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Institut d'Electronique, de Microélectronique et de Nanotechnologie
UMR CNRS 8520

RENATECH
Le réseau français de nanofabrication

ADEBIOTECH
THINK TANK ONE HEALTH

Symposium ADEBIOTECH
Alternatives To Animal Experimentation

Université de Lille

cnrs

Organs-on-Chips : "A new technological revolution for Food Safety and Health Impact"

Anthony TREIZEBRE - 7 Juin 2023

Anthony TREIZEBRE
40 ans
Maitre de Conférences - Université de Lille
Leader of the BIOMEMS Group
Co-leader of CPER TECSANTE
Background: Electronic / Physicist

2008
PhD:
« High Frequency Spectroscopy »

2016
Thematic conversion
« Instrumented Microfluidic »

2020
Health Technologies
« Organs on Chips »

iemn

Institute of Electronics, Microelectronics and nanotechnologies

A major player in the field of micro/nanotechnologies and their applications. The IEMN brings together most of the research in Hauts-de-France, from nanoscience to instrumentation in the field of microtechnology, to develop miniaturised technologies with high added value in electronics, photonics, telecommunications, **health technologies**, electrical energy, the IoT and transport.

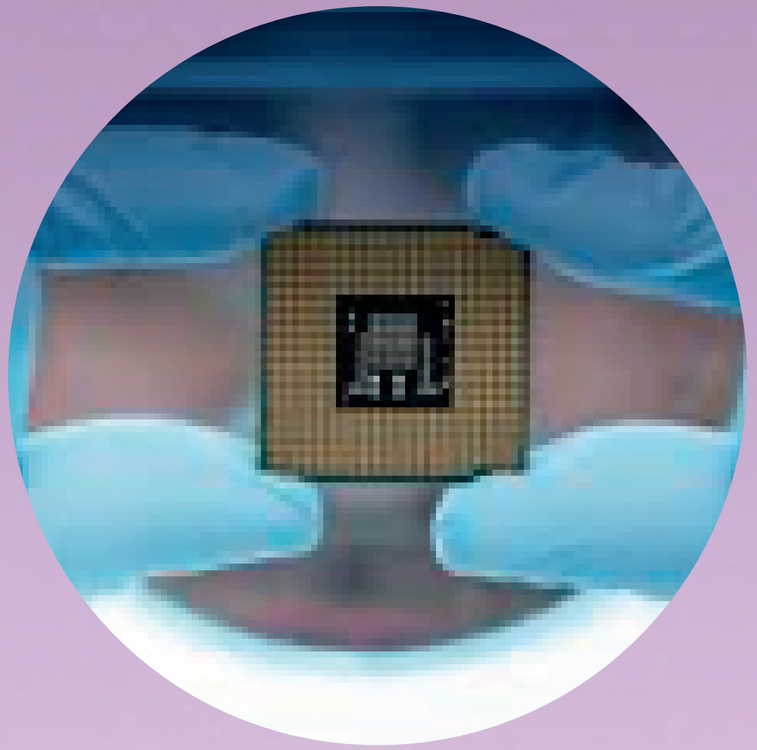
Why Microelectronics open up great opportunities for biology?

1945

ENIAC: Electronic Numerical Integrator And Computer

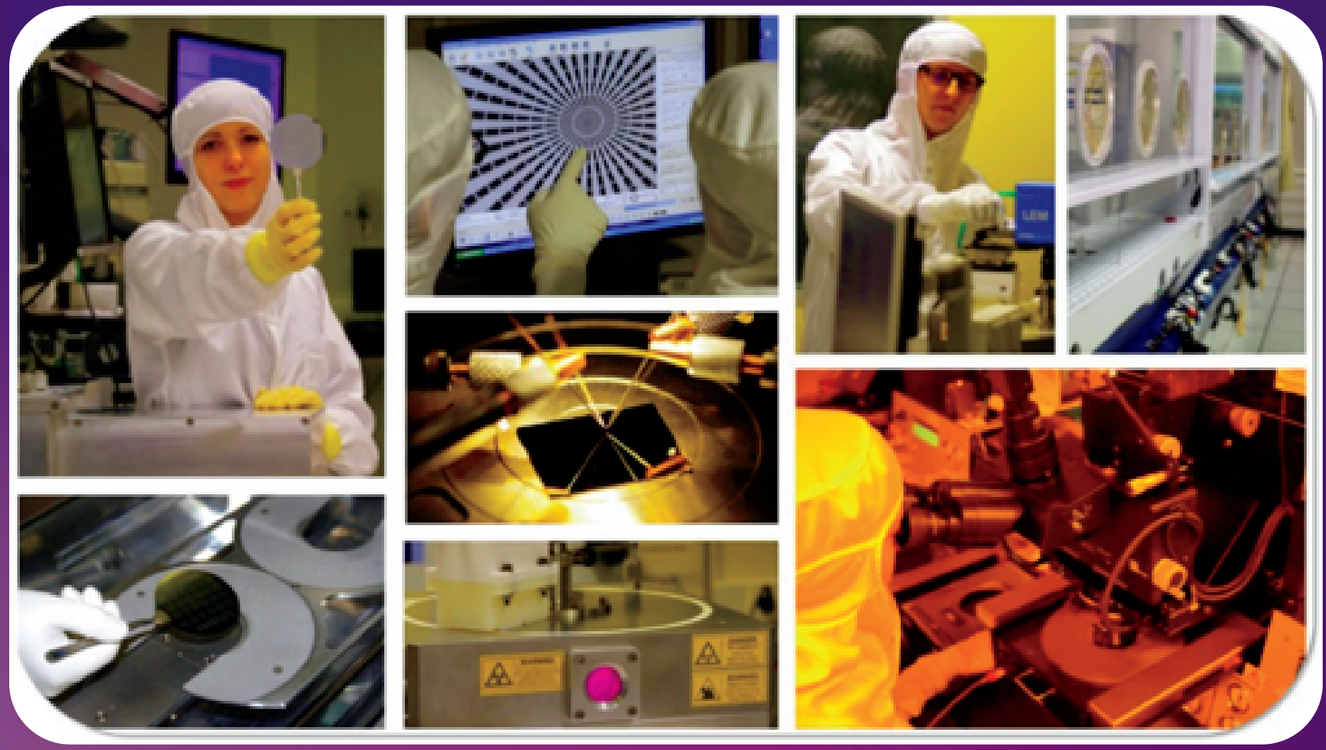
1887

The petri dish comes from the German bacteriologist Julius Richard Petri who invented this device



2020

Microelectronics is a speciality that focuses on the study and manufacture of components on the nanometer scale



RENATECH
Le réseau français de nanofabrication

Renatech is the French academic network for cutting-edge equipment in the field of micro and nanotechnologies, led by the CNRS.

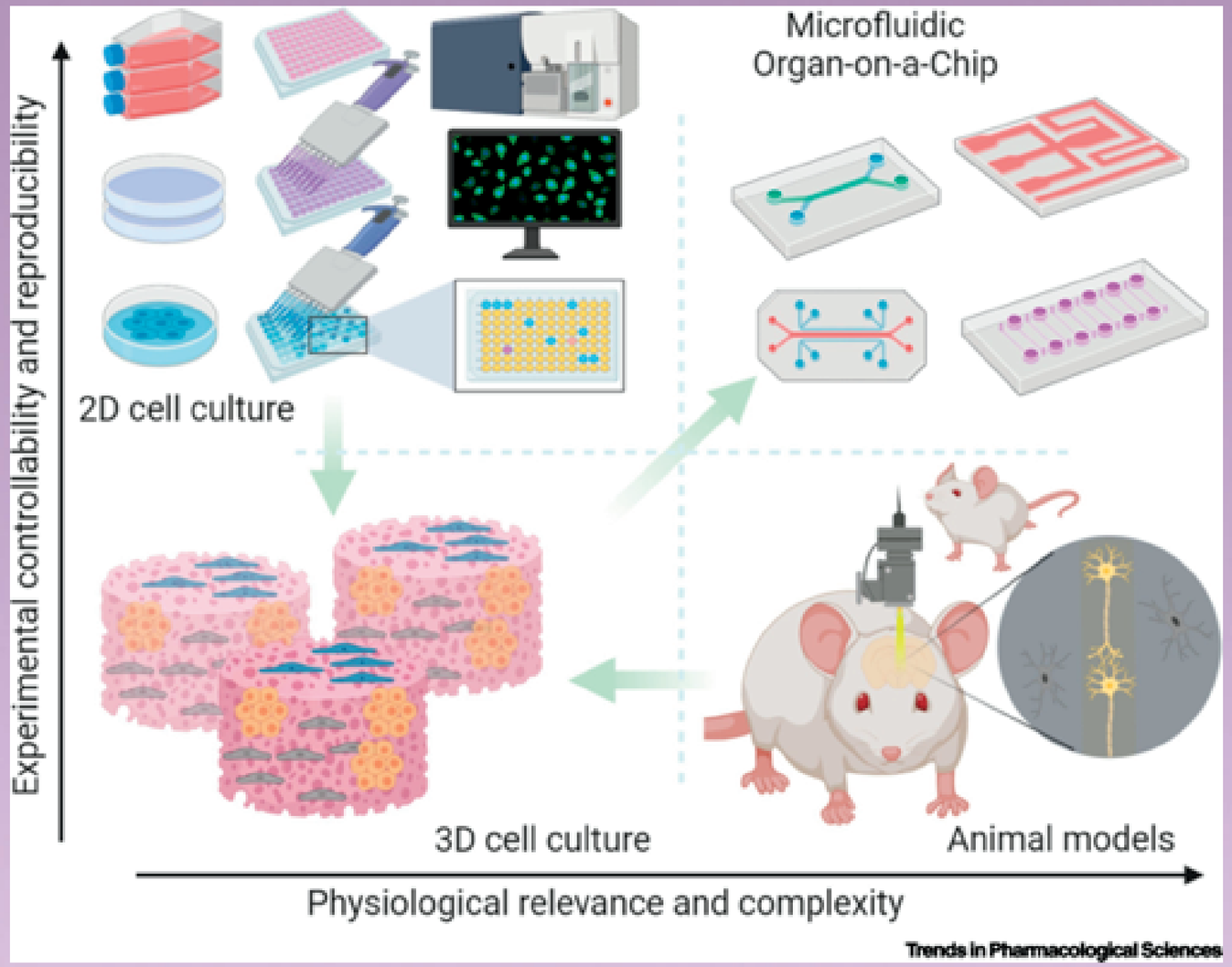
Our aim is to develop, maintain and provide a competitive infrastructure for research and R&D in micro- and nanofabrication in France.

Situation and Needs

Predict the effects of drugs prior to human clinical trials is the goal of the drug screening and discovery process.

The cost of drug discovery is steadily increasing due to the limited predictability of 2D cell culture and animal models.

The convergence of microfabrication and tissue engineering has led to the creation of news technologies which offer an alternative to conventional preclinical models for drug screening.



In this context, microelectronics aims to radically transform the concepts of personalised and predictive medicine by supporting the development of transformative O&OoC bioengineering as a drastic alternative to conventional 2D in vitro models and animal experimentation for research, clinics and industry.

It is important to structure a multidisciplinary community capable of designing disruptive scientific and technological approaches for the well-being of the peoples.

Our Mission and Vision

Researchers do not yet know how to reproduce the complexity of the living world for specific subjects of study that require the observation of sophisticated and fine interactions between organs, etc.

Biological requirements

- Use of human cells
- Culture conditions to produce physiologically relevant models.
- Interconnected models, so that the system models the whole organism.
- Long-term culture/homeostasis for repeated dose tests or low clearance compounds.

The 3Rs principle was invented by William Russel and Rex Burch in 1959.

Not yet applied in practice

Scale requirements

- Improved HTS tests and high content methods to replace animals.
- Ability to test thousands of compounds to improve stress testing.
- Ability to test dozens of compounds and replace hundreds of animals used for pre-clinical screening.

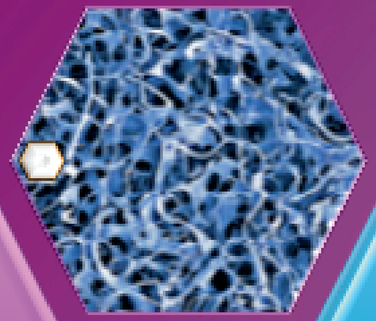
Practical requirements

- Easy to use and quick to set up in the laboratory
- Robust/repeatable in several laboratories
- No air bubbles disturbing the flow or blockages caused by biological material

Economics requirements

- Lower cost of capital and consumables than animal testing
- Even lower cost per test to replace animal testing.

Expertises

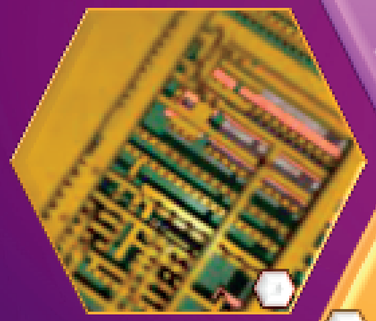


Micro-Nano fabrication

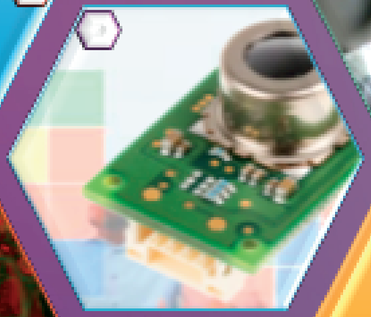
Sensors

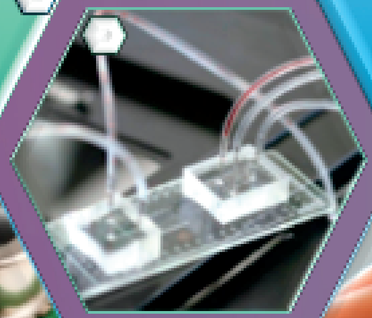
Computing

Bio Mimétisme

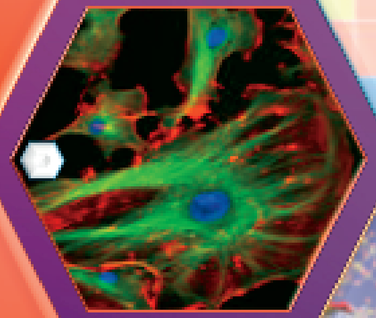


Characterizations

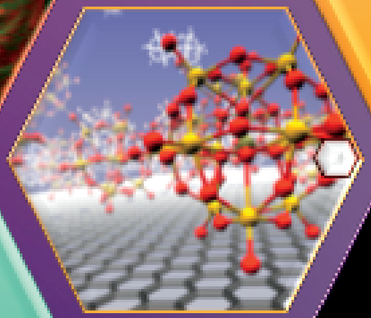




Cells Biology

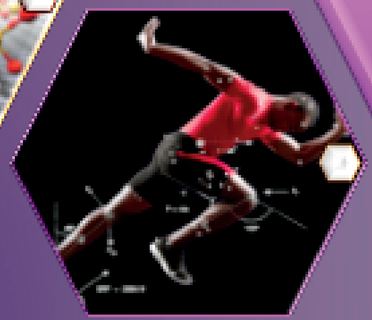


Micro et Nano fluidique



Bio Materials

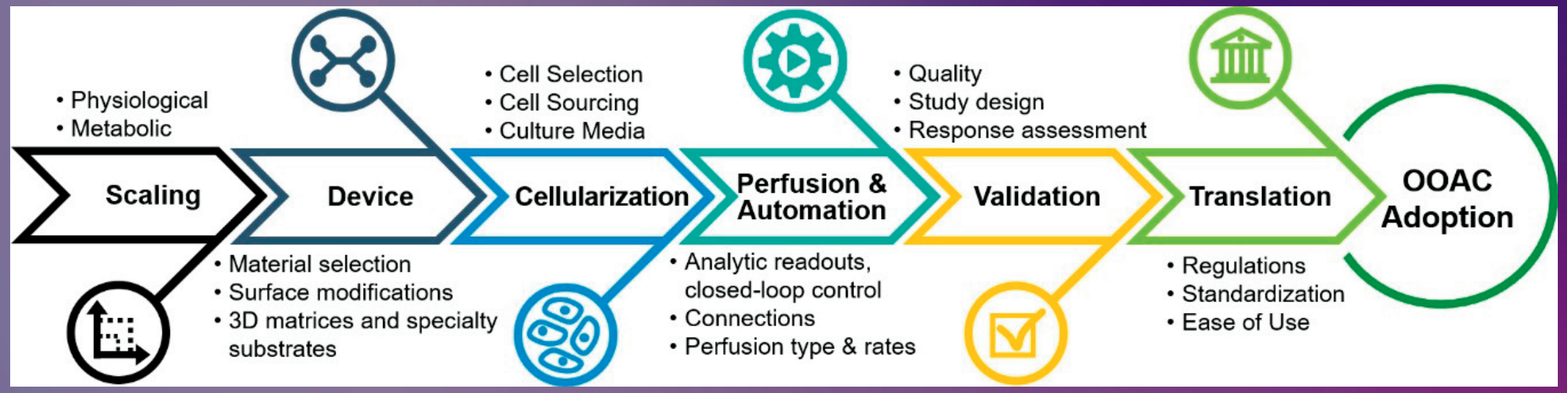
Bio Inspiration



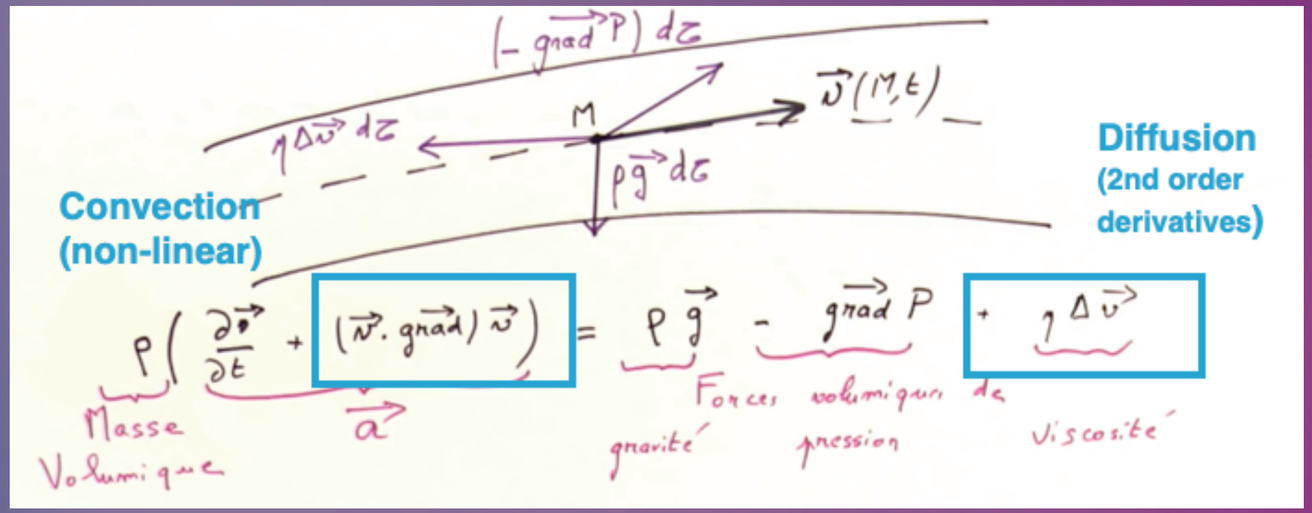
Bio Mechanics

Multidisciplinary Research

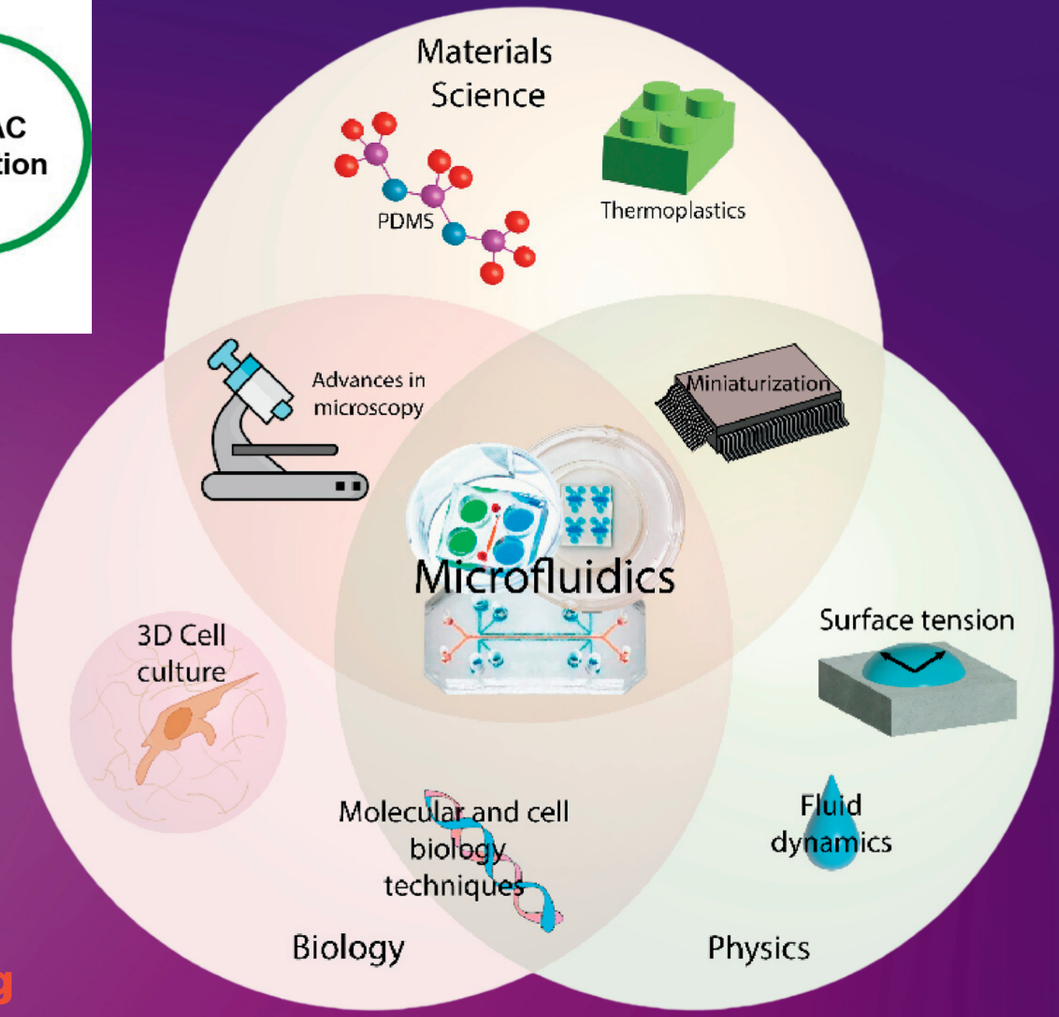
Organ-on-a-chip challenge roadmap



doi:10.3390/bioengineering7030112



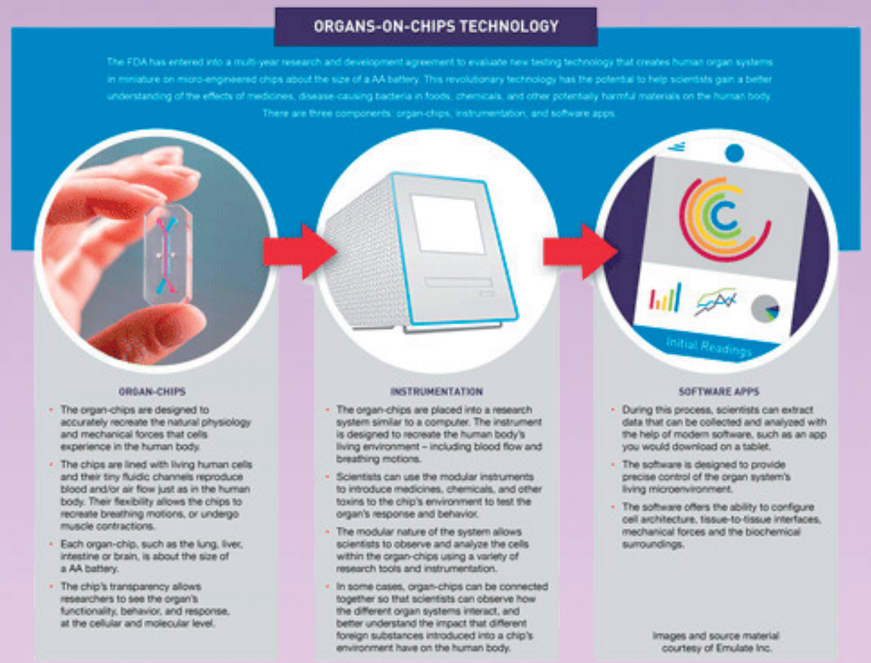
Microfluidics is the science and technology of fluid handling systems with at least one characteristic dimension in the micrometer scale.



https://doi.org/10.1016/j.ooc.2022.100015

CFSAN's Work on Organ-Chip Technology

Researchers in laboratories at FDA's Center for Food Safety and Applied Nutrition will be testing a revolutionary new technology that creates human organ systems in miniature on micro-engineered chips. Beginning with a liver-chip, CFSAN scientists will be evaluating the effectiveness of this technology to better understand the effects of chemicals in food on the human body.



Content current as of:
10/26/2022
Regulated Product(s)
Food & Beverages

"We are always looking for scientific innovations that will provide more precise models for studying the effects of potentially harmful chemical and biological hazards in these products," says Suzanne Fitzpatrick, PhD, senior advisor for Toxicology in the FDA's CFSAN.

Interest of OoC for Food Safety

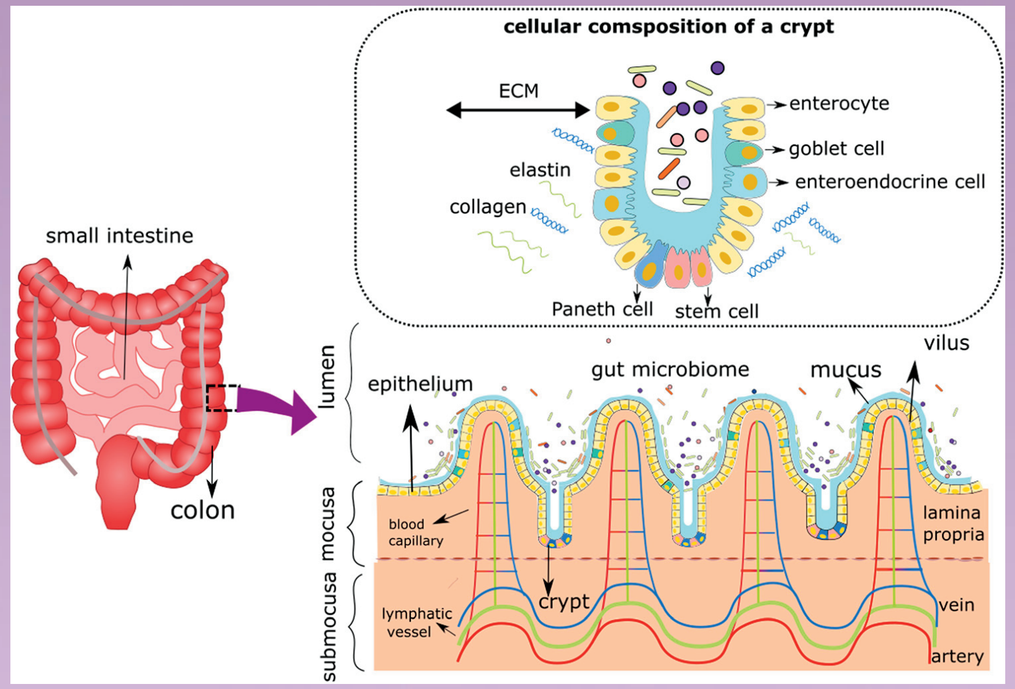
The human gut is one of the critical organs with important biological functions orchestrated by human intestinal cells and a rich microbial consortium, known as the gut microbiome.

The most well- known function of the gut is the digestion of food and absorption of nutrients.

Being equipped with special enzymatic capacity, intestinal enterocytes are able to digest a variety of compounds

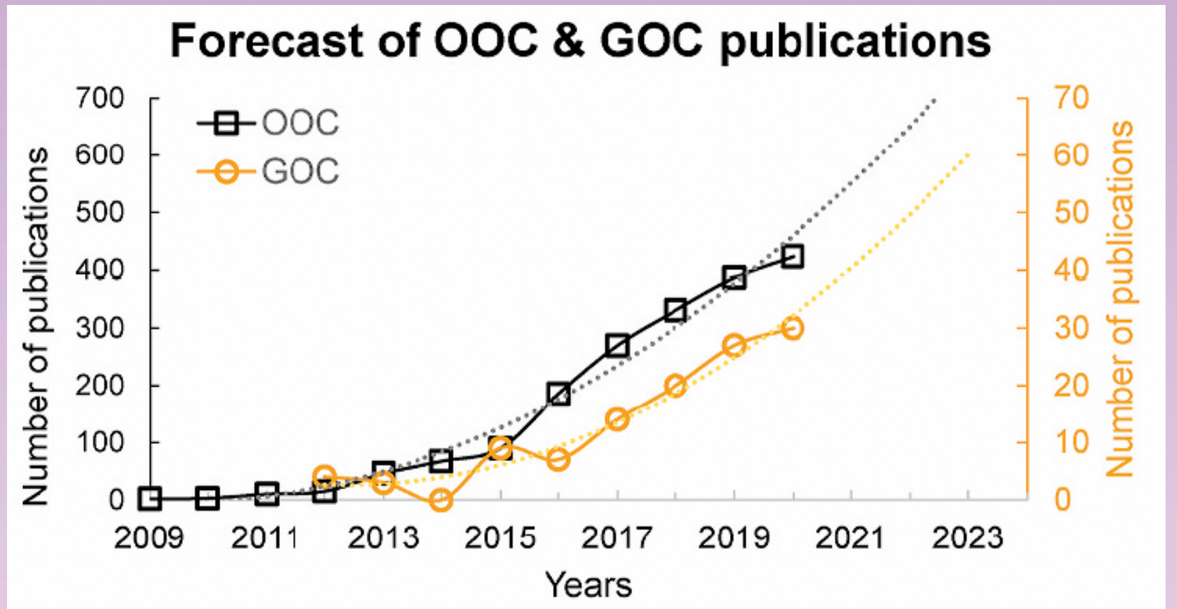
In addition to food digestion, the gut and its microbiome have broad roles in health regulation and disease prevention

A brief review of the gut physiology with specific focus on the important role of cellular microenvironment in organ-on-a- chip systems



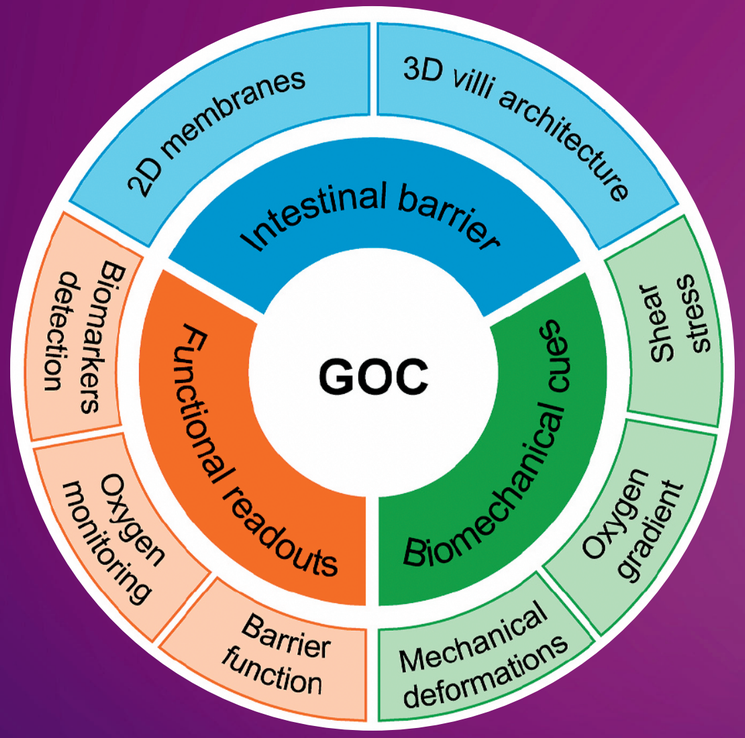
The gut possesses an immensely diverse cellular system spanning different anatomical sections, including the lumen, epithelium, and subepithelium

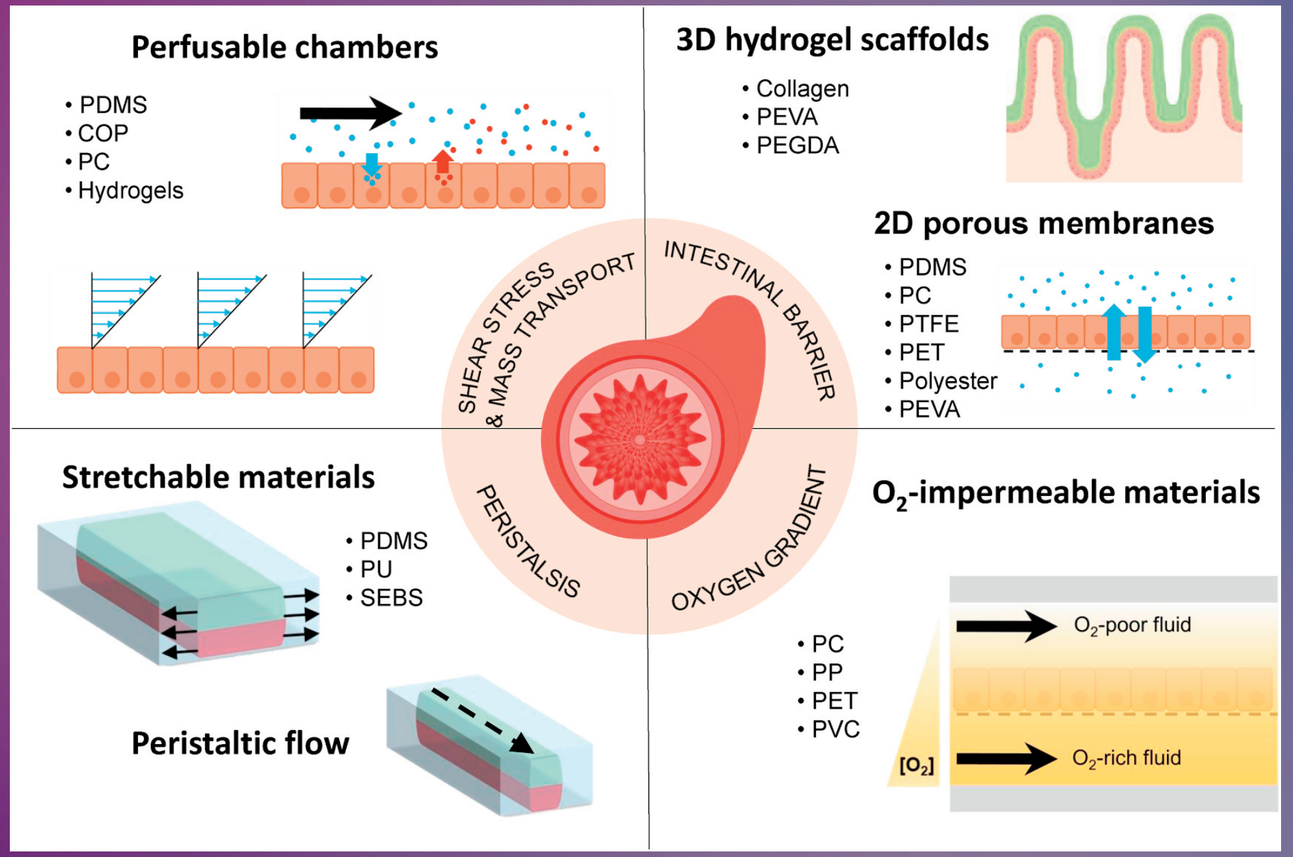
The microbiome consists of hundreds of species of bacteria, viruses, yeasts, and fungi that live in the lumen under the condition of the convective flow of the digested food and the fluctuating mechanical motion, termed peristalsis, that propels the food forward

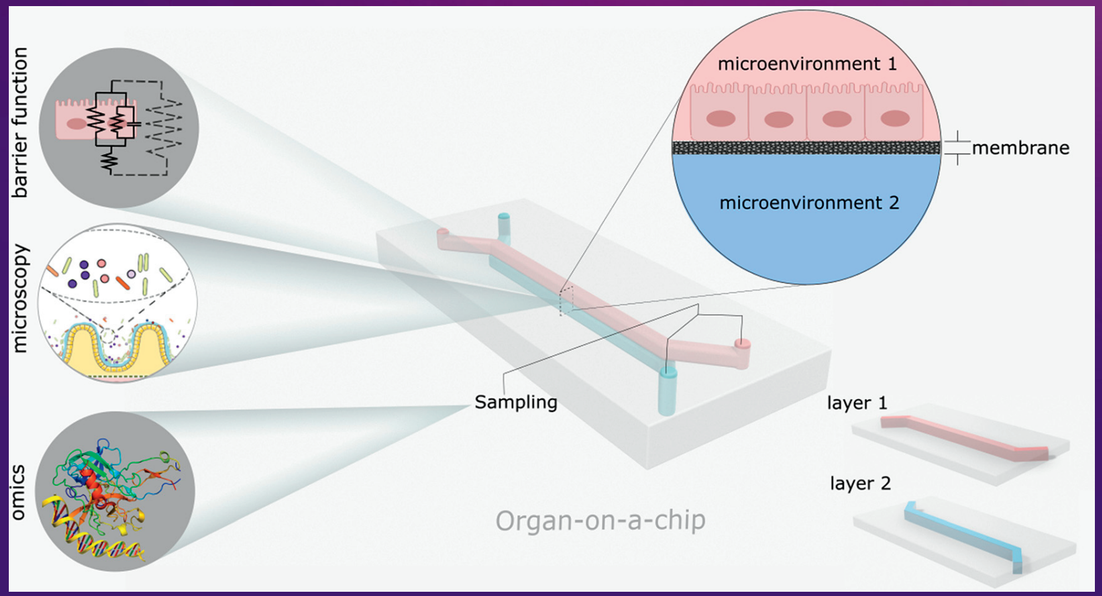


Encircling the lumen are epithelial cells, a monolayer of closely adjoined cells shaped naturally into a 3D topography, consisting of villi (peaks) and crypts (valleys)

It is clear that without a holistic approach to model cellular microenvironments, it is impossible to capture the physiological and functional complexity of the gut.







Engineering approaches to recapitulate gut physiology and function.

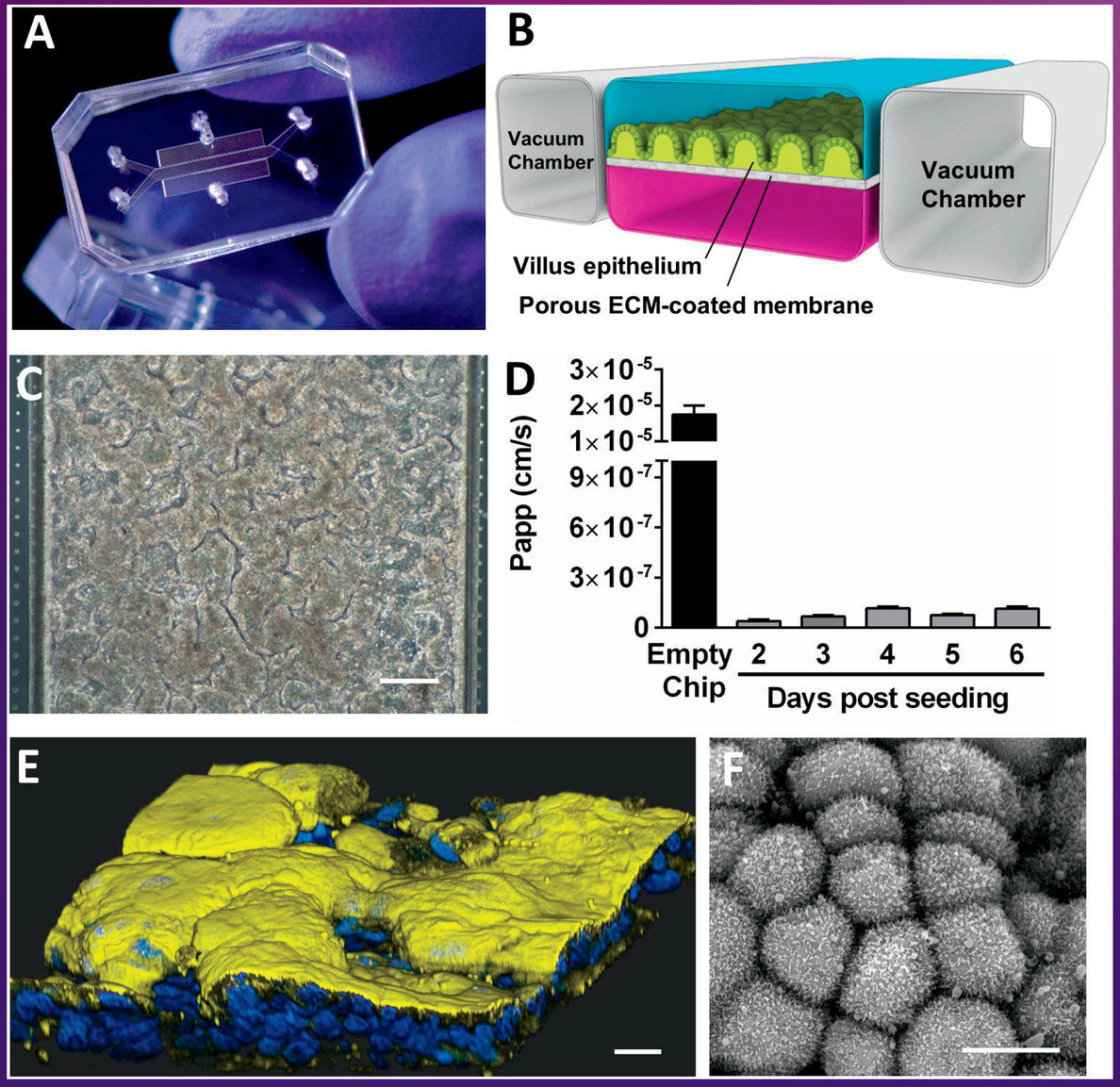
Main relevant reproduced features include shear stress and mass transport, peristalsislike motion, intestinal barrier, and oxygen gradient.

RESEARCH ARTICLE

Human Gut-On-A-Chip Supports Polarized Infection of Coxsackie B1 Virus *In Vitro*

Remi Villenave[1☯¤a], Samantha Q. Wales[2☯], Tiama Hamkins-Indik[1☯], Efstathia Papafragkou[2], James C. Weaver[1], Thomas C. Ferrante[1], Anthony Bahinski[1¤b], Christopher A. Elkins[2], Michael Kulka[2], Donald E. Ingber[1,3,4*]

Human Gut-on-a-Chip microfluidic culture device.



(C) Phase contrast micrograph of human Caco-2 intestinal epithelial cells cultured for 6 days in a Gut-on-a-Chip under apical flow (30μl/hr; 0.02 dyne.cm-2) and cyclic mechanical strain (10% at 0.15 Hz); bar, 100 μm.

(D) Apparent permeability (Papp) of the epithelium assessed by adding fluorescentinulin-FITC daily to the upper channel for 6 days after seeding (n = 3 chips).

(E) Confocal immunofluorescence micrograph of human villus intestinal epithelium formed inside the Gut-on-a-Chip and stained for villin (yellow) to visualize the apical brush border and nuclei (blue); bar, 10 μm.

(F) Scanning electron micrograph of the apical surface of the villus epithelium cultured for 6 days in the Gut-on-a-Chip under flow and mechanical strain. (bar, 10 μm).

PLOS ONE | DOI:10.1371/journal.pone.0169412

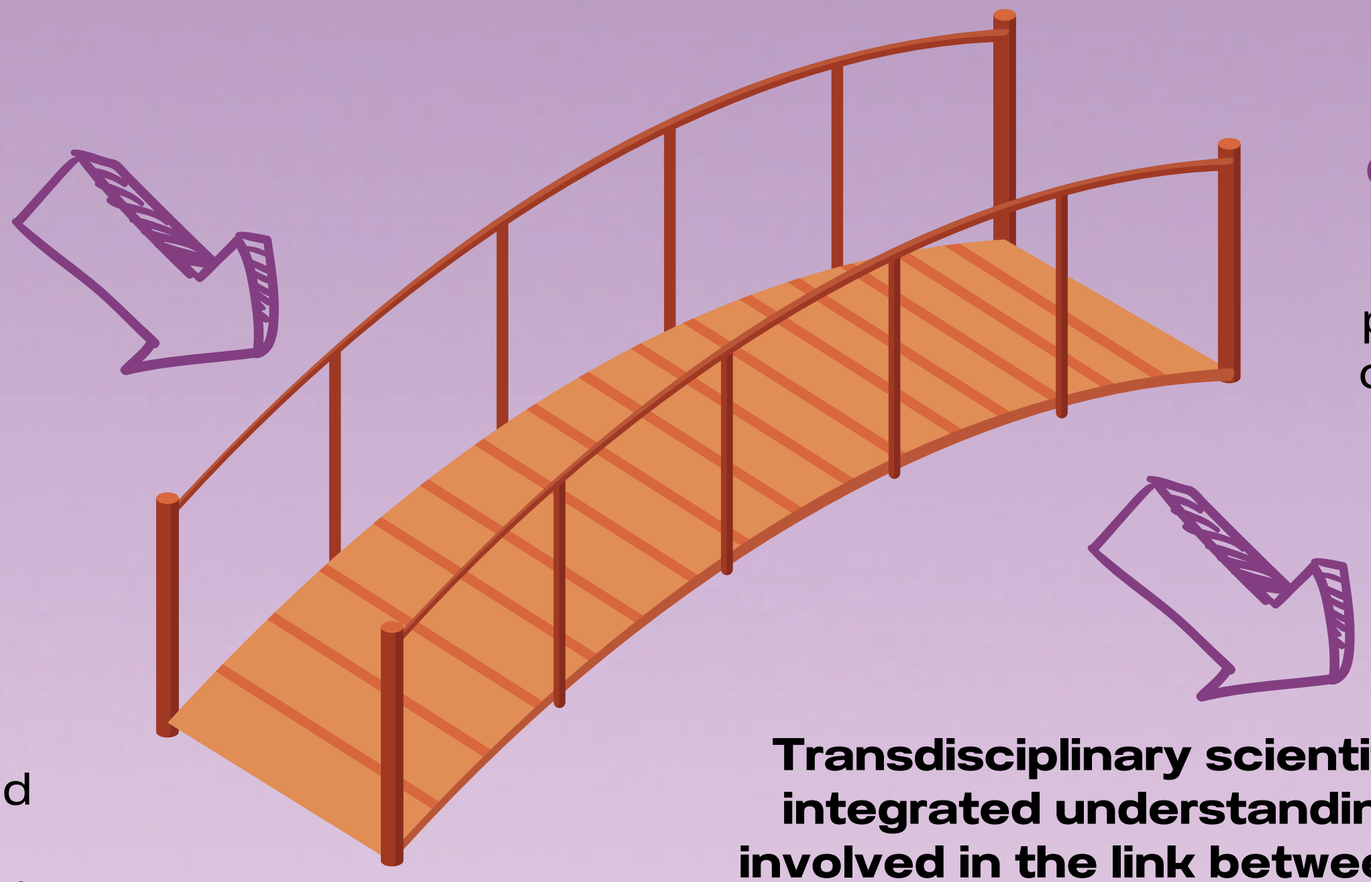
FoDigHe

Future food and digestive health

Lead by : Rozenn RAVALLEC and Djamel DRIDER

Digestive health

Nutritional impact and interaction with the intestinal environment



Nutrition of the future

Changing eating practices in a context of dwindling resources and zero waste

Transdisciplinary scientific approaches for an integrated understanding of the mechanisms involved in the link between nutrition and health

Alternative proteins, nutraceuticals, pre/pro/postbiotics, treated plants (biocontrol and/or biostimulants): what impact on the intestinal environment and inflammation?

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Thank You

Organs On Chip
A current tool for tomorrow's questions