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PRIZES & AWARDS

RESEARCHERS

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Alain Aspect has been awarded the **2022 Nobel Prize in Physics**. The Professor at the Institut d'Optique Graduate School (IOGS)/Université Paris-Saclay, Affiliate Professor at ENS Paris-Saclay and Associate Professor at the École Polytechnique, but also Emeritus Research Director at the Charles Fabry Laboratory (LCF – Univ. Paris-Saclay, IOGS, CNRS), shares this award with the American John F. Clauser and the Austrian Anton Zeilinger. This award recognises their experiments on quantum entanglement, which paved the way to quantum technologies.

Abdelhafid Bendahmane and **Michèle Tixier-Boichard** have both been awarded the **Gold Medal of the French Academy of Agriculture 2022**, presented by the French National Research Institute for Agriculture, Food and Environment (INRAE). Vice Director of the Institute of Plant Sciences Paris-Saclay (IPS2 – Univ. Paris-Saclay, CNRS, INRAE, Univ. d'Évry, Univ. Paris Cité), Abdelhafid Bendahmane is recognised for his creativity and the excellence of his work in the field of plant sciences. Michèle Tixier-Boichard, Research Director of the Animal Genetics and Integrative Biology unit (GABI – Univ. Paris-Saclay, INRAE, AgroParisTech), works to collect, characterise, conserve and distribute biological resources useful for the knowledge of biodiversity.

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Julien Bobroff, professor of Physics and Leader of the Physics Reimagined research team of the Laboratory of Solid-State Physics (LPS – Univ. Paris-Saclay, CNRS), has been awarded the **CNRS Medal for Scientific Mediation 2022**. A specialist in condensed matter physics, Julien Bobroff is also known for his work in popularising fundamental physics.

Bérengère Dubrulle, research director at the Condensed Matter Physics laboratory (SPEC – Univ. Paris-Saclay, CEA, CNRS), is the **winner of the Woman Scientist of the Year prize,** awarded at the Irène Joliot-Curie prize ceremony organised by the Higher Education and Research ministry. On this occasion, **Céline Bellard**, researcher at the Ecology, Systematics and Evolution laboratory (ESE – Univ. Paris-Saclay, AgroParisTech, CNRS), received the **Special Commitment prize** and **Nina Hadis Amini**, researcher at the The Laboratory of Signals and Systems (L2S – Univ. Paris-Saclay, CentraleSupélec, CNRS) was awarded the **Young Woman Scientist prize**.

David Ruelle, emeritus Professor at the Institut des Hautes Études Scientifiques (IHES), is one of three winners of the prestigious **Dirac medal**. Awarded by the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, this medal recognises researchers for their contributions to theoretical physics.

Henri Vicenti, from the Interactions, Dynamics and Lasers Laboratory (LIDYL - Univ. Paris-Saclay, CEA, CNRS) has been awarded the most prestigious prize in the field of high performance computing: the **Gordon Bell 2022 prize**. This award highlights the work of the team to which the researcher belongs on the realistic modelling of laser-based particle accelerators.

Eight researchers from Université Paris-Saclay have been rewarded by the French Academy of Sciences. **Nabila Aghanim**, from the Institute of Space Astrophysics (IAS – Univ. Paris-Saclay, CNRS), received the **Huy Duong Bui 2022 Grand Prize**; **Suheyla Bilgen**, from the Laboratory of the Physics of the Two Infinities – Irène Joliot Curie (IJCLab – Univ. Paris-Saclay, Univ Paris Cité, CNRS), received the **2022 Madeleine Lecoq Prize**; **Thierry Bodineau**, of the Alexander Grothendieck Laboratory (LAG – Univ. Paris-Saclay, IHES, CNRS), received the **2022 Sophie Germain Prize – Institut of France Foundation**; **Yann Brenier**, from the Orsay Mathematics Laboratory (LMO – Univ. Paris-Saclay, CNRS, Inria), received the **2022 EDF Ampère Prize**; **Marco Di Renzo**, from the Signals and Systems Laboratory (L2S – Univ. Paris-Saclay, CentraleSupélec, CNRS), received the **2022 Michel Monpetit – Inria prize**; **Igor Ferrier Barbut**, from the Charles Fabry Laboratory (LCF – Univ. Paris-Saclay, Institut d'Optique Graduate school, CNRS) and **Emmanuel Flurin**, from the Condensed State Physics Service (SPEC – Univ. Paris-Saclay, CEA, CNRS), received the **Jacques Herbrand Grand Prize 2022**; **Isabelle Grenier**, from the Astrophysics, Instrumentation and Modeling Laboratory (AIM – Univ. Paris-Saclay, Univ. Paris Cité, CEA, CNRS), received the **CNES prize – Astrophysics and Space Science 2022**; **Amaëlle Landais**, from the Laboratory of Climate and Environmental Sciences (LSCE – Univ. Paris-Saclay, UVSQ, CEA, CNRS), received the **2022 prize for scientific research in the polar and subpolar zones**.

STUDENTS

Herikalaina Rakotoarison, PhD student at the Interdisciplinary Laboratory for Digital Sciences (LISN – Univ. Paris-Saclay, CNRS, CentraleSupélec, Inria), won the **2022 STIC doctoral prize** of the Plateau de Saclay. This prize is organised by Université Paris-Saclay's STIC (Sciences and Technologies of Information and Communication) doctoral school, the Polytechnic Institute of Paris' doctoral school and the Labex DigiCosme. **Jeanne Redaud** of the Signals and Systems Laboratory (L2S – Univ. Paris-Saclay, CNRS, CentraleSupélec), has been selected as an **honourable mention for the thesis prize**.

Five young female researchers from Université Paris-Saclay have been awarded the **16th L'Oréal-UNESCO Foundation for Women in Science Young Talents France Award**: **Rachel Breton**, PhD student at Paris-Saclay Neuroscience Institute (Neuro-PSI – Univ. Paris-Saclay, CNRS), **Alice Contat**, PhD student at the Orsay Mathematics Laboratory (LMO – Univ. Paris-Saclay, CNRS), **Elsa Ducrot**, post-doctoral fellow at the Astrophysics, Instrumentation, Modelling Laboratory (AIM – Univ. Paris-Saclay, CNRS, CEA, Univ. Paris Cité), **Anne Nguyen**, PhD student at the Charles Fabry Laboratory (LCF – Univ. Paris-Saclay, IOGS, CNRS) and **Tina Nikoukhah**, PhD student in applied mathematics at the Borelli Centre (Univ. Paris-Saclay, CNRS, ENS Paris-Saclay, Univ. Paris Cité, SSA).

COMPANIES / PROJECTS

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At the ninth edition of the **Pépite prize**, organised by the Ministry of Higher Education and Research, in association with the Île-de-France Region and BpiFrance, two innovative companies managed by Université Paris-Saclay students were rewarded: **QuanTIM** and **Eyekeepit**.

EDITOR'S LETTER

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Given the current energy situation, at the end of September 2022, the Ministry of Higher Education and Research asked institutions to implement sobriety measures with the objective of reducing energy consumption by 10% in 2024 compared to 2019. Aware of environmental issues, Université Paris-Saclay has been committed for several years to a more sustainable development through its research priorities, the training of students and the reduction of its impacts.

In the laboratories of the University, a whole research community is working to develop low-carbon energy solutions, which could compensate for the shift away from fossil fuels, whose greenhouse gas emissions are the cause of global warming, and satisfy the energy needs of humanity. In this new issue of the University magazine, you will read about the involvement of some of these researchers in projects surrounding nuclear fusion and the development of future fusion reactors that may, on the long term, produce decarbonised energy.

This issue also highlights a silent disease that many women suffer from and the emerging research aimed at better understanding it: endometriosis. Another health topic is at the heart of this review: autism spectrum disorders, which are still poorly understood, and the question of their diagnosis. Finally, epigenetics, the study of the mechanisms that regulate gene expression without modifying the DNA sequence, fascinates scientists because of the diversity of fields in which it is involved.

Beyond these four themes, the entire research and innovation potential of the University and its laboratories is highlighted here through the many technological platforms of the University. Furthermore, in order to recognise the commitment (voluntary, associative, professional, etc.) of its students and their experiences, the University provides them with a system that values not the type of commitment chosen, but the transversal skills and knowledge acquired during the experience.

Finally, you will get to know our campuses better through certain films, TV films and series, which are popular filming locations for the production teams.

And as this winter issue is published at the very beginning of 2023, I would like to take this opportunity, on behalf of the University, its student communities and its staff, to send you my best wishes for this new year and to wish you every success in all your projects.

Estelle Iacona,
President of Université Paris-Saclay.

Keywords
Student engagement – Exchange of views between graduates and students

Title

Student involvement: a recognised and valued experience

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Today, many students are involved in voluntary work, professional activities, the operational reserve or as volunteer firefighters. In order to value these experiences, which are opportunities to acquire new skills, Université Paris-Saclay provides all its students with a scheme to recognise and value their engagements.

Legislative changes in recent years, and in particular law no. 2017-86 on Equality and Citizenship, have made it possible to advance the consideration of student engagement. Keen to recognise and value engagement in all its forms, certain constituent faculties and institutes and associate institutions of Université Paris-Saclay have, since 2018 (and sometimes even earlier, as in the case of the Université d'Évry) set up various kinds of procedures: teaching units that award ECTS credits, additional options, the granting of bonus points, etc. Although the methods used differ depending on the institution and constituent faculties and institutes, the objective is the same for all: to value, not the type of engagement chosen, but rather the cross-cutting skills and knowledge acquired during this experience. An objective that Université Paris-Saclay has now adopted by proposing, in addition to and not as a replacement for the existing one, a cross-functional system aimed at all its students.

Recognising the diversity of the profiles

All Université Paris-Saclay students who wish to assign value to their engagement can now obtain a student engagement certificate. "*With this scheme, our ambition is to recognise the diversity of our students' profiles and to value the acquisition of specific skills in each course,*" explains Dorian Colas des Francs, Coordinator of the Training Offer and Education Management Hub at Université Paris-Saclay's Department of Training and Success.

To obtain this certificate, candidates must provide a CV and a letter from a third party attesting to their engagement. "*They are also asked to write a report describing the activity they engaged in, the skills they acquired during this experience and their usefulness in relation to their course*," says Dorian Colas des Francs. Once finalised, this file is reviewed by the Engagement Coordinator of the constituent faculties and institutes and then submitted to an institutional commission which, after studying all the files, makes the certification decision.

A former student at the the Cachan Technical Institute (IUT), Kenzi Boukantar who was involved in tutoring high school students within the "Cordée – À nous la réussite" (Ropeway to success) programme was delighted to have been able to benefit from this scheme. "*While this certification can of course be used to add a line on a CV, it also helps to value engagement in all its forms. A great way to inspire other students to get involved!*"

Valuing engagement and stand out profiles

If there is one discipline where engagement is a tradition, it is medicine. "*Everyone saw this with the outbreak of the health crisis in 2020 and the incredible efforts of our students. But long before that, their engagement in humanitarian work, tutoring or student associations has always been important. It was therefore high time that, beyond simple recognition, these approaches were valued*," explains Olivier Lambotte, Professor at the Faculty of Medicine

of Université Paris-Saclay. This is why the Faculty has set up two schemes: a free teaching unit credited with 3 ECTS equivalent to 10% of the points awarded to valuing the engagement; the possibility of valuing the engagement in preventive actions by students in their third year of health studies.

At the Jean Monnet Faculty, between 60 and 80 students ask for their engagement to be recognised each year. "*A number that we have noticed has had a tendency to increase since 2018,*" says Maxime Jorland, Teacher responsible for Educational Monitoring at the Jean Monnet Faculty. Within this faculty, two ways of valuing engagement were also adopted at the start of the 2018 academic year: a Personal Project teaching unit for second-year undergraduate students, which provides the opportunity to value an engagement over the current year; an optional course open to all students and earning up to 0.25 bonus points per year. "*In addition to the desire to value cross-functional skills, it is also the prospect of encouraging stand out profiles that motivated our approach to valuing engagement,*" explains Maxime Jorland.

Opening up to other forms of engagement

A pioneer in the approach to valuing student engagement with the creation of a free teaching unit as early as 2011, the Université d'Évry took advantage of the implementing decree for the 2017 law to broaden its target audience and expand its valuing scheme with two new methods: giving a bonus of the overall average and exemption from subjects and internships. "*Through these different valuing methods, we not only want to value student engagement in all its forms, but also to promote it, thanks to the support of local partners such as the Sdis91, Animafac and AFEV,*" explains Maria Munier, Director of the Student and Campus Life Department of the Université d'Évry.

It is also this desire to open up to other forms of engagement that led the University of Versailles – Saint-Quentin-en-Yvelines (UVSQ) to create a free teaching unit credited with three ECTS, accessible to all UVSQ students who can prove an engagement of at least six months. "*Organised around seven sessions, this package allows students to learn how to showcase the skills acquired during their engagement on their CVs or in an interview, but also to discover other forms of engagement to which they can turn, whether within the university, in the reserves or in international solidarity. This approach leads to some very interesting exchanges and, sometimes, to new engagements!*" explains Sébastien Floquet, Professor and Defence Advisor at UVSQ.

A specific year of engagement for students of the École Normale Supérieure Paris-Saclay

Convinced that certain engagements help to build the scientific and civic personality of its students, in September 2022, the École Normale Supérieure Paris-Saclay set up a specific Year of Engagement for its students (ASPEN) to value this type of initiative within its degree. Positioned in the third year of the degree, the ASPEN is based on the student constructing an engagement project, completing this within a host institution during this year while following complementary courses, designed to offer useful tools for the implementation of the project. It aims to develop broad skills such as adaptability, autonomy, openness and the ability to co-construct in the students involved.

So, ready to engage?

https://www.universite-paris-saclay.fr/engagement-etudiant

https://ens-paris-saclay.fr/formations/diplome-ens-paris-saclay/parcours-du-diplome/annee-specifique-de-parcours-engagement

Title

An exchange of views between graduates and students, in the heart of Silicon Valley

During their immersive trip to San Francisco, the winners of the Challenge Start-up, a mentoring programme for students with start-up projects, exchanged views with University's alumni working in the country. These included Adrien Burlacot, founder of the Burlacot Lab who has lived in the United States since 2021 and Quentin Barreau, a student at the time who has now graduated from the University. Today, they talk about their respective educational journeys, their professional projects and their common interest in innovation in plant sciences.

Adrien Burlacot holds a 2nd-year of Master's degree in plant sciences from Université Paris-Saclay. He is currently an Assistant Professor at Stanford University and a researcher at the Carnegie Institution for Science. He launched the Burlacot Lab, halfway between a laboratory and a start-up, to work on carbon fixation by microalgae and perhaps lead to a reduction of CO_2 in the atmosphere. Recently graduated from the University with a Student Entrepreneur Diploma (D2E) and a 2nd-year of Master's degree in Innovation in Quality and Plant Production, Quentin Barreau has launched his company COCAGNE. Its product is an autonomous eco-designed planter that uses an innovative lowtech automatic irrigation system and a rich soil providing six months of nutrients. The company has recently entered the commercialisation phase.

Both passionate about the challenges of creating a more sustainable society using plant-based solutions, Adrien Burlacot and Quentin Barreau agree on the quality of the education they received at Université Paris-Saclay. "*It was an education that changed my way of seeing biology,*" says Adrien. "*I had many courses in the various centres in the south of Paris specialising in the study of plants: CEA, INRAE, CNRS.I had the opportunity to replace my end-of-studies master's internship with an entrepreneurial internship to launch my company. The D2E then allowed a significant acceleration of the company. I found the education to be high quality,*" says Quentin.

Due to their shared journey through the University, Adrien and Quentin quickly found a natural commonality when they met in the United States and both have fond memories of it. "*I really enjoyed the informal discussions and meeting the graduates who live and work in San Francisco and Silicon Valley,*" Quentin confirms. "*I was pleasantly surprised by these meetings. It's a good idea, a great experience that allows for enriching interactions. I am convinced of the importance of discussions between students and graduates,*" concludes Adrien.

https://www.universite-paris-saclay.fr/adrien-burlacot-et-quentin-barreau-echange-san-francisco-entre-diplome-et-etudiant-de-luniversite-paris-saclay

Title

Summer schools at Université Paris-Saclay

There are many summer school projects flourishing at Université Paris-Saclay. They aim to bring an awareness of science and the world of higher education to immersion students.

The number of summer schools at Université Paris-Saclay is increasing. The formats vary but they have similar objectives: secondary school students discover scientific disciplines and the range of opportunities offered by research and higher education.

In 2022, for the first ENS Paris-Saclay summer school, ten students were welcomed by four PhD students. After three days immersed in the daily life of research at the Paris-Saclay Mechanics Laboratory (LMPS – Univ. Paris-Saclay, ENS Paris-Saclay, CentraleSupélec, CNRS), the secondary school students produced posters entitled "Tell me about research".

Fighting against self-censorship among young people

"*It's important to showcase scientific practice rather than having students attend lectures, round tables, etc.,*" says Olivier Kahn, Director of the Diagonale Paris-Saclay. As part of the Science with and for Society (SAPS) label, the Diagonale also co-hosts STEM (science, technology, engineering, mathematics) summer schools with a committee that brings together staff and researchers from Université Paris-Saclay. The week-long school is made up of groups of 25 students from years 9 and 11, the pivotal years preceding important choices in terms of educational direction and at a time when there are no exams at the beginning of the summer.

The project, once reserved for girls because their numbers are so low in science classes (in the final year of high school, the number of girls taking at least six hours of maths per week has fallen by over 60% since the 2019 secondary school reform), aims to fight self-censorship. "*The objective is to introduce students to scientific disciplines and make them aware of these subjects before they choose their options in secondary school,*" explains Olivier Kahn. This summer school features many meetings with researchers, laboratory technicians and PhD students, laboratory experiments and visits to platforms (such as, last year, the botanical garden or the Institute of Space Astrophysics) along with many other workshops.

In summer 2023, CentraleSupélec plans to host the third edition of its Summer Camp for high school students from all over France. The programme includes seminars and conferences, workshops, visits to laboratories and Fab Lab to discover the sciences and all their applications.

http://www.sciencesociete.universite-paris-saclay.fr/participer/lyceennes-une-ecole-dete-pour-decouvrir-les-sciences/

Title

An international comparison of science-society activities

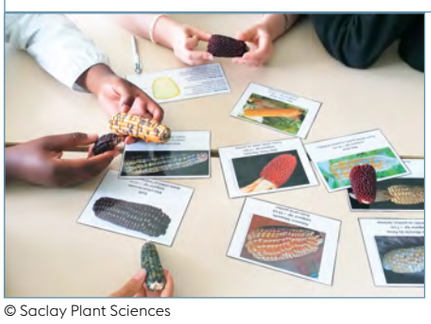
As part of the Science with and for Society accreditation awarded by the French Ministry of Higher Education and Research, Université Paris-Saclay and Sorbonne University have jointly called upon the consulting firm SIRIS to establish an inventory and comparative analysis of the best international science and society practices. In accordance with the Ministry's wishes, the aim is to propose a proof of concept that can be deployed within the institution and, if necessary, at other universities.

This study focused on four European partner universities of Université Paris-Saclay and Sorbonne University: Copenhagen, Utrecht, Barcelona and Hamburg. Three institutions outside the European Union, renowned for their research and whose size and ecosystem are comparable to those of the two French universities, are also included in the study: King's College London, McGill University (Montreal) and the University of Tokyo. Three French-speaking universities completed the panel: the Université du Québec à Montréal (UQAM), the University of Geneva and the Université Catholique de Louvain (UCLouvain).

With numerous examples, this study will soon be available online. Its presentation will lead to a discussion day in the first half of 2023.

Title

Students discover research in plant biology labs



© Saclay Plant Sciences

From November 2022 to June 2023, scientists of the Saclay Plant Sciences (SPS) network will be hosting school groups from throughout the Île-de-France region. This second edition of the "Plants and People" initiative will propose a range of half-day activities to students between the ages of 14 and 18. Interactive workshop including quizzes, card games and debates will focus on domestication, plant breeding and societal issues. Each class will also visit a laboratory and talk to researchers about their work and more generally the different jobs in research and the scientific approach. "*Our goal is to involve everyone connected with science, so that we can showcase the diverse range of profiles and subjects we deal with,*" boasts Pierre Hilson, who first launched the initiative. This year's edition is expected to bring in some 1,500 students.

https://www6.inrae.fr/saclay-plant-sciences/Plantes-et-Societe/Des-Plantes-et-des-Hommes

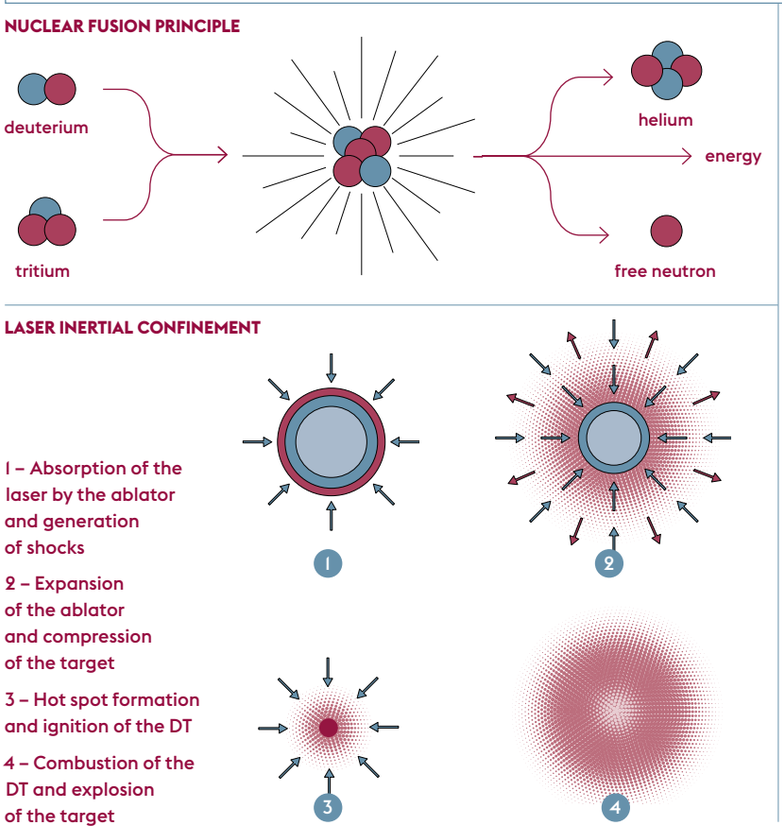
Illustrations right-hand page and page 22:
Cosmo Danchin-Hamard

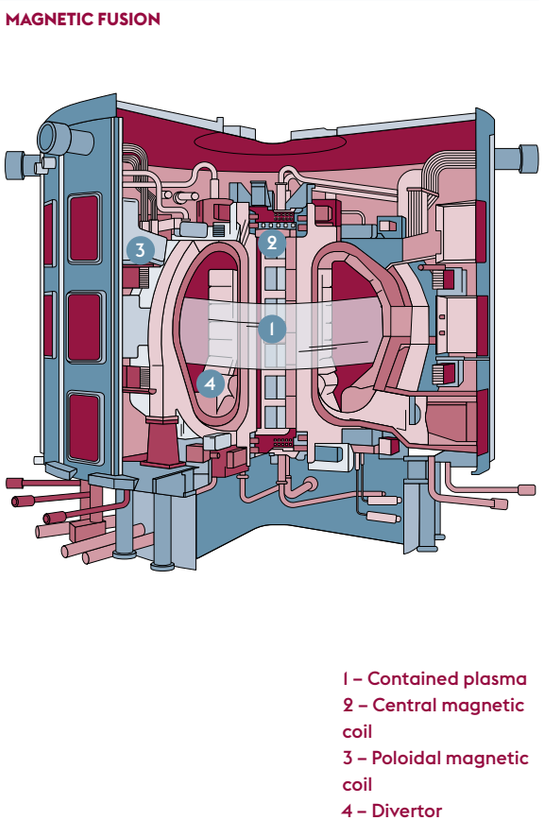

HOW DOES EPIGENETIC SHAPE US?
EPIGENETICS
NUCLEAR FUSION
COSMO

Keywords
Nuclear fusion – Magnetic and inertial confinement – Helium bubbles and oxide precipitates

Title

Nuclear fusion: steps towards energy production





As stars do, several experimental devices are able to initiate nuclear fusion reactions, which could be a source of colossal, low-carbon and safe energy, and the first steps towards future fusion reactors. Scientists at Université Paris-Saclay are involved in this research.

Initiated by the Covid-19 pandemic and brought to a head by the war in Ukraine, the current energy crisis is revealing truths that have long been ignored. It confirms the urgency of breaking our dependence on fossil fuels and the need for a transition to low-carbon energies (renewable and nuclear) in line with the fight against global warming.

At the same time, this crisis shows how important the world's energy needs are and the calls for energy sobriety underline how difficult it is to reduce these needs without efforts and profound changes. Moving away from fossil fuels to low-carbon energies is not easy, given their large share of the energy mix. Moreover, despite their many advantages, none of these energies is alone fully meeting the energy needs of the current societies. As a result, there is little hope of offsetting fossil fuels with a single source of low-carbon energy that is at the same time unlimited, clean, safe and affordable.

Merging nuclei for energy

One that raises hopes for the longer term is nuclear fusion, which is the opposite of nuclear fission, the process used by currently operating nuclear power plants to produce energy from atomic nuclei. Like what happens at the heart of stars, nuclear fusion reactions bring light atoms together to form slightly heavier atoms and release energy at the same time.

The most studied and promising reaction for energy production is the fusion of two variants, or isotopes, of hydrogen (deuterium, D, and tritium, T) to give one helium atom (alpha particle), one neutron and a large amount of energy. For the same mass, this energy is four times greater than that obtained by nuclear fission, and four million times greater than that released when coal, oil or natural gas are burned. Only a few hundred micrograms of fuel are needed for this. Moreover, no runaway reaction would be possible here. Another advantage is that deuterium is naturally present in large quantities in the oceans and tritium, which is available in smaller quantities, can be produced from lithium, which is abundant in nature. Nuclear fusion would also cause fewer waste management problems.

Unique conditions, to be reproduced

This process seems to have nothing but advantages. Yes, but it also requires a lot of effort... To merge atomic nuclei, they must be close together. This means overcoming their mutual electrical repulsion. In a star, the temperature – over 10 million degrees Celsius – lifts this barrier. Matter is in a plasma state, different from the solid, liquid and gas states. In a plasma, electrons (negatively charged) are torn from the atoms and no longer orbit the nuclei, which are ionised (positively charged). The extreme pressures found at the heart of stars confine the nuclei to a small space, which increases the probability of their collision, and therefore their fusion.

On Earth, such conditions do not exist naturally. Other means have to be used to reproduce them. Three conditions are necessary to make nuclear fusion an abundant and profitable source of energy. In addition to heating the fuel to a temperature ten times higher than in

stars and triggering the agitation and collision of the plasma nuclei, it is necessary to confine the plasma to achieve a sufficient density of nuclei and increase the probability of collision. Above all, it is essential to maintain the stability of the plasma and its confinement for a sufficient time to extract energy. Currently, two confinement methods are being developed: magnetic confinement and laser inertial confinement.

Inertial confinement fusion: the impact of the laser

On 5 December 2022, a major first was achieved by inertial confinement fusion. The 192 ultra-powerful laser beams of the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (USA), aimed at a gold cylinder containing a deuterium-tritium target enclosed in a bead (a so-called indirect attack scheme), succeeded in triggering a nuclear fusion reaction that delivered 3,15 megajoules of thermonuclear energy from a laser pulse of 2,1 megajoules, i.e. an energy gain of 1.5. "*This shot has boosted interest in inertial fusion energy, even though there are no plans to develop a fusion reactor for the time being,*" points out Benoît Canaud, from the Matter under Extreme Conditions Laboratory (LMCE – Univ. Paris-Saclay, CEA). This achievement must not eclipse the many challenges that still need to be met in order to develop a commercial solution based on inertial fusion: increasing the efficiency and rate of the lasers, increasing the energy produced by each experiment and lowering the manufacturing cost of the targets.

At the LMCE, Benoît Canaud and his colleagues are studying another laser attack scheme than that of the NIF. This is a direct attack. "*We use a very high-energy laser to illuminate a target (a microbead) of cryogenic DT (at a temperature of 20 K, i.e. -253.15 °C). This sets the target in centripetal motion so that it collapses on itself.*" The laser heats the outer layer of the target (shell) to several million degrees Celsius (over 1,000 eV or 1 keV) making it spray as plasma. "*The ablator, made of plastic, is expelled at very high speed and as it expands outwards from the shell, it pushes towards the interior of the target. This sets the cryogenic layer in motion, which gradually implodes until it collapses in the centre. As the cryogenic layer is increasingly compressed in the centre, the DT in the form of residual gas sees its temperature rise to around ten keV.*"

The way the laser hits the target is important. "*In inertial confinement fusion, we generate shocks of varying strength inside the ablator and the cryogenic DT. A shock dumps entropy (disorder) and increases the material's internal energy, which makes it much harder to compress.*" The art of inertial confinement fusion is therefore to make the target implode without putting too much entropy into the cryogenic DT to be compressed, in order to produce a high thermonuclear gain. "*The more we compress the target – that is to say, we reduce the volume – the more the density and power gain increase.*"

Magnetic confinement fusion: the tokamak device

Whereas inertial confinement fusion uses very short times, around 100 picoseconds (0.1 ns), in order to inertially confine the fusible matter to very high densities, magnetic confinement fusion uses long times and relatively low particle densities. Tokamaks or stellarators are currently the most advanced systems for future reactors. These toroidal or annular chambers are equipped with a fuel heating system and magnetic coils through which an electric current flows. As any charged particle in a magnetic field wraps around the field lines, ions and electrons in the plasma are magnetically confined in the chamber by the powerful magnets.

Some of these experimental devices show a few records, although none has yet managed to achieve a net power gain of more than 1, i.e. to produce more energy than that required to heat the plasma and confine it. At the end of 2003, the French tokamak Tore Supra – renamed WEST for Tungsten (W) Environment in Steady-state Tokamak and located at the CEA in Cadarache – maintained its plasma for six minutes and thirty seconds. At the end of 2021, the Chinese HL-2M tokamak did so for seventeen minutes and thirty-six seconds. The English tokamak JET (Joint European Torus), supported by the EUROfusion consortium comprising European and Swiss research institutes, has achieved a ratio of 0.67: by 1997, it produced 16 megawatts of fusion power for a total heating power of 24 megawatts. At the beginning of 2022, it delivered 59 megajoules of fusion energy for five seconds.

From experiment to industrial demonstrator: ITER

The missing link between these experimental devices and future industrial demonstrators is the international thermonuclear experimental reactor ITER in Cadarache, an ambitious project involving 35 countries. It must demonstrate the scientific feasibility of magnetic confinement fusion to produce electricity and the safety of the device. The start of operations and the production of the first plasma are expected in 2030. ITER will produce a deuterium-tritium plasma heated to over 150 million degrees Celsius and self-sustaining by the fusion reactions. The tritium used in the reaction will be regenerated within the chamber from the neutrons released during the reaction. For 400 seconds, ITER will deliver 500 megawatts of thermal power from an injected power of 50 megawatts, which means a gain of ten. To achieve this, the volume of its chamber (1 400 m^3) and its plasma (840 m^3) will be much larger than those of the current tokamaks.

Several laboratories of Université Paris-Saclay are part of the EUROfusion consortium and contribute to ITER through their research. The Laboratory of Plasma Physics (LPP – Univ. Paris-Saclay, CNRS, École Polytechnique, Observatoire de Paris, Sorbonne Univ.), whose expertise lies in the diagnosis of plasma fluctuation and turbulence, is one of them.

When turbulence comes to the plasma

"*An extremely hot and magnetised plasma is chaotic and complex. There is a zoology of instabilities due to gradients in temperature, density, average speed, current, magnetic field, etc.,*" explains Pierre Morel, from the LPP's Magnetic Fusion team. "*The temperature at the centre of the plasma is thus several hundred million degrees Celsius, while a few metres further on, the superconducting magnets are bathed in liquid helium, which is close to 0 K (-273,15 °C). The magnetic field is not homogeneous either: it is more intense inside the ring than outside. This is a source of instabilities, which grow exponentially and coexist on various scales in the plasma.*"

As they cannot grow indefinitely, these instabilities saturate and lead to turbulence, which is characterised by vortices that cascade and fracture into smaller vortices until they dissipate. These vortices can also coalesce and create larger structures. As the turbulence is predominantly perpendicular to the magnetic field, these structures end up mixing the hot particles in the centre of the plasma with the outer, colder ones. On the contrary, other phenomena have a beneficial effect on the turbulence, such as zonal flows that shear the vortices. "*We are studying how the structures that predominate in the mixture are formed, what their behaviour, their size and their life time are. Our aim is to maintain high heat and a high density of particles in the centre of the magnetised plasma in order to keep the plasma confined for as long as possible,*" explains Pierre Morel.

Because of the mixing, the quality of the energy and particle confinement deteriorates. "*The plasma confinement time, i.e. the average time during which the energy remains inside the system, is fixed by the turbulence. It can be increased by multiplying the layers of magnetic*

lines. As a result, less external power is needed to maintain the reaction. This is why we are developing a large machine like ITER," says Pascale Hennequin, head of the LPP's Magnetic Fusion team.

Diagnostics and numerical simulations: paving the way for ITER

The team is developing diagnostics that are implemented in different tokamaks, such as WEST, ASDEX Upgrade in Germany and TCV (Variable Confinement Tokamak) in Lausanne (Switzerland). They measure the turbulence rate of the plasma. The aim is to compare the different machines and their parameters. "*The purpose is to validate the new operating regimes in order to make the predictions of ITER and future reactors more reliable,*" says Pascale Hennequin. All observations are made by indirect measurements. "*We probe different parts of the plasma by scattering micrometric electromagnetic waves. It is a bit like a radar. We measure the speed of the density fluctuation of the particles at different scales. This speed plays a very important role in all the saturation and turbulence regulation processes*."

The team compares these observations with its numerical simulations modelling turbulence and the appearance and characteristics of instabilities. "*We use a kinetic description: we model the way in which the particles are distributed in speed and position within the plasma. Our aim is to produce simulations that faithfully and realistically represent what we see in our experiments and diagnostics.*" By extrapolating these results, scientists are seeking to provide reliable simulations before operating the ITER tokamak and to predict its confinement time.

Although process optimisation and a finer understanding of the physics have yet to be achieved, the barriers surrounding nuclear fusion energy production are gradually coming down and a potential industrial future is looming. Proof of this is the growing emergence of start-ups collaborating with research centres and universities to develop the activity.

Publications

• Mauro Temporal, Benoit Canaud, and Rafael Ramis. Dependence of Inertial Confinement Fusion capsule performance on fuel reaction rate, *Eur. Phys. J. D* (2021).

• U. Stroth *et al.* Progress from ASDEX Upgrade experiments in preparing the physics basis of ITER operation and DEMO scenario development. *Nucl. Fusion* 62, 042006, (2022).

Titre

Bubbles, defects and precipitates: materials in extreme conditions

At the Irène Joliot-Curie Laboratory for the Physics of Two Infinities (IJCLab – Univ. Paris-Saclay, CNRS, Univ. Paris Cité), Aurélie Gentils' team is working to understand the coupled effect of neutron flows and gas accumulation on the properties of materials in future fusion reactors.

In future fusion reactors, materials will be exposed to very high temperatures, neutron flows and an accumulation of light gases (helium and hydrogen), produced in non-negligible quantities by the fusion between deuterium and tritium. These elements have an impact on the microstructure of the material. This is because a solid, crystalline material has a periodically ordered arrangement of atoms, which are sometimes ejected on collision with neutrons released during the fusion reaction, leaving a gap or even a cavity resulting from a cluster of gaps. Helium ions, accumulated in the environment of the material, then get into it and create bubbles that grow and weaken the material.

At IJCLab, within the Energy and Environment unit, Aurélie Gentils's team experimentally simulates these damages using ion beams of the JANNuS-SCALP platform. "*This has the advantage of not making the material radioactive. Damage can be characterised in situ and in real time.*" A beam of energetic heavy ions simulates the damage induced by neutrons. "*The heavy ions pass through the material and create displacement cascades: they collide with the nuclei of the atoms they meet and interact with the electrons orbiting the nuclei.*" Using a second beam of lower-energy ions, the scientists promote the incorporation of helium (or hydrogen) into the material. Then, they study where the two damages are both present. "*The irradiation coupled with helium incorporation affects the material to a depth of between 10 and 100 nm.*"

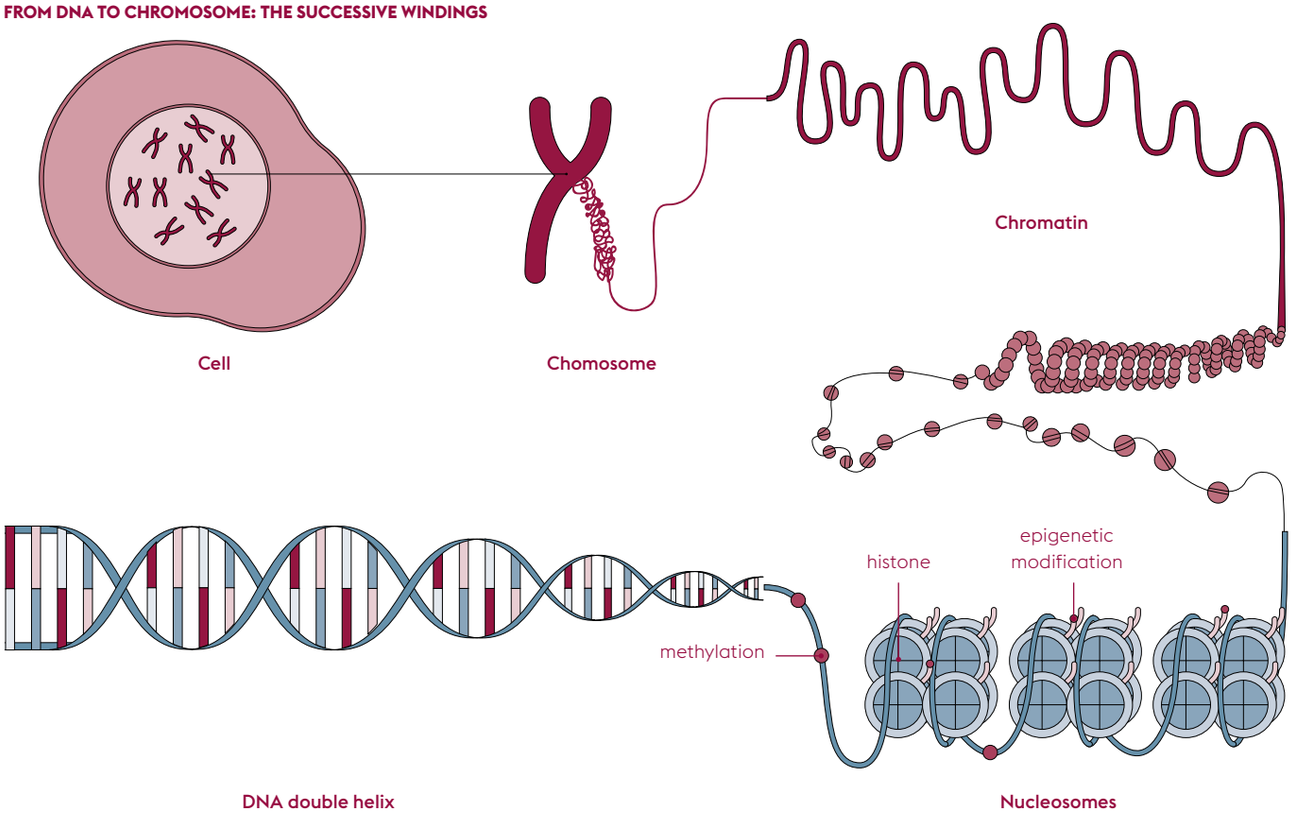
Using transmission electron microscopy (TEM), the team measures the size and density of the bubbles and check whether other defects in the arrangement of the atoms, such as dislocations and loops, have formed. In parallel, they carry out numerical simulations to understand, for example, the energy of bubble or defect formation and the helium diffusion at the atomic level. The ferritic steels used in current nuclear power plants have carbon precipitates present from the outset that slow down dislocation movements and give the steels good mechanical properties. However, these precipitates dissolve at very high temperatures. The IJCLab team is interested in ODS (Oxide Dispersion Strengthened) steels containing nanometric oxide precipitates made of yttrium, oxygen and titanium, which are more resistant at very high temperatures. "*We are working to characterise these conventionally and ion beam fabricated materials, before and after the incorporation of the elements, to understand how and where nanoprecipitates are formed, and what beneficial effects they have on irradiation-induced damage and gas accumulation.*" Other experiments are also being carried out on tungsten or aluminium nitride. "*This helps to determine the choice of materials used in future fusion reactors.*"

Publication • O. Emelyanova *et al.* Bubble-to-void transition promoted by oxide nanoparticles in ODS-EUROFER steel ion implanted to high He content. *Journal of Nuclear Materials*, 545 (2021).

Title

The unknown inner workings that control our genes

FROM DNA TO CHROMOSOME: THE SUCCESSIVE WINDINGS



What do the search for new cancer therapies, ripening tomatoes and the prediction of sperm fertility in bulls have in common? It is epigenetics, which is the study of the mechanisms that regulate gene expression without changing the DNA sequence. Because what matters is not always the sequence, but the way in which it is used.

Nestled at the heart of the nucleus of cells, DNA (or deoxyribonucleic acid) contains all the genetic information (or genome) of an individual. This molecule is organised into functional units, the genes, which determine the characteristics of the individual or of a species, much like a cookbook full of recipes. Like a constantly active kitchen brigade, multitudes of molecules are busy in both the nucleus and the cytoplasm of cells. Some are able to recognise the regions of DNA containing genes and initiate the production of messenger ribonucleid acids (mRNAs), and their export to the cytoplasm, while others translate these mRNAs into proteins, which are themselves involved in cellular functions and the life of the individual. But among all the recipes available in the DNA "book", each cell type chooses which dishes it concocts and in what quantity. What ultimately determines this "menu"?

The main answer comes from DNA compaction. To "fit" the molecule into the nucleus of a cell, several levels of compaction are required. First, DNA is wrapped around proteins, the histones, to form nucleosomes, the basic units of chromatin. Except during cell division, where it is found as chromosomes, chromatin looks like a more or less condensed coil of thread. Epigenetic molecular mechanisms regulate the level of condensation or decondensation of chromatin. These are chemical modifications, applied directly to the histones or to the DNA molecule. These modifications influence gene expression without changing the DNA sequence. Some highly condensed regions are thus packed so tightly that they are unreadable, as if some pages of the book were glued together. To make reading possible, the chromatin must be decondensed. The list of accessible pages therefore differs from one cell type to another and changes over time.

Like food critics, epigenetics researchers at Université Paris-Saclay are interested in the choice and execution of the dishes concocted by the cells: they study more particularly the regulation of epigenetic modifications.

Methylation as a prognosis for cancer

One of the modifications studied is DNA methylation. This is the addition of a methyl group (-CH_3), i.e. a carbon atom linked to three hydrogen atoms, on cytosines – nucleic bases that are one of the building blocks of DNA. The cytosines involved are located in a particular DNA sequence environment. This modification usually prevents the expression of nearby genes.

In pioneering work, scientists of the Laboratory for Epigenetics and Environment (LEE) at the National Centre for Research in Human Genomics (CNRGH – Univ. Paris-Saclay, CEA) have focused on this regulation mode. Jörg Tost's team has discovered that a DNA methylation differential helps to establish a prognosis for breast cancer. Using tumour biopsies, it monitored the epigenetic profile of patients' tumour cells during chemotherapy. The team found that those who responded well to treatment and survived for several years were those whose the DNA methylation profile of these cells was altered during chemotherapy. The challenge now is to successfully use

methylation as an early predictor of long-term survival, starting at the end of drug treatment.

Establishing a full epigenetic assessment

Jörg Tost and his team are also interested in inflammatory diseases. "*This research has tremendous potential, because the symptoms observed in inflammatory diseases are almost all related to epigenetics,*" says the researcher. "*We want to use a simple blood test to find out which epigenetic marks are indicative of the inflammatory state.*" For the time being, the technique is only in the early stages of research.

"*For the past few years, we have not only been looking at DNA methylation, our approach is more comprehensive.*" Chromatin accessibility, changes in histones, coding and non-coding transcriptome, small RNAs: the team scrutinises all levels of epigenetics to understand which molecular changes really have an impact on the functioning of the individual genome. The LEE is now combining its expertise in oncology and immune disease, and is conducting studies in immuno-oncology. The aim is to predict the chances of success of an immunotherapy before it has even begun. "*This will be a major topic of study in the coming years. Epigenetics holds the keys to the personalised medicine of the future,*" promises Jörg Tost.

Epigenetics: a written record of experience

Another area of study is the environment effects on epigenetic changes. Smoking, exposure to various pollutants or air quality, for example, can modify the epigenetic state of a cell. "*The epigenome, which is the set of epigenetic modifications, represents the memory of our exposure. If your mother lived on a farm during her pregnancy and your early childhood, you are much less likely to develop allergies or asthma,*" says Jörg Tost. The beneficial bacteria that are in the stables of large animals are the basis of this protection: this is the epigenetics of acquired immunity.

"*Everything that happens during gestation can have long-term consequences,*" say Hélène Jammes and Anne Gabory, of the Biology of Reproduction, Environment, Epigenetics and Development laboratory (BREED – Univ. Paris-Saclay, UVSQ, INRAE, ENVA). The team studies the link between a change in the maternal environment during gestation and the consequences on the development of the embryo and then the foetus and the fate of the individual post-natally. In particular, it examines the underlying epigenetic mechanisms. "*It is important to identify the epigenetic effects on the offspring of all the events occurring during pregnancy,*" explains Anne Gabory. "*This has an interest for prevention in human medicine but also for livestock farming.*" In mice, the maternal metabolic context thus influences foeto-placental development and predisposes to altered responses. When an overweight mouse gives birth to baby mice, the latter are more likely to gain weight in the case of an obesogenic diet. By analysing epigenetic marks present in the blood of the offspring of a litter, the team is trying to predict which mice will be overweight.

However, is the epigenetic profile of parents transmitted to their children and grandchildren, and even beyond? While epigenetic transmission over several generations has been proven in plants, the scientific consensus is not yet established for animals. After fertilisation, almost all epigenetic markers carried by the paternal (from the sperm) and maternal (from the oocyte) genetic heritages are reset. New markers are applied during the embryo's development, which seems, at first sight, to indicate an absence of epigenetic transmission between parents and children. However, some experimental results show that the erasure wave is not complete. Hélène Jammes explains: "*We prefer to talk about epigenetic intergenerational transmission, in parallel with genetic inheritance. It is rather information stored in the cell nucleus during gestation that changes the way cells respond to their environment. Thus, the mice studied are more likely to become obese but are not born overweight.*"

Male fertility: bulls and men

Within BREED, scientists are also working on ruminant fertility. "*It may seem surprising for the same team to work on different models, but our biological questions and objectives remain the same: to identify the epigenetic mechanisms that contribute to the development of traits and to use them as diagnostic and prognostic tools.*" Recent work reports the involvement of epigenetic information transmitted by the father's sperm on embryonic development at the time of fertilisation. Genetically characterised bulls, which are selected according to criteria aimed at improving the meat or milk quality of the offspring, are used to inseminate large numbers of cows and obtain large offspring. The fertility of these individuals can then be accurately assessed.

BREED scientists have identified several hundred cytosines whose methylation levels vary in relation to bulls' fertility. Methylation alterations target genes involved in sperm physiology and embryonic development. "*Epigenetics is not a tsunami, but rather a lacework,*" says Hélène Jammes. By combining epigenetic data and artificial intelligence, the scientists produced a mathematical model that was able to predict bull fertility at over 70%. This work also provides a better understanding of human male infertility. The bovine model is also being used in the European RUMIGEN project to explore the relationship between paternal transmission of epigenetic information and offspring performance.

Epigenetic diversity at the heart of breeding

The GEroNIMO (Genome and epigenome enabled breeding in monogastrics) project, co-coordinated by Tatiana Zerjal, from the Animal Genetics and Integrative Biology unit (GABI – Univ. Paris-Saclay, INRAE, AgroParisTech) and Frédérique Pitel, is also seeking to understand the extent to which the animal retains memories of environmental changes. "*We are looking to see if exposure to stress or other environmental influences leaves traces in DNA methylations. We are studying the possibility of a transmission over several generations, by analysing how changes in the parental environment modify the offspring several generations away.*" The chosen study model is a novel one: chickens and their eggs. Identifying the link between epigenetic marks and interesting agricultural traits is also the focus of the GEroNIMO project. This project proposes to analyse DNA and epigenetic marks over fifteen generations of pigs. For farmers, this means selecting their animals on agronomic criteria in the traditional way, and for scientists, monitoring their epigenome over the generations.

"*We combine two techniques, GBS (Genotype-by-sequencing) and MeDIP (Methylated-DNA-immunoprecipitation), to scrutinise the genetics and epigenetics of the animals. We analyse thousands of animals, which allows us to study population epigenetics of pigs, laying hens and quails. Our project is focused on the applied consequences,*" says Tatiana Zerjal. Here, epigenetics is used for comparisons between free-range and indoor farming, between temperate and tropical climates, or between different breeds of pigs and chickens. Although epigenetic and genetic diversity seem to be linked, a large part of the epigenetic variability is not yet explained. The aim of GEroNIMO is to develop new strategies for selection and conservation of this epigenetic diversity, in order to adapt farming to global changes.

Releasing transposons from tomatoes

In plants, scientists make lines with altered epigenomes to understand how epigenetic memory is passed on between generations.

They use the genome editing tool CRISPR-Cas9 or "molecular scissors". This molecular biology tool makes it possible to cut DNA at a precise location, at the level of specific sequences (CRISPR), using a particular protein (Cas9).

"*We are interested in the functional aspect of epigenetics and need these genetic tools associated to bioinformatics to process our large amounts of data. By targeting, for example, the MET1, DML2 or DDM1 genes of the plant, which control DNA methylation, we prevent regulation via this epigenetic mechanism,*" explains Nicolas Bouché, researcher at the Jean-Pierre Bourgin Institute (IJPB – Univ. Paris-Saclay, INRAE, AgroParisTech). His team is interested in the model organism *Arabidopsis thaliana*, the thale cress, a plant little known to the general public but much used by scientists because of its simple and easy-to-study genome. However, the researcher has extended his field of research to a cultivated plant: the tomato. "*Epigenetics is of particular importance here. If a tomato plant is prevented from demethylating, the fruit will not ripen.*"

The researcher explains: "*The epigenome of crop plants is complex. One of the main differences between thale cress and tomatoes is the amount of transposons present in their genome. These are portions of DNA that can move within the genome and modify it by inserting themselves into genes. Their mobility must therefore be very carefully controlled. They represent 20% of the genome in* A. thaliana*, but 70% in tomatoes. This large quantity of transposons is common to all cultivated species.*" At the moment, the role of transposons is not fully understood. They are generally repressed by DNA methylation and remain silent and inactive. In the IJPB greenhouses, plants engineered with CRISPR-Cas9 to decrease their methylation level no longer control their transposons, resulting in radical gene regulation disruptions. The changes observed as a result of these disruptions are used to associate epigenetic regions with a given agronomic trait, such as growth or flowering time. In particular, the team is interested in the epigenetic factors that control plant growth under drought conditions. A major issue in the context of global warming.

Wheat epigenetics

As far as climate change is concerned, there is no doubt that it will have a major impact on crops, especially wheat, which is very sensitive to heat. As part of the 3DWheat project, winner of a 2022 ERC Consolidator grant, Moussa Benhamed's team, from the Institute of Plant Sciences Paris-Saclay (IPS2 – Univ. Paris-Saclay, CNRS, INRAE, Univ. d'Évry, Univ. Paris Cité) is exploring the epigenetic response of this cereal to high temperatures. When it is too hot, the plant is under stress, which modifies its physiology. This change could be mediated by epigenetic mechanisms.

Moussa Benhamed's team is particularly interested in histones epigenetic modifications. For example, if one of the histones carries a repression mark, such as methylation of lysine 9 of histone H3, it compacts the neighbouring DNA into a tight coil. On the contrary, if the histone carries an activation mark, such as acetylation of lysine 14 of histone H3, it leaves the DNA around it loose, which allows gene expression. Nearby DNA sequences are thus co-regulated and the genes are expressed at the same time. Sometimes, a histone is doubly marked. The genes at this location are called bivalent and are often involved in the stress response. Moussa Benhamed's team wants to elucidate the molecular mechanisms at work. "*What is the impact of this bivalence? Is the gene response to stress faster? Does this confer a cellular memory?*"

Furthermore, as the DNA coil forms loops, it brings genes that are normally distant in the genomic sequence spatially closer together. Under the microscope, the IPS2 scientists observed clumps of an enzyme, RNA polymerase. These agglomerates are real gene expression factories. "*These factories connect several loops of DNA together, producing a co-regulation phenomenon between genes that are sometimes thousands of nucleotides apart. Another challenge of the 3DWheat project is to study the role of these epigenetic factories and their dynamics during the response to heat,*" concludes Moussa Benhamed.

Epigenetics is a rapidly expanding field that relies on the rapid progress of technologies to explain phenomena that were still unknown a few years ago. Research will play a key role in overcoming future challenges to human health and how human beings adapt to change.

Publications

• Corem, S., *et al.* Redistribution of CHH methylation and small interfering RNAs across the genome of tomato ddm1 mutants. *The Plant Cell*, (2018).

• Costes, V. *et al.* Predicting male fertility from the sperm methylome: application to 120 bulls with hundreds of artificial insemination records. *Clinical epigenetics*, vol. 14, 54, (2022).

• Coustham, V., *et al.* Epigenetics at the interface between environment and DNA: what importance for breeding practices and selection methods? *Animal – science proceedings*, vol. 13, 5, (2022).

• Fogel, O., *et al.* Deregulation of microRNA expression in monocytes and CD4+ T lymphocytes from patients with axial spondyloarthritis. *Arthritis Res Ther 21*, 51, (2019).

• Pedersen, C.A., *et al.* DNA methylation changes in response to neoadjuvant chemotherapy are associated with breast cancer survival. *Breast Cancer Res 24*, 43 (2022).

• Safi-Stibler, S., Gabory, A., Epigenetics and the Developmental Origins of Health and Disease: Parental environment signalling to the epigenome, critical time windows and sculpting the adult phenotype, *Seminars in Cell & Developmental Biology*, vol. 97, (2020).

Title

The platforms of Université Paris-Saclay

Université Paris-Saclay has a large number of platforms, which represent opportunities for collaboration and a strong potential for innovation.

Over
300
platforms

Themes explored:

- Aeronautics, aerospace, defence
- Chemistry, materials
- Complex systems and software engineering
- Digital
- Energy, ecology, environment
- Mobility and transport
- Quality of life, health, food
- Social, societal and solidarity-based innovation

Social sciences and humanities platforms:

- "Yvette" digital heritage library
- Design Centre
- COVADO SHS Platform

Engineering & sciences platforms:

(The same platform can be found in several categories)

- 6 Astrochemistry / Astronomy / Astrophysics
- 3 Calculations/Data processing
- 5 Characterisation
- 13 Condensed matter
- 3 Electronic systems
- 2 Ion implantation
- 23 Ion-matter / light-matter / laser-matter interaction
- 19 Irradiation
- 6 Liquid, gas and plasma phases
- 8 Magnetometry, superconductivity
- 38 Materials, micro and nanomaterials
- 7 Material of biological interest
- 17 Microscopy
- 6 Modelling / Simulation
- 27 Spectroscopy
- 2 Standardisation / Calibration
- 18 Structure of matter
- 3 Time-resolved experiments
- 7 Ultra-fast / flow dynamics

Examples of platforms:

- ALTO Orsay linear tandem accelerator (nuclear physics)
- C2N clean room (nanotechnologies)
- ICMMO microscopy platform
- LURPA's additive manufacturing platform
- Paris-Saclay Mesocentre (computing)
- PANOPLY (Paris-Saclay geosciences analytical platform)
- Platform for applied research and development activities in ground and space instrumentation (PARADISE)
- SOLEIL (physics, chemistry, biology, heritage sciences)

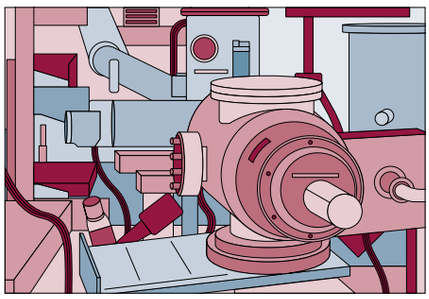
Life sciences platforms:

- 17 Animal facilities and functional exploration
- 14 Biobanks / Biological resources
- 12 Bioinformatics
- 8 Bioproduction
- 24 Cellular imaging
- 7 Chemistry / Screening
- 8 Cytometry / Histology
- 4 Food processes
- 22 Genomics / Post-genomics
- 30 In vivo imaging
- 3 Other life sciences platforms
- 26 Physicochemical analysis
- 10 Plant experimentation / Agronomy
- 17 Preclinical / Clinical exploration
- 22 Structural biology / Biophysics

Examples of platforms:

- ECOSYS laboratory platforms (biogeo-chemical processes, material and energy flows, functions of organisms in isolation or interacting with their environment)
- I2BC platforms (cell biology)
- IJPB platforms (plant studies)
- IPSIT laboratory platforms (drug development chain)
- MetaGenoPolis (microbiota science applied to nutrition and health)
- NeuroSpin (brain imaging and cognitive sciences)
- IDMIT and MIRCen laboratory platforms (preclinical and translational research on human infectious and neurodegenerative diseases)
- Technical platforms of the Gustave Roussy Institute (biological resource centre, immunomonitoring, cytometry and preclinical and clinical evaluation)
- Technical platform of the Frédéric Joliot Hospital Service (multimodal in vivo imaging, development of diagnostic and theranostic methods and agents, clinical applications in neurology and cancerology)

The platforms of the Physics Graduate School

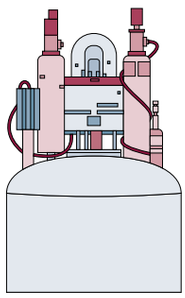


An important part of the physics developed at Université Paris-Saclay is illustrated through the 115 or so platforms of the Physics Graduate School. This concentration, unique in France, allows for cutting-edge disciplinary research to be carried out, complements university teaching, and allows the academic and industrial communities to benefit from technical and experimental expertise. These platforms are open to activities outside the laboratories where they are located. They cover the three research areas of the Physics Graduate School – physics of the two infinities (P2I), matter wave physics (PhOM), and astrophysics – and their versatility also opens them up to related fields (chemistry, engineering, biology, etc.). Their variety reflects the technical specificities of the phenomena studied, related to very different spatial and temporal or energy scales.

The P2I platforms are involved in the design, manufacture and operation of particle accelerators and high-energy phenomena detectors, materials characterisation, data analysis and exploitation. Within the PhOM area, the platforms are organised into six hubs: synchrotron radiation (SOLEIL), large lasers, clean rooms, electron microscopy platforms, irradiation means and small characterisation platforms. Finally, half the Astrophysics platforms contribute to PARADISE, a platform gathering all the integration, testing and calibration resources of the French space laboratories for the development of onboard instruments, subsystems, nano-satellites or instruments for large ground-based observatories. Many platforms involve several research areas of the Physics Graduate School as well as related Graduate Schools, such as the construction and testing of detectors, the study of materials and the use of lasers. In the coming years, the Physics Graduate School will endeavour to find ways to preserve and develop this heritage while encouraging its opening to a greater number of academic and industrial partners.

https://www.universite-paris-saclay.fr/en/facilities-and-platforms

The platforms of the Chemistry Graduate School

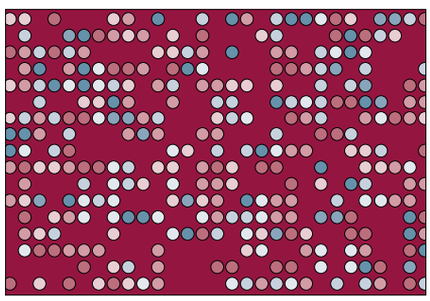


The Chemistry Graduate School laboratories of Université Paris-Saclay have many experimental platforms and computing centres. These are used to develop research activities that are either core (physical chemistry of elementary reactions, analytical chemistry, development and characterisation of materials and biomaterials, design of molecular structures of various sizes), or at the interfaces of physics or life sciences. As such, these laboratories have a unique expertise in the development, study and analysis of all types of samples, whether solid, liquid, gaseous, organic, inorganic or biological, as well as in methodological and instrumental development. There are about 30 internal platforms: transmission electron microscopy or scanning electron microscopy, photoelectron spectroscopy, multiple factor analysis, nuclear magnetic resonance, X-ray diffraction, electron paramagnetic resonance, chromatography, mass spectrometry, computational clusters, magnetometry, elemental analysis, chemical library, etc. These laboratories' various platforms actively contribute to the training offer at the Chemistry Graduate School, the University's visibility through several national and international collaborations, and are open to industrial partners.

In order to remain competitive, laboratories are constantly upgrading their platforms. The CRYOMORPHOSE@RMN_UPSAY project is intended to expand and modernise the NMR equipment of the Saclay platform in order to meet chemists' new spectroscopic requirements. The COCOM project covers the interface between biology and materials and the development of new probes for imaging in the near infrared (beyond 850 nm) through the acquisition of a new spectral confocal microscope dedicated to analysis in this wavelength range.

https://www.universite-paris-saclay.fr/en/graduate-schools/chemistry-graduate-school-platforms

The platforms of the Health and Drug Sciences Graduate School



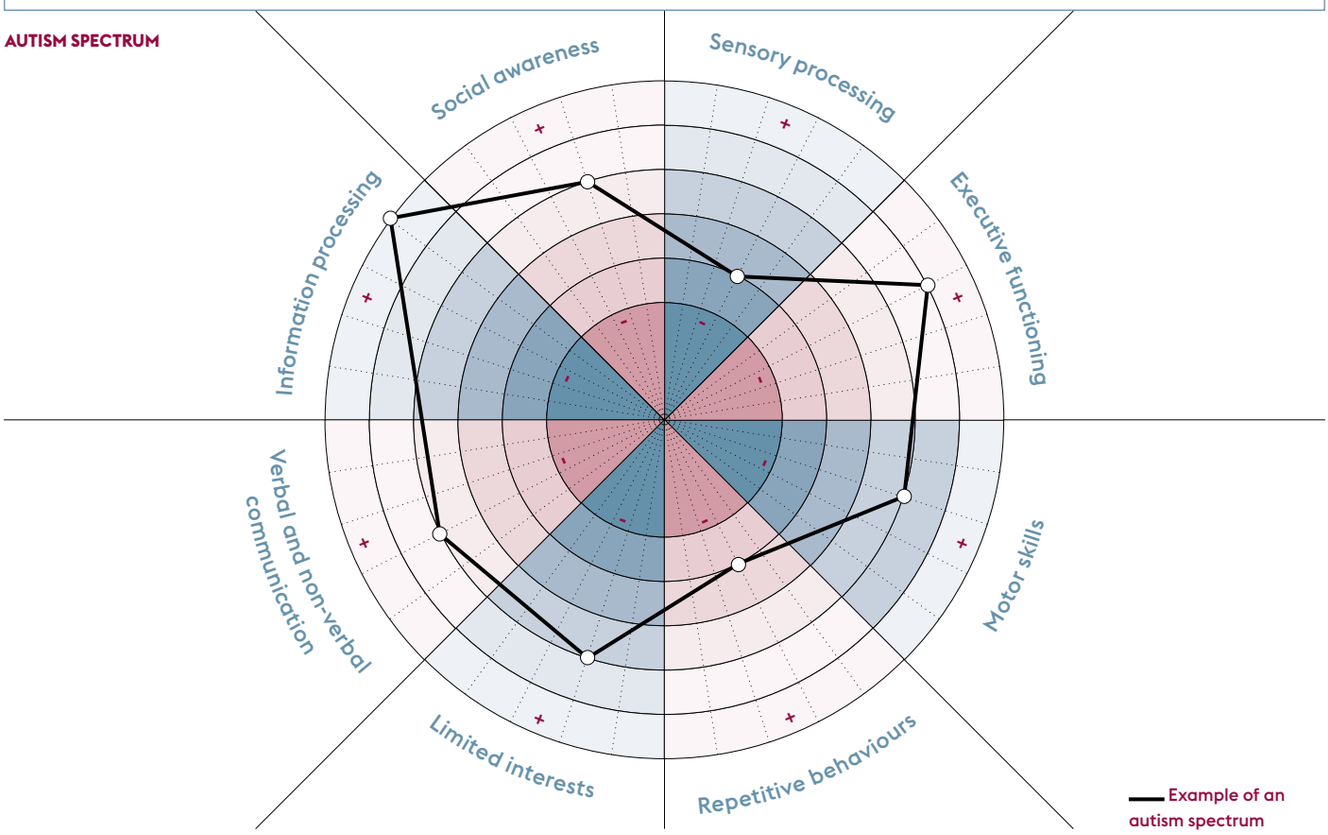
The research activities conducted within the Health and Drug Sciences Graduate School of Université Paris-Saclay are based on a network of some twenty platforms. These are hosted by the Faculty of Pharmacy of Université Paris-Saclay, the University of Versailles – Saint-Quentin-en-Yvelines and the CEA Paris-Saclay (notably the Frédéric Joliot Institute for Life Sciences). The multidisciplinary approaches covered are part of a continuum ranging from the molecular scale to that of the cell, tissue and individual. They use high-throughput assays, such as for genomic analysis or molecular screening, and are based on innovative analysis (transcriptomics, proteomics, lipidomics and metabolomics) and imaging techniques (virtual histology slides, mass cytometry and high definition microscopy) of preclinical and clinical models.

These platforms are open to academic and industrial organisations, and facilitate numerous research and training activities by providing access to cutting-edge technologies. The Engineering and Platforms for Therapeutic Innovation unit (IPSIT – Univ. Paris-Saclay, Inserm, CNRS) brings together eleven technical platforms for animal experimentation, cell biology, imaging, biochemistry and high-throughput analysis, ranging from chemical screening to discover bioactive molecules to omic analysis to discover biomarkers.

www.ipsit.universite-paris-saclay.fr/?lang=en

Title

Understanding the heterogeneity of autism forms



Researchers at Université Paris-Saclay are working on a better understanding of autistic disorders and their emergence factors, as well as their diagnosis.

The Wild Child (1970), *Rainman* (1988), *Forrest Gump* (1994) and more recently *The Specials* (2019). Autism inspires cinema. However, can people with autism see themselves in the description of their disorder? Because much is still relatively unknown and understood about autism, around which the collective imagination crystallises certain representations. Indeed, this neurodevelopmental disorder, which affects one in 160 people worldwide, covers particular mental functions that are often difficult to characterise and the origin of which still raises questions. It also takes on a multitude of forms and manifestations. This is called Autism Spectrum Disorder (ASD). This is primarily characterised by deficits in social and communicative interactions, repetitive behaviours and restricted interests.

With an increase in the number of cases detected in recent decades, the issue of diagnosing autism remains one of the most delicate. This diagnosis is based on a summary of information provided by health professionals, after examinations which are mainly interviews or exercises carried out with the patient. However, these standardised instruments are questionable and are only an aid to clinical judgement. The evolution of the disorder is different for each person, which makes the medical diagnosis even more complex. The impact that this diagnosis has on the patient is not insignificant either: their designation as an autistic person influences their own psychic and social construction, the patient positioning themselves in relation to their status.

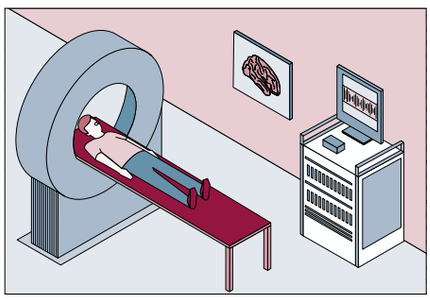
Understanding the causes of autistic traits helps to improve the medical examination, and consequently the diagnosis. Therefore, what avenues of research should be pursued to understand the factors of emergence, signs and diagnosis of ASD? Researchers at Université Paris-Saclay are making progress on these questions and are also proposing a range of possible approaches. Between neurodevelopmental approaches, microbiology and developmental epidemiology, their ambition is to understand the multidimensional aspect of autism.

Data science and open science in the diagnostic test

What if it were possible to predict autism from brain imaging techniques? Not to replace the diagnosis which is made after a clinical judgement, but to confirm it using MRI. This is what an international team of researchers is trying to demonstrate, some of whom are from the Paris-Saclay Center for Data Science (CDS) and the joint Inria-CEA Parietal team, from NeuroSpin (Univ. Paris-Saclay, CEA), to which the Physicist and Data Scientist Gaël Varoquaux belongs. Using an open science approach, since 2017, the members of this team have organised a challenge accessible to all volunteer data scientists with the aim of developing an ASD predictor. Using open Magnetic Resonance Imaging (MRI) data, the challenge was to submit the most optimal algorithms possible to predict the diagnosis of ASD. Over three months, 146 challengers put forward their algorithms, with a total of 720 submissions.

To check the validity of these algorithms, the teams supervising the challenge tested them on private MRI data. They obtained the ROC (Receiver Operating Characteristic) measure of the algorithm, i.e. the performance characteristic

of this classifier, classifying elements into two groups, according to their characteristics. This is a measure of the quality of the predictions, which is substantiated in the form of a curve: the ROC curve, which gives the rate (between 0 and 1) of true positives (positive cases actually detected) and that (also between 0 and 1) of false positives (negative cases detected by mistake) for the classifier studied. Using the AUC (Area Under the Curve) located under the ROC curve the quality of the predictions is revealed. "*The AUC gives us a kind of summary of all the possible decisions of our classifier*," explains Gaël Varoquaux. When the model succeeds in completely separating true positives from false positives, i.e. when the error rate is equivalent to zero, the performance is perfect. "*The ideal curve therefore jumps from 0 to 1 and stabilises at 1*."



At the end of the challenge, the scientists combined the ten best algorithm models and produced a good predictor of ASD, with an AUC of 0.80, a good level of discrimination. The scientists compared the effectiveness of the screening test to the diagnostic test. While the first argues the presence (or absence) of a disease on the appearance (or not) of symptoms, the second estimates the probability of the existence of this disease. It is therefore positioned upstream of the pathology's development. The predictor used as a screening test detects 88% of individuals with ASD, but at the cost of misclassifying 50% of controls. Used as a diagnostic test, the predictor detects 25% of individuals with ASD, but only 3% of controls are misclassified as patients. Although these results are still imperfect and incompatible with clinical application, they offer great hope for ASD prediction. However, MRI data are expensive and difficult to obtain for a large population. Research in this field is not easy, but this does not discourage Gaël Varoquaux: "*We have shown that there is useful research for autism in this direction. An interesting approach would now be to scan two-year-olds, wait a few years for the doctor to confirm the ASD diagnosis, and then make a longitudinal prediction*." The information provided by the MRI performed on the child would make it possible to follow the progression of the disease over time and provide useful early biomarkers, in addition to the study of behaviours.

Neuroscience and the analysis of the heterogeneity of ASD

The multiplicity of forms of autism makes its diagnosis and analysis complex. The major symptoms of autism are often accompanied by various psychiatric or medical disorders, as well as various genetic and immune factors. This variability in the spectrum prevents reproducibility of the biomarkers identified between different individuals with ASD. Researchers from the NeuroSpin centre (Univ. Paris-Saclay, CEA) propose grouping people whose ASD are homogeneous. This separation into several groups aims to understand the biological mechanisms specific to each of them. Each group thus reveals behavioural differences associated with "cortical signatures" detected by MRI.

Because autism does not provide a homogeneous category of patients, it is a spectrum with a multitude of symptoms. To analyse the disease, a simple binary categorisation between "person with ASD" and "person without ASD" is not applicable here. Otherwise, individuals with widely different behaviours would be assimilated into the same group. The work of Angeline Mihailov and Neurospin's Baobab team aims to distinguish individuals with ASD into multiple groups, which includes a "dimensional" approach, taking into consideration the type and degree of the patients' symptoms.

MARIANNE Cohort: the influence of environmental factors

There is also debate about the factors that cause ASD. The genetic factor is the best known and most frequently observed. However, the increase in the prevalence of ASD in the world population over the past 30 years suggests that additional factors are at play. While improved diagnosis and broader definitions of autism are contributing to an increase in the number of patients testing positive, they do not explain everything. "*This explains 50% of this increase, but it shifts the focus away from environmental factors, in which we had little interest, while models of neurodevelopmental disorders are highly developed,*" explains Amaria Baghdadli, a Psychiatrist and Researcher at the Centre for Epidemiology and Population Health (CESP – Univ. Paris-Saclay, UVSQ, Inserm) and Head of the Autism Resource Centre at the Montpellier University Hospital. By 'environmental factors', the researcher means the natural, social, family and cultural environment. "*The environment is able to leave its mark on our genome, our DNA. We then speak of 'epigenetic imprinting'.*"

Considering a multiplicity of factors at the origin of autism calls for a multidimensional approach. A project such as MARIANNE, which started in November 2022, is fully consistent with this. This project, coordinated by Amaria Baghdadli, has received six million euros in funding from the French Future Investment Plan (PIA). Its objective is to build a large research infrastructure by collecting data on 2,300 families. The aim is to establish the role of environmental and biological factors in the occurrence of an ASD or a neurodevelopmental disorder, in general. Unlike the previous cohort, ELENA, which focused on prognostic factors for ASD in children, MARIANNE is a prenatal cohort of children who are at significant risk of developing autism or other neurodevelopmental disorders because they have a sibling with autism.

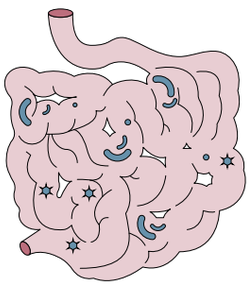
The MARIANNE cohort includes two groups, one of pregnant women who have already had a child with autism and where the risk of having another child with developmental difficulties is greater, and the other where such a risk is almost zero, close to that of the general population. Pregnant women, fathers and children in the first group are monitored for six years. "*The originality of our project comes first from its global health approach, where we are interested in general health and development, using a neurodevelopmental disorder's model that is autism. Interdisciplinarity plays a major role because we use psychiatrists, paediatricians, gynaecologists, midwives, geneticists, social, environmental and developmental epidemiologists... Finally, we believe that such a model of non-genetic inheritance is at work in many chronic diseases and yet still needs to be studied further,*" summarises Amaria Baghdadli.

The GEMMA project and the impact of intestinal microbiota

Determining how environmental factors influence the emergence of ASD sometimes requires a broader view of these troubles. At the Institute of Food Microbiology for Human Health (MICALIS – Univ. Paris-Saclay, INRAE, AgroParisTech), scientists are interested in the involvement of intestinal microbiota in certain aspects of ASD. The intestinal microbiota represents all the microorganisms (viruses, bacteria, parasites...) that populate the intestine and Léa Roussin, a doctoral student at MICALIS, confirms: "*The scientific literature shows us that children with autism have a particular microbiota. In mouse models of autism, whether genetic, environmental or idiopathic, many studies point to a disruption of the gut microbiota compared to the considered 'normal' mice.*"

The European research project GEMMA (Genome, Environment, Microbiome and

Metabolome in Autism), which started in 2019 for five years and of which Léa Roussin's thesis is a part, seeks to further these analyses. The project has a clinical ambition to detect predictive biomarkers for the development of ASD. It also includes a longitudinal study that consists in observing families with one child with ASD and a second child at a very young age, monitoring certain parameters in the latter (through blood, urine and immune system analyses, etc.) in order to determine what precedes the onset of ASD symptoms in children who will have them.



Another part of the project concerns the analysis of the influence of the microbiota of autistic children on the development of autistic-like symptoms in mouse models. "*In my thesis, I am working on axenic mice born without intestinal microbiota. They live in a completely sterile environment, in an insulator,*" explains Léa Roussin. For this research, the young researcher transfers the microbiota of human children with ASD to these mice. While these mice already exhibit altered behaviour, the goal is to observe if this microbiota has an additional impact on their behaviour. "*Inflammation of the gut is seen in some ASD patients, which can affect the microbiota and contribute to the onset or aggravation of symptoms,*" suggests Léa Roussin as a working hypothesis.

Given the impact that a diagnosis has on a child's and even an adult's life, research into autism spectrum disorders is essential. This fresco of autism, which has been in black and white for too long, is now beginning to move into colour.

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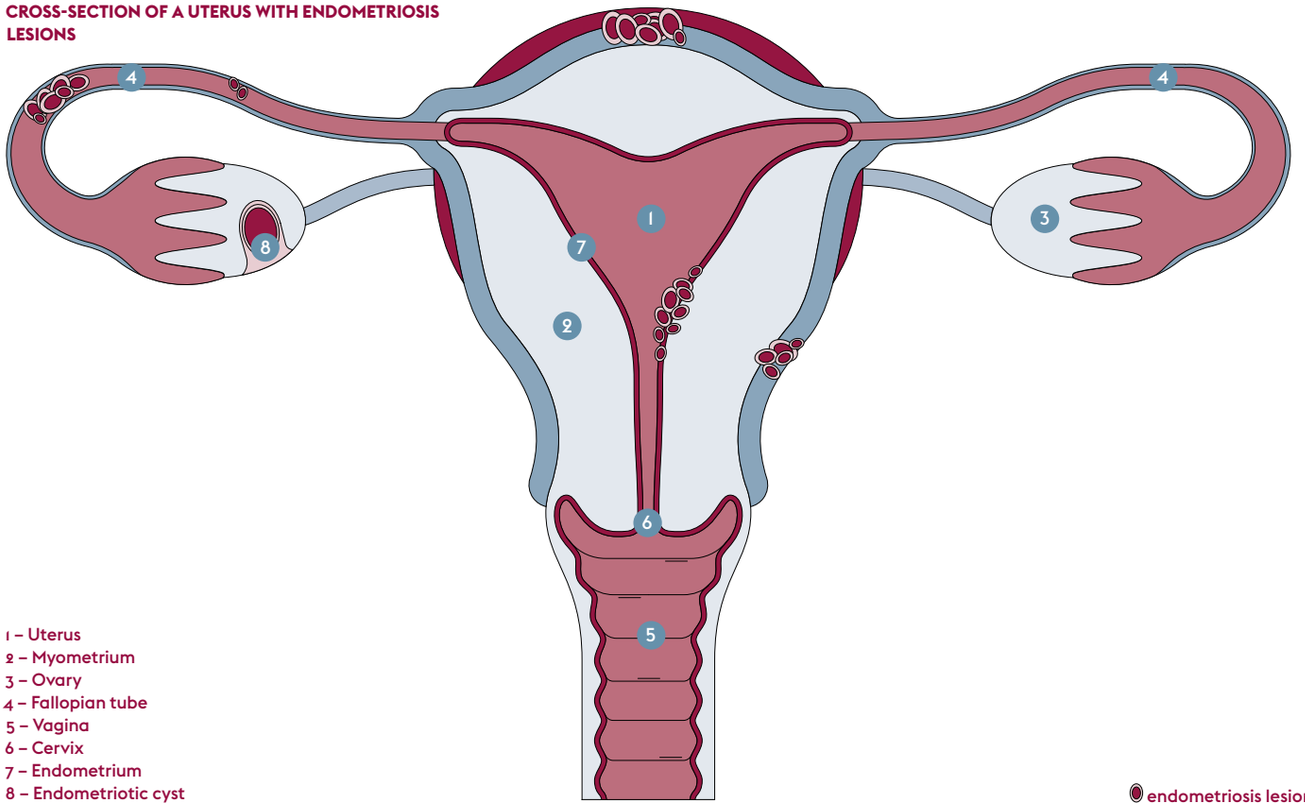
Keywords
Endometriosis, gynaecology – Reproductive system, gamete

Title

Endometriosis: the great unknown

CROSS-SECTION OF A UTERUS WITH ENDOMETRIOSIS LESIONS



1 – Uterus
2 – Myometrium
3 – Ovary
4 – Fallopian tube
5 – Vagina
6 – Cervix
7 – Endometrium
8 – Endometriotic cyst

Endometriosis affects approximately 200 million women worldwide, has been described since ancient times and can cause debilitating daily pain and infertility. However, this disease remains largely unknown, both by scientists and the general public. Researchers are now trying to bring endometriosis out of the shadows.

Today, it is estimated that endometriosis affects one in ten women of childbearing age (from the first menstrual period until menopause), i.e. about 1.5 million women in France, according to the Ministry of Health, and almost 200 million worldwide, according to the World Health Organization (WHO). This disease is related to the endometrium, the mucous membrane covering the inner lining of the body of the uterus. Endometriosis is characterised by the extrauterine presence of endometrial-like tissue. Recurrent and often disabling pain is its main symptom – whether felt during menstruation (dysmenorrhea), sexual intercourse (dyspareunia) or defecation (dyschezia) – located in the pelvic or abdominal area. Infertility, digestive and urinary disorders during menstruation period and chronic fatigue may also occur. Although it was not until 1860 that Austrian pathologist Karel Rokitansky first used the term endometriosis, the symptoms of the disease have been described for nearly 4,000 years, including in ancient Egypt.

However, endometriosis is still not well known. Marina Kvaskoff, an epidemiologist in the Exposome, Heredity, Cancer and Health team at the Centre for Research in Epidemiology and Population Health (CESP – Univ. Paris-Saclay, UVSQ, Inserm) is working to combat this fact. The researcher is the scientific manager and President of the Scientific Council of the ComPaRe-Endometriose cohort study of Assistance publique – Hôpitaux de Paris (AP-HP), President of the Scientific Council of the French Endometriosis Research Foundation and co-leader of the "research" working group of the national strategy to fight endometriosis. "*It is said that endometriosis affects one in ten women, but this is a very rough figure which requires clarification. Part of my work involves trying to better understand the heterogeneity of the disease, its different forms. Today, beyond the short definition we have of the disease, there are many basic questions to which we have no answers,*" she says. "*What are the risk factors for this disease? Does the environment influence the risk of developing it? What is the role of genetics, and which genes in particular? How does the disease evolve over time? When and how does it start?*"

What we know about endometriosis

When menstruation starts, the endometrium is naturally eliminated. In women with endometriosis, altered endometrial tissue becomes implanted in the pelvic cavity outside the uterus. The disease is classified according to four macrophenotypes. When the lesions do not exceed a few millimetres in diameter, the endometriosis is said to be superficial or peritoneal. If the lesions are larger than five millimetres and deeply embedded under the peritoneum, the membrane covering the entire abdominal cavity, it is called deep endometriosis. Endometriotic cysts can also appear on the ovaries and are called endometriomas. Lastly, extra-pelvic endometriosis describes the appearance of lesions typical of the disease in organs far from the uterus, such as the diaphragm, or less frequently lungs and even the brain. "*However, and this is quite*

disturbing, the existing stages of the disease are not correlated with the symptoms," warns Marina Kvaskoff. *"A woman with deep endometriosis may be asymptomatic while a patient may suffer greatly from superficial endometriosis. "*

Another notable fact is that endometriosis is a hormone-dependent disease. Lesions proliferate in the presence of oestrogen, which is produced in huge quantities during menstruation. Suppressing menstruation, through the contraceptive pill, is therefore one of the treatments offered for endometriosis. "*The pill is the first-line drug treatment,"* explains Marina Kvaskoff. Surgery is also possible, to remove the lesions. "*Unfortunately, lesions may return in some patients after surgery. There are different routes and surgery can be life-saving or may not work at all, or even make the situation worse. There appears to be a recurrence of lesions and pain in some cases,"* adds the researcher

There are four main theories to explain the pathogenesis of endometriosis. The reflux theory, known as retrograde menstruation, is the most commonly described. This hypothesis is based on the idea that during menstrual cycles, menstrual flow occurs through the fallopian tubes, which connect the ovaries to the uterus. The endometrial tissue then implants in the pelvic cavity. However, this theory does not explain all cases of endometriosis, and other hypotheses exist. The in-situ theory, for example, by attributing an embryonic origin to the disease, explains why endometriosis affects some women with Rokitansky syndrome (absence of uterus and fallopian tubes), some women before their first period, and some men. On the other hand, this theory implies a uniform distribution of lesions in the peritoneum; however, observations show that lesions are more often concentrated on the left side. The lymphovascular theory suggests that endometrial cells use lymphatic and vascular channels, like metastases, to travel to ectopic sites. "*While this theory perfectly explains cases of extra-pelvic endometriosis, it does not explain the other cases of the disease,"* comments Marina Kvaskoff. Lastly, stem cell theory explains the cases of endometriosis observed in infants and in particular the presence of vaginal bleeding in newborns. "*Practically speaking, no single theory explains every case of endometriosis observed to date. It is even possible that several occur in the same individual!*" adds the researcher.

Listening to patients is the cornerstone of diagnosis

"*In terms of diagnosing the disease, there are no validated biomarkers for endometriosis. The reference means of detection remains imaging: endovaginal ultrasound and MRI of the lower part of the pelvis,"* continues the epidemiologist. "*The problem is that not enough radiologists are sufficiently trained to detect the lesions, which may be almost invisible to the non-expert eye. We need better diagnostic tools, but we also need to listen to patients better.*"

Questionnaires have a major role to play in the management and diagnosis of endometriosis. Arnaud Fauconnier is Director of the Clinical Risks and Safety in Women's and Perinatal Health Laboratory (RISCQ – Univ. Paris-Saclay, UVSQ). His work focuses in particular on tools for measuring diagnosis and quality of life for patients. Arnaud Fauconnier, an obstetrician-gynaecologist by training, is also behind Endocap, a research programme on endometriosis, the measurement of patients' quality of life and the disability that the disease represents for them. "*An endometriosis diagnosis is extremely difficult, because it is a disease that can be invisible during routine gynaecological examinations,"* explains the gynaecologist. The programme is based on a database of nearly 1,000 patients with endometriosis. A questionnaire, called ENDOL-4D, which is filled out independently by candidates, is used to measure their symptoms and the alteration in their quality of life.

The Community of Patients for Research (ComPaRe) is a cohort of patients with different chronic diseases who agree to participate in research into these diseases using questionnaires. The endometriosis sub-cohort was launched in 2019. Study coordinator Marina Kvaskoff praises the importance of this participatory model in research: "*Patients are involved in the research by contributing to ComPaRe-Endometriosis and answering questionnaires about their disease, their daily life and their suffering.*" More than 10,000 patients have participated in the study to date, and initial results regarding patients' perspectives on improving their management have recently been published.

A terrifying and unacceptable diagnostic error

In addition to the questions about the pathogenesis and detection tools for endometriosis, the erroneous diagnosis of this disease is also a major problem. According to the Organisation for Economic Cooperation and Development (OECD), the average time between the onset of symptoms and diagnosis is between seven and ten years. "*Most women with the disease have been to the doctor around five times before getting the correct diagnosis. This diagnostic error is terrifying and unacceptable,"* laments Arnaud Fauconnier.

"*How can we explain this huge delay?*" asks Marina Kvaskoff. "*We are facing several problems. On the one hand, the trivialisation of symptoms. Women who experience pain during menstruation are usually not immediately concerned, and unfortunately neither are those around them or medical personnel. In ComPaRe-Endometriose, there are many testimonies from patients who report that a lot of doctors simply miss the symptoms, due to a lack of training, or simply say 'It's all in your mind'. There is a lack of training that could enable health professionals to recognise the disease*."

This period of error adds suffering to patients and also results in a methodological headache for the scientific community. "*All the studies conducted so far focus on endometriosis diagnosis. Lastly, it is complex to work on the risk of endometriosis or on the beginnings of the disease because very often the cases of endometriosis that we observe have been diagnosed and the patients have carried the disease for several years,"* notes Marina Kvaskoff.

In short, this is a disease that has been described for four millennia and for which neither the causes, the forms nor the means of diagnosis are known with certainty. For Marina Kvaskoff, it is anything but a coincidence that endometriosis research lacks resources, when the disease only affects women. "*Current data show that research into specifically male conditions is much better funded than research focusing on female conditions. Endometriosis is a glaring example of gender bias in research.*"

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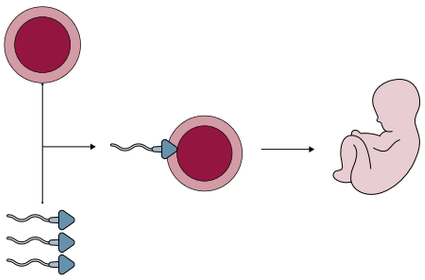
Titre

Explorations into the depths of the reproductive system



Despite their differences, living organisms share a number of common functions. One of these is reproduction, a process that results in the creation of a new individual. Abstruse and sometimes mysterious, it fascinates many scientists at the Université Paris-Saclay.

Reproduction can be sexual or asexual: in the first case, it requires two individuals of different sexes and results in the birth of an individual with new genetic material; in the second, an individual produces a "copy" of itself. In humans, as in every other mammals, reproduction is sexual: it requires two reproductive cells, one male gamete (spermatozoon) and one female gamete (egg), which carry the genetic information of the parent individuals. When the two gametes meet, fertilisation occurs: the egg and sperm fuse into a cell called an egg, which then divides. The embryo thus formed then becomes a foetus which develops until the new individual is born.

However, reproduction can sometimes break down, especially in humans. In the Human Reproduction and Animal Models (RHuMA) team of the Biology of Reproduction, Environment, Epigenetics and Development laboratory (BREED – Univ. Paris-Saclay, UVSQ, INRAE, ENVA), François Vialard is studying the cellular and molecular mechanisms at the origin of dysfunctions of the reproductive system. "*Our work consists of identifying genetic anomalies and then proposing therapies to circumvent them. We are working hard on the genetics of male infertility and, in this case, on meiotic arrest,*" the researcher explains.

Meiosis is a process of cell division involved in the formation of gametes. Meiotic arrest can lead to azoospermia, being the absence of sperm in the ejaculate, and thus to infertility. "*At the moment, we have only just demonstrated the existence of genetic alterations, which cause the anomalies. The problem must now be circumvented. The origins of these anomalies affect only one gene. If we are able to repair the anomaly in the gene, then it disappears,*" the researcher adds.

The team led by François Vialard is also interested in cases of recurrent miscarriage, with the idea that "*the female gamete would be the origin of chromosomal or aneuploid anomalies in the embryo*". The scientists in the RHuMA team are working on many other projects concerning the reproductive system. In particular, the team has developed a placental perfusion model to observe the transplacental passage of therapeutic molecules, particularly against cancer. The first uterus transplant in France was made possible in Suresnes following these studies.

Linking reproduction to mathematics

Based at the Inria Saclay centre, the Inria-INRAE-CNRS Multiscale population dynamics for physiological systems (MUSCA) project-team approaches the question of reproduction from a captivating angle: that of mathematical modelling. "*The ovarian function is an eminently dynamic system, which today is mainly observed in a sampled, ad hoc way and generally from different individuals. We need a dynamic reconstruction,*" explains Frédérique Clément, who cofounded MUSCA. "*Reproduction is also finely controlled by interactive participants, including hormonal ones: everything becomes extremely counter-intuitive. Modelling makes it possible to reconstruct coherence.*" The ovarian follicle, the multi-cellular structure in which the oocytes (future eggs) are brought to maturity, is at the heart of the studies carried out by the scientists in the MUSCA team. "*Our work either consists of finely characterising the evolution of a follicle during its development, in terms of structural development and cell dynamics, or to follow the evolution of the follicle population, representing each one by a marker summarising its maturity (its diameter, for example). Our aim is to merge these two approaches,*" adds Frédérique Clément.

Led within MUSCA by Romain Yvinec, the OVOPAUSE collaborative project is attempting to answer the major questions raised by follicular dynamics by adopting a comparative physiological approach between different species. "*It is by comparing different systems that we can extract the mechanisms that are specific and essential to the dynamics observed. The primary objective of OVOPAUSE is to explain the evolution of the female gamete population over the entire life span of an individual,*" adds the researcher. The project focuses on the reproductive systems of mice and medakas, small fishes from Southeast Asia. "*Several studies have already been carried out on the evolution of gamete populations over the ovarian cycle, but much less over the entire life span. We know that these dynamics begin at birth, even in the embryo. Events occurring very early in an individual's life can have consequences for their reproductive status,*" continues Romain Yvinec.

Like humans, the mouse is a mammal with so-called non-renewable, or quasi-renewable, folliculogenesis (processus of follicle creation): the stock of follicles built up at the perinatal stage decreases continuously during the individual's life. For female medakas, on the other hand, have asynchronous ovogenesis: the folliculogenesis is renewed by a sustainable production of new gametes. "*Our aim is to compare these two strategies in mathematical models, in order to explore how organisms manage a stock of gametes or its renewal over an individual's lifetime,*" concludes the researcher.

Ultimately, research in the field of reproductive biology will provide a better understanding of this complex process and the development of strategies for the diagnosis and management of reproductive disorders.

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AUTISM
ENDOMETRIOSIS
REPRODUCTIVE SYSTEM
ENDOMETRIOSIS

Journal
FRANCE 24

Title

COP27: WHAT CHALLENGES FOR THE CLIMATE CONFERENCE AS IT OPENS IN EGYPT?

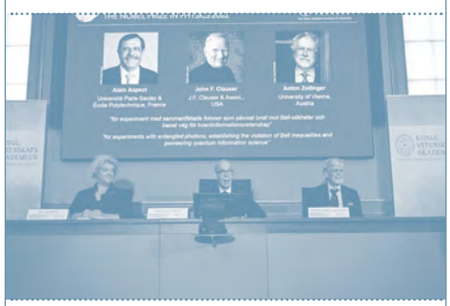
Political leaders from around the world are heading to COP27 which starts on Monday. They are under pressure to step up their climate commitments in the face of runaway global warming and provide financial support to poor countries, which are suffering the most. Paul Leadley, Professor of Ecology at Université Paris-Saclay, explains.

https://www.youtube.com/watch?v=FuB400Wb-DoA&ab_channel=FRANCE24

Journal
The New York Times

Title

NOBEL PRIZE IN PHYSICS IS AWARDED TO 3 SCIENTISTS FOR WORK EXPLORING QUANTUM WEIRDNESS



Alain Aspect, John F. Clauser and Anton Zeilinger were recognized for their experiments in an area that has broad implications for secure information transfer and quantum computing.

https://www.nytimes.com/2022/10/04/science/nobel-prize-physics-winner.html

Journal
The Washington Post

Title

WAIT, WHY ARE THERE SO FEW DEAD BUGS ON MY WINDSHIELD THESE DAYS?

After a long drive, the only thing that makes our stomachs churn faster than a windshield smeared with bug guts is a windshield bearing no evidence of insect life whatsoever. It feels like a fundamental pillar of the planet's ecology has snapped.

https://www.washingtonpost.com/business/2022/10/21/dead-bugs-on-windshields/

Journal
Frankfurter Allgemeine

Title

ATOMENERGIE? KLINGT NACH ZUKUNFT

Frankreich investiert in die Kernenergie, Deutschland will ganz aus ihr aussteigen. So unterschiedlich die Ausgangslage auch ist, stimmt doch eines für beide Länder: Es fehlt der akademische Nachwuchs.

https://www.faz.net/aktuell/karriere-hochschule/kerntechnik-es-fehlen-akademiker-im-bereich-atomkraft-18269675.html

Journal
INDEPENDENT

Title

EXPANDING VOTING RIGHTS CAN REDUCE VIOLENCE, STUDY CLAIMS

"In the current context of increasing discontent with democracy, understanding the voting-violence nexus is of extreme relevance," said the study's author.

https://www.independent.co.uk/independent-premium/expanding-voting-rights-reduce-violence-study-b2197889.html

Journal
it

Title

ORION'S SWORD STAR NURSERY CAPTURED IN NEVER-BEFORE-SEEN DETAIL

An extremely detailed image of a stellar nursery captured by UV light from massive young stars reveals the role of intense radiation in heating and shaping the fuel for forming stars, as per a report by Space.com.

https://www.indiatimes.com/technology/science-and-future/orions-sword-star-nursery-captured-in-never-before-seen-detail-579662.html

Keywords
Shooting locations

Title

Campuses get to the screen

What do the series *Le remplaçant* with Joey Starr, *I3P* with Marc Lavoine, and *Joséphine, ange gardien (Josephine, Guardian Angel)* with Mimi Mathy have in common? Or the films *Proxima* with Eva Green, *Le Lion* with Dany Boon, and *L'Événement (Happening)*, which won the Golden Lion at the Venice Film Festival 2021? They were all partly filmed in the corridors, classrooms and halls or outside spaces of Université Paris-Saclay. The students and staff of the University have surely noticed that for some time now, their classrooms have been welcoming a new group of people, attracted by the diverse range of scenery offered by the University's campuses.

As a pioneer in this area, CEA Paris-Saclay welcomed its first film crew in 2015, under the impetus of François Bugeon, Communication Manager in the Communication Unit of CEA Paris-Saclay. This was a real challenge, as it meant to enable this type of activity to take place in this secure area. At CentraleSupélec, it all began at the end of 2017, under the impetus of the then General Directorate of Services. The activity is coordinated by Cécile Arpin, Head of General Management/Events at the Department of Property and Work Environment (DPIET). At the Orsay Faculty of Sciences, this activity really began when the first lockdown ended, in spring 2020. As all the event activity of the scientific communication, mediation and heritage department was suspended due to the COVID-19 pandemic, Anne-Karine Nicolas, the Department's Assistant Manager, answered several filming requests. ENS Paris-Saclay received its first applications at the beginning of 2021. "*The school wanted to support the film industry, which was not doing very well after lockdown,*" says Maëva Baron, Communication Manager at ENS Paris-Saclay. Word of mouth worked very well for all of them and other requests flowed in very quickly.

Finding the right place

The process is always the same: a location scout commissioned by a production company contacts the institution, indicating the sets required and submitting a synopsis. If the request is suited to the institution and on the basis of a few photos, the scout visits the site to get a real sense of the place and take more photos. If the production company likes them, the entire team (production manager, director, set designer, cinematographer, stage manager, one or two actors, etc.) comes to visit the location.

The most sought after sites are those that can be transformed into a police station, hospital, school, airport terminal or unusual settings. With its 1970s and modern buildings and its exceptional facilities, such as its laboratory clean rooms, the Orsay campus ticks all the boxes. Similarly, the corridors and walkways, halls, lecture theatres, and car parks of the CentraleSupélec and ENS Paris-Saclay buildings are very popular. At CEA Paris-Saclay, the facilities are so diverse that production teams often create all the sets for their project there.

Each rental is subject to a signed agreement. Prices range from €1,500 to €9,000 excl. VAT per day depending on the type of location, the number of people expected and the host institution. "*For one day of filming, we have to count four days that the teams are present on site, because they need to install the decors and the people, and return the site to its original state afterwards,*" explains Anne-Karine Nicolas. "*We also invoice for these days.*" At the Orsay Faculty of Sciences, the money raised is used to renovate the buildings. At CentraleSupélec, the DPIET uses it to purchase new equipment to make its services more comfortable. This is also the case at CEA Paris-Saclay, which also devotes part of the funds to enhancing its heritage, such as the luminous façade of the former EL3 nuclear reactor.

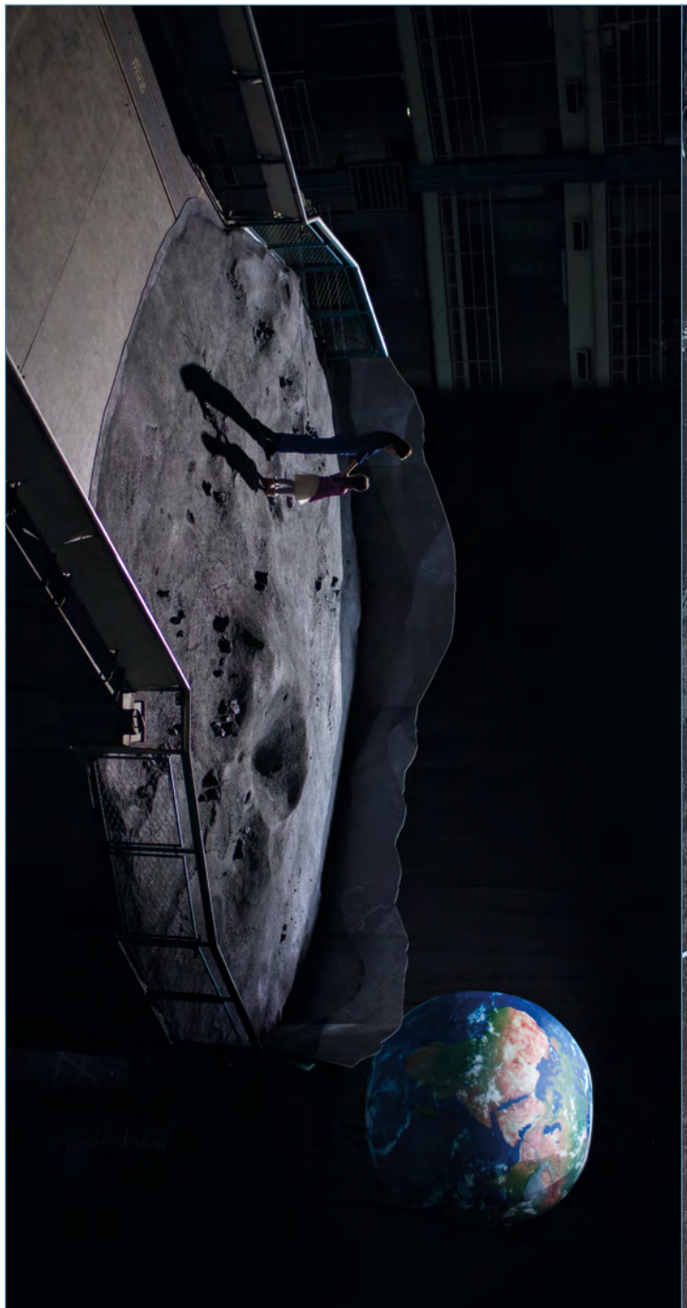
Comfortable shooting conditions

Advertising, documentary, video clip, series, TV film, film... The projects accepted are diverse and their quantity varies according to the capacities of each. In 2021, ENS Paris-Saclay hosted four film shoots. Three in 2022. Ten teams have set up their cameras at CEA Paris-Saclay since 2015. Between November 2018 and July 2022, the Orsay campus hosted around 20 shoots. At CentraleSupélec, the 2021 shooting activity represented around 50 calendar days, and more for 2022.

Today, the appeal of the University's campuses continues to grow. "*We turn down shooting requests every day,*" Cécile Arpin almost apologises. Requests are beginning to arrive to other constituent faculties and institutes, such as the Technical Institute (IUT) of Orsay and Cachan, the Jean Monnet Faculty and the Faculty of Sports Sciences. How can such enthusiasm be explained? "*We have incredible capacity,*" says Cécile Arpin. "*We can accommodate the shoot itself, and also allocate space for the canteen, the actors' dressing rooms, HMC (dressing, makeup, hair), equipment storage, the production office, the break rooms, etc., and park the trucks.*"

The people and services directly affected are informed each time, "*even if we are obliged to maintain a certain confidentiality,*" Maëva Baron concedes. There is no large-scale communication, in short. However, the cohabitation takes place without any problems and the shootings arouse amusement and curiosity. "*The students are very respectful, even if we are hosting top stars,*" notes Cécile Arpin. "*The film crews are very well organised. They know how to be discreet,*" notes Anne-Karine Nicolas. "*They are always willing to show their world,*" adds Maëva Baron. Staff and students often take part in the project as extras.

The few reservations initially linked to the potential inconvenience are now outdated. "*The activity is part of the school. It is a positive driver of communication that brings real visibility,*" says Cécile Arpin. "*Filming brings CEA Paris-Saclay to life through its heritage. It serves as a tool for internal communication and changes the way people see their workplace,*" says François Bugeon. "*These are like moments of pausing for breath.*" Recently, the filming of the series Rictus with Fred Testot was a pretext for festivities on the 70th anniversary of CEA Paris-Saclay. "*At the end of the day, these are not just university campuses, they are also places where there is life,*" concludes François Bugeon.



Film *Proxima* – Eva Green and Zélie Boulant on the lunar soil simulation built in EL3 (CEA Paris-Saclay) © Dharamsala – Darius Films

Film *L'Événement* – Exterior of the building 452 on the Orsay campus (University sets from 1970) © Orsay Faculty of Sciences

Film *Juste Ciel !* – Building 301 on the Orsay campus (corridor of a provincial hospital) © Orsay Faculty of Sciences

WE WERE THERE

OCTOBER 2022

Date	Location	Host
7 to 17	all campuses	Université Paris-Saclay

Title

SCIENCE FESTIVAL

Description

As every year, the Science Festival was held at the beginning of October on all campuses of Université Paris-Saclay! Children and adults alike were able to enjoy fun workshops, tours and discussions with the hundreds of scientists present.

https://www.universite-paris-saclay.fr/actualites/la-fete-de-la-science-2022-luniversite-paris-saclay

DON'T MISS

JANUARY 2023

Date	Location	Host
14/11/22 to 3/02/23	EDF Lab Paris-Saclay Atrium	EDF

Title

FAKE NEWS: ART, FICTION, LIES

Description

How does false information emerge? This is the question that a new exhibition in France, supported by EDF and bringing together French and international works, will try to answer. Presented in a "focus" format, the exhibition can be accessed from Monday to Friday.

https://www.universite-paris-saclay.fr/evenements/ceci-nest-pas-une-fake-news-venez-decouvrir-lexposition

FEBRUARY 2023

Date	Location	Host
6	Research building auditorium – 63 rue Gabriel Péri, Le Kremlin-Bicêtre	Faculty of Medicine Paris-Saclay

Title

"HEMOSTASIS AND THROMBOSIS" CONFERENCE

Description

Organised by the Scientific Council of the Faculty of Medicine of Université Paris-Saclay, this symposium aims to bring together specialists in thrombotic diseases, which are the leading cause of death in the world.

https://www.medecine.universite-paris-saclay.fr/actualites/colloque-hemostase-et-thrombose-06/02/23

Date	Location	Host
6 to 10	all campuses	DuoDay

Title

DUODAY PARIS-SACLAY

Description

In order to promote the inclusion of people with disabilities, the DuoDay week is repeated on Université Paris-Saclay campuses. The aim is for university staff to pair up with students with disabilities and share their daily lives for a day.

https://www.universite-paris-saclay.fr/evenements/duoday-paris-saclay

Date	Location	Host
8 to 10	ENS Paris-Saclay	The *Scène de recherche* of ENS Paris-Saclay

Title

THEATRE: "MAUVAISES FILLES" ("BAD GIRLS")

Description

This play, composed of portraits of emancipating women of yesterday and today, was co-created by L'Indicible compagnie, in residence at the *Scène de recherche* of ENS Paris-Saclay and students from ENS Paris-Saclay and CentraleSupélec.

https://ens-paris-saclay.fr/agenda/theatre-mauvaises-filles

Date	Location	Host
11 to 15	the various campuses of Université Paris-Saclay	Université Paris-Saclay

Title

POST-BAC 2023 OPEN DAYS

Description

A real highlight of the academic year, the Open Days offer secondary school and university students, and their families, the opportunity to find out about the courses offered at Université Paris-Saclay and to discover the different campuses: Sceaux, Orsay, Saclay, Cachan.

https://www.universite-paris-saclay.fr/journees-portes-ouvertes-post-bac-2023

Date	Location	Host
24	ENS Paris-Saclay	The *Scène de recherche* of ENS Paris-Saclay

Title

"DARK STARS" SHOW

Description

A true multi-scale project combining animation, photography and cinema, the Dark Stars show looks at the science of the light spectrum and the interaction between time, light and matter.

https://ens-paris-saclay.fr/agenda/spectacle-dark-stars

université PARIS-SACLAY

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READING HIGHLIGHTS

Launch of *Trajectoire(s)*, the scientific journal from Alumni-ONERA

On the sixth anniversary of its creation, the Alumni-ONERA association, which brings together ONERA's doctoral students, has created a journal: *Trajectoire(s)*. The first issue covers the association's activities in 2021. A look back at the conferences, round tables and exhibitions that have marked the life of this learned society.

https://www.onera.fr/fr/actualites/lancement-du-journal-alumni-onera

The *Terrains & Travaux* journal celebrates its twenty-second anniversary

Founded in 2000, the biannual social science journal published by ENS Paris-Saclay is back with its 40th issue entitled "Dire la sexualité" (Talk about sexuality). This theme reflects the subject of the second issue of *Terrains et Travaux*, published in 2001, which was entitled "Sexualités déviantes / sexualités militantes" (Deviant sexualities/militant sexualities).

https://www.cairn.info/revue-terrains-et-travaux-2022-1.html

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THE INTERDISCIPLINARY INITIATIVES OF UNIVERSITÉ PARIS-SACLAY (3/3)

2IM

The Institute for Integrative Materials Science (2IM) aims to unify and structure forces around materials science (composition, manufacturing, synthesis, characterisation of innovative, bio-inspired materials, etc.) with an emphasis on sustainable development, energy and resource conservation, recycling, toxicity and digital sciences. 2IM seeks to implement innovative and sustainable tools and processes throughout the "study – development – implementation – use – reuse or recycling" chain; to develop pioneering studies throughout this chain; to integrate modelling and the use of digital tools in the upstream design, processes and multi-scale characterisation of materials in order to give them the desired functions; to enhance research by developing training and careers in materials science; to nurture the industrial fabric as part of the development of industry 4.0.

GS involved: Biosphera; Chemistry; Computer Sciences; Engineering and Systems Sciences; Geosciences, Climate, Environment, Planets; Health and Drug Sciences; Humanities and Heritage Sciences; Institute for the Sciences of Light; Physics.

CS³

The Centre for Space Sciences at Université Paris-Saclay (CS³) aims to organise research in space sciences, whether for a better understanding of the Earth's ecosystem, the solar system or the formation of galaxies and cosmology. It focuses more specifically on the prospects offered by nano-satellites and on new methods for analysing massive and complex data, possibly associated with simulations.

GS involved: Engineering and Systems Sciences; Geosciences, Climate, Environment, Planets; Computer Sciences; Physics.

The aim of the Interdisciplinary Initiatives is to support the research, training, and innovation actions between different Graduate Schools (GS), thus promoting collaboration on cross-functional subjects.

MUSA

The Multidisciplinary Space on Social and Digital Normativity (MUSA) aims to shed light on the relationship between social and digital intelligence. While making scientific and institutional action central to its concerns, its purpose is to broaden the questioning, scientific production and public policy design paths with regards to issues of inequalities and the quality of governance in the face of the new perspectives opened up by digital technology. It aims to enhance dialogue with the bodies that develop quality standards, norms and regulations which guide the exercise of power and the validation of decisions made by social and digital intelligences, in areas such as global health, the governance of sustainable and resilient cities, access to justice and the settlement of disputes and the management of complex work organisation processes.

GS involved: Computer Sciences; Economics and Management; Humanities and Heritage Sciences; Law; Mathematics; Sociology and Political Science.

PALABRE

Heritage in a reflective laboratory (PALABRE) aims to intensify research and training partnerships between the various disciplines associated with heritage sciences, by incorporating scientific and societal issues related to the heritage economy and environmental challenges. The project is structured around three scientific priorities: Materials, gestures, systems; Dematerialization of objects, practices and operating modes; Vocabularies.

GS involved: Chemistry; Economics and Management; Education; Geosciences, Climate, Environment, Planets; Humanities and Heritage Sciences; Law; Physics; Sociology and Political Science.

SCULT

Science(s) and Culture(s): Knowledge societies and scientific mediation (SCULT) aims to unify its different communities around three major issues: culture as a vector and mediator of knowledge within democratic societies; the media as filters, relays or prescribers of scientific knowledge; the study of the relationship between knowledge and power. SCULT places great emphasis on questions of reflexivity and the epistemology of knowledge. It allows for a better evaluation of the ways in which human and social science research informs the mediation processes of all scientific knowledge.

GS involved: Education; Geosciences, Climate, Environment, Planets; Humanities and Heritage Sciences; Sociology and Political Science.