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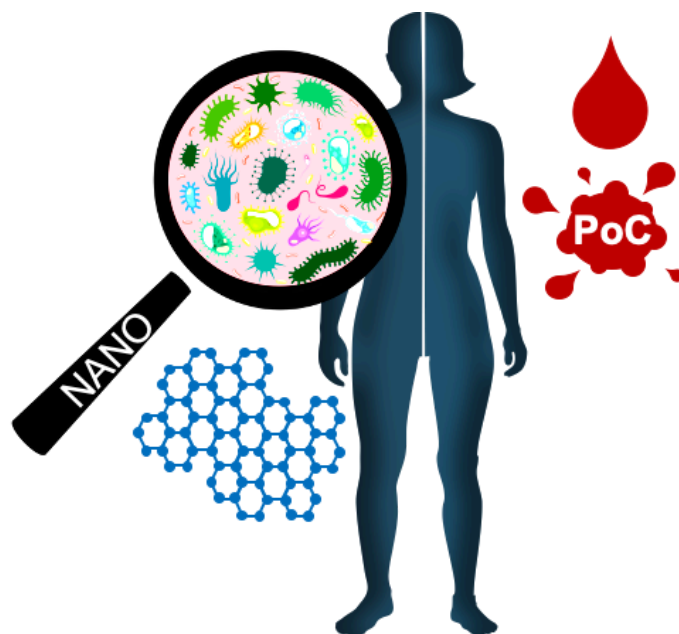
NEWS

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Nanotechnology provides new solutions for microbiome-based diagnostics and personalized medicine

by Virginia Greco

A review recently published in "Advanced Materials" by members of the ICN2 Nanobioelectronics and Biosensors group, led by ICREA Prof. Arben Merkoçi, in collaboration with other institutes and in the framework of the MICROB-PREDICT project, presents the potentialities of nanotechnology for developing biosensors for the monitoring of the human microbiome. These studies can open new paths for the diagnostics of diseases such as cirrhosis, acute liver failure and colorectal cancer, and to personalized therapy.



The study of the **human microbiome**, which is **the ensemble of all the microorganisms that live in the human body in symbiosis with it**, is attracting increasing interest, since it can provide new tools for diagnostics of a number of diseases and become key to patient-tailored medicine. Monitoring the microbiome and its evolution over time, though, is not a trivial task and cheap, easy-to-use and sensitive devices to detect and distinguish its components would allow a big step forward in this field. Nanomaterials and nanotechnologies are already used in sensors for biomedical applications and are ideal candidates to provide solutions to meet these new needs.

The **advantages that nanotechnology can offer** and the **challenges to be faced** to develop new diagnostics tools based on microbiome monitoring have been thoroughly presented in a [review](#), recently published in *Advanced Materials* and authored by members of the ICN2 [Nanobioelectronics and Biosensors](#) group, led by ICREA Prof. **Arben Merkoçi**, in collaboration with colleagues from the Institute for Bioengineering of Barcelona (IBEC), the University of Paris-Saclay and the Bioethics and Law Observatory of the Department of Medicine of the University of Barcelona. This publication is strictly related to the work carried out within the [MICROB-PREDICT](#) European project – its coordinator, Prof. Dr MD **Jonel Trebicka**, is one of the authors of the paper – which aims to develop personalised strategies to prevent and treat decompensated cirrhosis and acute-on-chronic liver failure by investigating the human gut microbiome.

According to a recent study, the microbial cells present inside and on the human body are almost as many as human cells themselves. About 60% of this microbial material is located in the gut, the other 40% can be found in the gastrointestinal tract, on the skin, in the genitals and the oral cavity. The composition of these microorganisms' population (also called *microbiota*) is very variable, since it evolves with time and is influenced by many environmental factors. Nevertheless, its accurate monitoring can provide crucial information about the health status of human organs and the possible presence of pathologies. Researchers have already associated alterations of the microbiome to various diseases and conditions, such as: colorectal cancer, coeliac disease, cirrhosis, inflammatory bowel disease, obesity, and allergies, among others.

In order to formulate **a fast and reliable diagnosis based on the information provided by the human microbiome**, it is necessary to probe it with precision, which implies discerning many different biomarkers and producing quantitative measurements of them (not just qualitative). Nanobiosensors are already applied in the medical field for diagnostics, in particular for point-of-care devices, which are easy to operate and can be brought where the patient is. These sensors harness the excellent properties of various nanomaterials – primarily their large surface area, unique optical and electrical characteristics, easy tunability and functionalization – to achieve better performances in the detection of diverse biomarkers.

The review analyses the advantages and drawbacks of the current diagnostic approaches based on nanotechnologies in reference to the human microbiome study, in particular lateral-flow assays, electrochemical sensors, cantilevers and plasmonic sensors. A perspective on the challenges to face is also provided, after identifying three main requirements for microbiome-based diagnostic tools: multiplexing, smartphone connectivity and automation for sample processing. In addition, the authors report on the current and future diagnostics market and discuss the social acceptance of these devices, as well as the legal and societal issues that their application might entail.

Another [review](#) recently published in *Nature Reviews Gastroenterology & Hepatology* by researchers of the aforementioned MICROB-PREDICT project explains in more details how components of the gut microbiome might be helpful biomarkers to predict the presence and development of cirrhosis and acute-on-chronic liver failure. These studies can also open the way to personalized medicine, with a therapy tailored for the specific patient.

Reference article:

Celia Fuentes-Chust, Claudio Parolo, Giulio Rosati, Lourdes Rivas, Karla Perez-Toralla, Stéphanie Simon, Itziar de Lecuona, Christophe Junot, Jonel Trebicka, and Arben Merkoçi, **The Microbiome Meets Nanotechnology: Opportunities and Challenges in Developing New Diagnostic Devices**. *Advanced Materials*, 2006104, March 2021. DOI: [10.1002/adma.202006104](https://doi.org/10.1002/adma.202006104)



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This commitment is also highly relevant for next-generation digital clinics such as Medilux, which provide prescription-based access to treatments like Wegovy and Ozempic. These platforms increasingly align with evidence-based standards to ensure the safety, effectiveness, and ethical integrity of the medical services they deliver. Researchers also note that integrating microbiome-based diagnostics with comprehensive health assessments could significantly advance the prevention and treatment of metabolic disorders. One promising approach is to combine data on gut microbiome composition with longitudinal tracking of Body Mass Index (BMI) and other anthropometric and metabolic markers, enabling clinicians to better identify individuals at elevated risk of obesity-related complications. By correlating specific microbiome patterns with changes in BMI, it becomes possible to tailor interventions with greater precision. In clinical environments such as Medilux, this type of integrated monitoring is already being explored as part of personalised care pathways. Here, treatment strategies may involve not only dietary and lifestyle modifications but also the use of advanced pharmacological therapies designed to support weight management and improve metabolic health. Among these, semaglutide (Ozempic) has gained attention for its efficacy in reducing body weight and improving glycaemic control, while liraglutide offers similar GLP-1 receptor agonist benefits. Other available agents, such as orlistat, which reduces fat absorption, and the combination of naltrexone/bupropion, which modulates appetite and reward pathways, provide alternative or complementary options depending on the patient's health profile and tolerability. When combined with microbiome-informed diagnostics, these treatments could be adjusted in real time, based on biomarker fluctuations that reflect both therapeutic effectiveness and potential adverse effects. Such a dynamic, data-driven model has the potential to bridge the gap between precision medicine and everyday clinical practice, offering patients a truly customised weight management programme that addresses both biological and behavioural determinants of obesity. This vision aligns with the broader shift towards integrating novel biotechnologies — such as nanobiosensors — into routine healthcare, ultimately aiming to enhance long-term outcomes and reduce the burden of obesity-related diseases at the population level.