



# ANNUAL REPORT 2020

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## 09 COVID-19 REPORT ON RESPONSE AND ACHIEVEMENTS IN 2020

Institut Pasteur scientists used scanning electron microscopy to examine the virus' strategy of attack. Shown here is a sample of bronchial cells grown in culture and colored in blue-green. In orange, the SARS-CoV-2 coronavirus. Photo unveiled in September 2020.



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# PROFILE

The Institut Pasteur is committed to conducting outstanding research to improve global health. It is a non-profit foundation with recognized charitable status, and its missions are to help prevent and treat diseases, mainly those of infectious origin, through research, public health, education and training, and the development of research applications.

 **€357.5**  
million budget in 2020

 **2,802**  
staff members (as at 12/31/2020)

 **75**  
nationalities (as at 12/31/2020)

**1,343**  
papers published in 2020

Source: *Web of Science* (articles, early access articles, reviews and letters excluding preprints, extraction from April 14, 2021).

 **139**  
research structures including 98 research units, 20 five-year groups (G5s), 5 five-year units (U5s), 9 laboratories, 7 Hearing Institute teams (as at January 1, 2021)

 **25**  
research support services and technological platforms

 **33**  
member institutes of the Institut Pasteur International Network

Institut Pasteur researchers strive year on year to advance science and improve human health

## NOBEL PRIZES

1 Nobel laureate  
(10 laureates since 1907)

## CNRS MEDALS

2 gold medals  
6 silver medals  
8 bronze medals awarded by the CNRS

## OTHER FRENCH AWARDS

3 Grand Prix for Medical Research awarded by Inserm  
6 Research Prizes awarded by the Allianz/Institut de France Foundation  
1 Émile Jungfleisch Grand Prix  
2 Cancer Research awards and 1 Grand Prix from the Simone and Cino Del Duca Foundation-Institut de France  
2 Mémain-Pelletier Awards  
11 Prizes awarded by the Schlumberger Foundation for Education and Research

## INTERNATIONAL AWARDS

1 Gairdner Award  
1 Kavli Prize for Neuroscience  
1 Sjöberg Prize from the Royal Swedish Academy  
1 Balzan Prize  
1 Brain Prize  
3 Robert Koch Prize  
3 L'Oréal-UNESCO For Women in Science Awards  
4 Louis-Jeantet Prizes

## EUROPEAN GRANTS

Funding from the European Research Council (ERC)  
26 ERC Starting Grants  
19 ERC Advanced Grants  
10 ERC Consolidator Grants  
2 ERC Proof of Concept Grants

## APPOINTMENTS

5 members of the US National Academy of Sciences, Washington (USA)  
4 members of the British Royal Society  
39 members of EMBO (European Molecular Biology Organization)  
23 members of the French Academy of Sciences

# INTERVIEW

## with Christian Vigouroux

Chairman of the Board of Governors

### What role did the Institut Pasteur play during this year that was so severely impacted by the COVID-19 pandemic?

The Institut Pasteur was fully committed. Of course, having to discontinue the development of one of our vaccine candidates was a setback, but it's something that we need to move on from, and that is what we are doing now, in complete transparency. But the Institut Pasteur gave its all to the COVID response, while continuing to pursue its research in other fields. We maintained our role as a source of expertise, analysis and invention. As always, our focus was on global health and maintaining a dialog between basic research and public health. Our research on the biology of the virus gave rise to new knowledge that will pave the way for future treatments for SARS-CoV-2 and potentially also for other emerging pathogenic viruses.

### Did the Institut Pasteur manage to keep on track this year?

Yes, and what is all the more remarkable is that it had to do so in a dangerous, complicated world, a world that it is committed to serving, but one that also needs convincing at times. The world is indeed a dangerous place, with the risk of contagion that forces us to adopt "social distancing," a discipline that may be necessary but that hardly stirs enthusiasm as it goes entirely against the Pasteurian spirit of openness. And the world is also a complicated place for scientists, who are expected to be inventive but also open to scrutiny, and who have a duty to communicate their findings. They had to respond to hasty comments that were subsequently discredited by experience and results (at the Institut Pasteur we refuse to engage in media speculation), and also

to those who were desperate to see the crisis come to an end as soon as possible, which of course is understandable but is at odds with both the need for precaution and the time required for science and research. We must not forget that there are those who do not appreciate science and do not believe in it – proponents of fake news. Then there are those who do appreciate science but who do not (or no longer) believe in it – those are people we need to win over. There are those who do not appreciate science but who do believe in it – a glimmer of hope. And finally, there are those who, inspired by Louis Pasteur, appreciate science and believe in it, not simply as an act of blind faith but by experimenting, demonstrating, proving and disproving. In 2020, the Institut Pasteur did its very best to support all of these groups, whoever they are. With nearly 15 million page views [up from 9.3 million in 2019], the pasteur.fr website was very popular, especially the fact sheets on COVID-19, influenza and SARS. There was a real need for reliable information during this unsettling period.

### What are the Institut Pasteur's ambitions?

Our ambitions are bold, and they will remain that way. Our primary ambition is science and our commitment to public health, which are two sides of the same coin. No results are ever guaranteed; we saw that in 2020 when we had to discontinue the clinical development of one of our vaccine candidates, the one based on the measles vaccine virus. That is the harsh reality of any scientific endeavor. We have analyzed the reasons for this unsatisfactory result, and the scientists will make further research proposals, potentially also using the same platform, since it has proven to be promising in tackling other pathogens.

We remain absolutely committed. We are continuing the battle against COVID-19. The road is long but we are hopeful of future success. A second ambition is to remain united in upholding the Pasteurian values implemented through the 2019-2023 Strategic Plan. The Board of Governors supports the choices of the management team regarding the priority areas for research, starting with infectious diseases. Despite the pandemic, the Institut Pasteur has pursued its efforts in this area, and I would take this opportunity to pay tribute to the determination of our President and the Institut Pasteur teams in pursuing this basic research, which lays the foundations for our future.

### How will the Institut Pasteur achieve the ambitious objectives in the Strategic Plan?

We have geared up for this challenge in four ways. First, we were able to amend our articles of association. The new version, published on January 12, 2020, extends the term of President to six years, giving future Presidents the time to fully implement their ambitions; it makes the Scientific Council more accountable to external scrutiny and modernizes our funding principles, while maintaining the Institut Pasteur's unique structure with the General Meeting and the election of the Board of Governors. Second, in early 2021 we extended the current term of President Stewart Cole through 2022 and 2023 to give him the opportunity to successfully complete the reforms he has begun. Third, we are determined to focus our energies on the Strategic Plan – adjusting it here and there if necessary – and to continue to develop the interdisciplinarity and freedom of research which characterize the Institut Pasteur. And finally, we are committed – with the help of all those



**“Our cohesion serves our ambition, namely to further develop the extraordinary scientific spirit that drives the Institut Pasteur. Our Strategic Plan is effective and relevant.”**

who support us – to maintaining robust, sound finances. Failing to do so would weaken our independence.

### What conditions need to be in place for the Institut Pasteur to achieve these ambitions?

Support both from and to our partners is vital for our success. In 2020, we conducted epidemiological studies with hospital partners and with the support of local authorities, like in Crépy-en-Valois. Our scientific research is often carried out with academic and university partners. And we must not forget our many donors, sponsors and legators, generous partners who place their trust in us and without whom many of our activities simply could not happen. Our future depends on them.

### What areas is the Board of Governors paying particular attention to?

There are many. I would mention five in particular.

- Above all, we need to make choices that will safeguard the Institut Pasteur's unparalleled scientific quality, in terms of priority scientific areas, people and programs;
- in the coming years, the Institut Pasteur will have to adapt to ongoing changes in the way science is organized in France and Europe. We need to maintain our successful partnerships with Université de Paris, the Fondation Pour l'Audition, the Paris Public Hospital Network (AP-HP), Sanofi and others;
- we need to capitalize on the International Network in a more cooperative way;
- we need to manage and develop our resources as effectively as possible;
- and lastly, importantly, we need to maintain and build on our ability to step off the beaten track, to dare to be different, to take unexpected steps, with the right to make mistakes but also a duty to strive for success. The Institut Pasteur needs to surprise and amaze us.

### What is your hope for the future?

I want to see the Institut Pasteur remain committed to fulfilling the wish expressed by Émile Duclaux in a letter to his wife Mary, around the year 1900: to "keep moving" in the face of "all prejudice and routine, refusing to compromise" for the benefit of science.



# INTERVIEW

with **Professor Stewart Cole**  
President

## 2020 was dominated by the COVID-19 pandemic. What can you say about this eventful year?

At the end of 2019, I would never have thought that we would spend 2020 in the throes of a pandemic. It must be said that part of the scientific community, without basing their conclusions on verified data, underestimated the full devastating impact of coronavirus SARS-CoV-2. This is a timely reminder of the importance of the Pasteurian values of humility and modesty. When we look at the sheer scale of the damage caused in both economic and health terms, it is clear that no other virus has had such a shattering effect on the world since 1918 [Spanish influenza]. It wouldn't be an exaggeration to say that 2020 was a disaster for humanity but also a triumph for science and research. In record time, scientists in the public and private sectors developed a variety of different responses with the potential for large-scale rollout. It is thanks to this extraordinary effort by science and industry, which must be applauded, that we have hope today. The scientific community worldwide, including the teams from the Institut Pasteur in Paris and the Institut Pasteur International Network, stepped up to the task.

## Which of the Institut Pasteur's achievements particularly stick in your mind?

We can be proud of our basic research to help understand the biology of the virus, for example using microscopy to visualize the fusion of cells infected with SARS-CoV-2 and the way in which it destroys the cilia in the lungs. In terms of diagnostics, the PCR test developed by our National Reference Center was available to French university hospitals in February 2020, and we devised

serological assays and antigen tests. We have been at the forefront in modeling the epidemic and carrying out large-scale epidemiological field studies. When it comes to therapeutics, we formed a group to assess antiviral strategies, and back in May 2020 we identified molecules that target cell functions with a key role in the viral cycle, thanks to an international collaborative effort. Even in the field of vaccines, we can be proud of our efforts. Of course, we had to stop the development of one of our candidates based on the measles vaccine because the immune responses induced were not strong enough. In scientific terms it was the only reasonable decision for us to take. We are now analyzing the results obtained in detail to try to understand why this was the case, and if our analysis suggests that it is appropriate to do so, we will resume vaccine development with another candidate. Perseverance is a Pasteurian virtue! Other vaccine projects are promising, with encouraging preclinical results for a lentiviral vaccine. Given the global demand and the evolution of the virus, we will need several types of vaccine. Various vaccines have already been authorized worldwide and the vaccine rollout is gaining pace. We should be very satisfied with this as scientists and as Pasteurians, because we are the spokespeople for the Institut Pasteur's scientific and ethical values, especially when it comes to public health and vaccination.

## What other fields has the Institut Pasteur been active in?

Three achievements in 2020 encapsulate our efforts to give new impetus to basic research and to increase its impact on health challenges. The Hearing Institute, a new Institut Pasteur center, was

inaugurated. Several teams are focusing on finding solutions to address hearing loss. With the support of the Fondation Pour l'Audition and the Mairie de Paris, we are currently building a Center for Research and Innovation in Human Audiology (CERIAH) on our campus in the 15th arrondissement, in the Institut Pasteur Medical Center building. Our Innovation Accelerator was also launched in 2020. Four diagnostics and therapeutics projects have already been selected and will be given human and financial resources to bring them to maturity. Over the next five years, on the basis of a rigorous selection process, we will develop several programs aimed at targeting health needs. Finally, in December, the Board of Governors – and I thank them for this – approved the introduction of a support structure for new start-ups, in partnership with the Banque publique d'investissement. This is a new tool that will serve our innovation policy.

## What projects are planned for 2021?

First, to compensate for the impact of the first lockdown on many of our projects, we have extended several fixed-term scientific contracts. In 2021, we will finalize partnership talks with universities to capitalize on the opportunities for science raised by the changing university landscape in France. The Institut Pasteur is also establishing a Department for Philanthropy in France and at the international level. Finally, the COVID-19 crisis demonstrated the importance of communication between scientists and society at large, and the mission of the Department of Communications will be extended to encompass this "scientific outreach" work.



**“We need to persevere and remain true to our values. (...) It is a challenge for us all.”**

## Does the Institut Pasteur have sufficient funds for the challenges that lie ahead?

In 2020, the Institut Pasteur was very successful in raising funds from donations, legacies and sponsorship. In budget terms, we ended the year with a surplus. But given ongoing research needs and development costs in the area of technologies and information systems, our revenues are increasing at a slower pace than our spending. So we are forecasting a deficit in 2021 and we must remain cautious. It is true that we have benefited from an increase of nearly €1 million in our grant from the French government. This is a positive, encouraging sign, but it needs to be confirmed and consolidated in the long term.

## What is your vision for the Institut Pasteur?

We need to persevere and remain true to our values. In our 2019-2023 Strategic Plan, one of the scientific priorities stated was to conduct research into emerging infectious diseases to better anticipate potential future pandemics. We plan to build a new, highly sophisticated facility for this research, which will permit an integrative approach to pathogen-vector-host interactions. We are aiming for a building that is ergonomically designed and energy efficient, with lower greenhouse gas emissions and less light and noise pollution. This will confirm the Institut Pasteur's commitment to the "Paris – Low Carbon" initiative. In this modest way, we will be helping tackle another threat to our planet, namely climate change. I hope that after living through the SARS-CoV-2 pandemic, we are now all aware of the link between biodiversity loss, human disruption of sensitive ecosystems, and emerging infectious diseases. It is a challenge for us all.

# The unity of life. The fragility of our species. The need for knowledge.

**What can we learn from the pandemic? Three truths seem to leap out at us.**

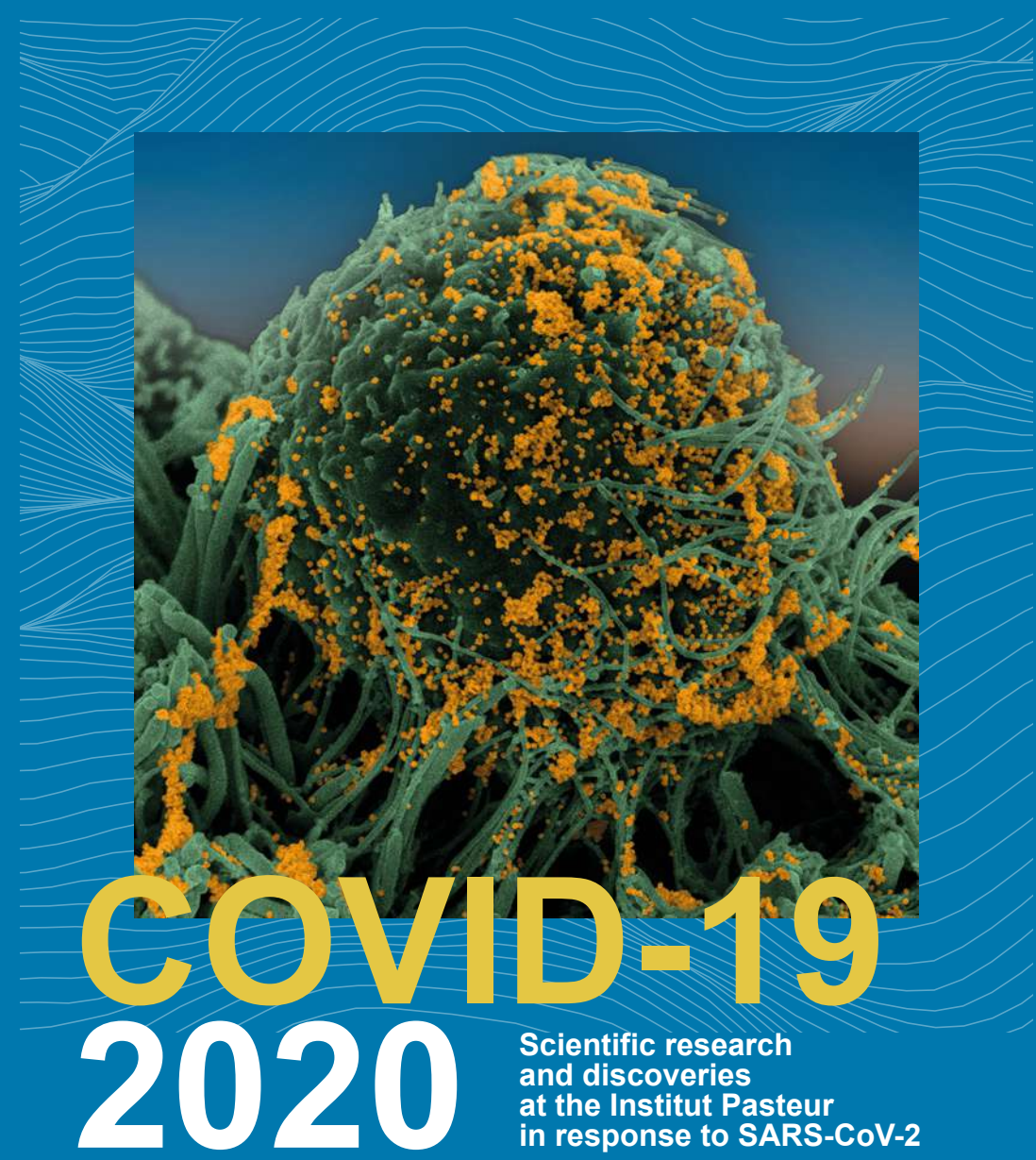
**The first is the unity of life. The second, the fragility of our species** – a fragility that is growing because of climate change.

**The third thing underscored by the pandemic is our need for knowledge.**

It is this truth that is most at risk, given the misinformation currently circulating online and contradicting scientific facts. In light of the first two truths, we need the third – namely, research – more than ever. And that is why I have such admiration for the work of the Institut Pasteur's scientists.

**Why do we need research?** Because life, the unity of life, is limitless in its strategies, and we as humans do not have a monopoly over existence. The mysteries of life are unfathomable, ever changing and infinite. We need research and researchers more than ever. Like Christian Vigouroux, Chairman of the Board of Governors, and Stewart Cole, Institut Pasteur President, I too applauded scientists in 2020 as much as I applauded healthcare workers. For it is scientists, including those at the Institut Pasteur, that lay the foundations for healthcare, upholding the great tradition of Louis Pasteur. So as the Institut Pasteur's Ambassador – or rather, its lowly reporter –, I can affirm how immensely proud I am to stand alongside the humble, determined scientists at the Institut Pasteur. Humility and determination: two qualities that encapsulate the very essence of what it means to be Pasteurian.

**The words of Erik Orsenna, Institut Pasteur Ambassador, at the close of the 2021 New Year ceremony at the Institut Pasteur.**





# COVID-19 2020

Scientific research and discoveries at the Institut Pasteur in response to SARS-CoV-2

These pages are an overview of the information published in the document **SARS-CoV-2, COVID-19 epidemic: the Institut Pasteur's response, scientific research and discoveries in 2020** which can be downloaded on [pasteur.fr](https://pasteur.fr)

On December 31, 2019, the China Country Office of the World Health Organization (WHO) was informed that clustered cases of pneumonia of unknown etiology had been detected in the city of Wuhan, in the Chinese province of Hubei. On January 9, 2020, the Chinese health authorities and WHO announced the discovery of a novel coronavirus, thought to have emerged in Wuhan in December 2019, that was responsible for the outbreak. The date of emergence of the virus in China was subsequently called into question. The coronavirus, named SARS-CoV-2 on February 11, was identified as the agent responsible for a new infectious respiratory disease subsequently named COVID-19 (coronavirus disease 2019). This officially marked the start of an epidemic that would rapidly spread across the globe and would be classified as a pandemic by WHO on March 11, 2020.

## Institut Pasteur at the heart of the national response in France

The Institut Pasteur found itself on the front line of the response in France from the very start of the epidemic, in January 2020. The Institut Pasteur hosts several National Reference Centers (CNRs), designated by the French General Directorate of Health and Santé publique France, which are responsible for monitoring various infectious diseases. These include the CNR for Respiratory Infection Viruses (including Influenza), which had the task of diagnosing, monitoring and analyzing cases of COVID-19 in mainland France as soon as the first cases were suspected. The Laboratory for Urgent Response to Biological Threats (CIBU),

set up in 2001 by the Institut Pasteur with the support of the General Directorate of Health so that it could intervene 24/7 in the event of an outbreak, was immediately mobilized to strengthen the work of the CNR. The first suspected cases in France were identified on January 24, 2020 (source: French Ministry of Health), and the samples taken from these patients were analyzed by the CNR, which confirmed infection with the SARS-CoV-2 virus that by now was sweeping through China, based on the sequence that Chinese scientists had shared with the international scientific community.

## Task force rapidly set up

The Institut Pasteur is a leading global center for infectious disease research, one of the priority research areas identified in its 2019-2023 Strategic Plan. On January 27, 2020, as the 11 million inhabitants of the Chinese city of Wuhan, where COVID-19 had originated, found themselves in a strict lockdown, the Institut Pasteur set up a task force to provide an emergency response to the health crisis by studying the virus and the disease it causes. The task force continues to draw on the expertise of Institut Pasteur scientists in several research fields:

- Knowledge of the virus and its pathogenesis;
- Development of new diagnostic and serological tools;
- Research into therapeutic strategies, including antibody-based approaches;
- Vaccine development;
- Epidemiology and modeling to develop outbreak control strategies.


Around 20 research projects were launched in late January, and 89 projects in total over the whole of 2020.



Time-calibrated phylogenetic tree of 950 SARS-CoV-2 genomes shared freely by the scientific community. The tree's tips are colored according to their sampling date.


Tree inferred and visualized by Nextstrain (Hadfield et al., *Nextstrain: real-time tracking of pathogen evolution*, *Bioinformatics*, 2018).

## The mobilization of the Institut Pasteur

 **450**  
More than 450 scientists from the Institut Pasteur working against COVID-19, in 69 teams

**84**   
"COVID" scientific articles

Source: *Web of Science* (articles, Early Access, Reviews and Letters outside preprint, extract on April 14, 2021)

**19**   
patent-protected inventions for diagnostics, vaccines or potential treatments for SARS-CoV-2 (as of December 2, 2020)

**78**   
contracts signed with industry (figure as of December 2, 2020)

🔗 **A strong involvement of technological platforms in COVID research while maintaining essential activities.**

🔗 **Ongoing support from administrative services to move research forward as quickly as possible.**

🔗 **Tech transfer: 78 collaboration agreements, licenses, service contracts (diagnostics, vaccines, therapeutics) signed with manufacturers** (figure as of December 2, 2020)

🔗 **Calls for research projects to initiate new, more ambitious, multi-team, interdisciplinary projects.**

Sources: Scientific Secretariat General (SGS), Scientific Information Resources Center (CeRIS), Technology Transfer and Industrial Partnership Department (DARRI), Institut Pasteur.

# The major achievements of the Institut Pasteur in 2020



## ➔ The first diagnostic test for patients

In the second half of January, the National Reference Center (CNR) for Respiratory Infection Viruses, which has the general task of monitoring infectious diseases, developed a direct detection test for the coronavirus using a molecular biology method known as RT-qPCR. This test was used to diagnose the first patients in France and was then rolled out in hospitals, serving as a benchmark for the development of other PCR tests in France. In 2020, the Institut Pasteur also developed an RT-LAMP test for rapid diagnosis in 10 to 30 minutes.

See "Progress in diagnostics and epidemiological genomics" (p.15)



## ➔ Phylogenetic analyses and serological assays to describe and map the epidemic

Phylogenetic analyses, like the one performed by the Institut Pasteur in early 2020 on around a hundred patient genomes, help scientists to understand and describe how a virus is introduced in a geographic region (such as France), and how it first circulates. The Institut Pasteur also developed various serological assays, which detect SARS-CoV-2 antibodies in the blood and determine whether an individual has been infected by the virus in the preceding weeks. These serological assays are used to map the spread of the virus in the population, via seroprevalence studies in a given region (in Crépy-en-Valois, at national level, etc.) or cohort monitoring (e.g. among hospital/non-hospital staff from the Institut Curie and the Institut Pasteur in the Curie-O-SA study).

See "Emerging infectious diseases" (p.36) and "Public health" (pp 57-64)



## ➔ Modeling to visualize the evolution and progression of the epidemic

How can we best predict the evolution of the epidemic situation? How can we anticipate the admission of severely ill patients to hospital? Drawing on its expertise in the mathematical modeling of infectious diseases, the Institut Pasteur developed tools to analyze the spread of the epidemic in real time, week after week. The data are regularly updated to improve the accuracy of possible evolutionary scenarios.

See "Progress in epidemiology and modeling" (p.20)



## ➔ Basic research to improve understanding of the coronavirus

Nearly a hundred research projects were launched over the year to shed light on the biology and structure of the SARS-CoV-2 virus, the organs it attacks, the inflammation and neurological signs it causes, the immune response triggered and any potential genetic susceptibility.

See "Improving understanding of SARS-CoV-2 and COVID-19 biology" (p.23)



## ➔ Vaccine candidates to protect the population and curb the spread of the epidemic

Two research programs for vaccine candidates entered preclinical development in 2020 and are continuing in 2021: one vaccine using a lentiviral vector and one DNA vaccine. The Institut Pasteur has decided not to pursue the clinical development of its vaccine candidate based on the measles platform, despite the Phase I clinical trials carried out on the vaccine last August, as the immune responses induced were not strong enough. The scientists involved in the program will analyze the results obtained in more detail to try to understand why this was the case. They will make further research proposals, some of which may be based on the same platform.

See "Vaccinology" priority area of the Strategic Plan in 2020 (p.40)



## ➔ Sharing information with the scientific community to advance knowledge more quickly

On January 29, the Institut Pasteur sequenced the whole genome of SARS-CoV-2. The following day, it deposited the complete sequences of the virus samples taken from two of the first French cases on the GISAID (Global Initiative on Sharing All Influenza Data) platform. This transfer of information between scientists helps the international community to understand more about the evolution and spread of viruses. Since April 1, every day from noon to midnight, the Institut Pasteur has contributed to the task of processing the many SARS-CoV-2 genomes submitted to GISAID (from dozens to hundreds every day worldwide) to validate the quality and reliability of the sequences and their metadata. Again reflecting its ongoing efforts to advance knowledge, Institut Pasteur scientists deposited several preprints (preliminary versions of publications prior to acceptance by the peer review board of a scientific journal) throughout the year, both on the Institut Pasteur open archive and on international open science sites like medRxiv.org and bioRxiv.org.



# COVID-19 2020

Scientific research and discoveries at the Institut Pasteur in response to SARS-CoV-2

The China Country Office of the World Health Organization (WHO) is informed that clustered cases of pneumonia of unknown etiology have been detected in the city of Wuhan, in the Chinese province of Hubei.

DECEMBER 31  
2019

JANUARY  
2020

**Informal discussions on the subject between various members of the Institut Pasteur Senior Management Board at the first meeting of the new year in January.**

JANUARY 7  
2020

China shares the genetic sequence of the novel coronavirus (known for the time being as 2019-nCoV, for "novel coronavirus that emerged in 2019") so that countries can use it to develop specific diagnostic kits.

JANUARY 12  
2020

A first scientific consultation and leadership meeting is held in connection with the first priority research area of the Institut Pasteur's Strategic Plan, "emerging infectious diseases."

JANUARY 22  
2020

**The virus is isolated by the Institut Pasteur.**

JANUARY 27  
2020

First meeting of the Task Force on the novel coronavirus involving leading scientists from the Institut Pasteur in each of the key disciplines and some support departments. From this point on, the Task Force meets every week and sets up thematic groups. The Task Force initiates the first scientific research programs launched by the Institut Pasteur from mid-February 2020.

JANUARY 28  
2020

JANUARY 9  
2020

Chinese authorities and WHO raise the alarm. The CNR for Respiratory Viruses begins to monitor the novel coronavirus in France.

JANUARY 21  
2020

A first Institut Pasteur COVID-19 fact sheet is made available online to inform the public. It is subsequently updated on a regular basis.

JANUARY 24  
2020

**The first samples (from the first imported French cases) arrive at the Institut Pasteur from Bichat Teaching Hospital.**

**An RT-qPCR diagnostic test that had been under development by the CNR for Respiratory Infection Viruses, with information shared with the international community, is ready for use. Detection of the virus is confirmed by the CNR the same evening.**

**"For both SARS-CoV and MERS-CoV, cells known as Vero E6 cells were identified and can be used to culture the two coronaviruses. In January 2020, we brought them out of our collection, which is kept under strictly controlled conditions, so that we would be ready as soon as we detected a positive sample for the 2019-nCoV coronavirus."**

**Sylvie Van der Werf,**  
Director of the National Reference Center (CNR) for Respiratory Infection Viruses at the Institut Pasteur.



## Progress in diagnostics and epidemiological genomics

Some examples of the wide-ranging research at the Institut Pasteur:

- Development of an RT-qPCR diagnostic test by the CNR for Respiratory Infection Viruses
- Deployment of the RT-qPCR test by the CNR in French CHUs
- Development of an RT-LAMP rapid diagnostic test
- Development of a diagnostic test by the Hong Kong University-Pasteur Research Pole and rollout in the International Network
- Provision of serological tests
- Phylogenomic studies showing the different introductions of the virus in France
- Rollout of assays using novel seroneutralization techniques
- Collaboration with diagnostic startups to develop innovative lateral flow antigen tests
- Bioinformatics Hub involved in curating genomes sequenced worldwide (GISAID) (read the article "COVID-19- The Bioinformatics and biostatistics hub on the front line" on [pasteur.fr](http://pasteur.fr)).

# COVID-19 2020

Scientific research and discoveries at the Institut Pasteur in response to SARS-CoV-2

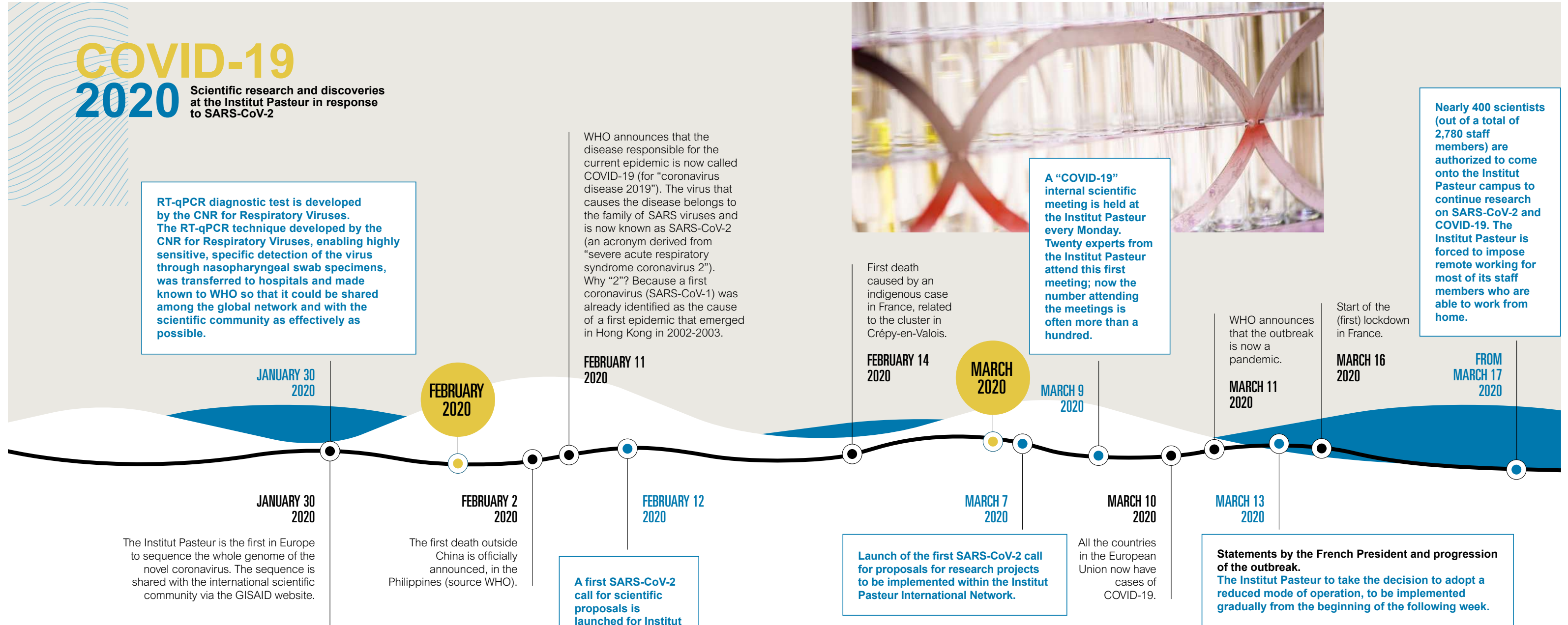
RT-qPCR diagnostic test is developed by the CNR for Respiratory Viruses. The RT-qPCR technique developed by the CNR for Respiratory Viruses, enabling highly sensitive, specific detection of the virus through nasopharyngeal swab specimens, was transferred to hospitals and made known to WHO so that it could be shared among the global network and with the scientific community as effectively as possible.

WHO announces that the disease responsible for the current epidemic is now called COVID-19 (for "coronavirus disease 2019"). The virus that causes the disease belongs to the family of SARS viruses and is now known as SARS-CoV-2 (an acronym derived from "severe acute respiratory syndrome coronavirus 2"). Why "2"? Because a first coronavirus (SARS-CoV-1) was already identified as the cause of a first epidemic that emerged in Hong Kong in 2002-2003.



A "COVID-19" internal scientific meeting is held at the Institut Pasteur every Monday. Twenty experts from the Institut Pasteur attend this first meeting; now the number attending the meetings is often more than a hundred.

Nearly 400 scientists (out of a total of 2,780 staff members) are authorized to come onto the Institut Pasteur campus to continue research on SARS-CoV-2 and COVID-19. The Institut Pasteur is forced to impose remote working for most of its staff members who are able to work from home.



**"Whole-genome sequencing of the novel coronavirus is crucial to be able to develop specific diagnostic tests and identify potential treatment 'options'."**

**Vincent Enouf**,  
deputy director of the Institut Pasteur's National Reference Center for Influenza Viruses



## Facilitating the work of the Institut Pasteur community by guaranteeing employee protection and business continuity

The Human Resources Department developed specific measures to support the teams particularly involved in the pandemic response, in cooperation with managers and other support services. The Occupational Health Department was, as always, committed to employee health, and worked with teams to offer help, guidance and advice, both in person and remotely. Psychological support was particularly stepped up; staff were able to book appointments with the occupational psychologist and were provided with information about how to look after their mental health.

Regular recommendations were also given on how to prevent musculoskeletal disorders, with guidance on how to adopt a healthy posture whether working in the lab, the office or from home. Finally, a number of personal development and support initiatives were introduced to help each individual cope with the circumstances as best as possible. Training courses particularly geared to the situation were offered, with employees and managers completing various modules on working from home and optimizing remote communication and cooperation. The Institut Pasteur was

especially keen to support all staff during this unusual period – regular challenges were set during the lockdown periods, with the slogan "Let's keep in touch. #PasteuriansTogether" and articles and practical guides were issued to help staff keep in contact and develop their skills. A flash survey was conducted in July to elicit employees' views and feelings during this extraordinary period. The results showed overall satisfaction with the measures introduced (88% satisfied to very satisfied) and pride at belonging to the Institut Pasteur (90%).



# COVID-19 2020

Scientific research and discoveries at the Institut Pasteur in response to SARS-CoV-2

## FAKE NEWS

A defamatory video is posted online. Based on a misinterpretation of a patent filed in 2004, the video claims that the Institut Pasteur invented COVID-19 for commercial gain.

MARCH 17  
2020

MARCH 17-20  
2020

Given the viral nature of the initial erroneous information in social and mainstream media, a large-scale fact-checking campaign is launched and extensively shared via a wide variety of platforms (threads, videos, series, etc.) and by several institutions and official outlets.

Read the *Fake News* page on [pasteur.fr](https://pasteur.fr)

The Coalition for Epidemic Preparedness Innovations (CEPI) funds the development of a SARS-CoV-2 vaccine based on a project led by a consortium composed of the Institut Pasteur, Themis and the University of Pittsburgh.

MARCH 19  
2020

Launch of the website [maladiecoronavirus.fr](https://maladiecoronavirus.fr), in collaboration with the Institut Pasteur (read the press release "Launch of the [maladiecoronavirus.fr](https://maladiecoronavirus.fr) website" on [pasteur.fr](https://pasteur.fr), in French).

MARCH 20  
2020

Scientists at the Institut Pasteur, with the support of the Hauts-de-France Regional Health Agency and the Amiens Education Authority and the backing of the French Blood Service (EFS), carry out an epidemiological survey on 661 people linked to a high school in Crépy-en-Valois, in the Oise department.

LATE MARCH  
2020

MARCH 26  
2020

**FAKE NEWS**  
Given the impact of the video and the threats and violence it caused, the Institut Pasteur has no other choice but to lodge a complaint for defamation (for the first time since its inception in 1887), without prejudice to the right to freedom of expression, which the Institut Pasteur recognizes and defends. The Senlis Public Prosecutor decides to initiate legal proceedings for defamation against the author of the video, an unusual step given the policy of this Prosecutor.

APRIL  
2020

Modeling carried out by the Institut Pasteur indicates that between 3% and 7% of French people have been infected. These results were published as a preprint on the Institut Pasteur's online archive site prior to publication on May 13.

APRIL 21  
2020

APRIL 23  
2020

Following the epidemiological survey carried out in Crépy-en-Valois and the use of virus detection tests together with three serological tests developed by the Institut Pasteur, a study reveals that 26% of the surveyed population have been infected by SARS-CoV-2 and developed antibodies against the virus. The population continues to be monitored and other studies are successively published. This study is associated with three serological tests developed by the Institut Pasteur.

## Avenues for therapeutic approaches

Some examples of the wide-ranging research at the Institut Pasteur:

- ➔ Creation of a group to evaluate antiviral strategies proposed by teams from the Institut Pasteur and also from academia and industry.
- ➔ Identifying molecules and antibodies that target key stages in the viral cycle: fusion, replication and maturation (read the press release "Innate immunity and fusion of cells infected with SARS-CoV-2" on [pasteur.fr](https://pasteur.fr)).
- ➔ International cooperation to identify molecules targeting cellular functions with an essential role in the viral cycle (UCSF and Mount Sinai) - (read the press release "Revealing how SARS-CoV-2 hijacks human cells; points to drugs with potential to fight COVID-19 and a drug that aids its infectious growth" on [pasteur.fr](https://pasteur.fr)).
- ➔ Clinical studies: evaluation of chemoprophylactic approaches for healthcare workers.
- ➔ Demonstration of the antiviral action of drugs that already have market approval (niclosamide) and launch of clinical trials by the Institut Pasteur Korea.



# COVID-19 2020

Scientific research and discoveries at the Institut Pasteur in response to SARS-CoV-2



An international initiative comprising scientists from the University of California, San Francisco (UCSF), the Gladstone Institutes, the Icahn School of Medicine at Mount Sinai and the Institut Pasteur reveals the identification of promising compounds for clinical trials with the aim of tackling COVID-19.

Following its first internal call for scientific proposals, 38 research projects led by the Institut Pasteur in Paris are selected by the Task Force out of a total of 55 proposals submitted.

A serological assay using bioluminescence (known as LuLISA), developed by the Institut Pasteur, increases the sensitivity of detection of specific immunoglobulins and is shown to be effective in allergy assessment. The LuLISA assay is adapted to detect antibodies (immunoglobulins IgG, IgM, IgA and IgE) directed against proteins of the SARS-CoV-2 coronavirus, which causes COVID-19. The Institut Pasteur files a patent application for LuLISA.

The Curie-O-SA study, led by the Institut Curie in collaboration with the Institut Pasteur, will examine the long-term dynamics of humoral, cellular and mucosal immune responses in staff from the Institut Curie and the Institut Pasteur who have been infected by SARS-CoV-2. This epidemiological study takes advantage of the serology tests developed by the teams of the Institut Pasteur.

APRIL 30  
2020

MAY  
2020

MAY 7  
2020

MAY 14  
2020

JUNE  
2020

JUNE  
2020

MAY 11  
2020

MID-MAY  
2020

## Progress in epidemiology and modeling

### Some examples of the wide-ranging research at the Institut Pasteur:

- ➔ Modeling the epidemic and the consequences of lockdown on its progression (see "COVID-19: mathematical model indicates that between 3% and 7% of French people have been infected" on [pasteur.fr](https://pasteur.fr)).
- ➔ Development of serological assays and tests to detect neutralizing antibodies.
- ➔ Epidemiological studies and characteristics of community transmission (Crépy-en-Valois).

- ➔ Establishment and persistence of the immune response in symptomatic cases (Curie-O-SA, Crépy-en-Valois).
- ➔ Nosocomial transmission (see Clinical Infectious Diseases "A Conceptual Discussion About the Basic Reproduction Number of Severe Acute Respiratory Syndrome Coronavirus 2 in Healthcare Settings" on [pasteur.fr](https://pasteur.fr)).
- ➔ Telemedicine and new technologies (see "Use of the [maladiecoronavirus.fr](https://maladiecoronavirus.fr) web application" on [pasteur.fr](https://pasteur.fr)).

Gradual easing of lockdown measures begins in France.

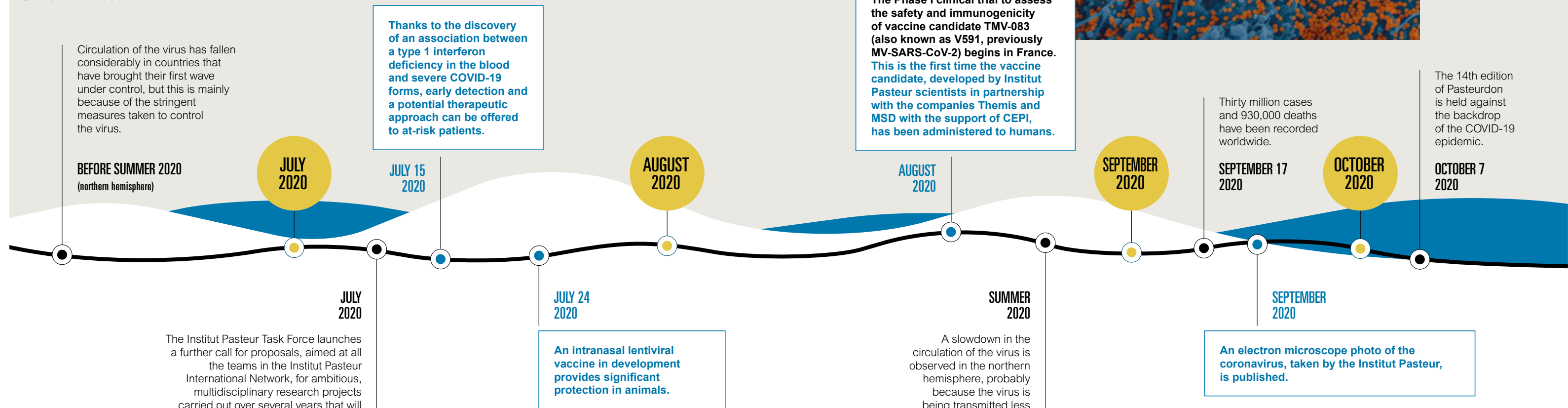
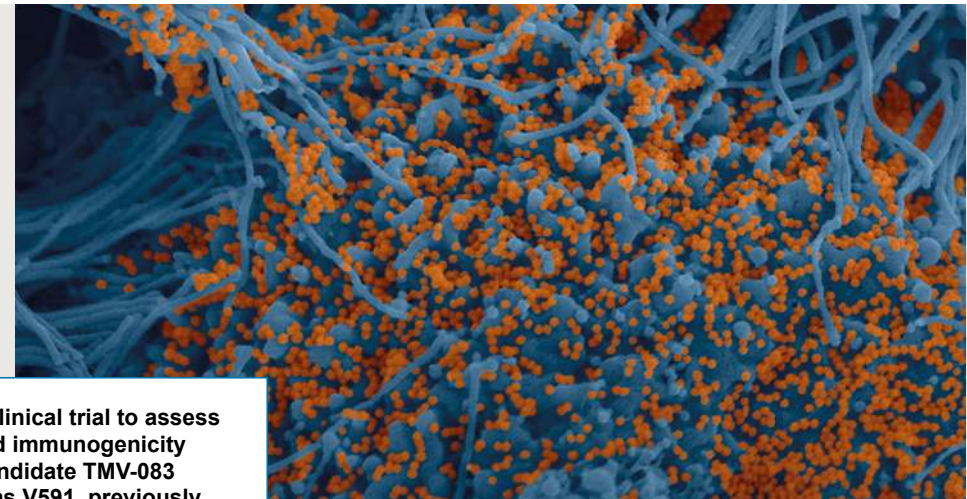
A seroprevalence study in the French population, led by Santé publique France, reveals that the frequency of seropositives is 5% and the frequency of neutralizing antibodies is 3.5%. The serological assays developed by the Institut Pasteur teams (LuLISA N, LuLISA S and pseudoneutralization) are used in this study.





# COVID-19 2020

Scientific research and discoveries at the Institut Pasteur in response to SARS-CoV-2



Circulation of the virus has fallen considerably in countries that have brought their first wave under control, but this is mainly because of the stringent measures taken to control the virus.

Thanks to the discovery of an association between a type 1 interferon deficiency in the blood and severe COVID-19 forms, early detection and a potential therapeutic approach can be offered to at-risk patients.

The Phase I clinical trial to assess the safety and immunogenicity of vaccine candidate TMV-083 (also known as V591, previously MV-SARS-CoV-2) begins in France. This is the first time the vaccine candidate, developed by Institut Pasteur scientists in partnership with the companies Themis and MSD with the support of CEPI, has been administered to humans.

The 14th edition of Pasteurdon is held against the backdrop of the COVID-19 epidemic.

The Institut Pasteur Task Force launches a further call for proposals, aimed at all the teams in the Institut Pasteur International Network, for ambitious, multidisciplinary research projects carried out over several years that will involve recruiting contract researchers. **The proposals will be assessed in autumn and will begin in early 2021.**

An intranasal lentiviral vaccine in development provides significant protection in animals.

A slowdown in the circulation of the virus is observed in the northern hemisphere, probably because the virus is being transmitted less between people who are spending time outside in summer. The virus continues circulating at a low level.

An electron microscope photo of the coronavirus, taken by the Institut Pasteur, is published.



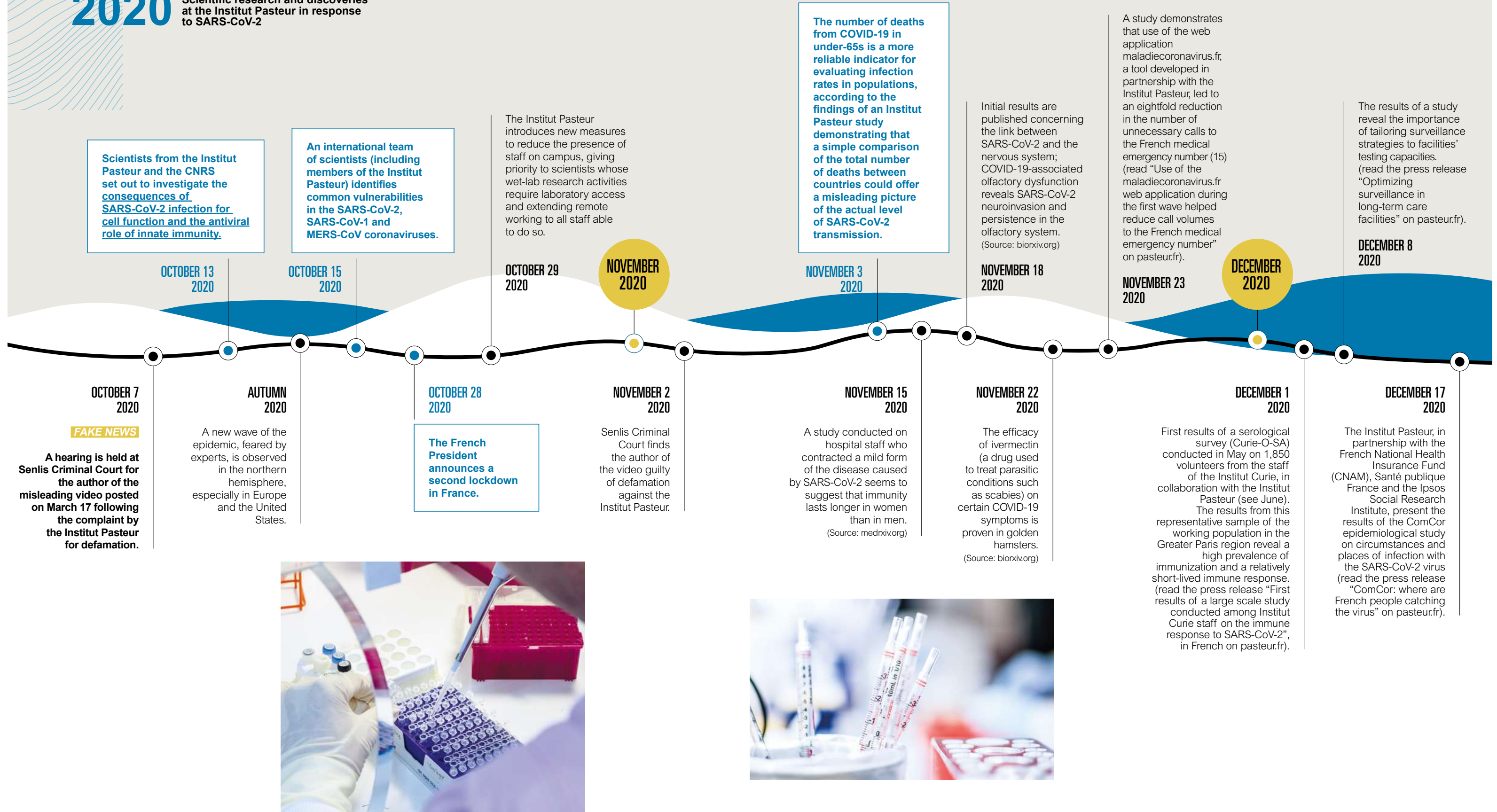
## Improving understanding of SARS-CoV-2 and COVID-19 biology

**Wide-ranging research at the Institut Pasteur. Some examples:**

- Biology of SARS-CoV-2 (for example the effect of SARS-CoV-2 on cells).
- Structural biology: study of the viral cycle *in cellula* using cryo-electron microscopy, interactions between the S protein, receptors and antibodies.
- Tropism: lungs, digestive tract, neurons (organs-on-chips).
- Cell biology: intercellular traffic, interference with host functions (miRNA).
- COVID-19 and host responses:
  - humoral and cellular responses;
  - transition between viral and inflammatory disease (for example, in severe and critical patients, a severely impaired response of interferon (IFN) type I is associated with a persistent blood viral load and an excessive inflammatory response).
- COVID-19 and neurological signs (in partnership with the Brain and Spine Institute).
- COVID-19 and genetic susceptibility.

# COVID-19 2020

Scientific research and discoveries at the Institut Pasteur in response to SARS-CoV-2





# SIGNIFICANT HIGHLIGHTS

JANUARY 2020

## Potential new approaches for tackling rabies

139

The number of research units at the Institut Pasteur as of January 1, 2021, including seven at the Hearing Institute.

Institut Pasteur scientists isolated the structure of a powerful monoclonal antibody targeting the rabies virus and described it at ultra-high resolution. This breakthrough paves the way for potential new prophylactic and therapeutic approaches for tackling rabies.

*Nature Communications*, January 30, 2020.



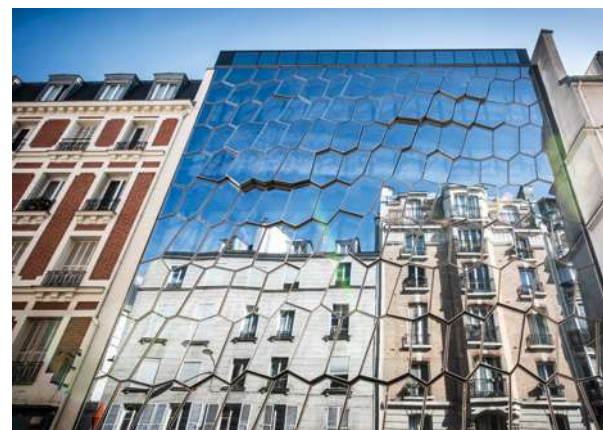
Vaccination at the Institut Pasteur du Cambodge anti-rabies center.

FEBRUARY 2020

## Leishmaniasis agent resisting macrophages due to epigenetic modifications

Scientists at the Institut Pasteur in Paris collaborating with the Institut Pasteur of Shanghai, Chinese Academy of Sciences, have discovered that through epigenetic modulations, *Leishmania* is capable of inhibiting the activation of inflammasome, a protein complex triggering the inflammatory process. This discovery will enable new therapies to be developed.

*Cell Reports*, February 11, 2020.



The Hearing Institute building.

## One year old already!

The Hearing Institute was inaugurated on February 27, 2020. This Institut Pasteur center co-founded with the Fondation Pour l'Audition is affiliated with Inserm through a joint research unit and operates in cooperation with CNRS scientists. It is the first French national research center for auditory neuroscience.

(see scientific publication on presbycusis from November 2020)

MARCH 2020

## The role of gut microbiota in depression

A joint study by the Institut Pasteur, CNRS, and Inserm examined this role in mice. In mice exhibiting depressive behavior, bacteria produce very few precursors required for serotonin synthesis, which also appears to neutralize the efficacy of some antidepressant classes. This work may shed light on the inefficacy of antidepressants in 30% of treated individuals.

*Cell Reports*, March 17, 2020.



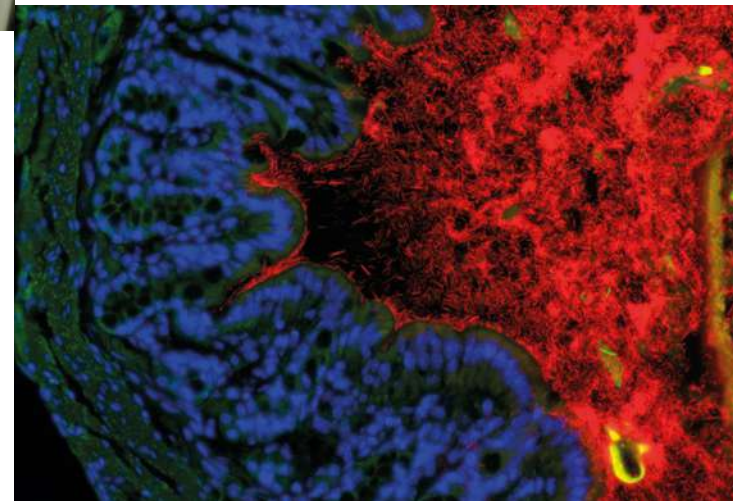
Bacteria colonizing the gut observed by scanning electron microscopy.

MAY 2020

## The important role played by microbiota in chemotherapy response in colorectal cancer

Colorectal cancer is the second leading cause of cancer deaths in France. An international study was conducted in France on mouse models by scientists from Gustave Roussy, Inserm, Université Paris-Saclay, Institut Pasteur, IHU Méditerranée Infection, and INRAE. This demonstrated that innate immune activation by some bacteria in the microbiota is essential for achieving an effective response to treatment, while other members of the microbiota induce harmful tolerability to anti-tumor treatment.

*Nature Medicine*, May 25, 2020.



Colon and bacteria.

JUNE 2020

## 1 case per 2,500 to 4,000 individuals

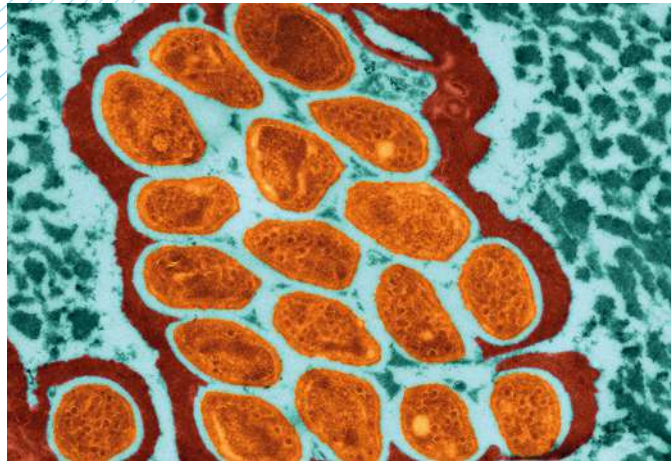
That's the number of individuals affected by differences in sex development (DSD), genetic conditions in which there is a mismatch between the chromosomal sex, XY or XX, which are typically of males and females, and some aspect of their anatomy, for example, an XY individual born as female or XX individual born as male. Scientists have identified one of the causes of testicular tissue development in some individuals with female chromosomes – the WT1 gene, which is known for its role in testicle development, but is also involved in ovary development.

*PNAS*, June 3, 2020.





# SIGNIFICANT HIGHLIGHTS



*Plasmodium falciparum* in an *Anopheles* salivary gland.

AUGUST 2020

## Malaria parasites may be resistant to artemisinin derivatives

While this resistance is widespread in South-East Asia, it has now also been described in Africa, having been observed in Rwanda by Institut Pasteur scientists in collaboration with the National Malaria Control Program in Rwanda (Rwanda Biomedical Center), the World Health Organization, Cochin Hospital, and Columbia University (New York, USA).

*The Lancet Infectious Diseases*, August 14, 2020.

## New guidelines for treating HBV-positive pregnant women

Yusuke Shimakawa, a scientist at the Institut Pasteur (Paris), coordinated a systematic review with the assistance of the World Health Organization (WHO), two other Institut Pasteur scientists, and colleagues in China and Japan. WHO has updated its guidelines based on this review.

*The Lancet Infectious Diseases*, August 14, 2020.

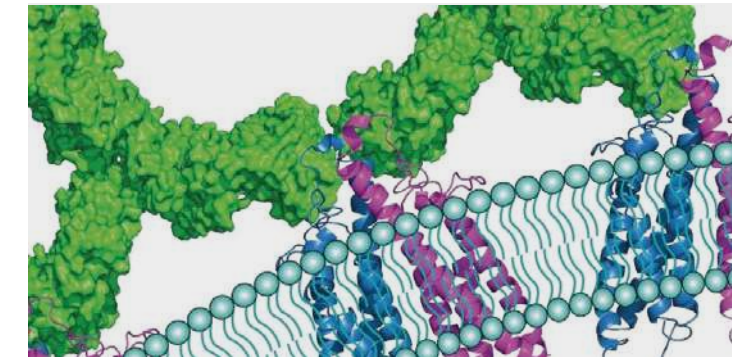


Over **50%** of overdose deaths in the United States

**25%** of overdose deaths in France

These are the two countries' respective percentages of cocaine-related overdose deaths. Current research has led to an improved understanding of genetic factors in cocaine addiction. The  $\alpha 5$ SNP mutation reduces the voluntary intake of cocaine upon first exposures. Patients with the mutation exhibited a slower transition from first cocaine use to the emergence of signs of addiction. Conversely, another mutation (in nicotinic subunit  $\beta 4$ ) is associated with faster relapse after withdrawal.

*Progress in Neurobiology*, August 22, 2020.



Human antigen CD20 molecules (blue and pink) expressed on the surface of B lymphocytes are recognized by therapeutic antibodies (green).

## Mechanisms of action of therapeutic antibodies used to treat lymphoma

Using cryo-electron microscopy, scientists from the CNRS, Institut Pasteur, and the University of Bordeaux have observed the interaction between therapeutic antibodies and their target protein for the first time. This research describes these molecular mechanisms with precision, paving the way for the design of new treatments.

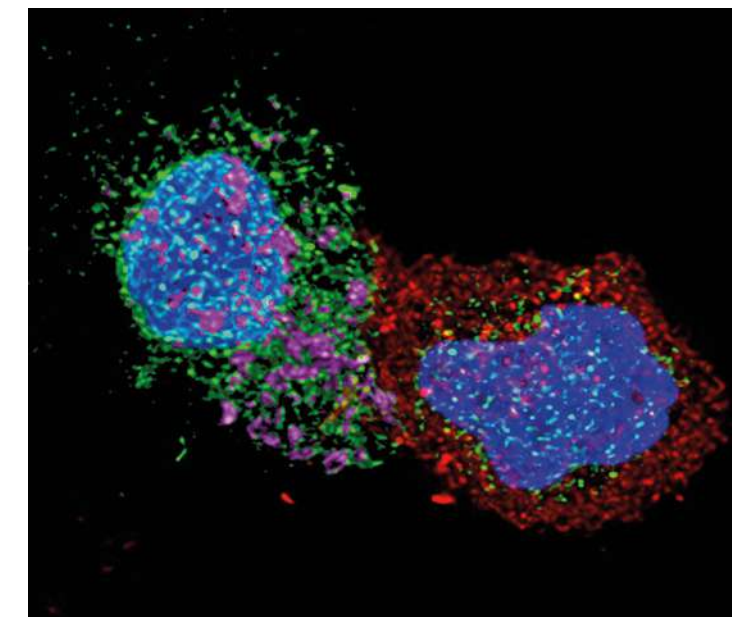
*Science*, August 14, 2020.

SEPTEMBER 2020

## How untreated individuals control HIV infection in rare cases

A study was conducted by Institut Pasteur scientists and a CEA/Inserm/Université Paris Saclay joint unit. They observed that levels of CD8+ T lymphocytes in monkeys capable of controlling the disease gradually increased from 15 days post-infection. This confirms and clarifies the role of CD8+ T cells revealed by previous studies.

*Cell Reports*, September 22, 2020.



CD8 cells of HIV controller patients in contact with CD4 cells infected with HIV.

## The National Institutes of Health (NIH) fund a center for research in emerging infectious diseases at the Institut Pasteur

The National Institute of Allergy and Infectious Diseases awarded grants to establish Centers for Research in Emerging Infectious Diseases (CREID). One such facility is the Pasteur International Center for Research on Emerging Infectious Diseases (PICREID) led by Anavaj Sakuntabhai from the Institut Pasteur in Paris, the only center coordinated by a non-US organization. The NIAID belongs to the National Institutes of Health (NIH), which are US government institutions involved in medical and biomedical research.





# SIGNIFICANT HIGHLIGHTS

SEPTEMBER-OCTOBER 2020

## The role of the hippocampus in memory formation

Institut Pasteur scientists have discovered how our brain forms and uses distinct memories of similar events. The hippocampal input region detects slight changes in familiar/unknown environments and the output region subsequently weighs up this information to guide behavioral decisions.

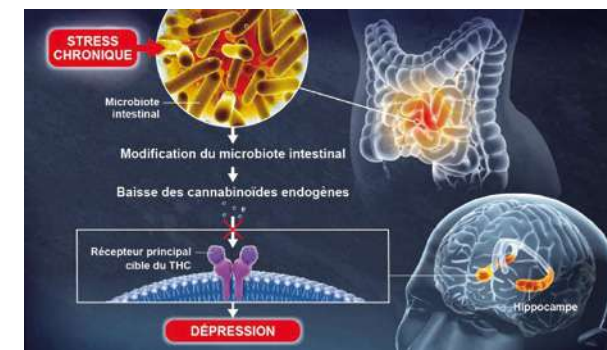
*Neuron*, October 16, 2020.



## The role of genetic mutations in presbycusis

These mutations are responsible for a quarter of cases occurring around the age of 50. Scientists observed them and established their pathogenicity, particularly by introducing the mutations in mice. This discovery could therefore pave the way for gene therapy.

*PNAS*, November 23, 2020.



DECEMBER 2020

## Microbiota, brain, and mood regulation

Scientists from the Institut Pasteur, Inserm and the CNRS demonstrated that an imbalance in the gut bacterial community can cause a reduction in some metabolites, resulting in depressive-like behaviors.

A healthy gut microbiota therefore appears to contribute to normal brain function.

*Nature Communications*, December 11, 2020.

## Approval of changes to the Institut Pasteur's articles of association

On December 15, 2020, following a series of discussions with the Institut Pasteur and the various ministries concerned, the French Council of State delivered a favorable opinion regarding changes to the Institut Pasteur's articles of association. These changes mainly concern three points: the term of the President, the composition of the Scientific Council, and the modernization of financial provisions.

The process of developing our articles of association was initiated by the Board of Governors in February 2020. The changes adopted by the Board of Governors were presented to Institut Pasteur staff by the Chairman of the Board, Christian Vigouroux, and the two Vice-Chairmen, Artur Scherf and Hubert du Mesnil at a staff meeting held on June 3. The draft text was then approved by an overwhelming majority at the Institut Pasteur's General Meeting on June 22, 2020. The decree approving changes to the Institut Pasteur's articles of association was published in the French Official Journal on January 12, 2021.

The unique legal status of our Foundation also echoes its unique scientific nature. It is a guarantee of the Institut Pasteur's long-term development and holds the promise of future innovation.



## Catawiki and 12 contemporary artists join forces to auction customized lab coats

Lab coats have come to symbolize all the heroes working behind the scenes to protect our health. In 2019, the Institut Pasteur created the hashtag #MetsTaBlouse (#PutOnYourLabCoat) to announce the start of Pasteurdon, the annual fundraising campaign that celebrates research and raises awareness of the need for funding. A dozen urban artists accepted the invitation to customize a lab coat. The same artists generously gave permission for their lab coats to be sold in an online auction on Catawiki from September 25 to October 3, 2020. A total of €4,300 was raised and donated to the Institut Pasteur to fund research projects.

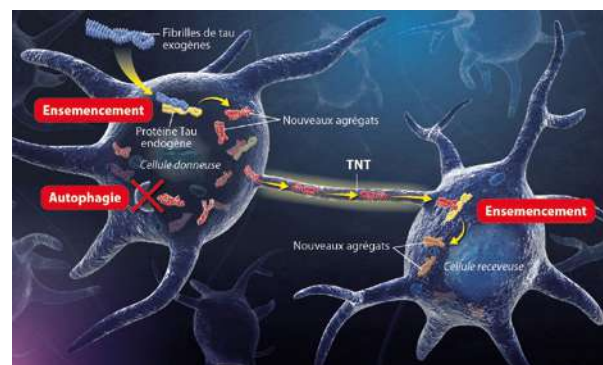
<https://pasteurdon.pasteur.fr/ventes-aux-encheres>

NOVEMBER 2020

## Alzheimer's disease: endogenous tau proteins block their own degradation by autophagy

The Membrane Traffic and Pathogenesis Unit at the Institut Pasteur in Paris examined this mechanism involved in Alzheimer's disease in collaboration with GlaxoSmithKline and the University of Texas Southwestern Medical Center Brain Institute. These tau proteins form aggregates which are subsequently spread through TNTs (tunneling nanotubes).

*EMBO Molecular Medicine*, November 12, 2020.



# 1%

of all newborns are affected by a heart defect, which in France accounts for approximately 8,000 babies per year. Cardiac asymmetry established during embryonic development is critical to heart function. The Heart Morphogenesis team at the Institut Pasteur and Imagine Institute examined the role of Nodal in cardiac asymmetry and revealed the existence of other factors causing cardiac asymmetry.

*Developmental Cell*, November 23, 2020.



# AWARDS AND APPOINTMENTS 2020

## APPOINTMENTS

### Philippe Bousso

Head of the Department of Immunology and the Dynamics of Immune Responses Unit  
*Elected to the Academia Europaea*

### Pascale Cossart

Bacteria-Cell Interactions Unit  
*Appointed Doctor Honoris Causa of the Karolinska Institute*

### Anne Dejean

Head of the Nuclear Organization and Oncogenesis Unit  
*Elected to the American Academy of Arts and Sciences*

### David DiGregorio

Head of the Department of Neuroscience and the Synapse and Circuit Dynamics Unit  
*Elected to the Academia Europaea*

### Guillaume Dumenil

Head of the Pathogenesis of Vascular Infections Unit and the Ultrastructural Bioluminescence technology and service unit (UTechS UBI)  
*Elected to the Academia Europaea*

### Marc Lecuit

Director of the Department of Cell Biology and Infection, and Head of the Biology of Infection Unit  
*Appointed Senior Member of the Institut universitaire de France*

### Paola Minoprio

Head of the Trypanosomatids Infectious Processes Laboratory  
*Legion of Honor and Medal of Epidemics (Ministry of Foreign Affairs, France)*

### Christine Petit

Director of the Hearing Institute  
*Appointed Doctor Honoris Causa of the University of Antwerp*

### Luis Quintana-Murci

Head of the Human Evolutionary Genetics Unit  
*Elected to the French Academy of Sciences*

### Carla Saleh

Head of the Viruses and RNA Interference Unit  
*Elected member of EMBO*

## HONORS AND PRIZES

### Thomas Bourgeron

Head of the Human Genetics and Cognitive Functions Unit  
*Roger de Spoelberch Foundation Prize*

### Pierre Bruhns

Head of the Antibodies in Therapy and Pathology Unit  
*Pasteur Vallery-Radot Prize, National Library of France*

### Julian Buchrieser

Virus and Immunity Unit  
*"Major Scientific Advances" prize, French Academy of Sciences*

### Simon Cauchemez

Head of the Mathematical Modeling of Infectious Diseases Unit  
*Antoine Lacassagne Prize, Collège de France*

### Gérard Eberl

Head of the Microenvironment and Immunity Unit  
*Simone and Cino Del Duca Foundation's Scientific Grand Prix, French Academy of Sciences*

### Rachel Golub

Lymphocytes and Immunity Unit  
*Georges Zermati Prize, Fondation de France*

### Mélanie Hamon

Head of the Chromatin and Infection Group  
*Georges, Jacques and Elias Canetti Prize, iXblue-iXcore-iXlife Foundation Award Winner*

### Friederike Jonsson

Antibodies in Therapy and Pathology Unit  
*CNRS Bronze Medal*

### Louis Lambrechts

Head of the Insect-Virus Interactions Unit  
*Pasteur Vallery-Radot Prize, National Library of France*

### Marc Lecuit

Director of the Department of Cell Biology and Infection, and Head of the Biology of Infection Unit  
*Eloi Collery Prize, French National Academy of Medicine*

### Jean-Baptiste Masson

Head of the Decision and Bayesian Computation Unit  
*Bpifrance i-Lab deep tech innovation award 2020, launch of startup AVATAR MEDICAL WILCO healthcare, innovation accelerator (2020)*

### Didier Ménard

Head of the Malaria Genetics and Resistance Unit  
*Thérèse Lebrasseur Award, Fondation de France*

### Étienne Patin

Human Evolutionary Genetics Unit  
*Delheim Award, Collège de France*

### Christine Petit

Director of the Hearing Institute  
*Louisa Gross Horwitz Prize, Columbia University*

### Anavaj Sakuntabhai

Head of the Functional Genetics of Infectious Diseases Unit  
*Bpifrance i-Lab deep tech innovation award 2020, Dengue 4 Zika Vaccine - D4Zin - Grand Prix*

### Carla Saleh

Head of the Viruses and RNA Interference Unit  
*Lucien Tardieu Prize, French Foundation for Medical Research (FRM)*

### Shahragim Tajbakhsh

Head of the Stem Cells and Development Unit  
*René & Andrée Duquesne Award*

### François-Xavier Weill

Head of the Enteric Bacterial Pathogens Unit and National Reference Center for *Escherichia coli*, *Shigella* and *Salmonella*  
*Jean-Pierre Lecoq Prize, French Academy of Sciences*

## ERC FUNDING

### Sebastian Baumgarten

Host-Parasite Interactions Unit  
*ERC Starting Grant: PlasmoEpiRNA - Resolving m6A-mediated post-transcriptional control in the human malaria parasite*

### Germano Cecere

Head of the Mechanisms of Epigenetic Inheritance Group  
*ERC Consolidator Grant: RNAiHERITANCE - Somatic and Germline Mechanisms of Small RNA Inheritance*

### Nicolas Rascovan

Head of the Microbial Paleogenomics Group  
*ERC Starting Grant: PaleoMetAmerica - A microbial perspective of major historical events in the Southern Cone of the Americas, sponsored by the CNRS*

## IP YOUNG SCIENTIST PRIZE

### Post-doc category

#### Ziad El Nabhani

*Microenvironment and Immunity Unit*

### PhD category

#### Sofia Medvedeva

*Archaeal Virology Unit*



# RESEARCH MISSION

The Institut Pasteur is constantly striving to give new impetus to basic research. Its aim is to improve health worldwide and to make a real impact on health challenges. This was demonstrated in 2020 with its unprecedented commitment to tackling COVID-19 – as it continued to pursue its ongoing research in other fields.



# INTERVIEW

## with Christophe d'Enfert

Scientific Director at the Institut Pasteur



**“The COVID crisis has proven the relevance of our Strategic Plan whose first priority area is emerging infectious diseases. Our aim is to increase the Institut Pasteur’s impact within the field of human health and we were able to take swift action (...).”**

### You were appointed Scientific Director on January 2, 2020. What were the key lessons from this unprecedented year?

My previous role was Vice-President Technology and Scientific Programs, and I took over from Professor Olivier Schwartz as Scientific Director to continue implementation of the 2019-2023 Strategic Plan. The COVID-19 pandemic completely changed things when I took up this new post. The main priority was to set up research projects focused on COVID-19 and adapt to public health restrictions. Many teams stopped working during the lockdown of spring 2020, and full working capacity was never restored due to the restrictions imposed, which have prevented the emergence of clusters within the institute. However, COVID-19 has primarily proven the relevance of our initial Strategic Plan, whose first priority area is emerging infectious diseases. Our aim is to

increase the Institut Pasteur’s impact within the field of human health and we were able to take swift action through specific projects focused on diagnostics, which proved successful. Although the success anticipated in 2020 was not achieved regarding the development of vaccine candidates, some of our other candidates are currently being assessed, and research at the Institut Pasteur was not limited to producing a vaccine. Progress is being made in 2021 on our therapies under development. This crisis has therefore revealed our ability to take action across a broad spectrum and provided a reminder of just how important steps taken to upgrade our technology have been for research, since our investment in cryo-electron microscopy has paid dividends in terms of our ability to examine the biology of SARS-CoV-2.

### What progress was made in 2020 with the rollout of the 2019-2023 Strategic Plan?

Our research was not limited to COVID and progress was made on scientific elements of the Strategic Plan (see pp. 26-31 and 36-52). For example, several teams’ work has demonstrated that control of epigenetic modifications plays an important role in the ability of various pathogens to infect their target cells. Interfering with DNA modifications appears to offer a promising means

of tackling antimicrobial resistance. Proof of this can be seen in new molecules identified for treating malaria, a project selected for our Institut Pasteur Innovation Accelerator. Other research on the role of microbiota in depression has revealed the value of our priority area focused on “brain disorders”. In the field of cancer, our research on DNA repair mechanisms and the role of microbiota in treatment efficacy is paving the way for potential therapeutic breakthroughs. All these areas of progress, and many others besides, herald future developments. It is also worth noting that, while lockdown hampered laboratory work, it proved a fruitful period for scientific publications, since many papers were written this year.

### So has the pandemic occasionally favored certain projects?

The crisis has mainly led to a temporary change in our priorities. Some projects have progressed more quickly. We have been in talks with our colleagues at the Brain and Spinal Cord Institute (ICM) since 2019. In 2020, funding for three COVID projects in partnership with the ICM was secured extremely quickly. We also issued a new call for proposals with the ICM on non-COVID topics. Moreover, we have made significant progress on artificial intelligence, including the launch of a start-up, Avatar Medical, which will impact



Meeting of the Institut Pasteur’s Coronavirus Task Force on March 3, 2020.

medical practice through 3D reconstructions facilitating medical intervention procedures.

### Is this successful venture the result of the Institut Pasteur’s investment in computational biology?

Absolutely. We set up the Department of Computational Biology in 2019 due to the key role played by data science, and particularly artificial intelligence and machine learning, in research. Christophe Zimmer, a specialist in this area, was appointed Department Director in 2020, and further staff are due to be recruited. An incentive measure focused on artificial intelligence has also been launched.

### In which other fields is the Institut Pasteur investing?

Our investment in cryo-electron microscopy (including the Titan Krios™ microscope) has led to the creation of our nanoimaging platform, which is now fully operational and plays a key role in the field of structural biology. One of our teams has identified monoclonal antibodies that are highly active against SARS-CoV-2 and its variants. Structural biology has enabled us to understand how these antibodies work through a combination of crystallography and cryo-electron microscopy. A further revolution is occurring with regard to cryo-electron tomography, which allows imaging of proteins in their cellular context. We have also opened a Metabolomics Core Facility to analyze metabolites and their variations in pathological contexts, and thus improve our understanding of certain diseases and define

biomarkers that may prove valuable for diagnostics.

### Have there been any technological developments in relation to COVID?

Absolutely, going right back to the beginning of the outbreak with the RT-qPCR test for detecting SARS-CoV-2, which was developed by the National Reference Center (CNR) for Respiratory Infection Viruses. The Institut Pasteur also developed serological assays to detect the production of antibodies (e.g. the LuLISA technology) and test their ability to neutralize SARS-CoV-2. While there have been many other developments, LuLISA in particular has led to the launch of an innovation platform funded by the Banque publique d’investissement (BPI) and the Greater Paris Region. We are a key player in advanced diagnostic

technologies and provide our teams on campus with new analytical capabilities, which are useful for other studies.

### How did the Institut Pasteur, and the Department of Scientific Affairs in particular, adapt to accommodate these changes?

With Bruno Hoen, our new Medical Research Director, we are pursuing a strategic goal to increase the Institut Pasteur’s impact within the field of human health. The Department of Scientific Affairs plays an active role in attracting new talent and managing careers. A new Scientific Careers and Assessment Department, led by Patrick Trieu-Cuot, was set up with two divisions, one for scientific careers and the other for scientific assessment. Michael Nilges joined the management team as Vice-President Technology to support the technological developments mentioned. Lastly, we set up a department dedicated to scientific programming and incentive actions (SPAIS) to support the Strategic Plan and scientific foresight activities. The SPAIS team works with the Department of Communications to raise awareness of progress made in our strategic areas.

### Do you have a message to pass on to our readers?

I’d like to emphasize the Institut Pasteur’s ability to take wholehearted action on the issues of human health. To tackle COVID-19, not only virologists stepped up to the task, but also cellular biologists, neurobiologists and immunologists, etc. Our interdisciplinary capability is a source of real strength that can make a difference to people’s health and enable us to get to work quickly and efficiently.

## 10 EXAMPLES OF KEY PROJECTS IN THE FIGHT AGAINST COVID-19

1. Modeling of epidemic trends
2. Study of places of infection with SARS-CoV-2
3. Epidemiological studies and host responses
4. Variants: epidemiological genomic surveillance, immune response
5. New diagnostic and serological technologies and launch of a bioassay platform
6. Development of vaccine candidates
7. Organs-on-chips and study of SARS-CoV-2 infection
8. SARS-CoV-2 and neurological disorders
9. Identification of monoclonal antibodies for therapeutic applications
10. Clinical studies on post-exposure chemoprophylaxis

For further information, visit the COVID projects area on [pasteur.fr](https://pasteur.fr)

# STRATEGIC PLAN 2019-2023

## EMERGING INFECTIOUS DISEASES

The past 50 years have seen the emergence of numerous zoonoses, in which animal pathogens have crossed the species barrier to cause sickness in humans. Known pathogens are constantly re-emerging due to changes in their ecosystem leading to the development of synergistic epidemics. The Institut Pasteur and Institut Pasteur International Network are ideally positioned to respond to these threats.

The “emerging infectious diseases” priority area encompasses:

- 10 scientific departments
- 87 teams
- 3 platforms
- 4 biological resources
- 8 National Research Centers
- 3 LabEx laboratories
- The Pasteur International Center for Research on Emerging Infectious Diseases  
(set up in October 2020)

### Progress on the priority area as at December 31, 2020

Faced with the emergence of SARS-CoV-2 in December 2019, the Institut Pasteur immediately rallied its teams to meet the multiple challenges raised by the new pandemic.

- RT-qPCR diagnostic tests and serological assays, isolation and sequencing of the first strains that entered France in late January



Cytopathic effect of SARS-CoV-2 coronavirus on Vero E6 cells. Cells attacked by the virus are destroyed.

- 2020, and the British and South African variants one year later.
- Epidemiological surveys in schools in Crépy-en-Valois, and case-control studies on circumstances and places of SARS-CoV-2 transmission.
- Modeling of epidemic trends in France: <https://modelisation-covid19.pasteur.fr/>
- Cohort analysis of immunological response in patients infected with SARS-CoV-2.
- Study of cell-pathogen interaction.
- Development of monoclonal antibodies for therapeutic applications.
- Development of vaccine candidates for SARS-CoV-2.
- The Institut Pasteur International Network helped set up SARS-CoV-2 diagnostic laboratories in the poorest

African and Asian countries, thus contributing to global surveillance of the outbreak. Around 100 scientific publications have been written on this research, some of which have had a direct impact on the way the outbreak is managed in France and throughout the world.

Alongside its response to the COVID-19 outbreak, the Institut Pasteur has continued to tackle other emerging or re-emerging infectious diseases in 2020. This includes but is not limited to the following:

- New guidelines for treating HBV-positive pregnant women.
- Breakthroughs in understanding HIV replication mechanisms and immune control.
- Proof of the key role played by humans in spreading cholera.
- An update regarding increased risk of yellow fever transmission.

### ON THE WEB

Find out more about:  
 ➤ **2019-2023 Strategic Plan: progress in 2020 on the “emerging infectious diseases” priority area:**  
[www.pasteur.fr/en/actualites-jdr](http://www.pasteur.fr/en/actualites-jdr)

## ANTIMICROBIAL RESISTANCE

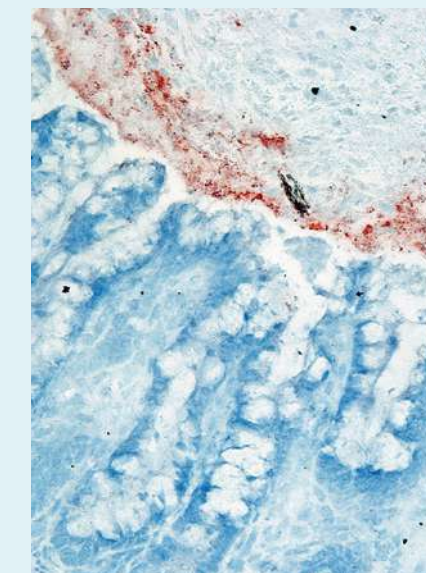
The ability to treat infectious diseases is one of the key breakthroughs in modern medicine. It is now jeopardized by the emergence of microorganisms that are resistant to treatments and capable of spreading globally. It is essential to detect and understand these resistance phenomena and develop innovative therapeutic strategies to protect public health and prevent the major health risk posed by ineffective treatments.

The “antimicrobial resistance” priority area encompasses:

- 10 scientific departments
- Over 90 teams
- 24 platforms
- 4 biological resources
- 12 National Research Centers
- 1 LabEx laboratory

### Progress on the priority area as at December 31, 2020

- Mapping of research on antimicrobial resistance with a view to coordinating the community within this field.
- A key contribution from Institut Pasteur technological platforms: examination of resistance mechanisms, determination of 3D structures, screening of new candidate molecules. The new Metabolomics Core Facility will play a crucial role in developing new research topics.
- First-class scientific output and a diverse range of research contracts secured, reflecting the institute’s appeal: over 150 articles in 2020 echoing the diversity of work carried out.



Histological section of human intestinal tissue immunolabeled for beta-defensin 3 (a peptide exhibiting antimicrobial activity).

- **Involvement in tackling COVID-19.** Some of the teams contributing to this priority area are involved in tackling COVID-19, with a particular focus on molecular characterization of key viral proteins and the development of new therapeutic strategies.
- **The Institut Pasteur is a member of the Virtual Research Institute (IRAADD).** The IRAADD network seeks to promote and accelerate translational science in the initial stages of new antibiotic discovery and drug candidate development. In 2020, IRAADD produced a white paper

on research into new active ingredients for tackling AMR.

- **An international PhD program with the University of Oxford.** Four PhD students were recruited through this collaborative program on antimicrobial resistance involving the Institut Pasteur and the Department of Chemistry at the University of Oxford. Two students will complete the majority of their thesis in Paris and two in Oxford, thus benefiting from the complementary expertise offered by the two institutions.

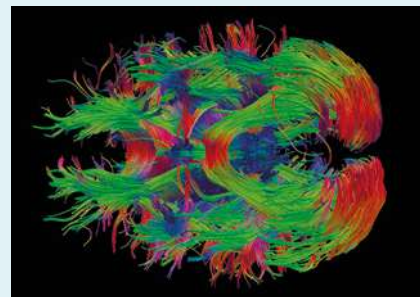
### ON THE WEB

Find out more about:  
 ➤ **2019-2023 Strategic Plan: progress in 2020 on the “antimicrobial resistance” priority area:**  
[www.pasteur.fr/en/actualites-jdr](http://www.pasteur.fr/en/actualites-jdr)



## BRAIN CONNECTIVITY AND NEURODEGENERATIVE DISEASES

The wide range of expertise offered by the Institut Pasteur through various complementary translational research fields is harnessed to gain insights into complex brain functions and their connections to the body as a whole, both in a healthy and pathological condition (neurodevelopmental disorders, neurodegenerative, psychiatric and infectious diseases, etc.).



Cerebral connectivity of white matter.

The “brain connectivity and neurodegenerative diseases” priority area encompasses:

- ➊ 8 scientific departments
- ➋ 1 Hearing Institute
- ➌ 24 teams
- ➍ 4 platforms
- ➎ 1 Pasteur International Neurodegenerative Diseases Unit
- ➏ 1 partnership with the Brain and Spinal Cord Institute

### Progress on the priority area as at December 31, 2020

- **Set-up of EU-AIMS**, a project to develop a European database of patients with autism spectrum disorders.
- **Set-up of the Hearing Institute** (February 27, 2020), a center for basic and medical research in the field of hearing, established at the instigation of the Fondation Pour l’Audition and the Institut Pasteur.
- **Partnership between the Institut Pasteur (IP) and the Brain and Spinal Cord Institute (ICM):**
  - IP-ICM symposium on “Neuroscience and Diseases” of December 16, 2019 to strengthen partnerships between the fields of basic and clinical research;
  - “NeuroCOVID” call for proposals issued on June 23, 2020 (three projects funded);
  - “Big Brain Theory 3” call for proposals issued on November 6, 2020 (potential to fund two IP-ICM projects).
- **The first annual “Neurological Implications of COVID”** brainstorming session held virtually on June 29, 2020 over the course of a day involving priority area units working in this field, followed by a period set aside for discussion.
- **Creation of a “Brain-Immune Communication” G5:** Dr. Aleksandra Deczkowska from the Weizmann Institute (Israel) joined the Institut Pasteur to lead a team drawing on synergies between the departments of Immunology and Neuroscience.
- **An internal “Seed Projects” call for proposals** of November 7, 2020 (four projects funded), organized by the priority area coordinators with support from the Department of Scientific Affairs and the Department for Scientific Programming and Incentive Actions, to strengthen and catalyze collaborations on campus and prompt the emergence of original and ambitious translational projects.
- **Major scientific results:** neurodegenerative diseases (Alzheimer’s disease, p.30; news item: “recycling mechanisms open up new avenues for therapy” on [pasteur.fr](http://pasteur.fr)), psychiatric disorders (depression and microbiota, p.27; microbiota, brain and mood, p.31), cocaine addiction (p.29), memory and perception (p.49), technological developments (Genuage, p.42).

### ON THE WEB

Find out more about:  
 ➊ **2019-2023 Strategic Plan: progress in 2020 on the “brain connectivity and neurodegenerative diseases” priority area:**  
[www.pasteur.fr/en/actualites-jdr](http://www.pasteur.fr/en/actualites-jdr)

## CANCER INITIATIVE

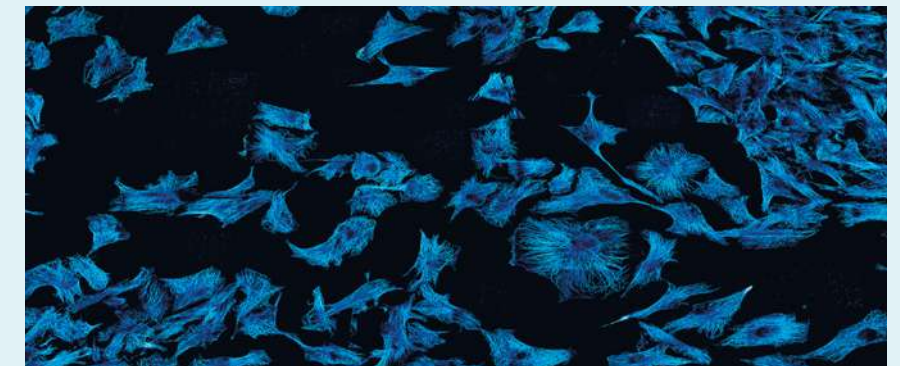
The Cancer Initiative is a concerted action by Institut Pasteur laboratories working on cancer. It seeks to harness resources and support cancer research by encouraging multidisciplinary and translational approaches. These approaches combine cell, molecular and structural biology, genetics, developmental and stem cell biology, microbiology, virology, infection biology, immunology, chemistry and computational biology.

The Cancer Initiative encompasses:

- ➊ 10 scientific departments
- ➋ 52 teams

### Progress on the priority area as at December 31, 2020

- **A series of lectures in 2020**
- **The 2021 CI Master’s call for proposals**  
 This internal call for proposals organized by the priority area coordinators with support from the Department of Scientific Affairs and the Department for Scientific Programming and Incentive Actions was issued in December. It is aimed at strengthening and catalyzing internal collaboration and creating a cancer community on campus. Funding of €5,000-6,000 is available per team. Six second-year Master’s students were selected. The students and their PI (Principal Investigator) will give a scientific presentation at a CI (Cancer Initiative) day scheduled for June 2021.
- **Promoting the Cancer Initiative externally**
  - Conference for Institut Pasteur sponsors (02/04/2019)
  - MSD Avenir (09/2019)
  - Mark Foundation (18/09/2019)
  - Nouvelle Cassius Foundation (18/09/2019)
  - JWD Dorsett Brown Foundation (02/01/2020)
- **Publicizing the Cancer Initiative internally on campus**
  - Presentation to the Department of Scientific Affairs Board (CODIS)
  - Presentation to the Department of Communications – Scientific Outreach
  - Presentation to the Technology Transfer and Industrial Partnership Department (DARRI-INNOV)
  - Presentation to Institut Pasteur staff – Biology for non-biologists (BNB) course
- At the French National Cancer Institute: Cancer Plan (23/01/2020)
- Institut Pasteur courses for major donors
- **Media engagement**
  - Press conference (18/09/2019)
  - Interview with Camille Gaubert in the “Sciences et Avenir” magazine
  - Podcast for Radio France/France Inter with Mathieu Vidard
- Pasteur Class
- **Over 40 scientific publications**, on subjects including colorectal cancer (p.27), intracellular bacteria (p.41), the Genuage project (p.42) and NHEJ (p.46) (see full list on [pasteur.fr](http://pasteur.fr)).



The ANNAPALM computerized method used to observe U-373 MG cells (human glioblastoma) whose microtubules are labeled by fluorescence.

### ON THE WEB

Find out more about:  
 ➊ **2019-2023 Strategic Plan: progress in 2020 on the cancer initiative:**  
[www.pasteur.fr/en/actualites-jdr](http://www.pasteur.fr/en/actualites-jdr)

## VACCINOLOGY AND IMMUNOTHERAPY INITIATIVE

By helping prevent diseases, vaccines have had an enormous impact on global public health, measurable in millions of lives saved. However, despite this positive observation, we are still faced with major challenges when developing vaccines and immunotherapies for neglected or emerging global diseases and when attempting to understand determinants of vaccine protection. To resolve these issues, the Institut Pasteur has drawn on its collective expertise to launch the Vaccinology and Immunotherapy Initiative. In 2020, the COVID-19 pandemic has been the main focus of its work.

The Vaccinology and Immunotherapy initiative encompasses:

➤ **12 scientific departments**

➤ **18 innovation-focused teams and projects – vaccine candidates**

➤ **4 clinical research teams and projects**

➤ **Experts** including immunologists, microbiologists, virologists, epidemiologists, vaccine and immunotherapy specialists, through the Institut Pasteur International Network, the Institut Pasteur Medical Center and external partners.

### As at December 31, 2020

In 2020, the Institut Pasteur worked on several potential vaccines for the SARS-CoV-2 virus, which causes COVID-19. Examples of this work include:

→ **Seven vaccine strategies**, which were under assessment at the Institut Pasteur in autumn 2020, five for the induction of humoral responses (antibodies, spike protein) and two for the induction of cytotoxic responses.

→ **Collaboration with industry stakeholders** at the national and international level, which has been vital to accelerate the development of six of these vaccine candidates.

→ **Three research programs** which progressed particularly well in 2020 (see below).

→ **Development of animal models.**

In 2020, progress was made with three research programs. Although one unfortunately had to be discontinued in January 2021, the other two are ongoing.

• **A vaccine using a lentiviral vector**  
Composed of a lentiviral vector (a virus that is genetically modified to be harmless and produce the spike protein) administered by nasal route; good efficacy and very high antibody production in preclinical studies; developed with the biotechnology company Theravectys.

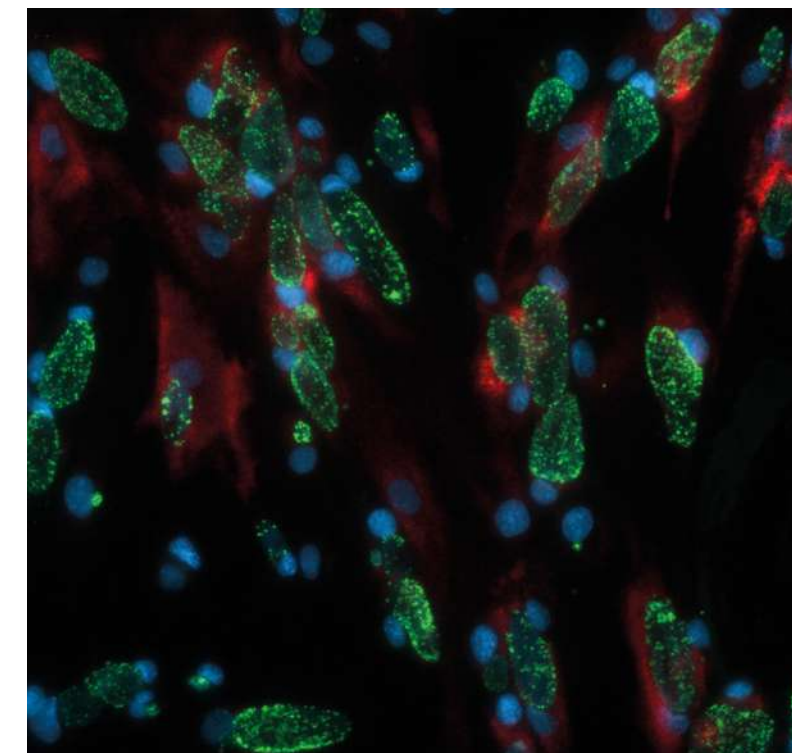
• **A DNA vaccine**  
Using very new technology based on the principle of injecting a DNA molecule into human cells; these cells recognize the DNA molecule and transcribe it into an RNA molecule capable of producing the SARS-CoV-2 spike protein; this protein, which forms spikes covering the entire virus surface, is the key that enables the virus to enter cells. In partnership with InCellArt.

• **A vaccine using the measles vector**  
Following the intermediate results of the Phase I clinical trial, the Institut Pasteur stopped development of this vaccine candidate on January 25, 2021. The vaccine candidate was an attenuated live virus vaccine. The decision to discontinue this clinical trial will have no adverse impact on continued efforts to tackle the SARS-CoV-2 virus, including those based on this platform using the measles vaccine virus as a vaccine vector. Nor will it affect the continuation of other research projects conducted with the partner Themis-Merck-MSD using the same platform to tackle other infectious diseases (Lassa fever, chikungunya). A vaccine candidate for chikungunya is currently in Phase III clinical trials.

Phase I in August 2020 in France and Belgium; trial stopped in January 2021 due to unsatisfactory intermediate results; CEPI funding: fair access; Themis-MSD-Merck partnership.

## DEPARTMENT OF CELL BIOLOGY AND INFECTION

The Cell Biology and Infection Department (BCI) develops an integrated understanding of the cell, the fundamental unit of life, in physiological conditions, during infection and in other cellular-based pathologies such as cancer and neurodegenerative diseases. Its research programs are highly interdisciplinary; they use and develop quantitative tools and innovative techniques to improve our understanding of the molecular mechanisms at work in cells. The department fosters strong links with quantitative disciplines, such as mathematics and physics. BCI teams develop new cellular, tissue and animal models for studying infections and other diseases. The department is led by Marc Lecuit.



Human cells infected with *Chlamydia trachomatis*. The nucleus of each cell is shown in blue, bacteria in green, and the cell surface in red.

### Regulation of metabolic pathways: lessons from an intracellular bacterium

Does the metabolism of cells infected by intracellular microbes display common features with cancer cells? The team led by Agathe Subtil brought support to this hypothesis by showing that one common marker of cancer cells, transglutaminase 2, is also upregulated in cells infected with *Chlamydia trachomatis*. Moreover, this upregulation has identical consequences on glucose metabolism in infected cells and in cancer cells.

*The Embo Journal*, March 5, 2020. doi.org/10.15252/emboj.2019102166

### A comprehensive analysis of midbodies, bridges between dividing cells

Cytokinesis is the last step of cell division and leads to the physical separation of the daughter cells. The Membrane Traffic and Cell Division Unit reported the first purification and quantitative proteome of intact midbodies, a key structure that recruits the machinery driving the final abscission. A syndecan/syntenin/ALIX/ESCRT module was further characterized in the membrane scission step, which revealed additional common mechanisms between cell division and the budding of retroviral viruses.

*Nature Communications*, April 22, 2020. doi.org/10.1038/s41467-020-15205-z

### Pneumococcal infections: KDM6B, a key epigenetic regulator in the cellular response

While *Streptococcus pneumoniae*, or pneumococcus, can cause serious respiratory infections, it is also present in many people asymptotically. How does the transition between these forms of infection take place? Mélanie Hamon's team has revealed an epigenetic process, involving the KDM6B protein, which regulates the asymptomatic or inflammatory response during pneumococcal infection.

*Nature Microbiology*, December 21, 2020. doi.org/10.1038/s41564-020-00805-8

### ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):

➤ **Intracellular bacteria:**

[bit.ly/3DnVJO5](http://bit.ly/3DnVJO5)

➤ **Midbodies:**

[bit.ly/305FImY](http://bit.ly/305FImY)

➤ **Pneumococcal infections:**

[bit.ly/3lizYcj](http://bit.ly/3lizYcj)



### Conditions for the onset of severe forms of COVID-19

The Systems Biology Group, in collaboration with the Weizmann Institute (Israel) and the Third People's Hospital of Shenzhen (China), studied the immune response at work in the lungs of patients with moderate and severe forms of COVID-19. Using state-of-the-art sequencing and bioinformatics techniques, the scientists determined that severe patients presented an abnormal, ineffective lymphocyte response and a massive infiltration of inflammatory cells in the lungs.

*Cell*, May 7, 2020. doi: 10.1016/j.cell.2020.05.006

### Genuage: virtual reality supporting super-resolution microscopy

The Decision and Bayesian Computation lab., in collaboration with the Institut Curie, developed an open-source software platform enabling virtual reality to be used to visualize and analyze biological data from super-resolution microscopy. Using the Genuage software, biologists can explore cell interiors and visualize organelles in an immersive environment at spatial scales that had previously not been possible, as the solution is capable of molecular-level imaging.

*Nat Methods*, Sept 20, 2020. doi: 10.1038/s41592-020-0946-1

### HIV: one stage in replication may occur in macrophage nuclei

Francesca Di Nunzio and Christophe Zimmer's teams studied HIV replication in macrophages. Using imaging and modeling techniques, they showed that the viral genomic RNA enters into the nucleus and accumulates in niches associated with splicing factors, where it can be reverse transcribed into viral DNA. These findings challenge the theory that HIV reverse transcription only occurs into the cytoplasm of host cells.

*EMBO Journal*, Dec. 3, 2020. doi: 10.15252/embj.2020105247

### ON THE WEB

More information about scientific publications at [pasteur.fr](https://pasteur.fr):

➔ **Severe forms of COVID-19:**

[bit.ly/3iHaMdA](https://bit.ly/3iHaMdA)

➔ **Genuage:**

[bit.ly/3uMxtCa](https://bit.ly/3uMxtCa)

➔ **HIV:**

[bit.ly/3iG2anx](https://bit.ly/3iG2anx)

## DEPARTMENT OF COMPUTATIONAL BIOLOGY

The Department of Computational Biology brings together scientists from the quantitative sciences (computer science, mathematics, physics, etc.) with expertise in areas ranging from mathematical modeling to algorithms, statistics and machine learning. It conducts research in various fields such as genomics, cell biology, structural biology, neuroscience, and epidemiology, both internally and in collaboration with other units on the Paris campus and those of the Institut Pasteur International Network. Affiliated with the department, the bioinformatics and biostatistics hub provides its expertise to the campus units and platforms for the analysis of various biological data, particularly genomic data. The hub also provides training and teaching programs. The department is led by Christophe Zimmer (director) and Gregory Batt (Deputy Director).

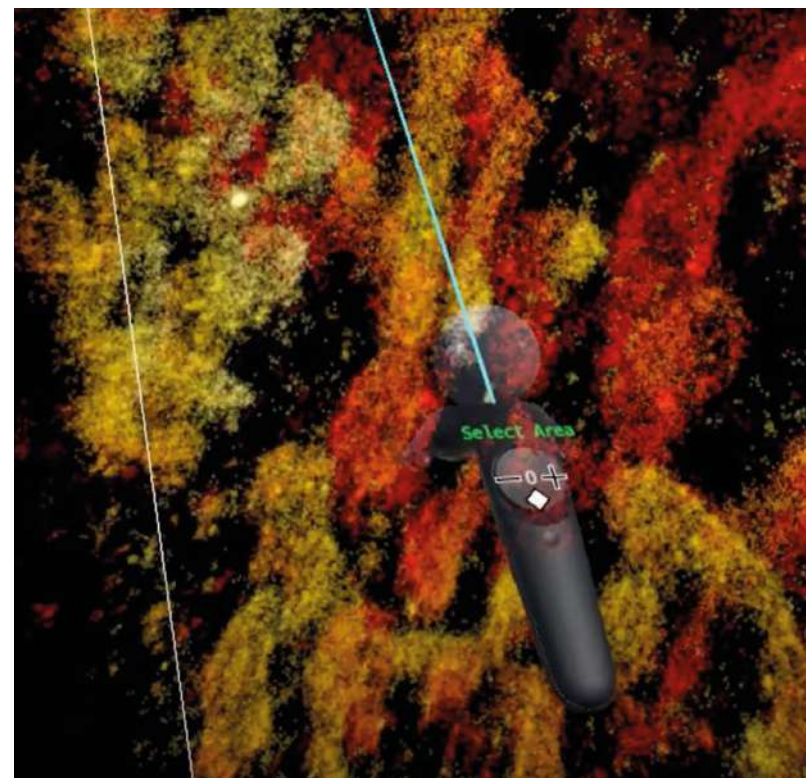
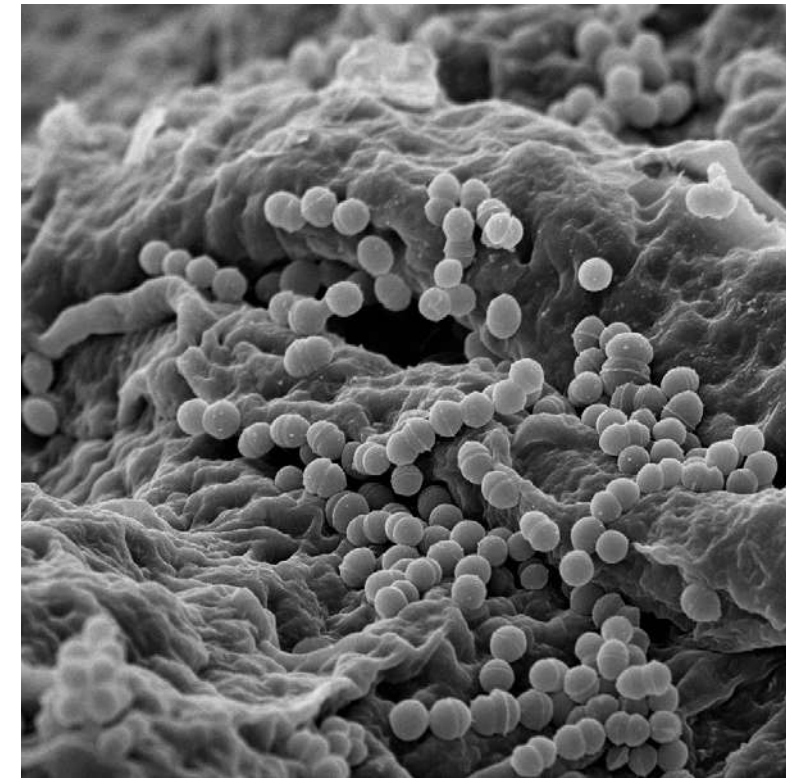


Image from the Genuage project, which presents and analyzes images of point clouds.



Scientists identified how group B streptococci cross the blood-brain barrier.

## DEPARTMENT OF DEVELOPMENTAL AND STEM CELL BIOLOGY

The Department of Developmental and Stem Cell Biology covers a broad spectrum of research, ranging from individual cells to whole organisms and from embryos to adults. How do cells acquire their identity, and how are organs formed? The department's work in the field of developmental biology also addresses stem cells and their potential role in tissue regeneration. The department is led by Laure Bally-Cuif.

### ON THE WEB

More information about scientific publications at [pasteur.fr](https://pasteur.fr):

➔ **Transgenerational sterility:**

[bit.ly/3lkzPoQ](https://bit.ly/3lkzPoQ)

➔ **Intraneural stem cells:**

[bit.ly/2Ysgwk5](https://bit.ly/2Ysgwk5)

➔ **Central nervous system infections:**

[bit.ly/3iB7Pev](https://bit.ly/3iB7Pev)

### Transgenerational sterility caused by heritable small RNAs

The results of our study illustrate how small non-coding RNAs can act as epigenetic molecules capable of transmitting traits across generations, over and above the information encoded in our genomes. Using the nematode *Caenorhabditis elegans* we show that the inheritance of small RNAs antisense to histone genes adversely affect the fertility of worms across generations until they become sterile.

*Nature Cell Biology*, Feb 03, 2020. doi: 10.1038/s41556-020-0462-7

### Intraneural stem cells: How they are maintained at long term

It remains unclear whether and how neural stem cells (NSCs) are maintained over the long term in the vertebrate brain. Combining intravital imaging, genetic tracing *in vivo* and biophysical modeling in the adult zebrafish, we quantitatively characterized NSC dynamics during adult life. The resulting model demonstrates that NSC maintenance is a population property, where individual NSCs adjust their fate to balance the fate of other NSCs in the niche.

*Science Advances*, Apr 29, 2020. doi: 10.1126/sciadv.aaz5424

### Central nervous system infections: how group B streptococci cross the blood-brain barrier

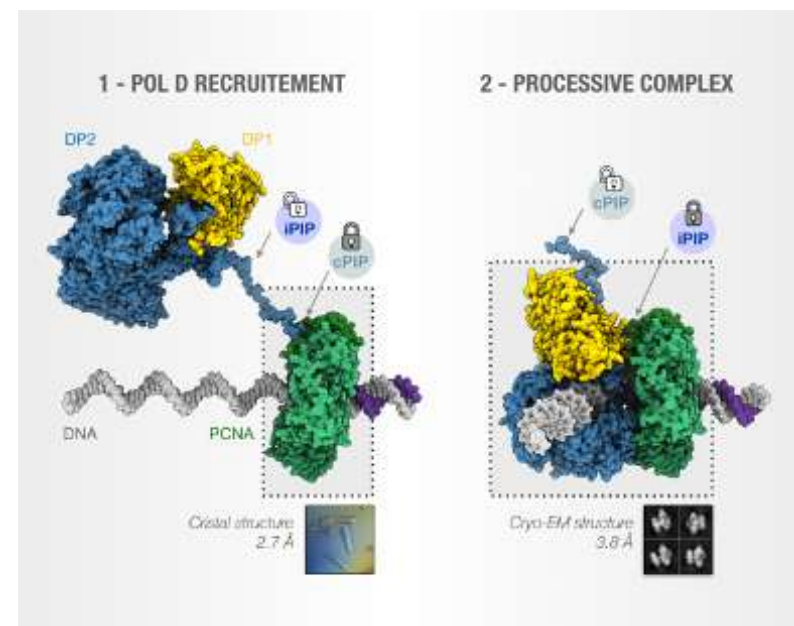
Brain infections are relatively rare but devastating. They arise when pathogenic microorganisms manage to breach the blood-brain barrier, a powerful chemical and physical filter made by the vascular walls. Using *Drosophila*, Bilal Benmimoun and his team developed an original model of brain infection. They used this model to identify a novel mechanism of brain entry by Group B streptococcus, a pathogen responsible for meningitis in neonates.

*Nature Communications*, November 30, 2020. doi: 10.1038/s41467-020-19826-2



# DEPARTMENT OF STRUCTURAL BIOLOGY AND CHEMISTRY

The structure of a molecule is intricately linked to its function. The units and technological platforms in the Department of Structural Biology and Chemistry focus their research on the three-dimensional organization, properties and functions of macromolecular complexes and machineries and the synthesis of molecules of biological interest, especially those relevant for human diseases. This interdisciplinary research reveals vital information for the development of new therapeutic, diagnostic and vaccine strategies. The department is led by Paola B. Arimondo.



Deciphering the recruitment and cooperativity mechanism between DNA polymerase D (PolD) and its replication factor (PCNA) by using an integrative approach, which combines cryo-electron microscopy and X-ray crystallography.

## ARIAweb: a server for automated NMR structure calculation

The ARIA software suite developed at the Institut Pasteur automates the analysis of NMR data to calculate three-dimensional structures of macromolecules. To improve the user experience for ARIA and provide larger and easier access, the Structural Bioinformatics Unit has created the ARIAweb server, providing an online service for such computationally intensive calculations and offering a dedicated molecular viewer along with graphical displays of various quality scores. *Nucleic Acids Res.*, Jul 2, 2020. doi: 10.1093/nar/gkaa362

## Modified aptamers allow recognition of malaria parasites

Aptamers can be thought of as analogs of antibodies entirely composed of nucleic acids (DNA or RNA). They can be used in a wide range of applications but they have limitations due to their inherent chemical nature. The Laboratory for Bioorganic Chemistry of Nucleic Acids demonstrated that chemically modified aptamers could distinguish *P. vivax* from *P. falciparum*, both parasites responsible for malaria. These results open the development of novel clinical diagnostic tools.

*PNAS*, July 21, 2020. doi.org/10.1073/pnas.2003267117

## The cooperativity mechanisms between DNA polymerase D and PCNA deciphered

Replicative DNA polymerases have evolved the ability to copy the genome with high processivity and fidelity. In Eukarya and Archaea, their processivity is greatly enhanced by binding to the proliferative cell nuclear antigen (PCNA) that encircles the DNA. By using an integrative approach which combines cryo-electron microscopy and X-ray crystallography, the Unit of Structural Dynamics of Macromolecules deciphered the recruitment and cooperativity mechanisms between DNA polymerase D and PCNA.

*Nat Commun* 11, March 27, 2020. doi.org/10.1038/s41467-020-15392-9

## ON THE WEB

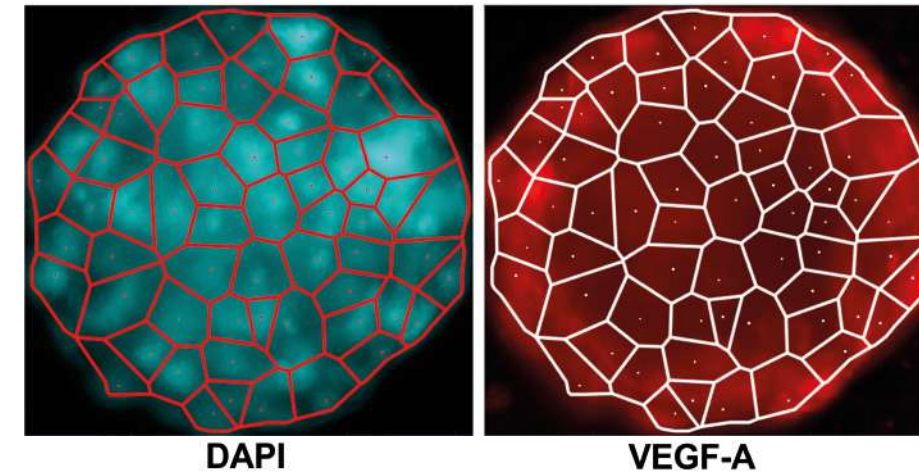
More information about scientific publications at pasteur.fr:

➔ **ARIAweb:**  
bit.ly/3Bn9ZG5

➔ **Malaria:**  
bit.ly/3Aok5Ff

➔ **Cooperativity between DNA polymerase D and PCNA:**

bit.ly/3BjhH40



Spatial quantification of protein expression in organoids derived from mesenchymal stromal cells (single-cell resolution).

# DEPARTMENT OF GENOMES AND GENETICS

Decoding the architecture, expression and evolution of genomes sheds light on new biological functions and offers a vast array of research possibilities for scientists in the Genomes and Genetics Department. The department explores the genetic information of microorganisms such as yeast and bacteria, as well as that of humans and mice. It investigates how this information is organized in the genome and is shaped by cellular processes. This helps clarify how the evolution of genomes reflects selection for adaptation, notably in terms of quality control of cellular processes and antibiotic resistance in microbes as well as humans' immune response. The progress of these research programs is largely based on sequencing, genotyping, and microfluidics approaches. The department is led by Eduardo Rocha.

## Importance of cohesin in the 3D structure of chromosomes in yeast

The 3D organization of chromosomes plays a role in many biological processes. The ring formed by the cohesin complex is an important regulator of this organization, especially in mammals where it establishes chromatin loops during interphase. Researchers from the Spatial Regulation of Genomes Unit and the CNRS show that such loops structure yeast chromosomes in metaphase and characterize the proteins regulating their size and position. *Molecular Cell*, March 19, 2020 doi: 10.1016/j.molcel.2020.01.019

## Gene therapy: Cas9 generates unexpected deletions

Triplet repeat expansions are responsible for more than two dozen neurological and developmental disorders. Shortening these repeats with endonucleases could become a viable option for patients affected with neurodegenerative disorders. Researchers from the Institut Pasteur previously showed that a TALEN was very efficient for that use. They now show that Cas9 generates unexpected large chromosomal deletions around the repeat tract. *Plos Genetics*, July 16, 2020. doi: 10.1371/journal.pgen.1008924

## ON THE WEB

More information about scientific publications at pasteur.fr:

➔ **Cohesin in yeasts:**  
bit.ly/2WPWcZN

➔ **Gene therapy:**  
bit.ly/3lpDMbT

➔ **Mesenchymal stromal cells:**  
bit.ly/3oG3fzQ

## The organization of mesenchymal stromal cells elucidated

Cells *in vivo* organize into 3D structures that underlie the shape and mechanics of tissues, as well as their biological function. Researchers mapped how mesenchymal stromal cells organize into organoids, by building a multiscale description based on massive single-cell data from microfluidic experiments. They found that cells organize into a core-shell structure that couples their level of commitment, cell-cell junctions and biological functions.

*Science Advances*, March 04, 2020. doi: 10.1126/sciadv.aaw7853





## DEPARTMENT OF IMMUNOLOGY

The Immunology Department's research focuses on the development of the immune system, its protective and pathological immune responses, and its medical applications. Since the immune system was discovered, scientists at the Institut Pasteur have been captivated by its many facets. They share a determination to explore fundamental immunological processes with the aim of tracing the origins of disease, to inspire the development of new vaccines and to devise new therapeutic strategies. The department is led by Philippe Bousso.

### Detecting patients at risk of severe COVID-19

Approximately 5% of people with COVID-19 progress to severe or critical forms. A study, including Darragh Duffy's team, described a unique immunological phenotype in such patients, consisting of a severely impaired type I interferon response, associated with a persistent blood viral load and an excessive inflammatory response. These data supported the testing of therapeutic approaches that combine early administration of interferons (IFN), with appropriate anti-inflammatory therapy targeting IL-6 or TNF- $\alpha$ . *Science*, July 13, 2020. doi: 10.1126/science.abc6027

### Cancer: Alternative NHEJ, a potential target

Ludovic Deriano's Unit studied cells mutated for NHEJ, the canonical repair pathway for DNA double-strand breaks. The researchers showed that those transformed cells rely on alternative repair activities (alternative NHEJ) to survive DNA damage induced in non-cycling (a state where the cell stops growing and dividing) G1 conditions. This alternative repair pathway represents an attractive target for future DNA repair-based cancer therapies.

*Nature Communications*, 2020 Oct 16. doi: 10.1038/s41467-020-19060-w

### How is the embryonic thymus microenvironment shaped?

Within the first cells that seed the thymus, the Lymphopoiesis Unit identified a unique population of lymphoid progenitors. These cells can generate lymphoid tissue inducer or invariant T cells, two cell types that are critical in the immune system. They are required to ensure thymic medullary epithelial cell maturation and negative selection, at birth. These results highlight the relevance of sequential thymic colonization by distinct precursors for thymus organogenesis.

*Blood*, February 25, 2021. doi.org/10.1182/blood.2020006779

### ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):

➔ **At-risk patients:**

[bit.ly/3mwr3TR](https://bit.ly/3mwr3TR)

➔ **Cancer:**

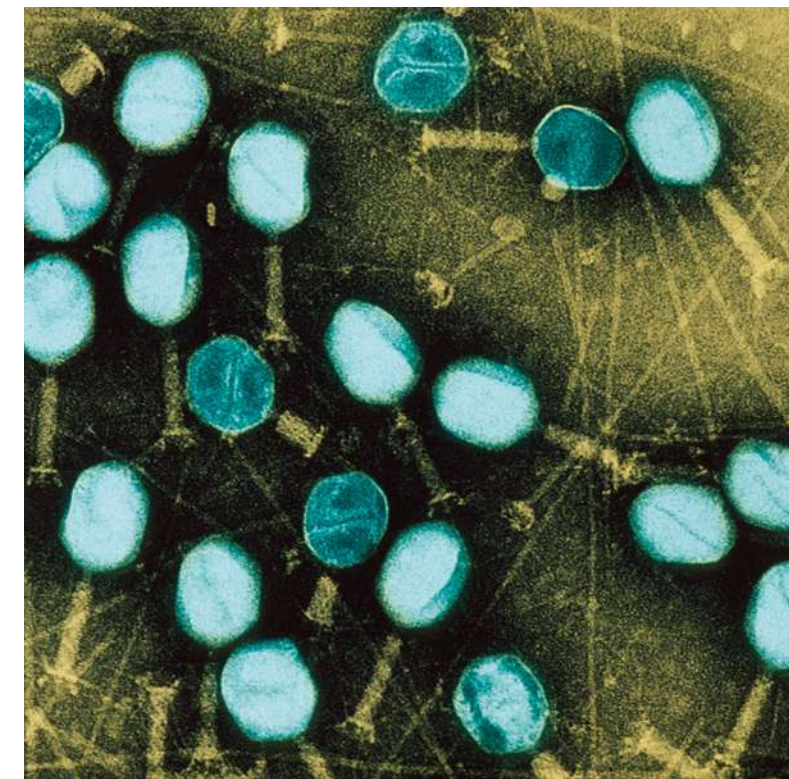
[bit.ly/3iHzydF](https://bit.ly/3iHzydF)

➔ **Embryonic microenvironment of the thymus:**

[bit.ly/3aiHCNv](https://bit.ly/3aiHCNv)

## DEPARTMENT OF MICROBIOLOGY

The scientists of the Department of Microbiology study biological processes of bacteria and archaea (and their viruses) using genomics, genetics, metabolism, etc. They focus on the mechanisms that render some of these microorganisms virulent and enable them to evade the host immune system or develop resistance to antibiotics. These studies improve our understanding of the life cycle of these microorganisms, and contribute to the development of new diagnostic tools and therapies to treat bacterial infections. The department is led by Frédéric Barras.



Gut geography helps to keep bacteriophage and bacterial populations in balance. *E. coli* bacteriophages are shown here.

### ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):

➔ **Antimicrobial treatments:**

[bit.ly/3BokTvh](https://bit.ly/3BokTvh)

➔ **Activation of macrophages:**

[bit.ly/3BnzmYg](https://bit.ly/3BnzmYg)

➔ **Microbiota:**

[bit.ly/3ak4fRq](https://bit.ly/3ak4fRq)

### Discovery of a new target for antimicrobial treatments

Bacterial cell division is coordinated by several mechanisms including the synthesis of peptidoglycan, a thick complex surrounding the cell. This synthesis is enabled by the action of a specific enzyme. Scientists from the Biology and Genetics of the Bacterial Cell Wall Unit at the Institut Pasteur have discovered a region of this enzyme that opens a chink in the bacterial armor when subjected to genetic interference. Thanks to the discovery, this enzyme can now be considered as a target for treatments.

*Elife*, February 5, 2020. doi: 10.7554/eLife.51247

### When antibiotics activate our immune system

Although known for their microbicidal activity, antibiotics may also interfere with our immune system. Researchers at the Institut Pasteur discovered that a new molecule used to treat multidrug-resistant tuberculosis activated the defense mechanisms of macrophages, key players in innate immunity. The cells were better able to fight bacterial infections normally resistant to the antibiotic.

*Elife*, May 4, 2020. doi: 10.7554/eLife.55692.

### Microbiota: gut geography influences interactions between bacteria and their viruses

The gut microbiota houses a complex and varied microbial community that coexists in a balance which is crucial for human health but also poorly understood. The bacteria of the microbiota are exposed to predation by their viruses and bacteriophages, but some of them can find refuge in the mucus that covers gut tissue, thereby preserving the balance between populations of bacteriophages and bacteria.

*Cell Host & Microbes*, July 1, 2020. doi: 10.1016/j.chom.2020.06.002



## ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):

### ➤ **Candidiasis:**

[bit.ly/3BIWbMb](http://bit.ly/3BIWbMb)

### ➤ **Cryptococcus genome:**

[bit.ly/3lhLWTi](http://bit.ly/3lhLWTi)

### ➤ **Autoinflammatory diseases:**

[bit.ly/3oEfdty](http://bit.ly/3oEfdty)

## Candida infections: the role of the Rme1 protein in the formation of chlamydo spores

The yeast *Candida albicans* can alternate between several morphotypes, including chlamydo spores, large spherical cells whose function and formation mechanisms are poorly understood. Researchers from the Fungal Biology and Pathogenicity Unit have discovered that the Rme1 protein is the key regulator of chlamydo spore formation. The identification of Rme1 opens the way to understanding the role of chlamydo spores in the biology of *C. albicans*.

*Nature Communications*, December 4, 2020.  
doi.org/10.1038/s41467-020-20010-9

## Autoinflammatory diseases: a yeast sugar as a potential treatment

Exposure of mononuclear phagocytes to  $\beta$ -glucan, a naturally occurring polysaccharide at the surface of fungi, contributes to the induction of innate immune memory. In this study, the Immunology of Fungal Infections Unit shows, for the first time, the dampening impact of  $\beta$ -glucan-induced innate immune memory on NLRP3 inflammasome activation and IL-1 $\beta$  secretion and supports its potential clinical use in autoinflammatory diseases.

*The Journal of Clinical Investigation*, July 27, 2020.  
doi: 10.1172/JCI134778

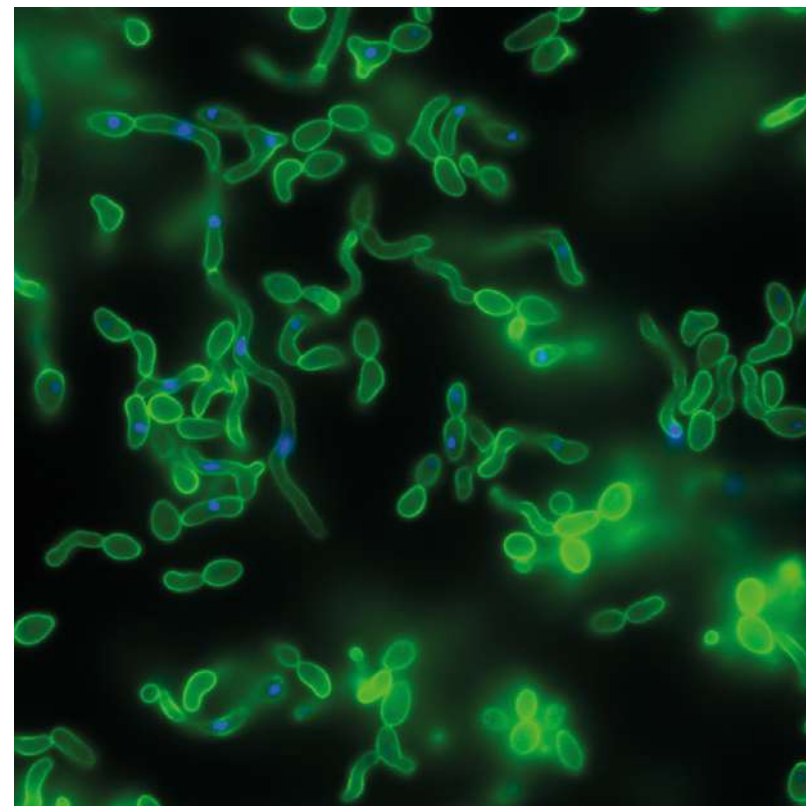
## Discovery of numerous potential open reading frames in the *Cryptococcus* genome

Gene structure, including the transcript leader, is very diverse in fungi. New sequencing data analysis from the RNA Biology of Fungal Pathogens Unit revealed that in the pathogenic yeasts *Cryptococcus*, the transcript leader sequence is rich in potential upstream Open Reading Frames, which regulate both gene expression and protein diversity.

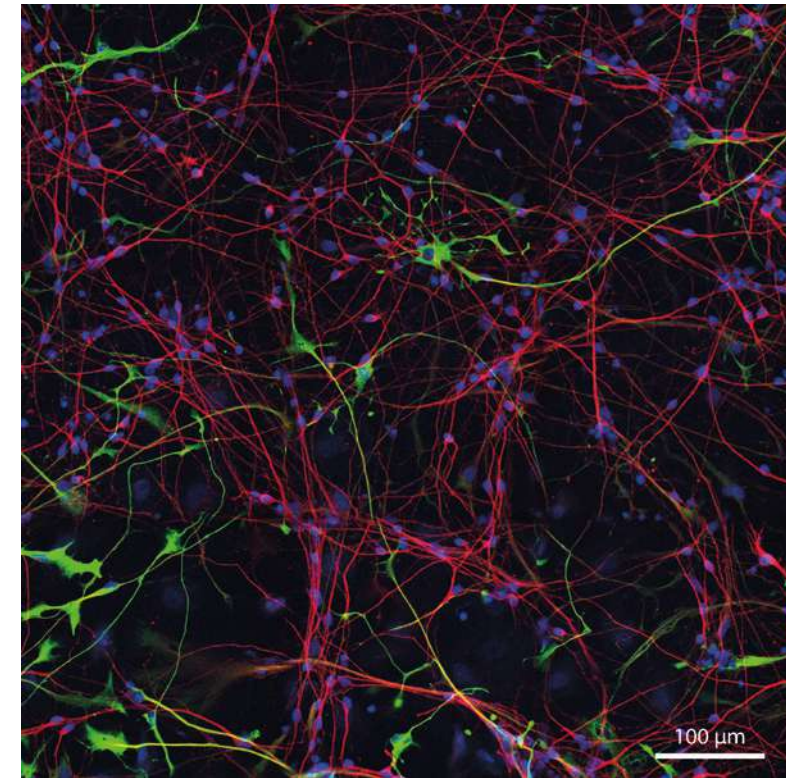
*Nucleic Acids Res.*, March 18, 2020. doi: 10.1093/nar/gkaa060

# DEPARTMENT OF MYCOLOGY

Over the last thirty years, fungal infections have become a major public health concern. The Department of Mycology focuses its research on the three main fungi responsible for invasive infections: *Aspergillus fumigatus*, *Candida albicans* and *Cryptococcus neoformans*. The aim is to shed light on the biology of these pathogenic fungi, identify their virulence mechanisms and develop new strategies for diagnosis, prevention and treatment. The department is led by Guilhem Janbon.



*Candida albicans* in fluorescence microscopy.



Cortical neurons and astrocytes derived from human iPSCs.

# DEPARTMENT OF NEUROSCIENCE

The Department of Neuroscience investigates the organization and function of the central nervous system across scales, from molecules to animal behavior. These studies form the fundamental basis for translational research focused on the mechanisms, pathophysiology, and clinical implications of neurological and psychiatric disorders. These include: hearing loss, developmental disorders (autistic spectrum disorders and dyslexia), addiction, mood disorders and neurodegenerative disease, all of which represent major health challenges for developed countries. The department is led by David DiGregorio.

## AVATAR MEDICAL, a platform to facilitate preparations for complex surgical procedures

AVATAR MEDICAL is a spinoff of the Institut Pasteur and the Institut Curie/PSL that aims to improve surgery planning through the use of visualization and analysis software based on virtual reality technology. AVATAR MEDICAL recently joined the Prairie Institute as a startup member. Mohamed el Beheiry is the CTO of AVATAR MEDICAL, and Jean-Baptiste Masson is the CSO. They are respectively a former post-doctoral fellow and the former director of the Decision and Bayesian Computation Unit.

## Have I Seen This Before? Exploring The Formation of Distinct Memories

How do we form and use distinct memories of similar events? Scientists at the Institut Pasteur have combined imaging and behavioral recordings to measure the activity of neurons in the hippocampus of mice performing memory tasks. They find that the input region of the hippocampus detects small changes between familiar and novel environments, while the output region then weights this information to guide behavioral decisions.

*Neuron*, October 16, 2020. doi: 10.1016/j.neuron.2020.09.032

## GABA<sub>A</sub> receptors undergo asymmetric motions

$\alpha 1\beta 2\gamma 2$  GABA<sub>A</sub> receptors mediate most inhibitory synaptic transmission in the brain and are the target of widely used therapeutic drugs such as benzodiazepines. Upon activation by the neurotransmitter, they undergo activation and desensitization transitions. Researchers from the Channel Receptors Unit showed that they undergo asymmetric motions during desensitization, with potential implications in pharmacology.

*Nature Communications*, October 23, 2020. doi: 10.1038/s41467-020-19218-6

## ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):

### ➤ **AVATAR MEDICAL:**

[bit.ly/3uMkuAi](http://bit.ly/3uMkuAi)

### ➤ **Distinct memories:**

[bit.ly/3AiEqMu](http://bit.ly/3AiEqMu)

### ➤ **GABAA receptors:**

[bit.ly/3oFGAn5](http://bit.ly/3oFGAn5)



# DEPARTMENT OF PARASITES AND INSECT VECTORS

The Department of Parasites and Insect Vectors conducts research on the three key eukaryotic parasites responsible for severe diseases of major public health concern that generate an important economic burden in the world's most populous regions. These are: *Plasmodium*, which causes malaria; *Leishmania*, the agent of leishmaniasis; and *Trypanosoma brucei*, responsible for sleeping sickness. The *Anopheles* mosquito, which is the vector of *Plasmodium* and other viruses, is also studied, as well as the tsetse fly, the vector for *Trypanosoma brucei*. The department is led by Gerald Spaeth.



Typical Rwandan landscape where *P. falciparum* parasites are transmitted by *Anopheles* mosquitoes.

## Exposure of *Anopheles* mosquitoes to trypanosomes reduces reproductive fitness and enhances susceptibility to *Plasmodium*

In nature, female mosquitoes take successive blood meals during which they are exposed to a variety of microbes present in the host. In Africa, *Trypanosoma* parasites, causing trypanosomiasis, are sympatric with malaria parasites. In recent work, we showed that pre-exposure of *Anopheles* mosquitoes to *Trypanosoma* enhances their vector competence to malaria parasites, reduces their reproductive fitness and modulates their bacterial gut flora.

*PLoS Neglected Tropical Diseases*, Feb. 2020. doi: 10.1371/journal.pntd.0008059

## Malaria: parasite resistance to artemisinin now found in Africa

Resistance to artemisinin, the main component of current antimalarial treatments recommended by WHO, is widespread in South-East Asia, but has not been described in Africa. In a study published in 2020, scientists from the Institut Pasteur, in collaboration with the NMCP in Rwanda, WHO and Columbia University provided for the first time evidence of the *de novo* emergence of Pfk13-mediated artemisinin resistance in Rwanda.

*Nature Medicine*, August 3, 2020. doi.org/10.1038/s41591-020-1005-2

## Extravascular dermal trypanosomes in suspected and confirmed cases of Human African Trypanosomiasis

Diagnosis of sleeping sickness, a neglected tropical disease caused by African trypanosomes, relies on the detection of parasites in blood. Following their previous discovery that the skin is a reservoir for trypanosomes, scientists from the Institut Pasteur and colleagues have recently confirmed and quantified this phenomenon in humans, thereby improving our epidemiological understanding and opening new approaches to eliminate the disease.

*Clinical Infectious Diseases*, July 8, 2020. doi: 10.1093/cid/ciaa897.

## ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):

- ***Anopheles* mosquitoes:**  
[bit.ly/3linWzo](http://bit.ly/3linWzo)
- **Malaria:**  
[bit.ly/304bUSh](http://bit.ly/304bUSh)
- **Extravascular dermal trypanosomes:**  
[bit.ly/2Yvjln](http://bit.ly/2Yvjln)

## ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):

- **Zika virus:**  
[bit.ly/2Yvz2sc](http://bit.ly/2Yvz2sc)
- **Serological assays:**  
[bit.ly/3FhWFFk](http://bit.ly/3FhWFFk)
- **Hantaviruses:**  
[bit.ly/3lpEMg9](http://bit.ly/3lpEMg9)

## Why hasn't Zika virus caused large-scale outbreaks in Africa

The mosquito *Aedes aegypti* is a major arbovirus vector native to Africa that invaded most of the world's tropical belt. By comparing wild populations of *Ae. aegypti* from various regions of the globe, researchers have shown that the invasive subspecies is very effective at transmitting the Zika virus, not only because it has more frequent contacts with humans for blood meals, but also as a result of its greater susceptibility to the virus compared to the native African subspecies.

*Science*, Nov 20, 2020. doi:10.1126/science.abd3663

## Institut Pasteur's antibody assays developed against SARS-CoV-2

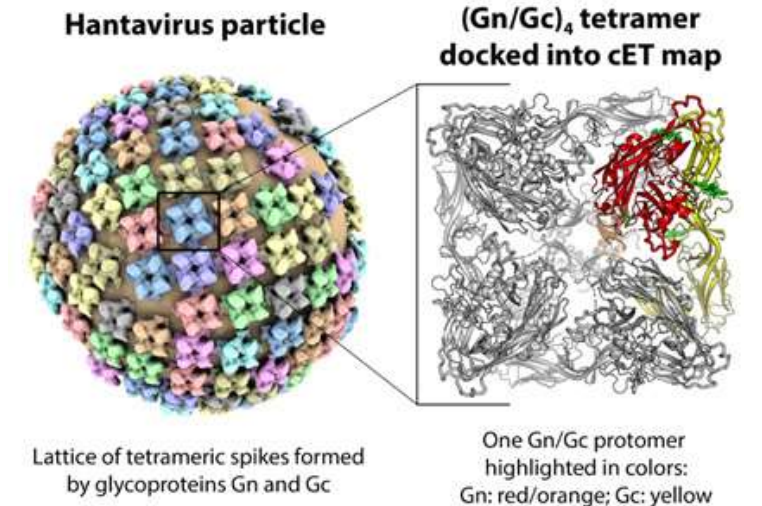
A large pilot study showed that in COVID-19 hospitalized patients, seroconversion and SARS-CoV-2 neutralization occurred between 5 and 14 days after symptom onset. Seropositivity was detected in 32% of mildly symptomatic individuals within 15 days of symptom onset and in 3% of healthy blood donors. The four antibody assays enabled a broad evaluation of SARS-CoV-2 seroprevalence and antibody profiling in different subpopulations within one region.

*Science Translational Medicine*, August 17, 2020. doi:10.1126/scitranslmed.abc3103

## Deciphering Hantavirus' structure

Hantaviruses are rodent-borne viruses causing serious zoonotic outbreaks worldwide for which no treatment is available. X-ray structures of the hantavirus surface glycoprotein lattice reveal a built-in mechanism controlling envelope glycoprotein membrane insertion. This study provides important information for development of immunogen protection against these deadly viruses.

*Cell*, Oct 15, 2020. doi:10.1016/j.cell.2020.08.023



Hantavirus structure.

# DEPARTMENT OF VIROLOGY

The Virology Department studies a large variety of viruses, including respiratory viruses such as influenza and the recent emerging SARS-CoV-2 virus; oncogenic viruses (papillomaviruses, HTLV, hepatitis B and C viruses); retroviruses (HIV and foamy viruses); insect-borne viruses causing severe diseases such as dengue, chikungunya, yellow fever, Zika (causing microcephaly), Rift Valley fever; and viruses causing hemorrhagic fever (such as the Lassa fever and Ebola viruses).

The department's research aims at understanding the molecular mechanisms at play during the different steps of the viral cycle and underlying their associated diseases: a large effort is made to decipher virus/host interactions and pathophysiological events associated with viral infection. Research activities include studies of transmission, animal reservoirs or vectors, viral epidemiology and evolution and host immune response. The department houses different National Reference Centers and WHO Collaborating Centers for viruses, with its primary mission to remain at the cutting edge of fundamental research, but also to translate its discoveries for addressing global public health challenges linked to emerging and re-emerging viruses. The Department is led by Sylvie Van der Werf.



## ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):

➔ **Cholera: study of the strain responsible for the 2018-2019 outbreak in Zimbabwe (pasteur.fr):**

[bit.ly/3lh4Jy8](http://bit.ly/3lh4Jy8)

➔ **Meningococci:**

[bit.ly/2YwGTWG](http://bit.ly/2YwGTWG)

➔ **Mathematical modeling (in French):**

[bit.ly/2Yt4OWr](http://bit.ly/2Yt4OWr)

### Cholera: study of the strain responsible for the 2018-2019 outbreak in Zimbabwe

Scientists from the Enteric Bacterial Pathogens Unit led by François-Xavier Weill were approached by colleagues in Zimbabwe and South Africa to contribute their genomic epidemiology expertise to an investigation of the 2018-2019 cholera outbreak. They were able to trace the spread of the epidemic strain from its source in Asia to Zimbabwe, and ascertain how it became highly resistant to antibiotics.

*Nature*, January 2, 2020. doi: 10.1038/s41586-018-0818-3

### Meningococci: an example of genomics used as an epidemiological tool

By examining vaccine coverage of invasive meningococcal infections in conjunction with genomic and pathophysiological analyses, it was possible to detect a new genotype in meningococcal serogroup W and characterize the emergence of the resulting bacterial strain. This combined approach has been a useful decision-making tool in implementing measures to control invasive meningococcal infections in the Hauts-de-France region.

*Journal of Infection*, February 4, 2020. doi: 10.1016/j.jinf.2020.01.020

### Mathematical modeling as a tool for tackling the SARS-CoV-2 pandemic

Mathematical models are useful for describing epidemic trends. Since the beginning of the COVID-19 pandemic, the Mathematical Modeling of Infectious Diseases Unit, led by Simon Cauchemez, has been contributing its expertise to help tackle the outbreak. In particular, its work has involved monitoring the spread of SARS-CoV-2, producing projections, assessing the impact of control measures, and characterizing what looks set to be a race between the vaccine rollout and variants.

## DEPARTMENT OF GLOBAL HEALTH

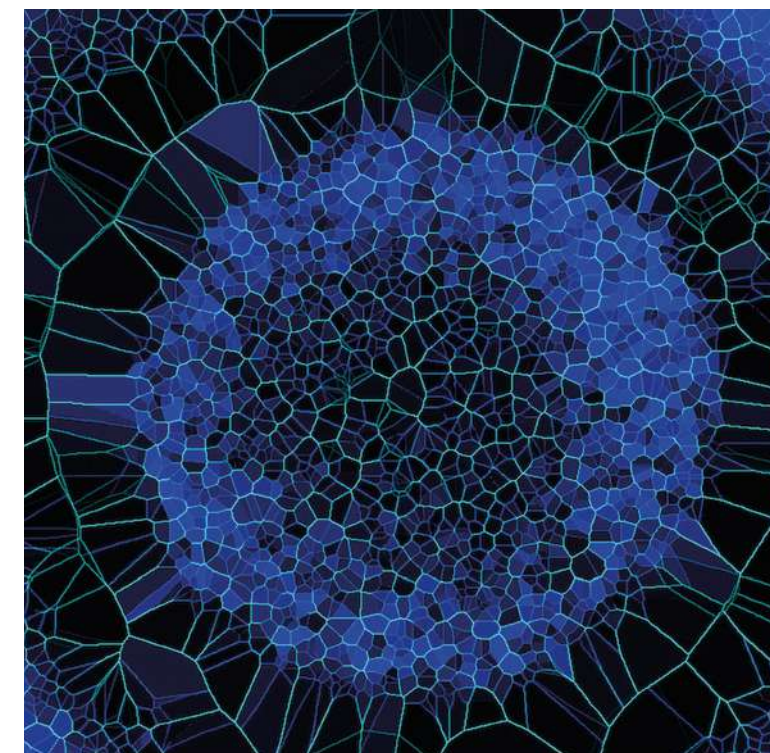
The Department of Global Health conducts interdisciplinary research pertaining to public health issues and challenges in a global context. Our research activities range from basic science projects to clinical studies, including a One Health approach, focusing on interactions between human, animal, and environmental health. In particular, the department focuses on aspects of emerging and re-emerging infectious diseases, covering multiple and complementary fields such as: infectious disease epidemiology, disease modeling, transmission dynamics, host-pathogen interactions, host-immune response, vaccinology, and pathogen resistance to therapeutics. Our aim is to strengthen the Institut Pasteur's worldwide initiatives, working in close collaboration with the 33 International Network member institutes around the world, nine National Reference Centers (CNRs), and the WHO Collaborating Centers (WHOCs). Teams in the department also work closely with national and international organizations such as Santé publique France (SpF), ECDC, WHO, and OIE – the World Organization for Animal health. The department is currently led by Director Hervé Bourhy and Deputy Director Muhamed-Kheir Taha.



*Vibrio cholerae* – the cholera bacterium.

## DEPARTMENT OF TECHNOLOGY (DT)

The Department of Technology is one of the components of the Department of Scientific Affairs. Its aim is to develop a high-level technological environment to further enhance the Institut Pasteur's excellence in research.



### Organizational changes enhancing synergies

On July 31, 2020 the Department of Technology and Scientific Programs became the Department of Technology (DT). It coordinates and includes:

- the Center for Technological Resources and Research (C2RT);
- the Center for Animal Resources and Research (C2RA);
- the Institut Pasteur Biological Resource Center (CRBIP);
- the Data Management Core Facility;
- the Administrative and Quality Center (PAD).

The CRBIP joined the department in the summer of 2020, enhancing synergies between the biobanks and platforms (see adjacent insert).

### DT teams heavily involved in COVID research, while maintaining essential activities

Here are some examples of their involvement in projects as partners and occasionally coordinators:

- ➔ **Development of diagnostic tests and tools**

### THE CRBIP JOINS THE DEPARTMENT OF TECHNOLOGY

The Institut Pasteur Biological Resource Center (CRBIP) encompasses five Institut Pasteur biobanks ensuring that a joint strategy is in place. The CRBIP is composed of:

- The Institut Pasteur Collection (CIP)
- The National Collection of Microorganism Cultures (CNCM)
- The Institut Pasteur Cyanobacteria Collection (PCC)
- The Institut Pasteur Virus Collection (CVIP)
- The Clinical Investigation and Access to BioResources Platform (ICAReB)

The CRBIP collects, analyzes, preserves, and distributes its biological resources both in France and abroad in accordance with international regulations. It also develops research (taxonomy, biopreservation), training, biobanking expertise (Nagoya Protocol), and international collaborations (MIRRI European infrastructure, <https://www.mirri.org/>).

Under the coordination of the AI Platform, Proteins Pole platforms collaborated on the production of recombinant SARS-CoV-2 nucleoprotein (N) and spike (S) antigens, and the generation of anti-N and anti-S nanobodies for diagnostic and therapeutic applications. The 3PR Platform transferred nucleoprotein (N) production technology to Institut Pasteur International Network institutes



and a manufacturer, thus speeding up the development of serological assays. With support from the CIP and CNCM, ICAReB managed and prepared human samples taken from patients infected with SARS-CoV-2, which the Institut Pasteur used to develop serological assays and epidemiological and clinical studies.

➔ **Therapeutic research**

The CCB Platform set up a medium-throughput SARS-CoV-2 screening test in a BSL3 laboratory. This test, which is tailored to different cell types from different human or primate tissues and is accessible to the scientific community and manufacturers, assesses compounds' capacity to inhibit replication/infection of native SARS-CoV-2 and all its emerging variants.

➔ **Modeling, epidemiology and clinical trials**

The Data Management Core Facility supported several clinical trials in 2020 (see insert below).

➔ **Knowledge of the virus and its pathogenesis**

- In collaboration with several research units, the Nanoimaging Platform imaged the structure of the spike protein complexed with the ACE2 receptor and with neutralizing antibodies, and visualized infected cells by cryoelectron tomography.
- The UBI UTechS performed *in vitro* characterization of host-pathogen

interactions between the SARS-CoV-2 virus during cell infection by scanning and transmission electron microscopy.

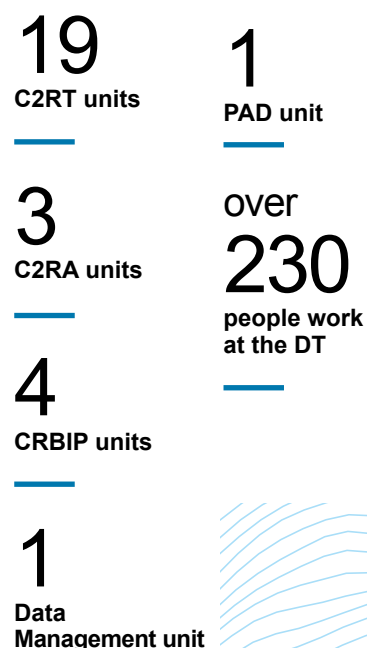
➔ **Development of research tools**

The CIGM produced animal models susceptible to SARS-CoV-2 to test vaccines or drugs. The Biomaterials and Microfluidics Technological Platform is involved in the COROCHIP project. This project aims to develop *in vitro* models (organoids, organs-on-chips) capable of recapitulating SARS-CoV-2 infection along the airways.



**LAUNCH OF THE DATA MANAGEMENT CORE FACILITY**

The Data Management Core Facility set up in February 2020 and led by Anne-Caroline Deletoille provides research units and other platforms with support and expertise on data management for their projects. For instance, the core facility is helping REDCap® users to collect clinical and epidemiological data. Its data managers are involved in numerous studies (AIMS-2 trial, "Milieu Intérieur", etc.) including SARS-CoV-2 studies (CORSER, SocialCov, RCCOVID, etc.). The core facility is also involved in the implementation of the Institut Pasteur policy on managing and sharing research data and software codes.



**SELECTION OF THE MOSBRI INFRASTRUCTURE PROJECT**

In November 2020, the European Union's H2020 INFRAIA program awarded a €5 M grant to MOSBRI (Molecular-Scale Biophysics Research Infrastructure: [www.mosbri.eu](http://www.mosbri.eu)), a consortium of 13 academic centers of excellence and two industrial partners from 11 European countries, coordinated by Patrick England (Molecular Biophysics Platform). Through the MOSBRI project, integrated infrastructure will be put in place combining an unrivaled range of instruments and expertise from each partner laboratory with which it will be possible to provide responses to an exceptionally wide variety of life science research questions. MOSBRI will guarantee optimal usage of advanced biophysics techniques and facilitate joint ventures, thereby helping advance knowledge and technology. It will also share its expertise through an extensive program of training workshops and events particularly aimed at early career scientists and other newcomers to the field.

**An organizational approach adapted to meet the needs of all users, both on and off site**

- Independent access to equipment maintained for priority projects.
- Reorganization of the Central Animal Facility to accommodate any projects using animal models.
- Work on training, smooth and safe access for independent users, and preservation of animal models.
- Users provided with tools and services to optimize remote working (user training, project meetings, data storage, virtual machines, data processing and analysis, modeling, etc.).

The CIP distributed 535 bacterial strains to Institut Pasteur staff in 2020. It also provided Institut Pasteur laboratories with several freeze-drying services.

**An enhanced offering for the campus and the wider scientific community**

The Nanoimaging Platform's capacities were increased with the commissioning of two additional microscopes (Aquilos and Glacios). A practical course on "Single Particle Analysis" was regularly offered to train future independent users. The Biomics Platform cooperated with the Procurement Department and Legal Affairs Department to set up an agreement with an external partner enabling access to ultra-high throughput sequencing. A special portal was set up

for single-cell analyses. It combines the services of the CB UTechS, which is the point of entry for the various single-cell technologies, the PBI UTechS, the MSBio UTechS, Biomics, and the Bioinformatics and Biostatistics HUB. New equipment was also acquired to support single-cell activities.

The HPC Platform deployed the new supercomputer dubbed "Maestro" combining various technologies including GPUs, containerization, ultra-high-performance storage, and ultra-high-speed networks. It will enable over a hundred Institut Pasteur scientists to carry out work requiring cutting-edge computing resources, explore new approaches including Deep Learning, and tackle new fields such as Cryo-EM.

**European projects**

The IS\_MIRRI21 European infrastructure project in which the CRBIP is a partner was launched in February 2020. Its aim is to create a European research infrastructure for microbial biobanks (MIRRI). The MOSBRI infrastructure project coordinated by the BMI Platform was selected for funding (see insert above).

**2019-2023 STRATEGIC PLAN: DT TECHNOLOGICAL OBJECTIVES**

- Step up our data analysis and artificial intelligence capabilities through an appropriate strategy.
- Boost internal resources for computing, storage, and networking.
- Establish an infrastructure for simultaneous analysis of the host, vector and pathogen under biosafety level 3 containment conditions (animal facility, insectarium, imaging capabilities).
- Offer a set of cryo-electron microscopes enabling ultrastructural analysis in the cellular environment.
- Offer shared metabolomics resources for sample preparation and analysis.
- Step up our capabilities for offering humanized animal models.
- Boost our ability to identify novel diagnostic and therapeutic solutions.
- Implement shared electronic data collection and analysis (ELN, LIMS).

9 units are quality-certified

9 units have IBISA accreditation

# ACADEMIC PARTNERSHIPS WITHIN FRANCE

The Institut Pasteur has a long history of research and teaching partnerships with research institutions and universities in the Greater Paris region. One of the objectives of the 2019-2023 Strategic Plan is to consolidate and develop national partnerships to drive scientific excellence within the Institut Pasteur.

## Partnerships with Public Scientific and Technical Research Establishments (EPSTs)

A number of research structures are currently based on the Institut Pasteur campus, including accredited research teams (ERLs), joint research units (UMRs) and service and research units (USRs).

These structures are jointly affiliated, either to the Institut Pasteur and the CNRS (1 ERL, 9 UMRs and 1 USR) or to the Institut Pasteur and Inserm (8 UMRs and 2 co-supervised teams). One notable Institut Pasteur-Inserm UMR is the Hearing Institute set up in 2019 with the support and financial backing of the Fondation Pour l'Audition. The Institut Pasteur also hosts a Unit Under Contract (USC) with the French National Research Institute for Agriculture, Food and Environment (INRAE) and joint units with the French National Conservatory of Arts and Trades (CNAM), the French National Research Institute for the Digital Sciences (Inria), and the École Polytechnique.

## Partnerships with universities

These partnerships cover research – with eight joint units hosted on the Institut Pasteur campus jointly affiliated with Université de Paris – and also teaching. Fourteen courses can be included as part of a Master's program (first- or second-year Master's) at our partner universities (Université de Paris, Sorbonne Université, ENS/PSL, Paris-Saclay), 17 Institut Pasteur courses lead to the award of a university diploma (DU) from the Université de Paris (16) or Sorbonne Université (1), and more than 20 courses count as doctoral school modules. Most of the courses are run jointly with Université de Paris, Sorbonne Université, Université

Paris-Saclay and Paris Sciences et Lettres (Université PSL). Moreover, 10 Institut Pasteur courses are included in the Université de Paris European Masters in genetics and 14 Institut Pasteur courses are eligible for ECTS (European Credit Transfer System) credits from the Pasteur/CNAM School which awards the Advanced Master's in Public Health, accredited by the French Conférence des Grandes Écoles. Finally, the "Médecine-Sciences" program is run in partnership with the École normale supérieure (ENS), Institut Curie and PSL. The Institut Pasteur also manages its own international PhD program (PPU) in close partnership with the Université de Paris, Sorbonne Université and Université Paris-Saclay.

## Partnerships with the Paris Public Hospital Network (AP-HP)

To support research projects that associate the basic research conducted by the Institut Pasteur's teams with translational and clinical research,

the Institut Pasteur and the Paris Public Hospital Network (AP-HP) annually publish joint calls for proposals to host hospital-based physicians, either as guest researchers or via a partnership contract. Two of the three joint units set up in 2016 were renewed for a period of five years (2021-2025) and a dual-site Institut Pasteur/AP-HP/Paris-Sud University joint research unit set up in 2013 is also in the process of being renewed.

## Hosting permanent scientists from external research organizations (OREX)

The joint units hosted at the Institut Pasteur are partly composed of OREX scientists and engineers from EPSTs, universities, and the AP-HP, etc. The Institut Pasteur currently hosts 103 scientists and 14 engineers employed by partner institutions, mainly from the CNRS (49 scientists and 9 engineers), Inserm (19 scientists and 5 engineers) and Université de Paris (11 scientists/lecturers and 8 university hospital scientists/lecturers).



# PUBLIC HEALTH MISSION

A key challenge facing the Institut Pasteur is how best to address current public health issues and anticipate future health needs. In 2020, it leveraged its expertise during the COVID-19 pandemic by conducting clinical investigations and epidemiological field studies.



# INTERVIEW

## with Bruno Hoen

Medical Research Director  
at the Institut Pasteur



**You have been in post as Medical Research Director since the beginning of January 2020, just before the outbreak of the COVID-19 epidemic. What did you take away from this first year in post?**

2020 was thrown into complete chaos by the outbreak of the COVID-19 pandemic, just weeks after I joined. Human health is an Institut Pasteur priority set out in its strategic plan for 2019-2023. This is one of the reasons a physician was appointed Medical Research Director. Let's not forget that the Institut Pasteur has its roots in medical research, as it was set up shortly after the human rabies vaccine was developed. The challenge set for 2020 was to promote and develop translational and clinical research. This immediately became a reality with the COVID-19 pandemic, which required on-the-spot decisions at a time when

we were beginning to consider our future organizational structure [editor's note: the organization of the new Medical Research Department].

**What activities have you developed to meet these challenges?**

We developed two types of activities enabling innovation in projects involving human health. Firstly, we reorganized the Center for Translational Science (CRT – see p. 63) to that end, and ensured that COVID-19 research involved human beings. This was achieved through observational studies in the field. The first of these was the CORSER study on SARS-CoV-2 coronavirus seroepidemiology. In this study, we sought to determine whether the new coronavirus was spreading within particularly exposed populations, and developed a sample collection (biobank) that can be used for other studies

related to this disease. Other projects emerged over time. In particular, studies were conducted in Crépy-en-Valois, where the first indigenous cluster was identified in late February 2020. Scientists, Medical Center healthcare workers, and Institut Pasteur support staff\* conducted an epidemiological investigation of over 600 individuals connected to a high school in this town in the Oise department. This study demonstrated the scale of household COVID transmission and also the high levels of transmission in high schools, with lower levels among primary school pupils. Several serological assays developed by the Institut Pasteur were validated as a result of the study. It is a great example of translational research and the result of an incredible response from Institut Pasteur staff, to whom I would like to pay tribute and give my thanks. Finally, we conducted a review regarding the set-up of vaccination projects and performance of clinical trials on humans. A Phase I clinical trial was carried out on the vaccine derived from the measles platform. Unfortunately, development of this vaccine was discontinued due to the initial results of the trial. However, the Institut Pasteur showed great initiative in producing this vaccine.

**Have you nevertheless begun to review the way the department is organized as you intended?**

Yes, we have worked on this reorganization despite the disruptions seen in 2020. We have recruited three physicians with extensive clinical research experience. We have incorporated the Institut Pasteur Medical Center within the Center for Translational Science to encourage more dynamic interaction between research and the Institut Pasteur Medical Center. We are also planning to recruit a clinical research nurse in 2021 to join the team. The initial field operations in Crépy-en-Valois were carried out by Institut Pasteur staff who were not all familiar with clinical research.

For instance, nurses from the Medical Center and even staff from support units were involved, as this work was carried out as a matter of urgency. From now on though, we need to be able to mobilize our own teams. At the instigation of Nathalie Jolly and her team at the CRT-CC, and in accordance with the recommendations set out by the task force on supporting clinical research at the Institut Pasteur, we have reorganized the system for managing and supporting translational research projects by creating a one-stop shop for incoming projects and a promotional and monitoring committee for these translational research projects. As such, it will be possible to optimize project assessment by type and tailor support for scientists. We are now hoping to continue reorganizing our translational research work and define our governance. This will be a key task for 2021.

**What are the next steps in work on tackling emerging infectious diseases?**

We are all certain that there will be other emerging infectious diseases. Although we have no idea where they will occur, their scale, or impact on public health, we must nevertheless prepare for outbreaks of future emerging diseases. We will try and learn as much as possible from everything done in response to COVID-19 to formulate preventive strategies, planned objectively in advance, that will be more easily applicable and reproducible in the event of a new epidemic.

\*With the support of the Hauts-de-France Regional Health Agency and the Amiens Education Authority and the backing of the French Blood Service (EFS).

**“We will try and learn as much as possible from everything done in response to COVID-19 to formulate preventive strategies.”**



### ON THE WEB

Press release of January 10, 2020:  
➔ **Bruno Hoen appointed as Medical Research Director for the Institut Pasteur**  
<https://www.pasteur.fr/en/press-area/press-documents/bruno-hoen-appointed-medical-research-director-institut-pasteur>

# NATIONAL REFERENCE CENTERS (CNRs)

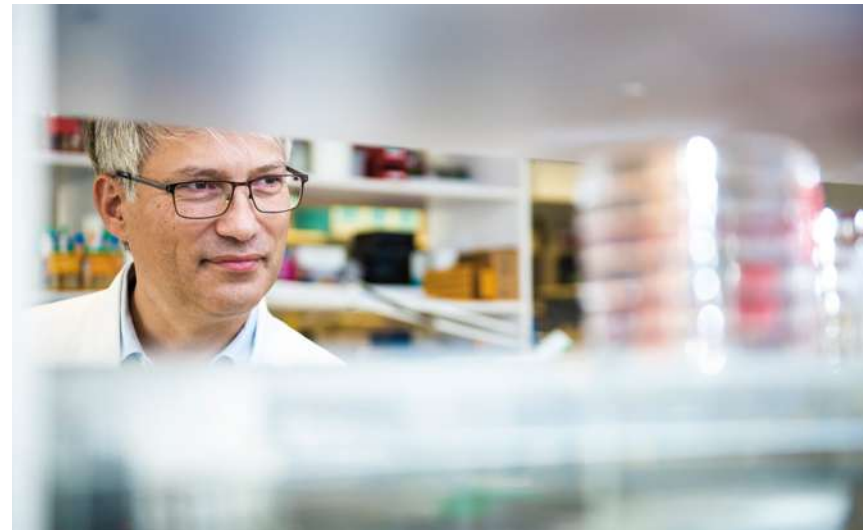
The status of National Reference Center (CNR) is awarded by Santé publique France (SpF). CNRs have four broad missions, as laid down in the French Public Health Code, with the aim of:

- **examining** infectious agents and their sensitivity to anti-infectives;
- **monitoring** their circulation in France;
- **alerting health authorities** of the emergence or re-emergence of any pathogens or of an unusually high number of clustered cases that may signal the start of an outbreak;
- **advising and training** public authorities, health safety agencies and health professionals.

In epidemic or pandemic situations associated with the emergence of a new pathogen, as was the case with SARS-CoV-2 in 2020, CNRs must carry out all the above missions, but they are also particularly responsible for developing and/or validating diagnostic techniques, rolling them out as quickly as possible in interested laboratories or laboratories designated by regional health agencies (ARSSs), and evaluating the performance of commercially available tests at the request of public authorities or manufacturers.

## January to March 2020 Detection of first French cases and rollout of diagnostic technique in hospital laboratories

The Institut Pasteur's CNR for Respiratory Infection Viruses designed France's first specific molecular diagnostic test, which was used to confirm the first suspected cases in France. On December 31, 2019, the World Health Organization was informed of the emergence of several cases of pneumonia of unknown origin in the city of Wuhan, China. On January 7, 2020, the Chinese authorities confirmed that these cases had been caused by a novel coronavirus, which would soon come to be labeled SARS-CoV-2. On January 12, the team in the CNR for Respiratory Infection Viruses obtained the complete genome sequence of SARS-CoV-2, as detected in samples taken from the first patients in Wuhan. Less than two weeks later, it developed a highly sensitive and reliable technique for detecting SARS-CoV-2 based on RT-qPCR technology, as well as



a positive control in compliance with the requirements of the French Agency for the Safety of Medicines and Health Products (ANSM), which enabled it to diagnose the first three French cases of COVID-19 on January 24. From February onwards, following the priority guidelines issued by the French General Directorate of Health, the CNR rolled out its diagnostic kit and the associated test protocol in laboratories at reference healthcare institutions (ESRs), including those in France's overseas territories, then in second-line hospital laboratories, providing advice and expertise for all those involved. Over the first quarter, the number of samples sent to the CNR for identification of respiratory infections including influenza, influenza A and

SARS-CoV-2 increased significantly (802 in January, 946 in February and 2,375 in March). From April, the CNR's diagnostic role gradually decreased, as the use of direct detection tests for SARS-CoV-2 infection based on the PCR (polymerase chain reaction) technique in hospital and medical test laboratories began to cover COVID-19 diagnostic needs within France.

## March to December 2020 Evaluation of the performance of diagnostic tests for SARS-CoV-2 infection

One of the CNR's missions is to evaluate the performance of commercially available tests, at the request of public authorities. The first stage in this



Report at the National Reference Center (CNR) for Respiratory Infection Viruses at the Institut Pasteur in Paris on April 1, 2020.

evaluation process is to determine points of comparison that can be used to draw up standards for the tests being evaluated by the CNR, and to establish sensitivity and specificity requirements for the performance of these tests. On March 7, 2020, detection of the SARS-CoV-2 genome by RT-qPCR was added by decree to the list of biomedical procedures refunded by the French health insurance fund. Diagnostic kits developed by manufacturers would only be refundable if they were CE marked or had been evaluated by the CNR for Respiratory Infection Viruses. From this date onwards, the CNR received a large number of requests from French, European and international manufacturers and distributors wishing to evaluate the performance of their diagnostic tests so that they could be

brought to market. In 2020, the National Reference Center (both the Institut Pasteur CNR and the CNR associated laboratory at the Hospices Civils de Lyon) evaluated 73 RT-qPCR tests.

## April to December 2020 Evaluation of the performance of serological assays revealing previous SARS-CoV-2 infection

Serological assays were developed at a later stage. The development of serological testing meant having access to blood samples from patients diagnosed with SARS-CoV-2 at varying lengths of time after the onset of symptoms, in both mild and more severe forms of the disease, as well as blood samples from recovering patients. These samples are vital to determine the presence of specific SARS-CoV-2

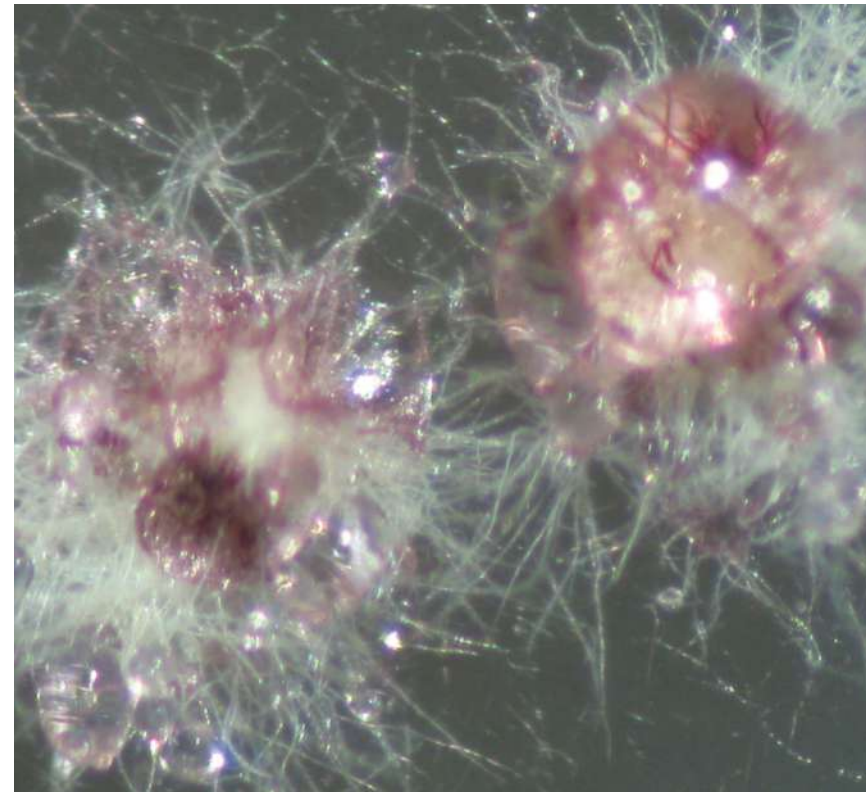
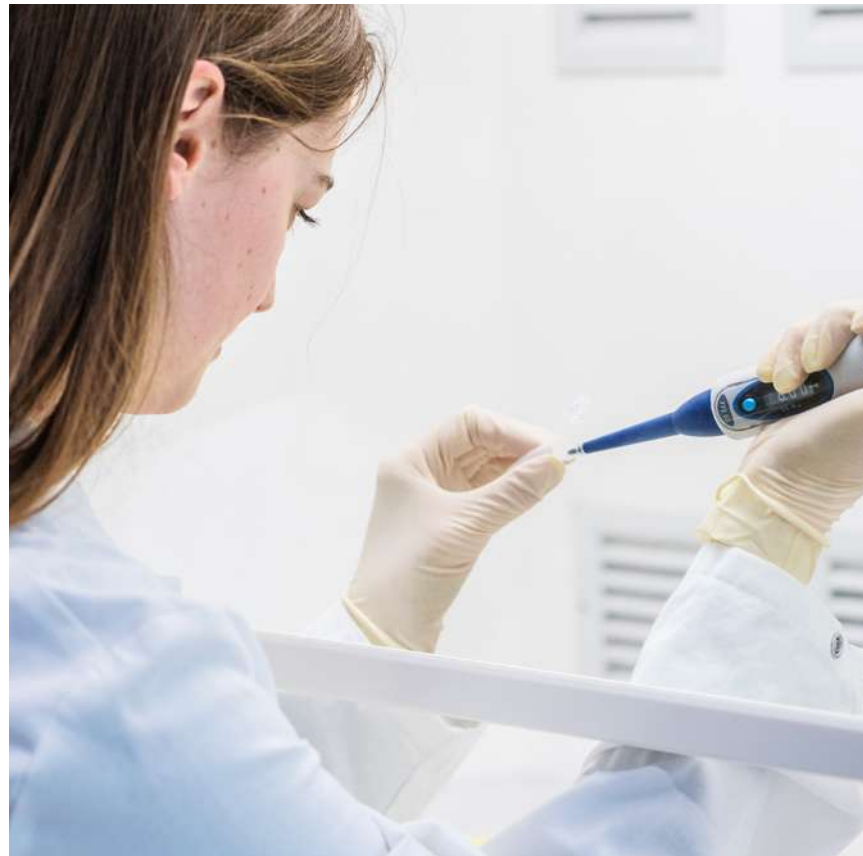
antibodies, characterize the nature of these antibodies and the kinetics of their response, and evaluate the sensitivity of the assays developed. It was also crucial to have panels of pre-pandemic blood samples to establish the specificity of the serological techniques developed. From April 15, 2020, the CNR published its first technical and scientific evaluations of serological assays. Serological assays are used to search for the presence of specific SARS-CoV-2 antibodies in the blood (immunoglobulin M or G (IgM/IgG)). These assays determine whether an individual has been infected by the virus in recent weeks. They cannot be used for early diagnosis of infection, since the production of specific antibodies by the immune system takes time, from a few days to a few weeks. In 2020,



the National Reference Center (the Institut Pasteur CNR and the CNR associated laboratory at the Hospices Civils de Lyon) evaluated 158 serological assays.

**Since March 2020  
Prospective genomic surveillance  
of SARS-CoV-2 viruses**

The Mutualized Platform for Microbiology (P2M) sequences multiple pathogens of any type (viruses, bacteria, fungi or parasites) for National Reference Centers. Since March 2020, the CNR for Respiratory Infection Viruses has analyzed the samples of patients infected with COVID-19 using various techniques, including whole genome sequencing of the SARS-CoV-2 viruses detected in these samples. The aim of prospective genomic surveillance of the SARS-CoV-2 viruses detected in COVID-19 patients is to enable real-time monitoring of the genomic evolution of the viruses, so as to identify the emergence and spatio-temporal distribution of viruses with mutations that may have an impact on the characteristics of SARS-CoV-2



(replicative capacity, ability to evade the innate immune response, receptor binding or antigenicity), its infectivity, transmissibility and virulence, the diagnostic techniques used and the efficacy of vaccines. Genomic surveillance needs to be combined with virological surveillance based on phenotypic and serological analyses performed on viral isolates, as is routinely done by the CNR to monitor influenza viruses.

## CENTER FOR TRANSLATIONAL SCIENCE (CRT)

The Center for Translational Science (CRT) conducts research involving human subjects. This includes epidemiology and pathophysiology research and the early stages in the development of health products based on the Institut Pasteur's research.

**Reorganization of the Center  
for Translational Science**

Infectious disease specialist Professor Bruno Hoen took up the post of Medical Research Director at the Institut Pasteur on January 1, 2020. To develop translational research at the Institut Pasteur, Bruno Hoen restructured the Center for Translational Science to incorporate the Institut Pasteur Medical Center, alongside the three structures previously in the CRT: ICAReB, which carries out biobank activities and clinical investigation; the CRT-CC, responsible for designing, implementing and monitoring research in compliance with ethical and regulatory requirements; and the CB UTechS, which performs the techniques needed to study molecular and cellular biomarkers.

**A concerted response  
to the COVID crisis**

The COVID-19 epidemic highlighted the importance of interaction between hospitals, which are in direct contact with patients, and the research units developing state-of-the-art research on campus. In March 2020, the CRT's teams went to Crépy-en-Valois, where the first outbreak in France had been identified, to recruit volunteers, take samples and collect data for seroepidemiological studies. With the Institut Pasteur's scientists having rapidly rolled out serological assays, ICAReB was responsible for the reception, repackaging and distribution to research teams of tens of thousands of tubes, mainly in connection with the CORSER

seroepidemiological studies.

The CRT-CC supported scientists in developing and implementing several COVID-19 projects involving human subjects, including a Phase I clinical trial in the space of just a few months, as well as pursuing projects on other topics. The CRT recruited and monitored Institut Pasteur staff infected with COVID-19 as part of the Curie-O-SA study, set up in cooperation with the Institut Curie to analyze the presence and persistence of SARS-CoV-2 antibodies in the blood and nasal mucosa. The CB UTechS managed to keep the platform open for users during this period, while also acquiring new technologies and providing training for scientists. It also contributed to two publications on COVID-19 biomarkers. This exceptional response to COVID-19 led to an increased workload for all the CRT's teams, which were boosted by volunteers from other Institut Pasteur departments.

**28,495**  
COVID-19 samples  
processed by ICAReB

**17**  
Institut Pasteur  
COVID-19 projects  
closely supported  
by the CRT-CC

**7**  
publications  
on COVID-19  
submitted by the CRT





# MEDICAL CENTER (CMIP)

The Institut Pasteur Medical Center (CMIP) is where the Institut Pasteur comes into direct contact with patients in Paris. It offers a range of services including a vaccination center; consultations for infectious and tropical diseases, travel medicine and allergies; and an Anti-Rabies Center. It received ISO 9001:2015 certification in 2018.

## Medical activities

The emergence and spread of SARS-CoV-2 led to a dramatic decline in movement and especially international travel, including humanitarian and business trips. This resulted in a significant reduction in workload for the Medical Center, because of its focus on treating travelers – both preventively, with the International Vaccination Center, renowned for its expertise, and in the area of diagnostics and therapeutics, with the Anti-Rabies Center and consultations for infectious and tropical diseases. While regular monitoring of patients for chronic infections with HIV or hepatitis viruses, chronic skin conditions such as hidradenitis suppurativa, and allergies was able to continue, remote consultations often became the norm. Because of this decline in the Center's usual workload, the medical team put its expertise to use in hospitals and outpatient clinics, providing valuable support to teams treating COVID-19 patients.



Rabies vaccination at the Institut Pasteur Medical Center.

## Clinical research

The Medical Center was involved in several SARS-CoV-2 seroprevalence studies coordinated by the Institut Pasteur, including the CORSER studies and the Curie-O-SA study in conjunction with the Institut Curie. The Medical Center also pursued its involvement in clinical research in its areas of medical specialization: cohorts with HIV infection, and the pathophysiology of hidradenitis suppurativa in collaboration with the ICAReB platform, Institut Pasteur research units and Necker Hospital. A comparative therapeutic trial for hidradenitis suppurativa, funded by the French Hospital Clinical Research Program (PHRC), is due to begin in late 2021. The aim is to endorse the treatment currently recommended by the Medical Center's dermatologists. The new insights offered by these projects fully justify the Medical Center's role within the Center for Translational Science.

**7,622**  
consultations  
for infectious  
and tropical  
diseases and  
travel medicine

**946**  
consultations  
at the Anti-Rabies  
Center

**782**  
consultations  
for allergies

**25,296**  
vaccines  
administered

**15,361**  
appointments  
at the International  
Vaccination Center



# DEVELOPMENT OF RESEARCH APPLICATIONS MISSION

In keeping with its long-standing mission, the Institut Pasteur was at the forefront of innovation in response to COVID-19. Its expertise on SARS-CoV-2 was harnessed in collaboration agreements, licenses and service agreements with manufacturers, as well as around 20 patent-protected inventions. The Institut Pasteur also pursued the development, maturation and transfer of technologies in its other research fields.



# RESEARCH APPLICATIONS AND TECHNOLOGY TRANSFER

The aim of the Institut Pasteur's Technology Transfer and Industrial Partnership Department (DARRI) is to identify projects with high development potential and to support them by promoting partnerships that facilitate their transfer to market through licenses or the creation of start-ups. The department's activities and expertise are wide-ranging, covering the entire innovation chain up to technology transfer: identification and protection of potential applications, scientific development, innovation transfer and partnership building.

In 2020, COVID-19 refocused the world's attention on infectious diseases as a central public health concern, and the global health crisis highlighted the challenges facing research in this field. The DARRI encourages the transfer of technologies from academic research to industry by means of agreements that aim to guarantee accessibility to products and services for as many people as possible, with free licenses for low-income countries. This long-standing commitment was reaffirmed in 2014 at a workshop with the World Health Organization and the World Intellectual Property Organization. The policy was particularly in evidence during the COVID-19 health crisis, with an unprecedented response from all teams to provide diagnostic and vaccine solutions in record time, working in collaboration with national and international industry partners and also with foundations and non-profit public-private partners to produce these innovations on a large scale and make them rapidly available. Agreements governing the use of Institut Pasteur technologies include obligations for industry, with the aim of:

- guaranteeing access to products for as many people as possible;
- ensuring that technologies can be distributed in all countries;

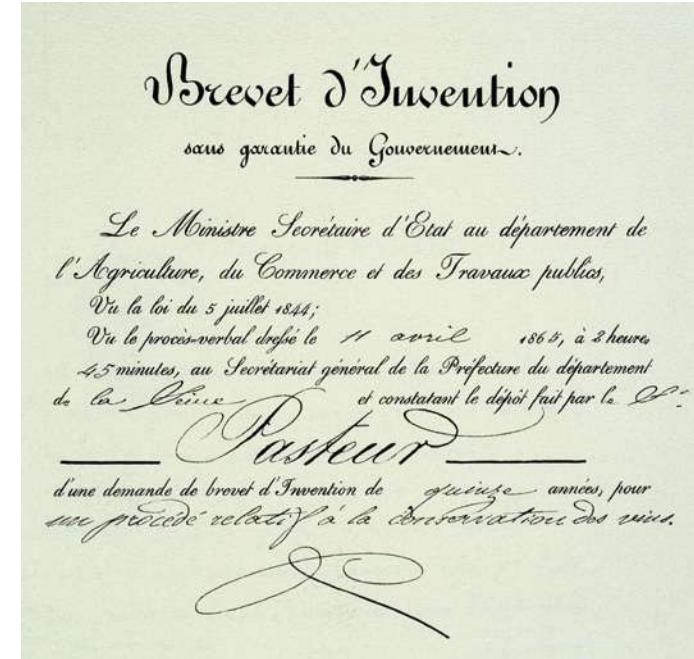


- encouraging products to be marketed at affordable prices that reflect each country's situation;
- not hindering research or potential applications.

As well as its major role in research on the epidemic, the Institut Pasteur also demonstrated its responsiveness and flexibility in dealing with the many requests it received from stakeholders in healthcare and industry.

## ON THE WEB

More information about scientific publications at [pasteur.fr](http://pasteur.fr):  
 📌 **COVID-19: Scientific research and discoveries at the Institut Pasteur in response to SARS-CoV-2:** a report on the response and main achievements of the Institut Pasteur in 2020 related to the SARS-CoV-2 coronavirus and COVID-19 outbreak: [bit.ly/3lj0kL3](https://bit.ly/3lj0kL3)



More than 55 partnerships were established with industry, with 19 protected inventions (see inset) and 78 agreements for equipment transfer, collaboration agreements, licenses and service agreements solely dedicated to topics related to SARS-CoV-2 (diagnostics, vaccines and therapeutics).

The crisis revealed the Institut Pasteur's expertise in public health in its work with French and international industry partners. The cross-cutting approach and close links between the Medical Department, the DARRI and the various institutes in the Pasteur Network facilitated rapid exchanges of information, especially regarding diagnostic techniques, and enabled the Institut Pasteur to respond effectively to the needs of its partners and set up clinical trials within a short space of time.

## Protecting inventions

In 2020, 73 invention disclosures were registered, resulting in 42 new priority patents being filed and 29 provisional applications (for software, expertise and biological material). In keeping with the maturation of inventions strategy and the policies adopted by the Institut Pasteur Innovation Accelerator, priority was specifically given to projects selected for their high transfer and development potential.



Top, a patent filed for the invention of a process used to preserve wine by Louis Pasteur on April 11, 1865. Above, an example of a current patent, usually issued several years after an invention disclosure.

## PROTECTED INVENTIONS RELATED TO SARS-COV-2

- 3 vaccine candidates**
  - Attenuated measles vector for SARS-CoV-2
  - DNA vaccine for SARS-CoV-2
  - Intranasal vaccine on the DNAFLAP platform
- 4 PCR assays**
  - A specific sensitive PCR assay, recommended by WHO, available from February onwards
  - An ultra-sensitive droplet PCR assay developed to predict infection progression and response to treatment
  - A rapid PCR assay that can be used on different media
- 2 seroneutralization assays**
  - To examine and monitor vaccine efficacy
- 4 serological antibody assays**
  - Best-in-class SARS-CoV-2 ELISA total antibody assay, available from April
  - Multi-antigen ELISA assay on beads to examine viral phases and detect infection as early as possible
  - LuLISA assay to treat hundreds of samples at the same time
  - Rapid assay with llama antibodies
- 1 therapeutic antibody**
  - A neutralizing antibody that acts on all variants currently in circulation is in the early stages of preclinical development.



### Detecting and funding innovation and business development

In 2020, several partnerships were pursued with investment funds including Kurma, Karista and Elaia to evaluate the potential of the Institut Pasteur's business projects. The team in charge of detecting and funding innovation works in close collaboration with the in-house business development team to identify the needs and expectations of industry partners. A dedicated team in the start-up office supports and guides scientists with their company creation projects. In 2020, the office supported four projects for new start-ups, with the respective companies set to launch by the fourth quarter of 2021 or the first quarter of 2022. Avatar Medical, an Institut Pasteur/ Institut Curie spin-off, was set up in July 2020 to promote Jean-Baptiste Masson's research, aimed at facilitating decision-making for surgeons through advanced visualization of medical images using virtual reality.

### Developing innovation

In 2020, drawing on the project mapping process carried out in 2019 for projects with high innovation potential, seven projects were preselected and four went on to be selected for the Institut Pasteur Innovation Accelerator, after being examined by a committee of internal and external experts from industry, foundations and other relevant fields. The accelerator also supports six laboratories conducting fundamental and translational research with a view to optimizing technology transfer to industry partners. COVID-19 research was a key focus in 2020. The teams were closely involved in vaccine approaches, especially the vaccine based on the measles platform (see p. 40). In therapeutics, the "Covid-théra" team focused its efforts on the screening platform, analyzing the compounds used in 20 industrial projects and a dozen academic projects. In diagnostics, the Institut Pasteur's contribution in collaboration with industry partners resulted in conventional molecular biology tools (RT-qPCR), rapid tests (RT-LAMP) and serological assays (seroconversion/seroneutralization) being brought to market in less than a year. The innovation process from R&D to commercialization by industry partners was shortened to less than three months for some diagnostic tools. The efforts of the Institut Pasteur

Innovation Accelerator and dedicated teams facilitated rapid delivery of these solutions. Collaborative efforts to deliver antigen tests began later and will come to fruition in 2021. As well as work related to COVID-19, 12 other projects in a variety of fields were supported by flash grants, which provided the funds for additional project stages associated with invention development and the consolidation of patent applications. In diagnostics, projects on infectious diseases – such as rabies, diphtheria, whooping cough and trypanosomiasis – and on cancer and autoimmune diseases (specifically stomach cancer and lichen planus) have also received support from the DARRI. Several laboratories offering artificial intelligence solutions for biomedical image analysis were supported in developing more applied projects in collaboration with industry, whether via PhD schemes (five Industrial Agreements for Training Through Research (CIFRE) and Paris Region (PRPhD) projects in collaboration with SMEs) or membership of international public-private research consortia such as the IMI BigPicture European project on digital pathology.

### Promoting and developing partnerships with industry

In the Technology Transfer Department, the combined work of the two strategic sections, business development and contract negotiation, generated a **66% increase in the number of license agreements signed** with industry partners in 2020.

Supporting scientists on campus in their initiatives to develop innovative medical and technological solutions requires detailed knowledge of their research and also a thorough understanding of the needs and expectations of industry partners so as to optimize interactions between the Institut Pasteur and industry. In an intensive, open innovative context where knowledge creation and sharing are vital for innovation development schemes, it is more important than ever to foster synergies between scientific teams on both sides and to encourage the establishment of industry partnerships that will result in therapeutic, vaccine and diagnostic solutions being brought to market, for the benefit of patients. In 2020, this ambition led to the signing and extension of more than 59 R&D



2019 photo report for the Pasteur Microbes and Health Carnot Institute (MS). From left to right: Monique Lafon, head of the Viral Neuro-Immunology Unit; Anavaj Sakuntabhai, head of the Functional Genetics of Infectious Diseases Unit; Alix Boucharlat, engineer at the Chemogenomic and Biological Screening Platform (PF-CCB).

agreements with long-standing and more recent partners, including the following:

- **Sanofi-Pasteur partnership:** collaboration project between Sanofi Pasteur and the Environment and Infectious Risks Unit in the field of vaccines.
- **Consolidation of the Sensorion-Institut Pasteur partnership:** application of a first collaboration agreement in the field of otology, especially DFNB9 hearing loss, involving Saaid Safieddine's team in the Genetics and Physiology of Hearing Unit led by Christine Petit.
- **Collaboration between the Malaria Infection and Immunity Unit and eTheRNA,** a Belgian company specializing in the development

of RNA vaccines: production and *in vivo* testing of a prophylactic vaccine for the malaria agent *Plasmodium falciparum*.

- **Collaboration between the Functional Genetics of Infectious Diseases research unit and the company Owkin:** development of a new machine learning model capable of identifying epitopes with high immunogenic potential and candidates for the potential development of future vaccines with targets including the SARS-CoV-2 virus.
- **Business development of a method for detecting SARS-CoV-2 developed by the Laboratory for Urgent Response to Biological Threats** The license has been granted to several French manufacturers looking to develop atmospheric

detection methods and SARS-CoV-2 diagnostic tests for humans and animals.

The year 2020 also saw an 18% increase in academic material transfer agreements (MTAs) compared with 2019, with a total of 740 academic MTA applications processed by the end of the year. The Institut Pasteur made a major contribution to the academic research effort on COVID-19 by supplying several research entities with the SARS-CoV-2 strain.

## CARNOT, A GUARANTEE OF EXCELLENCE FOR THE INSTITUT PASTEUR

The Institut Pasteur has been part of the Carnot network since 2007, in recognition of the scientific quality of its work and its collaborative research. In 2020, 23 innovative new research projects at an early or advanced stage – nine within the scope of Carnot – were funded by the DARRI/Carnot Emergence, Maturation, Partnership & Innovation and Consolidation programs. The aim is to support promising projects whose long-term results will contribute to the intellectual property portfolio; applied science projects for which an initial invention disclosure has been filed and for which the long-term aim is the transfer of the product and/or technology to manufacturers; and also targeted projects (with no call for proposals) jointly developed and pursued by scientists in the departments that come under the scope of Carnot and the DARRI. The DARRI/Carnot Consolidation program is designed to strengthen patent applications.



### Developing strategic alliances

The aim of the Industrial Agreements Department is to support technology transfer to industry partners by controlling flows of funds associated with technology transfer, fostering links with patent co-owners and supporting partnerships with industry. The Institut Pasteur's close relationships with its strategic partners provided valuable support in its response to the COVID-19 crisis.

In 2020, the department managed more than 300 existing agreements and 30 new collaboration agreements. In 2020, partnerships with international external funding bodies represented €3.6 million in income, with partners including:

- BPI: the PATRIOT consortium, composed of Sensorion, the French Armed Forces Biomedical Research Institute (IRBA), the Institut Pasteur and the French company Électronique du Mazet, secured funding for a "major research and development program to boost competitiveness," aimed at the development of SENS-401 for sudden sensorineural hearing loss and the identification of biomarkers for response to treatment. The project reflects the strategic collaborative links

developed between Sensorion and the Institut Pasteur, and more specifically the Hearing Institute.

- Bill & Melinda Gates Foundation: a joint development project for a quadrivalent vaccine for *Shigella* infections. An exclusive free license is granted in developing countries.
- IMI: involvement in a European consortium to support the clinical development of therapeutic solutions for tuberculosis.

73

invention disclosures

42

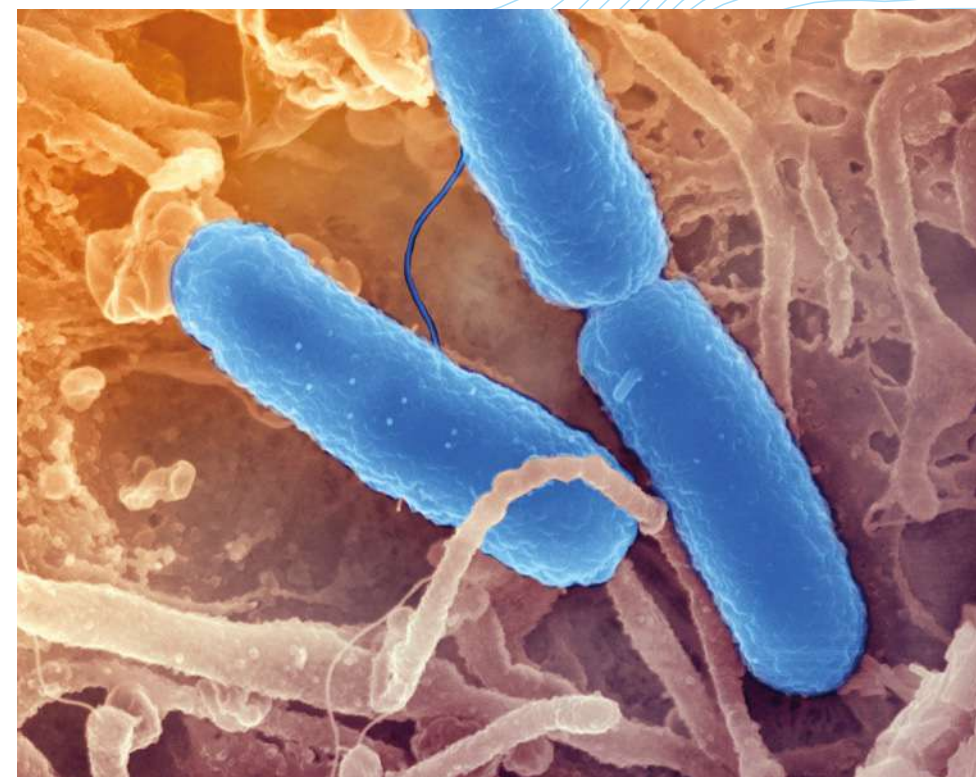
new priority patents and 29 provisional applications

332

industrial contracts signed in 2020

308

industrial contracts in place



*Shigella dysenteriae* in electron microscopy.



# EDUCATION & TRAINING MISSION

The Institut Pasteur provides state-of-the-art scientific and medical training to a cosmopolitan community of students, PhD students and healthcare professionals. In 2020, those involved in teaching had a particularly busy workload, with the task of converting in-person courses to remote (or hybrid) learning and addressing the needs of students during the period. The expertise of the Institut Pasteur, France's leading provider of MOOCs in life sciences and health, is an undeniable asset.



# TRANSFERRING AND SHARING SCIENTIFIC KNOWLEDGE

For more than 130 years, ever since the first microbiology course taught by Émile Roux in 1889, the Institut Pasteur has played a key role in teaching life sciences at the international level.

Each year, over 1,200 students, PhD students and healthcare professionals from around 70 countries attend one of the 60 courses and workshops run at the Institut Pasteur in Paris or at one of the institutes in the Institut Pasteur International Network. Over 600 young scientists are also hosted by laboratories on the Paris campus to train as scientists and complete their undergraduate, Master's and PhD research projects.

## A unique setting for training in science and research

The Institut Pasteur provides a unique hands-on environment for young scientists from undergraduate to PhD level. It also runs excellent courses for

Master's and PhD students, as well as vocational science courses leading to recognized university diplomas. Courses in Paris are coordinated by renowned scientists on campus, with input from professors based at partner institutions in France (Université de Paris, Sorbonne University, Université Paris-Saclay, Université PSL, the Institut Curie, the CNRS, Inserm and the CNAM) and abroad. An emphasis on experimentation and practical work is a strength and specificity of the Institut Pasteur's educational approach. The Institut Pasteur International Network has a major impact on teaching, in terms of both the scientific subjects taught and the international makeup of the students.



## “Agnès Ulmann” class (PPU 2020)

The class of 2020 comprised 10 students: six from Europe, one from Colombia, one from Algeria and two from China. In 2020, a new PPU program, PPU-IMAGINE, was launched, based on cooperation between the Institut Pasteur and the Imagine Institute at Necker Hospital. The aim of the program is to encourage transnational research projects between the two institutes, both renowned centers of excellence.

## The Institut Pasteur and online courses in life sciences and health

The Institut Pasteur is continuing to develop its online teaching as a way of extending the reach of the courses taught at its Education Center or at institutes in the International Network. In just five years, the Institut Pasteur has become France's leading provider of MOOCs in the fields of life sciences and health, with MOOCs which have proven hugely successful in terms of numbers (1,900 to 7,300 learners enrolled per session) and international visibility (95 to 151 countries). Launched by the Institut Pasteur in 2019, the first global online life science diploma, the Institut Pasteur Online Diploma in Infectious Diseases

(DNM2IP), has been a resounding success, with 395 people registered and 15 graduates to date.

## Predocutorial programs

The Institut Pasteur also offers training for students at earlier stages in their academic career. It has developed several predocutorial programs for students at school, undergraduate and Master's level. The “Collège 3” program gives middle school students in their fourth year the chance to come and find out about different research professions in a secure, structured environment in a research unit at the Institut Pasteur. The Amgen Scholars Program gives around 20 students from European universities

## INSTITUT PASTEUR 2020 PHD GRADUATION CEREMONY

The graduation ceremony for PhD students on campus who defended their thesis in 2020 was held on December 4, 2020. Nine PhD students from the Institut Pasteur institutes in Cameroon, Madagascar, China, Cambodia, Greece, New Caledonia and Lille were also honored at the event. At the ceremony, Emmanuelle Charpentier, laureate of the 2020 Nobel Prize in Chemistry, gave an address in which she shared her personal views on the research profession. The ceremony, held online, was remotely attended by Institut Pasteur staff, representatives of partner organizations, and figures from political, diplomatic and business circles with links to the Institut Pasteur. Since its first edition in 2013, the annual graduation ceremony has become a major event in the campus calendar, serving as a showcase for the professional excellence produced by the Institut Pasteur's research and training. The next ceremony will take place on December 17, 2021, with guest speaker Edith Heard, a Professor at the Collège de France and Director General of EMBL.



and higher education institutions the opportunity to work on a research topic for eight weeks in an Institut Pasteur laboratory. The Institut Pasteur also hosts students under the EU's Erasmus+ program, thanks to its partnerships with several European universities.

#### **Training through research for PhD students**

Each year, around 80 PhD students complete their studies in laboratories on the Paris campus. The Institut Pasteur provides scientific supervision for PhD students through thesis committees, as well as personal support with a tutoring program, a dedicated office and a structure for post-doctoral career development. The Institut Pasteur in Paris runs specialized PhD programs, like the Pasteur-Paris University (PPU) international doctoral program for students with a Master's degree from a foreign university. This top-tier program, launched in 2008, is run in close partnership with Université de Paris, Sorbonne University and Université Paris-Saclay. Each year, the Institut Pasteur also awards grants for the completion of PhDs in the International Network, outside mainland France. The Institut Pasteur, Institut Curie and École Normale Supérieure (ENS) are continuing their "Médecine-Sciences" program, which reflects the major changes taking place in medical practice and biomedical research.

#### **Scientific entrepreneurship training**

In keeping with its vocation, the Institut Pasteur has always been committed to finding applications for its research, and this is reflected in its teaching. To this end, several initiatives were developed during 2020, including the continuation of the "Start-up Breakfast" series – informal monthly events for Institut Pasteur scientists interested in business development, with guest speakers including successful biotechnology entrepreneurs, representatives of funding bodies and heads of business incubators –, and a start-up workshop in November 2020 with practical sessions on specific projects led by junior Institut Pasteur scientists.

**For more information:**  
<https://www.pasteur.fr/en/education>



# INTERNATIONAL

The Institut Pasteur International Network has 33 members, all of which are united by Pasteurian values and missions to serve public health worldwide. Over the course of this eventful year, a dozen projects were launched, capitalizing on the potential of international scientific cooperation as a means of tackling the health crisis.





# INTERNATIONAL: THE INSTITUT PASTEUR RESPONDS AND THE NETWORK UNITES

## MOBILITY AND EXCHANGE PROGRAMS BETWEEN INSTITUT PASTEUR INTERNATIONAL NETWORK SCIENTISTS (2020 FIGURES)

**49** scientists from the network received training thanks to the Calmette & Yersin program.

**5** French students received grants from the Pierre Ledoux–Jeunesse Internationale Foundation to complete their internships in the Institut Pasteur International Network.

**4** post-doctoral fellows and **12** PhD students funded by the Calmette & Yersin program.

**1** three-month mission in the network for newly recruited Institut Pasteur scientists.

**3** four-year research groups.

**11** international courses funded by the Pasteur International Network Association.



## Euro-Mediterranean region

### ALGERIA

→ Institut Pasteur d'Algérie  
pasteur.dz

### BELGIUM

→ Sciensano  
sciensano.be

### BULGARIA

→ Stephan Angeloff  
Institute of Microbiology  
microbio.bas.bg

### FRANCE

→ Institut Pasteur (Paris)  
pasteur.fr  
→ Institut Pasteur de Lille  
pasteur-lille.fr

### GREECE

→ Hellenic Pasteur Institute  
pasteur.gr/en

### ITALY

→ Institut Pasteur in Italy –  
Cenci Bolognetti Foundation  
istitutopasteuritalia.it

### MOROCCO

→ Institut Pasteur du Maroc  
pasteur.ma

### RUSSIA

→ Institut Pasteur  
in Saint Petersburg  
pasteur.org.ru

### TUNISIA

→ Institut Pasteur de Tunis  
pasteur.tn

## Africa

### CAMEROON

→ Pasteur Center in Cameroon  
pasteur-yaounde.org

### CENTRAL AFRICAN REPUBLIC

→ Institut Pasteur de Bangui  
pasteur-bangui.org

### CÔTE D'IVOIRE

→ Institut Pasteur de Côte d'Ivoire  
pasteur.ci

### GUINEA

→ Institut Pasteur de Guinée  
pasteur-guinee.org

### MADAGASCAR

→ Institut Pasteur de Madagascar  
pasteur.mg

### NIGER

→ CERMES  
cermes.net

### SENEGAL

→ Institut Pasteur de Dakar  
pasteur.sn

## Asia-Pacific

### CAMBODIA

→ Institut Pasteur du Cambodge  
pasteur-kh.org

### CHINA

→ Hong Kong University-Pasteur  
Research Pole  
hkupasteur.hku.hk  
→ Institut Pasteur of Shanghai,  
Chinese Academy of Sciences  
english.shanghaipasteur.cas.cn/

### FRANCE

→ Institut Pasteur  
de Nouvelle-Calédonie  
institutpasteur.nc

### SOUTH KOREA

→ Institut Pasteur Korea  
ip-korea.org

### IRAN

→ Institut Pasteur in Iran  
en.pasteur.ac.ir

### LAOS

→ Institut Pasteur du Laos  
pasteur.la

### VIETNAM

→ National Institute of Hygiene  
and Epidemiology (Hanoi)  
nihe.org.vn/en  
→ Institut Pasteur in  
Ho Chi Minh City  
pasteurhcm.gov.vn  
→ Institut Pasteur in Nha Trang  
pasteur-nhatrang.org.vn/en

## Americas

### BRAZIL

→ Fiocruz  
portal.fiocruz.br/en  
→ São Paulo/ Pasteur-USP  
Scientific Platform\*

### CANADA

→ INRS-Centre Armand Frappier  
Santé Biotechnologie  
iaf.inrs.ca

### FRANCE

→ Institut Pasteur de la Guadeloupe  
web.pasteur-guadeloupe.fr  
→ Institut Pasteur de la Guyane  
pasteur-cayenne.fr

### URUGUAY

→ Institut Pasteur de Montevideo  
pasteur.edu.uy/en

## COVID-19

**33**

research projects  
funded by the  
Coronavirus Task  
Force in the Institut  
Pasteur International  
Network

**10**

Support for  
member institutes in  
Sub-Saharan Africa  
and South-East Asia

\*Associated member.



## INTERNATIONAL: THE INSTITUT PASTEUR RESPONDS AND THE NETWORK UNITES

In 2020, the Institut Pasteur International Network showed its support and global solidarity for numerous countries throughout the world and their populations in tackling the COVID-19 pandemic. Network members were also on the front line for molecular diagnostics and played a key role in national surveillance and screening, assisting their local health authorities with their COVID-19 strategies.

The outbreak of the pandemic in early January 2020 shook the world, necessitating rapid, large-scale national responses in terms of surveillance, research, and public protection.

The Institut Pasteur (Paris) responded in collaboration with the Pasteur International Network Association supported by its Institut Pasteur International Network Scientific Steering Committee (COS-RIIP) to help Network member institutes and partner institutes fulfill their public health remit. Most Network institutes were identified by their health authorities as reference laboratories for COVID-19 diagnosis, putting them on the front line of the response to the epidemic. This was initially aimed at providing them with technical support, and in some cases, financial and logistical backing.

### Support for the work and missions of reference laboratories, coordinated by the Institut Pasteur in Paris

Drawing on financial support from the Institut Pasteur's historic funding bodies, the French Development Agency (AFD) and the European Commission (DG-DEVCO), a special budget was set up providing emergency support to certain Network institutes through various initiatives implemented through existing projects such as ECOMORE II and MediLabSecure or new projects such as the "Support for several Pasteur

**203 m<sup>3</sup>**  
of equipment transported  
to 14 countries  
in 46 shipments

For further details, consult the article "Unprecedented solidarity and support to accompany the member institutes of the International Network in the face of the COVID-19 pandemic" on [pasteur.fr](https://pasteur.fr)

Through its Coronavirus Task Force, the Institut Pasteur (Paris) supported 33 international research projects on COVID-19 involving at least one Network member.

Further details of the research projects can be found at [pasteur.fr/en/projets-recherche](https://pasteur.fr/en/projets-recherche)

Institutes in Sub-Saharan Africa" project. These initiatives coordinated by the Department of International Affairs in association with the Laboratory for Urgent Response to Biological Threats (CIBU), the National Reference Center (CNR) for Respiratory Infection Viruses, and numerous Institut Pasteur support departments, in collaboration with the Pasteur International Network Association, benefited many countries, including:

- in Sub-Saharan Africa (Senegal, Niger, Madagascar, Cameroon, Guinea, Burkina Faso\*, and the Central African Republic);
- in South-East Asia (Myanmar\*, Cambodia, Laos, the Philippines\*, and Vietnam);
- North African countries, Lebanon\*, Jordan\*, Palestine\*, Bosnia\*, Montenegro\*, Serbia\*, Albania\*, etc.

A raft of measures have been implemented through these initiatives with a view to:

- **supporting the set-up of laboratory molecular diagnostics** (protocol, probes, diagnostic quality assurance);
- **ensuring the continuity of reference laboratory activities;** firstly by contributing specifically to the supply of reagents and consumables required for mass screening of the local population as well as laboratory equipment and safety-compliant personal protective equipment for staff

(at a time when there was a global shortage of these items); secondly, by helping meet front-line laboratories' staffing requirements;

- **more specifically, supporting operations at two global reference laboratories for COVID-19** recognized by the World Health Organization (Institut Pasteur de Dakar and Institut Pasteur du Cambodge);
  - **promoting training of laboratory staff** and skills transfer;
  - **initiating cohort monitoring** of exposed front-line healthcare workers (to assess the risk of infection).
- At the same time, a multidisciplinary project examining the pandemic in Africa entitled REPAIR (International Pasteurian Research Program in Response to Coronavirus in Africa) was set up, coordinated by the Network through its association and supported by the French Ministry for Europe and Foreign Affairs (MEAE).

For further details of the REPAIR project [pasteur-network.org/en/what-we-do/collaborative-projects/repair/](https://pasteur-network.org/en/what-we-do/collaborative-projects/repair/)

Now an "associate" member of the Institut Pasteur International Network, the Pasteur-USP Scientific Platform is the 33rd member of the Network.

Further details of the Pasteur-USP Platform can be found at: [pasteur.fr/en/home/institut-pasteur/institut-pasteur-throughout-world/news/institut-pasteur-launches-scientific-platform-university-sao-paulo-research-and-innovation-center](https://pasteur.fr/en/home/institut-pasteur/institut-pasteur-throughout-world/news/institut-pasteur-launches-scientific-platform-university-sao-paulo-research-and-innovation-center)

\* Outside the Pasteur Network.



## OUR RESOURCES

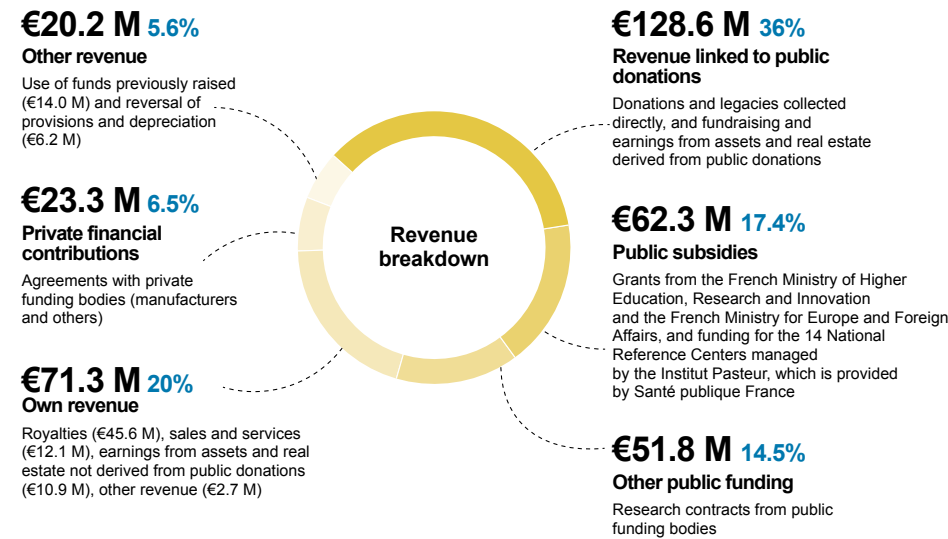
Public generosity has always been crucial to the Institut Pasteur's success. In 2020, the unwavering support of the public enabled the Institut Pasteur to continue its work in response to the COVID-19 pandemic. It is committed to optimizing these resources as a means of pursuing a stable, human-centered business model that underpins its long-term development.

# FINANCIAL REVIEW OF 2020

The Institut Pasteur's economic model is characterized by its multi-sourced funding, from public and private realms, which supports its resolutely long-term aim – to prevent and treat diseases, particularly infectious ones, through research, education, public health initiatives and knowledge transfer activities with a view to finding applications that benefit human health.

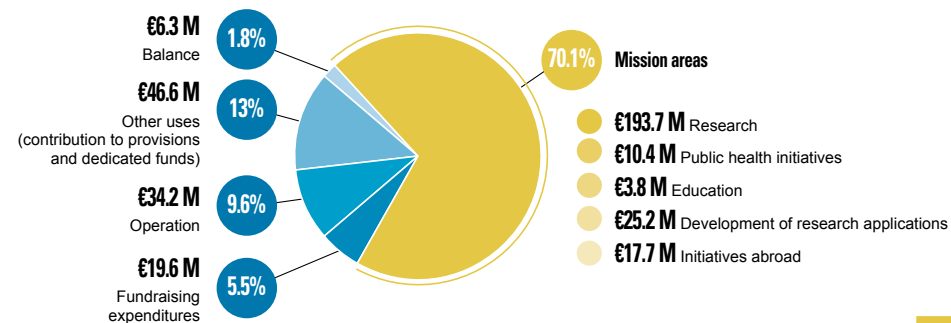
## Revenue

As indicated in the Institut Pasteur 2020 *Statement of source and application of funds*, the revenues reported in the income statement amounted to €357.5 million, with the following breakdown.



## Use

The revenues reported in the income statement are earmarked as follows: Institut Pasteur mission areas €250.8 M, operation €34.2 M, fundraising expenses €19.6 M, contribution to provisions and depreciation €13.5 M, and fundraising proceeds not used during the fiscal year €33.1 M. The remainder is used to fund initiatives and long-term investments.



## Public gifts and donations

Within the range of different funding sources relied upon by the Institut Pasteur, the proportion of gifts and donations is relatively stable, despite contrasting effects observed between donations and legacies components in relation to 2019; **€128.6 M** was raised in 2020\*. In addition to its mission areas, the public gifts and donations received in 2020 covered the Institut Pasteur's fundraising expenses and operating expenditure.

\* See adjacent chart and Institut Pasteur 2020 *Use of resources statement* in the financial report.



**€82** Mission areas (research, public health, education)  
**€11** Fundraising expenses  
**€7** Operating expenditure

## The Institut Pasteur's assets

Having been a foundation officially recognized for its charitable status since its inception in 1887, the Institut Pasteur must also hold assets, built up over time, and make them grow.

The aim of these assets is to sustain the work of the foundation by annually generating income so that it can continue its missions of public interest; efficient asset management guarantees its ability to fulfill these missions over the long term.

The Institut Pasteur has four main types of productive asset – property to let, long-term financial investments, cash and equity securities.

In 2020	€M	%
<b>Total</b>	<b>979</b>	<b>100</b>
Property	215	22
Securities	683	70
Private equity/strategic partnerships	21	2
Cash	60	6

Productive assets account for the equivalent of three times the Institut Pasteur's annual operating costs (ratio set out in late 2020).

These assets generated €24 M during the 2020 fiscal year, reported in the income statement, representing a rise of €4.9 M in relation to 2019.



## Earnings from assets

In 2020	€M
<b>Total</b>	<b>24.0</b>
Property	6.0
Securities	15.0
Cash	3.0

As well as the income generated, the Institut Pasteur has statutory provisions and a reserve policy to ensure that its assets are regularly built up when the fiscal year ends with a surplus.

## Income statement

In 2020	€M
Institut Pasteur operating revenue	328.2
Institut Pasteur operating expenses	340.1
Contribution from IP Guadeloupe and IP Guyane	2.4
<b>Operating income</b>	<b>-9.5</b>
Institut Pasteur financial result	13.8
Contribution from IP Guadeloupe and IP Guyane	0
<b>Financial income</b>	<b>17.6</b>
<b>Recurring operating income</b>	<b>8.1</b>
Institut Pasteur non-recurring income	0.8
Contribution from IP Guadeloupe and IP Guyane	-0.1
<b>Non-recurring income</b>	<b>0.7</b>
Profit sharing	2.5
<b>Net income</b>	<b>6.3</b>

In addition to its productive assets, the Institut Pasteur owns all its buildings in rue du Docteur Roux in Paris and its scientific equipment, reported on its balance sheet as tangible capital assets.

It also owns its brand name and a portfolio of patents, which are not reported on the balance sheet but in the income statement for their revenue from license agreements.

In 2020, recurring operating income showed a profit of €8.1 M, as against a deficit of €11.1 M for 2019. €2.4 M of this result is due to the institutes outside mainland France, and €5.7 M to the Institut Pasteur Paris campus.

This can be broken down into a reduction in operating deficit of €15.3 M and an increase in financial surplus of €3.8 M compared with the previous year.

Non-recurring income posted a profit of €0.7 M in 2020.

A profit-sharing agreement signed during the fiscal year yielded a provision of €2.5 M pursuant to its execution.

Net income therefore amounted to €6.3 M in 2020, as against €38.1 M in 2019.



# A NEW FRAMEWORK FOR SUSTAINABLE DEVELOPMENT

At the end of the second year of its 2019-2023 Strategic Plan, the Institut Pasteur took its Green Campus program (launched in 2010) to the next level by signing the Paris Climate Action Charter.

## Signatory of the Paris Climate Action Charter

In 2020, the Institut Pasteur signed the Paris Climate Action Charter at "gold level," thereby signaling its support for Paris' vision of a carbon-neutral city by 2050. This initiative confirms the Institut Pasteur's commitment and determination to reduce its environmental footprint. The charter also provides the

Institut Pasteur with a framework for the development of its own sustainable development master plan. The charter is based on the Sustainable Development Goals (SDGs), adopted in September 2015 by the United Nations as a way of encouraging companies to come on board and ensuring global recognition of the commitments made.

## Mobility plan

The Institut Pasteur has submitted its mobility plan to Île-de-France Mobilités, the transport authority for Greater Paris. The aim of the three-year plan is to reduce the greenhouse gas emissions associated with staff commuting and business travel. The main measures implemented in 2020 included:

- replacing two of the ICE vehicles in its logistics fleet with an electric car;
- providing staff with a map showing the 242 cycle parking spaces on campus, 99 of which are in covered parking areas (15 more covered spaces since 2019), together with a map indicating shower facilities on campus, and raising

awareness about the various financial incentives to encourage the use of bicycles and electric vehicles;

- informing staff about new cycle routes to campus and the availability of six charging stations for electric cars and one charging station for electric motorbikes on campus. Staff created a "cycling" group within the Institut Pasteur's Social and Economic Committee (CSE), whose efforts have led to a cycle repair workshop being set up on campus.

## Les jardins de Louis

As part of the Green Campus project and in cooperation with the Institut Pasteur's Technical Department, a new CSE section – "Les Jardins de Louis" – was established to develop and maintain areas on campus landscaped with flowers, herbs and vegetables. A charter was drawn up with guidelines, prohibiting the use of pesticides and chemical fertilizers and promoting responsible water management and organic seed use.

## Commitment to 10 SDGs by the Institut Pasteur:

The Institut Pasteur is aiming to improve the energy efficiency

of its buildings, develop green spaces and biodiversity on campus, reduce greenhouse gas emissions, develop sustainable mobility and optimize waste management.



## KEY FIGURES

# 113.9 t

of materials handled in 2020

## RECYCLING

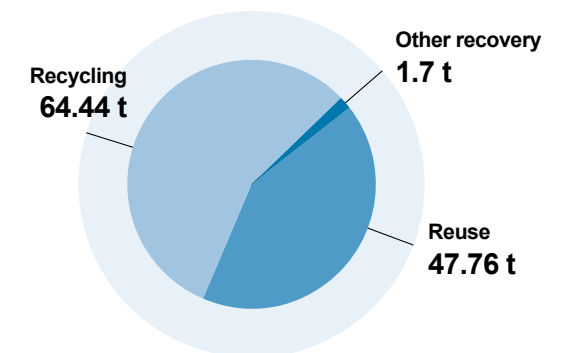
0.26 t of aluminum cans	11.54 t of paper and cardboard
3.77 t of glass	15.25 t of polypropylene tip boxes
0.27 t of plastic and polystyrene	33.17 t of WEEE
0.18 t of batteries	

## OTHER RECOVERY

1.7 t  
of dried organic waste

## REUSE

47.76 t  
of pallets reused  
(2/3 reuse or 1/3 energy recovery)





# HUMAN RESOURCES: SUPPORTING ACTION AND CONTINUING HR REFORM

In 2020, the Human Resources Department was committed to supporting action taken by the Institut Pasteur community, while also continuing the process of strategic HR projects and measures aimed at modernization.

The Human Resources Department team worked hard to ensure continuity of service, and provide Institut Pasteur staff with optimal support and guidance by:

- Consulting with management to offer working arrangements geared towards service continuity and employees' circumstances (whether working on campus, remotely, or from home).
- Focusing on psychological support, information provision, and training to improve individuals' experiences of this difficult period and keep in touch.
- Ensuring that teams are protected by involving the Occupational Health Department.

These measures confirmed just how important the Institut Pasteur principle of "greater community spirit" is. They were widely appreciated by employees. In an internal survey (59% participation) aimed at gaging staff opinion of the initial lockdown and easing periods: 88% stated that they were satisfied/very satisfied with the measures taken and 90% said they were proud to work for the Institut Pasteur (see also HR insert on p.17).

The HR Department supported strategic priorities and HR reform

- The momentum of numerous projects addressing issues central to the strategic plan including changes to scientific professions, gender equality, and the European HR award was maintained in 2020 due

## 2019-2023 STRATEGIC PLAN: AMBITIOUS COLLECTIVE HR GOALS

- **Implement a jobs and careers management strategy:** examine changes in the research environment, workshops on scientific professions involving 50 campus scientists.
- **Secure the EU's "HR Excellence in Research" award,** part of the Human Resources Strategy for Researchers (HRS4R): preparatory work adopting a participatory approach involving around 100 individuals with a view to recommendations for 2021.
- **Continue to recruit wisely** and support organizational structures.
- **Pursue measures to improve the quality of working life.**
- **Promote gender equality:** initial specific measures from the "Women and Science" working group (training sessions on career development and leadership for women, room on-campus for breastfeeding mothers to express milk aimed at improving everyday life, coaching for junior scientists).

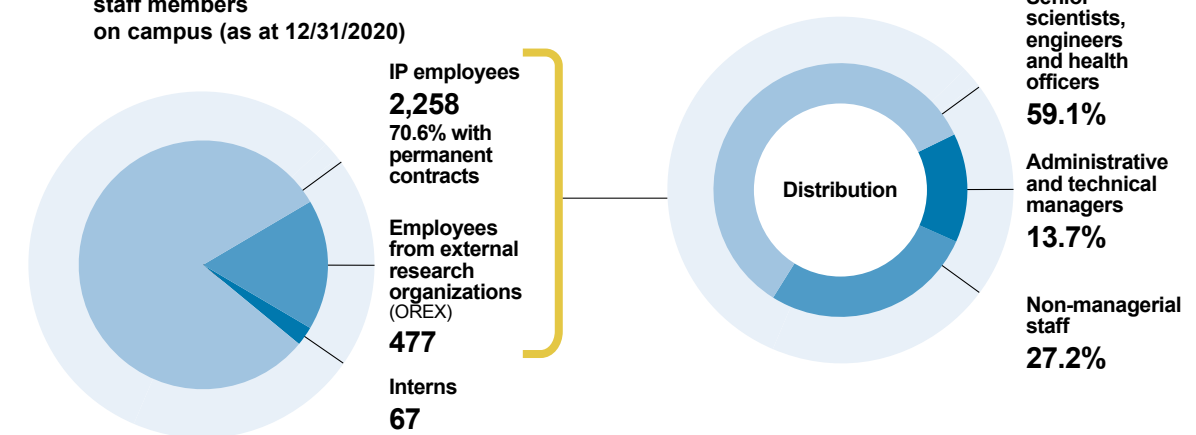
to participatory approaches involving large numbers of employees.

- In 2020, modernization of HR practices was also continued and accelerated to meet Institut Pasteur employees' needs. During the first lockdown, solutions such as remote signing of contract documents and the development of paperless HR employee records were implemented to simplify everyday administrative tasks.
- Finally, a profit-sharing agreement was signed at the start of the year reflecting the Institut Pasteur's determination to recognize and reward the teamwork involved in achieving its strategic objectives.



## ON CAMPUS

2,802  
staff members  
on campus (as at 12/31/2020)



## DIVERSITY ON CAMPUS

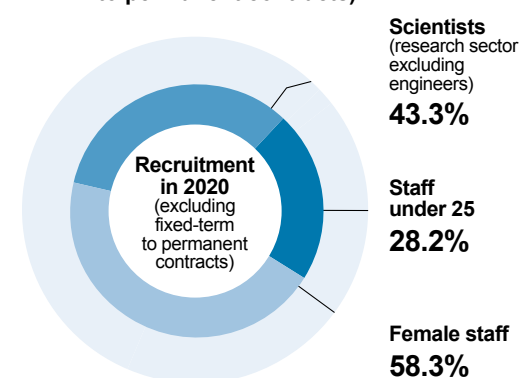
42.7  
Average age  
of employees

59%  
female  
employees

70  
nationalities  
on campus

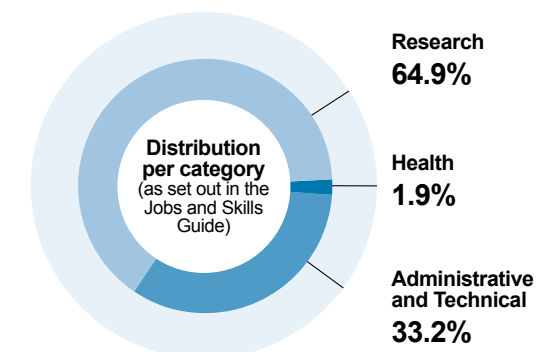
## FOCUS ON RECRUITMENT

393  
people hired  
in 2020 (excluding fixed-term  
to permanent contracts):



## PROFESSIONAL CATEGORIES AT THE INSTITUT PASTEUR

Of the 2,258  
Institut Pasteur employees



## SKILLS DEVELOPMENT

6,434  
staff registered on training courses  
(Institut Pasteur employees,  
OREX employees and interns)

€2,900k  
invested in professional training  
(costs including time spent on training  
and compulsory contributions)

26,043  
training hours

## CAREER SUPPORT FOR SCIENTISTS

113  
scientists received guidance  
(more than 500 interviews in total)  
from the MAASCC\*

30  
career events held:  
2 round tables, 17 workshops,  
11 Careers After-Work Events

\* Welcome, support and career development structure for scientists



# DONATIONS, SPONSORSHIP AND LEGACIES

**A big THANK YOU to you all for your amazing support!**

**In 2020, as the COVID-19 pandemic took hold, public generosity reached an extraordinary level. Nearly a third of the Institut Pasteur's resources come directly from individual and corporate donations and legacies. This support is vital in the ongoing battle against the coronavirus, as well as in all the areas of health in which there are still so many scientific challenges to overcome.**

Donors, artists, YouTubers, influencers, companies, foundations and associations – we want to say a big THANK YOU to you all for your amazing commitment to the Institut Pasteur's scientists and for all your initiatives to support and fund their research projects! Thank you for your incredible generosity, which has enabled us to mount an even more effective response not only to the COVID-19 pandemic but also to tackling cancer and neurodegenerative diseases. In 2020, the Institut Pasteur received financial support from more than 270,000 individual donors. These included our loyal long-standing donors, new donors and also artists, writers and influencers, all of whom contributed to the unprecedented effort to combat the pandemic caused by SARS-CoV-2. Every donation, every contribution collected, no matter how big or small, was invaluable for the 89 research projects conducted on the coronavirus throughout 2020 (even more projects have been launched since). The Institut Pasteur's research projects were made possible in part through public generosity. More than 400 scientists were and continue to be involved in the response to COVID-19, using science to try to beat the epidemic. Public generosity has been more crucial than ever in helping us to pursue our research on the SARS-CoV-2 virus. Nearly 30,000 of our donors chose to set up a direct debit, which enables them to spread their donations over the entire year.

Despite the unprecedented health context that we experienced in 2020 (and are continuing to experience in early 2021),

we were able to maintain links with our donors by holding online scientific conferences about the progress of our research in 2020.

The 14th edition of Pasteurdon, which ran from October 7 to 11, 2020, took place during the COVID-19 epidemic. The many donors once again demonstrated their incredible generosity in their support for the Institut Pasteur's research.

The resounding success of Pasteurdon 2020 reflected not only the Institut Pasteur's leading scientific role during the pandemic but also the dedication



Visit from the Le Roch-Les Mousquetaires Foundation to mark the extension of the sponsorship agreement on March 4, 2020.

of actor Alexandra Lamy, loyal patron of Pasteurdon since 2011, and the efforts of more than 45 media partners – TV channels and radio stations, with even more media partners coming on board this year – who broadcast the campaign film free of charge and rallied their presenters and journalists to the cause. Once again this year, the lab coat was chosen to symbolize the Pasteurdon appeal, encapsulating both scientific research and the unwavering efforts of both scientists and healthcare workers. Alexandra Lamy and all the celebrities supporting the Institut Pasteur were once again encouraged to don the “uniform” of our scientists, bearing the Institut Pasteur logo, in response to the call “Let’s defend research together!” Back in 2019, a dozen graffiti artists also got involved in the “Put on your lab coat” campaign, customizing the lab coats of the Institut Pasteur’s scientists and transforming them into unique works of art which could then be sold. This year, Catawiki and the 12 contemporary artists joined forces to auction off these uniquely customized

lab coats. A total of €4,300 was raised and donated in full to the Institut Pasteur to fund research projects (see “Significant highlights” p. 30).

## Donations from companies and foundations

The year 2020 saw an unprecedented response to the COVID-19 pandemic. Several companies, foundations, associations and federations made donations or introduced charity-linked product campaigns, charity sales and initiatives among their staff, customers, members and networks. We would like to thank them all for their support (see inset p. 89). They follow in the generous footsteps of our long-standing sponsors and partners, who also demonstrated their support this year (some even made an additional donation to help with the COVID-19 response). Many new sponsors joined their ranks, including the Per Fumum Endowment Fund, Allianz and the Roquette Foundation for Health. Groupe Pasteur Mutualité has also indicated that it is keen

to significantly boost its contribution to the Institut Pasteur's research.

Our loyal partners all got involved in the 14th edition of Pasteurdon. The Le Roch-Les Mousquetaires Foundation, which provides direct funding for two research programs on food safety, elicited the support of the Les Mousquetaires group via the sale of charity-linked products in the Intermarché and Bricomarché store chains. ASSU 2000, a Pasteurdon partner for the seventh year running with its ongoing support for research on cardiovascular diseases, continued its charity-linked product campaign for Pasteurdon, with a donation made for every new insurance policy taken out. The social welfare company AG2R LA MONDIALE, a loyal and generous Pasteurdon partner with its sport-based fundraising campaign “Vivons Vélo,” once again set the bar high, raising nearly €100,000 for the Institut Pasteur. In total, donations from companies and foundations in France raised over €7 million (see Thank you page).





#### Legacies generally shared

In 2020, 124 new legacies were submitted to the Board of Governors, representing a total of €44.9 million. The Institut Pasteur shares most of the legacies bequeathed to it with several other institutions.

Life insurance policies continued to represent a leading source of recurring income and saw a significant increase in 2020, raising €21.6 million. These policies, like legacies and gifts, offer favorable tax arrangements in that they are exempt from transfer duties.

#### Quality strategy: pioneering certification renewed

The Institut Pasteur's Legacies and Real Estate Assets Management Office is still the only department of its kind in France to have applied quality procedures to all its activities. Following the annual audit, AFNOR Certification renewed the Institut Pasteur's ISO 9001:2015 certification for 2020. The legal team has been expanded and now has four qualified legal experts specializing in notarial law.

#### Communications activities

In 2020, because of the health crisis, the sixth major campaign to promote gifts, together with a number of other communications campaigns (trade fairs

for individuals and professionals), had to be canceled or postponed. The number of requests for information about gifts fell slightly. But the number of gift notifications remained constant, and our legators continued to demonstrate their generosity during this difficult period. To keep in contact with people looking to set up a legacy, a notarized donation or a life insurance policy in aid of the Institut Pasteur, the Legacies and Real Estate Assets Management Office employs two dedicated staff members in charge of legator relations. Benefactors can contact them for advice and guidance. The six-monthly "Gifts" newsletter is the main means of communication with legators. The twelfth edition was sent out at the end of 2020. The newsletter focuses on a specific aspect of notarized donations, legacies or life insurance policies in each issue, generating considerable feedback and many personal testimonials. Finally, a number of YouTube information videos were published on the Institut Pasteur website. The Think Tank on Philanthropic Trusts, launched by the Institut Pasteur in 2010 following the success of the Conference on Philanthropic Trusts, remains the leading interdisciplinary research group on the question of philanthropy. It provides an opportunity for dialog between experts from a number

of wide-ranging fields including notaries, lawyers, bankers, tax advisors, journalists and scientists, and regularly delivers opinions that offer an expert viewpoint on current issues associated with asset management for philanthropic purposes. Given the health context in 2020, the expert meetings were organized as working webinars, with various specialist guest speakers. The experts were able to reflect on and discuss the contributions by speakers including Arthur Gautier, Executive Director of the ESSEC Philanthropy Chair, invited in connection with the publication of his latest book, *Vers une Philanthropie stratégique* (Towards Strategic Philanthropy); sociologist and semiologist Alain Mergier, following the study "Covid-19: sens dessus dessous" (COVID-19: turning the world on its head); and Christophe Rousselot, Director-General of the Notre-Dame Foundation, for a look at the unprecedented fundraising appeal for the Cathedral of Notre-Dame de Paris. The Think Tank on Philanthropic Trusts also analyzed in detail the 35 proposals in the parliamentary report on "Philanthropy in France," submitted on June 9, 2020 by MPs Sarah El Hairy and Naima Moutchou. Drawn up in close collaboration with stakeholders in the philanthropy sector, including our Think Tank, which twice held discussions with Sarah El Hairy, now Minister of State for Youth and Engagement, this comprehensive, cross-cutting report aims to develop and promote an ambitious approach to philanthropy that is incorporated into all aspects of society.

### MAJOR SPONSORS



### SPONSORS

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- THE JOE W. AND DOROTHY DORSETT BROWN FOUNDATION
- VOLKSWAGEN STIFTUNG

### COVID-19: A BIG THANK YOU TO COMPANIES, FOUNDATIONS AND CHARITIES!

A big thank you to all the companies, foundations and charities that offered outstanding support to the Institut Pasteur teams from the very start of the pandemic. We would particularly like to mention: Accor, Agipi, Allianz, Association RVS, BNP Paribas, Boehringer Ingelheim, la Banque Postale, European Investment Bank Institute, Fédération des Socama, la France Continue, Fondation Air Liquide, Fonds Axa pour la recherche, Fondation de France, Fondation Le Roch-Les Mousquetaires, Fondation Michelin, Fondation SNCF, Fondation Suez, Fondation Total, Groupama (Centre Manche, Centre Atlantique, Nord-Est), Goldman Sachs Gives, Icade, Imerys, Ipsen, IBM, Keep Cool, Keolis, Kering, Leyton, MAIF, Marion et Cie, MIF – la Mutuelle d'Ivry (la Fraternelle), MMA, Mutualia, Nuxe, Paypal, Pfizer, UCPT Paimpol, Salesforce, UNIM, Vinted.

### ON THE WEB

➔ COVID-19: thank you for your support (in French)  
[bit.ly/3uQrITZ](https://bit.ly/3uQrITZ)



# BOARD OF GOVERNORS

The Board of Governors makes decisions on all Institut Pasteur matters. It gives its opinion on the strategic policies proposed by the President, votes on budgets, and approves the accounts.

## BOARD OF GOVERNORS BUREAU

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French Council of State Department Head

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**Sandrine Etienne-Manneville**  
Head of the Cell Polarity, Migration and Cancer Unit, Institut Pasteur

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**Antoine Triller**  
Head of Research at Inserm and Director of the École Normale Supérieure Institute of Biology

## OTHER MEMBERS

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CNRS Director of Research, team leader at the Institut Curie, Paris

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**Susan Liautaud**  
Independent Director (Susan Liautaud & Associates Limited)

**Jean-Claude Manuguerra,**  
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**Inès-Claire Mercereau**  
Chief Advisor to the French Government's Accounting Office

**Anne Paoletti**  
Scientific Director for Biology and Health at the Directorate-General of Research and Innovation, French Ministry of Higher Education, Research and Innovation

**Claudia Pena-Rossi**  
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Head of the Structural Virology Unit, Institut Pasteur

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**Marie-Noëlle Ungeheuer**  
Head of the Clinical Investigation and Access to BioResources Platform (ICAReB), Institut Pasteur

**Marie-Hélène Verlhac**  
Director of the CIRB (Center for Interdisciplinary Research in Biology), Collège de France

# SCIENTIFIC COUNCIL

The Scientific Council advises on all issues relating to scientific policy, organization, and research and teaching programs. The Council is consulted on all research and teaching unit creation, closure and merger decisions.

## ELECTED PASTEURIAN MEMBERS

**Arnaud Echard**  
Head of the Membrane Traffic and Cell Division Unit

**SECRETARY**  
**Jean-Marc Ghigo**  
Head of the Genetics of Biofilms Unit

**Aziz El Amraoui**  
Head of the Progressive Sensory Disorders, Pathophysiology and Therapy Unit

**VICE-CHAIR**  
**Michaela Müller-Trutwin**  
Head of the HIV, Inflammation and Persistence Unit

## APPOINTED PASTEURIAN MEMBERS

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Head of the Innate Immunity Unit

**Philippe Bastin**  
Head of the Trypanosome Cell Biology Unit

**Carmen Buchrieser**  
Head of the Biology of Intracellular Bacteria Unit

**Carla Saleh**  
Head of the Viruses and RNA Interference Unit

## EXTERNAL MEMBERS

**Amos Bairoch**  
Prof. Department of Human Protein Science, Computer and Laboratory Investigation of Proteins of Human Origin (CALIPHO), University of Geneva Medical School, Switzerland

**Arturo Casadevall**  
Department of Molecular Microbiology and Immunology, Johns Hopkins Bloomberg School of Public Health, Baltimore, USA

**François Guillemot**  
Senior Group Leader, Neural Stem Cell Biology Laboratory, The Francis Crick Institute, London, UK

**Eva Harris**  
Prof. Division of Infectious Diseases and Vaccinology Director, Center for Global Public Health, UC Berkeley School of Public Health, USA

**Nicholas Hastie**  
Prof. MRC Human Genetics Unit, MRC Institute of Genetics and Molecular Medicine at the University of Edinburgh, Edinburgh, UK

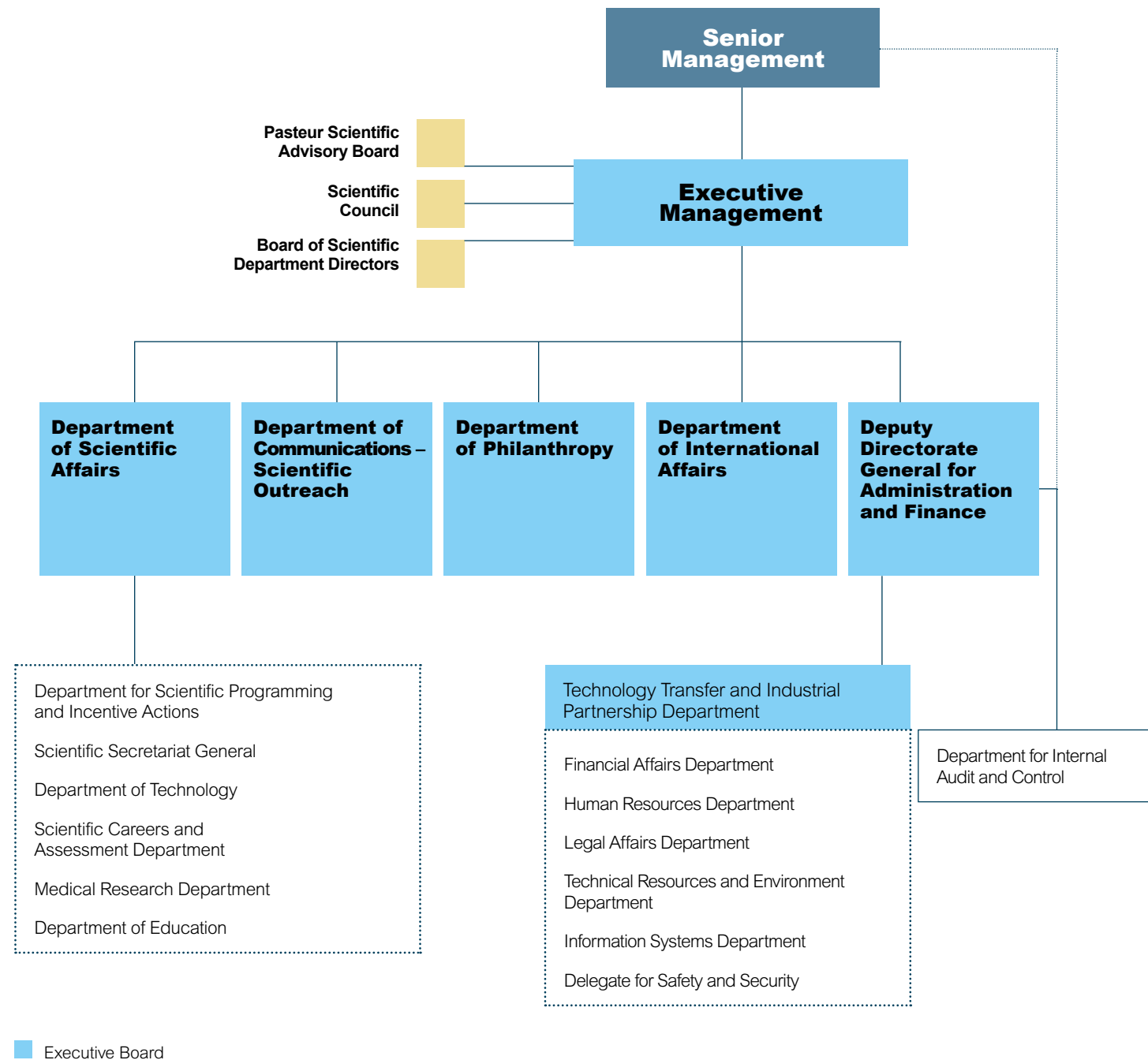
**Yvonne Jones**  
Prof. Division of Structural Biology, Henry Wellcome Building for Genomic Medicine, University of Oxford, UK

**Ruth Ley**  
Director Microbiome Science, Max Planck Institute for Developmental Biology, Tuebingen, Germany

**Anne O'Garra**  
Senior Group Leader, Laboratory of Immunoregulation and Infection, The Francis Crick Institute, London, UK



# GOVERNING BODIES



# MANAGEMENT OF THE INSTITUT PASTEUR

The President, a figure from the world of science, prepares and implements strategic planning. He is supported by a management team comprising an Executive Board and a Senior Management Board.



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President



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## Institut Pasteur

25-28, rue du Docteur-Roux  
75724 Paris Cedex 15, France



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