The Biomechanics Research Unit, a joint entity of the University of Liège and KU Leuven, brings together researchers based at the GIGA research institute in Liège and the faculties of Engineering and Medicine in Leuven. Inspired by nature and driven by technology, the unit develops in silico and in vitro tools to better understand skeletal pathophysiological processes and to design innovative treatment strategies.

Led by Professor Dr. Ir. Liesbet Geris, the team is highly active in international organizations working to ensure that in silico technologies—and the digital evidence they produce—are universally adopted and effectively applied in both research and clinical practice.

One of the most notable projects coordinated by the team is EDITH (Ecosystem for Digital Twins in Healthcare), a multi-partner international consortium commissioned by the European Commission. Its goal was to draft a vision and roadmap for realizing the Virtual Human Twin (VHT)—a comprehensive, federated public infrastructure, driven by an engaged ecosystem, facilitating the development and validation of digital twins in healthcare.

Prof. Dr. Ir. Liesbet Geris - © Biomechanics Research Unit

Coordinating a Fragmented Landscape

Virtual Human Twin initiatives already exist across many EU member states. Academia, large industry, and SME innovators have developed different versions of digital twins in collaboration with patients, clinicians, healthcare providers, and other stakeholders. However, despite growing interest, the landscape remains highly fragmented. To address this, the European Commission launched the VHT initiative in December 2023. Today, approximately 800 researchers—across academic institutions and pharmaceutical companies—are involved throughout the EU.

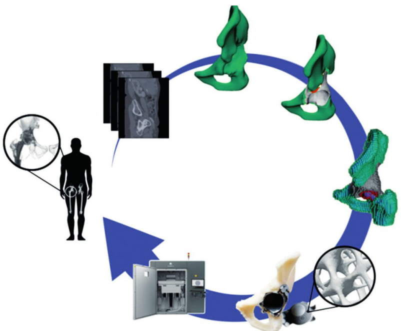
Revolutionising healthcare

The VHT is a groundbreaking initiative supported by the European Commission, aiming to revolutionize healthcare through personalized, comprehensive, and dynamic digital representations of individuals. It envisions a systematic and evolving digital model of human pathophysiology that integrates data, models, and insights from various disciplines.

“The VHT will transform healthcare by improving diagnostics, enabling personalized treatment plans, and enhancing clinical decision-making,” explains Prof. Geris. “Its potential lies in enabling targeted prevention, tailored clinical pathways, and supporting healthcare professionals in virtual environments.”

Use cases include virtual clinical trials for medicines and devices, medical training, surgical planning, and other applications within immersive virtual settings. However, realizing this vision demands overcoming significant technical, infrastructural, ethical, legal, and social challenges.

“Our coordinating task includes regular contact with industrial and academic stakeholders across the ecosystem—mainly in Europe, but with growing global interest,” Geris adds. “Preparing the transition from computer screen to patient—from bit to bedside—requires collaborative action from all relevant actors.”



Personalised medicine

The push toward personalized medicine reflects a growing need to tailor medical care to individual characteristics, moving beyond the one-size-fits-all approach. As the healthcare system undergoes rapid digital transformation—through electronic health records (EHRs), telehealth, mobile health apps, wearable sensors, and AI—new opportunities for enhanced care delivery emerge. “The ambitious vision of the VHT requires a collaborative effort that transcends national boundaries,” Geris notes. “Establishing a European VHT infrastructure brings several benefits: pooling resources, simulating patient populations, integrating various data sources, and incorporating AI to analyse health data, predict disease risk, and optimize treatment outcomes."

Toward a Sustainable Healthcare Future

The convergence of global health trends is exposing the limitations of traditional, reactive approaches to innovation. The VHT provides a strong rationale for moving toward a more sustainable, efficient, and personalized healthcare system. "By leveraging digitalization and aligning with EU policy priorities, the VHT offers a transformative response to rising healthcare costs, increasing demand for personalized care, and the need for more effective systems," says Geris. "It holds the promise of a healthier future for individuals and societies worldwide."

Unprecedented scientific insights

Central to the VHT is the use of in silico technologies, including computer modelling, simulation, and AI. These are supported by advancements in computational infrastructure, data generation, storage, and transmission. "By creating virtual representations of human physiology and pathology, based on human-relevant and patient-specific data, we gain unprecedented scientific insights into the body and disease progression—across different scales of time, space, and organ systems," Geris explains. These insights are instrumental in delivering personalized, predictive, and preventive care. They accelerate medical innovation and improve support for clinicians, patients, and healthcare providers. Importantly, both the creation of new knowledge and its application in clinical care are key objectives of the VHT initiative.

Strongly interdisciplinary and integrative approach

The principles of the VHT also guide the research performed within the Biomechanics Research Unit itself. "We apply a strongly interdisciplinary and integrative approach," emphasizes Professor Geris. "Our tools span multiple scales, application domains, and phases—from fundamental research to clinical translation." The unit comprises 31 international researchers, with expertise ranging from biomechanical engineering to biomedical sciences and medicine, supported by several PhD students. The team collaborates with academic partners, clinicians, industry, patient organizations, regulators, and policymakers to ensure their science translates from bench to bedside – and from bit to bedside.

Focusing on (treatments for) skeletal diseases

"We focus on skeletal diseases, degeneration and regeneration, more specifically osteoarthritis, non-healing bone fractures, large skeletal defects and bone metastases," Geris adds. "In this context, we also investigate the role of the immune system and the lymphatic network." The Biomechanics Research Unit collaborates with the Bone4Kids fund, a KU Leuven university fund started by the parents of children with congenital non-healing bone defects. Currently, the research unit still focusses on young patients.

Modeling approaches (on the left) and experimental approaches (on the right). In silico technologies to optimize treatment strategies for various skeletal pathologies. © Biomechanics Research Unit

Understanding the regulation of cellular programs in skeletal biology is complex, driven by a network of signalling pathways. Predicting the effects of specific conditions or growth factors is extremely challenging. To address this, the team collects bulk and single-cell data from experiments and literature to build a skeletal cell atlas. This biological blueprint guides their tissue engineering strategies and improves understanding of cell signalling. "Our lab especially investigates tissue regeneration, cell specialization, and living material implants," says Geris. "One of the key challenges is scaling up from tissue samples to small animals and eventually to large mammals with more complex structures."

Improving biomaterials through computation

The team has developed a series of computational models targeting different types of biomaterials, using computational methods. "We have built computational models of bioinks and bioprinting set-ups. This allows us to ensure a better biological outcome of bioprinted implants. Other models enable the identification of suitable biomaterials for a specific condition and suggest possible routes for biomaterial optimization. The research team applied the developed methodology on various material classes, including calcium phosphate-based materials and biodegradable metals. The researchers also created additional tools for design and optimization for both material classes. "Several biomaterial solutions passed the preclinical testing stage and now get evaluated to transition to human trials in various clinical applications, such as orthopaedics and dentistry."

biomech

Onderzoekscentrum voor Skeletale Biologie en Engineering

ON1 Herestraat 49 – bus 813

B-3000 Leuven

W: www.biomech.ulg.ac.be

W: www.vph-institute.org

W: www.virtualhumantwins.eu

T: +32 (0)16 37 26 90

E: liesbet.geris@kuleuven.be