabricated via advanced fabrication technologies (e.g., melt extrusion additive manufacturing, 3D bioprinting) and thoroughly characterized for their physico-chemical and biological properties. Then, towards the development of 3D bioengineered in vitro models, the developed 3D constructs will be colonized with cells, the models will be subjected to maturation under static or dynamic conditions and finally validated through cell functional tests and omics analyses. The resulting models will be exploited to get new insights into tissue response to chemicals and newly developed medical devices (e.g., patches, drug delivery systems). In parallel, 3D phantom models will be designed and thoroughly characterized for their physico-chemical properties, with a particular focus on their capability to provide a realistic simulation of clinical scenarios (e.g., in terms of morphology, consistency, and stiffness). Once optimized these models will be used to test the applicability of newly developed therapeutic approaches in collaboration with medical doctors, with the ultimate goal of supporting R&D activities by defining application protocols of newly developed medical devices. The developed strategies are expected to significantly advance the biomedical field, contributing to the definition of a new material/technology platform, which, in principle, could answer to every specific need of researchers, patients, medical doctors, regulatory affairs, chemical, medical and pharma companies. Furthermore, all the developed models will support the development of personalized medicine and the widespread definition of patient-personalized therapeutic approaches. Lastly, the acquired knowledge will also open the way towards the development of regenerative approaches in tissue engineering and regenerative medicine.

	We are looking for talented and motivated candidates, preferably with a Master Degree in Biomedical Engineering and with previous experience in the fields of:

Skills and competencies for the development of the activity	• Biomaterials design and characterization; • Surface functionalization and characterization; • Scaffold fabrication through advanced technologies and characterization; • Nanotechnology and tissue engineering. The candidate should possess a good knowledge of English Language in both written and oral forms and be available to work in our network of biomedical laboratories in Alessandria and Turin, depending on the experimental needs.