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127

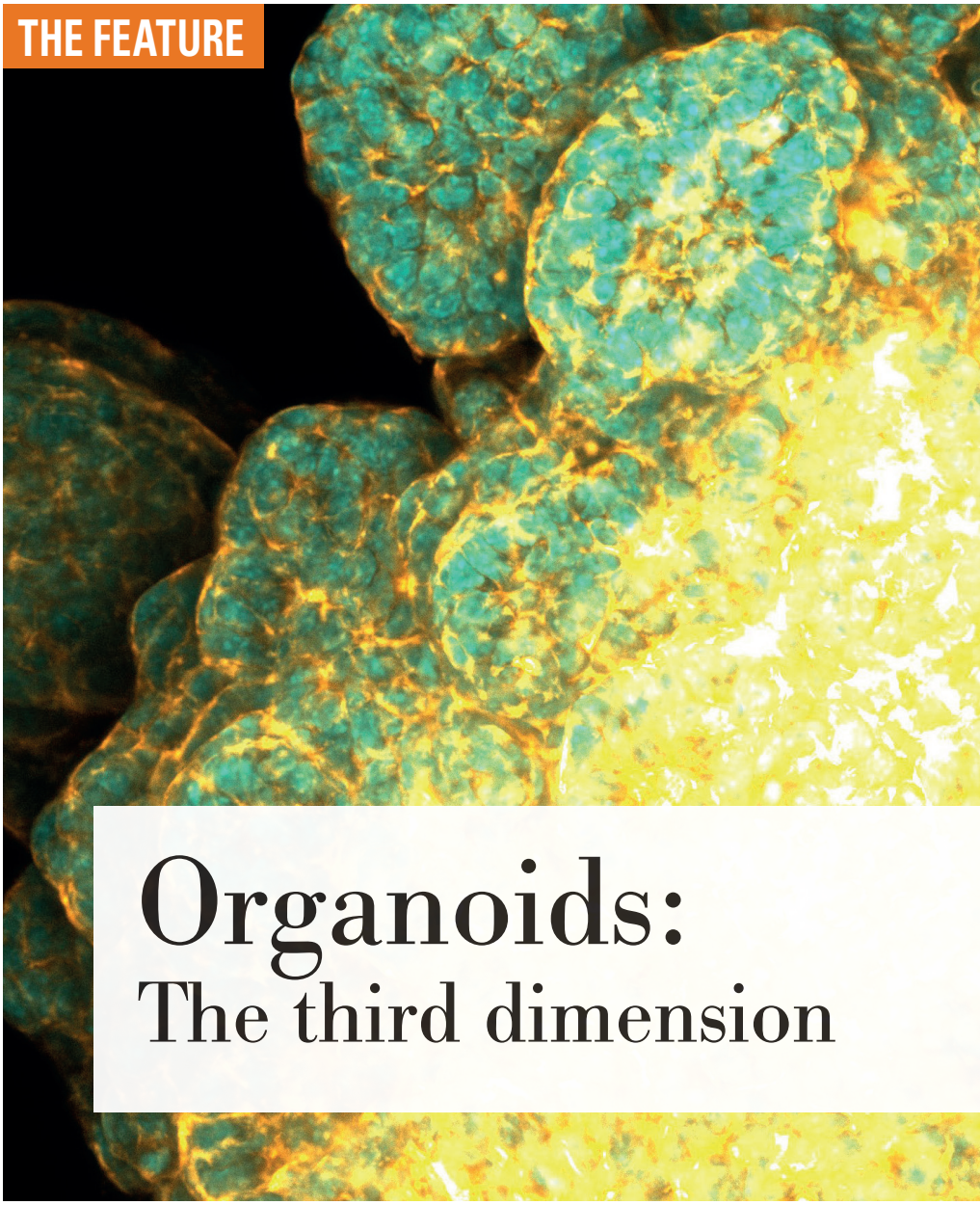
EDITORIAL

Incomparable Tools

All biomedical research relies on selecting the right tools to advance our understanding of life. To study human tissues, researchers often work with cultured cells. Many are now developing three-dimensional cellular structures to partially replicate various organs (heart, kidney, brain, lung, etc.): these are called "organoids". Thanks to organoids, the possibilities are significantly expanded, whether to better understand diseases, study their interactions with the microbiota, or test drug candidates. As you will discover in these pages, researchers can create organoids from patient cells to study skin diseases, chronic inflammatory bowel diseases, brain aging, Parkinson's disease, infections, or even cancer. Organoids allow us to delve much deeper into studying the human body and the diseases that threaten it. While they have become invaluable tools in many fields of research, they remain costly. We need your support to help our researchers access this unique technology.

Pr. Yasmine Belkaid,
President of the Institut Pasteur

THE FEATURE



Organoids: The third dimension

Organoid: this peculiar term might evoke science fiction for some or at least something bizarre! However, it simply means "resembling an organ." Organoids are structures that resemble organs, however at this stage, they cannot yet be considered true "mini-organs." Nevertheless, they are gaining tremendous interest among scientists and have become essential tools in various fields of biomedical research.

CONTINUED ON PAGE P. 2

Culture of cerebral organoids harvested by Molecular mechanisms of pathological and physiological aging unit (see p. 6).

Organoids are tiny three-dimensional biological structures created from stem cells that mimic some organ functions.

3D Models

These tiny three-dimensional biological structures, measuring just a few millimeters, are created in laboratories. As excellent models for studying the mechanisms of life and diseases, organoids mimic the function of human organs. For example, a thyroid organoid will produce thyroid hormone just like the actual organ. While organoids replicate some organ functions, they do not perform them all. For instance, a kidney organoid cannot mimic the organ's detoxification function, nor can a lung organoid replicate oxygen exchange. Despite their limitations, these tiny cultured spheres open up new avenues for discovering how our bodies function and studying the diseases that affect them.

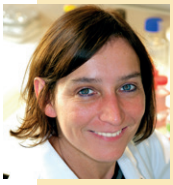
The Recipe for Organoids

To better understand these increasingly popular models among researchers, let's take a look at their fabrication: to form an organoid, "immature" cells - stem cells - capable of multiplying indefinitely (or nearly so) and differentiating into specialised cells with precise functions are used. These stem cells are cultured in vitro under laboratory conditions that drive their specialisation and organisation, similar to how cells behave in embryos or adult tissues capable of self-regeneration. Growth factors specific to each cell type (heart, liver, etc.) guide their specialisation, and a gelatinous matrix acts as a "molecular scaffold," allowing cells to create simplified 3D versions of most organs: liver, intestine, lung, kidney, heart, retina, brain.

ACTION PASTEUR

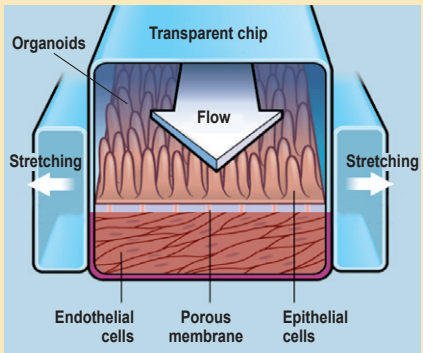
Infections, inflammatory bowel diseases, microbiota study

Organoids-on-a-chip: an advanced model



On the Biomaterials and Microfluidics Platform of the Institut Pasteur, **Nathalie Sauvonnet**'s group* studies the intestine using organoids placed on a "chip."

"*The chip is a transparent material one centimeter long,*" explains the researcher (see diagram). "*Inside the chip, there are two channels: one at the top to place our human colon organoids, and the other at the bottom that replicates a blood vessel. This chip also recreates the mechanical stimulations of the intestine, linked on one hand to the flow of food creating a flux and on the other to the peristaltic forces necessary for transit along the intestine, recreated in this device by cyclic stretching of the tissue, every six seconds.*" This small device has shown that during an infection with *Shigella* (which causes severe human diarrheal disease), mechanical forces are necessary for the bacterium to invade and destroy the colon, with 10,000 times more infection than in a "static" device. Today, research focuses on the microbiota: "*Mimicking it is extremely complex. We therefore use metabolites produced by microbiota bacteria.*" Among them, "short-chain fatty acids" have a beneficial effect on the intestine, digestion, and the entire body. Incubated on organoids-on-a-chip infected by SARS-CoV-2, they reduce infection and inflammation. "*With gastroenterologists from Saint-Antoine Hospital in Paris, we are developing inflamed organoids-on-a-chip to mimic chronic inflammatory bowel diseases. We are testing certain microbiota molecules to see if they reduce or increase inflammation.*"



Organoids-on-a-chip. This chip has two channels: the upper one contains intestinal organoids; the lower one mimics a blood vessel. The mechanical forces of the intestine are reproduced by stretching zones. Such a device allows the study of the effects of microbiota metabolites or infections.

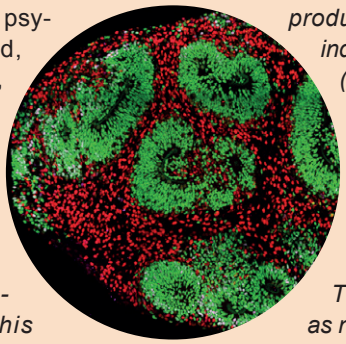
* Tissue homeostasis.

ACTION PASTEUR

Brain Organoids

Understanding "small vessel disease"

Melina Thetiot, a researcher in the Zebrafish Neurogenetics Unit at the Institut Pasteur, produces brain organoids (see image opposite) to mimic the early stages of brain development, particularly cortical structures. Her goal? Understanding the role of the "Notch signaling pathway," which enables cell communication. This fundamental question led her to study a disease caused by a mutation in the Notch3 gene: CADASIL*. Affecting at least 1 in 24,000 people, this disease alters the brain's small blood vessels and can lead to migraines, psychiatric disorders, and, for 3 out of 4 patients, repeated strokes, resulting in language, memory, and vision impairments. "*We know that the aggregation of the mutated Notch3 protein in vessels contributes to this pathology, but the impact of pathway alterations is not yet known*," explains Melina. "*To understand it, we produce brain organoids using induced pluripotent stem cells (iPSCs) from patients with the Notch3 mutation, as well as from healthy individuals. Our models provide insight into how the disease develops and take genetic factors into account. These studies are crucial, as no treatment currently exists for CADASIL.*"



*Acronym meaning *"Cerebral Autosomal Dominant Arteriopathy with Subcortical Infarcts and Leukoencephalopathy."*

Thanks to their three-dimensional structure, organoids more closely resemble what happens in the human body than traditional two-dimensional cultured cells. Cells behave differently when organised in 2D versus 3D. Organoids allow for more detailed analysis of biological processes and their pathological dysfunctions. Though they will never be identical to an organ, they are generally the closest approximation available.

Their development time depends on the organ being mimicked. For example, intestinal organoids can be produced in one or two weeks due to the intestine's rapid natural regeneration, replacing all its cells in just three days. In contrast, it takes several months to develop brain organoids.

Disease Models

Initially created to study development and understand how tissues are organised, organoids are now making breakthroughs in disease research and drug discovery: infectious diseases, cancers, neurodegenerative disorders, chronic intestinal diseases... many conditions are now being studied using these models.

Researchers can also create organoids from patient cells by extracting tissue samples through biopsies (abundant in adult stem cells, e.g., intestine) or by taking skin cells (fibroblasts), which can be reprogrammed

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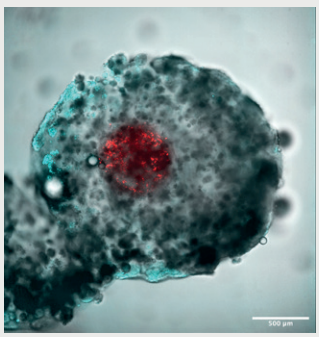
ACTION PASTEUR

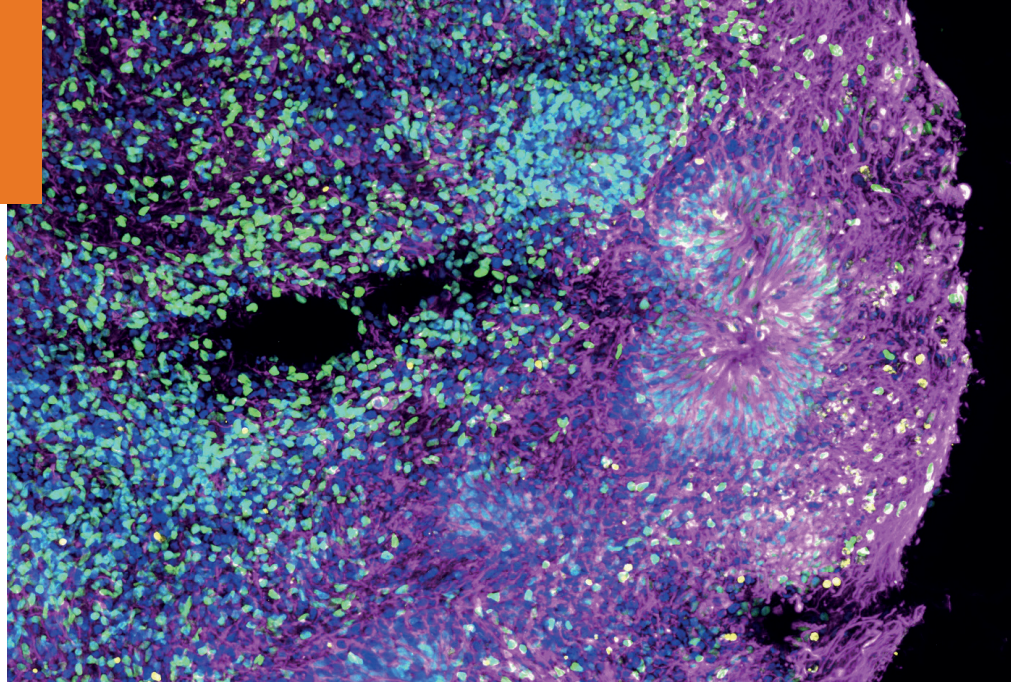
Brain Tumors

"Assembloids" for studying glioblastomas

Glioblastoma, caused by the abnormal proliferation of glial cells*, is the most common and aggressive brain cancer in adults, with at least 3,000 new cases annually, affecting both adults and children. In children, it is the second most common cancer (after leukemia) and the leading cause of cancer-related mortality. This underscores the importance of ongoing research on this currently incurable cancer. **Sandrine Etienne-Manneville**, head of the Cell Polarity, Migration, and Cancer Unit at the Institut Pasteur, studies these tumors using 3D structures known as spheroids and assembloids. "*Spheroids consist of tumor cells grown in a spherical shape. In the lab, we use gliomaspheres made of glioblastoma cells to study their invasion capacity, resistance to compression and radiation, and test potential drugs that could inhibit migration or kill tumor cells.*" Another approach involves coating a glioblastoma spheroid with healthy glial cells to create an assembloid, a recent development by Sandrine's team. "*We can partially mimic what happens in the brain and study interactions between cancerous and healthy cells. Can healthy cells prevent proliferation or invasion?*" These fundamental questions are being addressed using 3D *in vitro* models. The study of glioblastomas has moved to another dimension...



*Glial cells, such as astrocytes, provide physical and nutritional support to neurons and contribute to their functioning. It is the progenitors of astrocytes that give rise to glioblastomas.



Brain organoids derived from Parkinson's disease patients with an alpha-synuclein mutation are being studied in collaboration between the teams of Chiara Zurzolo (see the box below) and Miria Ricchetti (see p. 6).

For cystic fibrosis, Dutch researchers have developed intestinal organoids from patients to test drug efficacy and personalise treatments.

into induced pluripotent stem cells (IPS). This allows scientists to compare healthy and diseased organoids, providing crucial insights into disease mechanisms and testing potential therapeutic compounds.

Personalised Treatment

Cystic fibrosis is often cited as an example of organoid-driven advancements. This severe hereditary disease affects the respiratory and digestive systems, causing excessive mucus production. Mutations in the CFTR gene are responsible, with some being common and others rare. While treatments exist to correct the defect, they are not effective for all patients. Dutch researchers have created intestinal organoids from patients to test drug efficacy individually and tailor therapies accordingly: a personalised medicine approach that, although still in its infancy, could revolutionise patient care.

This personalised approach is also being considered for cancer treatments. Using cancer stem cells from patients, researchers can create "tumoroids," which could help test each patient's tumor sensitivity to available drugs.

Despite their potential, organoid technology remains expensive, limiting its widespread adoption.

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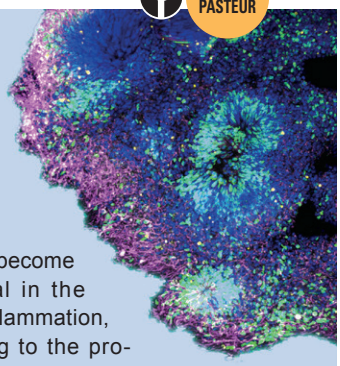
ACTION PASTEUR



Cancers, neurodegenerative diseases

Brain organoids from patients accelerate research

Chiara Zurzolo's team at the Institut Pasteur develops organoids from patient cells to study two different brain diseases: glioblastoma (also on p. 3) and Parkinson's disease. "*In collaboration with the Oncopole in Toulouse, we produce glioblastoma organoids from patient tumor stem cells*," explains Chiara Zurzolo. "*We use them to study interactions between cancerous and healthy cells, identify new therapeutic targets, and investigate how tumors develop resistance to treatment.*"

In parallel, the team is working on a Parkinson's disease model with excessive production of alpha-synuclein, a protein whose abnormal aggregation in the brain is linked to the disease. Brain organoids are produced from patient iPSCs*. They are used to investigate the mechanisms governing disease progression, and to study communication between neurons and brain immune cells (astrocytes, microglia, etc.).

These can become detrimental in the event of inflammation, contributing to the progression of neurodegenerative diseases. "*Compared to animal models, human brain organoids more accurately reproduce disease characteristics in vitro, which is crucial given significant differences between human and mouse cells, particularly in immune responses involved in both cancer and neurodegenerative diseases.*"

* iPSCs or induced pluripotent stem cells are obtained from patient skin cells (fibroblasts), which can be reverted to a stem cell state with a specific cocktail of molecules.

THE INTERVIEW

Barbara de Faria da Fonseca

Researcher at the Biomaterials and Microfluidics Technology Platform of the Institut Pasteur.

"We discover many things with conventional cell cultures, but there is a limit. With organoids, we have increasingly physiological models."

When did organoid technology emerge?

The term organoids appeared in scientific publications as early as the 1990s. However, it did not correspond at all to what we call organoids today. It has long been known that tissue samples, organs, and biopsies can be cultured *in vitro* in suitable culture media. These are known as "organotypic" cultures. What we have called organoids since around 2005/2010 refers to the three-dimensional culture of cells that reproduce the basic functions of an organ.

How long have they been a favored model in research?

These tools have been developed for about a decade in a growing number of research laboratories, even though culturing organoids is more difficult, time-consuming, and technically more complex than two-dimensional cell cultures. However, this depends on the type of organoid and the disease being studied. For example, during the Covid-19 pandemic caused by a respiratory virus, the use of lung organoids increased significantly and helped better understand SARS-CoV-2 infection and its variants. While we discover many things with traditional cell cultures, there are limitations. With organoids, we now have increasingly physiological models.

Do you specifically work on lung organoids? What is the goal?

I work both on improving the model and on studying diseases. We started with Covid in collaboration with Lisa Chakrabarti's team and others at the Institut Pasteur. At that time, there were very few models to study the respiratory axis, the nose, and the bronchi. This led to the development of the lung model. I also collaborate with microbiologists* who focus on bacteria that colonise the respiratory tract, particularly Streptococcus pneumoniae; we are working on replicating the infection using more advanced models, such as "organoids-on-a-chip," which involve a different technology.

Can you explain this technology?

What we call a chip is a silicone support the size of an eraser. Microchannels are created in this chip, into which cells are injected. For example, to study lung tissue with a blood capillary adjacent to a lung cell, I can mimic the capillary by placing blood system cells, including immune cells, in one channel of my chip. In another channel, I place pulmonary epithelial cells. Pores allow communication between the two. This technology, which enables the creation of very complex models, is becoming increasingly popular.

> "During the COVID-2019 epidemic, the use of lung organoids became widespread."

Are you developing other organoids within the platform?

Yes, Nathalie Sauvonnet is working on intestinal organoids on a chip to study SARS-CoV-2, but also Shigella infection, which causes severe diarrheal disease, and the intestinal microbiota (also on p.2). We have recently started developing brain organoids, and we are beginning a placenta organoid project with the Institut Pasteur of Uruguay and Senegal to study the effects of various pathogens causing neonatal diseases (malaria, toxoplasmosis, etc.). Currently, on the platform, we are seeking to improve organoid technology, but we are also considering a service activity to provide organoids to other laboratories, and we are exploring what might interest the Pasteur community the most.

* Michael Connor is a microbiologist in Melanie Hamon's team, in the Chromatin and Infection Unit, at the Institut Pasteur.

ACTION PASTEUR

Skin Organoids

Understanding a highly disabling skin disease

Skin organoids are expected to provide a better understanding of Verneuil's disease, a multifactorial skin condition affecting 1% of the French population, characterised by recurrent and painful abscesses. "*I developed a first model of human skin organoid in an American laboratory to study psoriasis*," explains **Laure Guenin-Macé**, from the Immunobiology and Therapy unit. "*Since returning to the Institut Pasteur a year ago, I have been working on adapting and using this model to study Verneuil's disease. I collaborate with a dermatologist at Saint-Louis Hospital in Paris, who has patients suffering from Verneuil's disease. He can perform excisions of their lesions, including a small portion of non-lesional skin that I can work with. The goal is to create control organoids from healthy skin and others from patient skin. Patients have a different microbiota compared to healthy individuals, but it is unknown whether this is the cause or consequence of the disease. Certain species are associated with the pathology and are not found in a healthy microbiota. I study the impact of these bacteria on the normal development of the epidermis*". Epidermal organoids will certainly help unveil the mechanisms of Verneuil's disease, offering hope for future treatments.

*Also known as *hidradenitis suppurativa*.

Premier Tools for Drug Testing

While increasingly used in academic research, organoids have seen significant growth in the pharmaceutical industry over the past five years. They have become prime tools for testing drug efficacy and toxicity before preclinical trials, also helping to reduce animal experimentation.

Another potential application of organoids is regenerative medicine. Some envision that with improved technology, organoids could be used as "spare parts" to repair organs. Although research is not yet at that stage, the possibility further increases interest in these 3D models. For such an application, the boundary between organs and organoids would need to blur, turning organoids into true mini-organs.

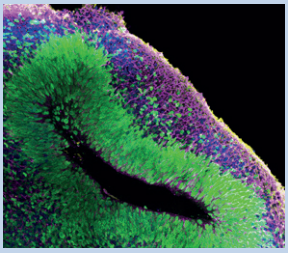
FEATURE BY THE EDITORIAL TEAM

ACTION PASTEUR

Aging

Organoids in space

Miria Ricchetti's team at Institut Pasteur is currently studying brain organoids that have spent time... in space!
"*It was the first time such complex human cellular structures were cultured in space*," notes the researcher, head of the Molecular Mechanisms of Pathological and Physiological Aging Unit.
"*84 brain organoids, developed with SupBiotech from cells of patients with premature aging syndrome or healthy individuals, were sent at the end of 2023 from Cape Canaveral to the International Space Station (ISS) to spend 40 days in space. This European scientific mission, named 'Cerebral Ageing,' was coordinated by the French National Centre for Space Studies (CNES), in collaboration with NASA. The astronauts were tasked with changing the culture medium of the devices once a week. It's a remarkable achievement in microgravity!"* Upon returning to the lab, these organoids were found to be *"of excellent quality, better than expected."* They are being compared with those kept on Earth in terms of architecture, cellular composition, and gene expression.
The ongoing analyses aim to better understand brain aging and assess the effects of space travel on astronauts, especially as several-month missions to Mars are already being planned. *"We plan to send our organoids back into space, but for longer periods of 3 to 4 months. The challenge is finding available space..."*

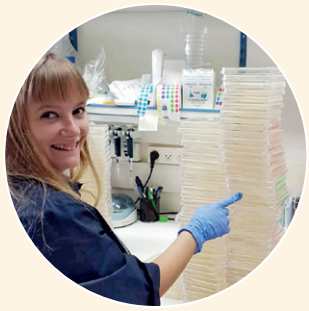


Speaking at the launch of the book co-written by Aude Bernheim *Artificial Intelligence, Not Without Women* in 2019, addressing gender biases in algorithms.

Aude Bernheim, between human and bacterial evolution

"Science is a continuous learning process, not a comfort zone."

At 35, the head of the five-year group on Molecular Diversity of Microbes at the Institut Pasteur is a curious and versatile researcher, committed to changing the way science is conducted.



Aude Bernheim in front of plaque lysis test boxes in 2019 at the Weizmann Institute during her postdoctoral studies.

Engaged in community activities since high school in Paris, Aude once faced a career counselor: "*I told her I wanted to fight world hunger, and she replied that I first needed to learn how plants grow*," she recalls with a smile. Despite her initial reservations about biology, she followed the advice and enrolled in preparatory classes, later joining an agronomy school. "*I became passionate about the Common Agricultural Policy, but it was also during this journey that I discovered molecular biology, which immediately fascinated me*."

For her Master's degree, Aude chose the Interdisciplinary Research Center, an institution offering a different, more creative, and socially engaged approach to science. It was there that she founded an association dedicated to gender equality in science. "*It was a unique scientific environment, full of freedom, which truly ignited my passion for research*."

She later passed the competitive exam for Engineers of Bridges, Waters, and Forests and spent a year managing public policies. However, science soon called her back. "*Discovering molecular biology sparked a philosophical curiosity in me to understand what is shared across living organisms, and I developed a love for experimentation*."

In 2014, she joined the Institut Pasteur for a PhD on bacterial "genetic scissors," the CRISPR-Cas systems that allow bacteria to fight viruses. During this period, she trained in bioinformatics and microbiology.

The G5 Molecular Diversity of Microbes team at the Dentelles de Montmirail in 2023.

"*I believe that the unknown should not prevent progress; it is both terrifying and exciting*."

For her postdoctoral studies, Aude worked at the Weizmann Institute in Israel alongside a pioneer in bacterial immune system discovery. In less than four years, over 150 new defense systems were identified and experimentally validated through their method, opening a new paradigm in the scientific community. "*What we learn during training becomes outdated the moment we enter the lab. I believe our duty as researchers is to master advancements to challenge them and explore what has never been observed before. Science is a continuous learning process, not a comfort zone*."

Upon returning to France during the Covid-19 pandemic, Aude Bernheim established a research group that joined the Institut Pasteur in 2023. "*I wanted to create a space of freedom for individuals with atypical backgrounds, united by 'enthusiasm, intellectual clarity, non-conformism, and friendship,' as described by the Pasteurian and Nobel laureate François Jacob*."

Her interdisciplinary team explores the conservation of immune systems across all living beings, from bacteria to humans, using interdisciplinary approaches that combine bioinformatics tools leveraging Artificial Intelligence and molecular genetics experiments. "*My goal is to push the boundaries of immune system research, understand the general rules of immunity, and discover new antiviral molecules*."

The researcher also collaborates with the Institut Curie to improve cancer immunotherapies, explores phage therapy, and trains doctors in fundamental research.

In addition to her scientific contributions, Aude Bernheim is actively involved in making science more inclusive and accessible to all. Her efforts were recognised by her appointment to the French President's Science Council in late 2023 and by winning the "Irène Joliot-Curie Young Woman Scientist" award in November 2024.

NEUROSCIENCE

Have dogs and humans found a common language?

Humans slow down their speech when addressing their pets, a reflex that could bring us closer to the dog's vocal rhythm and thus facilitate understanding. To explain this phenomenon, researchers* have studied brain waves—those electrical patterns in the brain that result from the synchronous activity of neurons and are involved in cognitive mechanisms, such as the ability to segment sounds into easily assimilable syllable sequences.

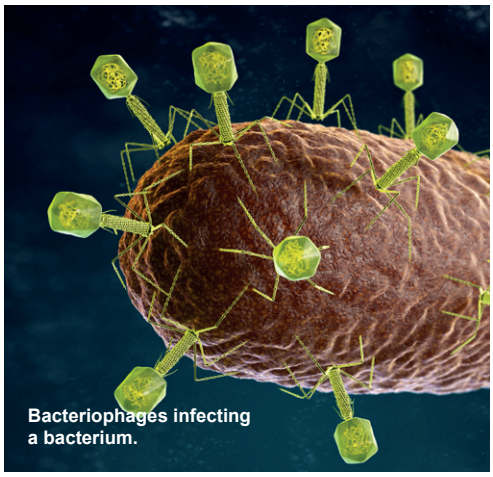
Through non-invasive electroencephalography (EEG) protocols conducted simultaneously on dogs and their owners, researchers have shown that lower frequency (i.e., slower) waves than ours are involved in the segmentation of auditory signals in dogs. Thus, dogs' understanding of speech does not rely on our syllabic rhythm, which is too fast for processing a series of information, but rather on a word-level or short-order scale (e.g., "sit," "stay," etc.). However, sound content remains important; dogs are not solely sensitive to our intonation, contrary to popular belief.

* Study led by Eloïse Déaux, researcher in animal behavior and neuroscience at the University of Geneva, and Anne-Lise Giraud, professor of neuroscience at the University of Geneva and director of the Hearing Institute, a center of the Institut Pasteur.

ANTIBIOTIC RESISTANCE

AI for phage therapy: towards an alternative to antibiotics

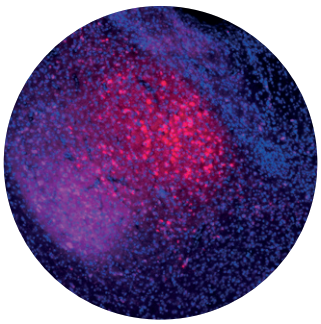
Some bacteria, including *Escherichia coli*, are becoming increasingly resistant to conventional antibiotics, directly or indirectly causing nearly 5 million deaths worldwide each year. To overcome this resistance, phage therapy is a promising avenue.



Bacteriophages infecting a bacterium.

This method uses viruses called bacteriophages, which infect only bacteria to specifically eliminate those that are pathogenic to humans. Since a bacteriophage can only infect certain bacterial strains, scientists* have studied more than 350,000 interactions between phages and Escherichia coli bacteria to determine whether their specific effectiveness could be predicted.
Thanks to this data, bioinformaticians have been able to design an artificial intelligence program that has proven capable of predicting, in nearly 90% of cases, the effectiveness of bacteriophages in destroying bacteria. This method, which can be easily used in hospital biology laboratories, is also designed to be easily adapted to other pathogenic bacteria, paving the way in the coming years for personalised and rapid selection of phage therapies.

* Study led by Aude Bernheim and conducted by Hugo Vaysset and Florian Tesson, respectively manager and PhD students at the Molecular Diversity of Microbes laboratory at the Institut Pasteur, and by Baptiste Gaborieau, a physician at AP-HP and researcher in the IAME unit of Inserm, Université Paris Cité.



Amygdala marked by fluorescence. In purple, neurons responsible for encoding negative stimuli, and in red, neurons primarily responsible for encoding positive stimuli.

DEPRESSION

Discovery of the origin of the "negativity bias"

A major national focus in 2025, depression affects between 15 and 20% of the population. It leads patients to perceive the world through a "negativity bias": pleasant stimuli become less attractive, while unpleasant stimuli become more aversive, which promotes the development and persistence of depressive symptoms.

Until now, the mechanisms of this bias were poorly understood. Researchers* have therefore decided to explore, in an experimental model, the structure that integrates and guides emotional responses in the brain—the amygdala—and observe its functioning during depressive episodes. They identified that the depressive state induces dysfunction in the amygdala circuits: a reduction in the activity of neurons involved in the perception of positive stimuli, and an overactivation of those responsible for perceiving negative stimuli. These findings are extremely valuable for developing new treatments for people with depression, nearly one-third of whom are resistant to conventional drug treatments such as antidepressants.

* Study co-led by Mariana Alonso, head of the Emotional Circuits group within the Perception and Action laboratory at the Institut Pasteur, with researchers from the Institut Pasteur and CNRS, in collaboration with psychiatrists from GHU Paris Psychiatry and Neurosciences, Inserm, and CEA.

GENETICS

What is Junk DNA?

The DNA molecule, in a double helix, is composed of a sequence of four nucleotides (Adenine, Thymine, Guanine, and Cytosine), represented by the letters A, T, G, and C. These approximately 3.2 billion "letters" form the "words" that are our genes.

Our DNA is often presented as a vast text of nearly 20,000 "words": our 20,000 genes coding for proteins, the building blocks of the cell. By "reading" and transcribing these genes, the cell can function and divide. However, the part that actually codes for proteins represents only 1 to 2% of our genome.

Some have hypothesised that our DNA is mostly made up of useless elements, remnants of evolution. Among them, geneticist Susumu Ohno coined the term "junk DNA" in the 1970s to refer to these "letters" that did not seem to form any "words."

However, the complete sequencing of our genome through the Human Genome Project, completed in 2003, has led to discoveries within so-called junk DNA. Estimates suggest that between 8 and 35% of this DNA consists of elements referred to as "regulatory DNA."

While they do not directly code for a protein, they are not without function. This regulatory DNA, of which only a small fraction is conserved between species, serves as a framework or "grammar" for the transcription of the "words" that are our protein-coding genes, helping to form coherent sentences.

Today, DNA is considered "junk" when it does not play an essential role in the survival of individuals and thus escapes the action of natural selection. However, it still contributes to the diversity of individual characteristics within a species.

With each newly discovered function, the concept of "junk DNA" is challenged and remains controversial, illustrating the limits of our understanding of the genome.

FOCUS

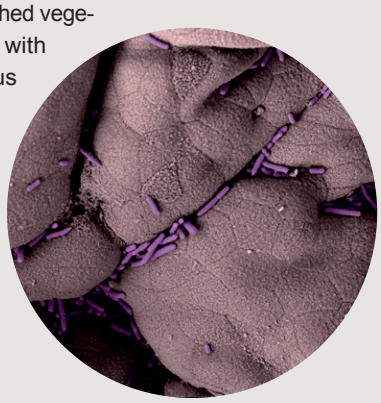
Can Eggs Cause Salmonella?

At the end of October 2024, nearly 3 million eggs were recalled across France. They were suspected of being contaminated by bacteria of the *Salmonella* genus, responsible for the second most common bacterial foodborne infection in Europe: salmonella. While the intestinal disorders it causes are often mild, the disease can become severe or even fatal for children, pregnant women, and individuals with weakened immune systems.

Salmonella can be present in the intestines of poultry, contaminating eggs during their formation or the shell at the time of laying. Consumption of products made with raw or undercooked eggs (mayonnaise, chocolate mousse, etc.) is a common source of *Salmonella* contamination for humans. Symptoms appear within one to two days and include abdominal pain, fever, diarrhea, and sometimes vomiting, which can lead to dehydration.

For severe infections or individuals at risk of developing complications, antibiotic treatment may be prescribed. Prevention remains the best way to combat salmonella. Thorough cooking of egg-based products (hard-boiled eggs, pastries, etc.) at +65°C effectively destroys *Salmonella*. However, for preparations containing raw eggs, maintaining the cold chain prevents bacterial growth but does not kill the bacteria.

Many other products, such as meats (including processed meats), raw milk cheeses, or improperly washed vegetables, can also be contaminated with *Salmonella*, demanding continuous monitoring by health authorities. The foodborne nature of the infection can lead to significant epidemic outbreaks. *Salmonella* remains a major public health concern in France, with an estimated 200,000 infections annually, of which about 4,000 require hospitalisation.



Interaction of *Salmonella Typhimurium* with the intestinal epithelium.

ONE HEALTH

The Institut Pasteur announces its “One Health” activities internationally

Members of the Institut Pasteur at the World One Health Congress in Cape Town.

The World One Health Congress is the renowned international conference on the “One Health” approach, a multisectoral collaboration between animal, human, and environmental health to understand and anticipate global health risks. For the first time, it was held on the African continent in South Africa, addressing major challenges related to this approach and facilitating discussions on research data sharing and policy developments.

In this context, the Operations Division of the International Affairs Department of the Institut Pasteur presented its flagship project, MediLabSecure. Supported by the European Union, this project brings together stakeholders in human, animal, and environmental health to develop a truly effective “One Health” approach to combat vector-borne diseases in 22 neighboring countries of the EU. The team from the Global Health Department of the Institut Pasteur also showcased their work, particularly on rabies.

8th world one health CONGRESS
CAPE TOWN SOUTH AFRICA
2024

PASTEUR NETWORK

A revolutionary initiative on messenger RNA technology

Signing of the partnership to accelerate mRNA vaccine research took place on October 23, 2024, in Brazil, in the presence of leaders from the Oswaldo Cruz Foundation (Fiocruz), the Institut Pasteur of Dakar, the Institut Pasteur Korea, the Institut Pasteur of Paris, and the Institut Pasteur of Tunis, all members of the Pasteur Network.

More than 60 years after the discovery of messenger RNA by researchers at the Institut Pasteur, the development of mRNA-based vaccine strategies represents a major breakthrough in biomedical research. To promote the use of this technology to address global health challenges, key members of the Pasteur Network, including the Institut Pasteur of Paris, signed a strategic memorandum of understanding last October in Rio de Janeiro.

The partnership aims to foster collaboration among member institutions to advance mRNA technology and develop sustainable solutions for vaccine production in resource-limited regions. Specifically, it will enable three members of the Pasteur Network – the Institut Pasteur of Tunis, Fiocruz in Brazil, and the Institut Pasteur of Dakar – to strengthen their local capacities for mRNA vaccine production. The participating institutions will be able to share knowledge and resources, creating a strong ecosystem for innovation and public health improvement. The Institut Pasteur of Paris will contribute its renowned research expertise and advanced technological platforms to support this initiative.

ASIA-PACIFIC

Strengthening research on infectious diseases

The Institut Pasteur and A*STAR IDL – the Singapore Agency for Science, Technology and Research – Infectious Diseases Labs – have signed a memorandum of understanding (MoU) in response to the urgent health threats posed by the rising cases of tropical infectious diseases in the Asia-Pacific region.

The MoU signing ceremony took place in the presence of Ms. Minh-di Tang, the French Ambassador to Singapore, Professor Yasmine Belkaid, President of the Institut Pasteur, and Professor Lisa Ng, Executive Director of ASTAR IDL. This partnership builds on the Institut Pasteur’s extensive experience in microbiology and infectious diseases, its global influence, and ASTAR IDL’s strong focus on cutting-edge translational research.
In the coming months, under this agreement, both institutions will work to develop and strengthen their partnerships by submitting joint grant applications to advance collaborative projects.

"PASTEUR 2030": A NEW STRATEGIC VISION FOR THE INSTITUT PASTEUR

"Today more than ever, it is crucial to protect and support biomedical research aimed at understanding, preventing, and treating diseases. The rapid evolution of environmental and infectious threats, as well as the global rise in non-communicable diseases, highlight the importance of our mission."

Yasmine Belkaid, President of the Institut Pasteur

Since its creation in 1887, the Institut Pasteur has faced the societal and scientific challenges of its time. Building on its heritage and strengths, and committed to preserving the freedom essential to creativity and scientific discoveries, the Institut Pasteur is responding to modern challenges by implementing a new strategic vision called "Pasteur 2030," which we would like to present to you here. The objectives are grouped around four major priorities:

Understanding the impact of environmental transitions on health:

In a world undergoing ecological transition, **our goal is to mitigate the consequences of climate and environmental changes on human health.** Our researchers will focus on diseases transmitted by vectors such as ticks and mosquitoes, as well as emerging infections.

Addressing infectious risks:

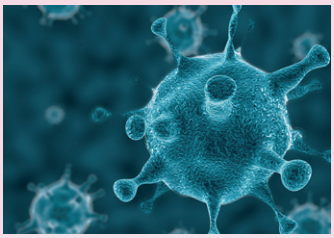
As we remain vulnerable to infectious diseases and the increasing resistance to antimicrobials, **our goal is to identify, better understand, and monitor pathogens.** These advancements will form the basis for the development of innovative therapies and vaccines to control infectious diseases.

Studying the origins of diseases:

To address the alarming rise in inflammatory and non-communicable diseases (cancers, neurodegenerative diseases, etc.), **our goal is to analyse, understand, and act on the factors that disrupt biological balance and promote the onset of diseases.**

Exploring health and disease at the extremes of life:

The early moments of life and the aging process are crucial stages of vulnerability for our health, requiring tailored approaches. **We will explore the mother-child relationship, which is still under-researched today, as well as the response of the aging body to vaccines and treatments.**



"Pasteur 2030" has been built as a collective effort that brings together all the strengths of the Institut Pasteur and more than 30 members of the Pasteur Network, fostering interdisciplinarity and collaboration. These commitments are materialised in several flagship projects, including:

- **A center for climate, environment, and infections:** a new building under construction with cutting-edge infrastructure to combat emerging and vector-borne diseases.
- **An epidemic investigation task force:** as part of the Pasteurian Pandemic Preparedness Initiative, in collaboration with AP-HP and Université Paris Cité.
- **A center for vaccinology and immunotherapy:** a structure dedicated to developing next-generation vaccines and immunotherapies, aligning with the "France Vaccines" initiative.
- **A center for drug discovery and development:** a future structure that will provide our scientists with access to the entire chain required to develop new therapeutic molecules.

PASTEUR
and you

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INSTITUT PASTEUR

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