2021
A YEAR AT THE CNRS

CONTENTS

Antoine Petit,
CNRS Chairman and CEO

> ONE OF THE MAIN ASSETS OF THE CNRS IS ITS ABILITY TO INVOLVE, DRIVE AND ASSOCIATE TEAMS AND LABORATORIES FROM DIFFERENT DISCIPLINES TO WORK ON JOINT SCIENTIFIC PROJECTS.

In the aftermath of the recent health crisis, what are the CNRS's ambitions to support economic recovery and contribute to French competitiveness?

The health crisis showed just how much science was needed to understand the virus and its impact and to prevent its ongoing effects. It also raised questions about French or European sovereignty. In this context the CNRS's role is to facilitate the development of fundamental research into disruptive innovations and promote the growth of companies by developing their performance and markets, as well as by creating jobs. To achieve these aims, the CNRS has two priorities – launching start-ups working on breakthrough technologies with high growth potential, and setting up joint laboratories in collaboration with industry. In this regard, November 2021 saw us celebrate the creation of our 200th active joint laboratory. We carry out basic research in these laboratories but the subjects are jointly defined with our industrial partners whom we constantly interact with. One of the main assets of the CNRS is its ability to involve, drive and associate teams and laboratories from different disciplines to work on joint scientific projects. The organisation particularly puts this strength to the benefit of Priority Research Programmes and Equipment (PEPR), which may be exploratory in nature or part of strategies aimed at driving and boosting industrial sectors. The CNRS is currently responsible or co-responsible for two thirds of the twenty plus PEPRs launched in 2021, around subjects ranging from quantum physics to recyclability, while also including the relationship between education and digital technology.

The CNRS was involved in the year's major international scientific events and programmes, particularly in the field of space. What are the assets that make it such a key partner for international research?

Science works and advances on a long-term basis. Over time, CNRS teams from our joint laboratories with universities have acquired exceptional worldwide recognition in the field of space and indeed in many other areas. The international impact of these projects is also the result of our longstanding and fruitful scientific collaboration with the French Space Agency (CNES). The Perseverance rover from the Mars mission in 2020 is a fine example of our scientists' success and expertise. More than 10 years ago, NASA selected the French consortium from over 80 applications. These successes have endowed our teams with know-how that makes them an essential component of most international projects involving American, Chinese or Russian partners. The CNRS also contributes to the development of European research, in particular by working closely with its counterparts from the G6 and in association with five other European research organisations (CNR, CSIC, the Helmholtz Association, the Leibniz Association, and the Max Planck Society).

The latest Horizon Europe framework programme was launched in 2021 and offers many opportunities for our scientists. As an organisation, the CNRS is the leading beneficiary of these framework programmes and more than half of the Horizon 2020 award winners from host institutions in France come from the CNRS. Nonetheless, we are convinced that there is still room for improvement, especially in the humanities and social sciences. This is why we drafted a roadmap for Europe, which was published in May 2021.

The CNRS Medal for Scientific Mediation was created in 2021. How important is scientific opinion in France and throughout the world and what responsibility does that entail?

On occasions the health crisis led to scientific opinion being questioned while the distinction between beliefs and knowledge became blurred. The scientific process is subject to rules and requires a rigorous approach. It is essential for the CNRS to become involved by increasing knowledge of science, scientists and the scientific approach, and we do so through our many digital and paper media, like Carnets de science (“Science notebooks”) for example. The creation of the Medal for Scientific Mediation was made possible by the Research Programming Law (LPR) and adds to the range of CNRS awards for its talents – the Gold, Innovation, Silver, Bronze, Crystal and Collective Crystal Medals. The new Medal was awarded for the first time in 2021 and the five recipients illustrate the richness and diversity of scientific mediation. The 3MT (Ma thèse en 180 secondes) competition run in partnership with the Conference of University Presidents (CPU) is another example of the scientific mediation initiatives that the CNRS is rolling out. This year we organised the international final of this fine event which highlights the work of PhD students, and welcomed 24 finalists in 2021. Also on the international scene, the CNRS is proud to have been selected to take charge of the Science Planet in the French pavilion at the Dubai World Expo, where we presented our research in Antarctica, bearing witness to the dramatic consequences of global warming.

In 2021 we celebrated 50 years of particle physics research and discoveries and 40 years of AIDS research. The CNRS has always been present on all fronts of knowledge. What are its main strengths today?

Like all research organisations, the CNRS above all draws strength from the quality of its personnel. I consider that our attractiveness is illustrated by the fact that around a third of the permanent researchers we recruit come from other countries. However, the CNRS is also driven by its exceptional capacity for interdisciplinarity based on disciplines at the highest international level, as well as by its remarkable network of French and international partners.

February
Research and innovation - the CNRS grasps the opportunities provided by the fourth Investments for the Future Programme (PIA4).

March
The presidents of the G6 made up of the main European research organisations (CNR, the CNRS, CSIS, Helmholtz Association, Leibniz Association and Max Planck Society) make a commitment to the freedom of research.

May
The CNRS sets out its European ambitions by presenting its "Europe" roadmap aimed at improving CNRS participation in EU research and innovation programmes.

November
- **The CNRS gives pride of place to open science on the occasion of HAL open archive's 20th anniversary and reiterates its commitment to the second National Plan for Open Science presented in July 2021 by Frédérique Vidal, the Minister of Higher Education, Research and Innovation.**
- **The CNRS celebrates the creation of its 200th active joint laboratory.**

December
The CNRS celebrates its 20-year commitment to professional equality.

2021
IN FIGURES

RESEARCH

Over
1 100 *units*

Over
55,000 *publications in 2021*

Nearly
65% *of publications co-signed with a foreign laboratory*

Nearly
80% *of publications in open access*

RESOURCES

Nearly
€3.8 *as the overall budget*

Including nearly
€1 *billion of CNRS generated income*

Over
33,000 *staff members*

Including over
28,900 *scientists (over 16,500 researchers, nearly 12,400 engineers and technicians)*

and nearly
4100 *administrative support engineers*

Over
200 *professions*

Over
1/3 *of researchers recruited from other countries*

INTERNATIONAL

Present in nearly **40** *countries*

Nearly
80 *international laboratories including 5 created in 2021*

Nearly
300 *international research projects and networks including 62 created in 2021*

Over
650 *winners of European Research Council (ERC) grants with 62 winners in 2021*

PARTNERSHIPS & INNOVATION

Over
130 *institutional partnerships (universities, schools)*

Nearly
210 *CNRS/company joint research structures including 35 set up in 2021*

Nearly
100 *start-ups created each year*

21 *framework agreements with major companies including 4 new agreements in 2021*

Nearly
8.500 *patent families in the CNRS portfolio including over 400 filed in 2021*

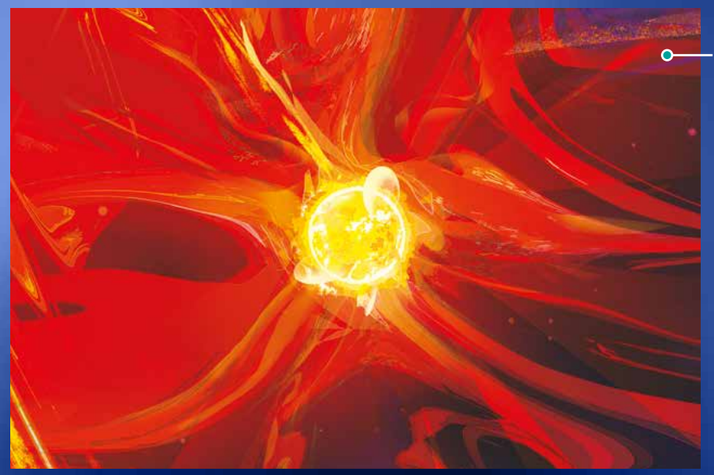
SCIENTIFIC HIGHLIGHTS

JANUARY
MATHEMATICS
In geometry, a new construction highlights the extraordinary diversity of groups of finite type.

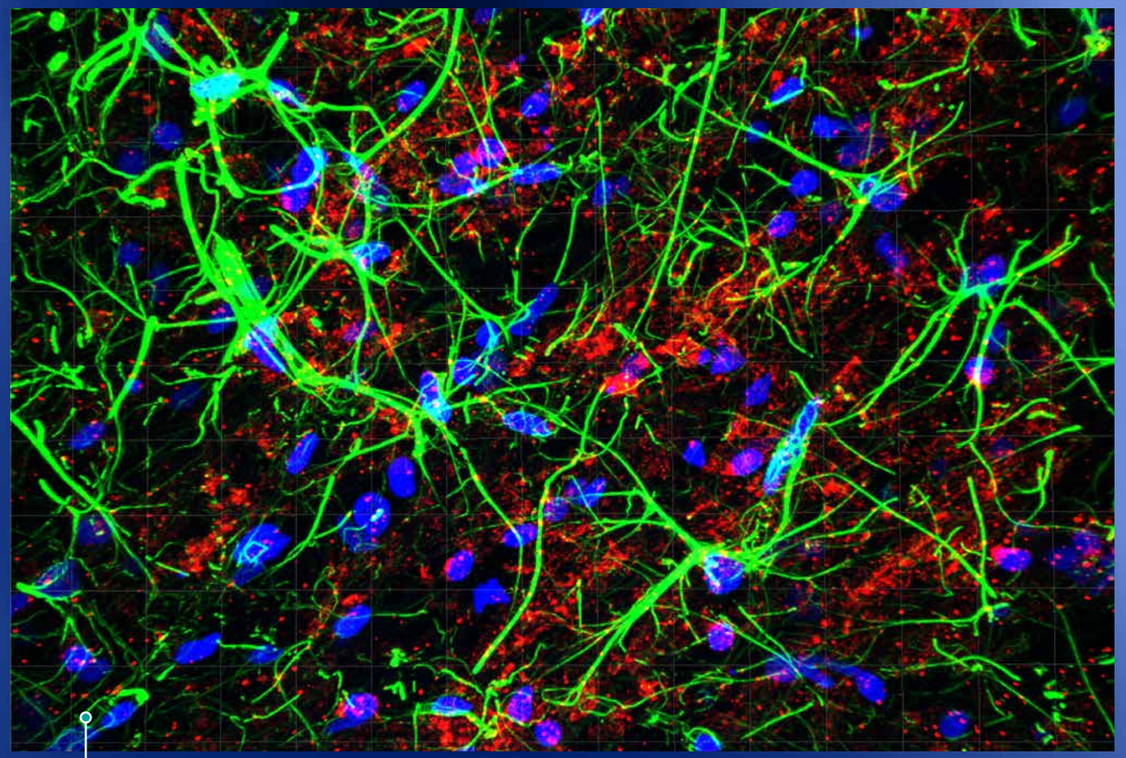
JANUARY
ENVIRONMENT
The Swings oceanographic expedition explores the Southern Ocean to study how it contributes to climate regulation.

JANUARY
CHEMISTRY
A unique method of producing molecular lassos is developed to imitate living organisms.

FEBRUARY
ENVIRONMENT
The world's wetlands are mapped at very high resolution.



FEBRUARY
THE UNIVERSE
The density of a very young exoplanet was measured for the first time.



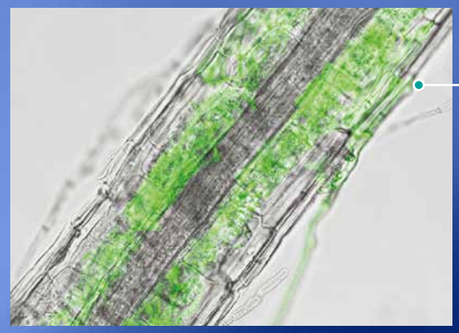
FEBRUARY
NEUROSCIENCE
Researchers demonstrate how oxytocin controls our emotions.

FEBRUARY
QUANTUM PHYSICS
A successful new experimental demonstration of the quantum advantage.

FEBRUARY
QUANTUM PHYSICS
Quantum fluorescent defects are observed in silicon on the individual scale for the first time.

MARCH
THE UNIVERSE
The first images of the cosmic web reveal myriad unsuspected dwarf galaxies.

MARCH
NEUROSCIENCE
Ultrasound is used to reveal the vascularisation of the human brain at a hitherto impossible scale.

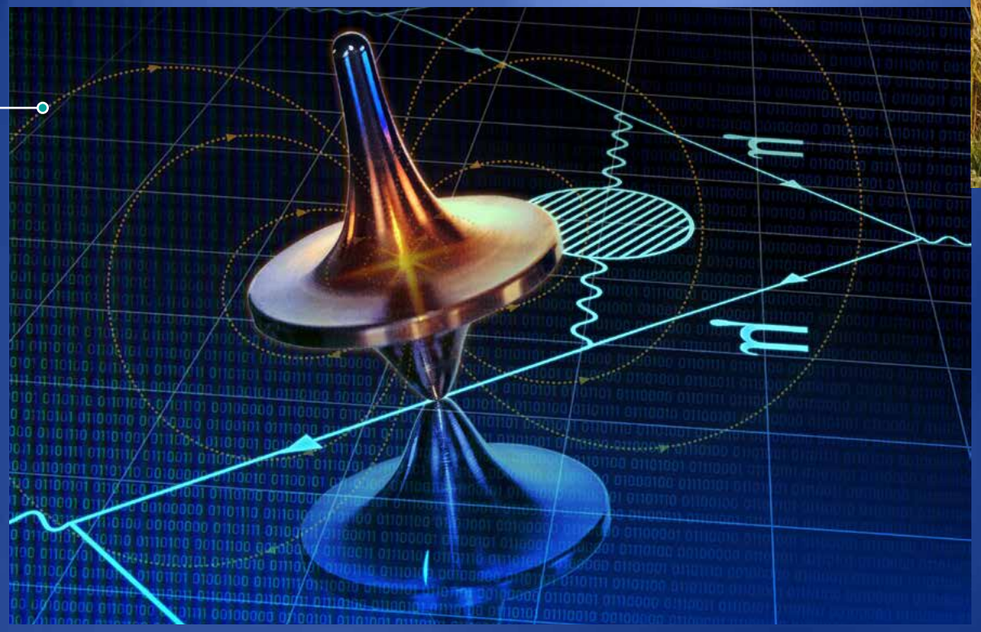


MAY
BIOLOGY
A plant-fungi partnership is found to have been at the origin of land vegetation on Earth.

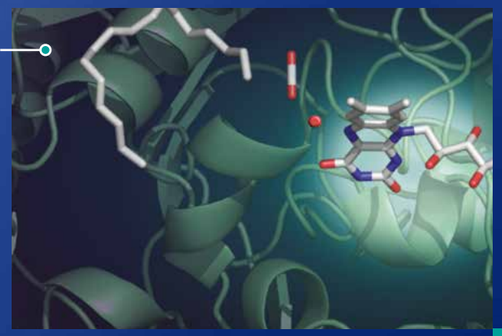
MAY
ENVIRONMENT
The overexploitation of water in agricultural boundaries is identified as the main cause of declining river flows.

MAY
MATHEMATICS
Proof of a principle of large particle deviations enhances microscopic understanding of a gas.

MAY
GEOSCIENCE
Nano-seisms are accurately reproduced in a laboratory.

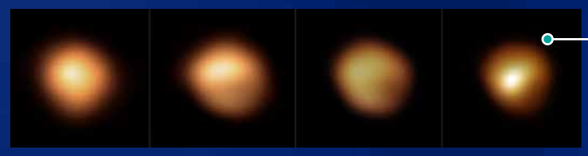


APRIL
PHYSICS
A new theoretical calculation describes the magnetic properties of muons more accurately.



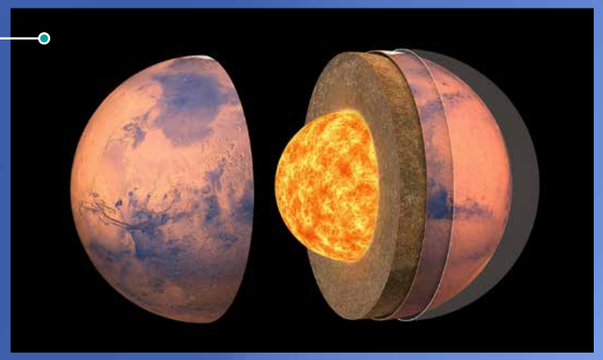
APRIL
BIOLOGY
The functioning of a key photoenzyme is deciphered.

JUNE
BIOLOGY
The stress of orphan chimpanzees is studied to improve our understanding of chronic stress in general.

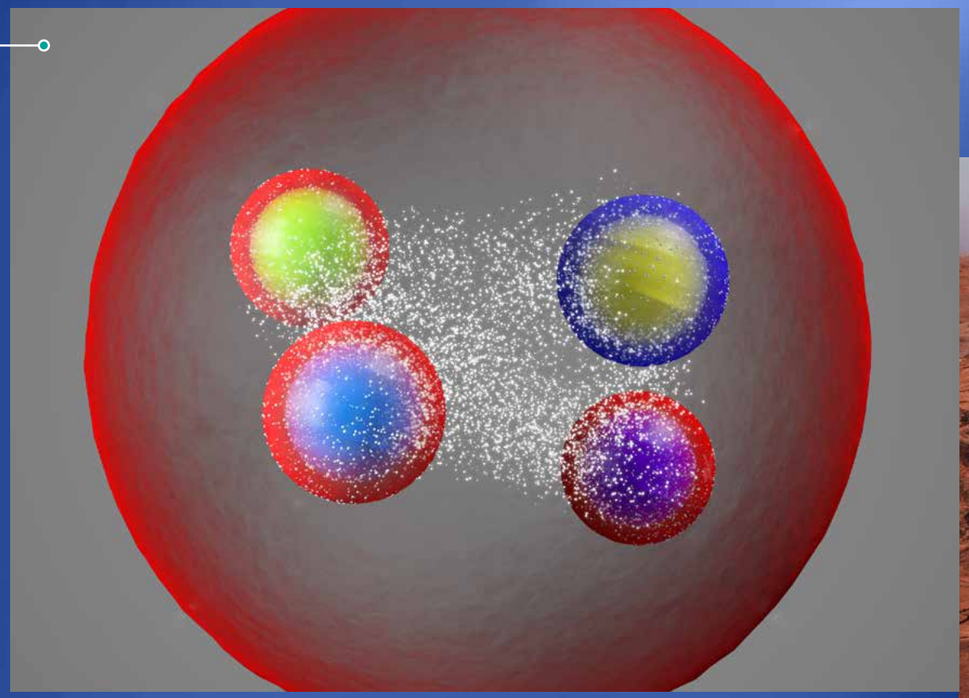


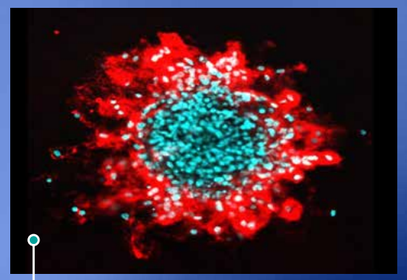
JUNE
THE UNIVERSE
The Betelgeuse star's historic loss of brightness is finally explained.

JULY
THE UNIVERSE
First seismic exploration of the internal structure of the planet Mars.



JULY
PARTICLE PHYSICS
A new exotic particle called Tcc+ that was predicted 40 years ago is finally observed.





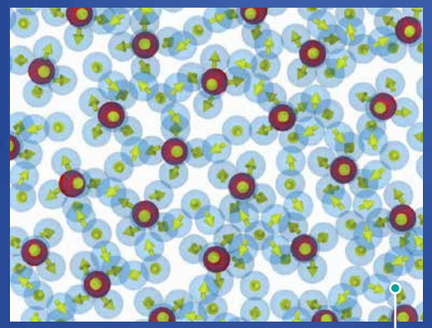
SEPTEMBER
HEALTH
The rupture of the nucleus of tumour cells is shown to promote the dissemination of these cells in breast cancer patients.

SEPTEMBER
MICROBIOLOGY
Characterisation of a new molecular mechanism of contact predation in a predatory bacterium.

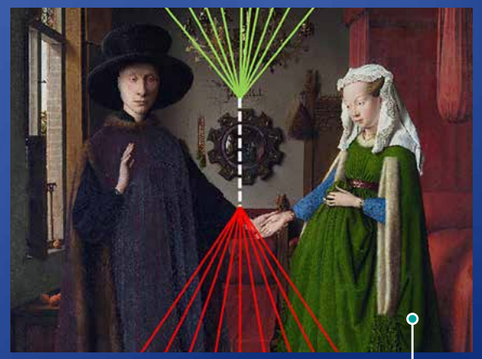
SEPTEMBER
HEALTH
A new family of receptors that activate antiviral immunity is identified.

SEPTEMBER
PHYSICS
For the first time a material's luminescence is measured at the nanosecond scale.

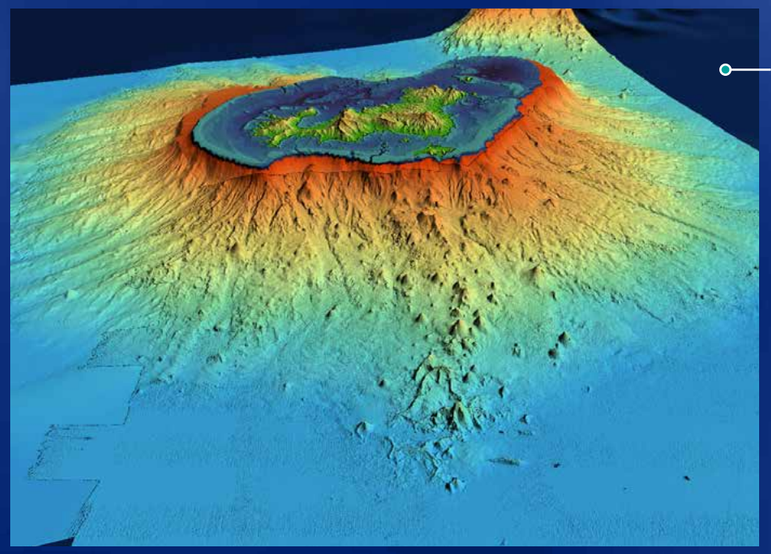
SEPTEMBER
ARCHAEOLOGY
The monumental sculptures at the Camel Site in Northern Arabia are dated to prehistoric times.



AUGUST
MATHEMATICS
The mystery of cement's cohesive power is solved thanks to new theoretical and numerical approaches.



AUGUST
DIGITAL
The Flemish painter Van Eyck's perspective technique is elucidated thanks to digital technology.

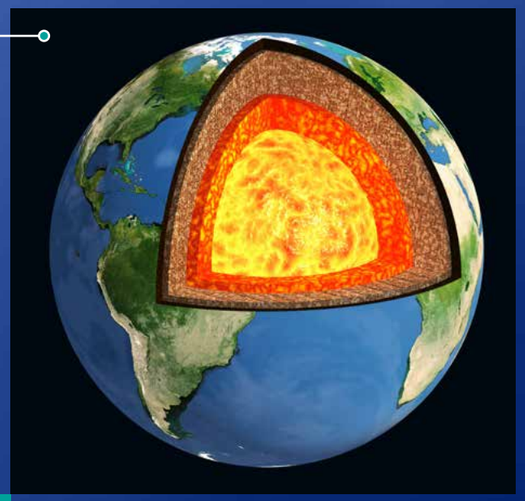


SEPTEMBER
GEOSCIENCE
Study of the birth of the underwater volcano in Mayotte – the largest underwater eruption ever documented.

OCTOBER
HEALTH
Skin fibrosis is treated by the application of an electric field to the skin.

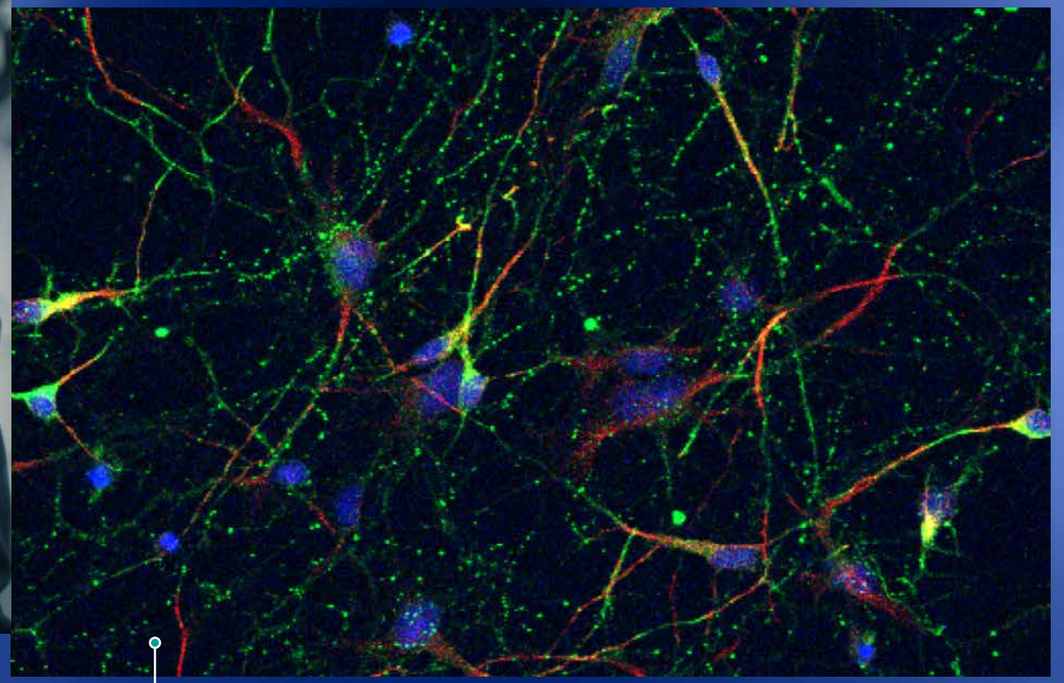
OCTOBER
HEALTH
First human trials of an innovative device to treat strokes.

OCTOBER
GEOSCIENCE
A new technique without seismic waves to map the earth's crust over four kilometres.

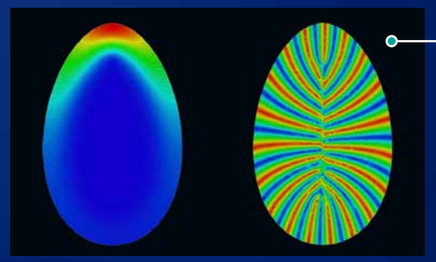


OCTOBER
HEALTH
Combining two vaccines against Covid-19 is shown to enhance protection.

NOVEMBER
COMPUTING
A new detection system which uses electromagnetic waves to scan for malware.



NOVEMBER
NEUROSCIENCE
Lactate is identified as being essential for brain activation and for performing behavioural tasks.



DECEMBER
MATHEMATICS
A recent theorem is used to explain mathematically the magnetic tunnelling effect.

DECEMBER
HEALTH
A treatment is found for cases of cardiomyopathy associated with Duchenne muscular dystrophy.

TALENTS & AWARDS

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JEAN DALIBARD

2021 CNRS Gold Medal

The CNRS gold medal for 2021 was awarded to the physicist Jean Dalibard, professor at the Collège de France, in the light of his 30-year career with the CNRS. He is a member of the French Academy of Sciences. This award was particularly in recognition of his contribution to the emergence of quantum technologies.
He achieved this through the development of sources of cooled atoms trapped by light and of quantum simulators which use these ultra-cold atomic gases to solve complex problems in other areas of physics.

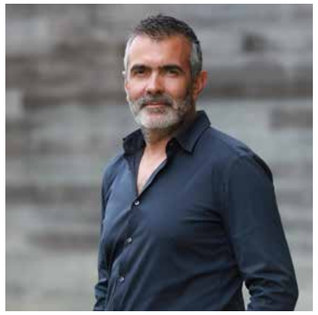
INNOVATION MEDAL

Antoine Aiello is the director of the Stella Mare platform[1] and a former president of the University of Corsica. He created and developed the Stella Mare scientific platform situated near Bastia in Corsica which specialises in marine and coastal ecological engineering. Scientists, marine professionals, environment "managers" and institutional figures work together on this platform towards the integrated management of fishery resources.

Nora Dempsey is a CNRS research professor at the Néel Institute[2]. She is internationally renowned in the field of high-performance micro-magnets and has developed model systems to optimise these magnets' performance levels. Her research has led to many collaboration projects with industry - notably with Toyota and Valeo. She also took part in creating the Magia Diagnostic start-up in the field of medical diagnostics and the MicroMagFab project which manufactures these micro-magnets and integrates them into microsystems.

François Jérôme is a CNRS research professor at the Poitiers Chemistry Institute - Materials and Natural Resources (IC2MP)[3] and an expert in biosourced and sustainable chemistry. His work has enabled the development and production of molecules of interest from biomass and patented surfactants from agricultural waste which are now developed by the BioseDev start-up. He also founded the CNRS Increase research federation and created the International Symposium on Green Chemistry which is a reference among green chemistry conferences.

Amanda Silva Brun is a CNRS researcher at the Matter and Complex Systems Laboratory[4] and has a doctorate in Galenic Pharmacy and Cell Biology. She develops technologies for the production and engineering of extracellular vesicles (EVs) and applications for regenerative medicine and delivering active ingredients. She has co-founded two start-ups - EverZom for vesicle production and Evora Biosciences for fistula treatment.



From left to right: Antoine Aiello, Nora Dempsey, François Jérôme and Amanda Silva Brun.

THE MEDAL FOR SCIENTIFIC MEDIATION

Jean-Michel Courty is a researcher belonging to the Quantum Fluctuations and Relativity team of the Kastler Brossel laboratory[1] and a professor at Sorbonne University. For over twenty years he has led many initiatives aimed at making physics more accessible to a very varied public. A notable example of this work is his YouTube channel "Merci la physique" (*Thanks, physics*) where he presents experiments that can easily be reproduced at home.

Audrey Dussutour is a research professor at the Research Centre on Animal Cognition[2]. She specialises in the collective behaviour of social insects and has characterised a new unicellular organism called "the blob" that is neither a plant, an animal nor a fungus. Her book "Tout ce que vous avez toujours voulu savoir sur le blob sans jamais oser le demander" (*Everything you always wanted to know about the blob but were afraid to ask*) was published in 2017 and was the inspiration for a 2019 documentary shown on the Franco-German TV channel Arte. In 2021, this work also led to the "Élève ton blob" (*Bring up your blob*) project which compared the behaviour of the blob on Earth and in space and involved the astronaut Thomas Pesquet, the French Space Agency (CNES), the CNRS and 5000 schools.

Mathieu Vidard is a presenter and producer on French radio and television who has been sharing his passion for science with the public for nearly 25 years. Through his radio shows "La Tête Au Carré" and "La Terre Au Carré" (*The Head/The Earth squared*) on France Inter, popular science books and documentaries, he aims to increase the awareness of as many people as possible about the major scientific theories, scientific stories and the careers of researchers in all fields, without distinction.

Le Festival international Jean Rouch is organised in Paris each year by the Ethnographic Film Committee. It is one of the most important European events for documentary films in the humanities and social sciences (HSS). For nearly 40 years now, the Festival has been screening current documentaries and ethnographic heritage films - notably from the CNRS Images collection - thus giving audiences from all walks of life a chance to discover or rediscover filmographies, researcher-filmmakers, trends and tendencies in the HSS.

ClimaTicTac is an educational, cooperative and eco-responsible strategy game. It was designed and is supported by a group of around twenty researchers, doctoral students and scientific mediators from the Pierre-Simon Laplace Institute (IPSL)[3] and the Association Science Technologie Société (ASTS). It is played by many secondary school pupils and adults and aims to help them understand the challenges of climate change in a fun way.

From left to right: Jean-Michel Courty, Audrey Dussutour, Mathieu Vidard, the poster for the 39th Jean Rouch International Film Festival and the ClimaTicTac game platform..

TALENTS IN FIGURES

31

projects linked to the CNRS were prize winners at the 23rd i-Lab innovation competition

11

start-ups derived from the CNRS won prizes at the i-Nov innovation competition

62

CNRS researchers won ERC grants in 2021

3

winners of "Étoiles de l'Europe" trophies came from CNRS laboratories namely Sabine Fourrier, Etienne Gheeraert and Philippe Potin

ARCHAEOLOGY

Florence Gaignerot-Driessen[1], Benjamin Mutin[2], Aline Tenu[3] et Jean-Pierre Van Staëvel[4] were awarded Clio 2020 prizes for their archaeological excavations in the Middle East and the Mediterranean basin.

MATHEMATICS

Jean-Michel Bismut, is an emeritus professor at Paris-Saclay University and a researcher at the Laboratory of Mathematics of Orsay[5]. He was awarded the 2021 Shaw Prize jointly with Jeff Cheeger, a professor at New York University, for their remarkable ideas that have transformed, and continue to transform, modern geometry.

MATHEMATICS

Michel Waldschmidt, Michel Waldschmidt is an emeritus professor at Sorbonne University and member of the Mathematics Institute of Jussieu–Parivs Rive Gauche[6]. He was awarded the American Mathematical Society's Bertrand Russell Prize for 2021 in recognition of his outstanding contributions to higher education and research in mathematics in developing countries and his work with mathematical communities throughout the world.

HISTORY

Françoise Briquel-Chatonnet, CNRS research professor, historian of the Ancient Levant and Near East and of the Syriac world at The Orient and The Mediterranean Laboratory[7] was made an academician by the "Académie des Inscriptions et Belles-Lettres" (a learned humanities society which is one of the five academies of the Institut de France).

ENGINEERING

Elisabeth Guazzelli, CNRS research professor at the Matter and Complex Systems Laboratory[8], and **Pierre Suquet**, CNRS emeritus research professor at the Mechanics and Acoustics Laboratory[9] were made international members of the National Academy of Engineering (NAE) in the United States in 2021. This is the highest professional distinction in the field of engineering.

THE UNIVERSE

Thérèse Encrenaz, CNRS emeritus research professor at the Paris Observatory – PSL[1] won the 2021 Gerard P. Kuiper Planetary Science Prize for her outstanding contributions in the field of planetary science.

PHYSICS

Julie Grollier, is a CNRS research professor and a researcher in spintronics at the CNRS/Thales Joint Physics Unit[2]. She was awarded the Irène Joliot-Curie prize for 2021 by the Académie de France in the "Woman Scientist of the Year" category. Her research focuses on how to use the power of spintronics to create artificial neurons and synapses which are inspired by the brain.

CHEMISTRY

Jérôme F. L. Duval, is a CNRS research professor at the Interdisciplinary Laboratory for Continental Environments[3]. He received the 2021 Lectureship Award from the Chemical Society of Japan Division of Colloid and Surface Chemistry in recognition of his research into the transformation of metals and nanoparticles in aquatic environments and their interactions with micro-organisms.

INFORMATION AND COMMUNICATION

Guillaume Cabanac, is an academic at the Institut de Recherche en Informatique de Toulouse (*Toulouse Computer Research Institute*)[4]. He was among the 10 personalities listed by the journal Nature as having left their mark on science in 2021 for his work on automating the detection of fraudulent scientific articles.

COMPUTING

Frédéric Magniez, is a CNRS research professor at the Paris Centre for Quantum Computing[5] and a professor at the Collège de France. He held the Collège's Informatics and Computational Sciences chair for the 2020-2021 year.

17

PhD students linked to CNRS laboratories won L'Oréal-UNESCO Young Talents France prizes

Over
30

CNRS scientists won Académie des Sciences prizes in 2021

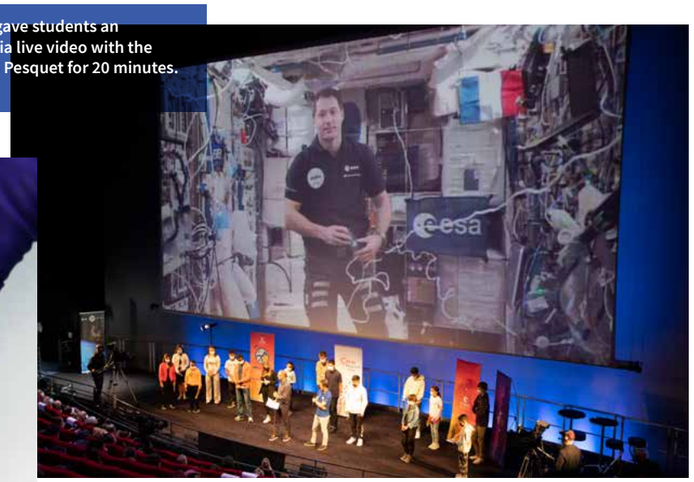
SCIENTIFIC **MEDIATION**

THE FIRST SCIENTIFIC MEDIATION MEDAL

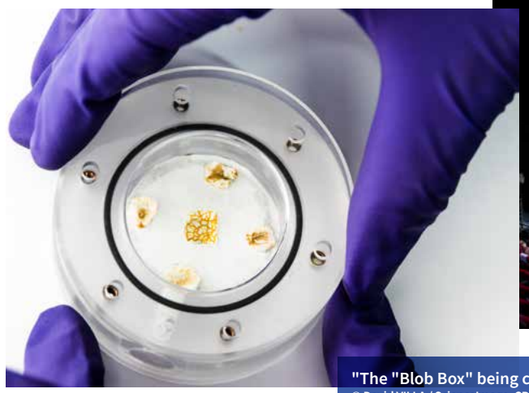
In 2021 the CNRS awarded a new medal to promote scientific mediation. This rewards scientists or research support staff for their efforts in promoting science in society, whether these activities are one-off or ongoing, personal or collective. This first medal was awarded to five laureates:

- The team which worked on ClimaTicTac, an educational, cooperative and eco-responsible strategy game.
- Jean-Michel Courty, a researcher who runs the YouTube channel "Merci La Physique".
- Audrey Dussutour, a research professor who popularises the "blob".
- The Ethnographic Film Committee for the Jean Rouch International Film Festival, one of the most important European events for documentary films in the humanities and social sciences.
- Mathieu Vidard, the scientific presenter and producer of the "La Terre Au Carré" (*The Earth Squared*) radio show.

RESEARCH GOES INTO CLASSROOMS



The "Inflight call" which gave students an opportunity to dialogue via live video with the French astronaut Thomas Pesquet for 20 minutes.
© Cité de l'espace / Manuel Huynh



"The "Blob Box" being closed.
© David VILLA / ScienceImage, CBI / CRCA / CNES / CNRS Photothèque

The blob continues to expand

In partnership with the CNES the CNRS offered around 5000 primary and secondary school classes the opportunity to take part in the educational experiment "Élève ton blob" (*Bring up your blob*) co-led by Thomas Pesquet on board the international space station. The aim was to compare these budding scientists' results with results obtained in space to learn more about this single-cell organism's exploration strategies. Each selected school received a kit containing four blobs created by the team led by Audrey Dussutour, CNRS research professor..

200 primary and secondary school pupils came to the Cité de l'Espace on October 6th to talk with Thomas Pesquet live from the international space station and for the launch of the educational experiment "Élève ton blob". This event was jointly organised by the CNRS, the French and European Space Agencies (CNES and ESA), the Cité de l'Espace and the Académie de Toulouse.

The "Étonnante Chimie pour un grand oral percutant" initiative (***Amazing Chemistry for a great baccalauréat oral examination***) run by the CNRS regional office in Alsace at the André Maurois secondary school in Bischwiller. © CNRS Institute of Chemistry

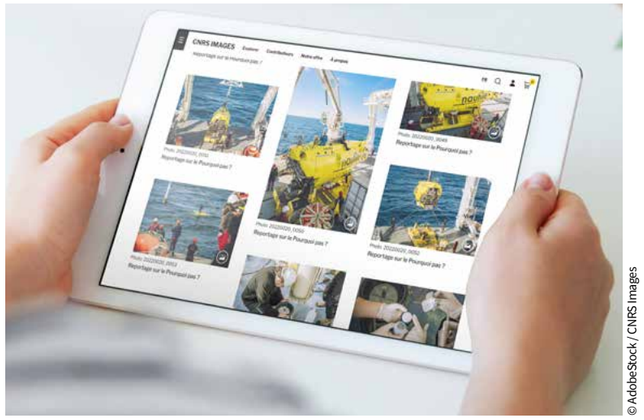
Chemists in contact with secondary school pupils

To mark the year of chemistry, the CNRS and the Ministry of National Education, Youth and Sports organised half-day meetings between secondary school pupils and chemistry researchers throughout France to help pupils prepare for the baccalauréat oral examination.

12 students

from the ISAE SUPAERO (National Higher French Institute of Aeronautics and Space) created a digital educational tool to raise awareness of space exploration. The project was initiated and led by Sylvestre Maurice, an astrophysicist at the Research Institute in Astrophysics and Planetology[1]

TOOLS TO DISSEMINATE SCIENCE



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CNRS Images launches a new platform

The CNRS audiovisual collection possesses a wealth of over 2000 videos and 50,000 photographs from all fields of research. These have now all been grouped together on a single ergonomic and editorialised platform which the public can access free of charge. For over 40 years CNRS Images has been collecting photographs and videos from laboratories and producing its own.

The CNRS is Universcience's scientific partner for the Palais de la Découverte

Antoine Petit, the CNRS Chairman and CEO, and Bruno Maquart, the president of Universcience, signed an agreement on November 8th for the two organisations' scientific contribution to creating new content and providing mediation at the Palais de la Découverte science museum until 2025.

SCIENTIFIC MEDIATION

Amazing chemistry

The book "Étonnante chimie" (*Amazing chemistry*) published by CNRS Éditions was made available in French bookstores in April 2021. It relates the daily life stories of 80 scientists who have helped established chemistry's fine reputation.

CNRS researchers working on climate change

Following a new IPCC report on the climate published in August and in parallel with the COP26 in Glasgow, the CNRS highlighted, notably at a press conference on 22 October, the expertise of its 2000 researchers who work towards enhanced understanding of the mechanisms governing our planet's ecosystem and climate.

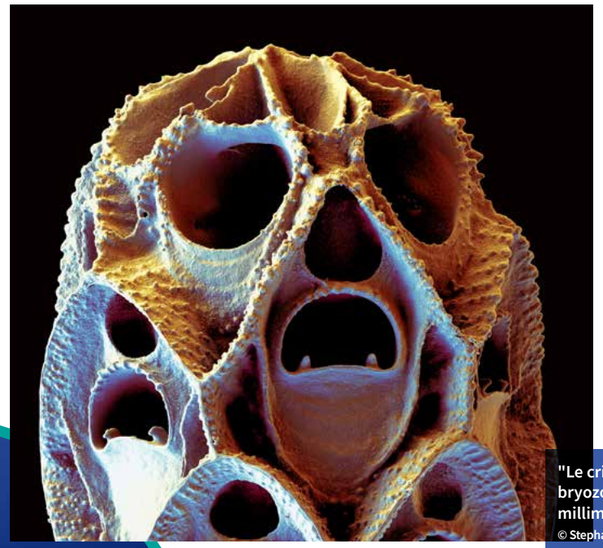
Carmin.tv, the mathematics channel

On December 10th, the CNRS and its partners launched carmin.tv[1], an audiovisual broadcasting platform offering over 4500 videos about mathematics and its interactions with other sciences, particularly physics, computer science and biology.

A chatbot in response to vaccine hesitancy

Scientists from the CNRS, the National Institute of Health and Medical Research (Inserm) and ENS-PSL have designed a chatbot which gives provides personalised answers to questions from people who are curious or hesitant about being vaccinated. This was the subject of an article published on October 28th 2021 by *the Journal of Experimental Psychology.*

COMPETITION



"Le cri", winner of the 2021 Public Prize. A structure built by bryozoans with carbonate skeletons - animals smaller than a millimetre that live in colonies in cold waters.
© Stephan BORENSZTAJN / Caroline THALER / IPGP / CNRS Photothèque

"La preuve par l'image", science from another angle

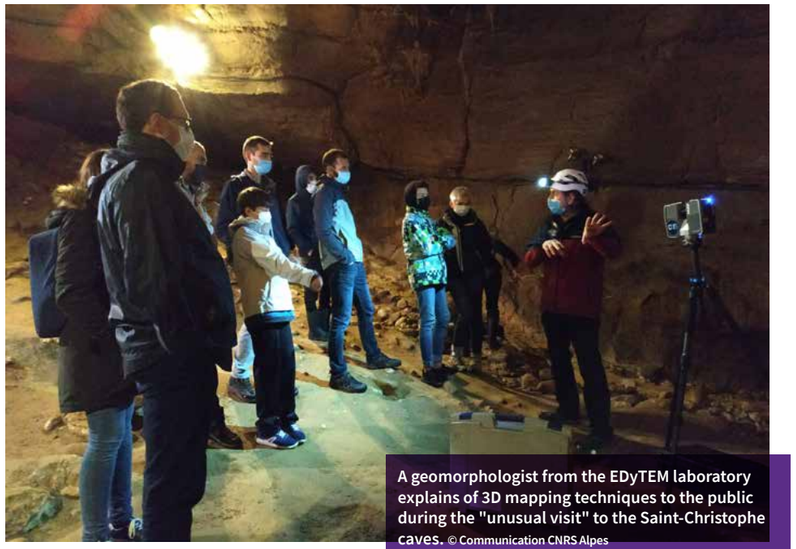
For the third year of the "La preuve par l'image" (*Proof through images*) competition, 20 scientific images (photographs, x-rays, models, microscope images, etc.) were selected for an exhibition. The jury's Grand Prize was awarded to Bertrand Rebière and Bruno Alonso for "Songe d'une zéolithe" (*Dream of a zeolite*) while the jury's Coup de Coeur (*Particular favourite*) prize was awarded jointly to Louise Griveau and Émilie Christin for "Van Gogh cellulaire" and to Jean-François Humbert for "À l'école des sentinelles" (*At the school for sentinels*). Finally, the public's prize was awarded to Stephan Borensztajn and Caroline Thaler for "Le cri" (*The cry* - opposite).

180 seconds to present your research

The international final of the "My Thesis in 180 seconds" competition organised by the CNRS and the Conference of University Presidents (CPU) was held in Paris on September 30th. The jury's 1st prize was awarded to Yohann Thenaisie who works in Switzerland on the implementation of a deep brain stimulation protocol to help Parkinson's disease sufferers with their walking. Aminata Sourang Mbaye Diouf, a doctoral student at Cheikh Anta Diop University in Dakar (Senegal) and Manhougbe Probus A. Farel Kiki from the University of Abomey Calavi (Benin) were respectively awarded the 2nd and 3rd prizes. The Public Prize was awarded to Prince Makay Bamba from the University of Kinshasa (Democratic Republic of Congo). A total of 24 international candidates were invited onstage individually for over two hours before an audience including Frédérique Vidal, the Minister for Higher Education, Research and Innovation, Antoine Petit, Chairman and CEO of the CNRS, Manuel Tunon de Lara, president of the CPU, numerous university presidents, journalists and the candidates' families and friends.

The candidates of the "My Thesis in 180 seconds" competition on the stage of studio 104 of the Maison de la Radio in Paris.
© David Pell

EVENT



A geomorphologist from the EDyTEM laboratory explains of 3D mapping techniques to the public during the "unusual visit" to the Saint-Christophe caves. © Communication CNRS Alpes

Open days offering "unusual visits"

In the framework of the 2021 Science Festival organised by the Higher Education, Research and Innovation Ministry from October 1st to 11th, the CNRS organised "unusual visits" to over 80 laboratories throughout France. More than 1000 people were given the opportunity to immerse themselves in the very heart of research and discover exceptional installations or experiments in the company of scientists..

23rd edition

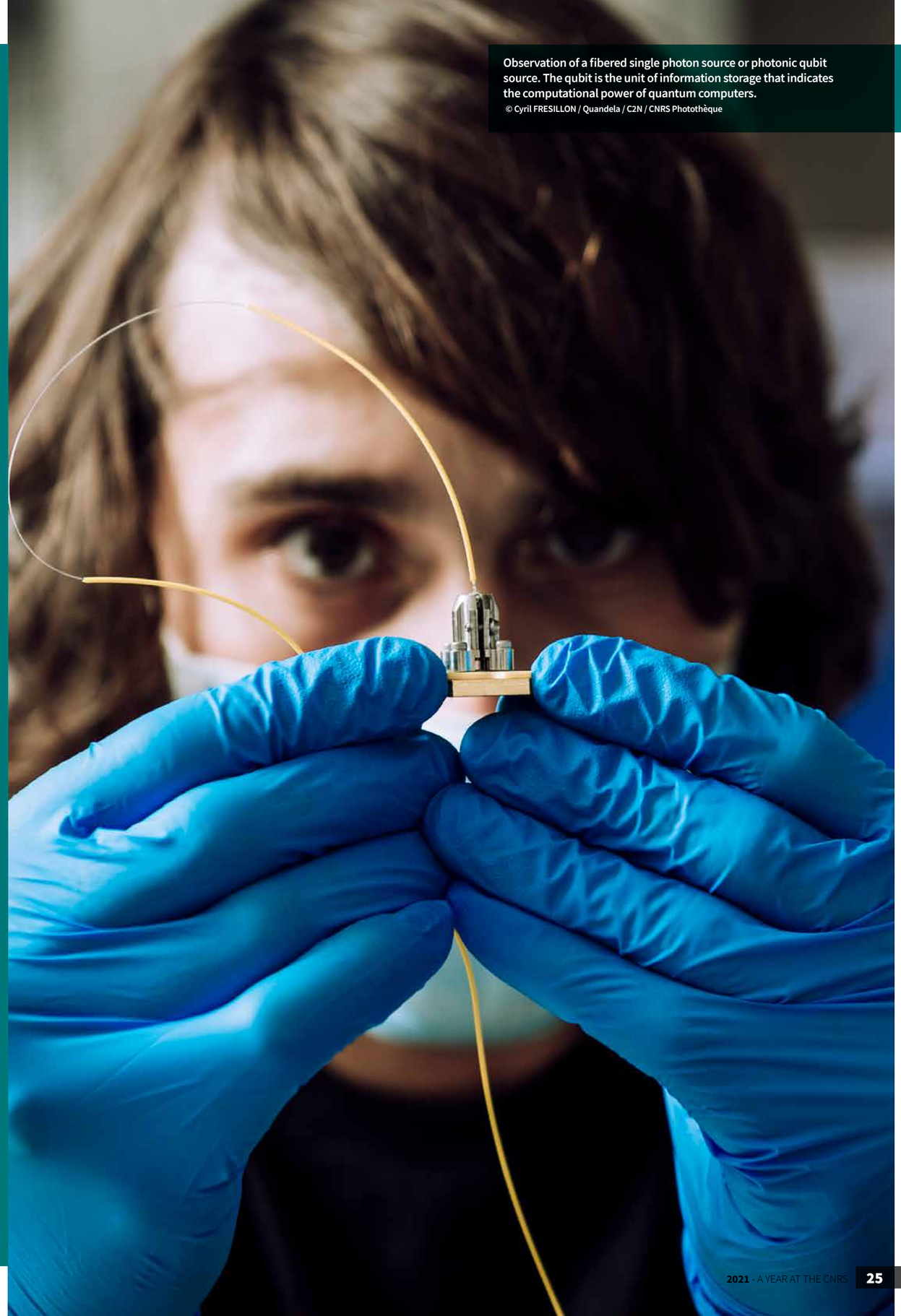
of Brain Awareness Week from March 15th to 21st with online conferences, digital workshops and podcasts of plays.

5th edition

of the NIMS Forum (New scientific mediation initiatives) on September 29th, organised by the CNRS and the CPU. This edition concentrated on the question of publics, particularly in the light of the health crisis.

THE CNRS ON THE **NATIONAL STRATEGY FRONT**

The CNRS is the world's second largest research institution and a major player in France's national scientific strategy which aims to develop strong, internationally competitive research and technology. Based on the CNRS's interdisciplinary approach, the organisation has set itself the challenge of responding to six major societal challenges - the energy transition, climate change, artificial intelligence, health and the environment, the territories of the future and educational inequalities.



Observation of a fibered single photon source or photonic qubit source. The qubit is the unit of information storage that indicates the computational power of quantum computers.
© Cyril FRESILLON / Quandela / C2N / CNRS Photothèque

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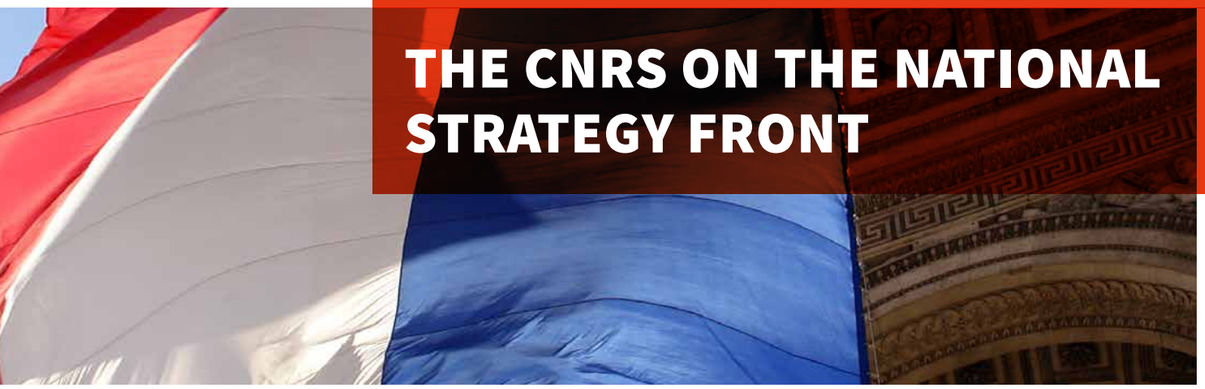


THE CNRS ON THE NATIONAL STRATEGY FRONT

The Research Programming Law of December 2020 and the fourth Investments for the Future Programme (PIA4) of January 2021 provided additional leverage tools, particularly with the 20 billion euros allocated to research over 5 years. The Investments for the Future Programme was initiated by the State in 2010 and is steered by the General Secretariat for Investment (SGPI). It finances investments throughout the country to enable France to increase its growth and employment potential. Four PIAs have been successively rolled out over the last ten years. Lessons were learnt from the PIA3 and thus the "Priority Research Programmes and Equipment" (PEPR) initiative of PIA4 aims to construct or consolidate French leadership in priority national and European scientific fields linked to large-scale transformations, whether these are technological, economic, societal, health or environmental. There are two types of PEPR.

National strategy PEPRs

These PEPRs are intended to contribute to France's recovery and prepare the country's future. 10 PEPR "Acceleration" projects have already been launched (with total funding of nearly one billion euros). Among these the CNRS is the project scientific leader or co-leader in the following fields - quantum technologies, decarbonised hydrogen, education and digital technology, cybersecurity, solutions for sustainable cities and territorial innovations, recyclability, recycling and reincorporation of recycled materials. The CNRS will also co-steer two other PEPRs to be launched in 2022. The first aims to support future generations of batteries working alongside the French Alternative Energies and Atomic Energy Commission (CEA) while in the second the CNRS will develop new, mainly low-carbon industrial processes with IFP Energies Nouvelles (New Energies, IFPEN).

Exploratory PEPRs

These are aimed at emerging scientific or technological sectors. Among the first four PEPRs selected in the first wave of this call, the CNRS is the scientific leader or co-leader in the following fields: the materials of tomorrow with Diademe, the carbon cycle with FairCarbon, DNA data storage with MoleculArXiv and water as a common good with the OneWater programme.

France Relance

The CNRS has also committed to preserving research and development jobs with French companies. The organisation aims to create or safeguard nearly 300 jobs through one of the measures with a total investment of €41 million from the government's "France Relance" Recovery Plan.

© Cyril Fresillon / LAAS / CNRS Photothèque

THE ENERGY TRANSITION

The CNRS has committed to the question of renewable energies through its laboratories working on these themes. The organisation drives the emergence of new possibilities based on frontier research, particularly the use of hydrogen to produce electricity and heat (fuel cells).

The "Decarbonated Hydrogen" acceleration PEPR

The CNRS and the CEA have been chosen to manage the PEPR dedicated to hydrogen in France and its budget of €80M over a period of 7 to 8 years. This project covers the entire value chain of production, storage, use and conversion as well as transversal socio-technical and economic aspects including impacts and risks.

A research federation focusing on hydrogen

The CNRS leads the Fédération Hydrogène (*Hydrogen Federation*) made up of over 270 researchers and 28 CNRS laboratories, working in partnership with universities, other research organisations and engineering schools. The federation coordinates the production, purification and storage of CO_2-efficient hydrogen and aims to progress in designing complete systems - from the production to the use of hydrogen using fuel cells.

A refrigerated lorry developed by the Chéreau company which uses a hydrogen fuel cell system developed by the H2Sys company.
© Cyril FRESILLON / FEMTO-ST / CNRS Photothèque

FOCUS **ON A START-UP**

Hybrid hydrogen generators

The H2Sys start-up, founded by researchers from FCLab [1] markets hydrogen-powered electric generators that combine a fuel cell with a means of storage which can supply electricity to sites in the absence of a power grid. This is an optimised, silent and environmentally friendly hybrid solution.

A stage in the production of an electrolyser cell that uses electricity to produce hydrogen from water. The electricity can then be stored, transported and finally used as energy, in a fuel cell for example.
© Jean-Claude MOSCHETTI / IMN / CNRS Photothèque

Responsible and sustainable solutions in many fields

To help increase and develop potential decarbonised energy advances, the CNRS contributes to the National Energy Research Strategy (SNRE) through its "Cellule Énergie" (Energy Unit). This unit responds to challenges linked to the energy transition by offering responsible and sustainable solutions in many fields - hydrogen, fuel cells, underground energy storage, intelligent buildings, carbon-free electricity, decarbonised chemical fuels and so forth.

FOCUS ON A **JOINT LABORATORY**

High performance solar thermal collectors

The Viessmann Faulquemont SAS company and the Jean Lamour Institute[1] in Nancy have created the joint laboratory SOLARIS to develop efficient solar thermal collectors. In particular this collaboration has led to the development of a thermoprotective coating which protects solar panels from damage linked to overheating. This thermochromic absorber is now used on 90% of the solar thermal collectors sold by Viessmann and has been installed on a cumulative area of 1,000,000 square metres.

The Viessmann Vitosol 200-FM solar collector equipped with Thermprotect technology.
© Viessmann

© Erwan AMICE / LEMAR / CNRS Photothèque

Limiting the impact of climate change requires an excellent understanding of the "climate machine" along with an accurate holistic assessment of different climate impacts and the uncertainties associated to these. The CNRS is leading a transdisciplinary community of scientists to respond to this challenge. This involves researchers working in fields ranging from climate science to ecology and including social and political sciences.

© Andreas Poznanski from Pixabay

The "FairCarbon" exploratory PEPR

The CNRS, the National Research Institute for Agriculture, Food and Environment (INRAE) and their partners[1] are in charge of the "FairCarbon" exploratory PEPR focusing on the carbon cycle. The aim is to identify ecological, agronomic and socio-economic levers and develop trajectory scenarios to achieve carbon neutrality and restore natural resources in continental ecosystems. The programme benefits from funding of €40M over a 6-year period and supports the implementation of these scenarios at local and national levels while also providing the scientific community with digital models based on open data sets.

Over
2 000
CNRS researchers are working to enhance our understanding of the mechanisms governing the ecosystems and climate of our planet.

Marine renewable energies

Through its EOL-EMR research network (GDR), the CNRS contributes to structuring the French academic community in the field of marine renewable energies (MREs) and more specifically offshore wind energy. The important issue here for society and industry is to reduce the costs and risks of the design, development and production phases of marine renewable energy projects.

Climate change and air quality

On October 31st, the CNRS and Météo-France (the French Meteorological Office) renewed their framework agreement. This effectively added another building block to their collaboration project which develops knowledge of weather forecasting, climate change and air quality. Among other initiatives, their collaboration involves the CNRS's national LEFE programme with its annual budget of around €1.2 million and 10 partner organisations[1]. The LEFE programme's aim is to encourage and support research into how the atmosphere and the ocean function and and how these couple and interact with other components of the climate system. The CNRS and Météo-France are also collaborating in the Mediterranean on forecasting water cycles and extreme forecasting in the framework of the international HyMeX research programme.

Counting corals on the external slope of the on the outer slope of the reef in Moorea, French Polynesia. © Thomas VIGNAUD/CNRS Photothèque

The "Ocean and Climate" PPR

The "Ocean and Climate" Priority Research Programme (PPR) was launched on June 8th 2021 for a six- year period with a budget of €40M. It is jointly led by the CNRS and the French Research Institute for Exploitation of the Sea (Ifremer) and aims to structure French research forces to enhance the understanding and protection of this ecosystem. It is working on responses to seven major challenges - predicting the impacts of climate change in France's overseas territories, intensifying research in the polar oceans, improving the protection and resilience of marine environments, sustainable exploitation of ocean resources, characterising environmental stress factors in the marine environment, developing innovative observation and modelling programmes and sharing all these discoveries with the public at large.

© Frédéric MALIGNE / LAAS / CNRS Photothèque

ARTIFICIAL, DIGITAL AND QUANTUM INTELLIGENCE

The CNRS's transdisciplinary expertise serves as the basis for the organisation's work in the key strategic areas of dematerialised technologies such as artificial and quantum intelligence, cybersecurity or data storage. This research may be theoretical and/or experimental as in the case of quantum intelligence and the aim of a lot of the research is for its results to be applied in the coming 5 to 10 years.

ARTIFICIAL INTELLIGENCE

The "Artificial Intelligence" acceleration PEPR

In the framework of the national artificial intelligence (AI) strategy presented on November 8th, the government announced a €134 million five-year research programme to be led by the CNRS, the CEA and the French National Institute for Research in Computer Science and Control (INRIA). It is dedicated to research aiming at the emergence of disruptive technologies and is fully in step with "Made In Europe", the European coordinated plan for the development and use of artificial intelligence. The French programme and the European plan share common priorities, particularly regarding the development of embedded AI or using AI to speed up the ecological transition.

The current boom in modern AI stems from the availability of large amounts of data and recent advances in fundamental research notably in the area of machine learning. The CNRS is coordinating four Research Networks (GDRs) focused on AI which promote exchanges between CNRS scientists, academic partners, companies and other stakeholders:

- The "IA" GDR focuses on the formal and algorithmic aspects of AI.
- The "ISIS" GDR focuses on information, signal, image and vision processing methods.
- The "MaDIC" GDR promotes interdisciplinary research positioned in the continuum ranging "from data to knowledge and decision making".
- The "TAL" GDR works on computational modelling of language in all its forms (written, spoken, signed), expressions and applications.

Over
1100
researchers and academics are working on the foundations, integration and applications of artificial intelligence.

Nearly
30%
of the start-ups derived from CNRS laboratories and those of its partners work in the information and communication technologies sector with a significant proportion involving AI technologies.

ARTIFICIAL INTELLIGENCE

Renault's autonomous "Zoe" vehicles equipped for collaborative V2V (vehicle-to-vehicle) driving tests.
© Jean-Claude MOSCHETTI / HEUDIASYC / CNRS Photothèque

FOCUS ON A **JOINT LABORATORY**

Developing a range of autonomous vehicles

Robotics and artificial intelligence researchers at the joint SIVALab laboratory run with Renault and the Heudiasyc laboratory[1] design software and test equipment to provide assistance for Renault in developing a range of autonomous vehicles. Between July 5th and 9th 2021, they ran one of the first autonomous car tests on roads in Rambouillet in France's Yvelines region to analyse how the car behaves when faced with other road users and to test how it navigates roundabouts.

DATA SECURITY

Over
200
researchers and academics from CNRS laboratories and those of its partners work in the field of cybersecurity.

The "Cybersecurity" acceleration PEPR

The CNRS, the Inria and the CEA jointly lead the Cybersecurity PEPR with its €65M budget which aims to accelerate innovation to bring French technology to the forefront worldwide and in particular to master key technologies in critical applications. The CNRS has mobilised its cybersecurity community around this PEPR thanks to its "Sécurité informatique" (*Computer Security*) GDR set up in 2016. This GDR focuses on coding and cryptography, formal methods for the protection of privacy, data security and multimedia and the security of systems, software, networks and hardware.

Over
1000
stakeholders make up the CNRS "Computer Security" research network.

FOCUS ON A **JOINT LABORATORY**

Cybermallix at the heart of cybersecurity

On December 7th, the CNRS, the Université de Lorraine, the Inria and the European cybersecurity software publisher WALLIX set up the joint laboratory Cybermallix. Its aim is to design and develop predictive cybersecurity solutions based on artificial intelligence and thus maximise the level of detection of malicious software.

FOCUS ON A **START-UP**

Exploiting data without compromising it

The Cosmian start-up was created in collaboration with the Computer Science Department at the École Normale Supérieure (ENS)[1]. It has created a platform for the dissemination and use of data - particularly of a personal nature - without compromising them. David Pointcheval, a CNRS research professor working in the ENS Computer Science Department, used this start-up as the basis for his ERC "Proof of Concept".

Post-quantum security

The CNRS Institute for Information Sciences and their Interactions (INS2I) is supporting the emerging research theme of post-quantum security, particularly through the Paris Centre for Quantum Computing (PCQC) Federation which coordinates its teams' work. Unlike standard systems, quantum cryptography is based on a "pure" quantum randomness that guarantees the inviolability and durability of the keys and the resulting communication protocols.

DATA STORAGE

A magnetic tape storage library at the CNRS National Institute of Nuclear and Particle Physics Computing Centre (CC-IN2P3).
© Cyril FRESILLON / CC IN2P3 / CNRS Photothèque

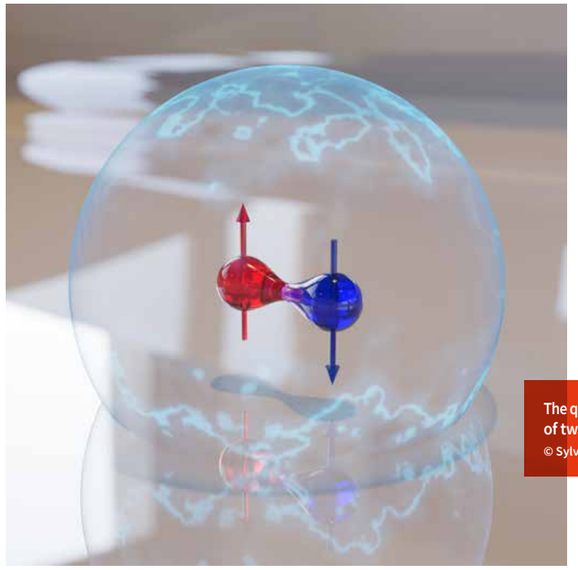
The "MoleculArXiv" exploratory PEPR

In partnership with the INRIA, the University of Strasbourg, Paris Sciences et Lettres University and the University of Côte d'Azur the CNRS is steering the exploratory PEPR "MoleculArXiv"[2]. This programme focuses on the storage of massive data on DNA and artificial polymers and aims to position French academic (computer science, chemistry, biology, nanotechnologies, microfluidics) and industrial research in this field at the highest international level.

FOCUS ON A **START-UP**

Technology enters the National Archives

The DNA Drive technology was developed by Stéphane Lemaire, a researcher at the Laboratory of Computational and Quantitative Biology[3] and Pierre Crozet, a senior lecturer at Sorbonne University. It serves to create capsules capable of containing a quantity of DNA corresponding to up to 5000 TB of digital data which can be preserved for thousands of years. On November 23rd 2021, this technology was chosen to store the Declaration of the Rights of Man and of the Citizen and the Declaration of the Rights of Women and of the Citizen at the French National Archives.



The qubit shown in the centre of this image is a superposition of two states - spin up (red) and spin down (blue).
© Sylvain BERTAINA / IM2NP / LASIRe / FSU / CNRS Photothèque

The "Quantum Technologies" acceleration PEPR

The CNRS, the CEA and the Inria jointly steer the PEPR for national quantum strategies with its budget of €150 million. The CNRS brings together the French quantum information community in its "Quantum Information and Communication" research network (GDR) made up of over 50 laboratories.

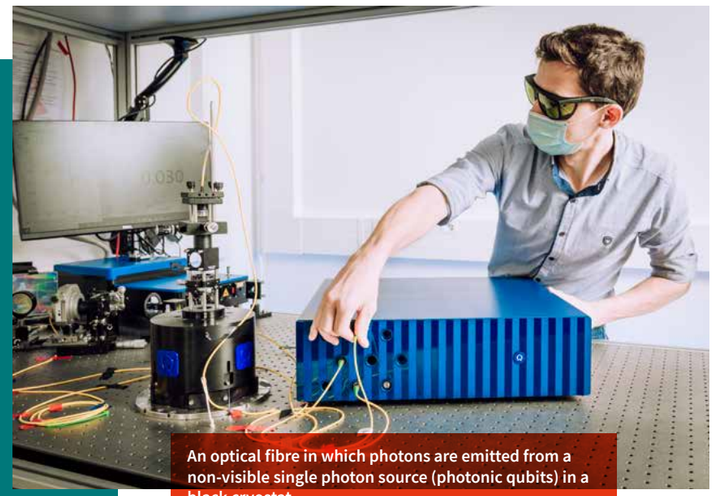
The challenges linked to transferring a quantum processor to industry

Alexia Auffèves, a CNRS research professor at the Néel Institute, coordinates the Grenoble Quantum Engineering programme funded by Grenoble Alpes University and the European Commission. It focuses on the philosophical and societal implications of quantum theory and technology and aims to respond to the challenges linked to transferring a quantum processor to industry.

FOCUS ON A **START-UP**

A second-generation qubit generator

The Quandela company is working on the emergence of new quantum computers and communication networks. The company was co-founded by Pascale Senellart, a physicist and CNRS research professor at the Centre for Nanoscience and Nanotechnology[1]. It has just won the Innov'up Leader PIA call for projects launched by the State with the Île-de-France Region and operated by Bpifrance.



An optical fibre in which photons are emitted from a non-visible single photon source (photonic qubits) in a black cryostat.
© Cyril FRESILLON / Quandela / C2N / CNRS Photothèque

© David VILLA / ScienceImage, CBI / INFINITy / CNRS Photothèque

HEALTH AND THE ENVIRONMENT

The CNRS has defined health and the environment as one of its six challenges. As such the organisation is part of strategies which accompany the major changes facing our societies, particularly those linked to ageing populations and the importance of ecosystems and hydrosystems in terms of health. The CNRS is also strongly involved in research into very high-performance sport and the results of this work will be used by top French athletes competing in the Paris 2024 Olympic and Paralympic Games.

A researcher using an experimental device to measure carbon gas exchanges in the La Guette peat bog in the Cher region.© Cyril FRESILLON / ISTO / CNRS Photothèque

The "OneWater" exploratory PEPR

The OneWater programme, jointly led by the CNRS, the BRGM (the French geological survey) and the INRAE along with many other stakeholders was one of the first four exploratory PEPRs selected by the State[1]. It funds upstream research on the theme of "water as a common good" to the tune of over €50 million over a ten-year period. The programme is organised to respond to different major scientific and technical challenges ranging from anticipating changes in water resources and adapting accordingly, the transition towards a new governance of resources for a sustainable resilient society and the theme of water as a sentinel.

The CNRS has chosen to involve its units carrying out water-related research in this programme. Nearly a third of these units work on issues linked to drinking water, sanitation and alternative resources like rainwater, grey water or desalination. Also, the great water cycle is studied in its entirety - from surface water to atmospheric water and including groundwater and its connections. This systemic and transdisciplinary vision means the CNRS can effectively respond to the full diversity of scientific, environmental, economic, industrial and societal water-related issues in the current context of global change.

Over
2900
scientists in over 200 research laboratories belonging to the CNRS and its partners carry out water-related research.

Using wastewater to track the Covid-19 epidemic

On October 19th, the CNRS and 9 other institutions[1] took part in the launch of Obépine's (*Epidemiological Wastewater Observatory*) Scientific Interest Group. Research carried out by the Obépine network has produced a new wastewater indicator that provides information about the circulation of the SARS-CoV-2 virus in water catchment areas which cover over 33% of the French population.

FOCUS ON A **JOINT LABORATORY**

The biological signature of water

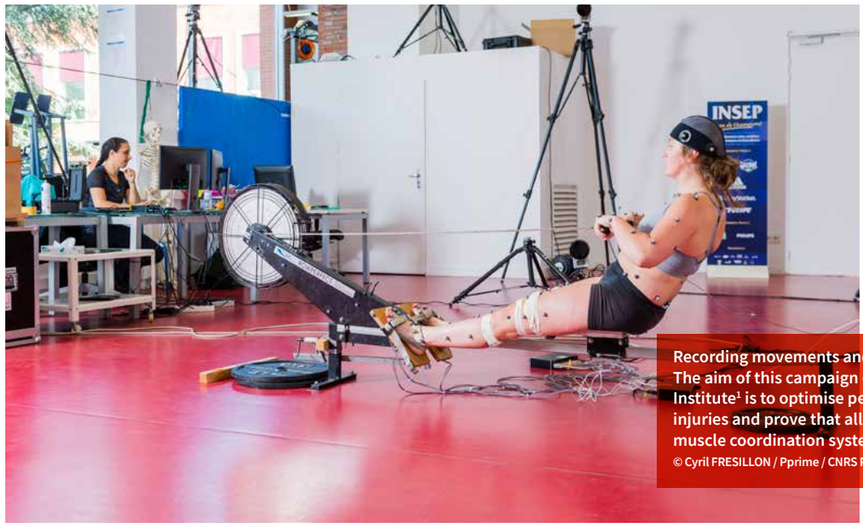
The Laboratory of Microbial Biodiversity and Biotechnology[2] and the Pierre Fabre Group are carrying out research into the biological signature of Avène thermal spring water in the framework of a joint research team (EMR). They have highlighted the benefits of a bacterial strain endemic to the site and used their finding to develop active ingredients which have been introduced into various products from the Avène thermal water brand. The EMR has also carried out extensive studies of the effects of sunscreens on marine biodiversity.

Partnerships in the water sector

The CNRS's Business Relations Department (DRE) organises research partnerships between CNRS laboratories, major corporations and SMEs in the water sector. A wide variety of technical solutions such as data production and management systems, new technologies or artificial intelligence are developed and used to quantitatively and qualitatively measure, monitor, analyse, treat, distribute, collect or reuse water in environments and networks.

The "Autonomy" PPR

The new PPR on autonomy piloted by the CNRS was launched in March with a five-year budget of €30 million. This PPR is situated at the crossroads of many disciplines and aims to preserve the autonomy of elderly and/or disabled people.



Recording movements and forces generated by rowing. The aim of this campaign carried out by the Pprime Institute[1] is to optimise performance levels, prevent injuries and prove that all rowers have their own muscle coordination systems.
© Cyril FRESILLON / Pprime / CNRS Photothèque

The "Sport" PPR

The CNRS has been entrusted with the scientific steering of the Sport PPR which has a €20M budget and focuses on very high-performance athletes. The 6 winners of the second call for projects for this PPR were announced in August 2021, with the aim of the programme being to fund sports performance research projects. The research results will be used by top French athletes preparing for the Paris 2024 Olympic and Paralympic Games.

A research network (GDR) dedicated to sport has been created in the context of this PPR bringing together research laboratories, industrialists, sports federations, athletes and citizens to work on themes linked to sports performance, the economy of sports-related products (equipment and materials, tourism and leisure, environment or major events, etc.) or health. Certain applications of this network's research are also of interest for the fields of pharmacology, nutrition, materials, physical phenomena, neuroscience, psychology, physiology and medicine.

Nearly
1400
scientists from over 150 laboratories are involved in the Sport GDR.

FOCUS ON A **START-UP**

Secure systems for drones

The Hyperion 7 start-up is marketing a drone which is ultra-secure insofar as there is no risk of it falling on the public or sensitive infrastructures. This system was developed by a team from the Laboratory of Vulnerabilities and Innovation in Sport (L-VIS)[2] and the Geology Laboratory of Lyon[3] and is aimed at use in sports or cultural event broadcasting and also for monitoring sites.

The Hyperion 7 start-up's ultra-secure drone.
© Hyperion 7

© stock.adobe.com

TERRITORIES OF THE FUTURE

CNRS research into sustainable cities, materials and mobility is contributing to the understanding and construction of optimal solutions to support the growth of the French population which is mainly concentrated in large urban areas and particularly in peri-urban areas.

DESIGNING THE CITIES OF TOMORROW

The "Solutions for a sustainable city and territorial innovations" acceleration PEPR

The shared objective of the CNRS and Université Gustave Eiffel through their "Solutions for the sustainable city and territorial innovations" national strategy PEPR is to encourage the emergence of new ways of designing, building and managing cities. This programme was allocated a budget of €40M in May 2021 and aims to create a new basis for urban development based on four challenges - simplicity, resilience, inclusion and urban production. The FERED (*Federation of Research in Environment and Sustainability*) jointly managed by the CNRS and the University of Strasbourg took part in the creation of this PEPR in the area of "Sustainable Cities" among others in the framework of the PEPR's overall strategy.

Climate change and city design

In the context of climate change and its impact on the design of cities, the CNRS and Météo-France are providing strong added value for enhancing understanding of heat islands and their impact on health through projects like H2C (Heat and Health in Cities) or ACRoSS. These study how the interactions between urban air masses and those emitted by vegetation contribute to the formation of noxious pollutants.

MATERIALS AND RECYCLING

The "Recyclability, Recycling and Reincorporation of recycled materials" PEPR

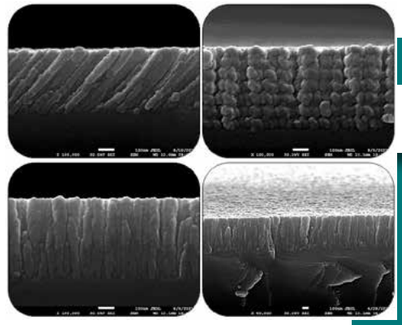
The CNRS is steering the "Recyclability, Recycling and Reincorporation of Recycled Materials" national strategy PEPR in response to the ecological, economic and technological challenges linked to the transition towards a competitive and environmentally friendly circular economy. This €40 million programme was launched on September 13th and focuses on five materials from everyone's daily lives - plastics, composite materials, textiles, strategic metals and paper/cardboard.

FOCUS ON A **START-UP**

Recycling metals and rare earths from batteries

The Mecaware start-up derived from research carried out at the Institute for Molecular and Supramolecular Chemistry and Biochemistry[1]. It works on the development of a process for the selective extraction of metals and rare earths from batteries that is less polluting and energy-consuming than current processes. The aim of this work is to prove it is possible to produce metals that meet the producers' specifications from a raw material derived from production waste or old batteries. The number of electric vehicles in Europe is constantly growing which means batteries need to be efficiently recycled.

MATERIALS AND INNOVATION



Electron microscope images of nanostructured surfaces. © PRIMEO

FOCUS ON A **JOINT LABORATORY**

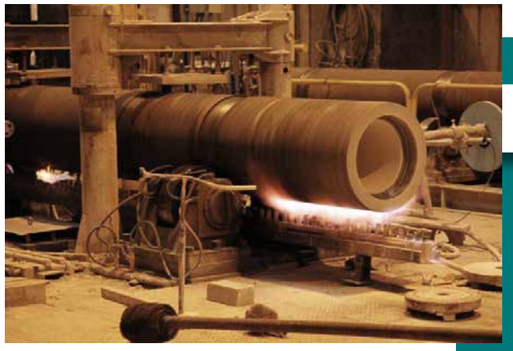
Materials for optical components

The joint laboratory PRIMEO was set up by the Pprime Institute[2] and Safran Electronics & Defense to work in the field of innovative optical materials and surface nanostructuring. The aims of this research are to develop technological building blocks and processes and bring them to maturation. This will provide a more effective response to technical and operational requirements while also developing more competitive product lines for Safran Electronics & Defense.

MATERIALS AND INNOVATION

The "Diademe" exploratory PEPR

A partnership between the CNRS, the CEA and universities[1] is to manage the exploratory PEPR "Diademe" (*Integrated Devices for the Accelerated Deployment of Emerging Materials*). This programme has funding of over €80m and aims to speed up the design and marketing of more efficient, sustainable materials made from non-critical and non-toxic raw materials. The PEPR's work is based on platforms initially dedicated to strategic classes of materials and the aim is to reduce the identification cycle of materials from 20 years to between 4 and 10 years.



The metal alloys developed by IPERS make excellent materials for the construction of ovens capable of withstanding extreme conditions.
© Manoir Industries

FOCUS ON A **JOINT LABORATORY**

Innovative alloys for competitive companies

The Materials Physics Group[2] and Manoir Pitres (a subsidiary of Manoir Industries) are developing new high-performance metal alloys in the framework of their joint research laboratory, IPERS. Their collaboration led to the invention and marketing of the Manaurite® XAl4 alloy which now accounts for a third of the company's sales of steam cracking tubes.

VEHICLES AND MOBILITY

A sector dedicated to vehicles and mobility

The CNRS is working on core research avenues opened up by the issues of regional planning and the well-being of citizens alongside major actors in the mobility and automotive sectors. The organisation is also using its scientific excellence to effectively respond to new technological, environmental and societal challenges through a dedicated research sector. The CNRS has defined four areas of research and innovation for this sector to contribute to people's freedom to move around in complete safety and comfort, both individually and collectively - sustainable design; mobility, well-being and inclusive cities; new energies and new energy systems; AI, intelligent systems and data sciences.

Over
1000
researchers and academics work on vehicles and mobility.

© Cyril FRESILLON / LSCP / ENS / EHESS / CNRS Photothèque

EDUCATIONAL INEQUALITY

The CNRS is the only organisation whose research units cover the full range of research required to fully understand educational inequality which means the organisation can contribute to finding effective solutions. Educational inequality is long-lasting, extensive and has been made a great deal worse by the health crisis. Digital education is one of the prime levers for improving the situation.

The "Digital teaching" national strategy PEPR

Aix-Marseille University, the INRIA and the CNRS are co-steering the "Digital teaching" national strategy PEPR with its €77M budget. This acceleration strategy should make it possible to boost and structure the digital educational sector by developing viable markets, particularly through work with the public sector and by supporting major national stakeholders. To work on this PEPR, the CNRS is notably involving a multidisciplinary thematic network dedicated to educational inequalities, comparative educational policies, and pedagogical practices and systems which is studying the links between research and school. This network is also involved in research into "Covid-19 and education" and puts forward solutions based on statistically representative approaches and innovative indicators of educational quality.

A child learns to read with Kaligo.
@Learn&Go

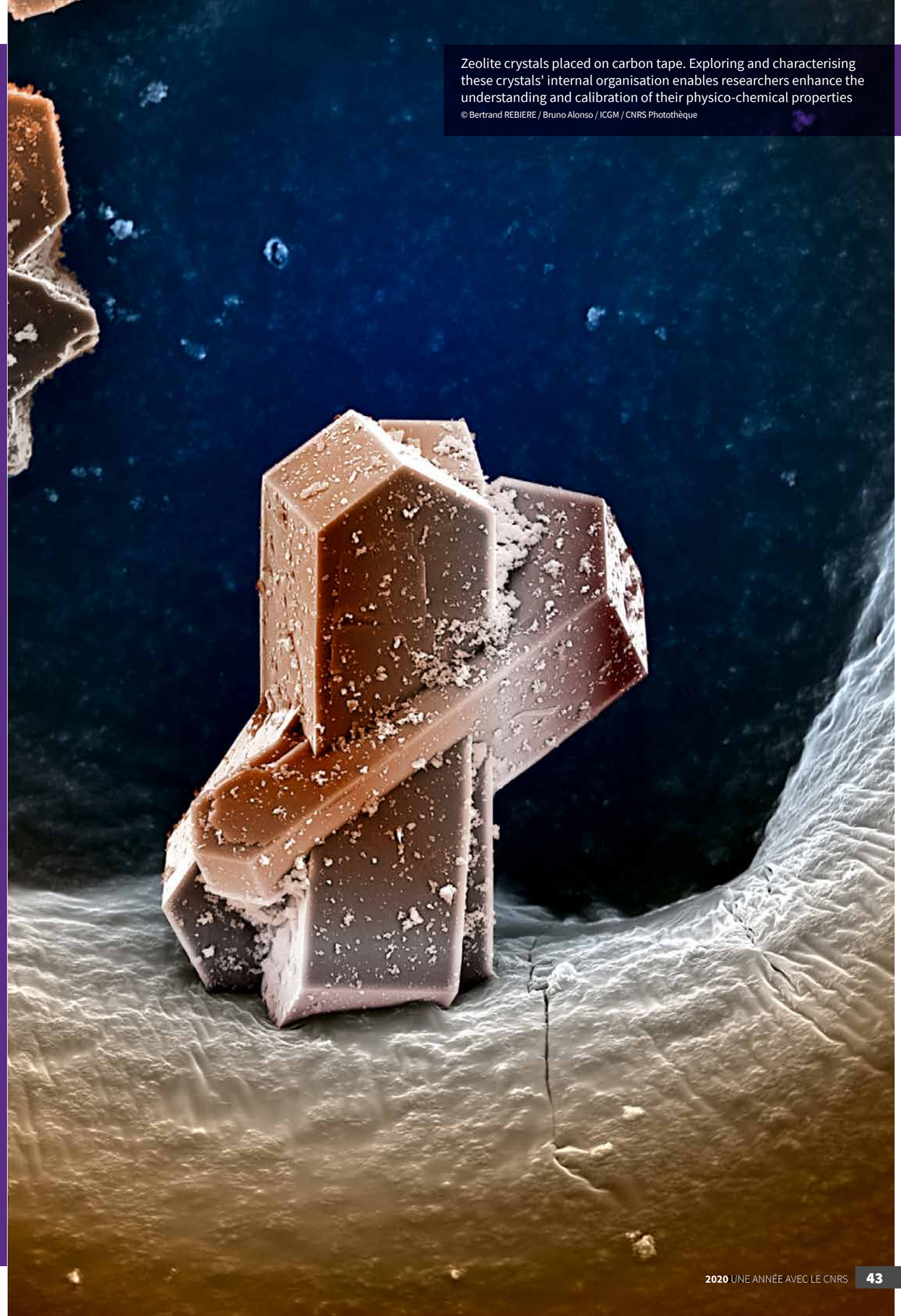
FOCUS ON A **JOINT LABORATORY**

Supporting learning

The Script&Labs joint laboratory involving the Learn&Go SME and the Irisa (Research Institute of Computer Science and Random Systems)[1] developed and industrialised the Kaligo software. This uses artificial intelligence to support pupils learning handwriting and mathematics.

SCIENCE
IN 2021

Climate change, educational inequalities, artificial intelligence, health and the environment, territories of the future and the energy transition are the six major societal challenges which the CNRS is responding to through the broad spectrum of its chosen scientific themes and by using its expertise in interdisciplinarity.



Zeolite crystals placed on carbon tape. Exploring and characterising these crystals' internal organisation enables researchers enhance the understanding and calibration of their physico-chemical properties

Alain Schuhl,
Deputy CEO
for Science

© Frédérique Plas/CNRS Photothèque

What role does the CNRS play in world research?

The CNRS carries out world-class basic research, cooperates with the most internationally renowned institutions and promotes scientific collaboration initiatives with laboratories all over the world. For example, in 2021 we set up two new offices in Australia and Canada to develop and enhance our scientific collaboration with Oceania and Canada. In December, the organisation also presented its "Africa Plan". This sets out a 10-year roadmap for building long-term scientific cooperation initiatives with Africa, where the number of publications has doubled in less than 10 years. In spring 2021, the CNRS also unveiled its European strategy which sets out over 20 actions to enhance its participation in the European Union's research and innovation programmes. These ideas include setting up mirror groups to promote the CNRS's position on the themes of future European calls for projects by the Ministry or Brussels, as well as appointing a manager to coordinate and increase the impact of our scientific projects with our European partners.

In France, the CNRS has vowed to respond to six societal challenges – climate change, educational inequalities, artificial intelligence, health and the environment, territories of the future and the energy transition. How would you describe the dynamic implemented to achieve this?

The CNRS aims to make a significant contribution to the response to these six societal challenges thanks to our broad disciplinary coverage. To achieve this, we have set up a working group for each challenge featuring representatives from all the CNRS institutes in order to provide new multidisciplinary solutions that complement existing disciplinary approaches. These working groups also help to strengthen the organisation's involvement in France's national research strategy by focusing on topics related to the PEPRs, which the CNRS steers or co-steers. How we approach these challenges varies according to the level of maturity of the research concerned and the initiatives that have already been implemented. Here are just a few examples of our first actions. The Artificial Intelligence challenge has already benefited from the launch of a digital interdisciplinary centre dedicated to "AI for science, science for AI" with funding of 1 million euros to date. To respond to the Educational Inequalities challenge we have recruited six dedicated doctoral students while our response to the Health and Environment challenge involved a call for interdisciplinary scientific projects dedicated to three multidisciplinary observatories – in the Camargue area, the Seine Territory and at i-Globe.

“OPEN SCIENCE – A PRIORITY FOR THE CNRS”

This year the HAL platform celebrated its 20th anniversary. What are the organisation's ambitions and priority issues regarding open science?

Open science is one of the CNRS's priorities and we strive to make scientific productions and data accessible. To achieve this, the evaluation of researchers has evolved to take greater account of the wide range of their missions and to make evaluation compatible with open science. The CNRS increased the number of its open access publications to nearly 80% in 2021 with a significant 10% rise in one year. The CNRS's data protection policy is part of the national strategy supported by the Ministry of Higher Education, Research and Innovation, which aims to set up a national data warehouse that will make the data involved "FAIR" – Findable, Accessible, Interoperable and Reusable.

ARTIFICIAL AND DIGITAL INTELLIGENCE

PR2, an autonomous service robot capable of recognising objects.
© Cyril Fresillon / LAAS-CNRS / CNRS Photothèque

AI for science, science for AI

At the end of November, the CNRS launched the interdisciplinary digital centre "AI for science, science for AI" which our Innovation Office provided with funding of €1 million. This centre is unique within the European research landscape and aim to respond to major scientific challenges and promote the emergence of new subjects for study at the interfaces between disciplines.

SCIENCE IN FIGURES

22
Nobel Prize winners

12
Fields Medals

Over
100
Academicians (Académie Française)

Nearly
80%
of CNRS publications in open access

The Balard pole's new building in Montpellier.
© Reichen et Robert & associés

A new excellence pole in chemistry

The Balard pole is housed in a new 25,000 m2 building on CNRS land and is funded by a State-Region contract with the Occitania/Pyrenees-Mediterranean region Region. It includes most of Montpellier's chemistry laboratories including the ICGM (*Charles Gerhardt Institute in Montpellier*)[1] and the IBMM (*Max Mousseron Biomolecules Institute*)[2] and will house all their teams on the same site thus rationalising costs and creating a whole new dynamic. This agreement was in preparation for 10 years before it was signed and provides for the pole's computing resources to be transferred to the National Computing Centre for Higher Education (CINES) in Montpellier which is one of France's three national computing centres.

HEALTH

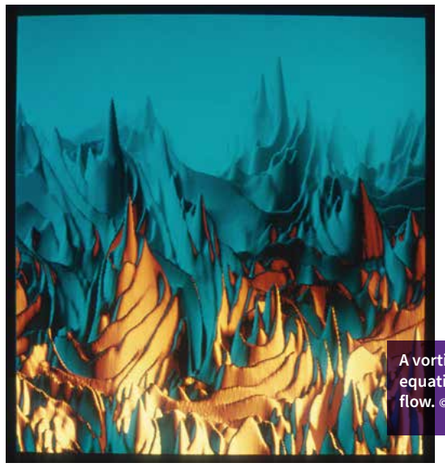
HSS involvement in the health crisis

In November 2020, the CNRS Institute for Humanities and Social Sciences (INSHS) published a report entitled "Les sciences humaines et sociales face à la première vague de la pandémie de Covid-19 – Enjeux et formes de la recherche". (*The Humanities and Social Sciences faced with the first wave of the Covid-19 pandemic - Issues and forms of research*). This report summarised current knowledge and the research questions that need to be addressed. It was written between the end of the first lockdown and the start of the second wave of the pandemic and reports on research carried out during that period, for example on subjects like open science, new methodologies in lockdown periods and strengthening collaboration between research disciplines. The analyses therein were updated for the publication of a collective work, "La Pandémie, un fait social total" (The Pandemic – a total social reality, CNRS Éditions, October 2021).

Olfactory rehabilitation with Covidanosmie.fr

The Covidanosmie.fr application optimises the olfactory rehabilitation of patients. It was designed by a team of medical experts and scientists from the CNRS, the Regional and University Hospital Centre of Tours and the University of Tours who worked alongside members of the patients' association "anosmie.org" and the Kelindi start-up which developed the application.

ENVIRONMENT



A vorticity field. A solution to the Saint-Venant equations simulating a two-dimensional turbulent flow. © M FARGE/Jean-François COLONNA/CNRS Photothèque

Mathematics working for the planet

On May 20th 2021, the CNRS and its partners[1] founded the Institute of Mathematics for Planet Earth to strengthen the collaboration of mathematicians and experts in all dimensions of Earth system science. It aims to respond to the environmental challenges of today and tomorrow.

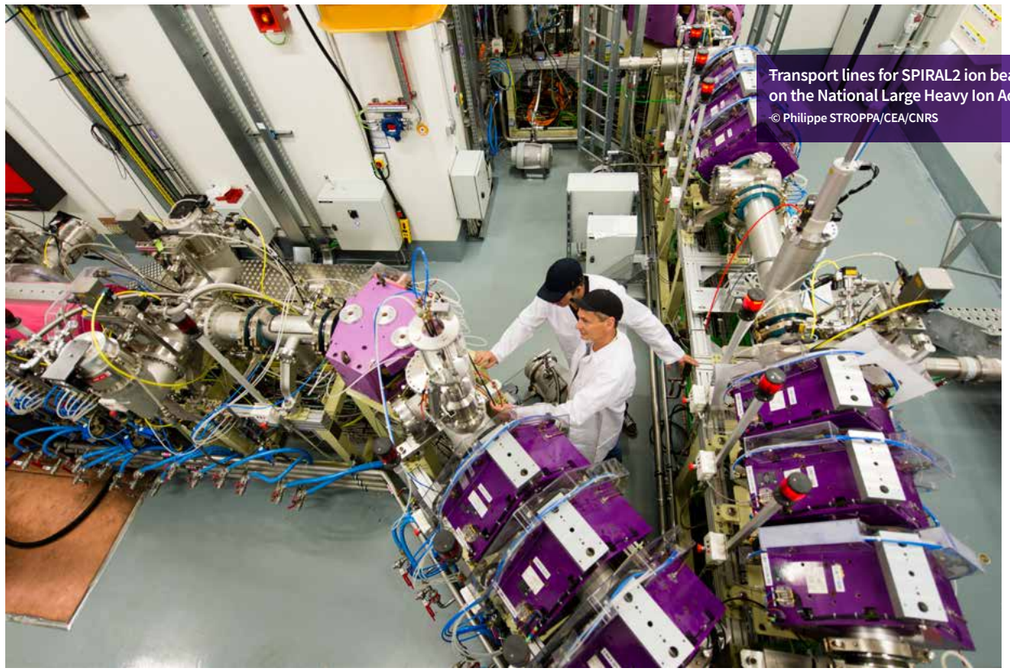
Sustainable development

In December Antoine Petit, CNRS Chairman and CEO, and Philippe Mauguin, the Chairman and CEO of the INRAE, signed a five-year framework agreement to respond to climate, health and environmental challenges.

Federating study of research's carbon footprint

The "Labos 1point5" Research (GDR) was launched in June 2021 and is supported by the French Agency for Ecological Transition (ADEME), the INRAE and the CNRS. It aims to structure study of the carbon footprint of French research over a period of 5 years. It measures and characterises French public research's carbon footprint in terms of greenhouse gas emissions, studies the organisation and practices of research in relation to this footprint while supporting and facilitating the implementation of reduction initiatives in laboratories.

PARTICLE PHYSICS



Transport lines for SPIRAL2 ion beams installed on the National Large Heavy Ion Accelerator (GANIL). © Philippe STROPPA/CEA/CNRS

The Spiral2 accelerator starts its first experiments

The Ganil-Spiral2 accelerator in Caen is jointly run by the CNRS and the CEA and has been operational since autumn 2021. It is more flexible than its predecessor and can produce both light particles and heavy ions.

The IN2P3's 50th anniversary

April 14th 1971 was the birthdate of the National Institute of Nuclear and Particle Physics (IN2P3). The Institute invited all its staff and partners to an inaugural event on April 14th 2021 attended by Antoine Petit, Chairman and CEO of the CNRS to mark its 50th anniversary and kick off celebrations in all its laboratories from April to October 2021.

The National Institute of Nuclear and Particle Physics Computing Centre (CC-IN2P3) designed and operates a system for the mass storage and processing of large amounts of data used in numerous international experiments. © Cyril FRESILLON / CC IN2P3 / CNRS Photothèque

WATER

Samples of water being taken from the Mangrove at Le Moule in Guadeloupe.
© Cyril FRESILLON / PEPSEA / CNRS Photothèque

A cell dedicated to important water issues

The CNRS launched its Water Unit on March 22nd, World Water Day. This unit is a true vector for cross-disciplinary research on subjects ranging from the availability and distribution of freshwater to how it is used in agriculture and the ensuing consequences for water quality, biodiversity and so forth.

7

station ships are operated by the CNRS and are part of the French oceanographic fleet which is one of the three largest fleets in Europe.

The CNRS is structuring French port research

The French Directorate-General for Transport, Infrastructure and the Sea requested that the CNRS draw up an inventory of French port research published in a white paper in early 2022. This request was part of the national ports strategy presented at a meeting of an Interministerial Committee for the Sea (Cimer) at the start of 2021. The overall strategy aims to enhance the competitiveness and attractiveness of French ports worldwide. It will notably be funded through the "France Relance" recovery plan which set aside €175 million to accelerate the ecological transition of French ports between 2020 and 2022 alongside other investments in the railways, river transport and alternative fuels like hydrogen.

A new Research Network (GDR) for Oceans

The "Omer" GDR was launched in January 2021 for a 5-year period and aims to make multi-disciplinarity its watchword by combining philosophy, the climate, sociology, maritime law, biodiversity and even signal processing of new sensors to study oceans. Ultimately, this GDR should bring together 4 to 5000 researchers to work on four central axes - the contextualisation of goods and services provided by oceans, using innovation to characterise the current state of oceans, modelling oceans and their evolution and the conservation, preservation and sustainable management of marine socio-ecosystems.

SUPPORTING RESEARCH

The CNRS Foundation extends its activities

On January 8th 2021, the CNRS inaugurated the Rescue Ocean Foundation - the first foundation under the authority of the CNRS Foundation which funds scientific projects. Rescue Ocean's aim is to develop initiatives through which citizens can contribute to research projects linked to the ocean and its preservation. These include training volunteers to collect plastics in the framework of the Preventing Plastic Pollution programme or supporting the ocean racing sailor Axel Thréhin, the association's ambassador by equipping his boat with microplastic sensors. Finally, Rescue Ocean will enable the MARBEC[1] laboratory to complete the genetic reference database containing rapidly consultable and exhaustive diagnoses of marine biodiversity worldwide. Through this work the Foundation aims to effectively accompany non-profit-making projects supported by donations and sponsorship working on subjects like the development of free software and data.

Biologists, ecologists, hydrogeologists and sociologists sample soil together to study the invisible underground environment in the framework of the winning Rivers2070 project selected by the 80|Prime programme.
© Laurent Longuevergne/CNRS

80

winning projects have been selected in the third edition of the 80/Prime programme which provides interdisciplinary, multi-team research projects with a maximum annual budget of €30,000 per year over two years.

The CNRS demands the release of Fariba Adelkhah

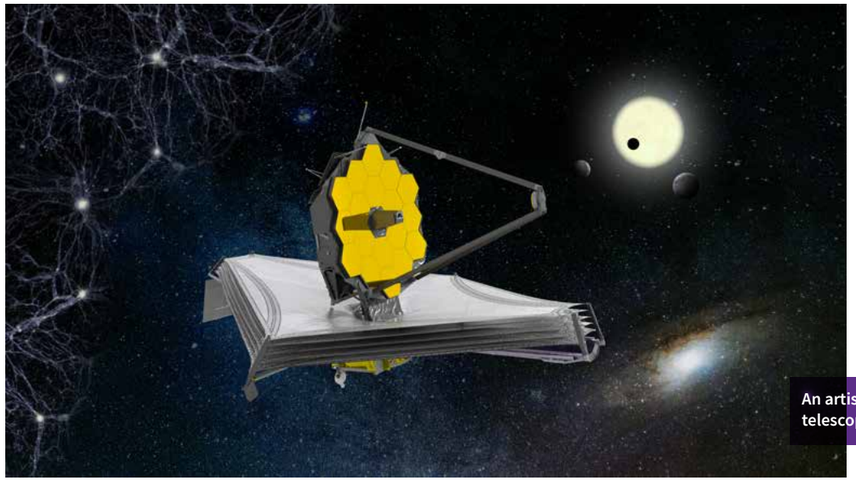
The CNRS strongly condemns the arbitrary detention of Fariba Adelkhah, an anthropologist and research professor at the CERI (*International Research Centre*)[2] who was imprisoned in Iran on June 5th 2019. She was under house arrest wearing an electronic bracelet on October 3rd 2020 but was put back into prison on January 12th 2022. The CNRS deeply regrets her imprisonment which it sees as a threat to the free movement essential for researchers and calls for her permanent release.

SPACE

An artist's view of the SuperCam instrument installed on board the Perseverance rover from the film "Supercam, des yeux et des oreilles sur Mars" (***Supercam - eyes and ears on Mars***). © CNRS / CNES - 2021

SuperCam, the Swiss Army Knife of Mars research

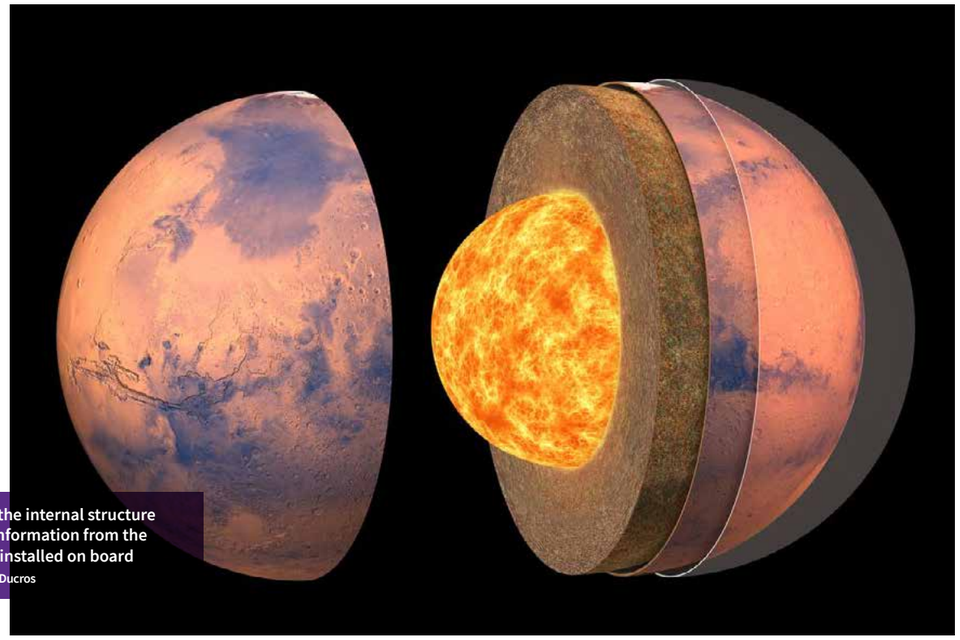
On February 18th 2021, the Perseverance rover landed on Mars, equipped with the SuperCam instrument developed jointly by CNRS laboratories and their partners along with the Los Alamos National Laboratory (USA). The SuperCam confirmed that the Jezero crater where the rover landed was indeed the site of a lake 3.6 billion years ago. These conclusions were published in the Science journal by an international team led by Nicolas Mangold, a CNRS research professor working at the Laboratory of Planetology and Geosciences[1] and including French scientists from Claude Bernard University-Lyon 1 and the University of Toulouse III Paul Sabatier[2]. SuperCam is seen as a true "Swiss Army knife" for the mission, capable of carrying out a myriad of tasks, equipped as it is with five measurement techniques designed to study the geology of the planet Mars and help select the samples for the rover to collect.



An artist's view of the James Webb telescope. © ESA/ATG medialab

The James Webb telescope is launched successfully

On December 25th 2021, the James Webb Space Telescope was successfully launched into space. It is equipped with the French MIRIM imager (MIRI iMager) developed by the CEA and teams from the CNRS and its partners[1] under the overall authority of the CNES.



An artist's view of the internal structure of Mars based on information from the SEIS seismometer installed on board InSight. © IPGP/David Ducros

The secrets of the Martian underground are revealed

Around ten earthquakes were detected on Mars by the SEIS broadband seismometer under the scientific authority of the Paris Globe Institute of Physics[3]. Now an international team of researchers from the CNRS and its partners[4] has made the first estimates of the size of the planet's core, the thickness of its crust and the structure of its mantle. The team's findings were published in three studies in the journal Science in July. This is the first seismological exploration of the internal structure of a terrestrial planet other than Earth and is an important step towards understanding the formation and thermal evolution of Mars.

OPEN SCIENCE

Working towards truly open science through publications and data

Nearly 80% of CNRS publications were in open access in 2021. This success reflects the organisation's proactive policy particularly through its modernisation of researcher evaluation and the decision to make deposits in the HAL open archives compulsory. Moving on from publications, the CNRS is committed to the sustainability of research data which is to be achieved through a national data warehouse as the organisation noted the absence of a long-term storage strategy in over 60% of its laboratories.

16

projects coordinated by the CNRS were selected following the EquipEx+ call for expressions of interest which is part of the 3rd Investments for the Future Programme (PIA3)

HAL's 20-year commitment to open science

On November 24th, the HAL open archive celebrated the 20th anniversary of its launch by the CNRS. It now contains over 2.7 million scientific documents and is made up of 139 institutional portals covering all scientific communities and a major part of French research institutions.

INTERNATIONAL

The CNRS has a presence on every continent and partnerships with the most internationally renowned institutions with which it conducts fundamental research at the highest global level.

EUROPE

Status report on the Horizon 2020 research programme

On January 1st 2021, the Horizon Europe programme replaced the Horizon 2020 research programme, the European Union's flagship research and innovation programme with its budget of almost €80 billion over seven years. The CNRS was the leading beneficiary organisation in France and Europe with a total of 1843 contracts signed for net funding of nearly €1.2 billion. The organisation's projects funded by this programme have an average success rate of more than 19%, placing the CNRS in first place among G6 research institutions. The funding received by the CNRS increased by more than 48% compared with the previous programme.

Amanda Silva Brun, co-founder of the EVerZom start-up, monitoring the production of extracellular vesicles in a stirred tank bioreactor.
© Frédérique PLAS/CNRS Photothèque

5

start-ups from the laboratories of the CNRS and its partners were selected in the European Innovation Council's Accelerator call and were awarded funding ranging from 2 to 10 million euros - Alice & Bob[1], EVerZom[2], Qubit Pharmaceuticals[3], Lactips[4] and Aenitis[5].

Working towards an innovative Europe

13 projects linked to the CNRS were winners in the European Innovation Council's EIC Pathfinder programme the objective of which is to detect and develop technological innovations liable to create medium- or long-term markets. CNRS is also the coordinator of 5 of the 6 projects led by French organisations. .

The first Franco-Spanish joint laboratory

FSLAC, the first French-Spanish International Research Laboratory (*French-Spanish Laboratory for Astrophysics in Canarias*), is the result of earlier collaboration initiatives between the CNRS and the Instituto de Astrofísica de Canarias (*Institute of Astrophysics of the Canary Islands, IAC*). It focuses on three main lines of research involving heavy equipment in very high-energy gamma-ray astronomy, solar physics and the effective measurement of the microwave cosmological background.

Roadmap for Europe

The Roadmap for Europe sets out the CNRS's European strategy for continuing and developing its participation in European programmes and increasing its influence in the European Research Area. It is organised in three complementary sections based on the following three watchwords - influence, support and encouragement. Twenty actions have been put forward and the first target is the new Horizon Europe Framework Programme for Research and Innovation for 2021-2027 with its budget of over €95 billion.

Germany-France: a delegation to bolster scientific collaboration

On September 27th, the CNRS and its Chairman and CEO Antoine Petit highlighted French scientific collaboration with Germany by receiving a delegation of presidents, vice-presidents and chancellors from nineteen German universities. Their visit was part of a one-week stay intended to enable the German delegation to get to know French research and higher education actors better.

A new Franco-Italian laboratory

In December, the CNRS and the Istituto Nazionale di Alta Matematica (the Italian research organisation that manages, promotes and coordinates mathematical research in Italy) set up the Ypatia Laboratory of Mathematical Sciences (LYSM). This is the CNRS's second International Research Laboratory (IRL) in Italy.

INTERNATIONAL FIGURES

80
international research laboratories including 5 created in 2021

Nearly 300
international research projects and networks underway in 2021 including over 60 new additions

Over 650
winners of European Research Council (ERC) grants including 62 in 2021

CNRS is the 1st
beneficiary organisation of the Horizon 2020 programme with over 1800 contracts signed for a total of nearly 1.2 billion euros

Over

50

projects presented at a midterm status meeting in Strasbourg in November were funded by the Make Our Planet Great Again (MOPGA) programme. Thanks to MOPGA, 21 American award winners have come to France to work on climate change research.

Russia: 20 years of collaborative research

In March 2021, the CNRS celebrated the 20th anniversary of the Interdisciplinary Scientific Centre Poncelet in Moscow, a fundamental mathematics, mathematical physics and theoretical computer science laboratory.

A new International Research Laboratory (IRL) in Russia

In April the CNRS and the Institute of Archaeology and Ethnography of the Russian Academy of Sciences' Siberian Branch (IAET, RAS) created the joint international laboratory ArchaeoZOOlogy in Siberia and Central Asia (ZooSCAn) which studies human/non-human animal relationships in these regions from the Pleistocene to the early Holocene.

AMERICA

An aerial view of Biosphère 2 at Oracle in Arizona. © Biosphere 2/University of Arizona

The first International Research Centre (IRC) in Arizona

On April 14th, the CNRS and the University of Arizona signed a partnership agreement to set up the organisation's first-ever environmental and space research and data science IRC.

The French research visit to America

In December Antoine Petit, the CNRS Chairman and CEO, accompanied Frédérique Vidal, the Minister of Higher Education, Research and Innovation along with other representatives of French research to the sixth Franco-American Joint Committee Meeting on Science and Technology Cooperation (Comix) held in Washington. The objective of this meeting was to boost collaboration between France and the United States in the areas of the environment, health and the battle against climate change while also defining priority collaboration initiatives based on emerging technologies. The result of the meeting was a promised framework agreement between the American National Science Foundation (NSF) and the French National Research Agency (ANR) to encourage and facilitate exchanges of researchers and scientific data between the two countries.

OCEANIA

The first International Research Laboratory (IRL) in Australia

The new IRL, Crossing, is the fruit of collaboration between the CNRS, IMT ATlantique, the University of Adelaide, Flinders University, the University of South Australia and the French Naval Group industrial company. It is dedicated to artificial intelligence and aims to find solutions for efficient and ethical collaboration between humans, artificial intelligence and autonomous systems.

AFRICA

A spectrocolorimetric analysis of a fragment of painted wall from earlier excavations at the shelter in Pomongwe in the Matobo Hills, Zimbabwe.
© Nicolas BAKER/TRACES/ARSCAN/CNRS Photothèque

A multi-year cooperation plan with Africa

The CNRS's objective is to improve and increase collaboration with African countries because Africa is a rapidly growing continent with great scientific potential. A call for proposals which closed in March 2021 made it possible to map the research interests shared by the CNRS and Africa thus heralding a multi-year roadmap particularly aimed at sub-Saharan African countries in the light of existing links with South Africa, the Maghreb countries and Egypt.

ASIA

An artist's view of the Hayabusa 2 probe.
© DLR/2018

€35 M

were allotted for five years to a major collaborative project on hybrid artificial intelligence led by CNRS@Create, a CNRS subsidiary in Singapore.

7th

IRL in Japan, ILANCE (International Laboratory for Astrophysics, Neutrino and Cosmology Experiments) - a partnership with the University of Tokyo which studies the infinitely small and the infinitely large.

A partnership between France and Japan to study an asteroid

The MicrOmega instrument was developed by the Institut Astrophysique Spatiale (*Institute of Space Astrophysics*)[1] and is used to analyse fragments of the Ryugu asteroid collected by the Hayabusa2 probe operated by the Japanese Space Agency (JAXA).

10 years of sustainable chemistry in Shanghai

The joint Eco-efficient Products & Processes laboratory run by the CNRS and Solvay celebrated its tenth anniversary this year and has been renewed for five years. It specialises in finding alternatives for sustainable chemistry particularly through catalysis and the replacement of petroleum derivatives.

An artist's view of the antennas of the Square Kilometre Array (SKA) radiotelescope.
© DLR/2018

A Data Challenge gold medal for France

A French team led by the Paris Observatory – PSL in collaboration with the CNRS, the Côte d'Azur Observatory and several French universities won the gold medal in the SKAO Data Challenge. This competition was launched by the intergovernmental Square Kilometre Array Observatory (SKAO) which has been tasked with building the world's largest ground-based radio telescope by 2027. This success was made possible by the GENCI's Jean Zay supercomputer developed by HPE and run by the CNRS's Institute for Development and Resources in Intensive Scientific Computing (Idris). In April, France also announced that it would be joining SKAO which was made up of seven countries at the time.

Over

40

doctoral contracts have been funded by the Joint PhD Programme since 2019. In 2021, the CNRS launched the 3rd Joint PhD Programme with notably the University of Arizona, the University of Tokyo and Wits University in South Africa and also two existing partners - the University of Toronto and Imperial College in London.

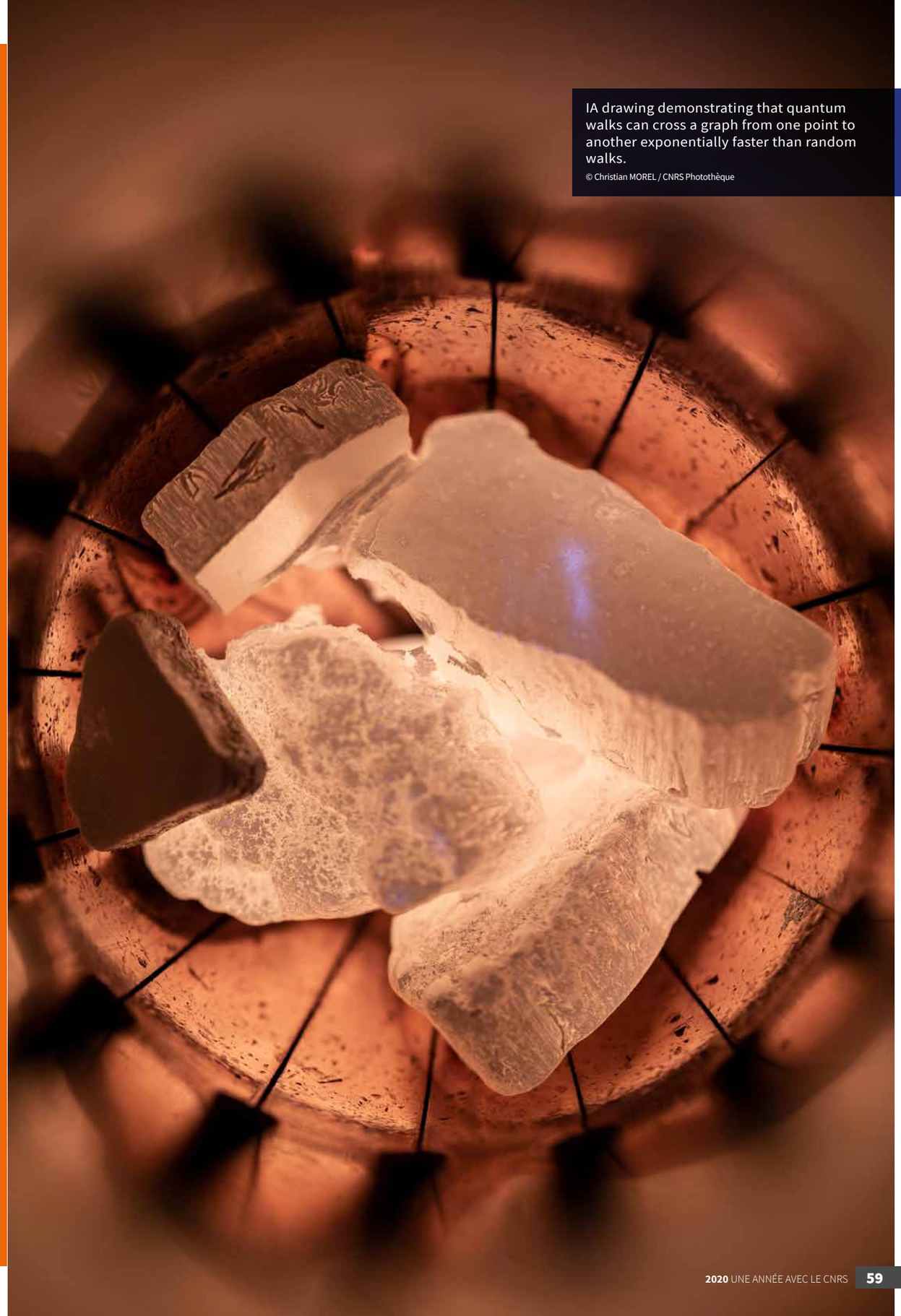
A world coalition for marine algae

The CNRS is responsible for the scientific steering of the Safe Seaweed Coalition, the first world coalition dedicated to the development of seaweed. It was launched on March 17th by the Lloyd's Register Foundation, the CNRS and the United Nations Global Compact (UNGC) and works on three main subjects namely food, environmental and workers' safety.

A tank used to cultivate microalgae, in this case spirulina. This cyanobacterium is the most widely produced in France and is considered a "superfood" because it is rich in proteins.
© Jean-Claude MOSCHETTI/AlgoSolis/CNRS Photothèque

INNOVATION
IN 2021

The CNRS uses its research excellence to promote the emergence of promising innovators and bring together people and skills to operate technology transfers.



IA drawing demonstrating that quantum walks can cross a graph from one point to another exponentially faster than random walks.

© Christian MOREL / CNRS Photothèque

Jean-Luc Moullet,
Deputy CEO
for Innovation

© Frédérique Plas/CNRS Photothèque

SMEs, VSEs and major companies all require the CNRS's scientific excellence to help them solve technological problems. How does the CNRS adapt to respond to these companies' specific requirements?

One of the organisation's strengths is its capacity to bring together high-level multidisciplinary experts to work on industrial issues in a coordinated way. This is of direct interest to industrialists, and it also enables us to fuel our research subjects by anticipating companies' scientific requirements. The CNRS Innovation Office plays a pivotal role in etablishing links with companies by creating a relationship of trust and a momentum that favours such exchanges. We work in close collaboration with our scientific institutes and regional offices to offer companies a very wide range of collaborations for identifying the right experts, services, research collaborations, joint laboratories, technological platforms, training, and so on. We also seek to identify and support inventions from our laboratories in order to gradually bring them to the level of technological maturity enabling their transfer to industry.

In 2021, the CNRS celebrated its 200th active joint laboratory. How do you explain the success of this type of partnership?

Joint laboratories run by the CNRS and a partner company have experienced a remarkable increase for several years now. Their number has doubled in five years and at least one is set up every two weeks. This success is based on the quality work of the researchers and laboratories involved, along with the relationship of trust established over time between companies and the CNRS, particularly through research collaboration initiatives. Joint laboratories are a very successful form of cooperation and make it possible to define concrete projects on which we can collaborate. They are based on a shared roadmap, common ambitions on an overall research theme, as well as shared governance and pooled resources. We are very proud that our joint laboratories are so long-lasting and that we have more than half a dozen with all our main partners – TotalEnergies, Michelin, Stellantis, Safran, Thalès and EDF. The watchwords of this success are trust, duration, flexibility and research excellence.

> “AT LEAST ONE JOINT LABORATORY IS SET UP EVERY TWO WEEKS”

The CNRS has established a specific activity oriented towards strategic industrial sectors. What are the first results of this new activity and what has been learnt from it?

A strategy aimed at industrial sectors was developed in 2019 and we have started to work on four priority areas namely vehicles and mobility, water, electronics, and new energy systems. The first stage involves mapping the CNRS's skills in each of these sectors and accurately identifying the right laboratories and dedicated expert researchers. This approach has enabled us to maintain a sustained dialogue with the CNRS's historical partners and initiate regular relationships with companies with which our contacts were previously more occasional. In the automotive sector, for example, this approach has enabled us to consolidate long-term connections with Renault, Stellantis and Michelin and develop new ones with Faurecia, Valeo and Plastic Omnium.

START-UPS

Prematuration - the springboard for innovation

In 2021, the CNRS prematurity programme funded 62 projects with its €7M budget. Through this programme, the CNRS supports the first stages of development of innovative projects thus facilitating their transfer to industry or the creation of companies.

RISE, tailored support for entrepreneurship

In 2021, the RISE programme run by CNRS Innovation helped 25 Deeptech companies to roll out more quickly in France and internationally. It acts as the CEO and puts them in contact with entrepreneurs and also mentors - scientists with entrepreneurship experience to better support scientists who are setting up start-ups and assist them in terms of positioning their product, studying real market needs and funding.

The prototype of the Cat-Qubits chip developed by the Alice & Bob start-up.
© Hubert RAGUET / Alice&Bob / LPENS / CNRS Photothèque

FOCUS ON A **START-UP**

The Alice&Bob start-up[1] aims to develop an operational universal quantum computer in five years based on an innovative quantum bit which is capable of self-correcting its errors. The CNRS made an investment in the company's equity in 2020 through CNRS Innovation.

INNOVATION IN FIGURES

80
start-ups supported by RISE including 25 new RISE projects in 2021

122
prematuration projects including 62 in 2021

Nearly
210
joint CNRS/company research structures including 35 joint laboratories set up in 2021

21
framework agreements with major companies including 4 new agreements in 2021

Over
8500
patent families including over 400 filed in 2021

69
winners in innovation competitions including 27 i-PhD, 31 i-Lab and 11 i-Inov winners

27
labelled Carnot Institutes linked to CNRS laboratories

"De Chercheur à Entrepreneur" (***From Researcher To Entrepreneur***), the first episode of the Deeptech series dedicated to research and entrepreneurship issues. © CNRS - 2021

A new mini-series on Deeptech

In partnership with the magazine Maddyness, the CNRS puts the spotlight on its researcher-entrepreneurs through a mini-series "Deeptech, au cœur des innovations de rupture" ("*Deeptech, at the heart of breakthrough innovations*") which has been available on the CNRS YouTube channel since March 2021.

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start-ups derived from laboratories under the CNRS's authority were rewarded by the French Tech Next 40/120 programme.

€250 M technology transfer funding for Corlieve Therapeutics

The Corlieve Therapeutics start-up derived from the Interdisciplinary Institute for Neuroscience[1] and the Mediterranean Institute of Neurobiology[2] has joined the uniQure company. Corlieve is developing a gene therapy to treat temporal lobe epilepsy.

31

projects linked to the CNRS (over 40% of the projects rewarded) were winners in the 23rd i-Lab innovation competition which detects and promotes the emergence of business creation projects.

A transfer platform for life science laboratories

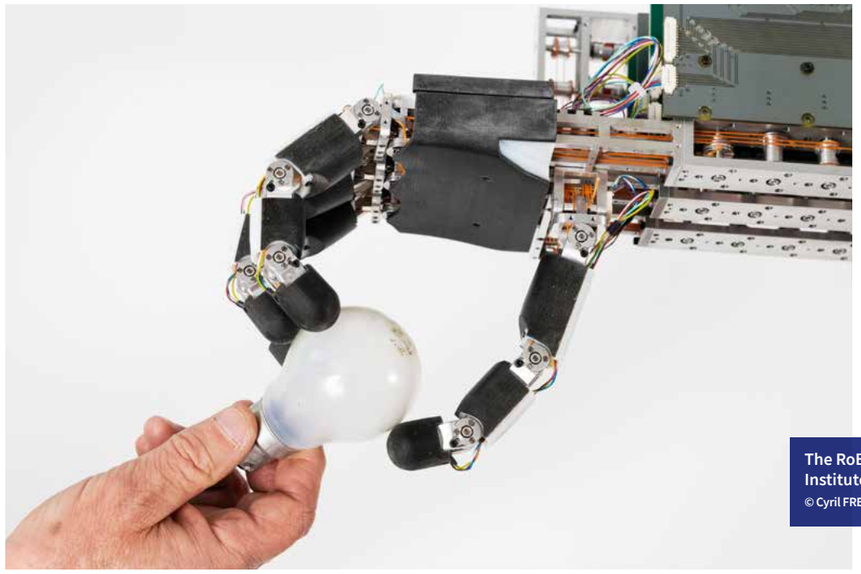
After two years of fruitful collaborative work, the CNRS has taken a financial stake in the Idylle platform dedicated to marketing innovative laboratory-designed research tools to enable the transfer of these tools to user communities. Idylle thus encourages exchanges between laboratories and is benefiting from financial support from the Banque des Territoires, the State's operator for the "University and Research Companies" component of the Investments for the Future (PIA) programme.

Equity investment

CNRS Innovation has made 48 equity investments in start-ups from laboratories under the authority of the CNRS and its partners to support their entrepreneurial initiatives including three in 2021. The BioProtection Laboratory start-up is developing a non-toxic, 100% bio-inspired mosquito repellent spray, Ion-X is preparing to market a new compact high-performance propulsion technology for satellites and Xdigit[1] makes CMOS image sensors which are innovative hybrid IP solutions

The world leader in the food sector Eurofins came from public research and entered the CAC 40

The Eurofins start-up was created in the 1980s and is now a global industrial corporation specialising in health checks and the excellence of medical biology. It has historical links to the CNRS and the University of Nantes. On September 17th 2021, Eurofins entered the CAC 40.



The RoBioSS team from the Pprime Institute was present at VivaTech.
© Cyril FRESILLON / PPRIME / CNRS Photothèque

The CNRS once again present at Vivatech

Once again, the CNRS took part this year in Europe's largest tech event, Vivatech, from June 16th to 19th 2021 in Paris. The organisation was thus able to showcase quantum technologies, hydrogen and medtech from over twenty start-ups from CNRS laboratories and its partners at the event.

11

start-ups from the CNRS have been rewarded by the i-Nov innovation competition in recognition of their particularly high potential for the French economy.

Four new framework agreements with major industrial companies

The CNRS signed four new framework agreements in 2021 to facilitate and accelerate the implementation of joint research projects between laboratories and large industrial companies and act as the basis for future scientific collaboration:

- With Naval Group to master complex digital systems and naval acoustics and further strengthen this field of excellence for naval defence applications.
- With Air Liquide, to respond to major industrial and societal challenges of the future like ceramic materials, additive manufacturing, hydrogen production and recovery, the transformation and reuse of CO_2, biogas generation and artificial intelligence.
- With Orano to develop geology, chemistry and radiochemistry research and applications related to radionuclides.
- With Faurecia to design the Cockpit of the future (with particular emphasis on human-vehicle interactions and cockpit heat management), hydrogen systems and sustainable materials (particularly involving the circular economy).

Antoine Petit, the CNRS Chairman and CEO, Jean-Luc Moullet, the CNRS Deputy CEO for Innovation, Paul-François Fournier, executive director of Bpifrance, Nicolas Dufourcq, CEO of Bpifrance and Johanna Michielin, director of CNRS innovation at VivaTech 2021. © CNRS

Supporting the creation of start-ups from public research

On June 16th 2021, Antoine Petit, the CNRS Chairman and CEO, Nicolas Dufourcq, CEO of Bpifrance, and Johanna Michielin, director of CNRS innovation, signed a convention at the VivaTech event to boost the transfer of public research results, particularly through setting up start-ups

Limiting particle emissions when trains brake

The Laboratory of Industrial and Human Automation, Mechanics and Computer Science (LAMIH)[1] is a partner in the Breaq project funded by the ADEME and piloted by Alstom. The aim of Breaq is to enhance understanding of the mechanisms for the production and diffusion of fine particles when trains brake.

The sociologist Mathias Blanc from the IRHis, co-developer of the Ikonikat application, analyses and compares the traces of different users of the interface.
© Claire-Lise HAVET/Musée du Louvre-Lens/IKONIKAT/CNRS Photothèque

Another view of art with Ikonikat

The Ikonikat application was developed by the Septentrion Historical Research Institute (IRHis)[2] and the "Sciences et Cultures du Visuel" Research Federation[3]. It explains to users what they perceive when looking at a work of art. Ikonikat was tested at the Louvre in Lens and is now available on the Orange Foundation's cultural MOOC platform.

Energy solutions at the Sustainable Energy Forum

The Sustainable Energy Forum was organised on July 6th 2021 by the Hub Institute in collaboration with the CNRS. The event attracted over 1500 decision-makers from the public and private sectors who discussed clean and low-carbon energy sources and opportunities thrown up by the green and circular economy.

Successfully banking on sectors

In 2021, the CNRS Business Relations Department implemented the organisation's strategy aimed at industrial sectors which had been developed in 2019 and involved the creation of eight sector-based teams. This approach to the energy, health, automotive, aeronautics, electronics, water, cosmetics and materials chemistry sectors has enabled the CNRS to reinforce its dialogues with its historical partners. The organisation has also been able to develop deeper relationships with companies with which it may previously have had more ad hoc relationships.

INTELLECTUAL PROPERTY

Intellectual property – a core strategic issue

The CNRS is the co-owner of around 8500 patent families and has reaffirmed its licensing strategy which grants industrial companies or start-ups a monopoly of usage on their own inventions while these are under development. This secures their investments until the inventions are ready to go on the market.

JOINT LABORATORIES

The CR2ME LabCom run by Lasire and TotalEnergies aims to chemically characterise new materials for applications in the energy sector.
© Sabrina NEHMAR/CNRS Images 2021

New joint laboratories

The advantage joint laboratories have over one-off research projects is that they establish a grounded relationship between the CNRS and a company for an average of five years. During this time they share the same roadmap and focus on the same concerns linked to an overall research theme to develop tangible subjects or projects to work on together. In 2021, the CNRS had nearly 210 joint laboratories including 35 created that year. These include: the CR2ME from the collaboration between LASIRE (*Spectroscopy Laboratory for Interactions, Reactivity and the Environment*)[1] and TotalEnergies for the chemical characterisation of new, more durable materials in the energy sector that will enhance the reliability and safety of all-solid batteries; Nano-PtoV, based on collaboration between the Laboratory of Astrophysics of Marseille[2] and Winlight System to work on advanced optical systems; ChemInTag (Chemical Inorganic Taggants) which results from collaboration between the Rennes Institute of Chemical Sciences[3] and the Olnica company and develops traceability solutions based on new generation luminescent markers.

The LCTS[1] – one of the CNRS's first joint laboratories

Safran Ceramics, the CEA, the University of Bordeaux and the CNRS have been working together for over thirty years within the Laboratory of Thermostructural Composites (LCTS). This work has led to the development of processes and materials that Safran still uses to produce several hundred tonnes of brake discs per year.

TOP 10
of the CNRS's main industrial partners in joint laboratories (and the number of laboratories involved):

TotalEnergies (12), Michelin (8), Stellantis (8), EDF (7), Safran (7), Thales (7), Solvay (5), Naval Group (3), Saint Gobain (3), CILAS-ArianeGroup (3), Groupe Airbus (3)

The Palais Brongniart where the Labcom event was held in the honour of joint CNRS/company laboratories.
© www.k-alex.com

The CNRS celebrates its 200th active joint laboratory

On November 29th the CNRS celebrated the creation of its 200th active joint laboratory run with a company at the Palais Brongniart in Paris. The event was attended by the Minister for Higher Education, Research and Innovation and many directors of our partner companies. Fifteen achievements from joint laboratories working on sustainable development, the industry of the future, mobility or new technologies were demonstrated to the general public the following day.

EUROPE / INTERNATIONAL

5

start-ups from CNRS laboratories and those its partners - Alice & Bob[1], EVerZom[2], Qubit Pharmaceuticals[3], Lactips[4] and Aenitis[5] - were rewarded by the European Innovation Council and will receive funding ranging from €2 million to €10 million in the framework of the EIC Accelerator call.

Photonics experts working for European SMEs

The CNRS is a partner of PhotonHub Europe, a one-stop shop launched in January 2021 with a €19M budget which is dedicated to supporting European SMEs working on innovative projects involving photonics.

A letter to promote France's scientific attractiveness

The CNRS, Business France and the National Agency Dedicated to the Internation-alisation of the French Economy signed a "letter of collaboration" on October 13th 2021 with a view to promoting France's scientific attractiveness abroad.

Intellectual property driving the growth of European SMEs

CNRS Innovation is a partner in the European Leadership4SMEs programme which encourages innovative start-ups and SMEs to exploit their intellectual property rights to better access funding and accelerate their growth.

A new "think tank" for a European strategy

The CNRS's Club Europe was launched at the start of 2021. It has around fifteen members including Air Liquide, Michelin and Thales and aims to effectively respond to and deal with the new Horizon Europe research framework programme and its directions and funding opportunities.

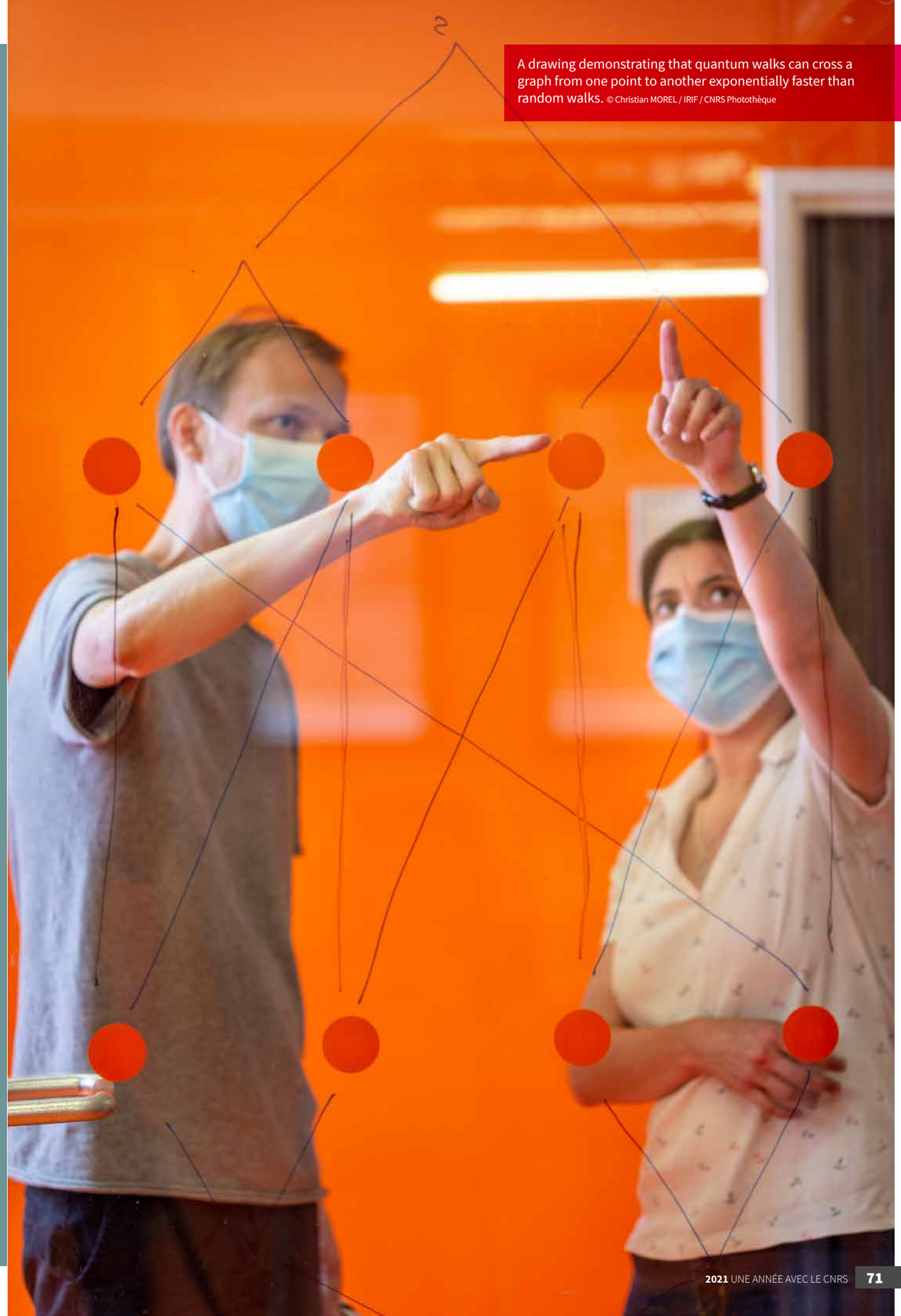
PIA4 - RECOVERY PLAN

Supporting companies through the France Recovery Plan

The CNRS committed to the R&D job preservation measure of the France Recovery Plan launched in response to the ongoing health crisis. An agreement to create nearly 300 jobs was signed with the National Research Agency in May 2021. Around 100 of these projects were signed off in 2021 in the framework of collaboration contracts with all types of companies ranging from large corporations to SMEs or start-ups.

RESOURCES
IN 2021

With salary upgrades, new work organisation, inclusion and training the CNRS is constructing its modern identity through its teams.



A drawing demonstrating that quantum walks can cross a graph from one point to another exponentially faster than random walks. © Christian MOREL / IRIF / CNRS Photothèque

Christophe Coudroy,
Deputy CEO
for Resources

The year 2021 was marked by the coronavirus just like 2020. How did this period affect CNRS support functions?

Our support functions were active on a daily basis to ensure the smooth running of our activities. Concerning IT, we provided secure electronic signature tools, opened a "portal for unit directors" containing all potentially useful information, and developed a training course available entirely online for finance and accounting staff. To support the return to physical presence at work at the start of the 2021 academic year, a set of reference sheets and documents was distributed on how to best strike the right balance between on-site and remote working, covering the practical organisation of work, meetings, spaces and so forth. A mass management training programme was launched in parallel. Finally, a fundamental study of the respective roles of the institutes and regional offices was carried out to enhance the complementary nature of their work alongside our laboratories. A major initiative aimed to clarify the positioning of the regional office's partnership and technology transfer services while the HR department carried out a more in-depth study of ten themes linked to modernisation.

The Research Programming Law and the Recovery Plan were implemented in 2021. What changes did they bring about?

Several decrees that are necessary to apply the research programming law were only published at the end of 2021, but salaries could be increased without delay. The research bonus was therefore brought to €1620 and €2220 for directors and researchers. In the engineers and technicians category, the IFSE allowance (for functions, constraints and expertise) rose significantly for technical assistants and to a lesser extent for other personnel ranks, for which this increase will be maintained in the coming years.
As far as the recovery plan is concerned, the 30 building projects selected were completed in 2021. With regard to contract engineering, we also supported the measure aimed at safeguarding R&D positions specifically intended to support jobs threatened by the crisis.

“ OUR SUPPORT FUNCTIONS WERE INVOLVED ON A DAILY BASIS TO ENSURE THE CONTINUITY OF OUR ACTIVITIES. ”

Which major modernisation projects were significant in 2021?

The joint contract with the Shared-Services Agency for Universities and Other Higher Education Institutions (AMUE) was signed in the summer of 2021 as planned. This means that in 2022 laboratories will have a common service provider for professional travel featuring a tool coupled with Etamine missions. This should simplify matters and thus be welcomed by all those involved. In the same vein, a tool that simulates and automatically generates research contracts was introduced in the autumn on an experimental basis.
It is also worth noting that the email system has been migrated to a new, more secure platform alongside the generalisation of individual email addresses to the cnrs.fr domain and the dematerialisation of payslips.

Delivery of two User First projects

In the framework of the User First project aimed at making life easier for laboratories, two of the eight projects to modernise IT systems were delivered in 2021. The first was the unit directors' portal which opened in June and facilitates the management of units particularly in terms of human and financial resources and laboratory life while the second was the automatic contract generation tool which opened experimentally in October for pilot units.

Collective thought about the positioning of SPVs

The organisation's partnership and technology transfer departments (SPVs) work at the crossroads of the objectives of the CNRS Scientific Office (DGDS), Innovation Office (DGDI) and Resources Office (DGDR) and are an integral part of an entire professional process - from the institutes to our laboratories. A great deal of work has been carried out to reinforce their position and thus ensure that all involved are effectively organised in the CNRS policy framework.

Quality of life at work

The CNRS launched two calls for projects in 2021 aimed at promoting the quality of life at work and in June also organised a dedicated week which ended with a widely-acclaimed webinar. Alongside these achievements, since 2017 196 winning projects from the "Quality of Life at Work" call for projects have benefited over 40,000 employees including more than 10,400 CNRS employees.

Psychosocial risks for researchers

In May 2021, the CNRS published a diagnosis of scientists' exposure to psychosocial risks. In September, a study group involving the unions represented on the CNRS Central Health, Safety And Working Conditions Committee (CCHSCT) was set up to help implement the new multi-year action plan for quality of life at work.

RESOURCES IN FIGURES

Over
33,000
staff members including 9000 contractual employees

Nearly
45%
women

Over
560
permanent staff recruited in 2021

Nearly
20%
of staff work from home

3rd
place in the top 10 of the favourite employers for students and young engineering graduates[1]

Près de
11,000
staff benefitted from training in 2021 with 30% using E-learning

For over 10 years, the CNRS has been committed to an ambitious proactive policy to recruit and maintain the employment of people with disabilities. © Adobe Stock

30

projects for the energy renovation of public buildings selected at interministerial level in the framework of the "France Relance" Recovery Plan were successfully completed in 2021

The CNRS plan for the disabled

The CNRS's disability action plan for 2020-2023 sets out the organisation's commitment to providing information on research professions to the disabled to help them construct their career plans. Therefore, in November 2021 the CNRS took part in DuoDay, an open day with volunteer professionals organised in the framework of the 25th edition of the European Week for the Employment of People with Disabilities (SEEPH).

The Research Programming Law (LPR)

Pay rises were implemented as part of the application of the research programming law. These meant that pay grades in higher education and research establishments were aligned with their interministerial equivalents while the salaries of researchers and academics in higher education and research were aligned as were those of engineers and technicians. The research bonus for researchers and research professors and the IFSE allowance (for functions, constraints and expertise) for engineers, technicians and administrators (IT) were thus increased in 2021 and will continue to increase until 2027.

850

CNRS staff members were given management training with 20% using e-learning

The management plan

The CNRS implemented several initiatives for its management staff through its management plan, notably: a precise definition of the managerial role and the managerial skills required to manage at the CNRS; providing newly appointed managers with a unique collective training system and personalised support (mentoring, assignment letters, astonishment reports, a review after four months) and mapping the 800 or so CNRS managers working outside the organisation to promote the creation of a dedicated network.

Dematerialised wage slips

As of August 2021, all CNRS employees were provided with a personal secure space containing their wage slips on the Public Finances General Directorate's ENSAP (*Secure Digital Space for Public Officials*) portal which is accessible 24 hours a day, 7 days a week.

Scientists discuss their work in a health context that still requires people to take care despite the decline in the Covid-19 epidemic. © Christian MOREL / IRIF / CNRS Photothèque

Post-Covid work organisation

Following on from the health crisis and the development of working from home, the CNRS carried out a study in which unit directors, research directors, heads of department and functional directors collaborated to rethink and adapt management to the new context. The aim of this is to change managerial practices, the way work is organised on a day-to-day basis, the way spaces are arranged and the use of digital tools. A series of fact sheets was distributed at the end of August 2021 to help achieve this.

Women at the CNRS

On November 19th and 20th 2021, the organisation celebrated the 20th anniversary of the CNRS Mission for Women's Integration with a hybrid conference held at the Town Hall in Paris's 11th arrondissement and also online. From November 8th to 30th, the "La Science taille xx elles" exhibition was installed on the gates outside the Hôtel de Ville of Paris. A new gender equality action plan for 2021-2023 was also implemented, focusing on 5 main issues:•

- Evaluating, preventing and dealing with gender-based salary differences.
- Ensuring equal access for women and men to ranks, grades and jobs.
- Enabling women to reconcile their professional lives with their personal and family lives
- Combating sexual and gender-based violence, harassment and discrimination.
- The governance, steering and monitoring of the professional equality policy.

Nearly

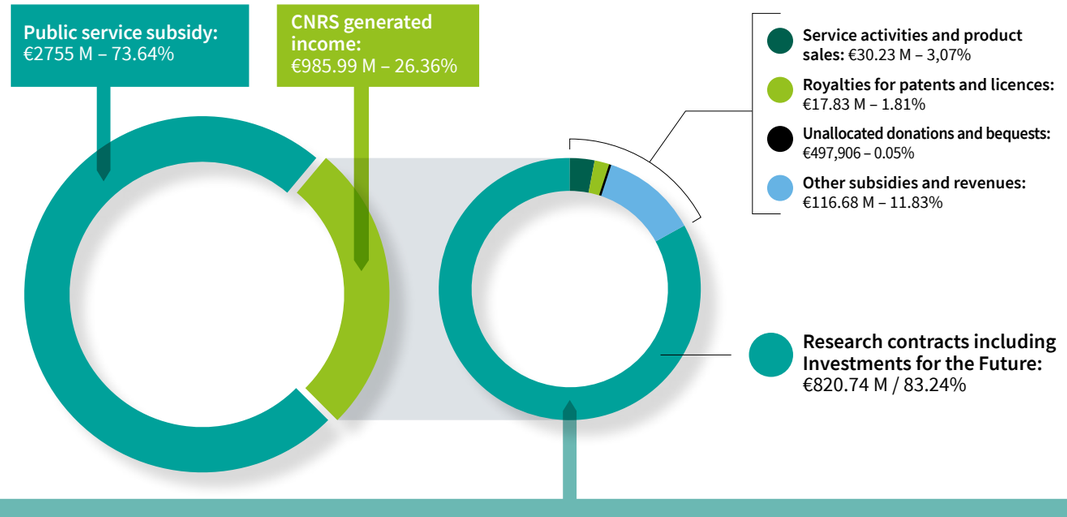
4000

staff had access to an e-learning module aimed at raising awareness of gender inequality in research and higher education.

STATISTICS AND INDICATORS

THE CNRS BUDGET

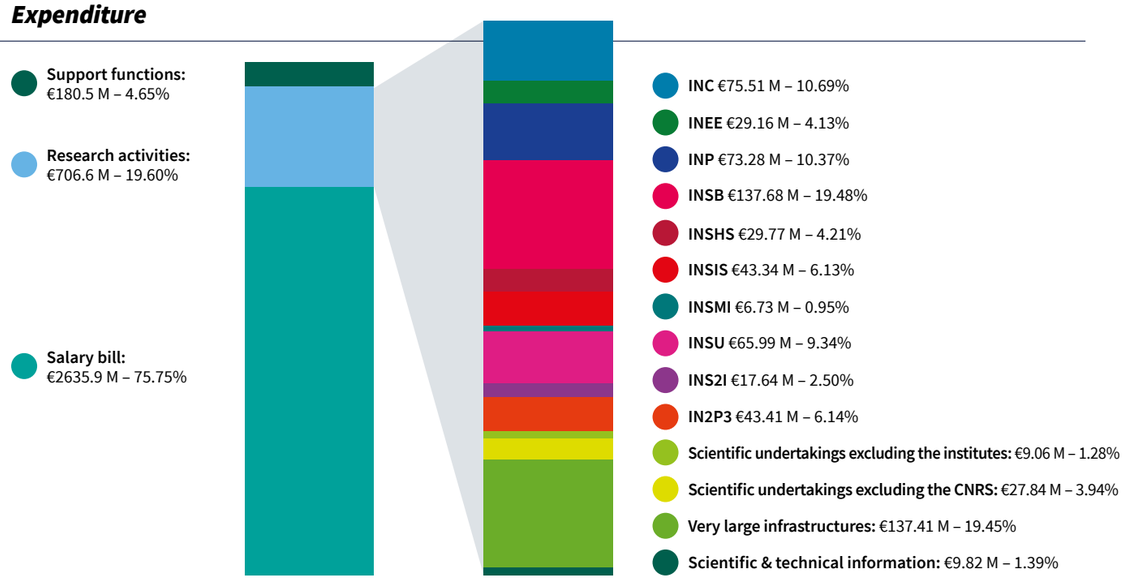
Resources



Research contracts including Investments for the Future

- French National Research (ANR): €225.36 M – 27.46%
- Other public institutions and companies: € 206.85 M– 25.20%
- Local authorities: €56.79 M – 6.92%
- European Commission: €126.63 M – 15.43%
- State: €88.63 M – 10.80%
- Private sector: €116.49 M – 14.19%

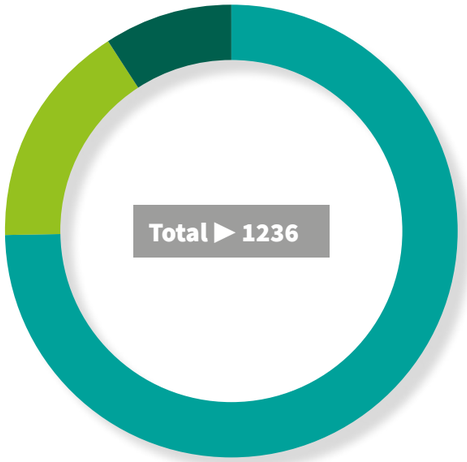
Expenditure



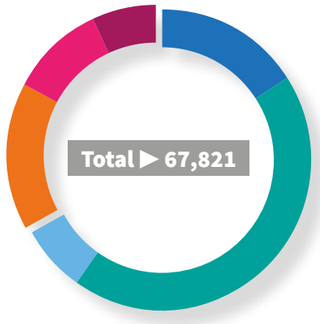
Source: BFC data – processing CNRS / DCIF-DSFIM

LABORATORIES LINKED TO THE CNRS AND ITS PARTNERS

Laboratories linked to the CNRS



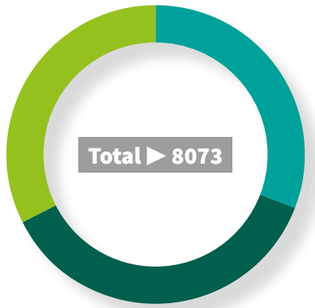
Tenured staff members in laboratories linked to the CNRS by personnel category and employing establishment category *(all institutes together; in natural persons on December 31st 2021)*



Tenured researchers and academics (civil servants and permanent "CDI" contracts)
Total ▶ 67%
- CNRS 16%
- Higher education institutions (universities and schools) 44%
- Other institutions (research organisations, non-profit organisations, ministries, etc.) 7%

Engineers and technicians (civil servants and permanent "CDI" contracts)
Total ▶ 33%
- CNRS 16%
- Higher education institutions (universities and schools) 10%
- Other institutions (research organisations, non-profit organisations, ministries, etc.) 7%

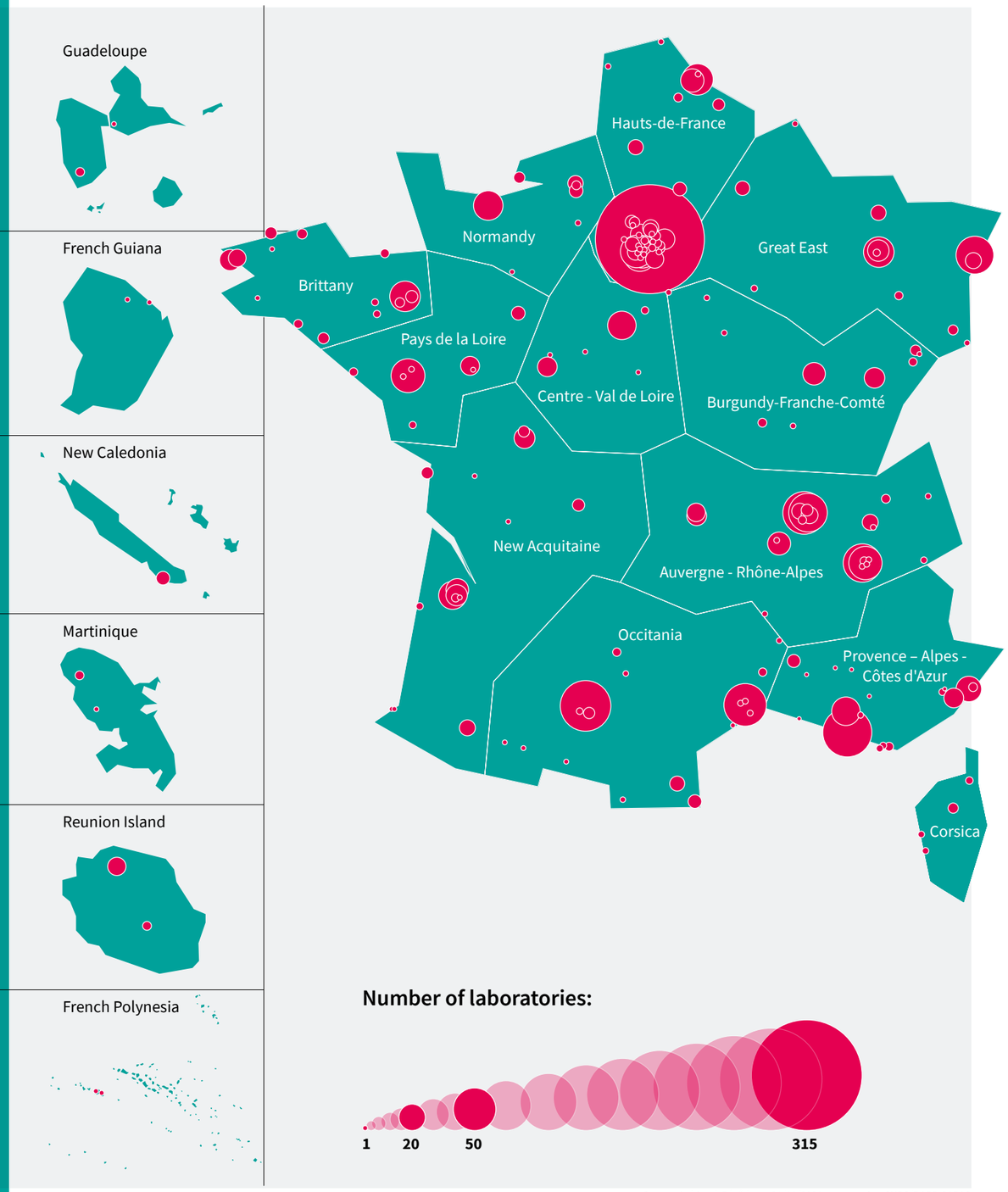
Non-tenured staff members in laboratories linked to the CNRS
(all institutes together; in natural persons on December 31st 2021)



Source: Réséda data on 31/12/2021 – processing CNRS/DAPP/SAP2S

LOCATIONS IN FRANCE AND INTERNATIONALLY

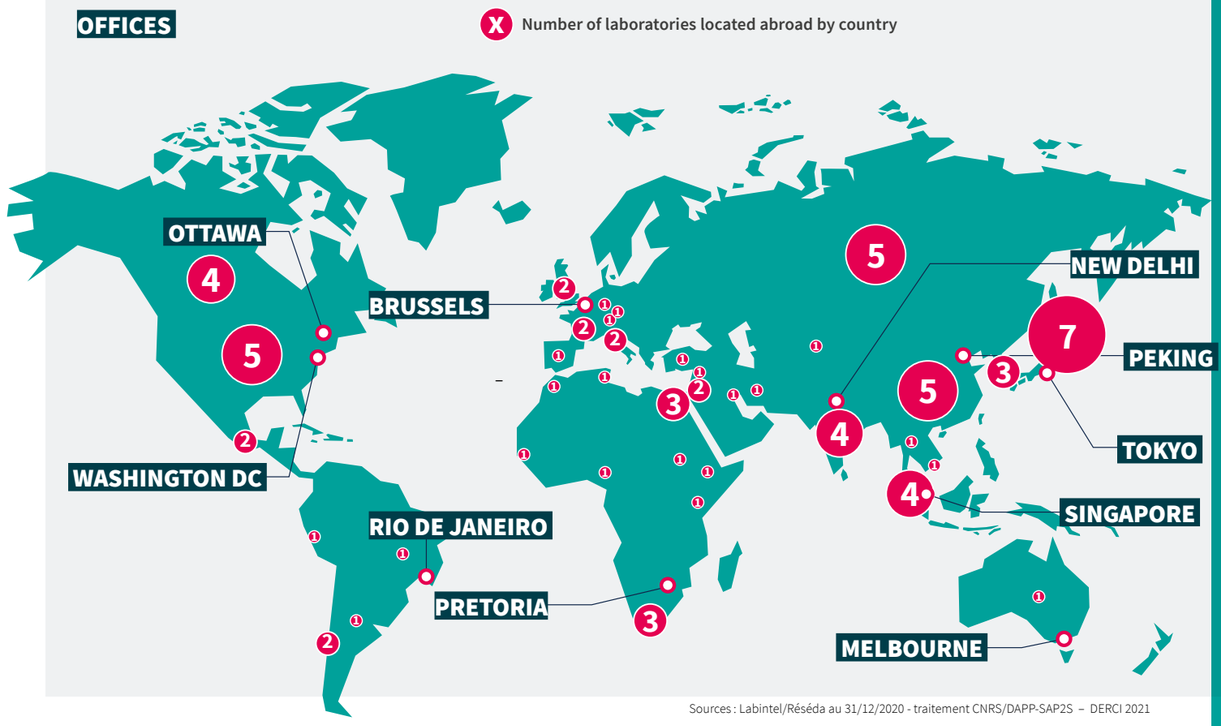
Locations of laboratories linked to the CNRS in 2021



Source: Labintel/Réséda on 31/12/2021 – processing CNRS/DAPP-SAP2S

Worldwide

The CNRS contributes to the influence of French research worldwide through around 80 international research structures and 10 offices abroad.



Sources : Labintel/Réséda au 31/12/2020 - traitement CNRS/DAPP-SAP2S – DERCI 2021

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Source: Labintel/Réséda au 31/12/2021 – processing CNRS/DAPP-SAP2S – DERCI

NOTES AND SUPERVISORY AUTHORITIES

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1. CNRS/University of Corsica Pasquale Paoli
2. CNRS
3. CNRS/University of Poitiers
4. CNRS/University of Paris

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1. CNRS/Sorbonne University/ENS Paris/Collège de France
2. Université Toulouse III – Paul Sabatier/CNRS
3. Federation of 8 laboratories from the Île de France region (CNRS/École Polytechnique/Université Versailles Saint-Quentin/CEA/Sorbonne Université/IRD/École des ponts ParisTech/Université Paris Saclay)

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1. Visiting researcher at the French School at Athens (EFA) working in the HALMA laboratory (CNRS/University of Lille/ French Culture Ministry), the Archéorient laboratory (CNRS/ Université de Lyon 2) and the Aegis group (UCLouvain)
2. Visiting researcher at the CNRS working in the Archaeology and Sciences of Antiquity unit (CNRS/University Paris Nanterre/University of Paris 1 Panthéon-Sorbonne/ French Culture Ministry) and visiting researcher at Harvard University
3. CNRS researcher working in the Archaeology and Sciences of Antiquity unit (CNRS/University Paris Nanterre/University of Paris 1 Panthéon-Sorbonne/French Culture Ministry)
4. Archaeology professor at the University of Paris 1 Panthéon-Sorbonne and member of the Orient & Méditerranée laboratory (CNRS/University of Paris 1 Panthéon-Sorbonne/Sorbonne University/Collège de France/ École Pratique des Hautes Études (EPHE)–PSL)
5. CNRS/University of Paris-Saclay
6. CNRS/Sorbonne University & University of Paris
7. CNRS/University of Paris 1 Panthéon-Sorbonne/Sorbonne University/Collège de France/EPHE–PSL
8. CNRS/University of Paris
9. CNRS/Aix-Marseille University/Centrale Marseille

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1. CNRS/Paris Observatory
2. CNRS/THALES
3. CNRS/Université de Lorraine
4. CNRS/Toulouse INP/Université de Toulouse III – Paul Sabatier
5. CNRS/Sorbonne University/University of Paris

Page 21
1. CNRS/Université Toulouse III – Paul Sabatier/CNES

Page 22
1. The Centre International de Rencontres Mathématiques (CNRS/Aix-Marseille University/ French Mathematical Society), Henri Poincaré Institute (CNRS/Sorbonne University), the International Centre for Pure and Applied Mathematics (CIMPA) and the Institut des Hautes Études Scientifiques (IHÉS)

Page 27
1. FCLab CNRS research federation

Page 28
1. CNRS/Université de Lorraine

Page 29
1. IIRD, CIRAD, CEA, University of Paris Saclay, Aix-Marseille University, University of Montpellier

Page 30
1. Ademe, CEA, Cnes, EDF, Ifremer, the Research Institute for Development (IRD), MEEM, Météo-France, Mercator Océan and other CNRS institutes.

Page 32
1. CNRS/University of Technology of Compiègne

Page 33
1. CNRS/ENS Paris/Inria
2. Steered by the CNRS in partnership with the Inria, the University of Strasbourg, Paris Sciences et Lettres University and Université Côte d'Azur
3. CNRS/Sorbonne University

Page 34
1. CNRS/University of Paris-Saclay

Page 35
1. Ifremer, IRD, Météo France, University of Bordeaux, Claude Bernard Lyon 1 University, University of Montpellier, University of Grenoble-Alpes, University of Rennes 1, University of Strasbourg, Federal University in Toulouse (Midi-Pyrénées).

Page 36
1. Eau de Paris, EPHE, Ifremer, Inserm, IRBA, Sorbonne University, University of Clermont Auvergne, Université de Lorraine and University of Paris
2. CNRS/Sorbonne University

Page 37
1. CNRS
2. Claude Bernard Lyon 1 University/Université de Lyon
3. CNRS/ENS Lyon/Claude Bernard Lyon 1 University

Page 39
1. CNRS/Claude Bernard Lyon 1 University
2. CNRS

Page 40
1. University of Paris-Saclay/Sorbonne University/Institut Polytechnique de Paris/University of Grenoble Alpes/Université de Lorraine/University of Bordeaux/Université de Lyon
2. CNRS/INSA Rouen/University of Rouen Normandy

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1. CNRS/University of Rennes 1

Page 45
1. Institut de Chimie Moléculaire et des Matériaux - Institut Charles Gerhardt Montpellier (CNRS/University of Montpellier/ENSC Montpellier)
2. Institut des Biomolécules Max Mousseron (CNRS/ University of Montpellier/ENSC)

Page 46
1. ENS Lyon and Clermont Auvergne, Grenoble Alpes, Claude Bernard Lyon 1 and Savoie Mont Blanc Universities

Page 49
1. Marine Biodiversity Exploitation and Conservation (CNRS/Ifremer/IRD/University of Montpellier)
2. Sciences-Po/CNRS

Page 50
1. CNRS/University of Nantes/University of Angers
2. In France, researchers from following organisations took part in this work - the Institute of Research for Astrophysics and Planetology (CNRS/CNES/Toulouse III - Paul Sabatier University), the Geology Laboratory of Lyon - Earth, Planets, Environment (CNRS/ENS Lyon/Claude Bernard Lyon 1 University) and the Institute of Mineralogy, Physics of Materials and Cosmo-Chemistry (CNRS/ National Museum of Natural History /Sorbonne University) also took part in this work.
3. CNRS/University of Paris/ Paris Globe Institute of Physics
4. On the French side, this involves the CNRS, the Paris Globe Institute of Physics, University of Paris and is supported notably by the CNES and the ANR

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1. Particularly the following: Paris Observatory – PSL, Sorbonne University, University of Paris, University of Paris-Saclay and AM

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1. Derived from the ENS Physics Laboratory (CNRS/ENS Paris/ Sorbonne University/University of Paris)
2. Co-founded by Amanda Silva Brun, winner of the 2021 CNRS Innovation Medal who works in the Matter and Complex Systems Laboratory (CNRS/University of Paris)
3. Led by scientists from the Laboratory of Theoretical Chemistry (CNRS/Sorbonne University) and the Parisian Institute for Physical and Theoretical Chemistry (CNRS/Sorbonne University)
4. Derived from the Polymer Materials Engineering laboratory (CNRS/Claude Bernard Lyon 1 University/Jean Monnet University/Insa Lyon)
5. Derived from the Physics and Mechanics of Heterogeneous Media Laboratory (CNRS/ESPCI Paris/Sorbonne University/University of Paris)

Page 56
1. CNRS/University of Paris-Saclay)

Page 61
1. Derived from the ENS Physics Laboratory (CNRS/ENS Paris/Sorbonne University/University of Paris)

Page 62
1. CNRS/Université de Bordeaux
2. Inserm/Aix-Marseille Université

Page 63
1. CNRS/University of Grenoble Alpes

Page 65
1. CNRS/ Université Polytechnique Hauts de France
2. CNRS/University of Lille
3. CNRS/University of Lille

Page 66
1. CNRS/University of Lille
2. CNRS/Aix-Marseille University/Cnes
3. CNRS/ENSC Rennes/University of Rennes 1

Page 67
1. Laboratory of Thermostructural Composites (CNRS/CEA/ University of Bordeaux/Safran)

Page 68
1. Derived from the ENS Physics Laboratory (CNRS/ENS Paris/Sorbonne University/University of Paris)
2. Derived from the Matter and Complex Systems (CNRS/ University of Paris)
3. Derived from the Laboratory of Theoretical Chemistry (CNRS/Sorbonne University) and the Parisian Institute for Physical and Theoretical Chemistry (CNRS/Sorbonne University)
4. Derived the Polymer Materials Engineering laboratory (CNRS/Claude Bernard Lyon 1 University/Jean Monnet University/Insa Lyon)
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1. Ranking compiled by Harris Interactive for the Epoka communication agency

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Installation of a hyperspectral camera to measure the way in which light waves are reflected by the fibres of an 18th century tapestry preserved at the International Tapestry Museum in Aubusson.
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