



Paris-Saclay **Health** **excellence**

Silicon Valley

Boston

Tech City London

Paris-Saclay

Paris-Saclay, a region at the service of innovation

The Paris-Saclay science and technology cluster represents 15% of all research in France and supplies 40% of public and private research jobs in the Paris Region. It's one of the eight most powerful innovation clusters in the world, along with the Silicon Valley, Boston, Tech City London, Beijing, Bangalore, Skolkovo Innovation City in Russia, and the Israeli Silicon Wadi.

Located on the outskirts of the French capital, Paris Saclay is a hotbed of innovation with a world-class reputation, boasting an unrivaled concentration of higher education institutions, state research laboratories, private R&D facilities and innovative businesses of all sizes.

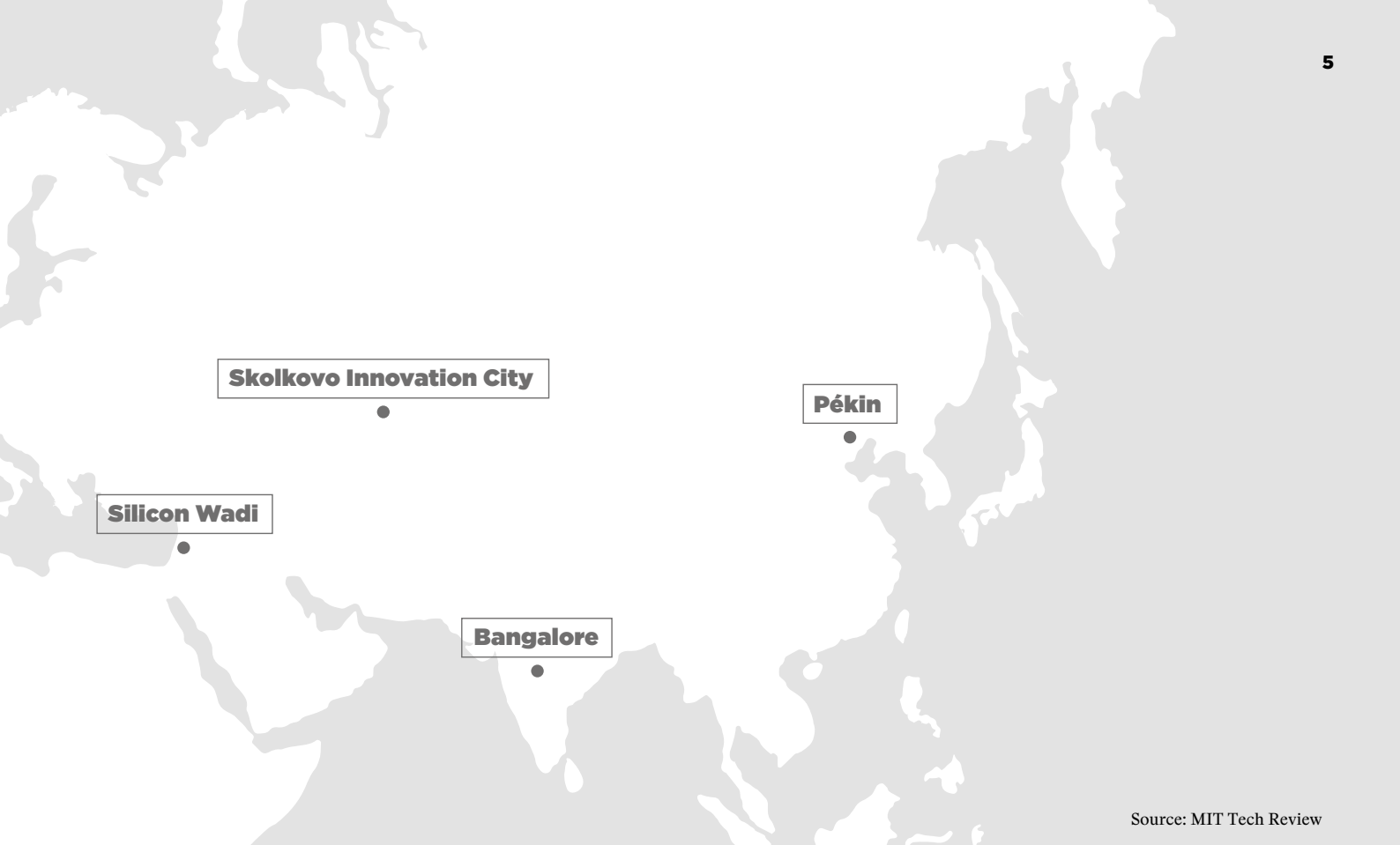
The wealth of resources and potential partners in the area makes Paris-Saclay one of the most attractive innovation hubs for investors, innovators, and entrepreneurs from all over the world:

- location in the heart of Île-de-France, Europe's leading economic region*;
- excellence of the training and research offer that meets the highest international standards supported by Paris-Saclay University and the Polytechnic Institute of Paris;
- abundance of large-scale scientific equipment and multidisciplinary laboratories;
- concentration, excellence and diversity of industrial players and start-ups;
- rare quality of life in a setting that values the natural environment.

Created in 2010 under the Greater Paris law, Paris-Saclay Development Authority (EPA Paris-Saclay) steers and coordinates the development of the science and technology cluster with local players and promotes the cluster abroad. The cluster's development strategy is based on three pillars: support

One of the
most attractive
innovation
hubs in the
world

*Source: INSEE



Source: MIT Tech Review

for innovation *through* the development of a community of companies, start-ups and innovation centers; promotion of the cluster's international appeal and its Paris-Saclay Innovation Playground brand; and the development of services to meet the needs of companies.

With this in mind, Paris-Saclay development authority is mobilizing and federating industrial and academic players around strategic sectors in order to strengthen the links between public and private research, promote innovation and entrepreneurship, and stimulate economic growth in the region. Six fields of excellence have been identified, analyzed and mapped: aerospace-defense-security, AgriTech/FoodTech, new energies, future mobility, health, and digital technologies. This document is intended to present the Health field of excellence.

6 STRATEGIC SECTORS

Aeronautics Defense Security

Airbus, Safran,
Thales, Nexter,
Arquus, etc.

16 start-ups
68 laboratories
and platforms

#NewSpace
#Cybersecurity

AgriTech and FoodTech

Danone,
Mondelez,
Syngenta

77 start-ups
110 laboratories
and platforms

#FoodFromTheFuture
#HealthyNutrition
#SmartFarming

Energy City Environment

EDF, Bouygues,
Colas

47 start-ups
123 laboratories
and platforms

#EnergyStorage
#Biofuel
#SmartGrids

Mobility

Renault, PSA,
Valeo, Fiat, etc.

12 start-ups
46 laboratories
and platforms

#AutonomousVehicle
#Hydrogen
#PackedSystems

Health

Sanofi, LFB, IPSEN,
GE Healthcare

146 start-ups
346 laboratories
and platforms

#Microbiota
#GeneTherapy
#Oncology
#ConnectedHealth

Digital technologies

Nokia, Ericsson,
HP, Dassault
Systèmes, etc.

106 start-ups
252 laboratories
and platforms

#AI
#QuantumPhysics
#IoT
#SmartManufacturing

Health, a strategic sector

Among the key industries in Paris-Saclay, the health sector is one of the most dynamic, with nearly 100 establishments in the area, approximately 15,000 jobs and a growing number of innovative start-ups. It is also, in the aftermath of the 2020 COVID-19 pandemic, one of the most strategic worldwide.

In order to study the contours and priority issues, the Établissement public d'aménagement Paris-Saclay, in collaboration with SATT Paris-Saclay, has initiated a vast study of the area.

Who are the players who today keep this industry alive in the heart of Paris-Saclay? What key technologies are deployed there? What is the structure of this sector? What are its assets? What are its dynamics over time?

The conclusions of this study, presented in this document, outline a leading region that combines world-class research, industry and innovation. Among its assets: the presence of major hospitals linked to cutting-edge clinical research, world-renowned academics, excellent facilities, dedicated training, a particularly dynamic industrial fabric and structuring projects with a promising future.

This sector, with its rich array of players and synergies deployed in the service of medical and pharmaceutical progress, is a veritable laboratory of innovations which, in the past, has marked the history of science and which, today, is shaping the medicine of tomorrow.

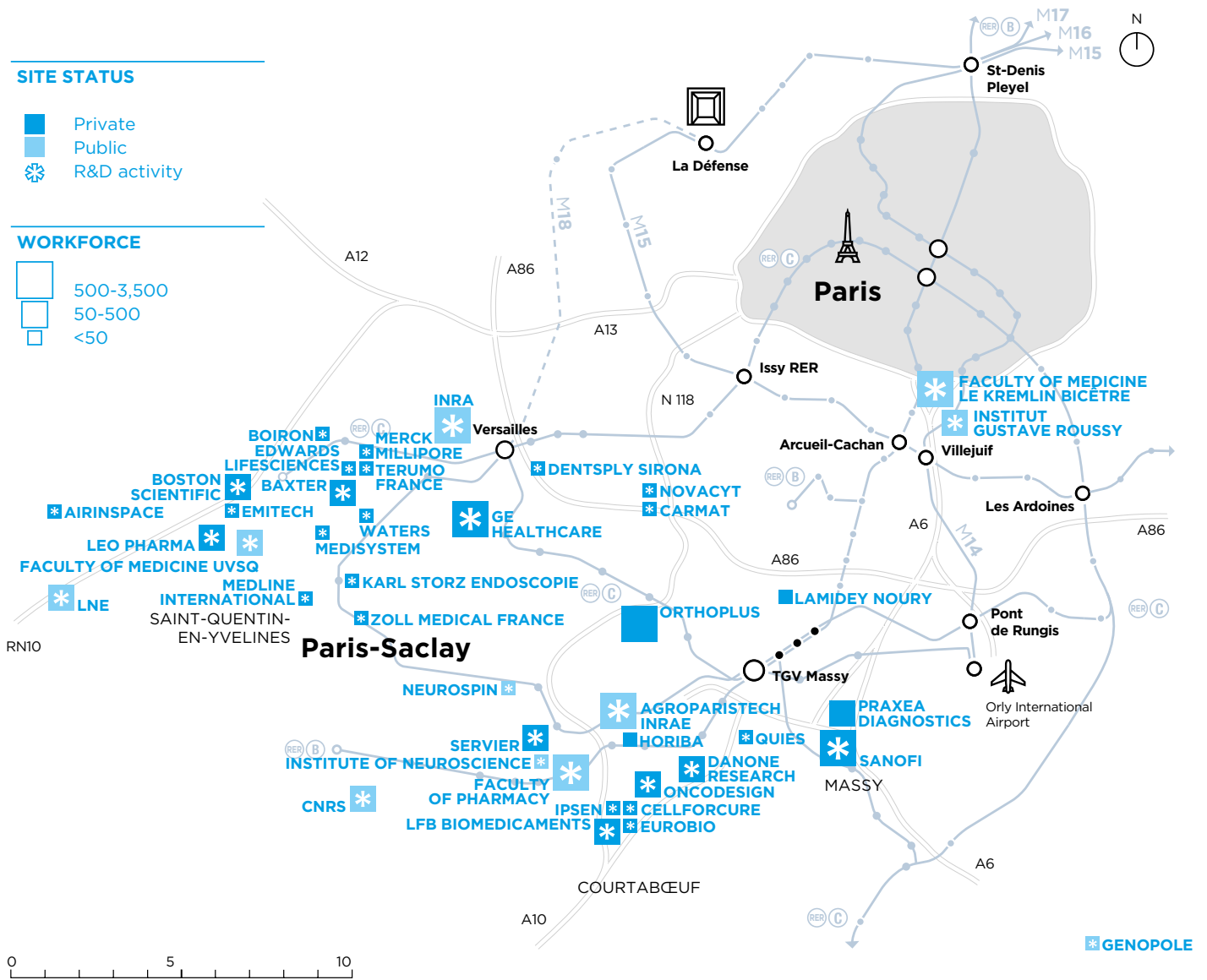
Specialized in particular in the understanding of the brain and the genome, as well as in the treatment of cancer and diabetes, the health sector in the Paris-Saclay region responds to current and future health issues such as the development of new therapies or diagnostic methods, the deployment of artificial intelligence, the growth of “nutricaments” or the rise of personalized and predictive medicine.

A leading region combining world-class research, industry and innovation in health

• **fig. 1** Laboratories of the Servier Group, the second largest French pharmaceutical company.



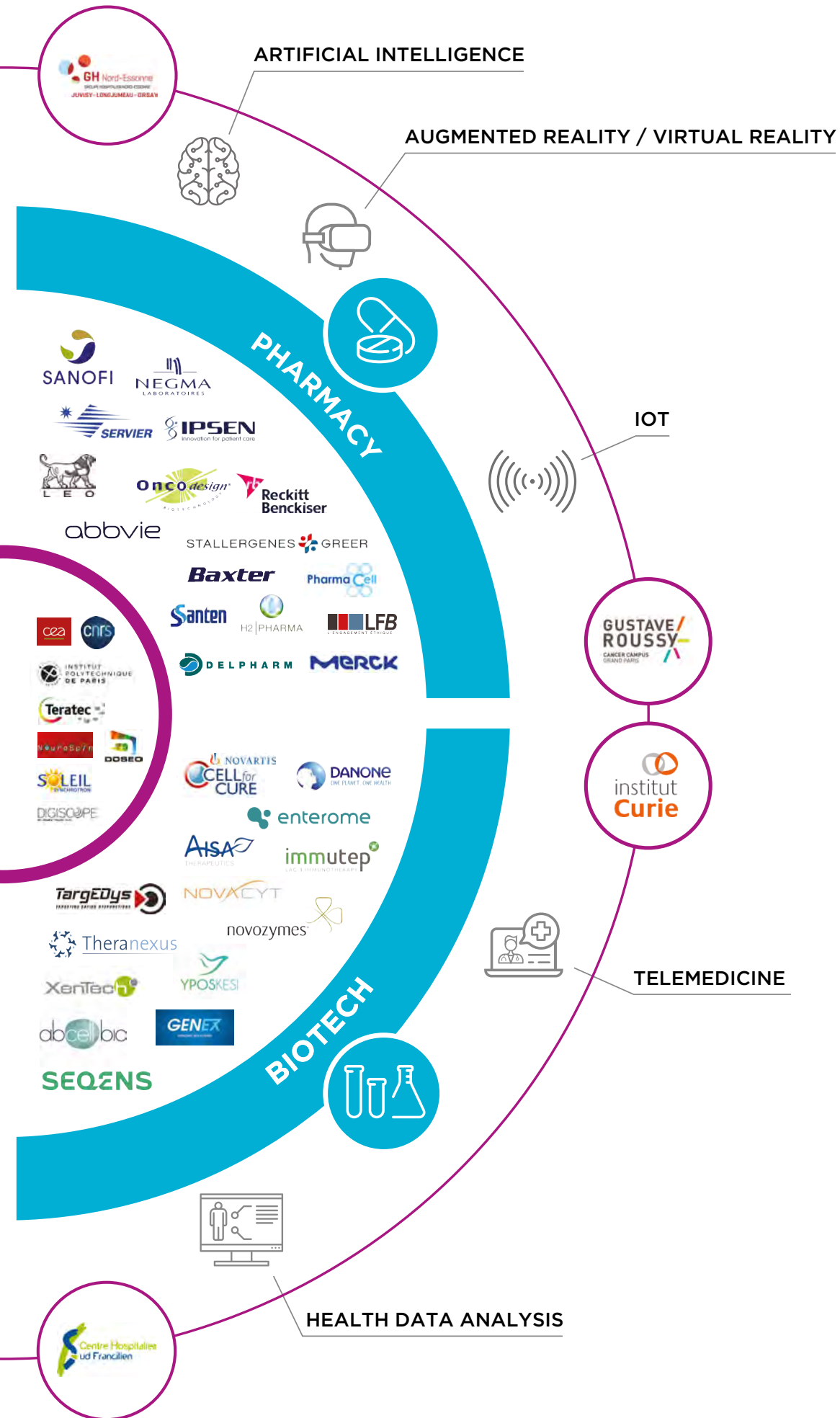
The health sector in the Paris-Saclay region



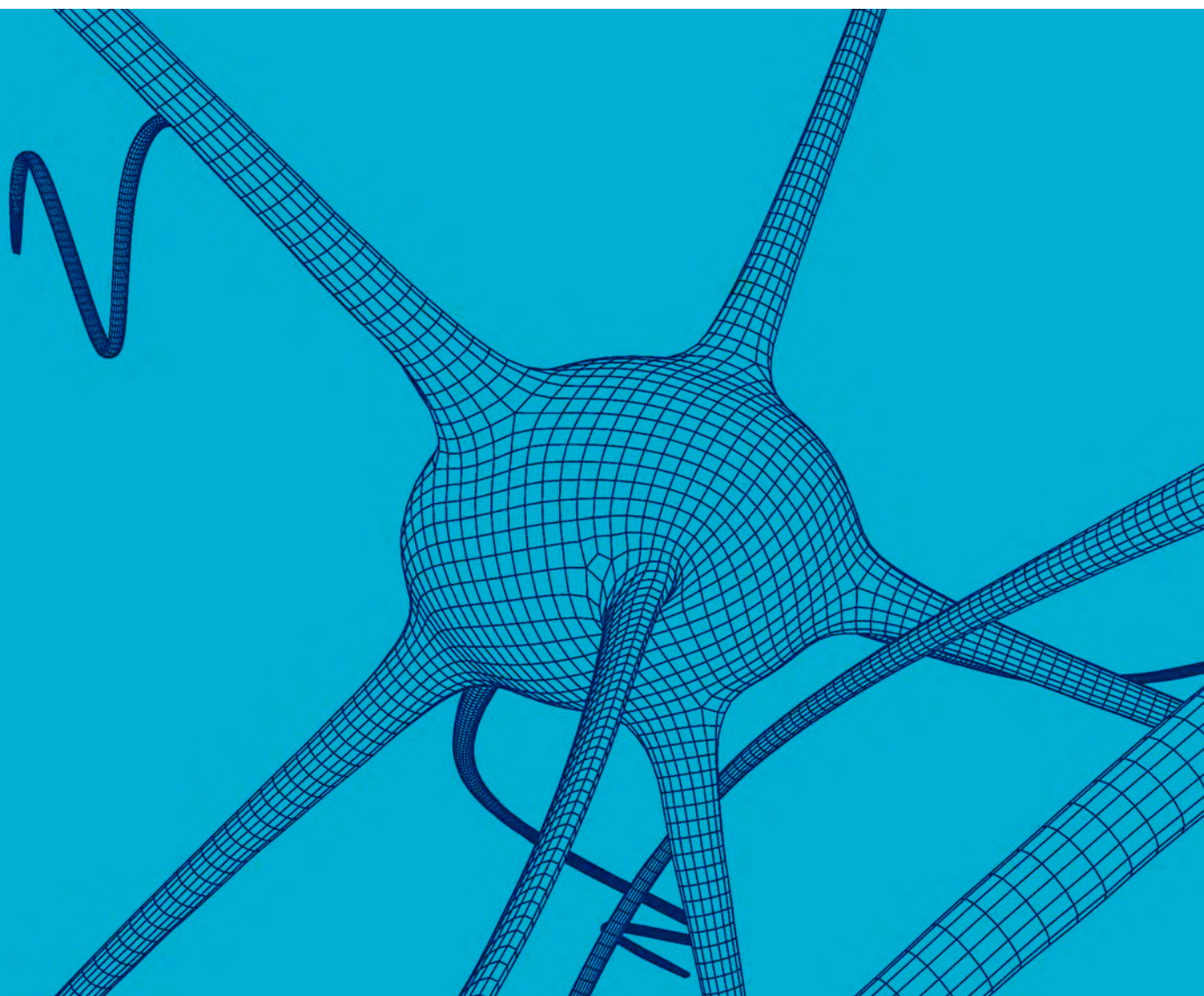
Health, a field of excellence within the Paris-Saclay science and technology cluster

- A sector rich in players: world-class higher education institutions and research laboratories, international industrial groups and high-tech start-ups, and some of the best hospitals in Europe.
- A sector structured around the leading health sectors: pharmaceuticals, biotech, medtech and instrumentation.
- A sector positioned on the key technologies of tomorrow's medicine: immunotherapy, gene therapy, regenerative medicine, microbiota, bioengineering, health data analysis, telemedicine, the Internet of Things, virtual and augmented reality and artificial intelligence.





The medical and pharmaceutical innovation chain

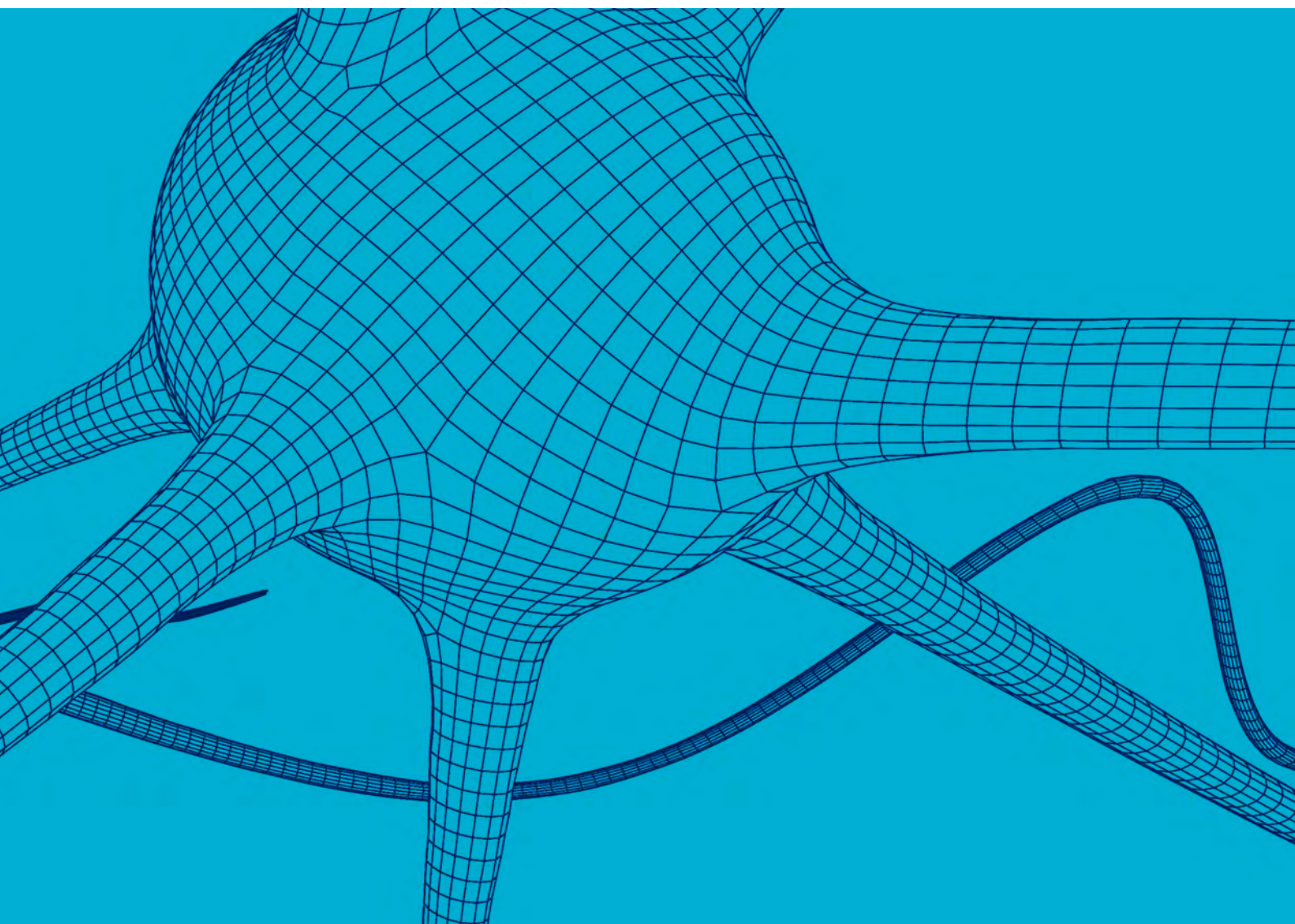


One of the strengths of the Paris-Saclay healthcare sector is the presence of all the players in the healthcare value chain at the heart of the region.

From basic research to clinical medicine, including applied research, student training and industrial innovation, the Paris-Saclay cluster brings together all the players in the medical and pharmaceutical innovation chain around the same objective: inventing the medicine of the future.

With world-class higher education institutions and research laboratories, international industrial groups, high-tech start-ups and some of the best hospitals in Europe, the Paris-Saclay region has a particularly rich ecosystem whose strength lies in the concentration of players, the density of skills and the synergies deployed between disciplines and technologies.

Today, the health sector includes 100 establishments, nearly 350 laboratories and technical platforms in the region and represents approximately 15,000 jobs.



Excellent academic research at the crossroads of scientific disciplines

Upstream of the innovation chain, higher education institutions and public research laboratories are at the origin of major scientific discoveries.

Paris-Saclay has prestigious institutions covering specialized research activities in biology or physics/chemistry focused on understanding biological mechanisms and developing therapeutic solutions. They are particularly well represented at **Université Paris-Saclay**, including the faculties of medicine at Kremlin-Bicêtre, the University of Versailles-Saint-Quentin and the Faculty of Pharmacy, as well as **AgroParisTech**, CentraleSupélec, the École normale supérieure Paris-Saclay and the Institut d'Optique *Graduate School*. Paris-Saclay is also home to national research organizations such as **Inserm** (Institut national de la santé et de la recherche médicale), **INRAE** (Institut national de recherche pour l'agriculture, l'alimentation et l'environnement) and the **CNRS** (Centre national de la recherche scientifique).

Among the expert research institutes in life sciences: **ICMMO** (Institut de chimie moléculaire et des matériaux d'Orsay) and **ICSN** (Institut de chimie des substances naturelles) are developing research on new molecules and therapeutic agents, **I2BC** (Institut de biologie intégrative de la cellule) brings together research teams on various aspects of the cell, while the **Micalis Institute** is investigating the field of food microbiology for health.

Higher education institutions and public research laboratories at the origin of major scientific discoveries

• **fig. 2** Cloning of a eukaryotic gene in a bacterium - Laboratories of the École polytechnique.

The Paris-Saclay academic cluster

The Paris-Saclay academic cluster is made up of two groups of higher education and research institutions: Université Paris-Saclay and the Polytechnic Institute of Paris. With nearly 69,000 students, more than 15,000 researchers and 19 institutions, this vast complex offers training and research that meet the highest international standards. It ranked sixteenth in the prestigious Shanghai ranking in 2022.



The Paris-Saclay science and technology cluster also has many major research organizations in optics, physics, mathematics, materials science, artificial intelligence and digital technology... all of which are cross-disciplinary and used for health applications. These are mainly present at the **Institut polytechnique de Paris (IP Paris)**, which includes the École polytechnique, Ensta ParisTech (École nationale supérieure de techniques avancées), Ensaie ParisTech (École nationale de la statistique et de l'administration économique), Télécom ParisTech and Télécom SudParis.

Multidisciplinary research institutes are also working on these themes, including the **Laboratory of Applied Optics**, the **Interdisciplinary Laboratory of Numerical Sciences** (Limsi) and the **Laboratory of Plasma Physics** (LPP).

In parallel with these fundamental and applied research activities, these institutions train the talents of tomorrow. Within Université Paris-Saclay, three *Graduate Schools* are dedicated to health: Public Health, *Health and Drug Sciences*, *Life Sciences and Health*. A number of transdisciplinary master's degrees teach mathematics for life sciences, data science applied to health, and biomechanics... all of which constitutes a formidable pool of future employees for the region's companies.

3

GRADUATE SCHOOLS DEDICATED TO HEALTH

- Public Health
- Health and Drug Sciences
- Life Sciences and Health

The CEA, a leading research player in Europe

The French Atomic Energy and Alternative Energies Commission (CEA) is a leading player in research and innovation at both national and European level. Founded in 1945 to develop applications arising from the atomic sciences, the CEA is now active in the fields of defense and security, low-carbon energy, technological research for industry, and fundamental research in life and material sciences. At the heart

of its mission: a strong applied health research activity with two emblematic sites located in the Paris-Saclay region - the Frédéric Joliot Institute for Life Sciences in Saclay and the François Jacob Institute of Biology located in Fontenay-aux-Roses. Within the former, NeuroSpin is an exemplary research center for innovation in brain imaging. It brings together physicists, mathematicians,

neuroscientists and physicians working in synergy to better understand how the brain works and to study new therapies. In particular, it has a clinical and preclinical MRI platform that is unique in the world, including the Iseult magnet, the most powerful MRI in the world, which can reach 11.7 Teslas for images that are 100 times more precise than the imagers currently used.

• **fig. 3** Descent of the Iseult MRI magnet into its cave, in 2017, at NeuroSpin.



World-renowned industrial groups

As an essential link in the innovation chain, companies and start-ups develop and commercialize the technologies resulting from scientific discoveries. Spurred on by the presence of internationally renowned research organizations and leading engineering schools, and attracted by major facilities open to industrial R&D, many companies have set up shop on the Saclay plateau.

These companies include major industrial groups such as **GE Healthcare**, one of the world's leading manufacturers of medical imaging equipment, whose international site of excellence brings together 600 R&D researchers and engineers in Buc, **Air Liquide**, which has been based in Les Loges-en-Josas since the mid-1960s, and **Horiba**, the world leader in scientific measuring instruments, which is located near the École polytechnique. The leaders of the French pharmaceutical industry are also present: **Sanofi, Servier, Ipsen and LFB** are four of the eight companies that make up the G5 Santé, a think tank of France's leading healthcare and life sciences companies. Not to mention **Delpharm**, producer of the Pfizer/BioNTech vaccine.

As an essential link in the innovation chain, many companies have set up shop on the Saclay plateau

• **fig. 4** The SOLEIL Synchrotron, a facility of excellence under the joint supervision of the CEA and the CNRS.

The SOLEIL Synchrotron, at the crossroads of research and industry

The SOLEIL Synchrotron is a particle accelerator and is a facility of excellence under the joint supervision of the CEA and the CNRS. It produces synchrotron radiation, a light that is ten thousand times brighter than sunlight, and thus makes it possible to explore inert or

living matter. In particular, it provides new opportunities to test materials, with a spatial resolution of less than one millionth of a meter and sensitivity to all types of materials. A structure that is now essential for research and industrial applications, open to industrial partnerships.





The future Servier Research Institute in the heart of Paris-Saclay

The second largest French pharmaceutical company, Servier is an international group with operations in 150 countries and 22,500 employees worldwide. At the heart of its activities: a constant commitment to cardiovascular and metabolic diseases, oncology, neuroscience and immuno-inflammatory diseases. Today, nearly half of its R&D is devoted to oncology, particularly immunotherapy. The Servier Paris-Saclay Research Institute brings together 1,500 researchers in a unique place of interdisciplinary innovation, at the heart of the Paris-Saclay scientific cluster of excellence. The ambition:

to innovate as a network to boost research and offer patients cutting-edge therapeutic innovations. In an open innovation approach, the Institute will also host an incubator for start-ups with innovative scientific and technological projects. With a surface area of 1,850 m², this incubator will include 80 workstations, combining highly equipped laboratories with specially designed office space.

1,500

**RESEARCHERS
AT THE FUTURE
SERVIER
PARIS-SACLAY
RESEARCH
INSTITUTE**

• **fig. 5** The Servier Paris-Saclay Research Institute brings together all of the Group's researchers in a single innovation facility at the heart of the Paris-Saclay scientific cluster of excellence. View of the circular garden.

INTERVIEW WITH LAURENCE COMTE-ARASSUS
 GENERAL MANAGER OF GE HEALTHCARE FOR FRANCE,
 BENELUX, AND FRENCH-SPEAKING AFRICA

GE Healthcare, a global industrial leader at the heart of the Paris-Saclay ecosystem



GE Healthcare is a world leader in the manufacture of medical imaging equipment. Its establishment in the Paris-Saclay ecosystem dates back to 1987 and follows the acquisition of the activities of Thomson CGR. General Manager of GE Healthcare for France, Benelux and French-speaking Africa, Laurence Comte-Arassus tells us more about the network of partnerships established over time with other stakeholders in this ecosystem and which the health crisis has prompted to be strengthened.

GE Healthcare has a long-standing presence in the Paris-Saclay ecosystem. How do you view its current evolution?

L C-A The French healthcare ecosystem as a whole is extremely rich and Paris-Saclay makes a major contribution to it, both in terms of research and innovation. We are fully integrated in this process through our Buc site, which has the particularity of combining R&D and production activities. This is where our interventional imaging, mammography and advanced visualization software are produced. We maintain close ties with several of its stakeholders, starting with higher education institutions, whose PhD students we host under a doctoral grant agreement. Committed to the development of artificial intelligence (AI) applied to medical imaging, we are members of the DATAIA Paris-Saclay Institute, and lead the AI DReAM project, winner of the call for structuring projects for competitiveness (PSPC) of the Government's Program for Future Investments.

If there is a challenge, it lies in the size of this ecosystem and the wealth of the stakeholders with whom we have the opportunity to interact. For an industrial company like GE Healthcare, which is of intermediate size, choices have to be made. Within our company, one function is entirely dedicated to partnerships and innovation. It is managed by Fatine El Jebbari, who is committed to evaluating each opportunity that arises, in order to invest in the most optimal way in the Paris-Saclay ecosystem as well as in the rest of the French healthcare ecosystem.

To what extent has the health crisis strengthened your commitment to this partnership approach and to continuing your involvement in Paris-Saclay?

L C-A The crisis has shown us how essential this partnership approach is more than ever. Alone, we cannot anticipate all the future developments in the health field as in many others. It is together, with industrial and academic partners, that we will be

able to find answers to clearly identified challenges and prepare for those that will arise without warning. This challenge directly questions the very principle of the plans that, until a few years ago, were being developed for the more or less long term. Not that we should give up, but we now have to work with more unknowns than ever before. This is a good reason to work more within an ecosystem like Paris-Saclay, which is particularly conducive to the establishment of win-win partnerships for all stakeholders.

“The French healthcare ecosystem is extremely rich and Paris-Saclay makes a major contribution to it in terms of both research and innovation.”

What about start-ups? Do you have the ambition to incubate them on your Buc site?

L C-A We have been collaborating with medtech start-ups for several years. In France, we integrate them into our projects by giving them the means to develop – they are stakeholders in the same way as we and our clients. Globally, together with Wayra UK, we launched the Edison Accelerator program in spring 2022 to identify start-ups that could join our AI projects through our collaborative platform.

As for whether we intend to host them on our Buc site in the future, this is not the option we are considering. Another one is emerging that we think is just as promising: reaching out to third-party venues that host them – incubators and accelerators.

In the meantime, we are setting another priority: to review the organization of our site to optimize internal collaborations. An issue that is close to my heart. Even before the health crisis and the lockdowns, we had begun by introducing the principles of teleworking. Since then, the situation has prompted us to accelerate the movement by initiating a reflection on how to best meet the needs of all our employees, from the youngest to the most experienced.

As a reminder, of the 2,800 or so employees of GE Healthcare in France, no fewer than 1,800 are located at the Buc site, including 600 in R&D (researchers and engineers) and 350 in production. This shows what is at stake in this reorganization.

High-tech start-ups

Alongside the large groups and SMEs present in the region, many start-ups have emerged over the past ten years. They are strongly represented in the **biotech** sector, particularly in innovative therapies – immunotherapy, oncology vaccines, new therapeutic molecules. They can also be found in the **medtech** sector through various applications such as *in vitro* diagnostics, bioengineering, remote medical monitoring or the development of exoskeletons.

Among the most emblematic biotech start-ups are **Cell for Cure**, a spin-off from the pharmaceutical group LFB, which has since been acquired by Novartis and whose innovative therapies are now at the origin of numerous personalized immunotherapy strategies, and **H-immune**, a spin-off from the CEA, which has been acquired by HIFIBIO Therapeutics, the world leader in the discovery of therapeutic antibodies. In medtech, **TheraPanacea**, **VitaDX** or **EG 427** are representative of the Paris-Saclay cluster. The start-up **Wandercraft**, created by three students from the École polytechnique, has developed the first autonomous walking robotic exoskeleton.

These start-ups have been able to benefit from the many places dedicated to innovation and the creation of innovative companies within Paris-Saclay. Incubators are run by the schools in the region: the **X-UP** incubator, Pépinière **X-Tech** at the École polytechnique, the **503 Entrepreneurship and Innovation Centre** at the Institut d'optique, and the **CentraleSupélec** incubator. Accelerators and incubators emanate from public or private structures: **IncubAlliance**, **WILCO**, **SATT Paris-Saclay**. Ilabs and fablabs are also dedicated to the development of innovative technologies, as well as large-scale bioclusters such as **Genopole**, the first biocluster in France dedicated to biotherapies, genetics and genomics research, and the Cancer Campus developed around the Institut Gustave Roussy.

NEARLY
100
START-UPS
CREATED
IN THE HEALTH
SECTOR
SINCE 2010

especially in the biotech
and medtech sectors

Start-ups
benefit from
numerous
places
dedicated to
innovation and
the creation
of innovative
companies
within the Paris-
Saclay plateau

Paris-Saclay SPRING, the innovation meeting place

Launched in 2019 and organized annually, Paris-Saclay SPRING has established itself as the true showcase of scientific and technological innovation in the Paris region. With more than 2,000 innovation professionals and as many business meetings organized, the event gives a glimpse of innovation where it takes place on a daily basis and ensures broad promotion of the entire Paris-Saclay ecosystem, particularly the most promising start-ups from the six strategic sectors of Paris-Saclay.

• **fig. 6** Maximilien Richly (left), CEO of the start-up Lumedix at the Paris-Saclay SPRING 2019 event.



TheraPanacea, a French medtech nugget

Created in 2017, the start-up TheraPanacea is an example of successful synergy between academic, industrial and clinical fields and scientific disciplines. At the origin of this French medtech nugget: Nikos Paragios, a professor of applied mathematics at CentraleSupélec, is now the company's CEO. He has spent more than ten years conducting research at CentraleSupélec and Inria (the French national institute for research in digital science and technology), and has been involved in a technology maturation program financed by Paris-Saclay TTO. TheraPanacea develops cutting-edge radiation therapy software

at the interface between mathematics, physics and artificial intelligence for smarter cancer diagnosis, prognosis and treatment. The company has historical links with the Institut Gustave Roussy, and is currently working with a number of partners including GE Healthcare and the American giant Biogen. It is also part of the AI DReAM consortium, which brings together clinical sites, research centers, SMEs and start-ups, with a view to accelerating the development and structuring of the national artificial intelligence sector in medical imaging. Since its creation, TheraPanacea has won prestigious awards and distinctions,

including the *Proof of Concept Grant* from the European Research Council (ERC), the digital innovation competition and the i-Lab competition from Bpifrance, the Grands Prix d'Innovation from the City of Paris and the H2020 - SME Instrument Phase 2 award for the most disruptive European companies in their market.



• **fig. 7** TheraPanacea develops advanced radiation therapy software for smarter cancer diagnosis and treatment.

Clinical medicine ranked number 1 in France

At the end of the chain, clinical trials conducted in hospitals help optimize medical and pharmaceutical innovations. In this respect, Paris-Saclay has exceptional hospitals in research and clinical medicine. According to the famous Shanghai Academic Ranking of World Universities, the University of Paris-Saclay is ranked first in clinical medicine in France.

The sector brings together, at the gateway to Paris-Saclay, major university hospitals, in particular **Université Paris-Saclay hospitals** (Antoine-Béclère, Bicêtre, Paul-Brousse) and the **Paris Île-de-France Ouest university hospitals** (Raymond-Poincaré, Berck, Ambroise-Paré, Sainte-Périne), which in 2019 will form the **University of Paris-Saclay university hospital group**. It also includes historical training centers, such as the **faculties of medicine and pharmacy** within Paris-Saclay University. The **Institut Gustave Roussy**, Europe's first Cancer Campus, and the **Groupe Hospitalier Nord-Essonne**, which have agreements with the region's universities, complete this major complex.

1ST

**PLACE
IN CLINICAL
MEDICINE IN
FRANCE FOR
PARIS-SACLAY
UNIVERSITY**

according to the
Shanghai Academic
Ranking of World
Universities (ARWU)

Paris-Saclay has exceptional hospitals
in research and clinical medicine

• **fig. 8** The Institut Gustave Roussy is the leading European cancer center and the fifth best cancer hospital in the world.



The new Paris-Saclay Hospital, a unique place combining excellent care, research and innovation

Currently under construction in the Corbeville district, the new hospital is being built by the Groupe Hospitalier Nord-Essonne, a structure that gathers all the hospitals in the north of the Essonne region, located in Longjumeau, Orsay and Juvisy. It will open its doors in 2024 and will offer an approach of excellence in care, research and innovation. The 45,000m² building will have 473 beds and places with 90% single rooms, 10 operating theaters, medical, surgical and acute medicine services: intensive care, cardiology and neurovascular intensive care. In addition, to respond to epidemic crises, the new hospital will have a dedicated infectious disease unit and a crisis unit.

A maternity ward will also be integrated into the project to accommodate 3,000 births per year. The emergency department will be able to accommodate 85,000 visits per year. The range of services will be geared towards outpatient care and innovative medical techniques. On the research side, the direct proximity with the French Atomic Energy and Alternative Energies Commission (CEA), which will set up a new research building near the chosen site, will facilitate a joint clinical research dynamic. The future hospital will also house a student health center to meet the demand for care and will carry out an innovative adolescent and young adult psychiatry project while continuing its role as a local hospital.

fig.9 The Simone Veil - Medecine faculty in 2019, is a training and research unit that has been attached to the University of Versailles Saint-Quentin-en-Yvelines since 2001.

The Institut Gustave Roussy, European leader in the fight against cancer

The Institut Gustave Roussy is the leading European cancer center and the fifth best cancer hospital in the world according to *Newsweek* magazine. The Institut Gustave Roussy is a healthcare, research and teaching institute that treats more than 46,000 patients each year with all types of cancer, with internationally recognized expertise in rare cancers and complex tumors. With 22% of its patients included in clinical trials, the Institute has developed a unique model of integrated research. It includes basic research, translational research and clinical research activities, which are sources of therapeutic innovations and diagnostic advances. Its work,

which focuses mainly on personalized medicine, immunotherapy and DNA repair, makes it the leading European center for personalized medicine and immunotherapy. In terms of teaching, Gustave Roussy trains professionals in tomorrow's oncology through the School of Cancer Sciences, which is attached to Paris-Saclay University. The Institut Gustave Roussy is also home to the Doctoral School of Oncology, the only monothematic doctoral school for oncology in France.

1ST
EUROPEAN
CANCER CAMPUS



INTERVIEW WITH MARIO SPERANZA

DIRECTOR OF THE UNIVERSITÉ PARIS-SACLAY GRADUATE SCHOOL OF PUBLIC HEALTH

A multidisciplinary doctoral school to train public health specialists



Operated by the faculties of medicine of Université Paris-Saclay and the University of Versailles Saint-Quentin-en-Yvelines (UVSQ), Inserm and the CNRS, the *Graduate School* of Public Health offers several training courses, including two master's degrees in public health and ethics, and a doctoral school. It has a total of 15,000 students, including 500 in master's programs, 150 doctoral students, and 700 training and research professionals. Its director,

Mario Speranza, tells us more about its particularities and its interactions with the stakeholders of the Paris-Saclay health sector.

Could you begin by characterizing your *Graduate School* and its particularities?

MS A first particularity is that public health is situated at the interface of science, health and society. This is an important difference from other specialized fields. This is our strength and our fragility. Our strength lies in the fact that we are indispensable partners in current discussions on all scientific research issues related to health, such as the impact on people's living environment, the energy transition or sustainable development. We are also directly involved in evaluating innovations in the medical field, at both national and international level. As for our fragility, this is due to the fact that public health still appears as one variable among others.

How do the ambitions of your *Graduate School* translate into research?

MS Our *Graduate School* of Public Health addresses major issues in physical and mental health across the lifespan, including psychiatry, infection- and environment-related diseases, cancer, chronic diseases, pharmacoepidemiology, ethics, primary care and prevention. Our multidisciplinary research mobilizes fields as diverse as epidemiology, biostatistics, clinical research and human and social sciences. It is based on large cohorts or health databases, on qualitative or mixed studies. It uses a range of advanced analysis methods, integrating large-scale biostatistics and promoting reflection on the ethical problems posed by medical and scientific advances.

“Our multidisciplinary research mobilizes fields as diverse as epidemiology, biostatistics, clinical research, and human and social sciences.”

The *Graduate School* was created before the health crisis. To what extent did this reinforce your initial biases?

MS It reinforced our approach to public health in terms of decision-making. The implementation of decision-making models is more necessary than ever, as is the evaluation of health systems. For me as a psychiatrist, and head of an Inserm team in child and adolescent psychiatry, it has also highlighted the major issues surrounding mental health, previously considered as a secondary variable of general health. I would add that several research projects were launched during the epidemic, including the national EpiCov cohort, which were able to contribute to knowledge about COVID-19 from an epidemiological perspective.

FOR what professional fields are the students of your *Graduate School* destined? Do you have the ambition to identify new professions?

MS Our doctoral school's primary vocation is to provide training in public health methodology applied to several specialized fields, ranging from cancerology to oncology, from radiology to psychiatry. To do this, it mobilizes specialists from different

fields who use methodologies that are adapted to the scientific objectives targeted and in line with the public health perspective: descriptive and analytical epidemiology methodologies to understand the causes of phenomena, but also evaluative epidemiology methodologies, which are currently under development (they concern the evaluation of interventions and care organizations).

You are part of the Université Paris-Saclay, which is part of an innovation ecosystem. What are your interactions with the stakeholders of this ecosystem: academics, companies, start-ups, investors, and so on?

MS Our work is intended to be applicable in the short or medium term, whether for prevention, care or the organization of health systems. Also, close collaborations exist with many players in society (hospitals, health agencies, ministries and public institutions, NGOs, private companies), mobilizing an important network of relations with prestigious European and international institutes.

“Close collaborations exist with many players in society: hospitals, health agencies, ministries and public institutions, NGOs, private companies.”

Your question is nevertheless at the heart of discussions that we have held within the Graduate School as to how far to push the partnership approach with private players. Several of our teams involve technological developments in pharmacoepidemiology or oncology. They are naturally oriented towards partnerships with industrialists. Data from national and international cohorts with tens or even hundreds of thousands of participants could be made available to private players for clinical studies. But health data is in the public domain. It is important to ensure proper use and to anticipate the impact of the results. As scientists and academics, we value the integrity of publications and the uses to which research results may be put. As soon as we publish work based on our cohorts, we have an ethical duty to evaluate the impact in societal terms.

Within Université Paris-Saclay, we have exchanges with several other *Graduate Schools*, in particular with the Computer Science and Digital Sciences Graduate School. There is a specific synergy to be developed in terms of the scientific appreciation of our cohorts *via* the contributions that data science experts (and start-ups) can offer with regard to the digitization and automation of health data with a possible development of disease prediction algorithms.

We are also very interested in the Paris-Saclay PASREL Hub project, which aims to make scientific innovation available to hospitals in the Paris region, as close as possible to patients' needs. We could be involved in scientific developments in the evaluation of innovations and the implementation of scientific strategies applied to large numbers in health.

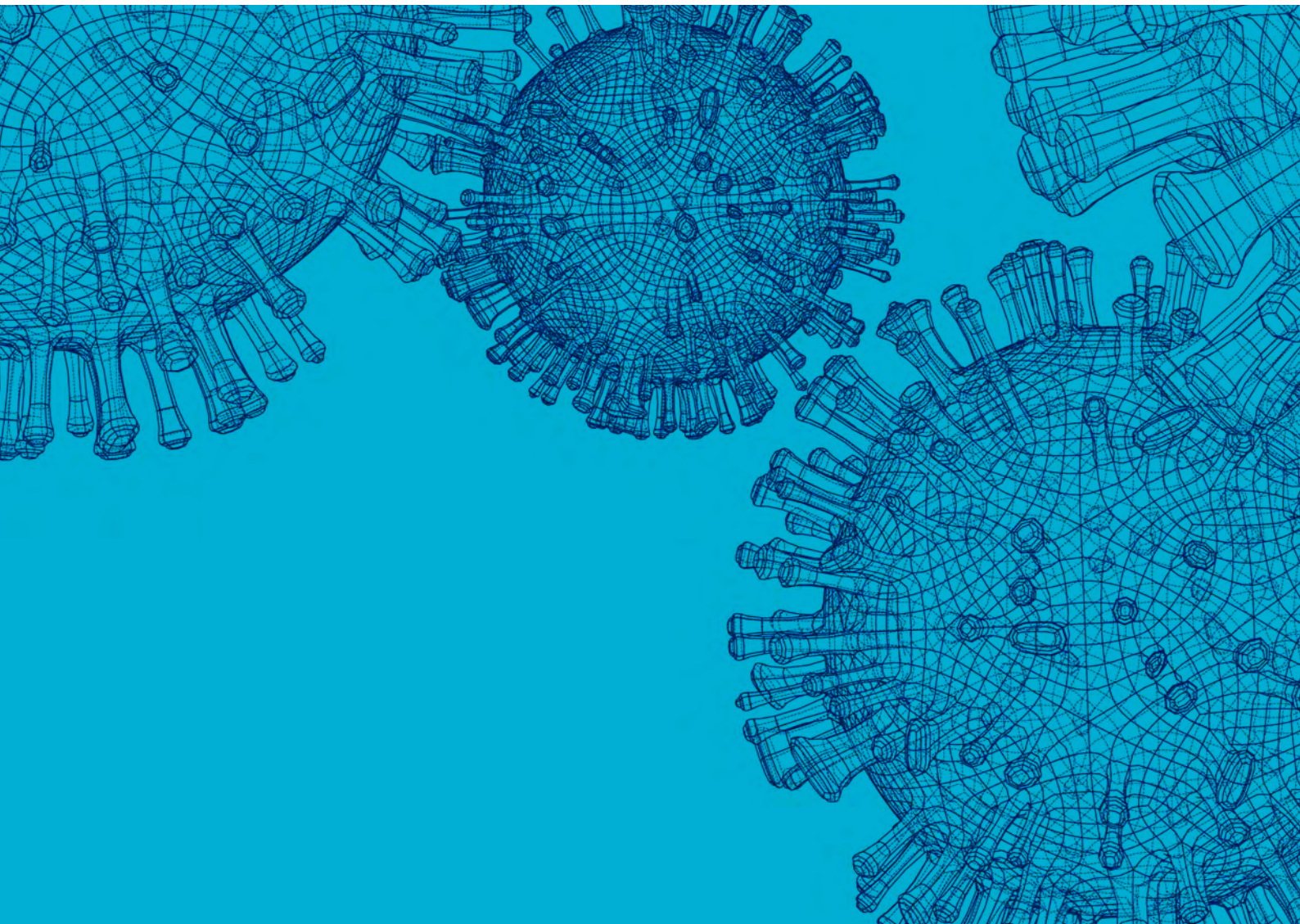
A word about the Paris-Saclay Hospital under construction in the Corbeville district, which aims to be open to the innovation ecosystem...

MS This is a project we are following with interest. I have great hopes for the digital medicine to which it will contribute. This is a unique opportunity to create innovative interfaces between science and health.

In the end, do you perceive a Paris-Saclay ecosystem effect?

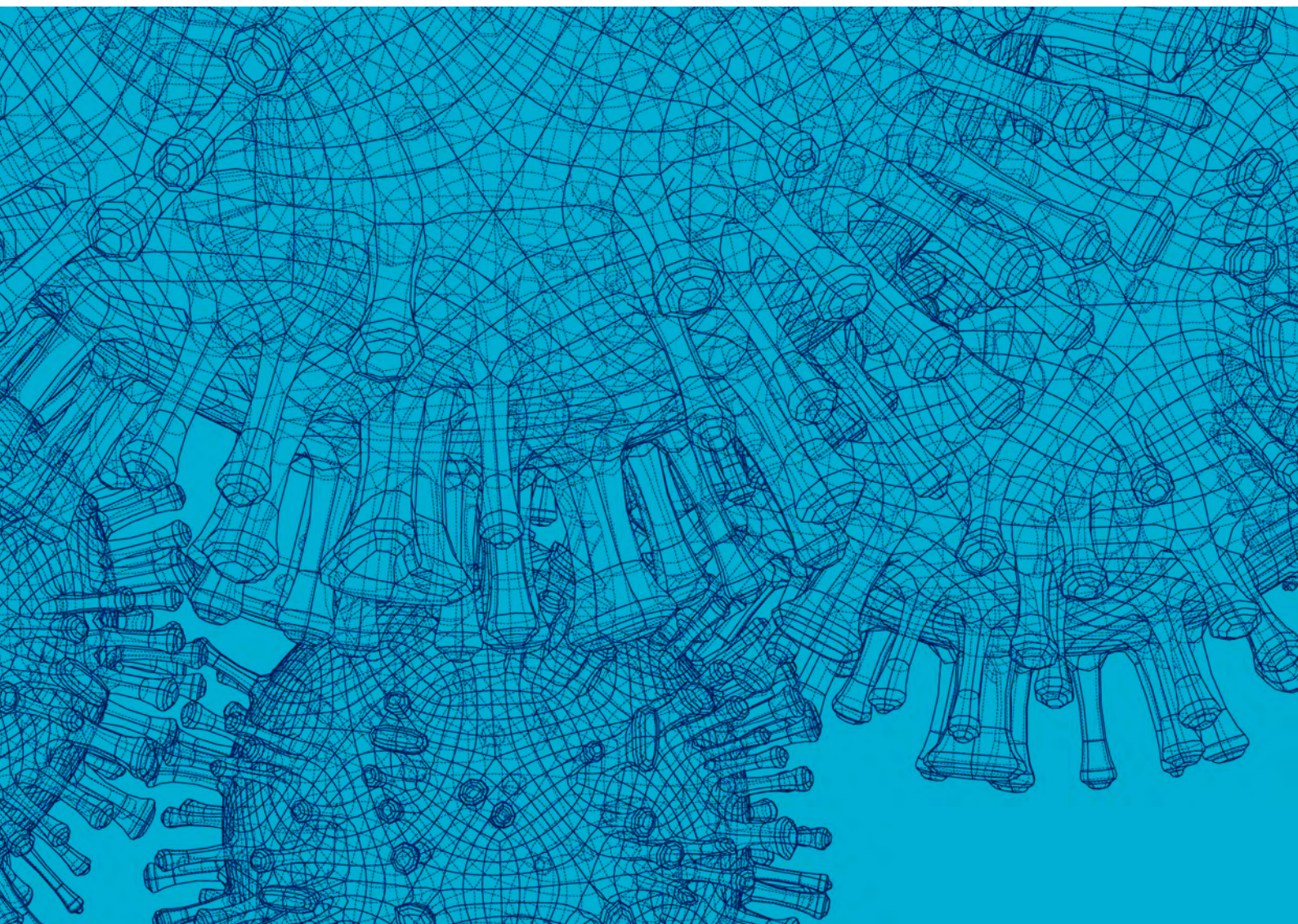
MS Undeniably. It is an ambitious project that is already being reflected in numerous initiatives. Its potential is such that it is sometimes dizzying! The number of requests for help is endless. It would probably be better to prioritize them. Despite the persistence of decision-making layers, things are moving forward. We should mention the EUGLOH European University project, which brings together several European universities, including Paris-Saclay, around the concept of global health. This project could represent a major contribution to an integrated vision of the health of the future, at the intersection of several fields - research, innovation, ethics, societal issues and health organizations.

Positioning in the key technologies of today and tomorrow



In the early 2000s, Leroy Hood, an American biologist and co-founder of the Institute for Systems Biology, defined the future of global medicine around the notion of 4 Ps: Personalized to take into account the patient's genetic and epigenetic profile, Preventive to encourage lifestyle changes to prevent disease, Predictive to develop treatments that delay or even prevent the onset of a disease, and Participatory to involve the patient more in managing his or her health. These major medical issues have been recognized worldwide for more than twenty years. They have changed little today and are at the heart of the innovations developed within the Paris-Saclay science and technology cluster.

These issues will shape the major trends in the medicine of tomorrow. The Paris-Saclay healthcare cluster is a leader in many of these fields, including gene therapy, regenerative medicine, microbiota and immunotherapy, and is strongly and strategically positioned in current and future key technologies.



Representation of key health sectors

With regard to the players present in Paris-Saclay, four major areas of activity in the health sector stand out as anchors for the sector in the region.

The pharmaceutical sector includes, alongside the two leaders of the French industry - **Sanofi** and **Servier** - big names such as **Ipsen**, **LFB**, **Merck** and **Novartis**. The French Association of Life Sciences Service and Innovation Companies (AFSSI), the leading French R&D center with 271 member companies in France, is also represented by the companies **Delpharm**, **Oncodesign** and **Drugabilis**.

With Université Paris-Saclay ranking first in France in biotechnology according to the Shanghai AWRU ranking, the biotech sector stands out for its large numbers of start-ups. **Theranexus**, **Eukarys**, **LPS BioSciences**, **Plasmabiotics**, **PEP-Therapy**, **Synelix** ... The Paris-Saclay cluster is home to some of the most innovative young companies in immunotherapy, oncology vaccines and the development of new therapeutic molecules.

Start-ups in the medtech field are also strongly represented with companies such as **Lumedix**, **Morphee +**, **Sensome**, **Cardiologs**, **Ximo** and **Myndblue**. They work alongside major groups such as **Carmat**, which is developing the first self-regulating bioprosthetic artificial heart, as well as **GE Healthcare**, **Abbott** and **Hitachi**.

The Paris-Saclay cluster is home to some of the most innovative young companies in immunotherapy, oncology vaccines and the development of new therapeutic molecules

• **fig. 10** The MetaGenoPolis biobank, a fully robotized system for storing several hundred thousand samples at -80°.

4 MAJOR FIELDS OF ACTIVITY REPRESENTED IN THE PARIS-SACLAY REGION

Pharma

The pharma sector covers the research, manufacturing and marketing of drugs and therapeutic solutions, in particular based on preclinical trials and clinical research (*Drug Discovery*).

Medtech

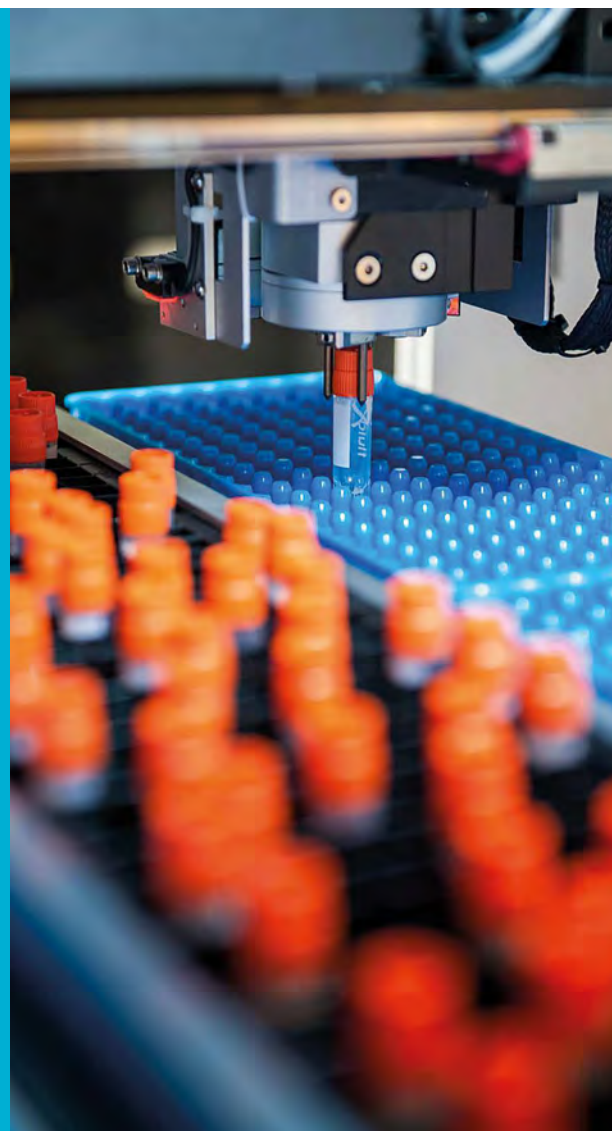
The medtech sector refers to all companies developing medical devices or diagnostic and decision-support solutions: medical imaging, remote medical monitoring, implantable or digital therapeutic devices, and exoskeleton development.

Biotech

Biotech brings together companies developing innovative therapies and processes in the fields of microbiology, biochemistry, biophysics, genetics and molecular biology, and more generally in life science engineering.

Instrumentation

Finally, instrumentation refers to the development of hospital equipment or medical research devices. It operates at the crossroads of various disciplines, including optics, microscopy, physics, biology, imaging, nuclear medicine and radiology.



Finally, instrumentation is particularly well represented by leading companies such as **Horiba**, **Air Liquide Healthcare**, **ThermoFisher Scientific**, **Dupont** and **Fujirebio**.

The medicine of the future is being invented in Paris-Saclay

Immunotherapy, gene therapy, regenerative medicine, microbiota, bioengineering, health data analysis, telemedicine, the Internet of Things, virtual and augmented reality, and artificial intelligence: these ten research areas will structure the industry worldwide in the coming years. In each of these areas, the Paris-Saclay cluster plays a leading role.

In the field of **gene therapy**, for example, the plateau includes major research organizations such as **Genethon**, a pioneering gene therapy laboratory dedicated to the design of gene therapy drugs for rare diseases. Several companies are also working in this field of future medicine, including large groups such as **Sanofi**, with research focused on rare blood diseases. High-tech start-ups complete this sector, such as **Yposkesi**, a spin-off from Genethon, which is now the leader in the production of viral vectors for gene therapy, **Bluebirdbio**, whose worldwide success in the treatment of b-thalassemia stems from a vector developed jointly by the CEA and Harvard, and **EG 427**. Not to mention **Genopole**, France's first biocluster dedicated to biotherapies and research in genetics and genomics.

TOMORROW'S MEDICINE MEANS

10

KEY TRENDS

- Immunotherapy
- Gene therapy
- Regenerative medicine
- Microbiota
- Bioengineering
- Health data analysis
- Telemedicine
- Internet of Things
- Virtual and augmented reality
- Artificial intelligence



• **fig. 11** The Japanese group Horiba, a specialist in the manufacture of analysis and measurement instruments, is located in Palaiseau.

Some of these players are also developing strong expertise in **regenerative medicine**, a field of research focused on the repair, replacement or regeneration of cells, tissues or organs. Within the **Institute for Biotherapies**, **Genethon**, the **Institute of Myology** and **I-Stem**, today leaders in the research and development of biotherapies, are working on these therapeutic innovations. The **Cell for Cure** industrial platform, located in Les Ulis, is one of the first and largest in Europe for the production of cell and gene therapy drugs. As for the national consortium of therapeutic innovations based on induced pluripotent stem cells and human tissue engineering, INGESTEM, it is composed of five research teams, two of which are from Paris-Saclay: **ESTeam Paris-Saclay** and **I-Stem**.

The last significant example is the importance of the Paris-Saclay cluster, which is at the forefront of research on **microbiota**. In this field, the ecosystem counts among its researchers the world opinion leader in the field, Joël Doré.

Paris-Saclay includes major research organizations such as Genethon, a pioneering gene therapy laboratory

EG 427, a pioneering gene therapy start-up

Founded in 2019 around a gene therapy for the treatment of neurogenic bladder, EG 427 is a pioneering biotech company in Europe. This innovation was born of a meeting in 2013 between researchers with complementary skills from the Raymond-Poincaré Hospital in Garches, the University of Versailles Saint-Quentin-en-Yvelines and the CNRS. Together, they created a research team to propose a new gene therapy based on the exploitation of the herpes virus for the treatment of neurogenic bladder, a urinary disorder of neurological origin affecting paraplegic or quadriplegic people suffering from spinal cord injuries.

After three years of research and a maturation program financed by SATT Paris-Saclay, EG 427 was created around Philippe Chambon, a venture capital expert in the field of biotechnology and today CEO of the company. With a €12 million Series A round of financing completed in 2021, a loan from Bpifrance and awards such as the i-Lab prize, EG 427 is pursuing ambitious goals, including first clinical trials in neurogenic bladder as early as 2023 and the development of a platform of novel precision gene therapies for multiple neurological pathologies.



He is a researcher in intestinal microbial ecology at the Micalis Institute, which has created numerous start-ups, including Enterome, Maat Pharma and NovoBiome. He is also scientific director of **MetaGenoPolis**, a center of excellence in microbiota analysis.

Université Paris-Saclay is particularly involved in this field of research with its institutions **AgroParisTech**, **INRAE** (National Research Institute for Agriculture, Food and the Environment) and the **University of Versailles Saint-Quentin-en-Yvelines**. On the corporate side, **Sanofi** has developed, in collaboration with INRAE, the Microbiosys range of food supplements, **Ipsen**, probiotic-based food supplements and **Danone** is developing cutting-edge research on probiotics and preventive medicine. Among the start-ups in the sector, we can mention **Diotheris**. The result of work by researchers at the University of Versailles Saint-Quentin-en-Yvelines, Inserm and the Raymond-Poincaré and Ambroise-Paré Hospitals, the young company is developing an innovative nasal probiotic against staphylococcus aureus.

The Paris-Saclay cluster is at the forefront of microbiota research

• **fig. 12** Manipulation under a fume hood in a laboratory of the MetaGenoPolis unit in Jouy-en-Josas.

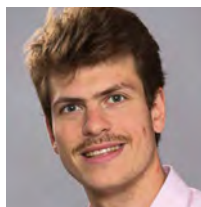
MetaGenoPolis, a global center of excellence in microbiota analysis

MetaGenoPolis is a pre-industrial demonstrator financed by the Programme d'investissements d'avenir (PIA), an INRAE unit dedicated to research on human and animal microbiota applied to nutrition and health. It brings together a leading interdisciplinary team. Today, MetaGenoPolis is a world reference for standardized protocols and is internationally recognized for its expertise in gut microbiota analysis. It is developing

a revolutionary scientific approach that explores the billions of bacteria present in the human gut to reveal how they affect human health. The ambition: to develop new products and components, prognoses and diagnoses for health and well-being. As part of its mission, MetaGenoPolis is developing numerous collaborations with research laboratories, industrial partners and start-ups in the region.

INTERVIEW WITH MAURICE LUBETZKI
CEO AND CO-FOUNDER OF THE START-UP EPILAB

A flagship medtech start-up produced by the Paris-Saclay ecosystem



Founded in 2020 and currently housed at the Drahi - X Novation Center (École polytechnique campus), EpiLab proposes to revolutionize testing for the treatment of tuberculosis. Its CEO and co-founder, Maurice Lubetzki, tells us more about what predisposed him to launch himself in medtech, at the heart of the Paris-Saclay ecosystem.

If you had to pitch EpiLab?

ML EpiLab was born out of a realization: before COVID-19, tuberculosis was still the number one infectious disease in the world, with 10 million new cases and 1.5 million deaths each year. Therapeutic solutions exist to detect this disease and are well known to the WHO, which has documented them. But in the countries of the South - the most affected, with 80% of cases - none of them allows a test to be carried out as close as possible to the patient, due to the lack of infrastructure and of qualified health personnel in sufficient numbers. With my partner Clément Dubois, we therefore set out to develop a less expensive and easy-to-implement solution - a miniaturized and automated test - using a patent filed by two researchers from the University of Burgundy and INRAE, Murielle Rochelet and Élodie Barbier. Clément is a graduate of the CentraleSupélec and has a master's degree in biotechnology; I am a graduate of Arts et Métiers and have set up a previous company. We bring our engineering expertise and experience in managing the hardware aspect of the project.

How did you end up at the Drahi - X Novation Center?

ML Very quickly, we went in search of an incubator to tackle the prototyping phase in the best conditions, in a deeptech environment. So we applied to the X program and were selected - we were one of the five winners out of about 100 applications. We have been there for two years, after having gone through X'Up, the acceleration structure (nine months), and then X Tech, the start-up maturation structure. In the meantime, our workforce has grown from four to a dozen people.

Looking back, what advantages would you highlight in being at the Drahi - X Novation Center?

ML I would highlight at least three. First, the credibility that comes from being located on the Ecole polytechnique campus. It makes it easier for us to find partners, funding and recruitment.

“The fact that we are present in Paris-Saclay gives us obvious visibility with investors and potential partners.”

Secondly, the human and technological resources to which it gives access: its fablab, which enables us to produce our prototypes using the latest generation of 3D printing machines; a nearby laboratory where we can carry out experiments on microphysical chips under the conditions of the R&D departments of major groups, which enables us to reduce costs significantly; and another, for microbiology, which is very close by, where we can carry out our tests directly. Finally, the third advantage: agility. Something essential when you know that a start-up needs to identify problems and mobilize resources accordingly to explore original avenues in the shortest possible time.

What are the avenues in this case?

ML At a disciplinary level, we started by investing in microbiology, electrochemistry (for the detection of tuberculosis from an electric current) and mechanical design before realizing that these fields were too

limited compared with our ambitions. This is how we came to invest the field of microphysics. To do this, we were able to use the École polytechnique network to identify microfluidic researchers and PhD students who were facing similar problems to ours. Little by little, we managed to prototype a microfluidic technology, even though neither Clément nor I had any expertise in this field.

What technological barriers have you overcome?

ML One of the first is biological. The sample we take from the patient has physicochemical characteristics: it has a different level of viscosity from one patient to another. It is therefore complicated to homogenize the characteristics. One approach is to use a chemical decoction that will penetrate the sputum sample and homogenize it. Then, we must allow our tests to be robust. Easier said than done, because we have to prototype the same way every time. However, the dimensions of the test are so small that extremely precise prototyping tools are required. Hence the prototyping issues I mentioned.

The campus is located in the heart of the Paris-Saclay ecosystem. What are the benefits for you?

ML It gives us obvious visibility with investors and potential partners. If we were in Paris Center, we would be one medtech among many others. Here, we are “the” medtech of the Drahi - X Novation Center...

Reassure us, there are many others?

ML Yes, indeed, but let's say that the ecosystem is still far from creating as many as the one in Paris, which is more software-oriented, admittedly. However, for a company like ours, which is in a disruptive technology, without yet making any sales, it is essential to gain visibility, to quickly demonstrate your ability to innovate to investors.

“Within the Paris-Saclay cluster, everyone knows each other. There is a real community of researchers, start-ups and investors.”

Being here makes even more sense because most of our employees come from the ecosystem and not just from Ecole polytechnique. Our R&D manager, Manon Giraud, and mentors are attached to the Center for Nanoscience and Nanotechnology (C2N). And Paris-Saclay is constantly attracting new players. Look at the Servier laboratory, which collaborates with BioLabs, a leading start-up accelerator. I don't see why we would go to Paris when we can stay here to develop our project.

Finally, here, everyone knows each other: there is a real community of researchers, start-ups and investors. Mutual aid is not an empty phrase. When we encounter a problem, we can submit it to others, including industrial sectors - many of them use hardware technology that is quite similar.

A word about the future hospital being built in the Corbeville district...

ML We hope that EpiLab will take off well before the inauguration of this hospital group! Having said that, I have high hopes for the latter to evolve the interactions between the different players. In France, we are still struggling to promote collaboration between the public and private spheres, particularly in the field of health. In the United States, and in many other countries, teaching hospitals have a long history of collaboration with private laboratories. It's no wonder that medtech giants have chosen to set up shop in Boston. Integrating a local hospital center focused on clinical research into an innovation ecosystem is necessarily a plus, provided that it is open to innovation, which is precisely the ambition of the future Paris-Saclay Hospital. If it could treat patients and in addition foster the clinical pathway to new technologies, everyone would win.

A strong growth dynamic



With the wealth and diversity of its players, the density of skills deployed and a significant cross-disciplinary approach that has led to major scientific discoveries and some of the most disruptive innovations, Paris-Saclay is at the heart of tomorrow's healthcare challenges. These assets have already enabled it to be at the origin of major medical and technological advances. They attract world-renowned scientists to the region and foster a very strong dynamic in the creation of start-ups at the cutting edge of technology. This synergy between players, skills and scientific disciplines has led to the creation of large-scale collaborative projects at the interface of academic, industrial and clinical fields. They will be a source of major progress in the future.



The mammography machine, a revolution in screening

In 1965, when the Compagnie Générale de Radiologie (Thomson CGR) marketed the first large-scale mammography machine, modern mammography was born. One of its goals was to replace the X-ray mammography system. Since the company was acquired by GE Healthcare in 1987, its Buc site in the Yvelines region of France has been home to a global center of excellence for interventional imaging, mammography and advanced visualization software. In the 1990s, GE Healthcare continued to innovate with this technology by developing the first digital mammography with a 3D visualization system. In 2016, GE Healthcare launched a next-generation mammography system: the Senographe Pristina platform. In an effort to encourage early detection, the mammography experience was completely redesigned for a more comfortable and engaging screening experience. Today, GE Healthcare remains the world leader in mammography from its Buc site.



Inventions that have made history

Major pharmaceutical, technological and medical advances have taken place in Paris-Saclay. These include: **proton therapy**, with the first particle accelerator created by Frédéric Joliot in 1937 and installed at Orsay in 1950, the first **mammography machine** in 1965 for breast cancer screening, **Taxol** in 1980, used in chemotherapy, and **lasers** for precision surgery in 1985 for the treatment of brain tumors or eye operations. The treatment of allergies by **skin patch** was also invented by the biotech company DBV Technologies, created in 2002 and incubated at IncubAlliance in Orsay. **Gene therapy** for spinal muscular atrophy is the result of an initial patent filed by a Genethon team. Finally, we should mention **Fibrinogen**, a purified human plasma derivative indicated in the management of patients with a rare genetic coagulation, developed by LFB in 2009, or **Iseult**, the most powerful MRI in the world, developed by CEA in 2017.

• **fig. 13** Among the inventions originating from Paris-Saclay that have left their mark on history, the mammography machine is a major medical advance in breast cancer screening.

1950

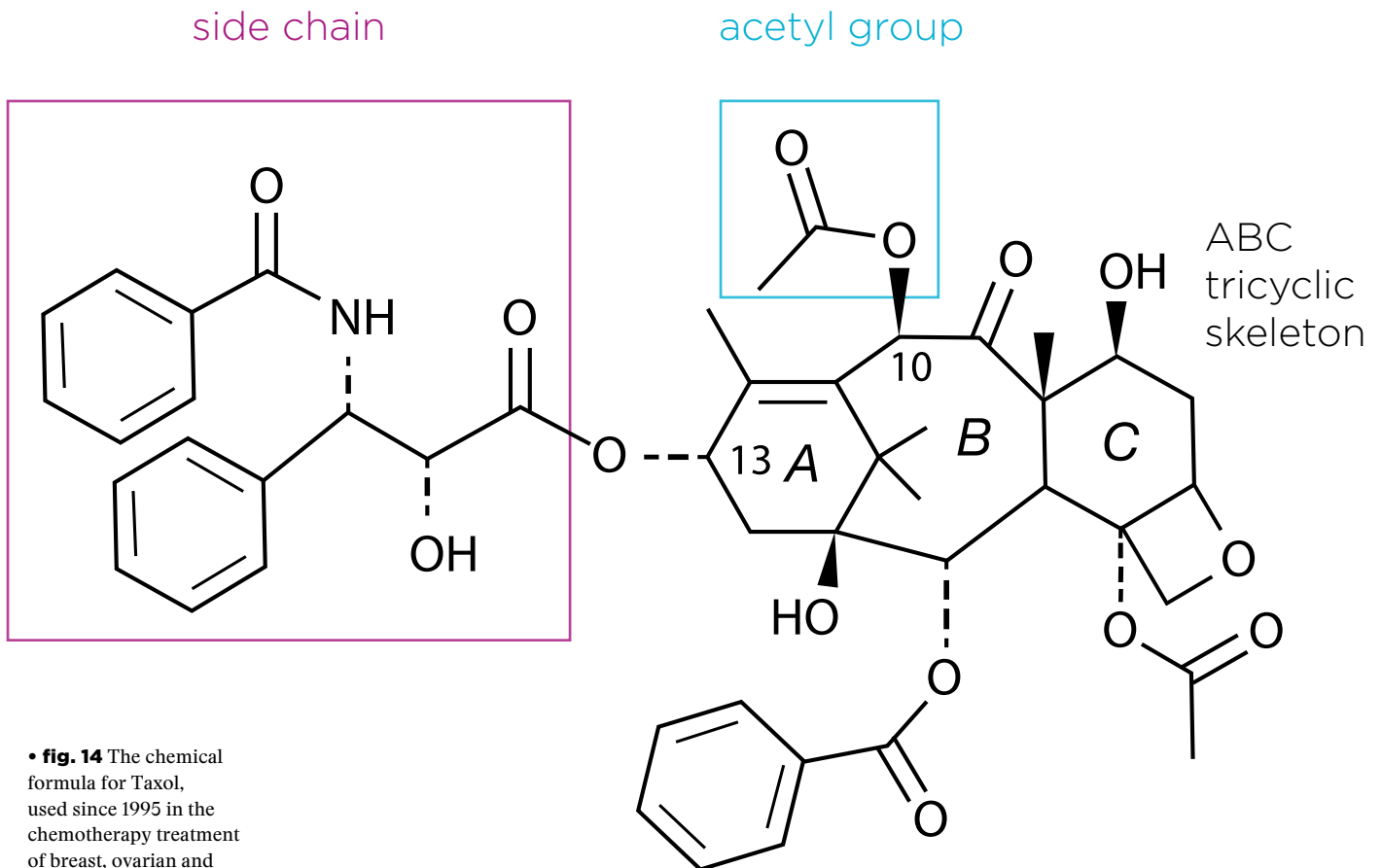
INSTALLATION OF
THE FIRST PARTICLE
ACCELERATOR AT ORSAY

1965

FIRST MAMMOGRAPHY
MACHINE USED FOR
BREAST CANCER SCREENING

1980

FIRST USE OF TAXOL
IN CHEMOTHERAPY



• **fig. 14** The chemical formula for Taxol, used since 1995 in the chemotherapy treatment of breast, ovarian and lung cancers.

Taxol, a new treatment in chemotherapy

Taxol, a revolutionary drug molecule used in chemotherapy, is the result of a discovery by the Institut de chimie des substances naturelles (ICSN) located in Gif-sur-Yvette. This invention is based on the discovery in the 1960s and 1970s of the anti-cancer properties of Pacific yew bark extract in a large study conducted by the US National Cancer Institute (NCI). In 1971, paclitaxel, the active molecule, was isolated. On this basis, in 1980, the team of Pierre Potier, then director of the ICSN, extracted the precursor

of paclitaxel from the leaves of the European yew, *Taxus baccata*, or 10-deacetyl-baccatin III, and discovered the process for synthesizing it in large quantities. At the same time, the team isolated a new molecule, docetaxel, known as Taxotere, which was twice as active. Taxol has been used since 1995 in the chemotherapy treatment of breast, ovarian and lung cancers. It has been listed as an essential drug by the World Health Organization (WHO) since 2013.

Major pharmaceutical, technological and medical advances have taken place in Paris-Saclay

1985

THE LASER IS USED FOR
PRECISION SURGERY

2002

TREATMENT OF ALLERGIES
BY SKIN PATCH

2017

DEVELOPMENT BY THE CEA
OF THE MOST POWERFUL
MRI IN THE WORLD

Talents of international stature

Attracted by world-class research institutions and laboratories, as well as by the prospect of collaborating with both prestigious researchers and leading industrialists, an increasing number of world-renowned scientists are joining the Paris-Saclay academic cluster. According to the *Highly Cited Researchers* ranking, which lists the world's most cited scientists each year, France is in eighth place with **36 scientists in the top 1% of their discipline** at Université Paris-Saclay. Ten of them are attached to the Paris-Saclay Faculty of Medicine, mainly cancer specialists. **Fabrice André**, an oncologist specializing in breast cancer, professor of medicine and director of research at the Institut Gustave Roussy, is one of these researchers recognized worldwide by his peers. He is renowned for his treatment of cancers using personalized therapy and is one of the 25 most influential people in the field of precision medicine.

36

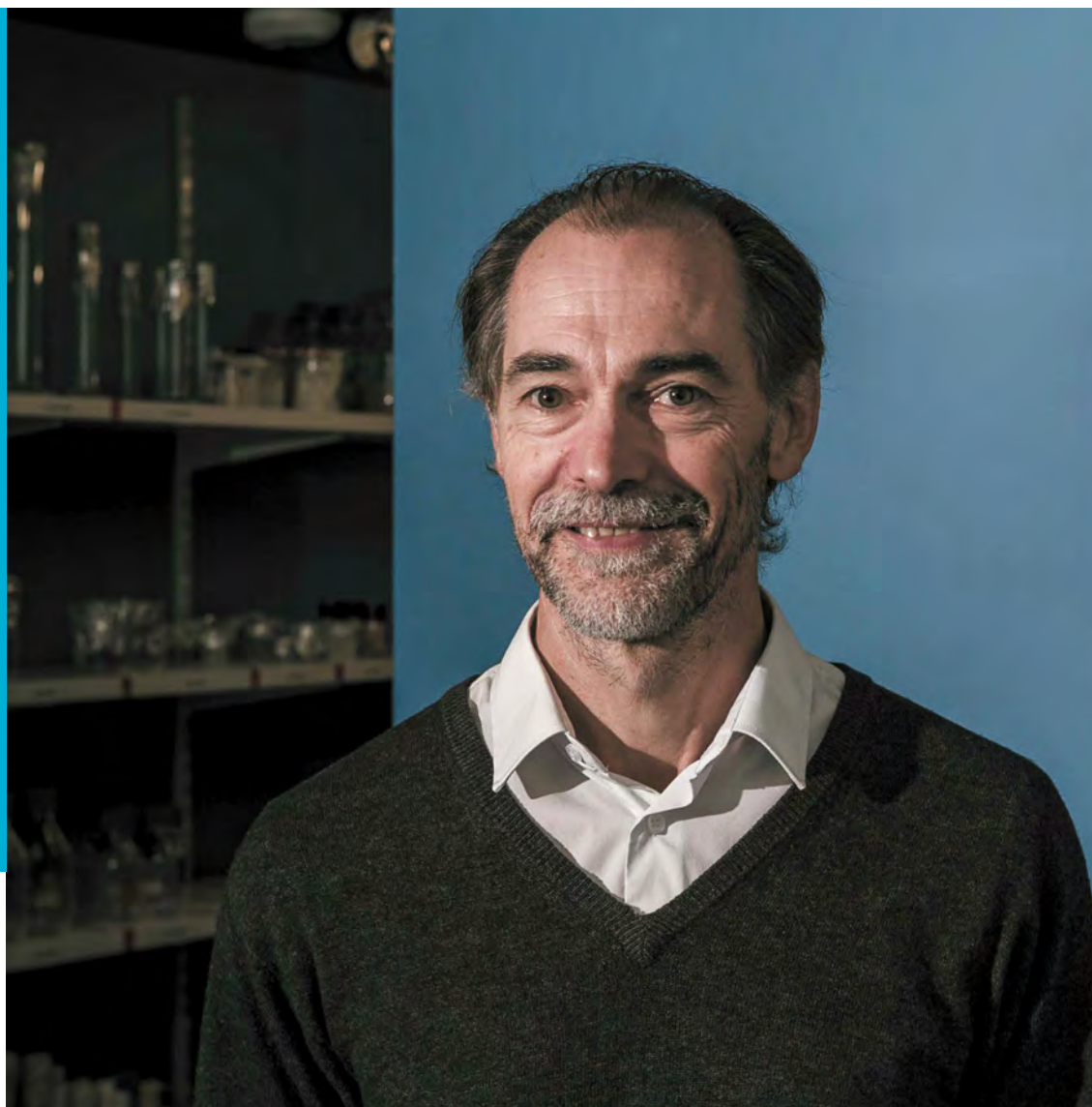
**SCIENTISTS
IN THE TOP
1% OF THEIR
DISCIPLINE**

Within Université Paris-Saclay according to the *Highly Cited Researchers* ranking, which places France in eighth place.

Joël Doré, world leader in microbiota research

Joël Doré joined INRAE more than 30 years ago after obtaining a PhD from the University of Illinois (USA). Today, he is the world's leading specialist in food and gut microbiology. A researcher at the Micalis Institute, research director at INRAE and scientific director of the MetaGenoPolis center of excellence, he has discovered the links between intestinal microbiota and certain chronic, neurodegenerative or neuropsychiatric diseases, including autism. He has developed these discoveries into numerous diagnostic and therapeutic applications, co-founding several start-ups including Enterome, Maat Pharma and NovoBiome.

• **fig. 15** Joël Doré, Research Director of the Micalis Institute, Scientific Director of the MetaGenoPolis unit and world leader in microbiota research.



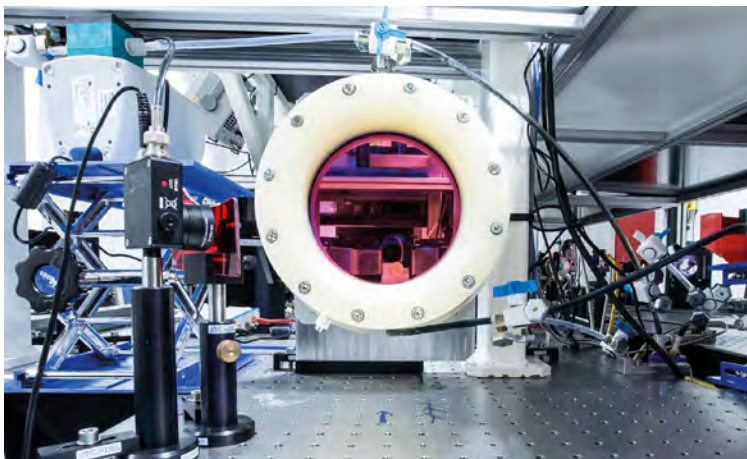
Laurence Zitvogel, a clinical oncologist at the Institut Gustave Roussy and professor of immunology at the Université Paris-Saclay, is internationally recognized for her major discoveries in the field of cancer microbiota. Actively contributing to the advancement of cancer research, particularly in the fields of immunology and immunotherapy, she is one of the most cited women in the world by **Clarivate analytics**. Other major academic figures contribute to the prestige of the Paris-Saclay cluster. These include: **Abdul Bakar**, a researcher at the École polytechnique in cellular and cardiovascular engineering, distinguished for his work on intelligent stents, **Patrick Couvreur**, a professor at Université Paris-Saclay and a specialist in medical nanotechnologies, **Joël Doré**, the world leader in microbiota research, and Nobel Prize winner **Gérard Mourou**.

Ten of the most cited scientists in their discipline are attached to the Paris-Saclay Faculty of Medicine

Gérard Mourou, Nobel Prize for Physics

After spending a large part of his career in the United States, particularly at the University of Michigan, Gérard Mourou returned to France in 2005 to direct the Applied Optics Laboratory shared by the École Nationale Supérieure de Techniques Avancées (Ensta ParisTech), the CNRS and the École Polytechnique. He is behind two major initiatives in the field of power lasers in France: the launch of the XCAN demonstrator at the École polytechnique and, in 2007, the creation of the Institut de la lumière extrême (ILE), whose objective is to build the first 10-petawatt femtosecond laser, called Apollon. In 2018, he received

the Nobel Prize for Physics with Canadian Donna Strickland and American Arthur Ashkin for their method of generating ultra-short, high-intensity optical pulses (laser amplification technique known as Chirped Pulse Amplification), whose applications in the medical field, particularly in refractive eye surgery, treatment of myopia, cataracts or brain tumors are now widely highlighted.



• **fig. 16** The Apollon laser, a major scientific project involving several laboratories of the École polytechnique (LULI, LSI, LOA and LLR) during its construction.

• **fig. 17** Gérard Mourou, Nobel Prize winner for physics in his laboratory at the École polytechnique.

An exponential innovation dynamic

With ten companies created in 2010, fourteen in 2015 and nearly thirty in 2019, the pace of start-up creation continues to accelerate and illustrates the immense vitality of innovation in Paris-Saclay. In total, over the past ten years, nearly one hundred high-tech healthcare start-ups have been initiated, incubated or established in the region. Among the latest companies developed: **Diotheris, Sonio, Ezymbio, Findimmune, Kimialys, ShareConfrère** and **Omini**. They are involved in a wide range of applications, from new therapeutic solutions to telemedicine supports, as well as new diagnostic, decision support and mobility tools. This dynamism of creation is largely the result of the structuring of the health sector over the last ten years. Higher education institutions, basic research organizations, applied research institutes, and companies: the exceptional concentration of resources and partners present on the Paris-Saclay ecosystem makes it one of the most attractive innovation clusters for investors, innovators, and entrepreneurs from around the world.

Over the past ten years, nearly one hundred high-tech healthcare start-ups have been initiated, incubated or established in the Paris-Saclay region

Start-ups in the region

Over the past ten years, the pace and number of start-ups created in Paris-Saclay has continued to accelerate, illustrating the strong innovation dynamic of the ecosystem in the health sector.

2010-2011

2012-2013

2014-2015





• **fig. 18** The start-up VitaDX offers software solutions for the early diagnosis of bladder cancer.

VitaDX, an emblematic start-up at the heart of the Paris-Saclay ecosystem

Founded in 2015 around software solutions for early cancer diagnosis, VitaDX is another example of these emblematic start-ups created and developed in Paris-Saclay. Its patented technology combining imaging and artificial intelligence is based on research conducted by researchers at the Orsay Institute of Molecular Sciences (ISMO, UMR CNRS and Université Paris-Saclay) and practitioners at the Bicêtre University Hospital (AP-HP). The company, which is incubated at Genopole, has developed its first

solution in collaboration with Onera as part of a maturation program supported by Paris-Saclay TTO. Using software that integrates *machine* and *deep learning* algorithms, it enables early diagnosis of bladder cancer. After a large-scale clinical trial and a clinical test study, the company obtained CE marking at the end of 2021, allowing it to launch its commercialization throughout Europe. A promising first application for a growing company.

2016-2017

2018-2019



The Paris-Saclay Playground, the new totem of innovation

EPA Paris-Saclay is committed to creating places that encourage networking and synergies. The latest addition, the Paris-Saclay Playground, which opened in October 2021, is intended to be a totem of innovation and entrepreneurship in the Paris-Saclay cluster. This 6,000 m² Playground an Incubator-Nursery & business Hotel (IPHE) was developed in partnership with the local authorities and Université Paris-Saclay. It aims to anchor local innovators by offering them incubation, acceleration and animation programs and more than 700 workstations.

INTERVIEW WITH CATHERINE BOULE

MANAGING PARTNER IN THE MANAGEMENT COMPANY KARISTA

Investing in the growth of start-ups in the ecosystem

Founded in late 2001, Karista is a French management company specializing in venture capital. In the spring of 2021, it invested in MyPL, a start-up from Paris-Saclay, which was part of the 2022 edition of SPRING 50*. Beyond the reasons for this choice, Catherine Boule, Managing Partner, testifies to her interest in the Paris-Saclay ecosystem.

If you had to pitch Karista?

cb Karista is a French management company, specialized in venture capital investment. Although anchored in the Paris region since its creation twenty years ago, Karista now projects itself on a French and even European scale. We invest in all sectors of digital and deeptech innovation, with a particular interest in healthcare, which represents around 40% of our investments. We have recently created a fund dedicated to digital health, with 50 million euros, whose purpose is to invest in young e-health companies raising funds in the seed or series A phase. Our investments range from 500,000 euros to 1.5 million euros for the first ticket and per company.

What do the Paris-Saclay start-ups represent in your portfolio?

cb Being identified as a well-established investment fund in the venture capital landscape, we receive a large number of applications, the majority of which are from start-ups in the Paris region, including several from the Paris-Saclay ecosystem. This is only natural, given the number of research institutions and engineers present in this ecosystem or linked to it, including in the health sector.

“We invest in all sectors of digital and deeptech innovation, with a particular interest in healthcare, which represents around 40% of our investments.”

Among the best known is DBV Technologies, which develops products for the diagnosis and treatment of food allergies – one of the first French biotechs to be listed on Nasdaq. More recently, we invested in MyPL (*My Personnel Lifescope*), which has developed a platform to collect and process data on cancer patients to facilitate decision-making in multidisciplinary consultation meetings, where doctors meet across specialties to diagnose and decide on treatments. This is a major challenge given the difficulty of obtaining this data and, therefore, of making good decisions in a short time.

MyPL, one of the start-ups selected for the 2022 edition of SPRING 50...

cb This doesn't surprise me, given what is at stake with its solution. Because of the increase in the life expectancy of patients, cancer has become a chronic

disease: the patient has a high risk of relapse or recurrence in another organ. However, each cancer has its own follow-up and treatment, knowing that the same category of cancer can be broken down into different variants that require specific responses. At the same time, the diversification of therapeutic solutions makes decision-making even more complicated. By making it possible to cross-reference all available data on a patient, MyPL meets a real need. Its solution can be of interest to physicians, pharmaceutical companies, *Clinical Research Organizations* and medical equipment manufacturers.

So many players present in Paris-Saclay... Does it make sense to talk about a health sector within this ecosystem?

CS There is no doubt that the cluster concentrates many research and innovation skills and capabilities. Does all this make for a sector? It is not so much the number of players and their diversity that determines its existence: it is still necessary for all these players to interact and develop synergies. This seems to be the case here in Paris-Saclay, judging by the massive investments that are being made. The arrival of the Servier laboratories, synonymous with additional skills, whether in research or innovation, is a case in point. As for the two university clusters, Université Paris-Saclay and IP Paris, they can only reinforce the attractiveness of Paris-Saclay in the eyes of industrialists and investors.

Do you follow the news of the future Paris-Saclay Hospital, under construction in the Corbeville district?

CS Even if there are already hospitals nearby, it is clear that this project, with its ambition to build bridges between clinical research and innovation, can only strengthen the ambitions of Paris-Saclay in the field of health, if there were any doubts about its potential. It represents an additional asset in the context of competition between innovation ecosystems on a global scale. A context that condemns us to never rest on our laurels!

* SPRING 50 is a selection of around 50 start-ups with the characteristics of tomorrow's nuggets, in one of the following six themes: FoodTech, greentech, mobility, health, biotech, digital technologies. Among them, half, five per theme, are invited to pitch in English during Paris-Saclay SPRING event (the others have a stand in the innovation village organized the same day).

Interdisciplinarity, collaboration and synergies for a future-oriented medicine

Among the innovative projects that will shape the medicine of tomorrow, the **Paris-Saclay Cancer Cluster** (PSCC) was officially launched on February 4, 2022. Unique in Europe for its size and scope, it will position France among the world leaders in tomorrow's cancer research by bringing together the expertise of the main players in oncology innovation: hospitals, universities, industry and start-ups. This high-potential ecosystem, co-founded by the Institut Gustave Roussy, Université Paris-Saclay, Sanofi, Inserm and IP Paris, aims to accelerate innovation in treatments, care pathways and quality of life for personalized medicine and new customized cancer treatments. It is based on four pillars: a collaborative, synergistic and interdisciplinary mode to share knowledge and create links between researchers, practitioners, academics, entrepreneurs, industrialists, but also investors and patients; a collaborative platform with a single point of access to experts; a technical platform with services and accelerating technologies; and state-of-the-art data storage and analysis infrastructures incorporating artificial intelligence. The Paris-Saclay Cancer Cluster will host all the players involved in the fight against cancer in a totem building: the **Oncology Prospective Center**.

Feb. 4 2022

OFFICIAL LAUNCH OF THE PARIS-SACLAY CANCER CLUSTER

co-founded by the
Institut Gustave Roussy,
Paris-Saclay University,
Sanofi, Inserm and the
Polytechnic Institute
of Paris



The PASREL project for the integration of innovation in hospitals

The PASREL project aims to link research, hospitals and industry to accelerate technological development and the deployment of innovations for the benefit of patients. The ambition is to promote dialog between disciplines and research communities by creating, within Paris-Saclay University, a large interdisciplinary network, positioned in six *Graduate Schools* of the University. In 2026, a PASREL building will be

constructed in the immediate vicinity of the future Paris-Saclay Hospital, which will bring together the services of the three hospitals of the Groupe Hospitalier Nord-Essonne (Orsay, Juvisy-sur-Orge and Longjumeau). A true showcase for the technologies developed at Paris-Saclay and an open collaborative platform, it will be dedicated to the integration of innovation in the hospital environment. It will house the teams

and equipment of the Frédéric Joliot Hospital Service, host academic and industrial research teams in the field of innovative technologies for medical research and organizational innovation in health, offer training at the interface of engineering sciences and medicine, and welcome the general public for exhibitions, conferences and open days. This complex will be a true pilot for the hospital of the future.



INTERVIEW WITH BENJAMIN GAREL

EXECUTIVE DIRECTOR OF PARIS-SACLAY CANCER CLUSTER

Accelerating the innovation process to fight cancer



In June 2021, the President of the Republic had announced the creation of the Council of Trust and Security Industries (CICS). In February 2022, Paris-Saclay Cancer Cluster was officially created as an association in the presence of the Ministers for Solidarity and Health, Higher Education, Research and Innovation, and representatives of the five founding members: Sanofi, Gustave Roussy, IP Paris and Université Paris-Saclay. Its general manager, a former director of Martinique University Hospital, tells us more about its ambitions and operating methods.

Can you begin by reminding us of the ambition of the Paris-Saclay Cancer Cluster?

BG It is to contribute to the fight against cancer which, even today, claims many victims in the world, about 10 million per year. Although important advances have been made, for some cancers, people are still waiting for new therapies. For pancreatic cancer, for example, there are still no effective treatments. The goal of the Paris-Saclay Cancer Cluster (PSCC) is therefore to accelerate the innovation process while reducing the cost of developing therapeutic solutions. Even today, it takes an investment of around one billion euros over twenty years to develop a new molecule. Paris-Saclay Cancer Cluster aims to accelerate the maturation of innovative projects led by industrial companies, research laboratories, and also biotech, medtech and e-tech companies and start-ups specialized in data. At a disciplinary level, it aims to cover expertise ranging from biology to medicine, including bioinformatics and the use of artificial intelligence.

With the idea of encouraging a collaborative approach?

BG Yes, collaborative, synergistic and interdisciplinary: whether they are researchers, practitioners, entrepreneurs, academics, industrialists or investors, our members are called upon to evolve mainly in the vicinity of Gustave RoussyHOSPITAL. However, we are not starting from scratch: a cluster already exists in the sense that researchers and start-ups are already working closely together, with premises at Gustave RoussyHOSPITAL. With Paris-Saclay Cancer Cluster, it is a matter of moving to a different scale. By joining our association, these various players have access to multidisciplinary, scientific and medical experts; to excellence training as well as to a multi-skilled mentoring offer; to a specialized technical platform bringing together a unique combination of research equipment, specialized support services to accelerate proof of concepts and easy access to samples; to consolidated and enriched specialized data, on the one hand, deep and longitudinal data from several sources, and on the other hand, to the infrastructures necessary for their storage and analysis.

How many members does your association have?

BG We have set ourselves the goal of quickly welcoming 80 and then around 200 by 2027.

“Cluster”: a notion that more than ever has negative connotations in the context of the health crisis. And yet, you display it in your acronym.

BG Yes, because we understand it in its classic sense: an aggregation of different players concentrated in one place, to promote synergies in the sense of open, collaborative innovation. This crisis has clearly shown how decisive the capacity for innovation is to face the situation and preserve the country's sovereignty in the therapeutic field as well as in drug production. The president of the association is none other than Eric Vivier: professor at the Assistance Publique Hôpitaux de Marseille, Aix-Marseille University, and a specialist in cancer immunology. He also has an entrepreneurial profile: he is one of the founders of Innate Pharma, a clinical-stage biotech company specialized in immuno-oncology.

Why Paris-Saclay? Because you became convinced that the ecosystem had the necessary skills for innovation in cancer?

BG Indeed, Paris-Saclay is a more than favorable breeding ground within and around Gustave Roussy HOSPITAL. Of course, other establishments of the Assistance Publique des Hôpitaux de Paris (AP-HP) or the Institut Curie are also at the forefront of research and innovation. But they don't have as much space as we do, so we invite them to join us. The 80 hectares at our disposal will allow the construction of several hundred thousand m² for delivery in 2024. A dedicated building will be at the heart of the Paris-Saclay Cancer Cluster: the Oncology Prospective Center. This project will promote cooperation between public and private players in the development of new molecules.

Do you have any international references in mind?

BG Yes, of course. Several references exist in the world from which we drew inspiration, starting with Kendall Square, in Boston, between MIT and Harvard: with its 2 million m² of private laboratories, spread over 6 km², it alone generates several billion euros of innovation in all sectors of health, and many biotech start-ups are born there every year. All the big names in the pharmaceutical industry are located there. Our ambition is to create nothing less than an equivalent of Kendall Square, in the specific field of oncology.

What predisposed you to take part in this adventure as General Manager?

BG Before joining the Paris-Saclay Cancer Cluster, I directed Martinique University Hospital. I was able to measure how the ability to innovate therapeutically was decisive in giving hope to patients. Before directing this university hospital, I was involved in setting up competitiveness clusters. This gave me a dual expertise, which is very useful for the position I now hold, in addition to convincing me of the need to strengthen the links between academic research and the pharmaceutical industry. This is precisely the vocation of the Paris-Saclay Cancer Cluster.

“A dedicated building will be at the heart of the Paris-Saclay Cancer Cluster: the Oncology Prospective Center. It will promote cooperation between public and private players in the development of new molecules.”

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