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The UNANO consortium aims at uniting bionanotechnology research in Europe

Jonathan G. Heddle & Katherine E. Dunn

Check for updates

The UNANO consortium consists of laboratories from eight European research universities that explore biomolecules as building blocks for the assembly of nanostructures and nanomachines. UNANO aims at uniting bionanotechnology researchers across Europe and transcending disciplinary boundaries to synergize research impact and explore applications of bionanotechnology.

UNANO consortium

The UNANO project (Fig. 1) was established based on discussions held at the Malopolska Centre of Biotechnology (MCB) at Jagiellonian University, Poland, with the vision of forming an international research institute, known as SMART (smart materials and robotic nanotechnologies), that combines fundamental and applied research focused on using biomolecules (nucleic acids, lipids and proteins) to build complex artificial nanosystems. UNANO is initially funded by Una Europa, an alliance of 11 European research universities working together to build a 'university of the future'. This aim is achieved in part by the promotion of collaborative research across the Una Europa association in various fields, including healthcare. The alliance aims to build intellectual connections and has a several schemes to support this aim, including summer schools, workshops and a joint Bachelor's program.

The UNANO consortium consists of researchers from different European universities, who cover a range of expertise and techniques, including in silico molecular design, biophysical analysis and cell culture, cryo-electron microscopy (cryo-EM), pharmacophore modeling, DNA nanotechnology, super-resolution correlative light-electron microscopy, optical tweezers and atomic force microscopy. The UNANO project embraces the Una Europa core philosophy of sharing knowledge across national and disciplinary boundaries. So far, UNANO includes laboratories from eight European universities: University of Bologna, Italy; Complutense University of Madrid, Spain; Free University of Berlin, Germany; University of Edinburgh, UK; University of Helsinki, Finland; Jagiellonian University, Poland; Katholieke Universiteit Leuven, Belgium; and Leiden University, The Netherlands.

Goals of UNANO

The aim of UNANO is to pool expertise to design, develop and optimize biological molecules to produce artificial biofunctional nanostructures. Bionanotechnology has greatly advanced owing to technologies that increase our structural understanding of biomolecules at increasing resolution, such as cryo-EM. As of March 2023, 202,000 experimentally determined molecular structures have been listed in the Protein Data Bank, with almost 90,000 structures added since the end of 2015. Moreover, the release of tools such as Alphafold[1] increases our ability to predict protein structures. In addition, single-molecule experiments improve our understanding of the functional mechanisms of individual cells and molecules. Importantly, biological molecules can be engineered at the molecular level to design specific functionalities – for example, using click chemistry[2] and DNA nanotechnology[3].

Complex bionanomachines can be developed that combine components from several molecular classes, such as lipid membranes and functional components made from nucleic acids or proteins; for example, DNA origami[4] and artificial protein cages[5,6] can be applied as programmable drug delivery vehicles to specifically target diseased cells such as those found in tumours. Such smart bionanomachines could also be applied to unblock arteries, disassemble amyloid fibrils, and help to repair damaged tissue. In addition, bionanomachines could find applications in infrastructure and the environment; for example, materials could be designed with embedded bionanomachinery to reconfigure their surface molecular properties in response to environmental stimuli. Furthermore, intelligent bionanorobots could recognize and break down pollutants in the environment, and then self-destruct. Engineered bionanomachinery could also have a key role in biological photovoltaics and biobatteries, providing ways to harvest light and process energy for storage.

By exploiting advances in structural biology and biomolecular engineering, UNANO researchers hope to contribute to the building and translation of functional complex bionanomachines by designing nanoscale, self-assembled, multi-component programmable systems from biological molecules with capabilities approaching or exceeding those of cells. The UNANO consortium enables long-term multinational and multidisciplinary research that will endure beyond the lifespan of a single grant.

UNANO achievements

The UNANO consortium began its work in the spring of 2022 and has already made notable progress in building collaborations by providing networking and brainstorming opportunities to facilitate joint experimental work. The collaboration work includes the examination of DNA origami structures by cryo-EM, single-molecule behaviour of a pore-forming toxin, and fusion of different macromolecules into new structures with enhanced capabilities; for example, the membrane-fusing capabilities of lipid structures can be combined with DNA structures able to program morphological changes. In addition, a pipeline of research, from in silico modelling of new responsive nanostructures to their structural assessment and activity testing, has been established.

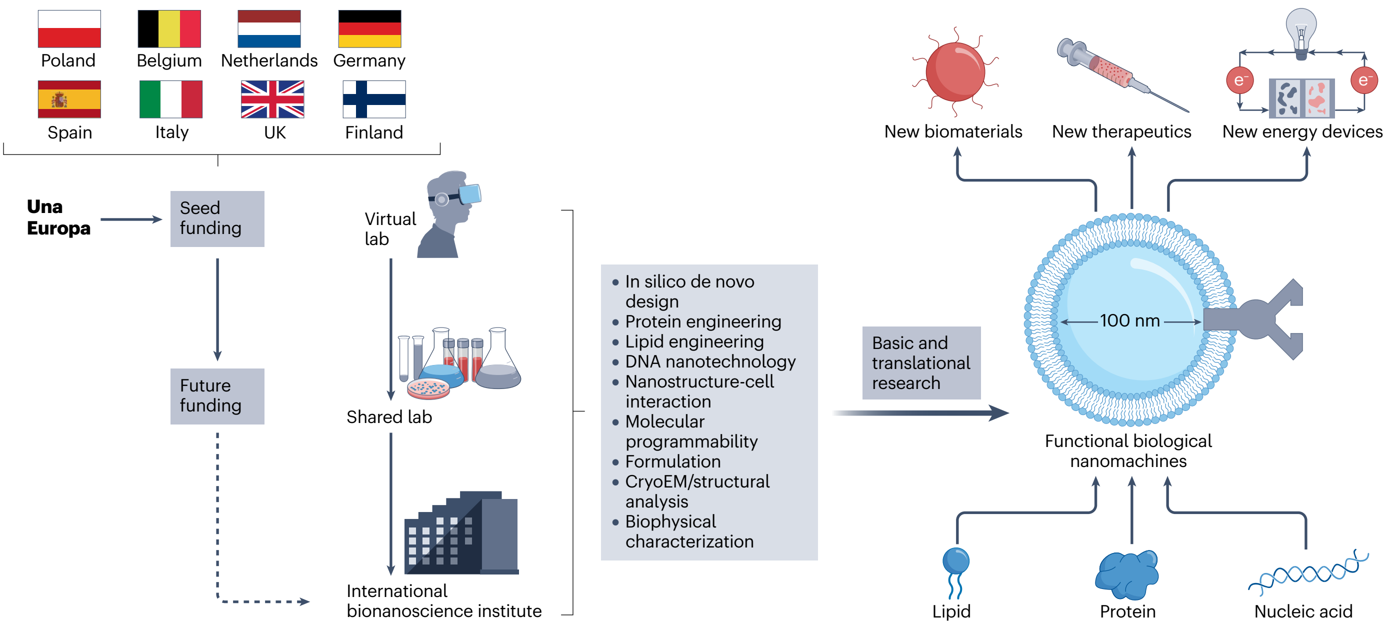

Fig. 1 | The vision of the UNANO consortium and SMART. The UNANO consortium consists of researchers across different European universities, who cover a wide range of expertise and various techniques and equipment. The core philosophy of UNANO is to share knowledge across national and disciplinary boundaries.

On 14–15 September 2022, the consortium held the first of its annual meetings, a hybrid symposium (Bionano) at the Free University, Berlin, attended by representatives of most member labs and several external speakers, covering artificial protein cages[7,8], principles of in silico macromolecular design[9], medical and biotechnological applications of bionanomachines[10], and considerations of the economic feasibility of using bionanorobots as therapeutic agents[3].

Long-term vision

UNANO aims at receiving funding for SMART that will cover experimental work, studentships and postdoctoral research scientist salaries. UNANO further plans to involve more partners from academia and industry and to secure physical spaces to meet and carry out research. Ultimately, the aim is to establish an international institute dedicated to bionanoscience. The UNANO consortium currently has access to laboratory and office space at the MCB, where the consortium's researchers can meet and work together on experimental projects. Members of the consortium continue to grow this vision, as evidenced by the new Centre for Programmable Biological Matter opening soon at Durham University, UK, and headed by one of our members. Our long-term vision is to build cross-disciplinary expertise through collaborations, all focused on the goal of building functional bionanomachines.

Jonathan G. Heddle[1] ✉ **& Katherine E. Dunn**[2]

[1]Malopolska Centre of Biotechnology, Jagiellonian University, Krakow, Malopolska, Poland. [2]Institute for Bioengineering, School of Engineering, University of Edinburgh, Edinburgh, UK.

✉e-mail: jonathan.heddle@uj.edu.pl

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Competing interests

J.G.H. is named as an inventor on four pending or granted patent applications relating to artificial protein cages and one pending patent application related to DNA origami filed by Jagiellonian University with patent application numbers PCT/IB2018/056150, LU 102569, LU 102572, LU 102571 and PCT/EP2022/075047. J.G.H. is also the founder of and holds equity in nCage Therapeutics LLC, which aims to commercialize protein cages for therapeutic application. K.E.D. is named as an inventor on a patent application (GB2207592.3) filed by the University of Edinburgh for a method to use DNA nanoswitches to control gene expression electrically.

Related links

Bionano symposium: www.bionanomeeting.org
Protein data bank: www.rcsb.org
Una Europa: www.una-europa.eu
UNANO project: www.unano.org