2015, a year at the CNRS

www.cnrs.fr

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Cover page: Roped up glaciologists on the "model" Astrolabe Glacier, near the Dumont d'Urville research station in Adelie Land, Antarctica.

The CNRS is a member of 14 networks of universities and higher-education institutions (ComUEs):

Sorbonne Universités, Université Paris-Saclay, Université de Lyon, Lille Nord de France, Université Sorbonne Paris Cité, Paris Sciences et Lettres, Languedoc-Roussillon Universités, Université Paris Lumières, Université Fédérale Toulouse Midi-Pyrénées, Université Paris-Est, Université Grenoble Alpes, Université Côte d'Azur, HESAM Université, Université Bretagne Loire.

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CONTENTS

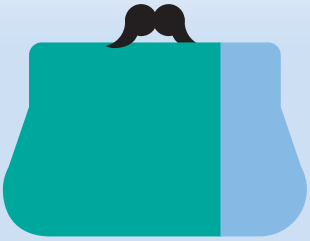
Stand-out scientific results

Institutional highlights

KEY FIGURES 2015

A budget of €3,309.13 million

State funding
€2,539.46 million

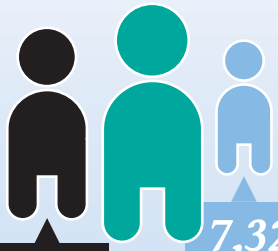


CNRS-generated income
€769.67 million

Source: CNRS/DSFIM/BFC

31,944 staff members

as at 31/12/2015



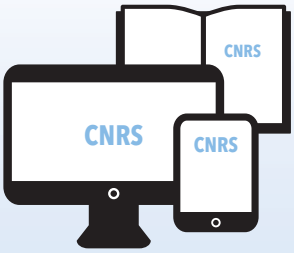
11,106 researchers

13,511 engineers and technicians (tenured positions and permanent contracts)

7,327 contractual employees

Source: Sirhus data as at 31/12/2015 processed by CNRS/DRH/OMES

The CNRS tops



the Nature Index

a new ranking based on the qualitative assessment of 68 publications of excellence over the past 12 months

Source: www.natureindex.com

and

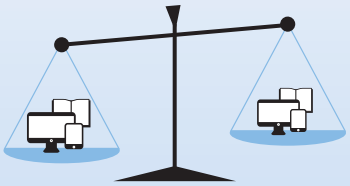
the university and research institutions ranking according to

the Scimago Institutions Rankings

Source: Scimago Lab/Scopus data (2014) www.scimagoir.com

Out of an annual average of

43,000 publications



60 %

are co-signed with at least one foreign laboratory

Source: Scopus processed by SCImago Research Group 2013 – www.scimagoir.com

300 researchers

and

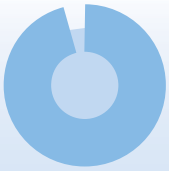
300 engineers and technicians recruited in 2015

Source: CNRS/DRH

950 joint research units

133 service units

33 intramural research units



96 %

of the research and service units operate in partnership with academic and research institutions or other types of organizations and businesses, both in France and abroad

Source: Labintel data as at 31/12/2015 processed by CNRS/SAP2S

The CNRS features among the world's

100 *leading innovators*

(Top 100 Global Innovators) since this list was established by Thomson Reuters in 2011

Source: 2015 Thomson Reuters Top 100 Global Innovators

The CNRS ranks

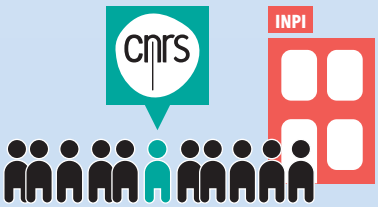
5th

in Thomson Reuters' newly-established list

of the World's Most Innovative Research Institutions

Source: 2015 Thomson Reuters Top 25 Global Innovators

6th *largest patent filer in France in 2015*



Source: CNRS/DIRE, INPI

26 ongoing

framework agreements

with listed companies

5,629 *active patent families*

1,281 *operating contracts*

100

active public/ private research structures

including

21 joint laboratories

between the CNRS and businesses

Source: CNRS/DIRE/FIST SA

61,000

missions abroad

with an average duration of 11 days
41,000 of which in the European Research Area

35

international joint units

Source: CNRS/DERCI

France achieved a success rate of

14.9% in the 2015 ERC grants

(out of a European average of 13.5%)

45.8% *of French laureates work at the CNRS*

44 *CNRS research projects* are financed by the ERC*

13	14	17
Advanced Grants	*Starting Grants*	*Consolidator Grants*

* laureates employed by the CNRS whose grants are managed by the CNRS and other institutions (April 2015)

Source: ERC/DERCI/CNRS

"Science has a voice on today's key societal issues."

In addition to taking an active part in international climate talks, the scientific community responded en masse to the call for proposals launched by the CNRS in the wake of the terrorist attacks in France. For the organization's president, this mobilization reflects the researchers' commitment to proposing solutions.

© F. Vernhet/CNRS Photothèque

INTERVIEW WITH CNRS President ALAIN FUCHS

In 2015 France was struck by two waves of terrorist attacks. You called upon the scientific community to take action and submit proposals. What were the reasons behind this appeal?

The scientific community could not stand on the wayside. After the initial shock caused by these events, we all felt the urge to understand and analyze them. And that is exactly what researchers are here for: to fulfill society's need for knowledge. Since we were not starting from scratch—far from it, in fact—this appeal was also a way to allow the academic community to make every effort to propose avenues of investigation, and follow new or neglected research leads.

We also want to ensure that research is not only supported but also taken into consideration by our political leaders. This is the reason why, following the attacks at *Charlie Hebdo* and the Hyper Cacher supermarket in January 2015, we emphasized the need to keep decision-makers informed on ongoing research, and urged the relevant scientific communities to take every step to achieve that objective. This need became all the more pressing after the horrific attacks of last November.

On 18 November 2015, you launched a call for research proposals to help fight terrorism. Did the response meet your expectations?

The response of the scientific community was immediate and massive. We received more than 250 proposals for research projects, along with many suggestions, testimonies and messages of encouragement. The researchers in the humanities and social sciences were the first to react, but we also had submissions from neurobiologists, mathematicians and chemists.

In addition to funding new research, which is a very good thing, this call for proposals made it possible to identify new scientific communities. We have started to organize workshops between the researchers involved. We want to make the most of this opportunity to promote collaboration rather than competition. An event scheduled in November will bring together all of the project leaders to present their initial results and discuss strategies and actions.

The CNRS endeavored to give science a voice at the COP21 climate conference in Paris. Was it heard?

I am inclined to say that the voice of science is being heard more than ever before on key societal issues. This is certainly the case with global warming: climatologists were among the first to ring the alarm bell through the Intergovernmental Panel on Climate Change (IPCC). But when it comes to proposing recommendations and

solutions, I have the feeling that the research sector is given less attention, and perhaps less credibility. At international political summits, science is very often absent or on the sidelines. In this sense, the COP21 was a definite step forward, as the scientific community was actively involved in offering solutions and not only observations. In particular, I have in mind the inclusion of the oceans in the climate negotiations, which is a real achievement.

You have set up an Office for Technology Transfer as part of the CNRS management. What does this focus on technology transfer mean for the organization?

The transfer of technology and research results is the fruit of the scientific partnership between laboratories and the business world. At the CNRS, it is our responsibility to create the best possible interface with business, and handle it ourselves, rather than delegate its management to intermediaries. Generally, we do not feel that it is appropriate to separate research structures from the socioeconomic sector by setting up new entities that do not directly serve these structures.

In this regard, the creation of a dedicated Office stems from a commitment towards better governance rather than an obsession with technology transfer, which involves numerous departments at the CNRS's headquarters and regional offices. This makes it necessary to improve our internal organization and vision of operations. In short, we want to regain the upper hand in this area.

According to many rankings, the CNRS has already achieved good results in technology transfer…

It seems to be a common belief that public sector research could fare better in terms of technology transfer. This point of view, often relayed by our own administrations, is not justified and does not reflect reality, as testified by Thomson Reuters' latest Top 25 Global Innovators ranking: France's research institutions are rated very highly, with the CEA topping the list (a remarkable result), and the CNRS and INSERM in fifth and tenth place, respectively. These good results, which debunk the popular myth, are quite encouraging.

Scientific integrity made the headlines last year, and the CNRS has been taking action thereon. Have we made progress? What remains to be done?

The CNRS has firmly condemned the incidents of proven misconduct and taken appropriate measures, without embarking on unwarranted investigations or turning the issue into a witch-hunt. The purpose of an organization such as ours is to help researchers work the best they can in the most favorable conditions and produce good results. Our role is not to be suspicious of each and every finding. That said, unethical behavior must obviously be disciplined. Today, even though misconduct is in the limelight, we have no reason to believe that it is on the increase.

I want the CNRS to remain firm without dramatizing the situation, while taking every opportunity to raise awareness among our researchers—especially the youngest—of the various factors that make scientific misconduct more tempting today. I am thinking of the pressure to publish, for example.

Another of your priorities for the CNRS is to maintain a good level of recruitment…

Indeed, and it must remain a priority in the years to come. We have budget constraints and no reserves. Any unexpected cut could be detrimental, in particular in terms of hiring. We must ensure that recruitment remains sufficient to sustain the organization's manpower. This is no mean feat: the current demographic low, due to a high retirement rate, is combined with a difficult situation with regard to public funding. Maintaining satisfactory levels of recruitment means having to make difficult decisions.

What is your assessment of the site policy implemented over the past few years?

Emerging university centers are making a real effort to become visible through IDEX or I-Site submissions. The idea of joining forces—not to become giants but to form multidisciplinary universities as elsewhere in the world—would have seemed unrealistic only a few years ago. Now the concept is gaining momentum, albeit with varying degrees of success. Certain sites are moving rapidly in the right direction while others are slower, but the time constant in the academic world is always long. You cannot change a complete higher education and research system in two or three years! Let me just point out that wherever things are going smoothly, the CNRS is involved.

Do these emerging centers have a positive effect on the CNRS?

There is no doubt about that, as we must clarify our priorities, goals and scientific strategy for each and every one of these academic sites. The time when universities were ill-equipped to pursue a scientific policy is well and truly over. Today more than ever, the CNRS is a key national and international partner, bringing genuine added value to the sites and acting as a skilled strategist through authentic partnerships, at the local level, with the various higher education and research entities. We are no longer in the condescending position of a Paris-based organization that decides every detail of the science conducted in France and the regions. We are now in the position of an arbiter—whose voice is heard and opinion valued.

HIGHLIGHT

Shedding light on oceanic eddies

Numerical simulations explain the origin of the turbulence observed every year in early summer in the North Pacific.

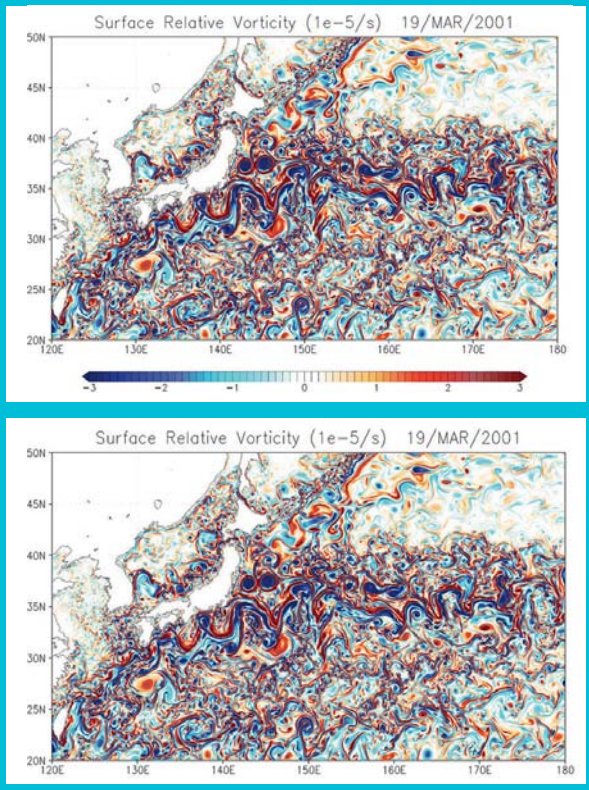
In early summer, a large part of the North Pacific is affected by a hitherto unexplained phenomenon causing the energy of oceanic eddies with a diameter comprised between 100 to 300 kilometers to increase. To find out why, a French-Japanese team including researchers from the LOPS[1] carried out very high-resolution numerical simulations on the Japanese "Earth Simulator", one of the most powerful computers in the world[2].

"We discovered that under the effect of winter atmospheric flow, small oceanic eddies form near the surface in February, before merging during several months to give rise to these larger structures whose energy peaks in June," explains Patrice Klein at the LOPS. This type of mechanism is a typical example of ocean-atmosphere interaction, which needs to be taken into account and modeled to elucidate the dynamics of climate change.

These findings will soon be compared with observations carried out by latest-generation altimeters, such as that on board the French-US Surface Water and Ocean Topography (SWOT) space mission, scheduled for 2020.

1. Laboratoire d'Océanographie Physique et Spatiale (CNRS/UBO/Ifremer/IRD).
2. Results analyzed as part of an international collaboration between IFREMER, the CNRS and JAMSTEC.

Nature Communications, December 2014



Oceanic eddies in the northwest Pacific on 19 March 2001 and 25 July 2012, as determined by numerical simulations carried out on JAMSTEC's "Earth Simulator" (Japan). In this study, the area analyzed was 140E-165W.

BREAKING NEWS

PERMAFROST CARBON TRAPPED IN MARINE SEDIMENT

An observation campaign has shown that part of the carbon originating in the Arctic's frozen soil is not responsible for global warming.

Under the effect of climate change, the organic matter in the Arctic's frozen soils (permafrost) is breaking down, causing the massive release of carbon dioxide into the atmosphere.

A study[1] carried out on the Mackenzie River in northern Canada by an international team of geochemists, including scientists from the IPGP[2], has now revealed that not all of this frozen carbon enters the atmosphere. "We have found out that a large proportion of the organic matter carried down the river comes from the erosion of the permafrost, and that 65 to 100% of it ends up trapped in the marine sediments of the Arctic Ocean, which protects them from decomposing," explains Jérôme Gaillardet from the IPGP.

However, this process is not sufficient to offset anthropogenic CO_2 emissions.

1. CNRS/IPGP/Université Paris Diderot/Université de la Réunion.
2. Institut de Physique du Globe de Paris.

© L. Caillouce/Takuvik/CNRS Photothèque

Thermokarst ponds (here seen snow-covered) resulting from melting permafrost in Nunavik, an Arctic region of Quebec.

IN BRIEF

OVERHEATING IN THE DEEP OCEAN

In the darkness that reigns at depths below 200 meters, the ocean's deep layers mitigate global warming by absorbing vast amounts of carbon dioxide and heat. However, two CNRS researchers have now sounded the alarm: their findings suggest that the buffer role played by the deep ocean is impacting its ecosystems, which are suffering from heat stress, acidification, deoxygenation and deterioration of nutrient resources. Understanding these effects better is essential for protecting key ecosystems.

Science, November 2015

IN BRIEF

PAVING THE WAY WITH MICRO-ALGAE

Researchers have successfully produced bitumen from the residues of tiny algae. The key to this success is a process called hydrothermal liquefaction that can convert this biomass into a black, viscous oil dubbed bioasphalt. Indeed, its appearance, deformation, ability to coat mineral aggregates, the cohesion of its granular structure and its resistance to loads, are analogous to those of bitumen made from petroleum products, which it may eventually replace.

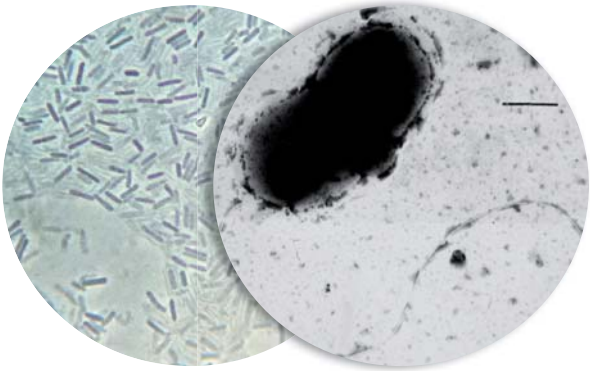
ACS Sustainable Chemistry & Engineering, March 2015

© C. Frésillon/IPhy/CNRS Photothèque

Growing micro-algae in an incubator.

BACTERIA JOIN FORCES TO PRODUCE GREEN FUEL

Anaerobic bacteria can break down biomass and produce molecular hydrogen. A team of biologists has discovered that, when in a state of nutritional stress, the *Clostridium acetobutylicum* and *Desulfovibrio vulgaris* bacteria communicate and exchange proteins. As a result, production of the gas–which can be used as a fuel–is tripled, five times faster, and far more stable over time. All of which could make these micro-organisms the active agents of a sustainable energy sector.



© Geoman3/Wikimedia commons

Clostridium acetobutylicum and *Desulfovibrio vulgaris,* two anaerobic bacteria that can break down biomass.

PROTECTING CORALS FROM CLIMATE CHANGE

As a result of climate change, many coral reefs are dying, victims of widespread bleaching. In the Seychelles in 1998, this process destroyed as much as 90% of the reefs. Yet, surprisingly, some of them recovered. In an effort to explain this phenomenon, an international team studied 21 coral reefs in the region before and after this episode. They discovered that their resilience was linked to the coral's good health before bleaching, and to their location in relatively deep and unpolluted waters.

Nature, January 2015

BREAKING NEWS

RECYCLING CARBON DIOXIDE WITH IRON AND LIGHT

Using sunlight, a cheap, novel catalyst reduces carbon dioxide.

Carbon dioxide is not just a waste product. It can be converted into carbon monoxide to manufacture materials or certain liquid fuels such as methanol. However, this chemical reduction process requires catalysts based on both rare and expensive metals.
To speed up the development of this recovery method, researchers at the LEM[1] have produced a novel iron-based catalyst. Combined with a light-sensitive organic compound, it can reduce carbon dioxide using sunlight as its only source of energy. "This new formulation also overcomes the stability and selectivity problems affecting the catalyst," points out Julien Bonin from the LEM. The new technique opens up interesting new avenues for using solar energy to recycle CO_2.

1. Laboratoire d'Electrochimie Moléculaire (CNRS/Université Paris Diderot).

Journal of the American Chemical Society, November 2014

GALLERY

ELUCIDATING THE NEPAL EARTHQUAKE

In spite of its magnitude of 7.9 on the Richter scale, the earthquake that struck Katmandu on 25 April 2015 did not cause extensive damage to the capital of Nepal. In a bid to understand why, a French team compared satellite images of the disaster area taken before and after the quake with measurements of the resulting seismic waves.
Their analysis reveals that the rupture of the fault occurred at a constant rate, a process that limits the propagation of high-frequency waves, which cause the greatest material damage.

Geophysical Research Letters, October 2015

© Peretz Partensky/Wikimedia commons

The old town of Katmandu.

BREAKING NEWS

MICRO-SUPERCAPACITOR STRIKES GOLD

A novel electrode material multiplies the energy stored in a micro-supercapacitor a thousandfold.

Compared with batteries, micro-supercapacitors have a distinct advantage: they have high power density and their lifetime is almost infinite. Unfortunately, the amount of energy they can store is so tiny that at present they have no applications. Together with Canadian colleagues, researchers from the Laboratory for Analysis and Architecture of Systems (LAAS)[1] have developed a novel electrode material consisting of an extremely porous gold structure into which ruthenium oxide has been inserted. "This material enabled us to create a micro-supercapacitor that can store 1,000 times more energy than existing ones," explains David Pech from the LAAS. On a par with Li-ion micro-batteries on this point, and while maintaining its intrinsic qualities, this micro-supercapacitor has an obvious advantage for on-board electronics, and could soon be used to power all mobile devices.

1. CNRS.

Advanced Materials, September 2015

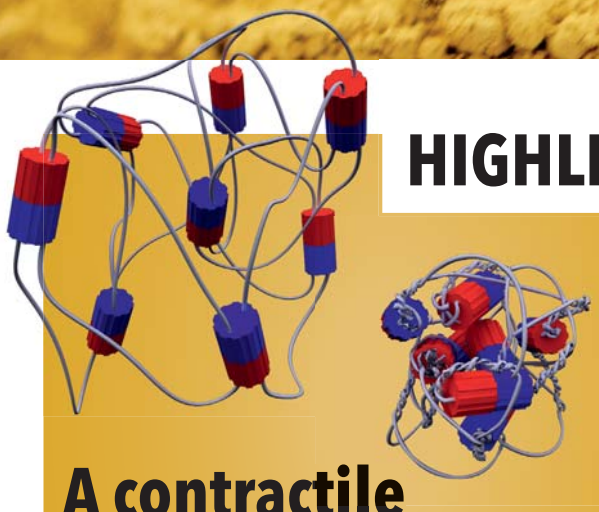
IN BRIEF

CLEAN CATALYSTS FOR THE SYNTHESIS OF HYDROCARBONS

Chemists have developed a new approach enabling them to obtain nanocrystals of faujasite, a mineral of the zeolite family containing aluminum and silicon. Until now, the production of this microporous compound, used as a catalyst for the synthesis of various hydrocarbons, was only possible in the form of microcrystals. The new synthetic pathway makes it possible to obtain crystals with unrivalled catalytic performance, a crucial advantage in refining, petrochemistry and fine chemistry.

Nature Materials

HIGHLIGHT



When exposed to light, these nanoscale motors twist the polymer chains in the gel, which as a result contracts by several centimeters.

© Gad Fuks / Nicolas Giuseppone / Mathieu Lejeune

A contractile gel stores light energy

Controlling the coordinated motion of molecular motors activated by light provides an alternative for producing and storing mechanical energy.

In living organisms, macroscopic movements such as the contraction of a muscle are the result of the coordinated nanoscale motion of vast numbers of molecules.
To reproduce this dynamic transfer from small to large scales, researchers at the ICS[1] have developed a gel made up of polymer chains connected by molecules composed of two parts that can twist around each other when supplied with light energy. Activated by absorbing ultraviolet light, such molecular motors were previously used to generate motion at the nanometer scale. In this novel assembly, they twist the polymer chains, causing the gel to contract by several centimeters, which is visible to the naked eye. "This is the first time that such motion has been generated in a coordinated manner on the macroscopic scale," enthuses Nicolas Giuseppone from the ICS. It is also possible to store as mechanical energy a significant amount of light energy, which the scientists hope to soon be able to re-use in a controlled way.

1. Institut Charles Sadron (CNRS/Université de Strasbourg).

Nature Nanotechnology, January 2015

BREAKING NEWS

BESTIOLE BOOSTS THERMAL POWER PLANTS' EFFICIENCY

A novel facility tested at the Odeillo solar furnace, in southwestern France, provides greater energy efficiency and longer storage lifetimes for solar energy.

© D. Gauthier/PROMES/CNRS Photothèque

The pilot solar collector *Bestiole* arriving at the Odeillo solar furnace in the French Pyrenees. *Bestiole* is based on a process that uses solid particles as a heat transfer fluid and storage material.

> www.csp2-project.eu

With the advent of the energy transition, efficient conversion of solar energy and its storage are a pressing challenge. In a solar thermal plant, sunlight is focused so as to heat a fluid. Once transferred to steam, the heat powers an electric turbine. However, with molten salts–the fluids used at present–the plants' operating temperatures do not exceed 550 °C, which reduces thermal efficiency and heat storage time.
To improve this, the European CSP2 project, coordinated by the PROMES[1], designed *Bestiole*, a pilot solar collector in which the molten salts have been replaced by solid airborne particles.
From April to May 2015, this innovative process was tested at the focus of the 1-megawatt solar furnace in Odeillo. "We were able to heat the particles to 750 °C, which makes it possible to increase the efficiency of power plants by 20% and their storage lifetime by 50% compared with current systems," explains Gilles Flamant at the PROMES. A pre-industrial demonstrator could soon be on the way.

1. Laboratoire Procédés, Matériaux et Énergie Solaire (CNRS/Université de Perpignan Via Domitia).

IN BRIEF

A CONDUCTIVE INK FOR FLEXIBLE ELECTRONICS

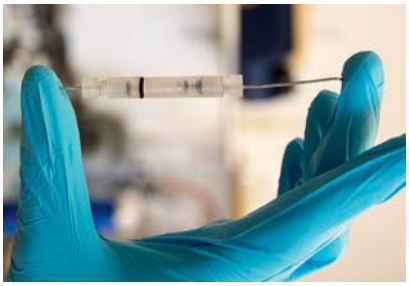
Researchers from two laboratories have patented a novel, conductive ink that can be printed on polymer-based flexible films. The new technology, which is both easy to implement and cheaper than current techniques, provides an interesting alternative for the manufacture of electrodes that are both transparent and flexible, and could play a key role in the development of flexible electronics and its applications for lighting, photovoltaics and foldable touch screens.

Angew. Chem. Int. Ed., June 2015

A NEW INSIGHT INTO BATTERIES

By adapting electron paramagnetic resonance, a method similar to medical imaging, researchers have succeeded in visualizing for the first time the electrochemical reaction in an operating battery. They closely observed the transport of ions during the charge/discharge cycles and established a detailed map of this activity. Their breakthrough should contribute to the development of more powerful, longer-lasting batteries.

Nature Communications, February 2015



© C. Colin/Lionel Fedele/RS2E

Electrochemical cell for the EPR study of battery materials (7x55 mm).

IN PERSPECTIVE

BREAKTHROUGH IN THE DESIGN OF SYNTHETIC SUGAR RECEPTORS

Novel molecules can recognize and discriminate between sugar molecules with unparalleled selectivity.

The various types of sugar molecules, such as glucose, fructose and lactose, are not only very similar but they also exist in several forms. Discriminating between them is therefore quite a challenge. Using an innovative molecular tool, Ivan Huc and colleagues at the Institute of Chemistry & Biology of Membranes & Nano-objets (CBMN)[1] have now found a partial solution.
Specifically, the chemists have developed artificial molecules in the form of long strands, similar to DNA and proteins. What makes them special is that they have a foldable modular structure within which a smaller molecule such as a sugar can bind selectively, due to the complementarity between the shape of the cavity and the target molecule, which is therefore recognized.
"Using this method, we have successfully designed a receptor exhibiting unprecedented selectivity for fructose," Huc explains. This finding could be of interest to the wine industry for monitoring the various stages of fermentation, as well as to the biomedical sector. In addition, the method could potentially be applied to molecules other than sugars.

1. CNRS/Université de Bordeaux/Institut Polytechnique de Bordeaux.

Nature Chemistry, March 2015

BREAKING NEWS

NANOTUBES THAT CHANGE DIAMETER TO ORDER

By modifying the acidity of the medium, researchers can control the diameter of nanotubes.

When placed in water, certain molecules spontaneously assemble into a specific shape. This process is known as self-assembly. Until now, the geometry and size of these structures, once formed, remained constant over time. Yet physicists from the Institute of Physics (IPR)[1] in Rennes, the French Alternative Energies and Atomic Energy Commission (CEA), Université de Rennes 1 and Ipsen have created self-assembled nanotubes that change their configuration according to the acidity of the medium. Specifically, the diameter of the nanotubes–which are made up of a molecule called triptorelin, a peptide analog of a natural hormone called gonadorelin–increases from 10 to 50 nanometers when the pH of the solution containing them exceeds 6.5.
"Using several complementary techniques, we realized that the key to this conversion lay in the change in electrostatic properties of one of the amino acids making up triptorelin," explains Franck Artzner from the IPR. This could lead to the manufacturing of various nanometer-scale objects of controlled size, and to a better understanding of viruses, whose shape also depends on the acidity of the medium.

1.CNRS/Université Rennes 1.

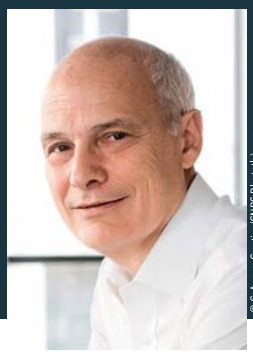
Nature Communications, July 2015

@CNRS
90 teslas for 9.1 milliseconds. A new record in pulsed magnetic fields for materials under extreme conditions.

AWARD

LUDWIK LEIBLER, EUROPEAN INVENTOR OF THE YEAR

Director of the Laboratoire Matière Molle et Chimie and professor at the ESPCI ParisTech, Ludwik Leibler has received the 2015 European Inventor Award. A member of the French Academy of Sciences since 2014, the physical chemist, who was granted the CNRS Medal of Innovation in 2013, is world-renowned for designing many materials with novel properties. In particular, he is the inventor of vitrimers, a substance that can be shaped like glass, is unbreakable like plastic, and is self-healing. Leibler also created an adhesive that can suture wounds.



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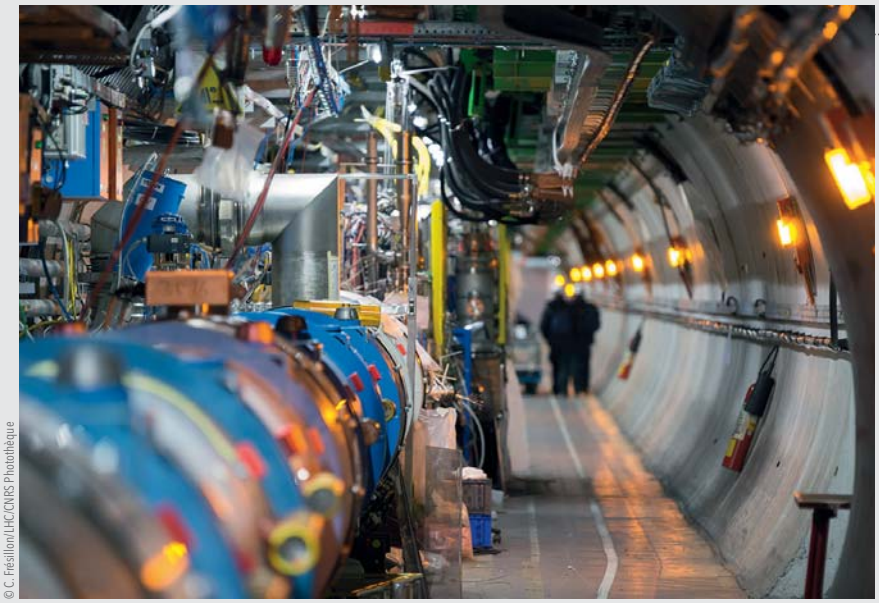


© C. Fresillon/LHC/CNRS Photothèque

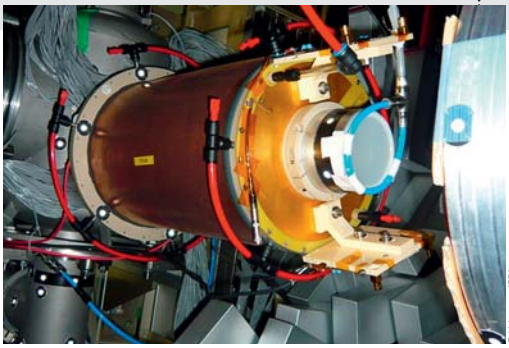
NEW PARTICLE DISCOVERED AT THE LHC

The new particle discovered at the LHC, CERN's giant particle accelerator near Geneva (Switzerland), is called a pentaquark. The particle, which had been predicted for 50 years, is made up of five quarks, the elementary building blocks of protons and neutrons. The precision of the LHCb instrument allowed this discovery to be made and should enable physicists to elucidate how the strong interaction, one of the four fundamental forces in Nature, binds quarks together.

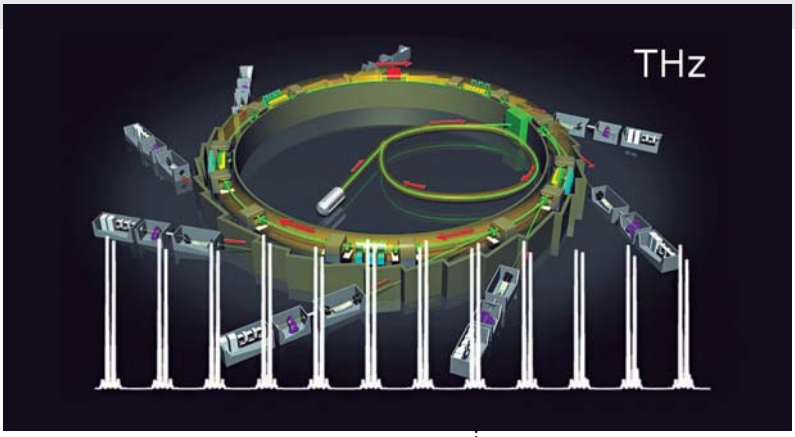
GALLERY

MINOS STUDIES NUCLEAR MAGIC NUMBERS

Certain atomic nuclei, known as "magic" nuclei, are especially stable, a property related to the number of neutrons and protons they contain. The French-Japanese MINOS instrument, set up in Japan, aims to shed light on this phenomenon. The first experimental campaign studied the most neutron-rich chromium and iron nuclei ever created until now. It showed that the "magic" character of these nuclei is lost when the number of neutrons reaches 40 or more. This is an important step towards obtaining a better description of atomic nuclei.



© V. Lapoux/CEA



© O. Pirali/ISMO

COHERENT SYNCHROTRON RADIATION: A POWERFUL FREQUENCY COMB IN THE TERAHERTZ RANGE

Using a new ultra-high-resolution spectrometer, researchers have shown that so-called coherent synchrotron radiation is made up of a multitude of very fine spectral lines occurring at regular frequency intervals, whereas it had been thought to be continuous. This provides a new insight into coherent synchrotron radiation in the terahertz frequency range, where it forms an extremely dense frequency comb. These results could find applications in time metrology, as well as in ultra-high-resolution spectroscopy and in reaction kinetics induced by synchrotron radiation.

Nature Communications, July 2015

NEMO CLOSES IN ON NEUTRINO MASS

Is the neutrino its own antiparticle? To find out, the international experiment NEMO-3, set up in the Modane Underground Laboratory[1] in the French Alps, attempted to detect an extremely rare and as yet unobserved radioactive process known as neutrinoless double beta decay. Analysis of the data collected from 2003 to 2011 ended in 2015, but provided no evidence for the process. However, it did set an upper limit for the mass of the neutrino, which remains unknown.

1. CNRS/Université Grenoble Alpes.

© B. Rajau/CNRS Photothèque

HIGHLIGHT

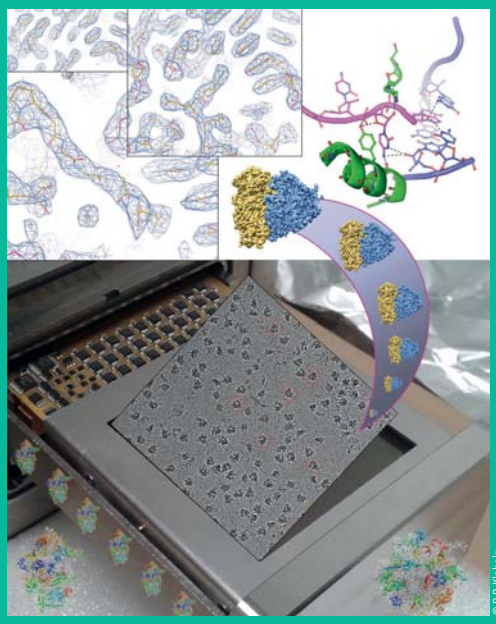
Mechanism of the human ribosome revealed

By using several cutting-edge methods, a team of biologists has successfully determined the structure and dynamics of the ribosome.

Inside the cell, ribosomes operate exactly like nano-factories for gene expression and protein synthesis, which is why biologists have always dreamed of uncovering their 3D structure on the atomic level as well as their dynamics. To achieve this, a team from the Institute of Genetics and Molecular and Cellular Biology (IGBMC)[1] used a cryo-electron microscopy device, the only one of its kind in France, coupled with data processing and 3D reconstruction software. This enabled them to obtain images with an unparalleled resolution of 3 Å. "We were able to show that, once transfer RNA has delivered its amino acids, it continues to interact with the ribosome at a specific site—and that during protein synthesis, the ribosomal subunits remodel the 3D configuration of the structure at their interface." explains Bruno Klaholz, who led the work. Such detailed images will make it possible to study precisely the side effects of certain antibiotics designed to attack bacterial ribosomes, which can mistakenly target the human ribosome.

1. CNRS/Université de Strasbourg/INSERM.

Nature, April 2015



© B.P. Klaholz

3D reconstruction of the atomic structure of the complete human ribosome applied to images obtained by cryo-electron microscopy.

IN PERSPECTIVE

NANOCAPSULES AGAINST CANCER

Encapsulated in nanoparticles, an anti-cancer drug proves more effective and less toxic.

Can drugs be effective against cancer cells, overcome resistance and be non-toxic to healthy cells? This is the challenge for chemists from the CINaM[1], as part of a French-Chinese-Italian collaboration.
The scientists used nanocapsules about ten billionth of a meter in size, within which they placed a highly toxic anti-cancer drug, doxorubicin, before putting them in contact with various types of cancer cell.
"Due to their highly effective mode of entry, 100% of these nanocapsules had entered the cells after only 30 minutes, and their anti-cancer activity proved to be 30 times greater than that of doxorubicin alone," explains Ling Peng from the CINaM. Better still, in nano-encapsulated form, doxorubicin escapes the mechanisms used by tumor cells to expel it.
Administered to mice with resistant tumors, the therapeutic nanocapsules were shown to be effective, as well as being non-toxic due to their ability to enter and remain in cells.

1. Centre Interdisciplinaire de Nanoscience de Marseille (CNRS/Aix-Marseille Université).

PNAS, March 2015

@CNRS
Researchers have discovered that marmycin A attacks tumor cells by building up in their lysosomes, the organelles that control intracellular digestion.

BREAKING NEWS

MICROMACHINES COMBAT CANCER

Several teams are developing microscopic electromechanical devices to improve detection and treatment of the disease.

The battle against cancer will soon be waged on the microscopic scale, suggests the research work being carried out in several CNRS laboratories using ultra-miniaturized Micro-Electro-Mechanical Systems (MEMS). Researchers from the IEMN[1], for instance, are reproducing the 3D environment of the brain. "We are seeking to elucidate the mechanisms underlying the rapid migration of certain cancer cells, and identify therapeutic drugs that could slow it down," explains Vincent Senez.
At the Toulouse-based Laboratory for Analysis and Architecture of Systems (LAAS)[2], other MEMS are being developed using antibodies for the detection of pancreatic cancer in its very early stages.
Finally, in Japan, researchers at the Laboratory for Integrated Micro Mechatronic Systems (LIMMS)[3] are designing MEMS that can measure the rupture rates of DNA strands during radiation treatment in real time. In 2017, these systems will be tested at the Lille University Hospital in northern France. This could lead to customized treatment for patients as part of a precision medicine approach.

1. Institut d'Electronique, de Microélectronique et de Nanotechnologie (CNRS/Université de Lille/Université de Valenciennes/Isen Lille/Ecole Centrale de Lille).
2. CNRS.
3. CNRS/Institute of Industrial Science, University of Tokyo.

BREAKING NEWS

Sequencing sex chromosomes made easier

A new sequencing technique opens up new prospects for studying the specific features of sex chromosomes.

Until now, low-cost sequencing tools could be used to read only a few hundred base pairs at a time on a chromosome. This is not enough for sex chromosomes, which have many particularly long, almost identical sequences, and are therefore difficult to reassemble once all the fragments have been sequenced.
Using a novel technique that can decode fragments with 8,000 base pairs at a time, researchers from the ESE laboratory[1] have overcome this obstacle, and successfully sequenced and assembled the entire sex chromosomes of the fungus *Microbotryum lychnidis-dioicae*. "We were thus able to confirm that the part of the chromosomes that does not recombine, in other words that does not exchange genetic material with the other chromosome, accounts for over 90% of the length of the chromosomes, as can be observed in certain plant and animal sex chromosomes," explains Tatiana Giraud who was involved in the study. More generally, the new method should help the scientists to elucidate the specific evolutionary forces at play in sex chromosomes.

1. Ecologie, Systématique et Evolution (CNRS/Université Paris-Sud/AgroParisTech).

Genetics, June 2015

© M. Hood

A flower of the *Caryophyllaceae* family parasited by a pathogenic fungus, *Microbotryum lychnidis-dioicae*, which sterilizes these small mountain flowers.

IN BRIEF

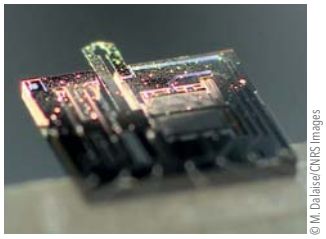
DECIPHERING CELL DIVISION IN BACTERIA

How is information of bacteria duplicated and partitioned during cell division? By combining several techniques, biologists have shown that the DNA and proteins involved in the process self-assemble stochastically under the effect of synergetic interactions. In addition to shedding new light on bacterial DNA segregation, this approach can also be applied to many types of molecular machinery that self-assemble into functional superstructures.

Cell Systems, August 2015

NANOTWEEZERS TO STUDY DNA

A French-Japanese team has designed an electromechanical microsystem (Bio-MEMS) made of silicon that can manipulate DNA by using two mobile arms with pointed tips. These "nanotweezers" can be used for instance to stretch DNA strands subjected to various doses of radiation in order to measure their breakage rate in real time. Applied to DNA in tumor cells collected from patients, the technique could be used to customize the radiation dose required to treat a tumor.



© M. Dalaise/CNRS Images

Silicon nanotweezers, a microtool that can manipulate and analyze cells and molecular fibers.

MALNUTRITION: A HELPING HAND FROM BACTERIA

A team of biologists has shown that in the event of chronic malnutrition, certain lactobacilli found in the intestine facilitate the expression and activity of digestive enzymes. This mechanism for optimizing digestion, which is observed in the fruit fly, leads to improved assimilation of available nutrients. The work sheds light on the key role of intestinal microorganisms, or microbiota, in the physiological response to chronic malnutrition, and in particular its importance for juvenile growth.

Cell Host and Microbe, October 2015

IN PERSPECTIVE

ENVIRONMENTAL GENOMICS: A FRESH LOOK AT THE LIVING WORLD

Thanks to novel genomics techniques, understanding the complexity of the living world and its interactions is within reach. A book published by the CNRS provides an overview of this revolution.

At the interface between environmental science and biology, environmental genomics studies the living world, its complexity and functioning, by analyzing vast amounts of genetic information. This novel approach is made possible by high-speed DNA sequencing. "Studying the ecology and evolution of a large number of species, which until recently proved impossible, is now within our reach," believes Denis Faure, from the Institute of Integrative Biology of the Cell (I2BC)[1], and coordinator of the Environmental genomics research group[2].
Aimed at the general public, the book *Empreinte du vivant, l'ADN de l'environnement* ("The imprint of the living world, the DNA of the environment"), published in November 2015 and written by CNRS researchers and their collaborators, is an invitation to discover environmental genomics. This emerging discipline provides an exceptional opportunity to meet the challenges posed by the environment, climate change, and more generally by the impact of global change on ecosystems.

1. CNRS/Université Paris Sud/CEA.
2. https://gdr.3692.wix.com/gdrge

IN BRIEF

AN AUTOMATIC MRI ANALYST

The online platform volBrain, which automatically analyzes 3D MRI images of the brain, has now been operational for a year. The result of four years of work by a French-Spanish team, this free, open-access research tool measures the volume of subcortical structures in less than fifteen minutes. The information is compared to standard values in order to detect any possible anomalies, especially those caused by neurodegenerative diseases.

> http://volbrain.upv.es/

THE BELL-EVANS MODEL CHALLENGED

Cells probe their environment via chemical bonds known as ligand-receptor bonds. According to the Bell-Evans model, these bonds have a specific feature: any attempt to break them makes them stronger. However, by using an atomic force microscopy technique, the researchers observed for the first time that the opposite can also be true. This"anti-Bell-Evans" effect gives researchers new insight into the interactions between a cell and its substrate.

J. Mater. Chem. B, January 2015

GEOGRAPHICAL MAPS FOR THE VISUALLY IMPAIRED

The Accessimap project aims to help the visually impaired read visual data such as maps–and eventually provide them, along with blind people, with a touch digital device with functions comparable to those of conventional maps, such as a zoom and change of view. The device will enable users to create and explore geographical maps without any outside help.

AWARD

ERIC KARSENTI AWARDED THE 2015 CNRS GOLD MEDAL

The internationally renowned biologist Éric Karsenti, CNRS senior researcher emeritus, has been awarded the 2015 CNRS Gold Medal for his outstanding contributions to the understanding of the mechanisms underlying cell division. A biologist with a great sense of adventure, Karsenti led the Tara Oceans expedition, launched in 2009 with the aim of mapping the biodiversity of the oceans and shedding light on the role of their microscopic life.

© F. Plas / CNRS Photothèque

IN PERSPECTIVE

REMEMBER LAST NIGHT?

A study shows that it is possible, during sleep, to create memories of events that never happened.

The Dream, Henri Rousseau.

The mental representation of space originates in the hippocampus, more precisely in the so-called "place cells", which also need to be reactivated during sleep to consolidate the memory. Now, researchers at the Brain Plasticity Unit[1] have shown that these cells can be manipulated to create false memories in mice.
With his team, Karim Benchenane, a neurobiologist who led the experiment, used a brain-machine interface to pinpoint the place cells solicited when the awake animal moved to a specific spot. Once the mouse was asleep, the scientists activated the reward circuit in its brain at the very moment the spontaneous reactivation of the place cells occurred.
"We observed that when the mouse woke up, it went directly to the spot visited the day before in order to get a reward that had, however, never existed," Benchenane explains.
Aside from the ethical aspect of this experiment, the possibility of creating complex artificial memories could open up new avenues for the treatment of post-traumatic stress disorder during sleep.

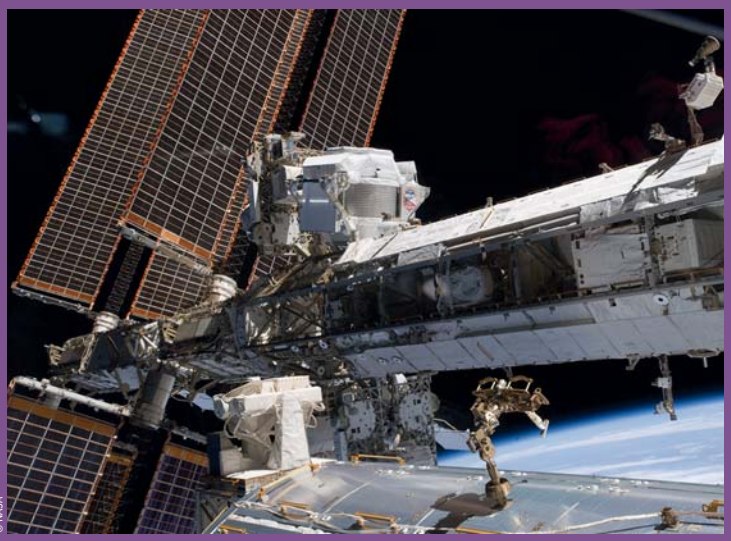
1. CNRS/ESPCI-Paris Tech.

Nature Neuroscience, March 2015

HIGHLIGHT

Closing in on dark matter

Although not conclusive, several experiments have provided indirect information about this invisible component of matter.



© NASA

AMS-02 installed on the S3 truss of the International Space Station.

The true nature of dark matter, which is thought to make up more than 80% of the mass of the Universe, remains mysterious. However, recent experiments designed by physicists in an attempt to detect a few particles of it are gradually refining their profile of this elusive matter.
For instance, the international EDELWEISS-III instrument, installed at the Modane Underground Laboratory[1] in the French Alps, has now definitively excluded the existence of dark matter particles with a mass of around 10 gigaelectronvolts (ten times the mass of a proton), which four other collaborations believed they had found between 2010 and 2013[2].
In addition, the international collaboration XENON100, set up at the Gran Sasso underground laboratory in Italy, has now ruled out signals detected in 2013 by another experiment. At the time, the signals were attributed to unknown particles thought to be able to interact with electrons of ordinary matter[3].
Meanwhile, the international AMS instrument on board the International Space Station has recorded a flux of positrons and antiprotons whose characteristics could be explained by the presence of dark matter, although this phenomenon could be due to other astrophysical processes.

1. CNRS/Université Grenoble Alpes.
2. arxiv:1603.05120, 2016
3. The XENON Collaboration, *Science* 349, 851, 2015.

BREAKING NEWS

MUSE REVEALS THE DISTANT UNIVERSE

At the end of its first observational season, the MUSE spectrograph provides an unparalleled 3D view of the very early Universe.

Set up in 2014 at the European Southern Observatory's Very Large Telescope (VLT) in Chile, the MUSE spectrograph, developed by seven European laboratories led by the CRAL[1], has delivered its first results. After a mere 27 hours of observation, it has calculated the distance of 189 distant galaxies, which is ten times more than in the previous fifteen years. This provides astrophysicists with the most precise three-dimensional image ever taken of the Universe shortly after its birth. "Most of the galaxies observed are very distant and date from less than a billion years after the Big Bang," enthuses Roland Bacon, principal investigator for MUSE. Better still, 26 had never been detected before.
As well as having high sensitivity and a wide field, MUSE can also determine the distance, chemical composition and dynamics of many objects simultaneously. As it observes thousands of galaxies in the next few years, it should enlighten scientists as to how the earliest of them formed and evolved.

1. Centre de Recherche Astrophysique de Lyon (CNRS/Université Claude Bernard Lyon 1/ENS Lyon).

Astronomy & Astrophysics, February 2015

IN BRIEF

FALSE ALARM FOR BIG BANG GRAVITATIONAL WAVES

In early 2014, the BICEP2 collaboration claimed to have detected traces of gravitational waves from the Big Bang in the cosmic microwave background, the oldest light emitted in the Universe. Sadly, a joint analysis of data from the US experiment and the European Planck spacecraft[1] showed that this was not the case. The signal detected by BICEP2 was actually caused by dust present in our Galaxy. The collaboration was however able to establish an upper limit on the intensity of primordial gravitational waves.

1. The latest findings of the Planck mission, piloted by the IN2P3 and INSU, were announced this year.

Phys. Rev. Lett., March 2015

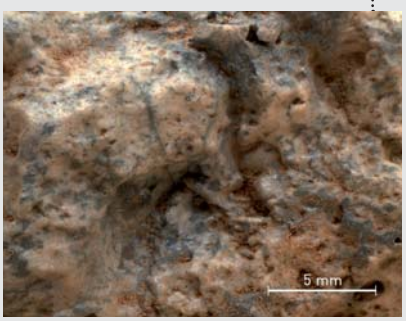
NOEMA RADIOTELESCOPE BEGINS OPERATION

With the launch of a seventh antenna, the Plateau de Bure observatory, in southeastern France, becomes NOEMA, the most powerful millimeter radiotelescope in the northern hemisphere. In four years' time, the installation will comprise twelve 15-meter diameter antennas, enabling astronomers to observe objects in the Universe with very high precision. The radiotelescope is already very promising: it has discovered a vast region of star formation in the Medusa galaxy merger, 100 million light years from Earth.

CURIOSITY DISCOVERS ANCIENT CONTINENTAL CRUST ON MARS

NASA's Martian rover, Curiosity, has discovered the remains of primitive continental crust, thought to be more than 4 billion years old, on the Red Planet. Analysis of rock samples in the Gale crater by the ChemCam instrument, piloted by a French-US team, showed that the rocks have a similar composition to that of the Earth's continental crust. The presence of this very ancient crust could indicate signs of plate tectonics when Mars was very young.

Nature Geoscience, July 2015



SOLAR RADIATION ALTERED ORGANIC MATTER IN THE PROTOPLANETARY DISC

Certain meteorites known as carbonaceous chondrites contain organic matter that is particularly rich in deuterium, an isotope of hydrogen. Until now, the reason for this was unknown. A French team including CNRS researchers has elucidated the phenomenon: radiation emitted by the early Sun altered the primitive organic matter present in the disc of gas and dust that was to give birth to the planets. The process is thought to have taken place in the warm regions of the disc, in other words in the vicinity of the Earth today.

Nature Communications, October 2015

SUGARS PRODUCED IN INTERSTELLAR ICES SIMULATED IN THE LAB

For the first time, an international team has synthesized in the laboratory organic molecules of the sugar family, from ices similar to those found in the interstellar medium, where stars and planets form. Such sugars are key constituents of the genetic material in living organisms. The discovery lends weight to the idea that the elementary building blocks of life may have formed in the interstellar medium before being carried to Earth by comets or asteroids.

PNAS, January 2015

GALLERY

ROSETTA SHOWS A SURPRISING COMET

Announced in 2015, the first scientific findings of the European Rosetta mission, in orbit around the Churyumov-Gerasimenko comet–dubbed Churi–since August 2014, changes researchers' perspective of these objects in the Solar System. From orbit, the spacecraft revealed a body with an extremely rugged and highly porous relief. On the surface, the Philae lander showed that Churi is made up, not of ice, but of large carbonaceous grains inside which ice grains are trapped, along with a wide variety of carbon-based compounds, four of which were identified for the first time in a comet.

Science, January 2015

BREAKING NEWS

© DEUX/CORBIS

INS2I AT THE HEART OF COMPUTER SECURITY

In spring 2015, researchers from the CARAMEL team at the Lorraine Research Laboratory in Computer Science and its Applications (LORIA)[1], discovered a serious weakness, dubbed LogJam, in the protocol that secures Internet connections. This logarithm is used to protect websites beginning by "https://", such as email servers. "This involves very basic work in arithmetic, but one that has immediate repercussions in the field of computer security," says Michel Bidoit, director of the INS2I. Thousands of servers were subsequently reconfigured.

1. CNRS/INRIA/Université de Lorraine.

IN PERSPECTIVE

HELPING LAME ROBOTS GET BACK ON THEIR FEET

A new algorithm allows robots to carry on working after a breakdown.

Living organisms have a capacity to adapt to their injuries. A dog with an injured paw, for instance, quickly finds a way of limping to walk. How can robots be given this adaptive ability to remain operational even in the event of an accident? Researchers from the Institute for Intelligent Systems and Robotics (ISIR)[1] and the Lorraine Research Laboratory in Computer Science and its Applications (LORIA)[2] have come up with a two-stage approach. Firstly, using an algorithm inspired by Darwinian evolution, the robot draws a detailed behavior-performance map of thousands of different ways of carrying out a task such as walking. Then, in the event of a problem–for example a faulty leg–an optimization algorithm draws on the information provided by the map to rapidly work out a new type of behavior, in this case, another way of moving. "After only a dozen attempts, the robot discovers a new manner of walking," explains Jean-Baptiste Mouret from the French National Institute for Computer Science and Applied Mathematics (INRIA). This innovative method should facilitate the development of more robust and efficient autonomous robots capable of moving about in a difficult environment without help, for instance.

1. CNRS/UPMC/INSERM.
2. CNRS/INRIA/Université de Lorraine.

Nature, May 2015

BREAKING NEWS

Computer memories inspired by the brain

Used cleverly, so-called ST-MRAM magnetic memories provide unparalleled potential for information processing.

On paper, so-called ST-MRAM memories are unbeatable. Unlike the volatile memories in our computers, they do not require a continuous electrical power supply. Moreover, they are much faster than non-volatile memories such as USB keys and CDs. Yet there is a significant risk of writing erroneous information in case of insufficient energy supply. This prompted researchers at the IEF[1] and the French Alternative Energies and Atomic Energy Commission (CEA) to use them in a device inspired by the brain, where errors are used probabilistically to undertake learning functions. Simulations have shown the effectiveness of this type of system for carrying out cognitive tasks such as image recognition with reduced energy costs. An initial prototype is under development.

1. Institut d'Electronique Fondamentale (CNRS/Université Paris Sud).

IEEE Transaction on Biomedical Circuits and Systems, April 2015

IN BRIEF

TWO INFORMS PRIZES FOR JEAN-BERNARD LASSERRE

A CNRS exceptional class senior researcher at the Laboratory for Analysis and Architecture of Systems (LAAS)[1], Jean-Bernard Lasserre has received the John von Neumann Theory Prize and the Khachiyan Prize from the international society INFORMS, which brings together professionals in operations research and management science. The prizes reward his entire career, and particularly his seminal work in the field of polynomial optimization.

1. CNRS.

A FLYING ROBOT INSPIRED BY INSECTS

Robotics specialists have developed the first robot able to navigate without an accelerometer, just like insects. The new aerial device avoids obstacles by redirecting its panoramic eye in relation to the ground slope, which it does by observing the speed at which the landscape passes by. This type of system based on optic flow, which is very light, could be used as backup for inertial navigation in spacecraft.

Bioinspiration & Biomimetics, February 2015

HIGHLIGHT

Bounded L^2 curvature conjecture in general relativity finally solved

Theoretical work can be used to specify the conditions under which solutions to Einstein's equations exist.

Postulated by Albert Einstein 100 years ago, general relativity has seen its predictions experimentally verified with unparalleled precision, as yet again illustrated with the first direct detection of gravitational waves this year. However, at the mathematical level, Einstein's equations have by no means given up all their secrets. How do their solutions evolve over time? Can they form singularities, regions where the gravitational field is infinite, anywhere other than inside black holes? These questions remain largely unanswered.
In collaboration with two researchers from Princeton University, Jérémie Szeftel from the Jacques-Louis Lions Laboratory[1] has solved the so-called bounded L^2 curvature conjecture, which specifies the conditions for the existence of a solution to Einstein's equations. Specifically, "it states that Einstein's equations always admit a solution if, at the initial time, the mathematical object that describes the way the Universe curves under the effect of gravitation is square-integrable, in other words, if the integral of its square is a finite number," Szeftel explains.
Dry though this may sound, it is of crucial importance as it could eventually demonstrate the physical validity of general relativity.

1. CNRS/UPMC/Université Paris Diderot.

Inventiones Mathematicæ, October 2015

BREAKING NEWS

MATHEMATICS INTERACTS WITH BUSINESS AND SOCIETY

In 2015, a number of events highlighted the concerns of the mathematics community regarding technology transfer, especially to business and society.

The results of a national report on the social and economic impact of mathematics in France, published in May, illustrate this, with two key figures: mathematics accounts for 15% of GDP and 9% of jobs in France. These figures reflect the involvement of CNRS mathematicians with business and society, as shown by the INRIA Grand Prize awarded to Benoît Perthame, a "bio maths" pioneer whose work has helped to optimize chemotherapies, as well as by the Maxwell Prize of the International Council for Industrial and Applied Mathematics (ICIAM), handed to Jean-Michel Coron for his fundamental contributions to the control of partial differential equations, implemented for example to regulate the Meuse and Sambre rivers in Belgium. On a day-to-day basis, this process is coordinated by the Agency for Interaction in Mathematics with Business and Society (AMIES)[1], in collaboration with modeling and simulation structures. Mathematicians are also engaging with society and the general public: 2015 saw the setting up of GdS Audimath, a CNRS network for academic players involved in disseminating mathematics, such as Etienne Ghys, who won the Clay Award for Dissemination of Mathematical Knowledge in 2015.

1. CNRS/INRIA/Université Grenoble Alpes/Société française de statistique/SMAI/SMF/EU Maths IN.

BREAKING NEWS

SOFTWARE TO SCRUTINIZE POLITICAL DISCOURSE

Are politicians consistent? Do they tell the truth? Do they change their minds? A new application will soon be able to find out for certain.

An application that vets statements by politicians? This is the idea proposed by Xavier Tannier from the Computer Science Laboratory for Mechanics and Engineering Sciences (LIMSI)[1] and Ioana Manolescu from the French National Institute for Computer Science and Applied Mathematics (INRIA). With an award from Google and funding from the French National Research Agency, this project is carried out in collaboration with the French newspaper *Le Monde*. It aims to develop tools drawing on a database supplied by journalists as well as on a set of statements, such as politicians' personal websites and Twitter accounts. It should eventually be able to analyze opinions and language elements in political discourse to determine, for instance, whether such-and-such a politician has formulated two contradictory opinions at two different times.

1. CNRS.

AWARD

JEAN-MICHEL MOREL RECEIVES THE CNRS MEDAL OF INNOVATION

Jean-Michel Morel, from the Research Center for Applied Maths (CMLA)[1], has been awarded the 2015 CNRS Medal of Innovation for his work in the field of image processing. His denoising algorithm, now installed on millions of smartphones, has greatly improved the quality of their cameras. During his career, Morel also collaborated with the French national space agency (CNES) for the design of observation satellites, as well as with numerous businesses for applications ranging from video processing to night vision.

© C. FRESILLON/CNRS Photothèque

1. CNRS/ENS-Cachan/Université Paris-Saclay.

BREAKING NEWS

HERCULANEUM'S CARBONIZED PAPYRI CAN NOW BE READ WITHOUT DAMAGE

X-ray phase-contrast tomography can detect traces of ink inside ancient scrolls.

Discovered 260 years ago, the Herculaneum papyri were buried by the eruption of Vesuvius in 79 AD. Many of them were opened from 1784 onwards, yielding some of their secrets, but were irreversibly damaged in the process. Now, an international team has found a way of deciphering the priceless but totally charred manuscripts without unrolling them. The scrolls were preserved by the eruption, which left their ink intact–hence previous, unsuccessful attempts to access their content through various imaging techniques.
To finally achieve this, the researchers used X-ray phase-contrast tomography at the European Synchrotron Radiation Facility in Grenoble (France), a technique based on the different optical properties of the ink and paper as well as the slight relief of the letters. "We managed to identify a few words as well as a nearly complete Greek alphabet," enthuses Daniel Delattre from the IRHT[1]. This breakthrough could eventually make it possible to decipher the philosophical texts contained in the scrolls of Herculaneum's "Villa of the Papyri" that remain intact.

1. Institut de Recherche et d'Histoire des Textes (CNRS).

Nature Communications, January 2015

@CNRS
The urban geographer Denise Pumain is the first researcher in social sciences to be awarded the French annual *Trophée de la Femme d'Innovation* prize.

IN PERSPECTIVE

THREE THOUSAND YEARS OF STORMS IN THE MEDITERRANEAN RECONSTRUCTED

On the coasts of the Western Mediterranean, stormy periods coincide with cold spells.

Violent storms are a serious threat to the densely populated coastal lowlands of the western Mediterranean. As part of the DYLITAG program supported by the ARCHIMEDE Laboratory of Excellence, researchers from the Archéologie des Sociétés Méditerranéennes[1] research unit, working in collaboration with Geosciences Montpellier[2], have managed to reconstruct and date successive storm events over the past 3,000 years, using geochemical and magnetic analysis of sediments from the Bagnas lagoons, on the French Mediterranean coast. As well as highlighting a strong correlation between significant storm activity and reputedly colder periods, the scientists also identified a connection between storms and large-scale changes in human societies–the end of the Roman Empire, for example. They will now attempt to determine the precise impact of these phenomena on human activity.

1. CNRS/Université Paul Valéry Montpellier 3/French Ministry of Culture and Communication/INRAP.
2. CNRS/Université de Montpellier/Université des Antilles.

Quaternary Science Reviews, December 2015

HIGHLIGHT

Deciphering the brain mechanism involved in learning through negative stimuli

Learning to seek pleasure ("reward") and avoid pain ("punishment") plays a fundamental role in the survival of any animal, including humans. The neurosciences shed light on the poorly understood mechanism of learning through "punishment".

Learning through reward is based on the fact that obtaining pleasure results directly from a positive action, which therefore encourages an individual to repeat it. However, learning that is not based on a positive stimulus appears to be just as effective. Why should this be? Researchers at the GATE[1] and the Institute for Intelligent Systems and Robotics (ISIR)[2] studied the way in which the brain works when it learns to avoid punishment. Using the example of an animal that hides in a hole to escape a predator, they have shown that the right choice—to hide—acquires a positive "relative" value, and reinforces learning.

Demonstrated theoretically by an algorithm, this model was then validated experimentally by using brain imaging to show that, in the presence of contextual information, non-punishment is perceived by the brain as being similar to a reward.

1. Groupe d'Analyse et de Théorie Économique (CNRS/Université Lumière-Lyon 2/Université Jean Monnet-St-Etienne/Université Claude Bernard-Lyon 1/ENS Lyon).
2. CNRS/UPMC/INSERM.

Nature Communications, August 2015

Punishment, extract from *Penrod*, Booth Tarkington.

BREAKING NEWS

The CNRS and the terrorist attacks

Following the 2015 terrorist attacks, the CNRS undertook a major review of the considerable amount of research carried out over the years by its researchers into issues linked to the rise of Islamist terrorism. The organization also launched a call for proposals on any subject relevant to the challenges facing our society as a result of the attacks and their consequences, thus opening the way to novel solutions–whether social, technical or digital.

© R. Bord/Getty Images

In the wake of the terrorist attacks, nearly 4 million people demonstrated throughout France, as pictured here in Paris.

UNDERSTANDING THE EMERGENCE OF DAESH

Elucidating the reasons for the emergence and persistence of Daesh–especially in Iraq and Syria–is essential for fighting the terrorist organization. "The collapse of states in the Middle East following the degeneration of the Arab Springs, underpins the success of the 'Islamic State', and not the opposite," explains the historian Pierre-Jean Luizard, who is a member of the GSRL[1], and the author of the book *Le piège Daech* ("The Daesh Trap")[2], which won a prize in France.
In the wake of the Paris attacks, his laboratory redirected part of its research program *Islam, politiques, sociétés* ("Islam, policies, societies") toward analyzing the failure of certain Arab states. At a conference in Rome in April 2015, Luizard questioned in particular the processes–which differed from one country to another–underlying the rise of religion. A collective work partly based on the conference proceedings, entitled *Vers un nouveau Moyen-Orient ?* ("Towards a New Middle East?") was published in June 2016.

1. Groupe Sociétés, Religions, Laïcités (CNRS/EPHE).
2. *Le piège Daech, L'Etat islamique ou le retour de l'Histoire,* Pierre-Jean Luizard, La Découverte, 2015.

MODERN SOCIETIES FACED WITH DIVERSITY

"There has been a tremendous desire for single-cause explanations and prescriptive answers since the terrorist attacks," says the political scientist Nadia Marzouki, a specialist in Islam at the CESPRA[1].
Based on recent work in sociology, Marzouki challenges the notion of a Muslim community whose culture and identity are unchanging. "Most French Muslims are perfectly happy with the rules of secularity," she points out. Managing religious diversity is also the main focus of the work of Philippe Portier, a specialist in the history of secularity within the GSRL[2] research group, which is investigating ways of reconciling public spiritedness with an increasingly diverse society, notably in Europe.

1. Centre d'Etudes Sociologiques et Politiques Raymond Aron (CNRS/EHESS).
2. Groupe Sociétés, Religions, Laïcités (CNRS/EPHE).

RETHINKING THE FIGHT AGAINST TERRORISM

Although France has a long experience in counter-terrorism as well as tried and tested public policy instruments, its institutions and systems are ill-adapted to current threats. Jérôme Ferret and Vincent Spenlehauer's project *L'action publique antiterroriste* (APAT)[1] examines how public stakeholders respond to the terrorist threat: the institutionalization of public action, its organization, professionalization and management, its partnerships with private operators, and its reflexivity in highly exposed democratic countries. Their working hypothesis is to go beyond the confidential nature of counter-terrorism policy-making, and bring it to the public arena. The survey covers France in a comparative perspective with Spain, the US, the UK and Israel. The way in which these countries draw inspiration from each other when it comes to fighting terrorism will also be taken into account (policy transfer studies).

1. MSH Toulouse, with École des Ponts ParisTech and an international network.

Europe matters

In order to strengthen its participation in European programs, the CNRS strives to make its voice heard in Brussels.

© CNRS/Délégation PMA

PATRICK NÉDELLEC,
Director of the DERCI

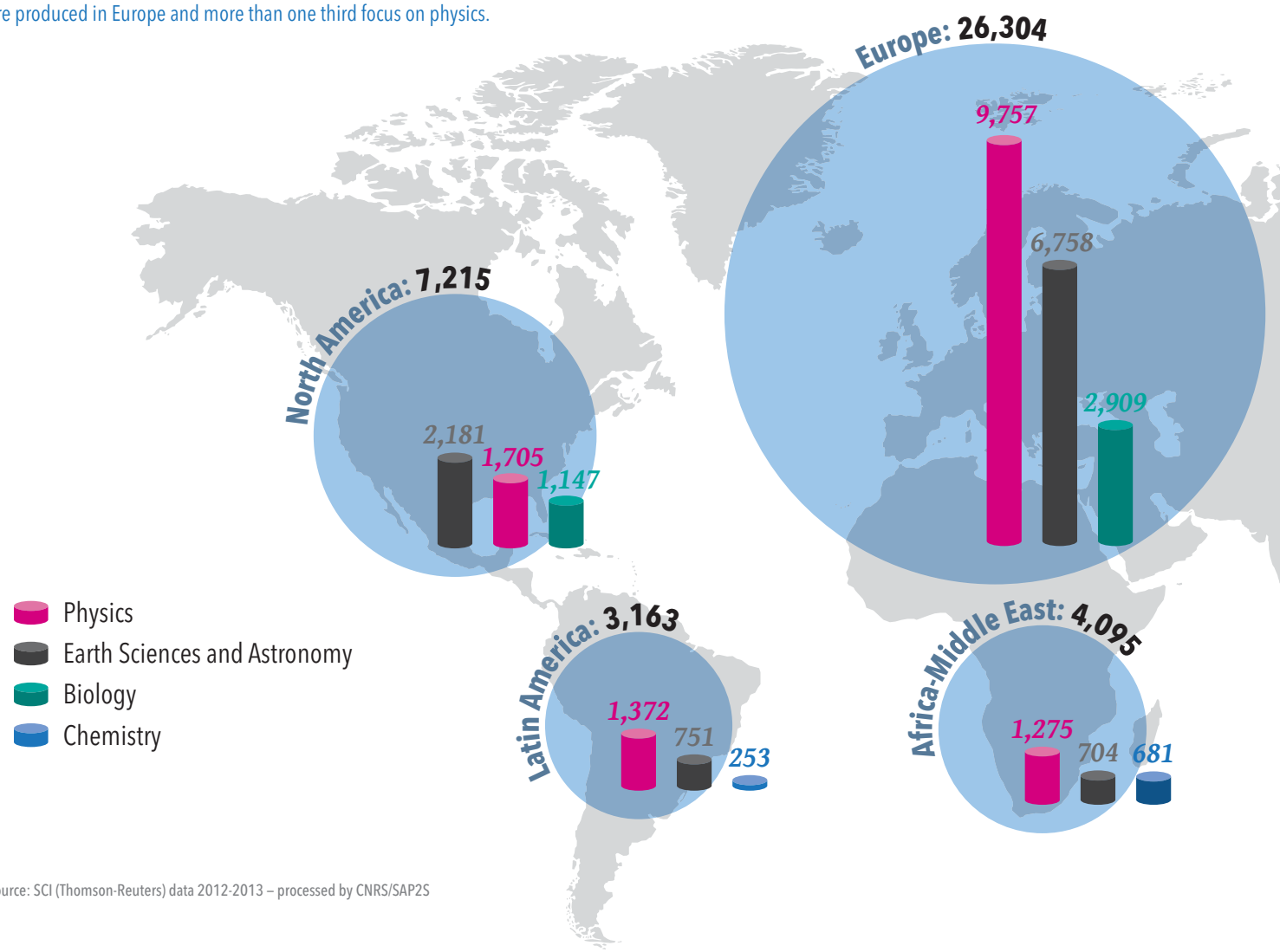
"Europe is our main priority," says Patrick Nédellec, director of the CNRS European Research and International Cooperation Department (DERCI). "We want to take full advantage of the funding and exchange opportunities of the Horizon 2020 program." The only way to achieve this is to submit many winning proposals. In 2015, the number of projects proposed by CNRS researchers increased slightly, but their acceptance rate fell, essentially due to stricter EU selection guidelines. As in previous years, CNRS researchers fared relatively well in the "Excellent Science" category (Pillar I), with 44 projects selected by the European Research Council (ERC) out of 259 submissions. However, the number of applicants—and thus of laureates—would be much higher if more researchers submitted proposals.

MAKING USE OF THE HORIZON 2020 APPROACH

In the Industrial Leadership category (Pillar II), which is presumably less of a focus for the CNRS, results have

CNRS JOINT PUBLICATIONS WORLDWIDE

More than half of all CNRS joint scientific publications are produced in Europe and more than one third focus on physics.



Source: SCI (Thomson-Reuters) data 2012-2013 – processed by CNRS/SAP2S

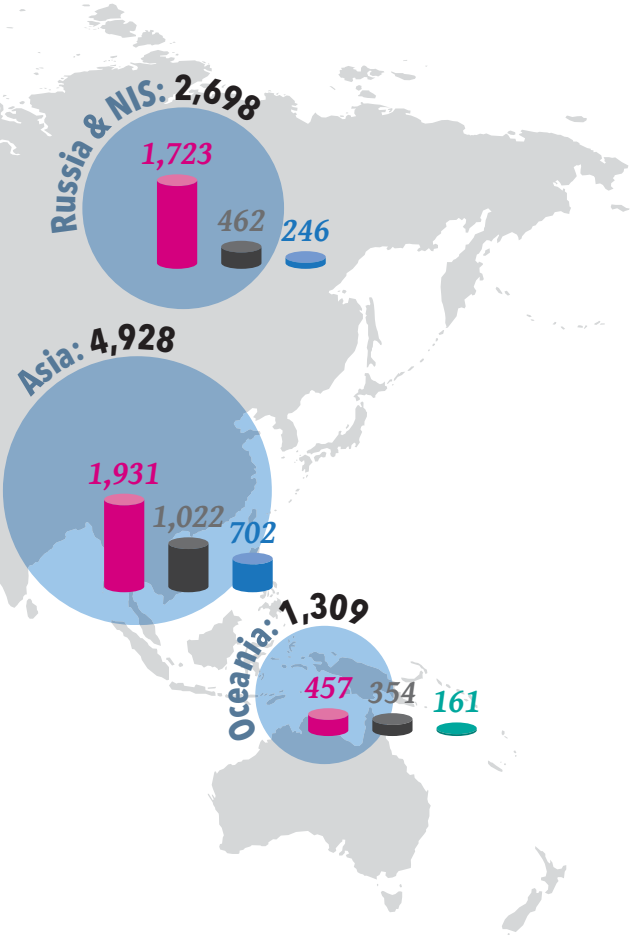
been encouraging, with 15 projects selected for a success rate of 13.3%. "The scientific community is beginning to make use of the new possibilities offered by Horizon 2020," says Pascal Dayez-Burgeon, head of the CNRS Brussels office since June 2015. Yet there is room for improvement, especially in Societal Challenges (Pillar III), whose solution-oriented interdisciplinary projects can deter researchers, especially in the humanities and social sciences. "However, participating in these projects generates considerable added value in the research-innovation continuum," Dayez-Burgeon notes. "It enhances our international visibility and gives us a chance to take part in the programming of future calls for proposals."
The CNRS is taking action to increase its project submission rate. "Through the European steering committees, the organization's Institutes and departments are working hand in hand to define a common position and improve researcher support mechanisms," Nédellec says. To this end, the team of European project engineers has again joined forces and the possibility of an allowance for project coordinators is being examined. In 2015, an ERC unit was formed with the aim of facilitating exchanges between project leaders and the CNRS regional offices so as to anticipate and help overcome any potential obstacles. The unit is jointly managed by the DERCI, the ERC National Contact Point (NCP), and the Mission for the Monitoring of and Relations with CNRS Regional Offices and Institutes (MPR). The CNRS is also developing an action plan to support submissions by researchers in the humanities and social sciences.

TECHNOLOGY TRANSFER GOES GLOBAL

Japan is the CNRS's main partner in Asia. In October 2015, the organization signed a cooperation agreement for technology transfer with Kyoto University. "This move is unprecedented," explains Louis Avigdor, a CNRS engineer at the Innovation and Business Relations Department (DIRE), who will be based in the Japanese metropolis over the next two years. "We are going to compare our individual methods and organizational processes to get to know each other better. We will then correlate our scientific results with our respective technological needs." In other words, the partnership will seek out Japanese businesses that could make use of CNRS patents, while raising their French counterparts' interest in those held by Kyoto University. A list of potential purchasers in France has already been established, in cooperation with FIST SA, the CNRS technology transfer subsidiary, in fields such as photovoltaics, carbon nanotubes and microalgae.

© DR CNRS

Kyoto University President Juichi Yamagiwa and CNRS President Alain Fuchs, on 4 October, 2015.



LOBBYING AT THE EU LEVEL

Having a say in the scientific programming of the calls for proposals is another key aspect of the DERCI's EU-wide mission. "Horizon 2020 focuses on innovation—in other words, on research that can rapidly boost economic growth," Nédellec explains. Following the creation of the Juncker Commission, which promotes private funding of research, the CNRS must try even harder to make its voice heard. For this reason, the organization is working upstream on projects with industry in Brussels, in particular through the •••

IRAN: TOWARD RESUMING INSTITUTIONAL RELATIONS

© Burna_Mir/Fotolia

Milad Tower in Tehran.

With some 22,500 papers each year, Iran produces by far the largest number of scientific publications within the vast Africa-Middle East zone. It is especially prominent in the engineering sciences, chemistry and medical research, not to mention mathematics, a field in which the country has a strong tradition of excellence. "Despite relatively few joint publications, Iranian research has always been dynamic and in touch with the rest of the world," notes Chamira Lessigny, deputy director in charge of the region at the DERCI. Iran has upheld a tradition of high-quality education, and its PhD students are much sought after in other countries. "As Iran's leading scientific partner in France, the CNRS will contribute, as of this year, to resuming more structured academic and institutional cooperation efforts, which are now made possible by geopolitical developments," Lessigny adds.

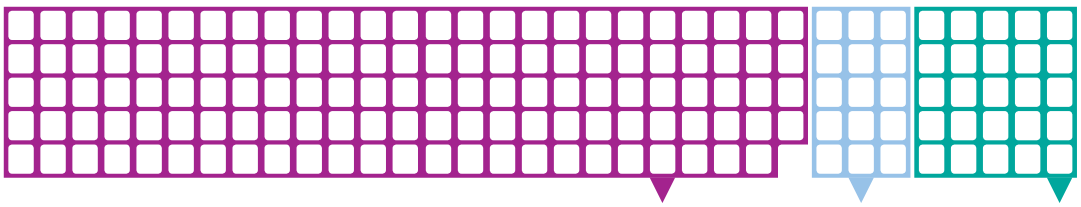
••• public-private Joint Technology Initiatives (JTI). In 2015, a collaborative effort by the DERCI, the Innovation and Business Relations Department (DIRE) and the Institute of Chemistry (INC) was able to steer the project proposals involving bio-based industries in the right direction. Another important assignment of the DERCI is to maintain close ties with the European Commission, executive agencies like the ERC, the European Parliament and other research institutions. As Nédellec puts it, "decision-makers must get used to calling upon our expertise in order to overcome technological obstacles and take on today's main societal challenges."

STRATEGIC ROADMAPS

In terms of international cooperation, the DERCI continued its internal reorganization in 2015. The number of geographic zones was brought down to four: Europe; Africa, India and the Middle East; the Americas and Oceania; and Asia. This streamlining made it easier to define new "roadmaps", the first two of which focused on, respectively, Africa and the Middle East; and Japan, South Korea and Taiwan. Serving as strategic planning guides, these documents identify actions to be undertaken as of 2016, such as prospecting in countries or zones with strong scientific potential like Iran and the Arabian Peninsula, structuring exchanges with South Korea, and facilitating research in strategic fields in Sub-Saharan Africa and the Indian Ocean. In addition, the partnership process with Asia is still going strong, as evidenced by the highly successful meeting held in Singapore in October 2015 between the CNRS International Joint Units and industry players. Finally, Nédellec points to the encouraging outcome of the EU project ERANET CONCERT-Japan[1], which the Japan Science and Technology Agency has decided to perpetuate by opening a dedicated desk at the CNRS office in Tokyo. Europe matters the world over!

1. Connecting and Coordinating European Research and Technology Development with Japan.

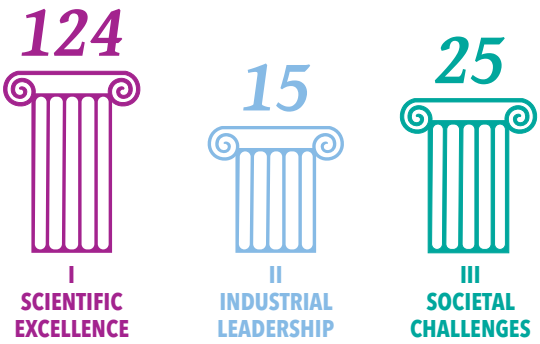
HORIZON 2020: THE CNRS'S PERFORMANCE IN 2015



Of the 1,311 projects submitted by CNRS researchers in 2015,

164

obtained funding from the Horizon 2020 programme, for an overall success rate of **12.5** %.



Source: CNRS/DERCI

Collaborating to find research applications

To improve its overall performance, the CNRS is bolstering the strategic monitoring of its technology transfer initiatives.

© CNRS/Délégation PMA

MARIE-PIERRE COMETS,
Director of the DIRE

© CNRS/Délégation PMA

NICOLAS CASTOLDI,
Technology Transfer Officer

Technology transfer partnerships involve working directly with industry in the laboratory, which makes it possible to take business requirements into account from the early stages of a scientific project. This approach has prompted the CNRS to set up more than 100 public-private research structures, including 23 laboratories operated with industry. "This type of partnership makes it unnecessary to transfer research findings to industry, as innovation is developed jointly," explains Nicolas Castoldi, who in October 2015 became Technology Transfer Officer, a new executive position within the organization. "A balance is struck: technology transfer is not external to research, which on the other hand is not steered from the outside."

STRUCTURING PARTNERSHIPS

Convinced of the relevance of this model, and in accordance with its Technology Transfer Action Plan (2014-2018), the CNRS is stepping up efforts to develop such partnerships. In addition to providing funding, the businesses involved raise new questions and contribute unique data and experiments. For Marie-Pierre Comets, director of the DIRE, "these exchanges show that academic research matches the needs of society and industry. The solid partnerships we have maintained with multinationals for the past 20 or 30 years stand as proof." With a portfolio of 26 framework agreements with large industrial groups listed on the French stock exchange, the CNRS renewed its partnerships with Safran, Essilor, Thales and Total in 2015. And Castoldi hopes to take these cooperations further: "We want to work with our industrial partners to define strategies in fields such as health and energy." The goal is to have a joint discussion, with input from all CNRS institutes that are involved.

SUPPORTING BREAKTHROUGH INNOVATION

In addition, the CNRS also plans to better identify and support the innovations spawned every year in its laboratories. In 2015, a scheme was set up to support projects with potential for groundbreaking innovation in their early stages. With a budget of €2 million a year, "the program aims to substantiate the concept, define intellectual property, and identify future directions for technology transfer," Comets explains. Out of 230 projects submitted, 25 have obtained funding. Others were redirected to the SATT technology transfer companies, in which the CNRS is a shareholder, or offered a different kind of support. While the 14 SATTs are in charge of promoting technology transfer at the regional level, the CNRS nonetheless retains its national dimension and pursues its policy of pooling resources in critical fields. This strategy is centered on key "Transfer Focus" scientific areas involving close collaboration with the SATTs.

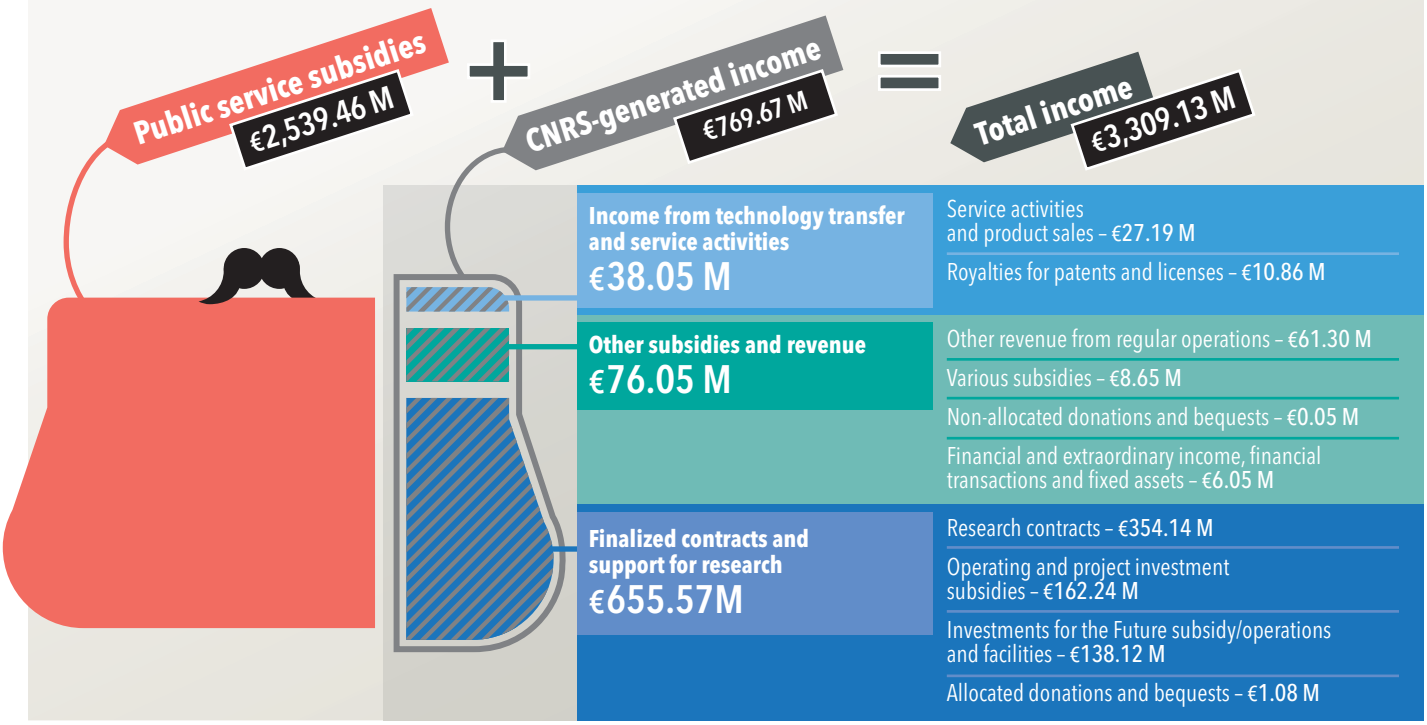
This national approach helps startup companies develop their full potential through substantial intellectual property portfolios that offer greater international opportunities. Some 1,200 companies based on technologies from CNRS laboratories have thus been launched since 1999. Furthermore, the organization improves the financial conditions applicable to startup founders.

THE CNRS "TRANSFER FOCUS" AREAS FOR INNOVATION

- → **Graphene and 2D nanomaterials**
- → **Memory technology** (magnetism, spintronics)
- → Optoelectronics: **LED, THz sources, therapeutic light sources**
- → Oncology: **immunotherapy, biomarkers, tumor stem cells, epigenetics**
- → **Alzheimer's**
- → **HIV**
- → **Dermocosmetics**
- → **Molecular imaging agents**
- → **Batteries**
- → **Photovoltaic solar energy (organic, thin-film)**
- → **Lignocellulosic biomass applications**
- → **Industrial use of CO_2**
- → **Service robotics**
- → **Big data**

Budgetary and financial information

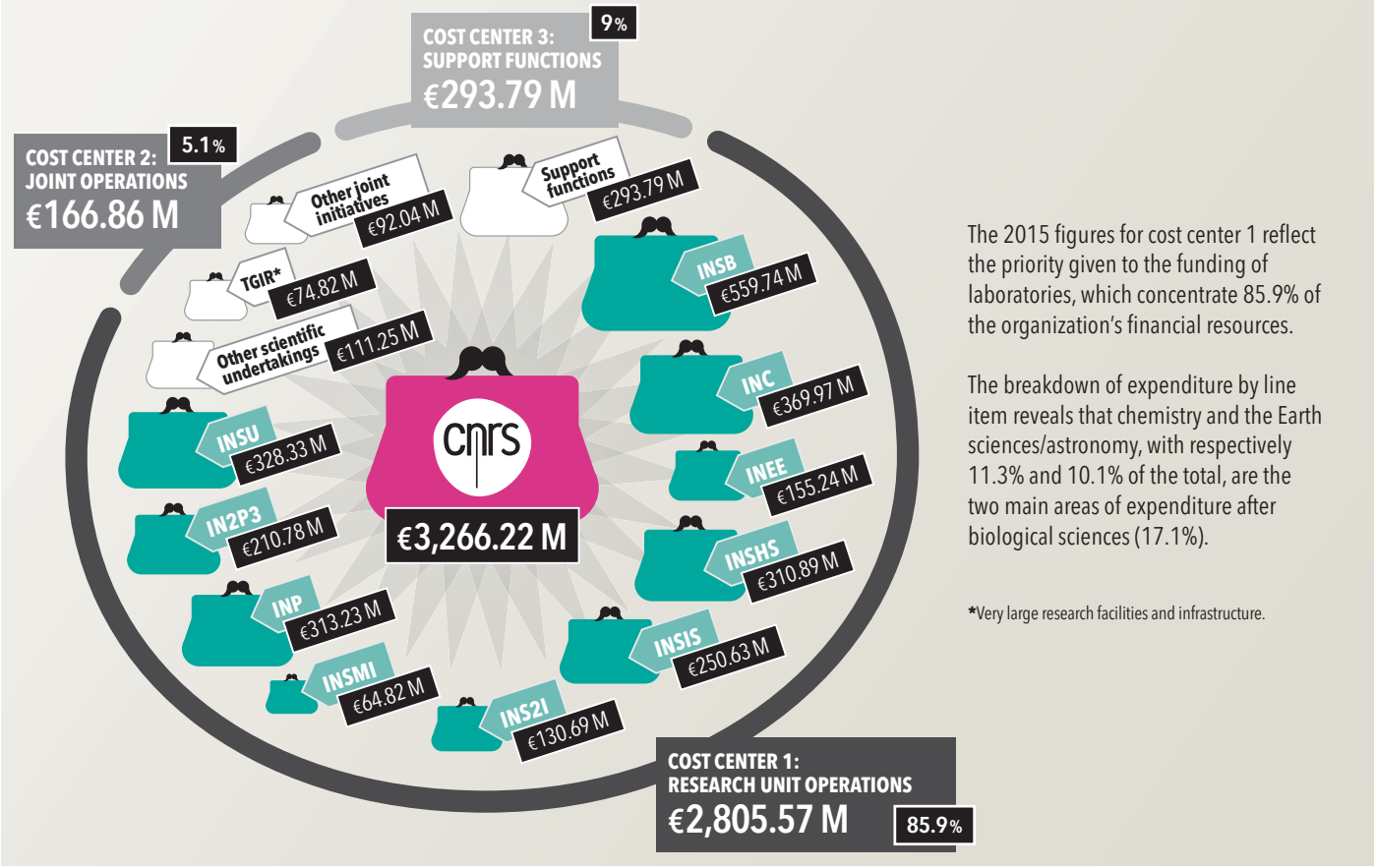
CNRS financial resources in 2015



Source: BFC/DSFIM

In 2015, the organization's funding came primarily from public service subsidies (€2,539.46 M), which represent 76.7% of the total. Research contracts (€354.14 M, excluding the "Investments for the Future" program) are the primary source (10.7% of total income) of CNRS-generated income (€769.67 M).

Expenditure by cost center and line item



The 2015 figures for cost center 1 reflect the priority given to the funding of laboratories, which concentrate 85.9% of the organization's financial resources.

The breakdown of expenditure by line item reveals that chemistry and the Earth sciences/astronomy, with respectively 11.3% and 10.1% of the total, are the two main areas of expenditure after biological sciences (17.1%).

*Very large research facilities and infrastructure.

Source : BFC/DSFIM

ORGANIZATIONAL CHART
2016

Alain Fuchs,
President

Anne Peyroche,
Chief Research Officer
*succeeds **Philippe Baptiste** CRO until 15 November, 2015*

Christophe Coudroy,
Chief Resources Officer

Nicolas Castoldi,
Technology Transfer Officer
since 21 October, 2015

Marie-Hélène Beauvais,
Head of Cabinet Office

Institute of biological sciences (INSB)
Catherine Jessus, Director

Institute of Chemistry (INC)
Dominique Massiot, Director

Institute of Ecology and Environment (INEE)
Stéphanie Thiébaut, Director

Institute for Humanities and Social Sciences (INSHS)
Patrice Bourdelais, Director

Institute for Information Sciences and Technologies (INS2I)
Michel Bidoit, Director

Institute for Engineering and Systems Sciences (INSIS)
Jean-Yves Marzin, Director

National Institute for Mathematical Sciences (INSMI)
Christoph Sorger, Director

Institute of Physics (INP)
Alain Schuhl, Director
***Jean-François Pinton,** Director until 31 January, 2015*

National Institute of Nuclear and Particle Physics (IN2P3)
Reynald Pain, Director
***Jacques Martino,** Director until 31 November, 2015*

National Institute for Earth Sciences and Astronomy (INSU)
Pascale Delecluse, Director

Mission for Interdisciplinarity (MI)
Anne Renault, Director

Department for the Territorial Organization of Research (DASTR)
Jean-Noël Verpeaux, Director

European Research and International Cooperation Department (DERCI)
Patrick Nédellec, Director

Innovation and Business Relations Department (DIRE)
Marie-Pierre Comets, Director

Scientific and Technical Information Department (DIST)
Renaud Fabre, Director

Communications Department (DIRCOM)
Brigitte Perucca, Director

Mission for the Monitoring of and Relations with Regional Offices and Institutes (MPR)
Joëlle Raguideau, Director

Accounts and Financial Information Department (DCIF)
Marie-Laure Inisan-Ehret, Director

Financial Strategy, Real Estate and Modernization Department (DSFIM)
Jean-Marc Oléron, Director
since 1 June 2015

Department of Human Resources (DRH)
Pierre Coural, Director
since 1 May, 2015

Legal Affairs Department (DAJ)
Myriam Fadel, Director
***Nicolas Castoldi** until 20 October, 2015*

Information Systems Department (DSI)
Jean-Marc Voltini, Director

Security Department (DIRSU)
Philippe Gasnot, Director

National Prevention and Safety Coordination (CNPS)
Yves Fenech, National Coordinator

National Coordination of Preventive Medicine
Dr Arnauld Vasseur, National Coordinator

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