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Eiffel Tower

The universal symbol of Paris celebrates its 120th anniversary.

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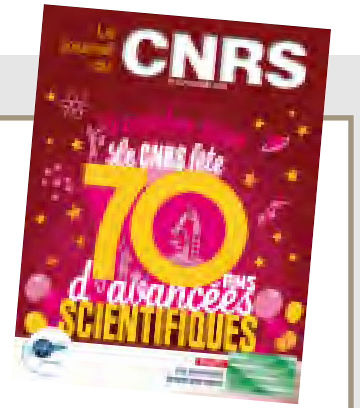

→ ANNIVERSARY

CNRS Turns 70

Founded on October 19th, 1939, at the initiative of Jean Perrin, CNRS revolutionized French research. Seventy years later, the organization boasts no fewer than 30,000 staff members and 1100 laboratories.

Before the founding of CNRS in 1939, there was no real national drive for French research," explains CNRS historian Denis Guthleben, whose book on the subject has just been published.[1] "At the time, researchers–then more commonly called 'savants'–were employed by the State as professors in universities or 'grandes écoles,' and their research had to take a back seat to their teaching duties," he continues. CNRS thus literally revolutionized French research by "inventing" a status for researchers and organizing their work into teams, which were often multidisciplinary.

The idea of creating such an organization, along with the relentless perseverance to see it through to completion, is attributed to one man: physicist Jean Perrin. When he received the Nobel Prize in physics in 1926 for his work on the structure of matter, Perrin noticed that scientific research in France would have a lot to gain by drawing inspiration from its German neighbors. "In Germany, the principle of funding scientific research within large institutions was introduced in 1911," highlights Guthleben. At that time, in France, the system was based on prizes and distinctions, and only those who had already made a discovery were rewarded.

In 1927, with financial support from philanthropist Edmond de Rothschild, Jean Perrin first created the Institute of physico-chemical biology in Paris, with chemist André Job and physiologist André Mayer. "This desire to bring together different disciplines clearly marked the beginning of Perrin's project," says Guthleben. Very quickly, Perrin realized what the same initiative could accomplish at a nationwide level. Having introduced a "petition for French research" that garnered the signatures of over 80 scholars, including 8 Nobel Prize winners, Perrin managed to convince the Minister of education to establish a high council for scientific research in April 1933. This body, which represented all disciplines "that played a role (...) in the progress of Humanity," was the first building block of the future CNRS. The second, laid in 1935, would be the "Caisse nationale de la recherche scientifique," a purely financial organization in charge of coordinating the initiatives of the different pre-existing institutions that funded research.

"The following year, Perrin, who had become Deputy State Secretary for research, established a national division for scientific research with the power to set up laboratories," continues Guthleben. Henceforth, all of the pieces were in place to found CNRS: an assembly for the democratic debate of scientific issues, a funding body, and a government executive arm–but these pieces still needed to be put together. "With war declared on Germany, there was an urgent need to unite the French scientific community. A journalist of the time wrote that the mobilization of French laboratories amounted to the creation of a new regiment," adds the historian. CNRS was founded on October 19th, 1939. Unfortunately, its researchers had only nine months to contribute to the war effort before France's capitulation.

After the gloomy occupation period, CNRS was reorganized and underwent considerable change, especially in the 1960s. Would Perrin recognize his brainchild today? Evidently, the form and size of CNRS have changed considerably. It has gone from about 1000 people and approximately 40 laboratories centered around Paris and Meudon in 1945 to about 30,000 people and 1100 laboratories throughout France in 2009. "But it has maintained its objective to embrace all sciences by stimulating advanced research, and to preserve researchers' freedom to explore all scientific avenues," says Guthleben. "For 70 years, CNRS has never stopped adjusting to the surrounding context and expectations. Its achievements, far-reaching scientific discoveries, and significant contributions to overall growth and development during this period have been absolutely enormous."

Charline Zeitoun

1. Denis Guthleben, *Histoire du CNRS de 1939 à nos jours* (Paris: Armand Colin, 2009).

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A laboratory at the Meudon-Bellevue CNRS site in 1959.

editorial

Gilberte Chambaud
Scientific Director, Institute of Chemistry.

Chemistry, Key to our Future

Nature needed billions of years to assemble atoms in the complex edifices from which life emerged. Then, some tens of thousands of years were necessary for the first humans to tame nature and begin transforming matter: their first act as chemists was perhaps cooking their food to spare their teeth; their second, a more deliberate action, was undoubtedly to succeed in extracting metal from its ore to design tools, but also weapons. Moving from isolated actions to community efforts, man gradually developed his talents as a creator of new materials to improve his everyday life. He used grapes to produce wine, transformed sand into glass, mastered color for his artistic expression and, more recently, turned wood into paper.

The major revolution in chemistry took place in Europe during the 19th century. It was during the industrial era that chemistry played an essential role, supplying new materials that enabled the development of hygiene, communications, and comfort. A great shift occurred that steered human knowledge from empiricism and the mysteries of alchemy to understanding, analysis, and prediction. We soon discovered that matter was made up of a small number of different atoms that could be combined ad infinitum. Chemistry thus turned into a science that brought fascination, penetrated all facets of life, and became a source of progress.

Today, chemistry is everywhere. Such an assumption conveys both positive and negative feelings. It is somehow proof of its usefulness, but sometimes too often linked to risks, pollution, and toxicity, while we forget its necessity in preserving the environment and in providing many innovations and medicinal products. Yes, chemistry is key to our future. To answer current–and more importantly, future–needs, those active in the field of chemistry are finding the solutions to global challenges like renewable energy sources, climate change, water and food supplies, demographic growth, health, preservation of resources, and the environment. More interestingly, as you will read in our feature article, this field also enables a clearer understanding of our heritage, the creation of new materials, or even the development of more natural cosmetic products.

As a source of innovation, chemistry has a major impact on improving quality of life, and is also an essential motor for economic growth in all industrial sectors. At CNRS, the Institute of Chemistry is set to become the national reference for advancing knowledge in all fields of chemistry, ranging from molecules to materials and all their cross-disciplinary developments. It provides a national framework for sharing high-performance tools, like high-field nuclear magnetic resonance spectrometers (NMR), the Chemical Analysis Central Service,[1] which performs complex analyses for both private and public sectors, or the French National Chemical Library.[2] The institute initiates and supports national and international collaborations based on excellence and complementary skills. Its activities are carried out in 12 CNRS intramural laboratories and 141 joint laboratories in close partnership with universities and other research institutions, including industry. The entire workforce involved in academic research in chemistry represents nearly 7500 people (half from CNRS), with 5000 researchers (including those teaching in universities), and 2500 technical staff.

In support of the UN resolution which designates 2011 as the "International Year of Chemistry," all French actors in the field have signed a document in May 2009 formalizing their intention to act in concert.

1. Service Central d'Analyse. (www.sca.cnrs.fr)
2. Chimiothèque nationale. (http://chimiotheque-nationale.enscm.fr)

HEALTH

Teaming Up Against Diabetes

Three laboratories in the French city of Lille have come together to form the European Genomic Institute for Diabetes. Their goal is to pool their approaches and resources to better prevent, predict, and treat diabetes and its complications.

Preparing DNA chips from T2D patients. Researchers in Lille used these chips to create the first genetic map of T2D.

It's the early afternoon on the Calmette Campus in Lille. In a small room on the second floor of a building, two technicians are busy extracting DNA from blood samples from diabetes patients. Downstairs, automated instruments are sequencing genes from the patients' cells at a furious pace. Down a hall, bioinformaticians and biostatisticians are analyzing genetic data on their computer screens. The summer sees no decrease in activity for the teams at the Genetics of Multifactorial Diseases Research Unit,[1] one of the three labs that make up the new European Genomic Institute for Diabetes (EGID) launched last May. And researchers are no doubt spurred on by their recent findings. Also heading the section of Genomic Medicine at London's Imperial College, EGID Director Philippe Froguel and his colleagues were the first to draw up the genetic map not only of type 2 diabetes (T2D), but also of the severe obesity which strongly predisposes people to the disease. This type of diabetes, which is rapidly spreading, already affects 180 million people all over the world (*see box*). The scientists have also shown that there is a link between the disruption of the body's biological clock and the onset of T2D. And they certainly don't intend to stop there. "Our goal now is to discover the rarer DNA mutations involved in type 2 diabetes," says Froguel. To help them achieve this, the lab has one of the best high-throughput genomic platforms in France. "This new device is technically able to sequence the entire human genome in a week," claims an engineer. In addition, the team has one of the largest gene banks in the world. "In these cold chambers, we keep around 25,000 samples of DNA from diabetic and obese families," he adds. "And our anonymous databases contain biological and medical information on approximately 40,000 people." Froguel and his team are now trying to discover the epigenetic factors involved in T2D, in other words the environmental factors that affect the expression of the genes involved in the disease. "Right now, we're focusing on the study of the genome of obese patients whose T2D appears to abate considerably after a surgery that treats their obesity by connecting the stomach to a lower part of the intestine," he explains.

DNA extraction from patients' blood samples using one of the best high-throughput automated platforms in France.

The Institute houses one of the largest DNA banks worldwide, constituted of around 25,000 DNA samples taken from diabetic or obese patients.

A high-throughput automated DNA sequencer is used to track gene mutations tied to T2D.

Helping Froguel is surgeon François Pattou, the director of the Diabetes Biotherapy Unit,[2] one of EGID's two other labs. He regularly carries out this operation on his patients at the Lille Regional University Hospital Center (CHRU). "Short-circuiting the upper part of the intestine seems to trigger overproduction of intestinal peptides that revive the secretion of insulin," he explains. "That's why we're now beginning to offer this operation to T2D patients who are not necessarily suffering from severe obesity." Yet this surgical treatment should only be carried out on patients suffering from the most serious forms of the disease. During the surgery, Pattou takes tissue samples which are sent to Froguel's lab for genomic analysis. The aim is to discover the genes involved in the resumption of insulin secretion.

But the biotherapy carried out in Pattou's unit goes even further. One of his teams, led by the diabetes specialist Marie-Christine Vantyghem, has recently obtained spectacular results by transplanting islets of Langerhans, clusters of pancreatic cells that produce insulin and which are defective in so-called type 1 diabetes. "Half of the fourteen transplanted patients no longer need insulin injections, even as long as five years after the transplant. This is the best result ever obtained worldwide," adds Pattou. The key to this success lies in part in continuous technical improvements performed in the laboratory animal facility, across the courtyard. For instance, researchers there are attempting intramuscular transplants of islets of Langerhans into pigs. But success also relies on work performed before transplant. In the aseptic environment of the biotherapy platform, Julie Kerr-Conte's team has acquired an internationally recognized expertise in isolating islets of Langerhans. Currently, islets are removed from the pancreas of brain-dead donors. In the future, they may come from embryonic stem cells differentiated into pancreatic cells.

EGID's third laboratory, housed on two university hospital campuses,[3] is headed by Bart Staels.[4] His team tests drugs that may regulate the expression of the genes involved in diabetes and in the resulting cardiovascular diseases. Following the discovery of a link between the disruption of the body's biological clock and diabetes, the scientists have started studying mice whose circadian rhythm has been perturbated. They identify the genes whose expression is perturbed, and study their transcriptional regulation. The lab has great expertise in the nuclear receptors involved in the transcriptional regulation of genes, some of which are defective in diabetics. "For instance, we're trying to improve pharmacological molecules that may act on one of these receptors called PPARg," Staels explains. He is also one of the founders of the firm Genfit, which is developing a new antidiabetic drug that acts on this type of receptor. The drug is currently being tested on a small number of patients. "Our lab is also investigating the role of macrophages–immune cells–and of bile acid in the disease. Here again, certain nuclear receptors seem to play an important role," he adds.

Fighting the disease on multiple fronts, EGID's success lies in the genuine synergy between its different teams, all of which enjoy international recognition. "Our goal is to make the Institute one of the world leaders in diabetes research and in the fight against the disease," explains Jean-Benoist Duburcq, CNRS regional representative and head of the EGID project. "To succeed, we'll be pulling out all the stops to attract the best foreign researchers and students, work with renowned private sector partners, and bring together French diabetes clinicians. We're also committed to high-level training and general public information." At the end of 2012, the three teams, numbering 137 colleagues in all, will be brought together on one site, on the Lille university campus.

Jean-Philippe Braly

1. Génomique et physiologie moléculaire des maladies métaboliques (CNRS / Université Lille-II / Institut Pasteur de Lille).
2. Thérapie cellulaire du diabète (CHRU de Lille / Université Lille-II/ Inserm).
3. Université Lille-II and Institut Pasteur de Lille.
4. Récepteurs nucléaires, maladies cardiovasculaires et diabète (Inserm / Institut Pasteur de Lille / Université Lille-II).

Biotherapy platform specialized in isolating human islets of Langerhans. The researchers' expertise in this field is internationally renowned.

RNA microchips are used to analyze the genes expressed in islets of Langerhans. The failure of these tissues to produce insulin is a key factor in diabetes.

DIABETES

There are two types of diabetes. Type 1 diabetes is an autoimmune disease that destroys certain cells in the islets of Langerhans in the pancreas, where insulin is made. The lack of insulin leads to an excessive level of glucose in the blood (hyperglycemia), and to neurological, ocular, and kidney complications. Type 2 diabetes is provoked by a lack of response of the body to insulin, known as insulin resistance, due to both genetic and environmental factors (weight gain, sedentary lifestyle). It also leads to hyperglycemia and associated complications, and usually appears after the age of forty.

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MATERIALS CHEMISTRY

Nanosized Memory

In the world of technology where downsizing is essential, a development led by CNRS researchers promises further advances down the path of miniaturization. The innovation is in the field of molecular nanomagnets–tiny magnets capable of storing binary information due to their magnetic bistability, i.e., the ability to pass from one state to another (on and off) in response to an external stimulus.

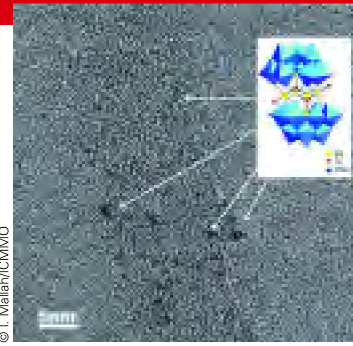
Until now, bistability had only been found in condensed molecular clusters, since isolated molecules tend to lose this trait. However, a team[1] led by Talal Mallah, from ICMMO[2] and the Institut Lavoisier[3] has now managed to isolate a single-molecule magnet (SMM) that keeps its memory storage capacity.[4]

The team's winning strategy is to graft an SMM of Fe_6-polyoxometalate[5] onto a single-wall carbon nanotube, retaining not only its chemical integrity but also its magnetic bistability. Currently being used to develop a device called nanoSQUID (Superconducting Quantum Interference Device) for measuring the magnetism of tiny objects, the advance also paves the way for what Mallah calls "information storage systems with remarkably high density."

Information can be stored by SMMs in ultra-compact electronic devices only if scientists find a way to manipulate their magnetism. And as results indicate that the carbon nanotube's electronic properties help the SMM switch magnetic states, future devices can potentially capitalize on this synergy.

The team further shows that the carbon nanotube and polyoxometalate mix speeds up electron travel between electrode and molecule, causing "a significant energy gain," according to Mallah. This discovery opens up prospects for the hybrid system as a "high-performance electrode" in electrocatalytic procedures for energy conversion or hydrogen production.

Taking its tests beyond polyoxometalates, the team is now exploring the possibility of grafting other types of single magnetic molecules, as well as single photoactive ones that respond to light.



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Isolated single-molecule magnet of Fe_6-polyoxometalate (High resolution Transmission Electron Microscope image) assembled on carbon nanotubes.

Fui Lee Luk

1. Laboratoire de Chimie Physique (CNRS / Université Paris-11), Laboratoire d'Électronique Moléculaire (CEA-Saclay), and the Institut Néel (CNRS).
2. Institut de Chimie Moléculaire et des Matériaux d'Orsay (CNRS / Université Paris-11).
3. CNRS / Université de Versailles Saint-Quentin.
4. A. Giusti et al., "Magnetic Bistability of Individual Single-Molecule Magnets Grafted on Single-Wall Carbon Nanotubes," *Angew. Chem.*, 2009. 121: 5049-52.
5. A polyoxometalate is a polyatomic ion where transition metal compounds are linked by oxygen atoms.

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ANTHROPOLOGY

Out of Africa

The discovery of two new primate fossils, in Africa and in Asia, supports the theory that Asia, not Africa, was the ancestral homeland of anthropoid primates.

Elucidating the origins of anthropoid primates (the group humans, apes, and monkeys belong to) and their relationship to earlier and more primitive primates known as prosimians (the ancestors of lemurs and tarsiers) has lately been a major area of interest in paleoanthropology. Until a decade ago, most paleontologists believed anthropoid primates originated in Africa, where the first fossils were found. Yet the recent discovery of specimens in other parts of the world–47 million year-old remnants were found in China, and later specimens in Thailand, Pakistan, and Myanmar (also known as Burma)–sowed doubts on their geographical origins.

Now, the hypothesis of an Asian birthplace is further supported by two recent discoveries made in Africa and in Asia by scientists including researchers from CNRS' ISEM in Montpellier.[1]

Until now, the *Algeripithecus* primate, of which two fossilized teeth were discovered in 1992 in the Algerian Sahara, was considered to be the most ancient anthropoid, approximately 50 million years old. "Its teeth were very similar to those of Egyptian fossils that are more complete and unmistakable remnants of anthropoid primates," says CNRS researcher Rodolphe Tabuce. "So by extension, researchers assumed *Algeripithecus* was an anthropoid too." Nevertheless, much controversy surrounded this assumption.

The excavation of additional jaw and skull fossils on the Algerian site suggests *Algeripithecus* was in fact not an anthropoid but a prosimian.[2] Fragments of a mandible display characteristics typical of lemur-like ancestors, like the presence of a dental comb, used to clean the animal's fur. "Anthropoids did not have dental combs, but prosimians did," specifies Tabuce. Similarly, pieces of a skull suggest cranial nerve routes similar to those found in prosimians. "By eliminating the *Algeripithecus*, the Egyptian specimens become the oldest African anthropoid fossils, dating back 30-37 million years," explains Tabuce.

© L. Marivaux/CNRS

Fossil excavation site of Ganle, a small village in Myanmar.

The same team has made yet another discovery that further supports the theory of an Asian birthplace. In Myanmar (Asia), they excavated a 37 million-year-old fossil–thus older than the Egyptian fossils.[3] The specimen is the second oldest fossil found in Asia, and corresponds to fragments of the lower jawbone and teeth of a new species of primates–*Ganlea megacanina*–named after their greatly enlarged lower canine. The jawbone's morphology and marks found on the remaining teeth suggest feeding characteristics common to some modern monkeys (Saki, Titi...), which nowadays use their canines to crack open tropical fruit to extract the nutritive seeds. "This behavior is only found in monkeys and has never been documented among extinct or existing prosimians," notes CNRS researcher Laurent Marivaux. "*Ganlea* looks and acts like an anthropoid, not a prosimian," he says. "These two complementary findings provide strong support to the hypothesis that anthropoid primates originated in Asia and could have later spread to Africa."

Clémentine Wallace

1. Institut des Sciences de l'Evolution (CNRS / Université Montpellier-II).
2. R. Tabuce et al., "Anthropoid vs. strepsirhine status of the African Eocene primates *Algeripithecus* and *Azibius*: craniodental evidence," *Proc. Biol. Sci.*, 2009. [Epub ahead of print].
3. K.C. Beard et al., "A new primate from the Eocene Pondaung Formation of Myanmar and the monophyly of Burmese amphipithecids," *Proc. Biol. Sci.*, 2009. 276: 3285-94.

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CANCEROLOGY

A Better Outlook for Breast Cancer Patients

Cancer patients could receive personalized treatment if patients susceptible to develop metastases could be identified early. At the Institut Curie in Paris, researchers have identified a new prognostic marker that is associated to patients' susceptibility to develop metastasis after a primary breast cancer tumor.[1] Heterochromatin protein 1α (HP1α) is a protein necessary to normal cell division, but Geneviève Almouzni's team has now shown that it also favors tumor growth when overexpressed. The higher the level of HP1α, the greater the risk of breast cancer patients developing metastases and dying.

HP1α, as well as its two isoforms β and γ, belongs to a family of proteins called epigenetic (non-genetic) factors, which take part in packing and folding DNA in the nucleus. During normal development, cells acquire a specific pattern of gene expression which is then recorded to be faithfully propagated in a given cell lineage. This record is ensured by epigenetic factors, such as the HP1 isoforms. Almouzni's team analyzed human cells and tissue samples to investigate the expression of the three forms of HP1, in particular during cell proliferation and tumorigenesis. They found that only HP1α is associated to cell proliferation and that large amounts of this protein may facilitate cell growth. Conversely, a reduction of HP1α (not β and γ) causes serious defects in dividing cells, implicating HP1α in cell division.

Moreover, they observed that HP1α was expressed at higher levels in tumor breast cells than in healthy ones, and therefore further investigated HP1α levels in a major retrospective study on 86 samples from breast cancer patients diagnosed in 1995. Only samples from early-stage tumors with no detectable metastases were included since researchers wanted to find prognostic markers for metastasis development. Interestingly, high HP1α expression correlated with the development of metastases. "Further work is needed to confirm these results," says team member Leanne De Koning. In particular, prospective studies will be used to compare the prognostic value of HP1α with standard markers.

Barbara Rush

1. L. De Koning et al., "Heterochromatin protein 1alpha: a hallmark of cell proliferation relevant to clinical oncology," *EMBO Mol Med 1*, 2009. 178-91.

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FOCUS

A Mandible that Speaks Volumes

© J.-P. Raynal

Part of a child's mandible dating back 500,000 years was discovered this past May in Morocco.

A human mandible fragment belonging to a child and estimated to be 500,000 years old was recently unearthed in the Thomas 1 quarry in Casablanca by a team of French and Moroccan archeologists co-directed by Jean-Paul Raynal, of the PACEA[1] laboratory. These are the only child remains ever found for this period in North Africa. Fossilized adult fragments had already been discovered at the quarry in 1969 and 2008, and were attributed to *Homo rhodesiensis*, the immediate predecessor of *Homo sapiens*. The recent discovery suggests that the dating for *rhodesiensis*, previously set at 300,000 years, should be revised. It also points to the fact that a population of this exact type of hominin species was clearly settled in the area half a million years ago. The site provides the earliest testimony to the existence of these hominids, so very close to becoming modern humans.

1. De la Préhistoire à l'Actuel: Culture, Environnement et Anthropologie (CNRS / Université Bordeaux-I / Ministry of culture and communication).

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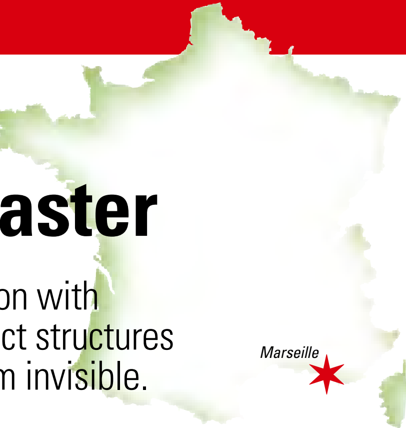


ENGINEERING

Cloaking Ourselves from Disaster

A team at the Institut Fresnel[1] led by Stefan Enoch, in collaboration with researchers in the UK,[2] have developed a novel approach to protect structures from powerful earthquakes and Tsunamis. The secret? Make them invisible.

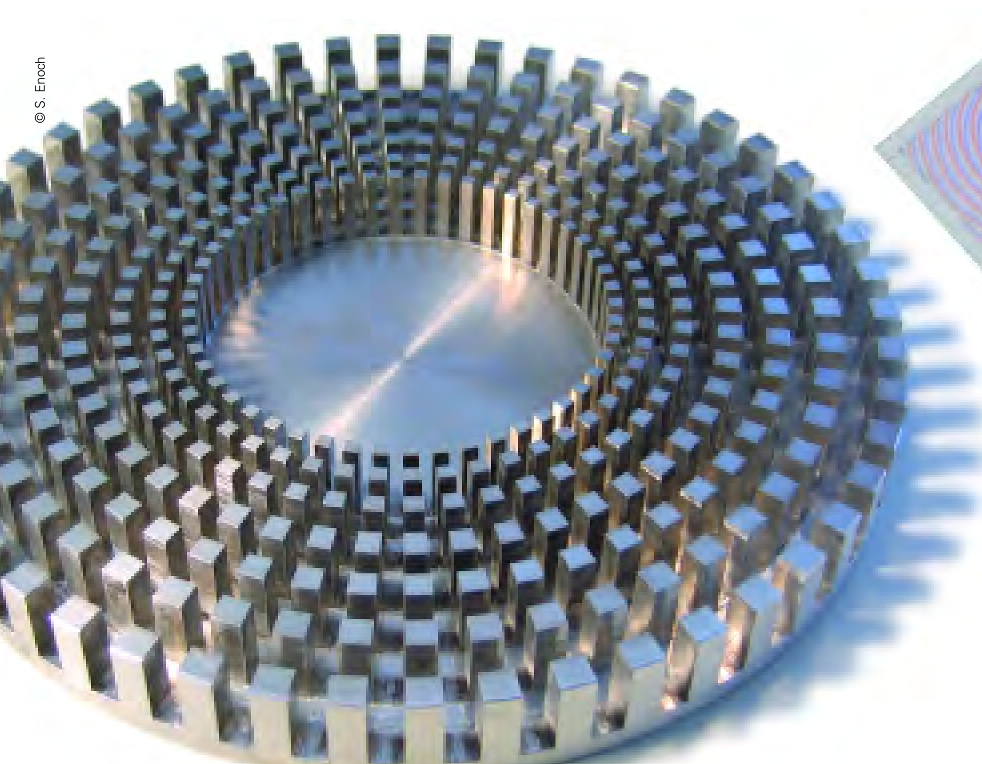
Listening to Sébastien Guenneau, researcher at Marseille's Institut Fresnel, invisibility is just around the corner. In fact, it already exists, but at wavelengths much longer than our visible spectrum. "Our human eye can only detect electromagnetic waves between 440 nm (purple) and 700 nm (red). But there's a lot more out there, from radio waves (the longest, anywhere between 1 m-1 km) all the way to gamma rays (approximately 0.01 nm). All these electromagnetic waves can be detected because objects either emit them (like stars), or reflect them–the reason you and I see each other. But what if we could make a cloak that would not reflect them, but guide them around an object?" That object would become invisible.

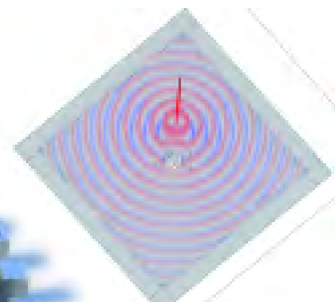
"And this is no longer just theory," Guenneau explains, referring to the incredible progress made by the physicist John Pendry (Imperial College London) and his colleague David Smith (Duke University), who stipulated in 2004 that for an object to become invisible to a specific electromagnetic wave, it would have to be surrounded by a material whose structures were ten times smaller than the wave itself. Though it is still impossible to tackle visible light (the structures would have to be 10 nm), specially-built metameterials[3]–as they are known–could be fine-tuned to tackle microwaves (with structures in the millimeters). Two years later, Pendry and Smith were able to shield an object from microwaves at a certain frequency by placing it at the center of a metamaterial (12 cm in diameter) made up of a system of concentric rings: the first successful invisibility cloak.

"We realized that the principle would hold no matter the type of wave: electromagnetic, acoustic, or mechanical, like waves moving on the surface of a liquid," explains Guenneau. In 2008, the team grabbed headlines with the promise of an anti-tsunami shield[4] which would manipulate ocean waves to hide a central object. In the lab, they created a metamaterial that consisted of an aluminum disc 20 centimeters in diameter covered by 7 concentric rows of pillars surrounding a flat center, and submerged under the surface of a liquid. Waves that entered the maze would bounce off the pillars, cancel each other out, and end up traveling around the "corridors" to exit on the opposite end of the disc, leaving waters in the "eye" of the disc relatively calm. The scientists believe it would be possible to replicate this type of structure to shield oil platforms, and possibly entire coastlines from tsunamis and severe storms, though at this scale, cost could become prohibitive.

But Guenneau and his colleagues didn't stop there. Their current research[5] tackles seismic waves. In the lab, they devised an elastic "thin plate" on which sits a cylinder 120 cm in diameter and 1 cm in height representing the object to shield. The metamaterial is in this case made up of six different types of plastic polymers arranged concentrically around the cylinder, each tuned to a specific wavelength. Vibrations hitting the plate are deflected by this metamaterial, leaving the central cylinder untouched. And if the model currently only works with surface waves–the most destructive–theoretical work is in progress to bend coupled pressure and shear body waves as well,"[6] he explains, stating that they are in the process of filing a patent with CNRS for this elastic cloak, which would have potential applications ranging from the car industry to aeronautics and anti-earthquake systems. From cloaking stadiums from seismic waves to protecting oil platforms from tumultuous seas, invisibility has never looked so promising.

Saman Musacchio





Above: Propagation of surface waves on a thin plate. The waves travel around the obstacle.

Left: Large-scale models of this small structure (10 cm in diameter) could make entire coastlines or offshore platforms "invisible" to tsunamis.

1. Laboratoire CNRS / Universités Aix-Marseille-I and -III / École Centrale Marseille.
2. Alexander Movchan, Division of Applied Mathematics (University of Liverpool, UK).
3. These are materials not found in nature, but built from one or more materials, or by modifying existing materials, to answer a specific function. They can be engineered using chemistry, physics, or mechanics.
4. M. Farhat et al., "Broadband Cylindrical Acoustic Cloak for Linear Surface Waves in a Fluid," *Phys. Rev. Lett.*, 2008. 101: 134501.
5. M. Farhat et al., "Ultrabroadband Elastic Cloaking in Thin Plates," *Phys. Rev. Lett.*, 2009. 103: 024301.
6. M. Brun et al., "Achieving control of in-plane elastic waves," *App. Phys. Lett.*, 2009. 94: 061903.

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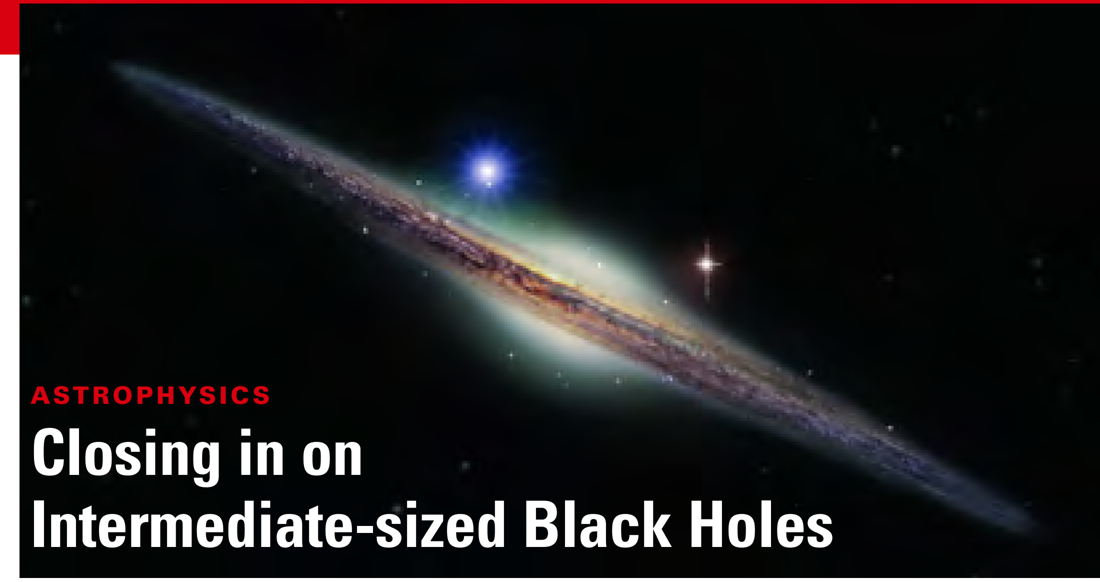

Artist's rendition of the recently discovered HLX-1 source (blue spot above the galactic bulb), located in the ESO 243-49 spiral galaxy.

ASTROPHYSICS

Closing in on Intermediate-sized Black Holes

Using the ESA's XMM-Newton X-ray space telescope, Olivier Godet[1] and his colleagues at CESR[2] believe they have found the "missing link" in black hole formation.[3] A black hole is a region of space so dense that nothing–not even light–can escape it. To date, two types of black holes have been observed: stellar ones, formed by the collapse of a star and which are relatively small (3-20 solar masses), and supermassive ones (millions to billions of solar masses) that can be found at the center of galaxies like our own. Yet the formation of the latter have stumped astrophysicists for years. A theory is that they are the result of smaller black holes colliding and continuously accreting more matter. But if this is the case, why have we never been able to detect intermediate-sized black holes?

There are at least two ways of identifying–and "weighing"–black holes: by observing stars that orbit an area of space that seems empty, (common for stellar mass black holes), or by using powerful X-ray or Gamma-ray telescopes to scan the universe for the energy emitted by a black hole's accretion disc, as gas and dust spin faster and faster before being swallowed up. If the latter works well for estimating the size of supermassive black holes, intermediate-sized ones are more treacherous to identify because they are far away, and they have a more limited impact on their immediate surroundings.

Yet Godet and his colleagues are confident that the object that they have discovered at the edge of a galaxy called ESO 243-49, more than 290 million light-years away, is an intermediate-sized black hole. Dubbed "Hyper-Luminous X-ray Source 1" (HLX-1), it has an estimated size of more than 500 solar masses. HLX-1 was first observed by XMM-Newton in 2004, but the researchers needed to rescan the area in 2008 to confirm its nature. This is the only black hole that has been observed in this galaxy so far, "but we are planning a battery of multiwavelength observations to find out if this source is part of a star cluster, which would have all the gas necessary to make it grow," he concludes.

Saman Musacchio

1. Department of Physics and Astronomy, University of Leicester, UK (now back at CESR).
2. Centre d'Étude Spatiale des Rayonnements (CNRS / Université Paul Sabatier).
3. S. Farrell et al., "An Intermediate Mass Black Hole of ≥ 500 Solar Masses in the Galaxy ESO 243-49," *Nature*, 2009. 460: 73-5.

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PALEONTOLOGY

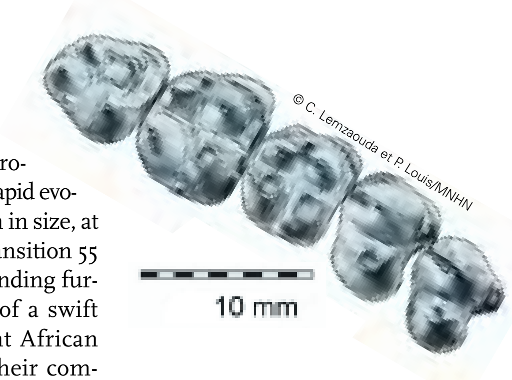
Elephants Started Small

If elephants never forget, neither does the Earth, safeguarding the many traces of evolution–including those of elephants. For despite having only three surviving species, elephants have a strikingly long and rich history. A history even longer than previously believed, following a discovery made through a French-Moroccan program[1] in the North African country's Ouled Abdoun phosphate basin: 60 million-year-old fossils of the elephant's ancestor, dating back to the Paleocene era.[2] It has been named *Eritherium azzouzorum*, after the Ouled Azzouz villagers who helped recover the fossils.

Weighing just 4-5 kg, the marmot-like *Eritherium* may seem a far cry from today's large mammal, but its teeth and skull remains belie a common lineage. One such example is its prominent incisors, the forerunners of tusks. *Eritherium azzouzorum* has now become the oldest-known member of the elephant order (proboscideans), unseating the 55 million-year-old *Phosphatherium*, found in upper levels of the same basin by the same team.

Emmanuel Gheerbrant[3] explains that *Eritherium* is one of the earliest fossil examples of modern placental orders, setting an "important milestone" for calibrating the placental tree. It is also the oldest African ungulate[4] to date, suggesting ties between proboscideans and groups such as condylarths[5] and elephant shrews. *Eritherium*'s extreme primitiveness means that it is "close to the ancestral form from which the initial diversification of ungulates took place," declares Gheerbrant.

Top dentition of the proboscidean *Eritherium azzouzorum*.



The mammal's primitive state implies that proboscideans underwent a rapid evolution spurt, one of which in size, at the Paleocene-Eocene transition 55 million years ago. The finding further supports the idea of a swift divergence of the extant African ungulate orders from their common ancestor after the Cretaceous-Tertiary mass extinction, notably of dinosaurs, 65 million years ago, when an "extraordinary opportunity arose for other animals to evolve," concludes Gheerbrant.

Fui Lee Luk

1. Paris Muséum National d'Histoire Naturelle (MNHN), Moroccan Ministry of Energy and Mines, Office Chérifien des Phosphates, Universities Cadi Ayyad (Marrakech) and Chouaïb Doukkali (El Jadida).
2. E. Gheerbrant, "Paleocene emergence of elephant relatives and the rapid radiation of African ungulates," *PNAS*, 2009. 106: 10717-21.
3. Centre de recherche sur la paléobiodiversité et les paléoenvironnements (MNHN / CNRS / Université Paris-VI).
4. A herbivorous mammal with hoofs, claws, or nails.
5. Primitive early Tertiary ungulates with feet that had five hoofed toes.

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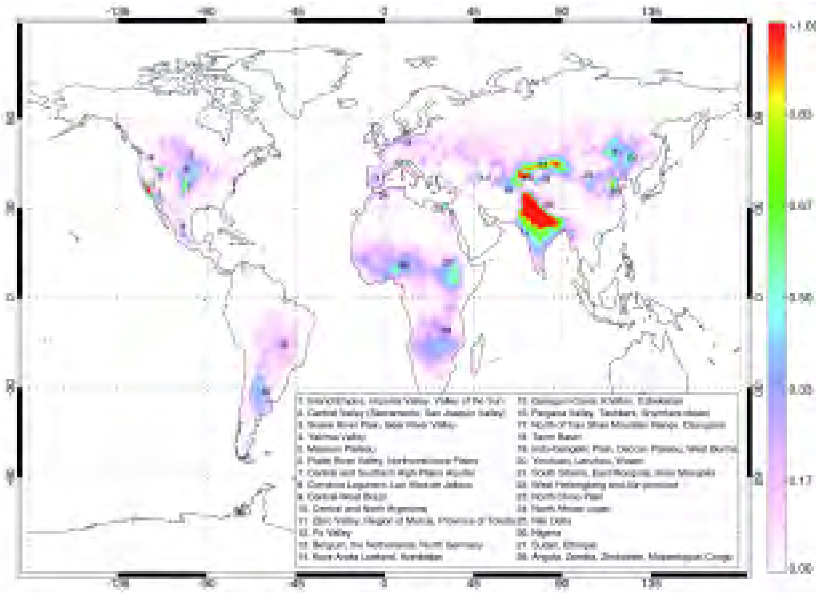
ENVIRONMENT

First Global Map of Ammonia Sources



© IASI-NH3/ULB & LATMOS/INSU-CNRS

Global distribution of ammonia in 2008, as measured by the IASI instrument on the MetOp satellite. The yellow to red colors indicate high ammonia concentrations.

According to Cathy Clerbaux, from LATMOS,[1] the first global map of ammonia emissions[2] came about nearly by accident. Her team, collaborating with researchers in Belgium, had been analyzing data from the Infrared Atmospheric Sounding Interferometer (IASI) on the MetOp satellite (IASI/MetOp) designed for operational meteorological soundings with a very high level of accuracy. Their goal was to learn as much as possible about the chemistry of the Earth's atmosphere. This entailed studying concentrations of atmospheric carbon monoxide, methane, ozone, and other persistent gases. Ammonia (NH_3), however, had not been on the agenda.

Ammonia is a pollutant that contributes to the formation of airborne particles harmful to human health, and to other environmental effects. It comes from many sources, some natural, but the bulk is a result of agricultural activities. Despite ammonia's far-reaching effects, there is very little data on global emission levels. The gas tends to stay in the atmosphere for a short period of time–a few hours at most–making satellite observations almost impossible. Global data was therefore limited to a patchwork of Earth-based measurements.

"When we were analyzing our data, there was a very weak signal that we could not identify. It turned out to be ammonia," explains Clerbaux. Although the IASI/MetOp satellite, launched in 2006, was not designed to observe ammonia, its two passes over the Earth's entire surface every 24 hours generate millions of observations a day. By accumulating data over a one-year period, the team was able to compensate for the gas's weak signal by filtering out background "noise" in their images, and then create a global map of ammonia emissions worldwide.

Their map was a wake-up call. It revealed many sources of the gas that had been previously unknown, and it showed high ammonia-concentration regions in South Asia, Europe, and California.

"We will continue to monitor ammonia to determine how the sources evolve and change over the years," says Clerbaux. Now that her team has shown it is possible to observe ammonia from the skies, the MetOp follow-on satellite currently in development could be designed to measure these emissions more accurately.

Mark Reynolds

1. Laboratoire atmosphères, milieux, observations spatiales (CNRS / Universités Paris-VI and Versailles-Saint-Quentin).
2. C. Lieven et al., "Global ammonia distribution derived from infrared satellite observations," *Nature Geoscience*, 2009. 2: 479-83.

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SOCIAL PSYCHOLOGY

Incivilities: Who Reacts?

On a sidewalk, a pedestrian tosses a used tissue right next to a trash can. On a bus, a passenger talks loudly on his phone. Will these individuals be asked by others to correct their behavior? The answer is "probably," if it occurs in Spain, but "not likely" if this happens in the US or the UK. These are the findings of Markus Brauer, a CNRS researcher in social psychology[1] who has compared the reactions of inhabitants of eight western countries[2] when faced with 46 types of uncivil behavior, such as cutting into a line, degrading buildings with graffiti, or urinating in the street.[3] Brauer wants to understand why certain individuals express their disapproval of such misdemeanors while others do not. The scientist found that in Portugal, Spain, and Italy–countries defined by "collectivist cultures" according to Geert Hofstede[4]–people are more inclined to reproach uncivil behavior than in "individualist" countries such as the UK and the US, a category that also includes France, although to a lesser extent. "In 'collectivist' cultures, individuals feel more dependent upon each other, and consider the whole community as an integral part of their own identity," Brauer explains. In the same line, previous studies from the same laboratory suggested that individuals are more likely to reproach uncivil behavior if they feel personally affected by it. "Thus, intervention depends on how individuals define themselves," concludes the researcher. "For some, the 'self' only includes their home, while for others, it also includes their neighborhood, or even the whole city." In the latter case, any incivility, especially if it debases the environment, is perceived as a personal assault. And even if expressed in the form of a courteous remark, their reaction can be defined as self-defense. In short, to combat common uncivil behavior, there is nothing so effective as feeling at home... everywhere.

Stéphanie Arc

© J. Lund/P. Zacharias/Getty Images/Blend Images

According to Markus Brauer, people are more likely to react to this man's rude behavior in Spain than in Germany.

1. Laboratoire de psychologie sociale et cognitive (CNRS / Clermont Université).
2. The US, UK, Germany, Belgium, France, Italy, Spain, and Portugal.
3. M. Brauer and N. Chaurand, "Descriptive norms, prescriptive norms, and social control: An intercultural comparison of people's reactions to uncivil behaviors," *Europ. J. Soc. Psychol.*, 2009. DOI: 10.1002/ejsp.640
4. Geert Hofstede defined indicators that reflect the mean degree of individual integration in the different groups that make up society (close family, distant family, etc.). www.geert-hofstede.com

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COMPUTER SCIENCE

Memories of the Future

Scientists at CNRS have worked with the binary coding found in electronic devices to allow for a smoother encryption and viewing of stored data. This promises significant memory optimization in miniature computers.

Two CNRS teams have focused their research on refining the manipulation and readout of polarization and magnetization states used to encode information respectively in ferroelectric and ferromagnetic memory systems. This type of so-called non-volatile memory uses electric and magnetic signals to access data that can be stored long term, even when the device is not powered. Volatile memory, on the other hand, disappears as soon as the computer is off.

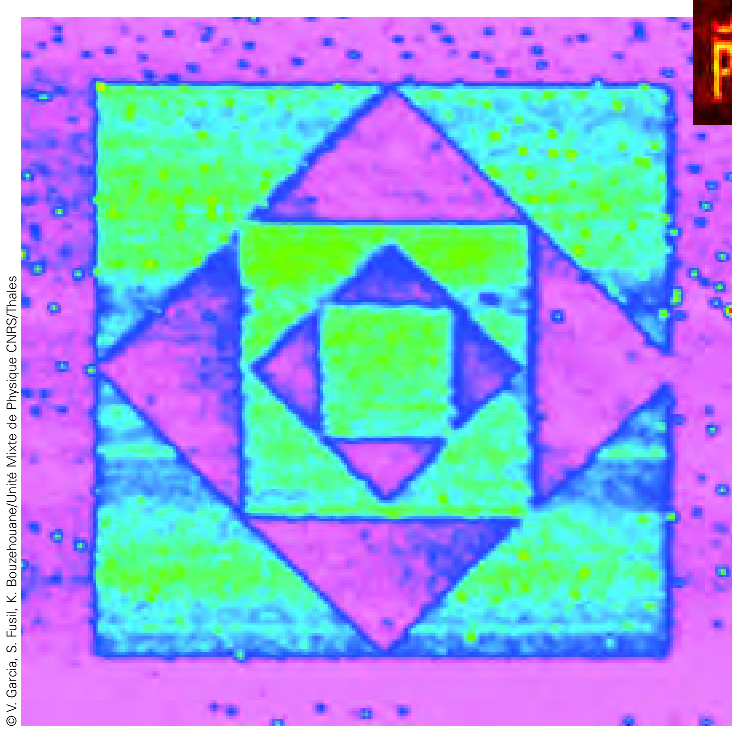
Manuel Bibes and co-workers, from CNRS/Thales,[1] have made major advances in the use of ferroelectric memory (FeRAM).[2] Up to now FeRAM, which is actually faster than the flash memory used in most electronic devices, was hindered by a limited storage density and by a "destructive" data readout process (the voltage sweeps that read the tiny current peaks also destroy the data). To fix this problem, the team showed that the direction of the polarization (0 or 1) may be more simply read in terms of the magnitude of the tunnel current passing across an ultrathin ferroelectric film: It turns out that the amount of tunnel current varies depending on the direction of the polarization within the device. With tunnelling, one can detect these amounts, and decipher the data's binary code. "We have found the right conditions so that the layers can maintain their ferroelectric quality in spite of their very thin dimensions. The main advantage is that one can view the information without destroying it," explains Bibes.

In a related study, Jean-Yves Bigot's group[3] managed to increase the magnetic memory access rate by speeding up the process of magnetization reversal required to view the data. The researchers obtained this by shining very short laser pulses on a thin metallic ferromagnetic film.[4] The action takes place within a millionth of a billionth of a second, which is 100,000 times faster than the swiftest devices on today's market. According to Bigot, "the brief laser pulse triggers a magnetization reversal much more effectively than the slower pulses produced by an electric current or a simple magnetic field."

The goal is to reduce the focusing of the laser beam so that the memory's code may be accessed within an increasingly tiny volume–paving the way for an even further miniaturization of electronic devices, as in the FeRAM/ tunnelling discovery. The market is likely to quickly capitalize on these high-speed technologies, which promise to reduce costs and energy consumption, as well as increase storage density and longevity.

Melisande Middleton

© J.-Y. Bigot



© V. Garcia, S. Fusil, K. Bouzehouane/Unité Mixte de Physique CNRS/Thales

Right: Tunnel electroresistance cartography of a $BaTiO_3$ thin film (conductive-tip atomic force microscope technique). The different colors correspond to square shaped ferroelectric domains of different polarities rotated at 45° angles.

Far right: Inscription on a film of $CoPt_3$ using femtosecond laser pulses.

1. CNRS / Thales / Université Paris-XI, in collaboration with the University of Cambridge.
2. V. Garcia et al. "Giant tunnel electroresistance for non-destructive readout of ferroelectric states," *Nature*, 2009. 460: 81-4.
3. Institut de physique et de chimie des matériaux de Strasbourg (CNRS / Université de Strasbourg).
4. J.-Y. Bigot et al., "Coherent ultrafast magnetism induced by femtosecond laser pulses," *Nature Physics*, 2009. 5: 515-20.

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MINERALOGY

Origins of the Solar System Revisited

Six years ago, not far from the Siberian village of Isheyevo, a Russian farmer happened across a strange rock in one of his fields. Little did he know, but the 16-kilogram meteorite he had discovered was a key to understanding the formation of the early solar system.

Researchers working at LMCM[1] have discovered that the Isheyevo meteorite carried within it a record of the history of Earth's immediate neighborhood. And though it is impossible to unequivocally identify the specific parent body of this meteorite, it is believed to have broken off from an asteroid, possibly after a giant impact.

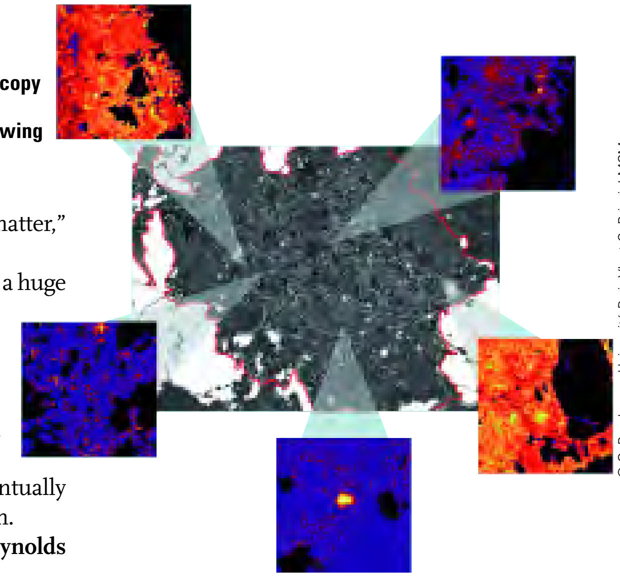
Team member Giacomo Briani explains that the meteorite was found to contain several "intrusions." These are small assemblages of minerals called xenoliths (literally "foreign rock") that have an origin different from that of the other components of the host meteorite. The Isheyevo xenoliths contain basic organic matter, which includes elements such as hydrogen and nitrogen. "The usual interpretation is that the organic matter formed before the solar system, in the interstellar medium," says Briani. The Isheyevo xenoliths have unique variations in their nitrogen isotopic composition–in fact, one sample showed the highest values of the $^{15}N/^{14}N$ ratio ever recorded in a meteorite.[2] "Solar system origin models we have at present explain this nitrogen isotopic composition as being caused by reactions between ions and molecules in the interstellar medium," explains Briani. And according to those models, the high concentrations of heavy nitrogen should be accompanied by high levels of deuterium (a hydrogen isotope). But since the Isheyevo xenolith lacks the levels of deuterium that would seem to be required by its nitrogen levels, those models are now in question: "It is a problem that concerns the evolution of the primordial organic matter," says Briani.

Though Isheyevo has left a huge impact crater in our understanding of the solar system, Briani says that the stone is billions of years old–and therefore a cache of information about the free-floating interstellar soup that would eventually coalesce into the solar system.

Mark Reynolds

1. Laboratoire de minéralogie et cosmochimie du Muséum (CNRS / Muséum National d'Histoire Naturelle).
2. G. Briani et al., "Pristine extraterrestrial material with unprecedented nitrogen isotopic variation," *PNAS*, 2009. 106: 10522-7.

High resolution electron microscopy of an inclusion (center) with NanoSIMS images (around) showing enrichment in ^{15}N (yellow dots).



© O. Boudouma, Université Paris VI, et G. Briani, LMCM

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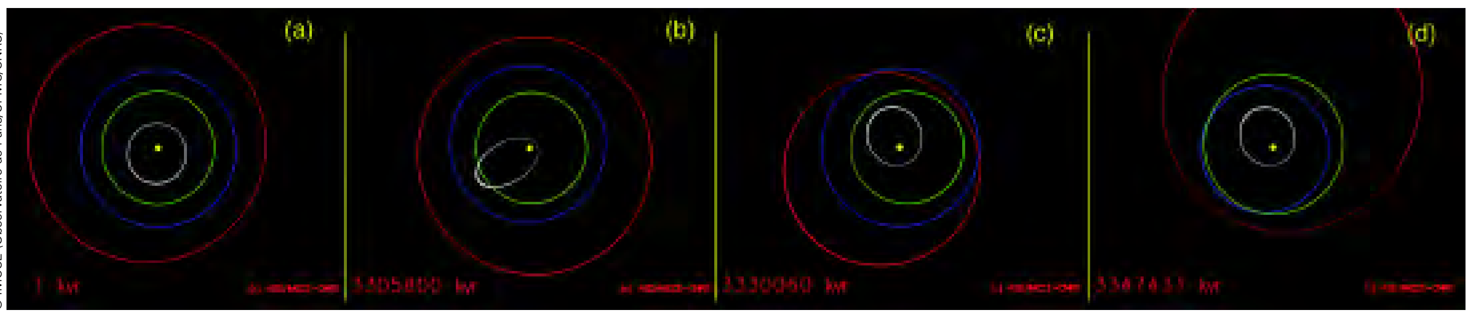
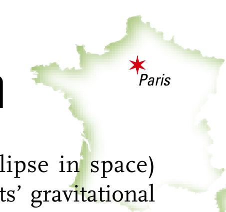


© IMCCE (Observatoire de Paris/UPMC/CNRS)

Example of long-term evolution of the planetary orbits: Mercury (white), Venus (green), Earth (blue), Mars (red). Time is indicated in thousands of years (kyr). Various scenarios show possible collisions between the planets.

ASTROPHYSICS

Future Collisions in the Solar System



Ever since Newton, astronomers have been trying to understand the gravitational interactions of planets to predict their orbits. The movements of the planets in our Solar System were thought to be mostly stable and predictable, with slight but regular modifications. This changed in 1989, when French astronomer Jacques Laskar demonstrated that the Solar System's inner planetary orbits were in fact largely chaotic, and that this could even lead to a collision between Mercury and Venus on billion-year time frames. Could this happen before our sun begins to die, in 5 billion years?

To find out, Laskar,[1] together with fellow researcher Mickaël Gastineau, recently used the new Jade supercomputer at the French National Computing Center to do the 7 million hours of calculations needed to chart the motions of planets in 2500 different scenarios over the next 5 billion years.[2] Jade took only five months to do the maths. In each simulation, minute changes were made to Mercury's orbit (0.38 mm sequentially), taking into account the moon, the eight planets and Pluto's contributions, as well as Einstein's general relativity. All simulations start the same, but after tens of millions of years, variations begin to accumulate and trajectories start to diverge. In most cases, the Solar System is unaffected: Orbits deform and precess (a slow rotation of the ellipse in space) through the planets' gravitational interactions but without any of them being ejected or colliding. However, in about 1% of cases, Mercury's eccentricity (the elongation of its orbit) increases dramatically–up to 0.9. This may lead, in one case, to an increase in Mars' eccentricity, which in turn results in a total destabilization of the Solar System approximately 3.4 billion years from now. In this latter scenario, Mars has a 2.5% chance of being ejected, whereas the other solutions lead to planets colliding with each other, and a 24% chance of the Earth being involved in such a collision.

Astronomers are quite sure that a collision could happen in less than five billion years. "The next step is to try to predict the earliest date at which a collision with Earth could occur," concludes Laskar.

Marion Girault-Rime

1. Institut de mécanique céleste et de calcul des éphémérides (CNRS / Observatoire de Paris / Université Paris-VI).
2. J. Laskar et al., "Existence of collisional trajectories of Mercury, Mars and Venus with the Earth," *Nature*, 2009. 459: 817-9.

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IN BRIEF

Melatonin Slows the Effects of Aging

Melatonin, known as the "sleep hormone," slows the appearance of signs of aging in shrews,[1] according to a study by researchers at the Arago laboratory in Banyuls-sur-Mer.[2] Naturally secreted at night in vertebrates, melatonin allows the organism to synchronize with the circadian rhythm (day/night alternations). With age, however, the quantity of melatonin synthesized by the organism drops until it disappears. Presenescent shrews (i.e.,14-16 months old for laboratory animals) receiving a steady delivery of melatonin showed delayed signs of aging as compared to non-treated animals. In particular, the characteristic age-related troubles in locomotor activity were delayed by three months in the treated animals, which represent a 10% lifespan increase. This study shows that melatonin, otherwise known for alleviating sleep disorders and for its antioxidant and antidepressant properties, could also play a role in the process of aging.

1. E. Magnanou et al., *PLoS One*, 2009. 4: e5904.
2. CNRS / Université Paris-VI.

POLLUTION CONTROL

A Fungus that Decontaminates Soil

Using a fungus that is able to degrade pesticide derivatives, researchers have found a promising means of remediating cultivated land.

After several decades of modern intensive farming, much research is now aimed at purging our soils of numerous substances of industrial origin. One promising solution may come from an ordinary filamentous fungus, *Podospora anserina*.[1] A collaborative study[2] led by Philippe Silar (IGM) and Jean-Marie Dupret (BFA) has shown that *Podospora anserina* is indeed capable of "digesting" pollutant molecules by chemically modifying them, using one of its enzymes. Indeed, where another living species might have perished, this fungus assimilates the pollutant and transforms it into a harmless substance, thus remediating the environment.

Because fungi constitute a remarkable reservoir of enzymes with astonishing properties, the scientists decided to test the resistance of several species of molds to a major class of pollutants, aromatic amines. Two of them survived, indicating that these fungi are endowed with enzymes that allow them to "digest" these aromatic amines. The researchers chose to focus their efforts on *Podospora anserina*, which is already well-known to research, and whose genome has been entirely sequenced. They were able to identify, clone, and purify an enzyme involved in these resistance mechanisms: PaNAT2. To define its role more precisely, Silar's team produced mutated strains in which the gene for the PaNAT2 enzyme was inactivated, and challenged them with a derivative of a pesticide found in some types of agricultural land, 3,4-dichloroaniline (3,4-DCA). In a liquid medium, about 45% of the pollutant was degraded by the normal strain of *Podospora anserina* after 3 days, versus only 5% by the mutated strain of the fungus. "This proves unambiguously that the PaNAT2 enzymatic pathway is involved in the ability of this fungus to tolerate certain aromatic molecules," explains Dupret.

The scientists then tested the remediation (i.e., soil decontamination) capacity of the fungus. They planted lettuce seeds (known for their sensitivity to 3,4-DCA) in a soil containing the pollutant, which had been treated with the fungus for three days. The salad seeds germinated normally, even at an extremely high concentration of the pollutant, thus proving irrefutably the remediation capacity of *Podospora anserina*. This fungus presents another considerable advantage as a candidate for soil remediation: it multiplies by sexual reproduction. To prevent its uncontrollable proliferation, simply inoculating strains of only one mating type will make the fungus disappear after a certain period of time.

However, before field-scale trials can begin, the team needs to answer a few questions: How can the fungus be produced in large quantities? Does it need to be buried, or can it just be spread on the soil surface? Only once they have the results of these preliminary experiments will the scientists consider testing the method under real-life conditions.

Caroline Dangléant

1. M. Martins et al., "An acetyltransferase conferring tolerance to toxic aromatic amine chemicals: molecular and functional studies," *J Biol. Chem.*, 2009. 284: 18726-33.
2. Unité de Biologie Fonctionnelle et Adaptative (BFA) (CNRS / Université Paris-VII); Institut de Génétique et Microbiologie (IGM) (CNRS / Université Paris-XI); Interfaces, traitements, organisation et dynamique des systèmes (ITODYS) (CNRS / Université Paris-VII).

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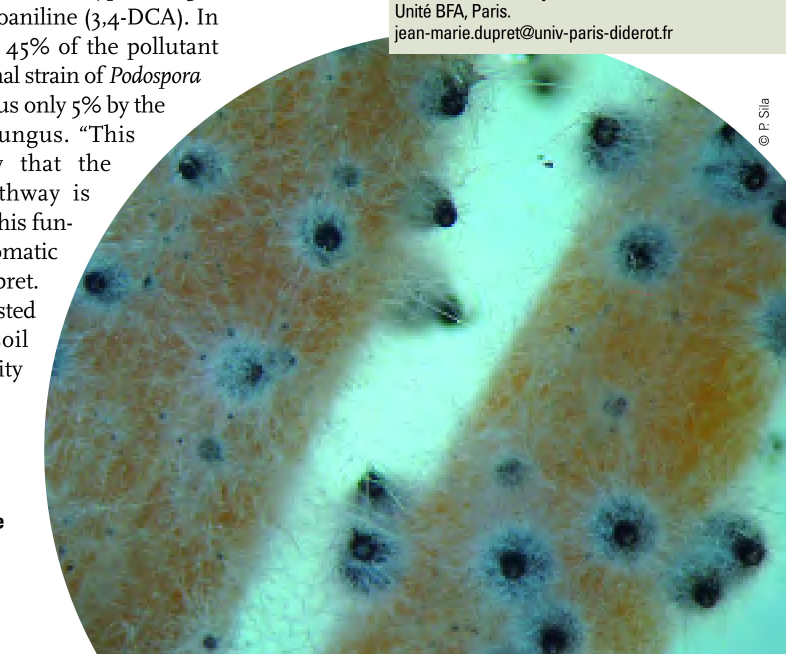
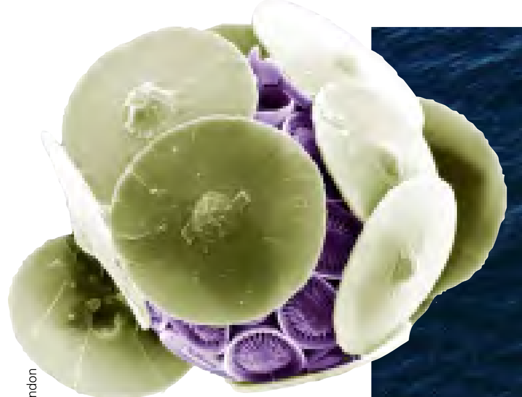


© P. Silar

After fertilization, *Podospora anserina* develops fruiting bodies (small furry pear-shaped outgrowth about 0.75 mm long) that protect the reproduction events.



© Courtesy of Jeremy Young/The Natural History Museum, London

How will coccolithophores, single-celled algae covered by a calcareous skeleton, react to ocean acidification? Tara Ocean may provide some answers.

Only 36 meters long, the Tara schooner is relatively small for an oceanographic vessel, and can therefore adapt to difficult sampling conditions.

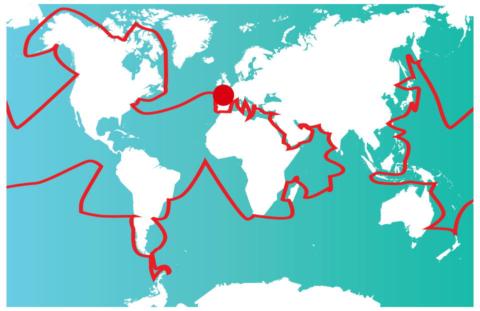
© F.Latreille/taraexpeditions.org

THE TARA MISSION

Marine Life Survey

Sailing the oceans from September 2009 to 2012, an international team of researchers on board the schooner Tara will investigate the abundance and diversity of bacterial and planktonic life.

This September, the schooner Tara set sail from Lorient, France, for the Mediterranean, then the Persian Gulf, the Indian Ocean, and beyond. It is due to return at the end of 2012. “By then, it will have sailed across most of the world’s seas and oceans,” says biologist Éric Karsenti, a CNRS researcher on temporary assignment to the European Molecular Biology Laboratory in Heidelberg, Germany, and co-director of the Tara Ocean expedition. “This voyage, roughly the equivalent to circling the globe twice, will have taken us through areas that are extremely varied in terms of biological resources, biodiversity, and human impact on the environment. Furthermore, the route lets us sail with prevailing winds, thus limiting our fossil fuel consumption.”



Roadmap for Tara, which will travel 150,000 km on four oceans and many seas, stopping in 50 countries.

The mission follows on from the Tara Arctic expedition, which had the schooner locked in Arctic pack ice, drifting with it for two years (and across a distance of 1800 km) to study climate change phenomena at high latitudes. Tara Ocean’s mission is focused on understanding and assessing the impact of global warming–and the acidification of the oceans that accompanies it–on the life of marine micro-organisms.

It is exploring in particular the world of plankton, an ecosystem whose diversity and working mechanisms are poorly understood. As the ship sails on, the on-board instruments can collect a host of data from the surface all the way down to a depth of 1000 meters. These include physical, chemical, and biological measurements like temperature, salinity, pH, and biomass density of sea water, as well as carbon flux from the surface to the sea floor. But the planktonic organisms themselves are also picked up for research. The collected samples, ranging from protists (a group of unicellular organisms), to viruses, bacteria, microalgae, microcrustaceans, and larvae of various organisms, are then packaged on board and sent to the various laboratories taking part in the mission.

“Due to the ship’s relatively small size, it can only host five scientists, but a large number of researchers from all over the world–especially colleagues from CNRS–are part of this project: oceanographers, biologists, geneticists, physicists, etc.,” adds Karsenti. Onboard imaging systems enable them to rapidly receive initial images of the organisms collected, which is likely to lead to the discovery of many new species.

The aim is also to improve our understanding of ocean-climate interactions, and to predict their evolution. “The seas and oceans produce half the oxygen we breathe and absorb 50% of overall CO_2 emitted into the atmosphere, half of which stem from human activity. And if we know that these properties are mainly due to planktonic organisms, we still need more experimental data to understand and quantify how this ‘biological carbon pump’ works, and how climate change is affecting it. A major question for anyone trying to predict future climate change is to find out how these planktonic ecosystems will adapt to global warming and pollution,” Karsenti explains.

All the data gathered, with their GPS position, will be fed into an integrated public database, the Bio-Bank. This will create a reference for future research into climate change’s effects on marine ecosystems and the ocean carbon pump. “And as Tara continues its journey, we will be able to draw up a ‘functional map’ of the oceans, which will be available online to help raise public awareness about these issues,” Karsenti concludes.

Marie Lescroart

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CATHERINE MARRY, SOCIOLOGIST

Beyond the Glass Ceiling

One of the first to identify–and boldly state–that girls did better than boys at school, Marry has dedicated her research to gender discrimination, at school, at home, but mostly at work, where she continues to inspire others to follow in her footsteps.

It took me quite some time to think of myself as a feminist. When I was young, I was probably more of a misogynist,” laughingly admits Catherine Marry, a sociologist and CNRS senior researcher at the Centre Maurice Halbwachs[1] in Paris. An unexpected revelation, coming from a researcher who, 20 years ago, started analyzing the gender relationships–and the inequality suffered by women–both in school and at work. And especially as she recently jointly published a guide[2] on “how to put an end to male domination.” Her work and involvement exposing some of the gender inequalities in our society won her the 2008 mentoring prize (Prix du Mentorat), awarded by the jury of the Irène Joliot-Curie Prize for her remarkable initiative to help young women early in their careers. Indeed, she is involved in many associations that encourage and promote women in the scientific field. As the leader of the “Professions, Networks, Organization” (PRO) group, made up of approximately 40 researchers, research engineers, academics, and PhD students, Marry encourages her teams to give a “gender dimension” to their work, whether it is about trade unions, artists, or career networking.

Although Marry initially studied economics, chosen “by default” and because “it was a field dominated by men,” she rapidy moved to sociology. After she completed a diploma of higher education in industrial relations in 1971, Marry, then 23, joined the LEST,[3] in Aix-en-Provence, a laboratory involved in labor economy and sociology. A year later, together with two research engineers, she took part in the “France-Germany Comparison,” which was then one of the biggest projects in the social sciences. They observed that French managers were better paid than their German counterparts. “Economic theory was unable to explain these differences by the relative scarcity of the workforce, because relative to the total number of workers, there were more managers in France than in Germany.” Through sociological studies, they realized that if French managers were on average overpaid, it was paradoxically because their professional training was not as well recognized as that of their German counterparts. In Germany, managers received in-depth training and thus had greater professional legitimacy. It was then not necessary to grant them power through a higher salary. These results created considerable stir. “But surprisingly, we had completely excluded women from the study,” Marry recalls, still amazed at the omission. “Part-timers, maternity leave, extremely varied jobs, etc.: We found that all of this upset our analysis.” As the study went on, Marry, who believes economics is “out of touch with reality,” became increasingly drawn to sociology. But it wasn’t until 1983 and her meeting with CNRS sociologist Anne-Marie Daune-Richard, who was investigating women at work, that she really became involved in the subject. Together, they explored a topic that she feels strongly about: women who opt for “male” careers. Somewhat out of tune with the feminist theories of the time, which decried the exploitation of women, Marry, fired with the desire to get her ideas across, was more interested in the possibilities of transforming gender relations. “At that point, I had found my path.” In 1985, she had already joined LASMAS,[4] where she focused on women engineers, a seemingly obscure subject. As a result, she intensified her research in the sociology of education. “I was one of the first to show that girls did better at school than boys. Right from the start, I felt that this was a seismic change.” In 1991, she obtained a position as a researcher at CNRS.

Her second key encounter was with sociologist Margaret Maruani, with whom–among others–she founded the “Labor Markets and Gender” (MAGE) European Research Network in 1995, a “stimulating” multidisciplinary exchange group which focused on issues of sexual inequality both at school and in the family, or at work. MAGE, which she headed for four years (1999-2003), rapidly garnered European recognition. The introductory seminar into male/ female issues that Marry has conducted at EHESS since 2001 has met with the same success. But she is realistic: “We benefited from the increasing popularity of gender studies that started in the late 80s.” For although she is resolutely optimistic, Marry, who has just completed a report on women biologists at CNRS, knows how difficult it can be for her fellow women to pursue their careers. “I’ve been really lucky, but we mustn’t forget that for many women, the glass ceiling hasn’t disappeared.”

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Stéphanie Arc

1. CNRS / ENS Paris / EHESS Paris / Université de Caen.
2. Ilana Löwy and Catherine Marry, *Pour en finir avec la domination masculine. De A à Z* (Paris: Les Empêcheurs de penser en rond / Seuil, 2007).
3. Laboratoire d’économie et de sociologie du travail (CNRS/ Universités Aix-Marseille-I and -II).
4. Former name of the Centre Maurice Halbwachs.

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THE HIDDEN TALENTS of Chemistry

Pushing full throttle into the 21st century, the field of chemistry is going through major changes and garnering much attention. Last May, French academic and industrial actors in chemistry made a joint declaration announcing their commitment to develop sustainable–also known as green–chemistry, key to preventing pollution at its source. Throughout this feature, it is the entire discipline that will be explored, with its far-ranging applications into fields as vital as health (food quality analysis, water and air monitoring, or even natural cosmetic products), and as surprising as culture (what works of art can tell us about our heritage). Chemistry is indeed a source of innovation that is often active where it is least expected, as CNRS researchers are keen to explain.

A Rejuvenated Industrial Sector

With an estimated yearly revenue of €82 billion, €3 billion of investment in research and development, and approximately 200,000 employees, France's chemical industry is an international heavyweight, the second largest producer in Europe today and ranking fifth worldwide. Within the country, it is the third largest industrial sector after the automobile and steel industries. Bernard Chambon, president of France's Union of Chemical Industries (UIC),[1] explains that one of the reasons for this success is that chemistry is the "industry of industries." He confidently assesses that "more than 70% of the products manufactured by the chemical industry are destined for use by other industrial sectors, while less than 30% go directly to end consumers. Chemistry is thus a motor for innovation in all industrial sectors."

And although this industry must constantly innovate to meet market needs, it also has to overcome certain challenges, the first of which is shedding the negative image it has long suffered from. Following industrial accidents–like the 2001 explosion at a chemical factory (AZF) in Toulouse–but also pharmaceutical disasters like thalidomide[2] or the harmful effects of pesticides, the chemical industry has had a bad reputation for many years, casting a shadow over its many innovations.

The Roquette plant in Lestrem (Pas-de-Calais) where CNRS is participating in the Biohub project to develop chemical molecules from cereals.

GREENER, AND IN ALL AREAS

Since the early 1990s, following increasing concern over environmental, health, and safety issues, there has been a growing interest in "ecological chemistry." Europe is in fact allocating many resources to this area to combat global warming, aiming to remain world leader in sustainable development. "Chemistry is essential for reaching this objective, as it will provide other industries with cleaner technological solutions that >

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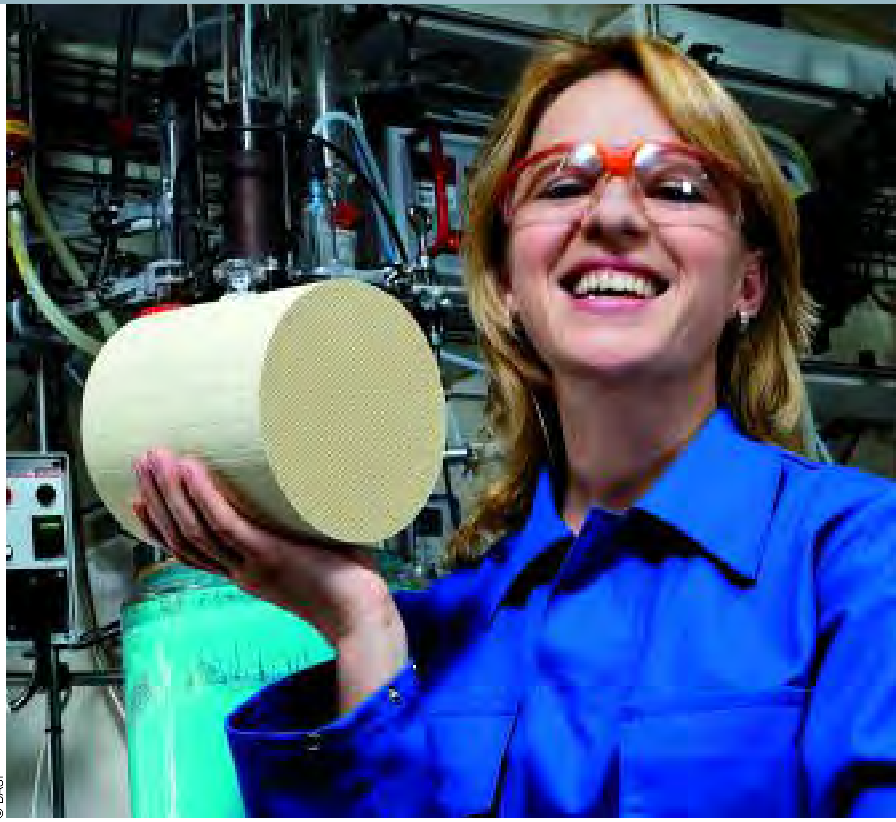
© BASF

Catalysis is one of the eight high-priority areas for French research in chemistry. This honeycomb catalyzer is developed by BASF for use in catalytic converters.

> consume less energy and fewer raw materials," explains Chambon. When a new generation of hydrogen fuel cells or photovoltaic panels is developed, the entire automobile and housing industries will benefit from the ensuing reduction in energy consumption, leading to decreased carbon dioxide emissions.

The European regulation REACH, for "Registration, Evaluation, Authorization and Restriction of Chemicals," introduced in 2007, has also pushed chemistry towards a cleaner future. It requires industry to prove the safety of chemical products with respect to human health and the environment. "Specifically, the objective is to verify so-called 'existing substances' that were put on the market before 1981–before adequate toxicity tests were required–and to eliminate those that present a risk," explains Brigitte Diers, responsible for Health and Safety at CNRS' Institute of Chemistry (INC). Between 2009 and 2018, more than 300,000 substances produced in or imported into Europe will be analyzed and registered with the European Chemicals Agency in Helsinki, starting with those used in quantities that exceed 1000 metric tons per year. In addition, mutagenic, carcinogenic, and toxic substances, which constitute a risk to human reproduction or a threat to aquatic species, will also have to be registered before November 2010. "This regulation is very ambitious, but will be beneficial to both the environment and the consumers. It will also act as an incentive for finding safer replacement products," concludes Diers.

SETTING PRIORITIES

To meet these challenges, the aptly named "Chemical Challenges and innovations" working group of France's Chemical Industries Strategic Council (COSIC)[3] has identified eight priority areas: toxicology and analysis methods, nanomaterials and intelligent materials, energy management and the exploitation of CO_2, biotechnologies, renewable resources, molecular electronics, water, and catalysis. "We are one step ahead in many of these fields, though competition from the US and China is increasingly fierce," explains Olivier Homolle, president of France's Chemical Society (SCF)[4] and the French subsidiary of BASF, the largest chemical company in the world. "We have the skills and the know-how, and it's our job to put them to good use."

Laurianne Geffroy

1. Union des industries chimiques. (www.uic.fr)
2. At the end of the 1950s, this drug was prescribed to pregnant women to prevent nausea, but caused severe malformations in several thousand fetuses throughout the world.
3. Conseil Stratégique des Industries Chimiques.
4. Société chimique de France. (www.sfc.fr)

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A PROGRAM FOR A SUSTAINABLE WORLD

Three questions to Isabelle Rico-Lattes, head of CNRS' cross-disciplinary program on "Chemistry for Sustainable Development."[1]

What is the aim of this program, initiated in 2006?

Isabelle Rico-Lattes: Its objective was really to develop a tool that could federate French research on chemistry for sustainable development. Four networks, involving CNRS institutes and other research organizations, were thus set up, such as the one called "Renewable resources as starting materials, a source of novel products and materials," for which INRA[2] is closely involved with CNRS.

Why is the cross-disciplinarity of this program so important?

I.R.-L.: Because a lot of progress is expected if chemists work in closer relation with other disciplines. This is how it will gain in visibility, credibility, and innovation. In the context of the CNRS cross-disciplinary AMAZONIE program, for example, a team of ecologists and chemists is studying the molecules that certain trees emit to protect themselves from fungi. The mechanism of action of these fungi is in fact analogous with that of certain human mycoses. If we can identify the chemical structure of these antifungal molecules, we may very well discover a new source of medicinal products for humans.

What are your objectives for the years to come?

I.R.-L.: We would like to develop new links between chemistry and other disciplines, such as ecology, ecological engineering, or biotechnology. We would also like to integrate human and social sciences researchers in our work so that together with chemists, they can reflect on the role that chemistry can play in a sustainable society. We need to fully embrace people's fears and questions, and meet their expectations in a transparent manner. We have not yet grasped the full measure of the original findings–in terms of novel concepts–that will emerge from chemistry with respect to sustainable development.

Interview by Laurianne Geffroy

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2. Institut scientifique de recherche agronomique.

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Chemistry Set at the Museum

There is a false assumption that chemists have little to do at a museum. Although Old Masters' statues or ancient musical instruments tend to be the prerogative of art historians and archeologists, some of the secrets of these works of art would have remained unsolved if chemistry had not been involved. "Part of the history of objects and lifestyle of previous generations has been recorded at an elemental and molecular level in ancient materials," explains Martine Regert from a Nice-based center specialized in archeometry and archeology (CEPAM).[1] "It is this information that the chemist can seek out." Using increasingly sophisticated technology, chemistry can investigate our heritage and inform us on forgotten cultural practices, the know-how of an artist, or the transformations undergone by a work of art over time. This information is as valuable to scientists as it is to restorers and curators.

UNDERSTANDING THE NATURE OF AN OBJECT

The first objective when reconstituting the history of an object is to understand its true nature. Its composition in inorganic materials[2]–like metals or glass–can be studied directly without damaging the object. For example, simply placing a statuette of the Goddess Ishtar, discovered in Mesopotamia in 1863, in the beam of the Aglaé particle accelerator (which is located in the basement of the Louvre Museum), revealed precious information about the stones in its eyes and navel. "A gemologist was unsure about the nature of these incrustations. An X-ray spectrum obtained in just five minutes showed the presence of aluminum oxide and chromium in the gems, demonstrating they were rubies, and not glass paste," explains Philippe Walter, a physical chemist and director of France's leading museum restoration laboratory (LC2RMF).[3] This type of technique can also reveal impurities in materials, which are excellent clues to determining their original source. For the Goddess Ishtar, for example, traces of metals indicated the source of the rubies–Burma–showing that even at that time, about 2000 years ago, a gem trade existed between South-East Asia and Mesopotamia.

The same spectacular results have been achieved with organic materials (wax, resin, perfumes, etc.). However, they present a minor drawback: A sample needs to be collected, and in many cases, destroyed. Using analytical chemistry methods based on chromatography[4] and mass spectrometry,[5] Regert was able to identify fragments of resin found at the site of the medieval port of Sharma, in Yemen: "It transpires that these fragments were copal from East Africa or Madagascar, and not frankincense, as previously believed. We therefore have evidence of the use of a new material at this site, as well as a new trade route running from the East African coast to Yemen."


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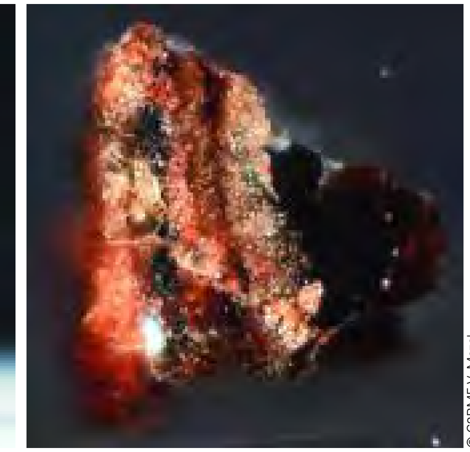
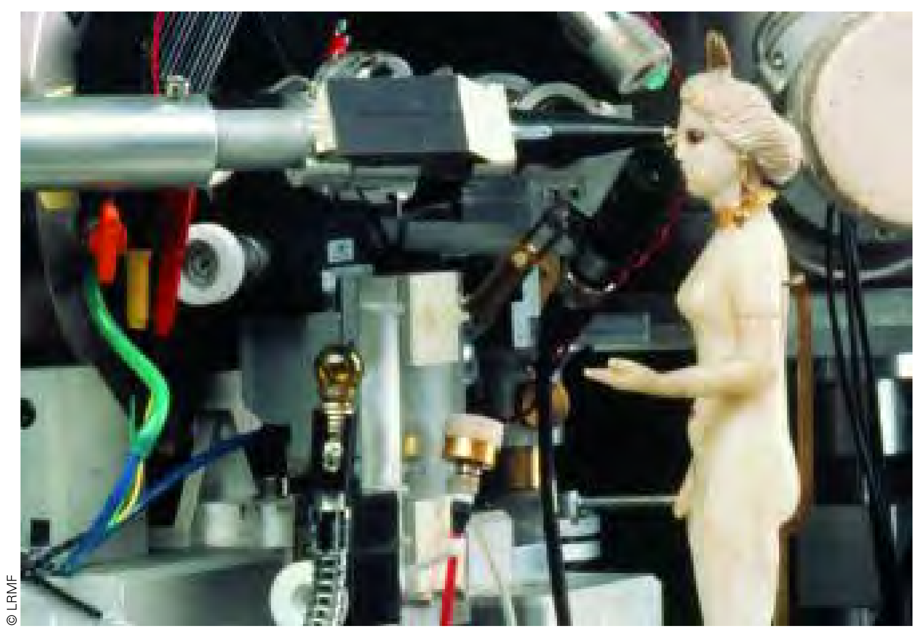

© C2RMF, V. Mazel

Analysis of a sample of patina (right) from a Dogon statuette (left) revealed the use of animal blood during certain rituals.

AT THE HEART OF CULTURES

Though this type of research still requires a sample to be collected, technological developments have led to some astonishing results. A fine example is described by Pascale Richardin, from LC2RMF, and her colleagues, who detected traces of blood on a small, $1\,mm^3$ chip of patina from some 14th century Dogon statuettes from Africa. "By coupling molecular imaging and mass spectrometry–which offers micrometric resolution–with synchrotron infrared microspectroscopic imaging,[6] we managed to localize on the same spot both heme molecules and iron ions, two components that confirmed it was blood," explains Alain Brunelle, senior researcher at ICSN.[7] This unique finding is of major importance to historians, as it confirms the use of animal blood during certain Dogon rituals.

There is yet another area where chemistry can provide useful insight: when looking into the practices of an artist. Using crystallography to examine minerals in the Issenheim altarpiece, the famous work by Matthias Grünewald on display in Colmar (France), scientists[8] were able to show that the artist did not use the same white lead for the under and top layers. "This agrees with historical documents mentioning that three types of white lead were available on the Frankfurt market at the beginning of the 16th century. The painter thus certainly chose extremely fine, good quality pigments to lighten his colors, but >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By analyzing the statuette of the Goddess Ishtar (Mesopotamia), the Aglaé particle accelerator was able to identify the incrustations in the eyes and navel as being rubies.

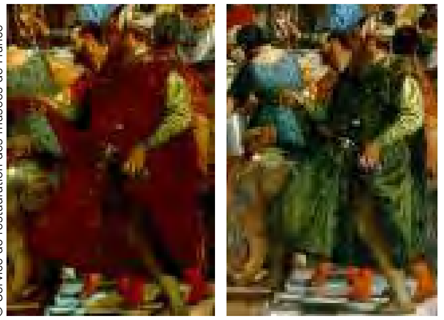
© J.-P. Échard/Cité de la musique

Using analytical chemistry, scientists have been able to study the effects of time on the oils and resins in violin varnish.

> cheaper pigments to underlay them," explains Philippe Walter.

GUIDING RESTORERS

After its creation come the many transformations that a work of art will undergo throughout the centuries. And this is key knowledge for restorers, who make up another group heavily assisted by chemistry. "Distinguishing the original parts of a work from those that have been altered or added is essential in deciding how it will be restored," explains Christiane Naffah, director of LC2RMF. "For example, previous restoration work may have to be removed because it is hampering our view of the original work." Using analyses performed by the LC2RMF, restorers discovered that the robe of the steward of the Wedding Feast at Cana–the largest painting in the Louvre–was not originally red, so they decided to expose the green color chosen by Veronese. In other words, and as emphasized by Naffah, underlying knowledge about a work of art obtained via chemical analysis may help make the "right choice."



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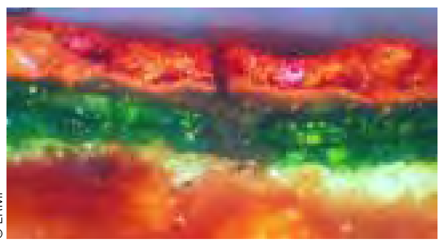

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Chemical analysis exposed the green color originally chosen by Veronese for the robes of the steward in the Wedding Feast at Cana (Louvre Museum).
Below: Stratigraphic section of paint from the robes prior to restoration.

AN AID TO CONSERVATION

Unfortunately, it is not always possible to repair the damage that a work of art has undergone over time. Priority is then given to stopping the damage by preserving an object in the best possible conditions. Yet the job of a curator is not only to protect, but also to disseminate knowledge: "Works of art are displayed for centuries, and thus suffer from sunlight, climatic variations, and simply from being moved. Yet they must still be displayed so that they can spread their message," explains Naffah. This is a tricky question when dealing with a musical instrument, designed to be used, not just to be seen. Jean-Philippe Échard, a conservation scientist at the Music Museum in Paris, and attached to a center specializing in conservation research (CRCC),[9] works on the varnishes used to protect violins–including Stradivarii–and lutes kept in the museum. He is trying to determine their resistance to wear caused by both time and usage. "As it ages, the composition of the varnish changes: The oils and plant resins used in making it start to oxidize. Using analytical chemistry, we can evaluate the degree of oxidation and know whether the ageing process is still active," he explains. "We are also trying to evaluate the effects of perspiration, and the risks taken when these ancient instruments are played."

Laurianne Geffroy

1. Centre d'études préhistoire, antiquité, Moyen Âge (CNRS / Université de Nice).
2. Not produced by living organisms. Minerals or metals, for example.
3. Laboratoire du centre de recherche et de restauration des musées de France (CNRS / Ministère de la Culture et de la Communication).
4. Chromatography separates different components within a mixture.
5. Mass spectrometry identifies molecules as a function of their mass.
6. A beam of light whose intensity can very precisely determine the composition of a material.
7. Institut de chimie des substances naturelles (CNRS).
8. Associating researchers from LC2RMF, Institut Néel and ESRF in Grenoble.
9. Centre de recherche sur la conservation des collections (CNRS / MNHN / Ministère de la Culture et de la Communication).

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The Chemistry of Cosmetics

You may not realize it every morning when you shave or put on makeup, but chemistry is everywhere in your bathroom cabinet. It may be hidden, but it is at the heart of the properties of cosmetic products, from long-lasting lipstick to the shimmering tints of eye shadow and the anti-wrinkle effects of certain creams. And despite these innovations, much more lies ahead. Indeed, it is in today's cosmetics industry that we find one of chemistry's major challenges: to introduce an increasing number of natural ingredients into the formulas of beauty products to meet current expectations, but also, more pragmatically, to comply with the REACH regulations (*see p. 20*). "We are under considerable regulatory pressure regarding the formulation of new products, but in terms of research, this opens the door to other, more stimulating projects," explains Xavier Fernandez, who works at a laboratory specialized in aroma and bioactive molecule research (LCMBA).[1]

USING BIODIVERSITY

Jojoba oil in shampoos, soy lecithin in day creams, natural vanilla extracts in perfumes... beauty products are increasingly promoting their "organic" profile. To enrich the palette of available ingredients, CNRS laboratories and several companies like Adonis (a division of Alban Muller International), LVMH Recherche, or GreenPharma (a start-up launched in 2000 with the help of CNRS) are sifting the world's biodiversity–from plants to fungi and microorganisms–to find tomorrow's leading cosmetic products. The latest discoveries include resveratrol, a compound found particularly in grapes, that increases the life expectancy of skin cells, or pro-Xylane, a sugar extract from beech wood that stimulates collagen synthesis, and thus firms up tissues.

The methods that enable the use of these natural compounds are currently undergoing major change. For example, it is indeed essential to develop new and efficient extraction processes to extricate valuable molecules from raw materials not yet fully exploited, like leaves, roots, or even wood. "Regarding perfumes, the more rapid and gentle the extraction process, the more closely the odor of the extract will match that of the plant," explains Fernandez. "We have thus recently developed extraction methods using microwaves or ultrasounds."

RETURN TO NATURE

Besides answering consumer demand for organic products and discovering novel molecules, the search for natural compounds has another purpose: finding substances that are harmless to humans and the environment to replace compounds whose safety is currently being questioned.

In this context, parabens are the unequivocal example. These petroleum-derived synthetic preservatives, widely used to protect cosmetics from molds and bacteria, are now suspected to also be toxic and carcinogenic. To bypass parabens, an Orléans-based institute dedicated to analytical and organic chemistry (ICOA)[2] is trying to identify and isolate active substances in Guyanese plants that may have antimicrobial properties.

But, as pointed out by Fernandez, "natural molecules are not necessarily innocuous." For example, rose essential oil contains methyleugenol, possibly carcinogenic, and lichen extracts contain chlorine compounds that can provoke skin reactions. A given odor contains tens or even hundreds of components. "A single toxic or allergenic component may compromise marketing of the final product. If that component has no value from an olfactory point of view, we try to inactivate it," explains Fernandez. To achieve this, his team is working on a selective biocatalytic method. "The aim is to selectively transform the structure, and hence the toxicity, of restricted molecules using microorganisms, which also lets us retain the 'natural' label," underlines the scientist. "We hope to be able to inactivate the toxicity of the problematic molecule while keeping the odor of the extract unchanged."

The green revolution is also affecting surfactant agents, molecules that favor the mixing of water and fats into an unctuous cream. Teams are currently working on replacing the hydrophilic part of surfactants –currently of petrochemical origin–with plant sugars, which would certainly be considered an added value to the "Made in France" perfumes and beauty products renowned throughout the world.

Laurianne Geffroy

1. Laboratoire de chimie des molécules bioactives et des arômes (CNRS / Université de Nice).
2. Institut de chimie organique et analytique (CNRS / Université d'Orléans).

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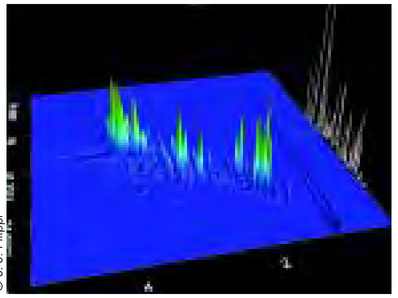

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Chromatographs (above) enable the study of the composition of different aromas (top), in this case vetiver.

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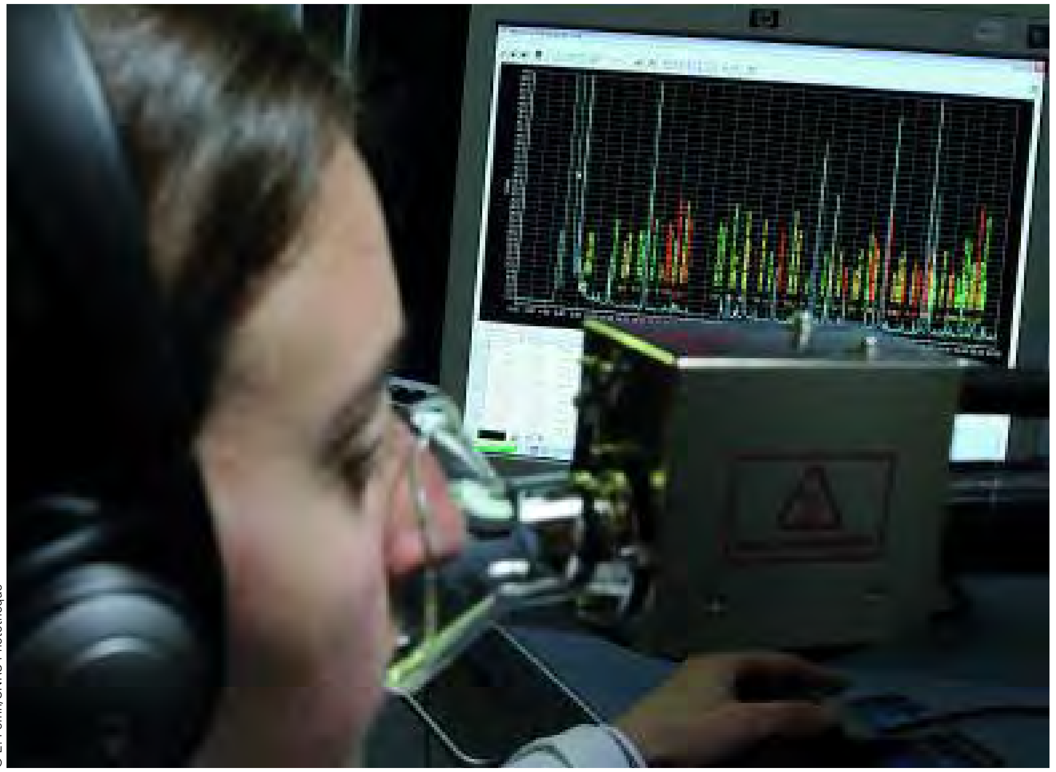
Cosmetics and perfumes use a considerable number of natural substances. Pictured is myrrh, an odorant resin produced by an Arabian tree.



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At LCMBA, different substances are analyzed using chromatography coupled with sensory perception.

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Tracking Down Fraud

© G. Rolle/REA

Detecting formalin in baby lotion, determining a patent breach for a medicinal product, tracking illicit drugs in sportsmen, or discovering a pesticide in an organically-labeled product: All these activities depend on the increasingly sophisticated know-how and techniques of chemical analysis. They are developed and currently used by CNRS' Central Analysis Service (SCA)[1] in Lyon, headed by Jean-Jacques Lebrun.

"Chemical analysis is one of the tools used to expose fraud," explains Lebrun. French courts, legal authorities, police, and various ministries regularly ask the SCA to test certain products. "Most requests concern the areas of agrifood, pharmaceutical or cosmetic products, and doping substances," adds Lebrun. Although spectacular, this is only one aspect of the workload of the SCA, which also carries out analyses for CNRS, universities, and the private sector, and dedicates a quarter of its time to research and training.

CHECK THE LABEL

The most important area, where demand for analysis is seeing the most growth, is the agrifood industry. Whether asked to detect the addition of water in a "100% fruit juice," sugar in a "sugar-free" product, or synthetic molecules in "100% natural" royal jelly, SCA analysts use ultra-sophisticated methods to find substances that may sometimes only be present as traces. "Modern measuring instruments can detect a substance at a concentration of one part per billion, i.e., one nanogram per gram of matter. Our methods allow us to increase the sensitivity by a thousand," explains Lebrun. However, it requires that the target substance be concentrated up to a thousand times in the sample, without accumulating agents that could mask it along the way.

To understand how this works, imagine evaporating 1000 liters of water, and placing the dry residue in 1 liter of pure water; it is now concentrated a thousand times. One drawback is that some of the substances you are seeking may have evaporated with the water. "The performance of measurement instruments has not improved in recent years, so it is selective enrichment that will enable the greatest progress." A method often made more difficult by the complexity of the search, as, for example, when testing in a single procedure for the presence or absence of 90 different pesticides in a sample of honey."

Chemical analyses allow customs officials to detect counterfeit products: in this case, fraudulent Viagra tablets.

TOUGH CONSTRAINTS

When working on traces, sample preparation is crucial, and the utmost precautions are needed to avoid contamination. "When we tested honey for the presence of an insecticide called Fipronil, we realized that our results were compromised because a lab member was using Fipronil to treat his dog against ticks," explains Lebrun. Any search for substances that can only be present as trace amounts require extra precautions, to avoid making any mistakes. Like when trying to detect traces of by-products in a medicinal product, the presence of which would be indicative of the fraudulent application of a patent-protected manufacturing process. Or when searching for traces of Tamoxifen, a breast cancer treatment that is also used by some sportsmen to mask the use of anabolic steroids.

"We also need to brace ourselves for a new type of fraud that is becoming increasingly prevalent in France," warns Lebrun. Taking advantage of the current trend for natural products, companies are selling them over the internet to avoid any controls. "You can buy anything on internet, including extracts of plants from the Amazon basin that do not contain the slightest trace of plant extracts." But chemists can only go so far, and it is up to consumers to be wary, and aware that it is impossible to control everything traded on the World Wide Web.

Denis Delbecq

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CHEMISTS IN THE KITCHEN

Hervé This, in his laboratory.

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"Food is not chemistry," says Hervé This.[1] A surprising statement when coming from the creator, together with Oxford physicist Nicholas Kurti, of molecular gastronomy. After all, this discipline is focused on understanding the complex phenomena at play when food is transformed during cooking.
But in his opinion, there is no doubt: Chemistry is a science, while cooking is a technique, sometimes enriched with art. However, he regularly shares his know-how as a chemist with his friend, the chef Pierre Gagnaire.[2] "In our laboratory, we have had theses on carrot broth or the storage of onions in sauces–trying to understand what comes out of the plant tissues, and above all, how?"
One study in particular used quantitative nuclear magnetic resonance techniques and showed that the molecules that migrate from plant tissues to broths and sauces (mainly sugars and amino acids) were contained in the vessels that enable the circulation of sap. "You therefore need to grind up the carrots if you want to recover all their flavorful compounds in a broth," suggests Hervé This. This work also showed that a broth could be colored without adding browned onions, but simply by exposing it to light during the cooking process.
"We are now studying the underlying mechanisms," he concludes.

D.D.

1. UMR 214 (INRA / Institut des sciences et techniques du vivant et de l'environnement (AgroParisTech)).
2. Their collaborative recipes (in French): www.pierre-gagnaire.com/francais/cdthis.htm

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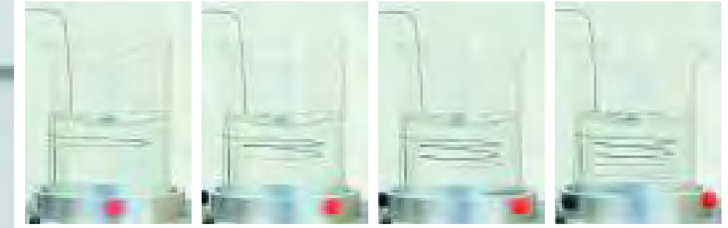


When injected in a special bath, called coagulation bath, carbon nanotubes in solution can form nanotube fibers.

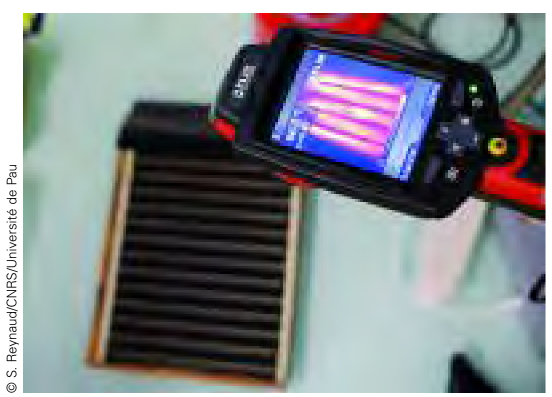
New Materials

What will materials be like in the future? Lighter, stronger, and with astonishing properties, answer chemists. And these materials will be used in a multitude of applications, ranging from motorcycle helmets to bone repair.

Take carbon nanotubes, for example, millionths of millimeters in diameter, but with a length a thousand times greater. They exhibit a very large surface area relative to their volume. Their exceptional properties have been known for a decade, but it may take some time before they can be put in practice. "They have an amazing ability to absorb violent shocks, much higher than that of carbon fiber in composite materials. This is due to their very unusual structure and geometry," explains Philippe Poulin from CNRS' Paul Pascal research center (CRPP)[1] in Bordeaux. They also have exceptional rigidity, as well as lightness and excellent conductivity. But to make use of these qualities, scientists need to overcome a considerable obstacle: the disorganized structure of nanotubes. "Currently, we are only able to produce raw nanotubes in a powder or 'bulk' form," says Poulin. "The challenge is to get these tubes organized in a structure because their mechanical or electrical properties collapse if they are not assembled in an optimal manner. The Bordeaux team is thus intensely focusing on this problem, by incorporating the tubes in fibers that are subsequently stretched. The nanotubes are then organized along the direction of this stretching. "We hope that three to five years will be enough to know whether they can be used to build bullet-proof vests, protective clothing, or motorcycle helmets," adds Poulin. "Our goal is to produce our first textile using these mixed fibers within that time frame."

For now, nanotubes are mainly developed to replace carbon black, a material formed of carbon microspheres and produced using heavy petroleum products. It is used as a highly sought-after antistatic agent for the packaging of electronic items, the storage of powders, and the construction of fuel tanks and lines. "In this area, we are already obtaining the same properties as with carbon black, but using ten times less material," concludes Poulin.

Some conductive polymer-based films can emit heat, visible in this case on an infrared measuring instrument.



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FILM MAKERS

Further south in Pau, at IPREM,[2] a research institute dedicated to materials and the environment, work is focusing on electrically-conductive polymer films. They could be used for heating surfaces, protection against corrosion, or for specific sensors capable of distinguishing between soft and hard surfaces, something that might be of interest for robotics. "The heating surfaces application is currently the most advanced," explains Stéphanie Reynaud, from IPREM. "These could be used in very low energy consuming buildings, or to produce heating textiles." The Pau scientists are also trying to anticipate future oil shortage: "With this in mind, we are testing compounds that combine oil-based polymers with polymers derived from agricultural or marine resources."

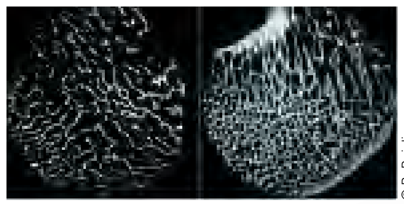
At the other end of the country, CNRS' Charles Sadron Institute (ICS) in Strasbourg works on polyelectrolyte multilayers, a concept with applications in antireflective or anti-corrosive coatings, as well as antibacterial surfaces. These could, for example, be used to prevent ship hull fouling, or to develop self-cleaning windshields. ICS researcher Pierre Schaaf explains the process: "We are developing organic surface coatings using >

> charged polymers that alternate coats endowed with positive and negative electrical charges. This makes them adhere to one another." The choice of materials depends on the properties sought. Schaaf's team has many ideas, one of which is to create materials for biological use: "In fact, we are already working with INSERM, France's health and medical research institute. We integrate DNA in the films, in order to develop implant coatings with biological functions, and we would like to create films that could for example trigger chemical reactions simply by stretching the substrate."

© Garftys

CHEMICAL REPAIR

Indeed, biomedical materials are a rapidly expanding field of research. At a Nantes-based laboratory dedicated to chemical analysis and modeling (CEISAM),[3] and working in collaboration with an INSERM team, Bruno Bujoli is looking at so-called "repair" materials. "We are trying to develop cements that could be injected to prevent osteoporotic fractures, a major public health problem." Such cements, made of calcium phosphate, a material similar to the main component of bone, could for example be loaded with a drug active against osteoporosis. It would then be implanted in the femoral neck, where, over time, biological fluids and bone cells would penetrate the cement and diffuse the drug around the implantation site, thus stimulating bone re-growth. "We are completing pre-clinical studies," explains Bujoli, "and we hope to be able to start phase 1 clinical trials this year in collaboration with a company (Graftys)."



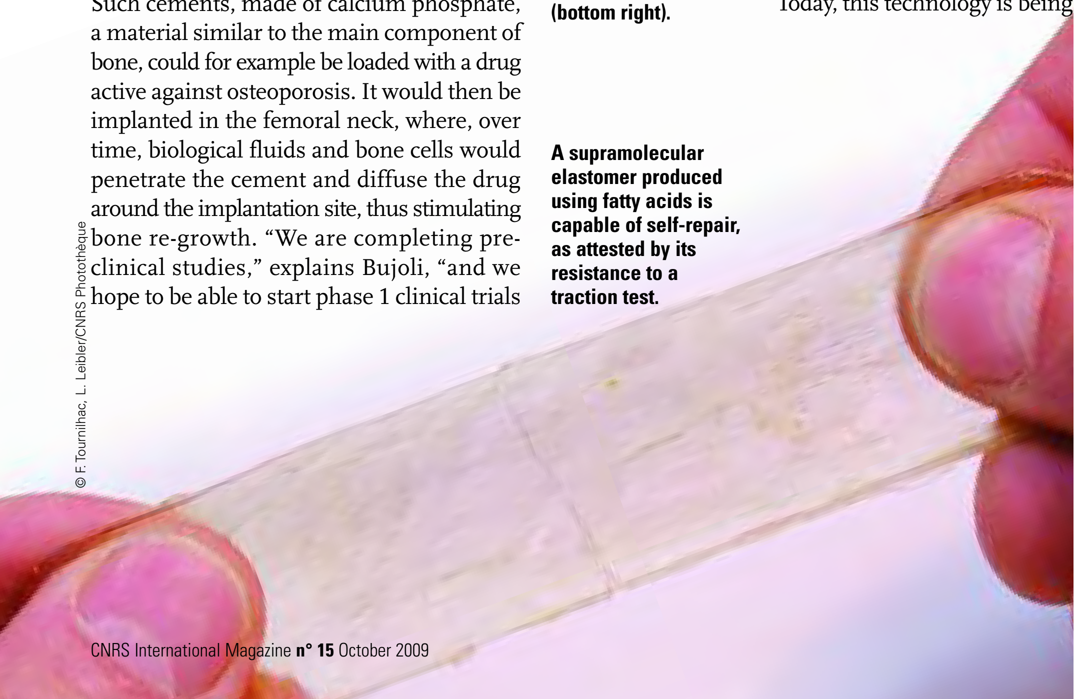
© B. Bujoli

A calcium phosphate-based cement is combined with a drug (biphosphonate) and injected into an osteoporotic femur (bottom left) to enable bone re-growth (bottom right).

In Toulouse, at the CIRIMAT Carnot Institute,[4] similar research is taking place. There, the team led by Christèle Combes is working on hard biological tissues, and particularly on the nanocrystals that make up 70% of our bones. "We are studying their role in the bone mineralization process," explains Christian Rey, a fellow researcher. Besides, the team is also focusing on the use of these minuscule crystals for medical imaging. "We have started a project with the Cancer-Bio-Health Cluster in Toulouse," he adds. "By rendering these nanocrystals luminescent, and by fixing a compound on their surface that makes them recognizable by cancer cells, we hope to be able to improve tumor imaging techniques."

Back in Paris, Ludwik Leibler's laboratory, specializing in soft matter and chemistry (MMC),[5] recently made the headlines. With his team, he succeeded in producing an extraordinary elastic material capable of self-repair. Having cut this material in two pieces, simply putting the extremities in contact was enough for the material to recover its initial resistance. This is due to molecules capable of self-assembly in the same way as molecules in a DNA strand can "recognize" each other and pair up. "During the self-repair process, the bonds that were broken reform and restore the cohesiveness of the material," explains Leibler. It takes only one hour for the elastic material to recover its initial extensibility of 700%. Today, this technology is being marketed by a French chemical company called Arkema, and applications for these extraordinary products are currently in the works, including adhesives, protective films, automobile tires, and perhaps applications in construction.

Denis Delbecq



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A supramolecular elastomer produced using fatty acids is capable of self-repair, as attested by its resistance to a traction test.

1. Centre de recherche Paul Pascal.
2. Institut pluridisciplinaire de recherche sur l'environnement et les matériaux (CNRS / Université de Pau et des pays de l'Adour).
3. Chimie et interdisciplinarité: synthèse, analyse, modélisation (CNRS / Université de Nantes).
4. Centre interuniversitaire de recherche et d'ingénierie des matériaux (CNRS / Université Toulouse-III / INP Toulouse), Institut Carnot.
5. Laboratoire Matière molle et chimie (CNRS / École Supérieure de Physique et de Chimie Industrielles de la Ville de Paris).

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Environmental **Sentinels**

Chemists are closely involved in pollution control. In fact, nothing matches their ability to track aquatic and atmospheric pollutants. But the task is substantial. "In aquatic environments alone, we are faced with thousands of compounds," explains Hélène Budzinski, leader of a research group on environmental toxicochemistry at the French Molecular Science Institute (ISM).[1] With her colleagues, she is trying to detect the presence of organic compounds and diagnose their effects on aquatic organisms. The list is already impressive: pesticides, medicinal products, solvents, flame retardants, and all sorts of agents that can disturb animal endocrine systems and are believed to trigger the so-called feminization phenomena observed in numerous aquatic organisms. "And the substances we are finding are mainly linked to human activity." For this reason, the researcher sometimes calls on her colleagues in the human and social sciences. "Social studies and surveys can save us a lot of time," she explains, "because they can narrow down the number of compounds we need to look for in any given environment. In many cases, each town, country, or region has its own specific habits."Last summer, a study by Barcelona University performed in the waters of a Spanish wastewater treatment plant showed that cocaine and MDMA (the molecule found in ecstasy) increased substantially after weekends.

Wastewater treatment plants, like the one pictured here in Bordeaux, are excellent sites for chemical studies of the environment.

© Photos : H. Budzinski/ISM

POCIS (Polar Organic Chemical Integrative Sampler) passive sampling systems can collect the organic compounds present in water.

AIR AND WATER SURVEYS

To further refine their results, chemists handling aquatic pollution must be able to use appropriate analytical tools to detect substances that are frequently found at trace levels. One example that has proved quite problematic is amoxicillin, an antibiotic whose presence in the environment could lead to the selection of resistant bacterial strains. The scientists also need to imagine new methods for measurement. "Occasional analyses, both in time and space, carry little meaning. For this reason, we are trying to develop sensors and passive samplers that could store the molecules present in the environment over time. In this way, a single record would be sufficient to monitor the pollution accumulated over a 15-day or a 1-month period."

If human activity is definitely a threat to aquatic organisms, it is also a source of pollution of the air we breathe. At a Lyon-based institute specialized in catalysis and environment (Ircelyon),[2] Christian George and his colleagues are studying the physicochemical modifications undergone by compounds emitted into our atmosphere, and notably by aerosols, these dusts and droplets that are rarely inert. "We are trying to observe and simulate these transformations to determine their impact on climate and air quality." The Institute is pursuing a number of novel paths, including a study of secondary organic aerosols that arise from the oxidation of pollutant gases like nitrogen dioxide, mainly produced by cars. "We recently realized that these predominate in the air. We have shown how interactions with light may constitute an essential step in their ageing." In this case, most of the work is carried out in the laboratory to reconstitute the formation and fate of aerosols, and determine, for example, the by-products generated by photochemical reactions. "But we have also participated in recent measurement campaigns using an aerosol mass spectrometer (AMS), a highly original instrument so far unique in France," emphasizes George. In just a few minutes, the AMS can reveal the size and chemical composition of each particle. "All measurements performed to date have underlined the chemical complexity of atmospheric particles." Today, major cities are quite well equipped to monitor "simple" pollutants such as ozone. But much research is still needed to determine the impact of aerosols, especially to understand the physical chemistry of these particles, which are small (less than a micrometer) but nonetheless harmful to both health and air quality.

Denis Delbecq

1. Groupe de recherches de physico- et toxicochimie de l'environnement de l'Institut des sciences moléculaires (CNRS / ENSCP Bordeaux / Universités Bordeaux-I and -IV).
2. Institut de recherches sur la catalyse et l'environnement de Lyon (CNRS / Université de Lyon).

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SPECIES ON GUARD

The more advances it makes, the more chemical analysis is faced with the problem of small doses, and the difficulty in evaluating the effects that surrounding substances may have on our health. According to toxicologist Jean-François Narbonne, from the French Molecular Sciences Institute (ISM),[1] it is now urgent to develop "bioassays," i.e., tests that can be performed on living tissues. "A substance, or a mixture of substances, may be undetectable but can definitely modify cell behavior. Bioassays are essential for the future." One such assay is the famous "mouse" test that detects the presence of toxins in oysters: A sample is collected from the mollusks and injected into the abdomen of three mice. Death of two mice out of three within 24 hours is indicative of a danger to man, and triggers a ban on consumption.

"We are working with France's national food control agency (AFSSA)[2] to determine the most sensitive and specific types of cells to detect phycotoxins, algae toxins that may accumulate in mollusks and fish," explains Narbonne. "For the past 30 years, we have also been developing biomarkers in sentinel species that act as indicators on environmental contamination." Mollusks, for example, are able to detect pollution along French coastlines. Major national and international experts are all working on this issue, but it is difficult to reach a consensus. At present, most regulations are based on chemical analyses, which are interpreted by simple comparison with a defined value. They represent an enormous market. But simple chemical assays may soon be insufficient. Faced with increased health challenges due to globalization and the presence of mixtures of contaminants (cocktails), bioassays and biomarkers are essential to better assess the hazards and risks to man and his environment.

D.D.

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2. Agence Française de Sécurité Sanitaire des Aliments.

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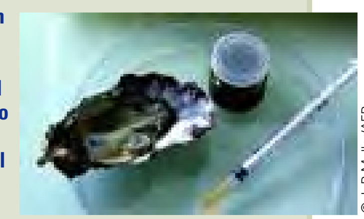

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The inoculation of an extract from the digestive gland of an oyster into a mouse helps detect potential food poisoning in humans.

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ENGINEERING

Gustave Eiffel MASTER OF IRON

© H. Lewandowski/RMN/Photo de presse

Since its construction, more than 120 million visitors from all over the world have marveled at the Eiffel Tower. This year, the universal symbol of Paris celebrates its 120th anniversary. The historian Bertrand Lemoine, senior researcher at CNRS, is the scientific commissioner of an exhibition on the career and achievements of its prolific builder, Gustave Eiffel. He takes us on a guided tour of Eiffel's most outstanding constructions, and explains the scientific advances that were taking place at that time.

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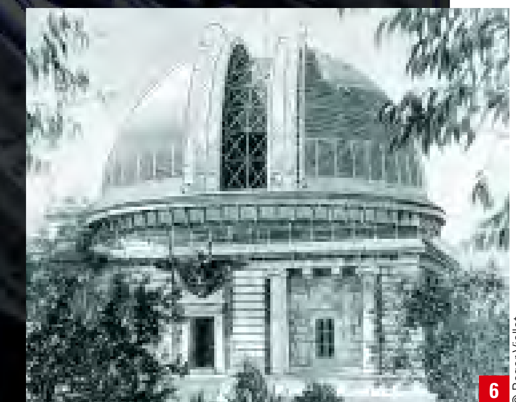

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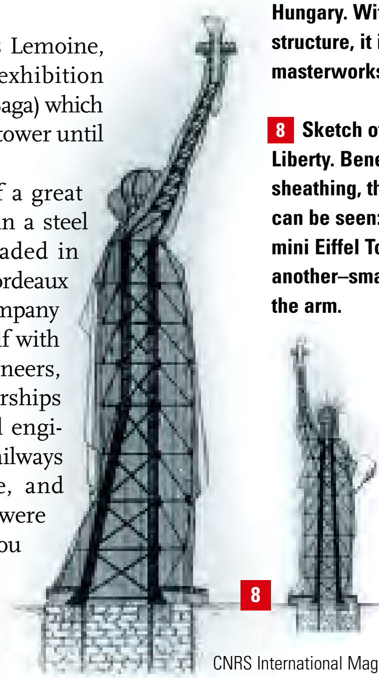
Gustave Eiffel was the perfect example of a 19th century engineer: inventive and daring," says Lemoine, who is himself an engineer, architect, and specialist in the history of architecture at CNRS.[1] "Eiffel graduated from the Central School of Arts and Manufactures[2] in 1855, a major time of growth, stemming from several concurrent factors: the rapid economic expansion of Europe, at the height of its industrial revolution; the appearance of a new material, rolled iron, which was lighter and cheaper than stone; and decisive progress in mechanics." In this favorable context, Eiffel became an internationally renowned structural engineer not only through the design of the world-famous Eiffel Tower, but also as a result of the 300 or so structures he built all over the world, including bridges, viaducts, roof structures, churches, and stations. His contributions to scientific research shouldn't be forgotten either. "This is why we opted to show all the different facets of this visionary man," explains Lemoine, the scientific commissioner of the exhibition "L'Epopée Tour Eiffel" (The Eiffel Tower Saga) which will be on show on the first floor of the tower until December 31st.

And Eiffel had all the makings of a great engineer. Encouraged by his success in a steel construction company, where he headed in particular the construction site for the Bordeaux railway bridge, he set up his very own company at the age of 32. He surrounded himself with efficient technicians and inventive engineers, and started establishing lasting partnerships with investors. At the time, structural engineering was increasingly in demand. Railways were expanding throughout Europe, and stations, bridges, and public buildings were changing the landscape. "Iron enabled you to build fast: The parts were mass-produced in workshops, and they >



© Collection Tour Eiffel

1 Gustave Eiffel in 1889. Trained as a chemical engineer, he was supposed to take over his uncle's chemical plant. However, a victim of family quarrels, he turned to steel construction, at which he excelled.

2 and 3 The Eiffel Tower: 18,000 parts assembled with 2.5 million rivets. Its shape was directly dictated by wind resistance calculations: its flared base provided the stability necessary for a structure over 300 meters tall.

4 Construction of the Porto Bridge, in Portugal, in 1876. Instead of scaffolding, Eiffel used cables to hold up an arch that met up with another on the opposite bank.

5 The Garabit Viaduct, in France, was built several years later along the same lines as the Porto bridge.

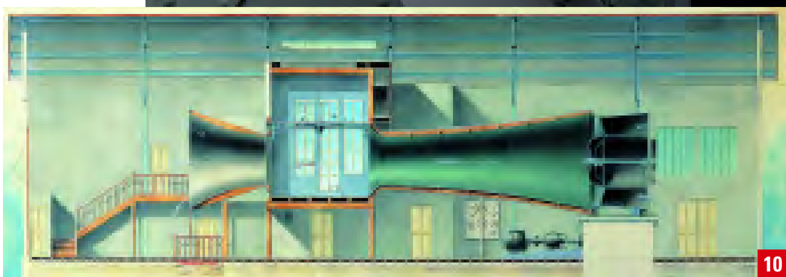
6 The Nice observatory. In order to follow the motion of the stars, the dome needed to revolve. Eiffel, who built it in 1884, decided to have it float in a tank of water so as to eliminate any friction. It could thus be operated using a simple handle.

7 Budapest train station, Hungary. With its vast iron roof-structure, it is one of Eiffel's masterworks.

8 Sketch of the Statue of Liberty. Beneath its copper sheathing, the iron framework can be seen: put simply, it is a mini Eiffel Tower topped by another–smaller one–inside the arm.

© Collection Tour Eiffel

9 December 1887: Before the first level was completed, making the whole structure stable, the four legs were held up by scaffolding. Eiffel had the idea of placing boxes filled with sand inside them, as was done in Ancient Egypt. Removing a little of the sand slightly lowered an entire leg, and above all, enabled all four legs to be adjusted to the same height. Had they been just a few millimeters off, the rivets would not have fit in the holes of the plates that were then assembled.



© Laboratoire aérodynamique Eiffel / CSTB /J.-M. Seguin/Photo de Presse

10 Wind tunnel set up in 1912 in the rue Boileau, Paris. After leaving his construction firm, Eiffel embarked on a genuine career as a researcher. He designed this wind tunnel, more efficient than the one built at the base of the Eiffel Tower.

© Collection Tour Eiffel

11 Numerous experiments in aerodynamics like this one were carried out at the Eiffel Tower from 1903 on. For example, Eiffel measured the air resistance on objects falling from the second level, at an altitude of 115 meters.

DR

12 Inauguration in 1922 of the radio station at the Eiffel Tower by actor Sacha Guitry (at the microphone), opera singer Yvonne Printemps, and radio pioneer General Ferrié. Converted into a giant antenna, which was initially used for military communications, the Eiffel Tower won another reprieve from its planned destruction.

> could be sent back to the factory in case of problems. On site, all you had to do was to assemble them with rivets," Lemoine explains. It was not unlike a Meccano model construction kit, but on a grand scale, in sharp contrast to traditional building sites, where stones had to be cut and recut on the construction site to fit–a process that could drag on for years. Furthermore, the scientific laws that explained how materials deformed due to the stresses and shapes of structures, discovered by Claude-Louis Navier in 1821, were now commonly being applied. "The shapes of beams and buildings were designed so as to optimize their resistance, while at the same time making them lighter," Lemoine explains. Structures made increasing use of openwork. And you could build them bigger and taller without any fear of them collapsing under their own weight, or breaking in high winds. Among the new generation of engineers, Eiffel won many contracts due to technical innovations that could cut costs. "For instance, for the Maria Pia Bridge in Porto (Portugal), he suggested using cables to hold up the two arches that met to form the bridge," adds Lemoine. As a result, there was no need to put up expensive scaffolding in the river.

The Garabit viaduct in France, the internal structure of the Statue of Liberty in New York... no sooner had Eiffel finished one job that he moved on to another. And he was soon to embark on his life's greatest achievement. "For the Universal Exhibition of 1889, which marked the 100th anniversary of the French Revolution, France wanted to pull out all the stops," says Lemoine. The idea of a tower was being mooted. It would be taller than any structure ever built, even outstripping the Washington Monument, which was 169 meters tall. Two engineers from the Eiffel company, Émile Nouguier and Maurice Koechlin, designed a 300 meter-high tower. Although Eiffel initially showed little interest, he was won over by the embellishments added by the architect Stephen Sauvestre, and registered a patent.[3] The tower won one of the four prizes in the exhibition's architecture competition. Publicity in the press and public meetings helped to make Eiffel's project increasingly credible, and an agreement with the government was finally signed. Funded partly by Eiffel's own money, the project would finally get off the ground. Work began in January 1887 to be completed a mere 26 months later. The tower was to amaze two million visitors during the six months the exhibition was open. "It was supposed to be torn down after 20 years, when the free lease granted by the city of Paris expired. But Eiffel saved it by demonstrating its scientific importance as a site for a radio antenna, and for carrying out experiments, in particular in aerodynamics,"adds Lemoine. Eiffel retired from business at the age of 61, but continued a career as a researcher until the ripe old age of 88.

Charline Zeitoun

1. Centre André Chastel (CNRS / Université Paris-IV / Ministère de la culture et de la communication).
2. École centrale des arts et manufactures.
3. Patent registered under the names of Eiffel, Nouguier, and Koechlin, which Eiffel later bought back from the two engineers.

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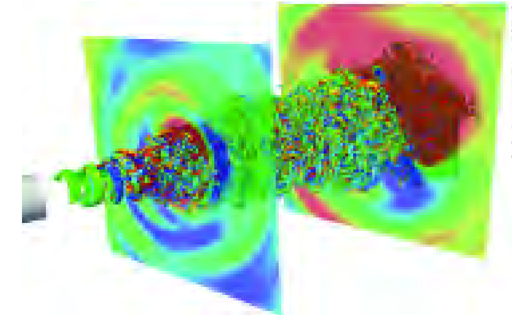
FLUID MECHANICS

Computing Better Engines

The European Research Network in Computational Fluid Dynamics is exploring new avenues to make engines more efficient and less noisy. This Franco-German partnership associates 19 different research teams from both countries.



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No switching errors or technical hitches to report. For the last 20 or so years, French and German researchers from CNRS and Deutsche Forschungsgemeinschaft (DFG) have been taking part in a considerably innovative research program on fluid dynamics. Their primary objective is to reduce turbulence phenomena in air and land transport. To do so, they need to acquire a very detailed understanding of the turbulence phenomena that occur behind airplane engines and cars, in order to reduce the resulting noise, particularly in civil aviation turbojet engines. The expected result is to improve aerodynamics and lower fuel consumption, not just in planes but also in cars.

Since the late 1980s, the two countries have been coordinating the efforts of their scientific communities around increasingly finely targeted research themes. From bilateral exchange programs to collaborative projects, they eventually created a European Research Network (GDRE) in Computational Fluid Dynamics for the current period (2004-2011). Twenty years after the first collaboration, 19 different research teams working in 14 French and German laboratories[1] are currently involved in this program. Its annual budget–estimated at €2.5 million–is funded on the one hand by CNRS, the French Ministry of Research, and ONERA, and on the other by DFG.

"This initiative brings together experts in fluid mechanics, acoustics, modeling, and high-performance computing," explains Patrick Bontoux, director of M2P2[2] in Marseilles. One of the leading scientific approaches is Large Eddy Simulation (LES), a type of numerical meshing that makes it possible to simulate the large and most energetic turbulent scales–also known as eddies–while at the same time modeling the smallest ones, which formerly went unrecorded by the system. The GDRE's expertise in this field has largely benefited from the considerable computational power found in various national centers, such as IDRIS,[3] as well as from the vector supercomputers recently acquired by CNRS, like IBM Blue Gene, the 9th most powerful supercomputer in the world which has a combined computational power of more than 15,000 last-generation laptops.

LES makes it possible to isolate and study specific phenomena like the jet flows emitted by airplane engines, which have an impact on both noise and atmospheric pollution. Another phenomenon being studied is viscous drag, the resistive force that air exerts on vehicles in movement. "We try to predict and reduce drag and the flow separation that occurs near the sides of vehicles, which also generates eddies," explains Bontoux. A complex task, but one well worth the effort: The reduction of such effects by fine-tuning the geometry of the vehicle leads to lower fuel consumption.

Since 2004, the GDRE's teams have published six books and nearly 200 articles, and have organized more than a dozen seminars. The GDRE has already advanced our understanding of the physical mechanisms involved in turbulences, and improved the techniques and models currently used in industry. This success can be in part credited to the close ties established with various companies and organizations like Dassault Aviation, Snecma, Rolls Royce, MTU, Airbus, Renault, CEA, CNES, DGA, EDF, and ONERA.

In the long run, this program aims to "make numerical simulation a common language at a European level." Discussions are underway to expand the GDRE beyond 2011. The new PRACE initiative (Partnership for Advanced Computing in Europe) suggests concentrating supercomputing facilities in several international centers to give European scientists the computing power necessary to meet tomorrow's challenges.

Séverine Lemaire-Duparcq

1. Some of the participating laboratories on the French side: LEA in Poitiers, LMFA in Lyon, M2P2 in Marseille, LMF in Nantes, LEGI and LJK in Grenoble, IMFT in Toulouse, LJAD in Nice, LIMSI. On the German side: RWTH in Aachen, TU in Berlin, Darmstadt, Munich, and Dresden, as well as the universities of Stuttgart, Karlsruhe, Hamburg, and Erlangen.
2. Mécanique, modélisation et procédés propres (CNRS / Université Marseille-I and -II / Ecole Centrale Marseille).
3. Institut du développement et des ressources en informatique scientifique.

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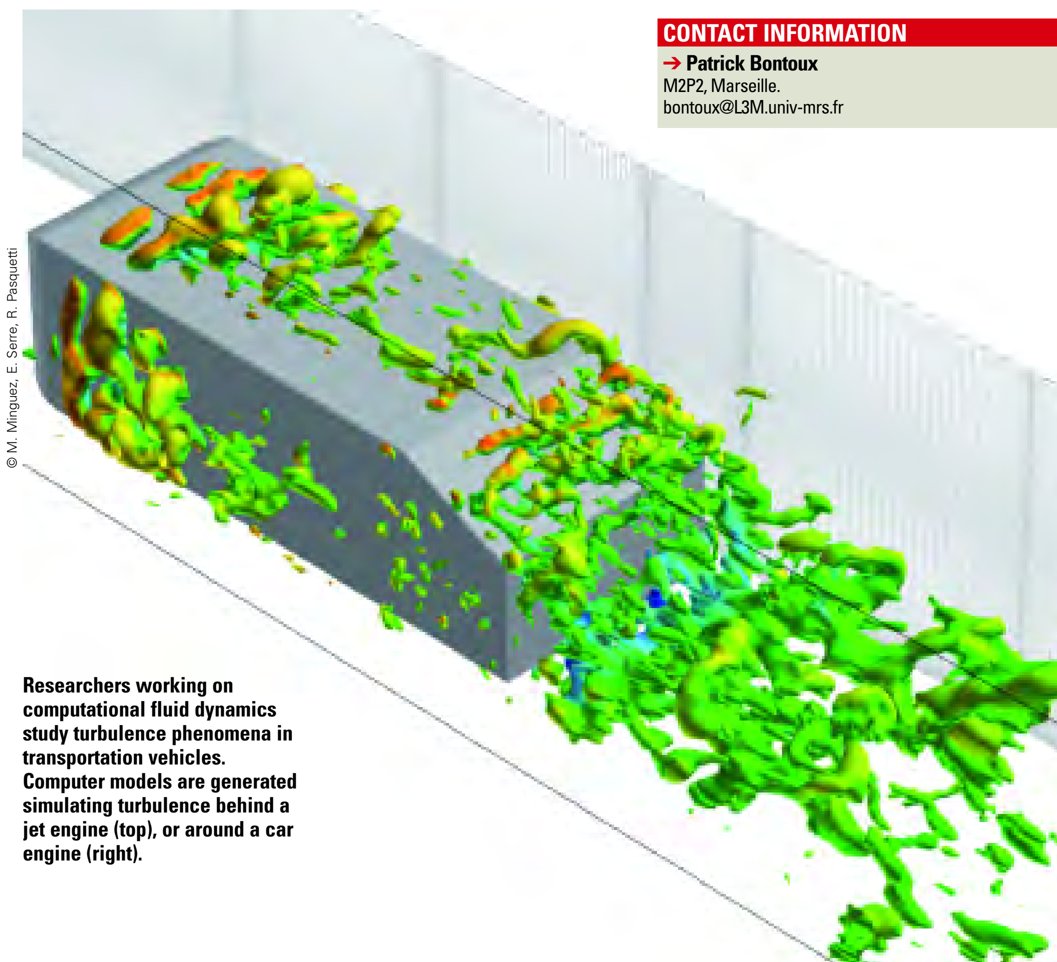

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Researchers working on computational fluid dynamics study turbulence phenomena in transportation vehicles. Computer models are generated simulating turbulence behind a jet engine (top), or around a car engine (right).

Pablo Gluschankof

Using Yeast to Fight AIDS

Of course, listening to a tango fills me with emotion. But I can also be moved by the songs of the French singer Edith Piaf. I feel very much in tune with French culture, and above all with Marseille, a very eclectic city which fiercely defends its right to be different. And this right to being different is something I uphold, both at work and in life." After a few words in French, Pablo Gluschankof's Argentinian roots resurface. Currently working in Marseille, he is both CEO and scientific director of AmiKana.BioLogics, a CNRS spin-off company created in December 2007, that specializes in the diagnosis of viral diseases. For now, the company is hosted by the Faculty of Medicine's unit on infectious diseases (URMITE).[1]

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The 52-year-old biochemist first arrived in France in 1982. After starting a degree in chemistry in his hometown of Buenos Aires in the mid 1970s–"a time when to be young in this country was dangerous," as he puts it–and then getting his Master's degree at the University of Jerusalem, he moved to Paris for his PhD and joined CNRS in 1985. Yet four years later, he had left for Stanford University in California. "I became extremely interested in the yeast *Saccharomyces cerevisiae*, a unicellular organism which resembles a human cell, both in struture and biology," Gluschankof recalls. "It's easy to alter its own genetic information to make it produce exogenous proteins, like those, for example, expressed in a cell during viral infections."

When he returned to Europe in 1992, Gluschankof started using yeast and their "protein factory" capabilities to investigate the mechanisms of budding and replication of the AIDS virus. "In 2003, while working at URMITE, I started using yeast to study HIV resistance to certain antiretroviral drugs," he explains. Because HIV protease, an enzyme that takes part in the synthesis of certain viral proteins in infected cells, is often a target in the design of antiretroviral drugs, he specifically expressed this protein in yeast. In this way, he could easily test the effect of various drugs on this type of genetically modified yeast. "The advantage is that the cellular response is much easier to interpret in this simple micro-organism. Besides, there is no need to manipulate the yeast expressing HIV protein in an L3 containment lab,[2] as must be done for HIV infected cells," he adds.

This approach turned out to be very successful and propelled Gluschankof's research to the forefront. A patent was registered in June 2004 by both CNRS and the University of Aix-Marseille-II. Wishing to "escape the cocoon of academia" as he puts it, he gradually accepted the idea of becoming an entrepreneur. Hosted by various business incubators and rewarded with several prizes, AmiKana.BioLogics is currently developing a diagnostic kit based on Gluschankof's principle. The objective is to help physicians prescribe the right treatment at the right time by offering a test that can rapidly, reliably, and at low cost determine whether strains of HIV or the hepatitis C virus are resistant or not to specific drugs.

In 2006, Gluschankof took a training course in management at the French business school HEC. He is also working on the design of other products and services aimed at improving antiviral treatment that will be offered to both hospital departments and the pharmaceutical industry. He hopes that the first of the kits currently in development phases will reach the market by the end of 2012, "but it all depends on raising the necessary funds," he concludes.

Philippe Testard-Vaillant

1. Unité de recherche sur les maladies infectieuses et tropicales émergentes (CNRS / Université Aix-Marseille-II).
2. A restricted containment laboratory required for the handling of highly pathogenic biological agents.

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Valentina Emiliani

Bridging Physics and Biology

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The meeting takes place at the Paris Descartes University, in the heart of Paris's famous Saint-Germain-des-Prés neighborhood. Valentina Emiliani, a renowned physicist with a lilting accent that betrays her Italian origins, takes me up three floors to the laboratory where she works, specialized in neurophysiology and new microscopies (LNNM).[1] By way of introduction to her complex field of study, Emiliani sums up her work as lying at the interface between physics and biology. It has now been nearly four years since this specialist in optical properties of quantum semiconductors set up one of the lab's four teams. The team's goal is to develop novel microscopy techniques for neurophysiology.

Now 42, this native Italian is enjoying her life as a researcher, after a circuitous career that took her from Italy to France. When she started out, Emiliani, who grew up in Rome, was as keen on architecture as she was on physics. She chose physics "because of my family's attachment to research." She studied for her PhD at the University of Rome while working with a non-linear optics lab[2] located in Florence.

Then, in 1996, she was offered a job in surface physics in Rome. "It was a bit too soon for me and, above all, a bit too far removed from my field of research," she explains. Before accepting the job she decided to find out about surface physics by doing a postdoc at the Berlin Technical University. Emiliani was possibly more captivated by the German capital than by her new discipline. So she stayed in Berlin, but moved to a laboratory dedicated to the recently developed near-field optical microscopes, which have high spatial resolution.

In 2000, she returned to Florence, knowing full well what she wanted to do: apply this state-of-the-art technology to biology. It was then that France came knocking, mainly through her Italian researcher husband. "Things were complicated, because he was working in France," Emiliani recalls. In 2002, fed up with endless travels back and forth, she opted for a postdoc at the Institut Jacques Monod in Paris. Both the change in her status and the language handicap weighed heavily on her, and she missed her independence. But this didn't stop her from continuing to investigate the links between physics and biology, by studying the reactions of cells to mechanical stimulation of their environment. "To do this, we used optical, so-called holographic, tweezers,"[3] she explains. "Based on special types of laser beams, they can be used to stimulate cells in their three dimensions. It was during this project that I realized that holographic manipulation of light opened up other applications in biology."

In 2004, she obtained a position at CNRS. To carry out her project, however, she wanted to have her own team. A stroke of luck led her to cross paths with LNNM Director Serge Charpak, who wished to strengthen the physics in the laboratory, and they struck a deal. She successfully applied to the 2005 European Young Investigator Award (EURYI Award), and was able to move into her new premises, purchase state-of-the-art optical equipment, and build an invaluable team. "Here, the permanent contact with biologists in the lab combined with their awareness of the role of physics allow us to share a common language," she says. This is a perfect setting to extend the use of holography to other applications, such as exploring, both in time and space, the mechanisms of communication between neurons.

With a renowned team, and having fully embraced the offerings of France's capital city, Emiliani has postponed her return to Italy, maybe indefinitely.

Patricia Chairopoulos

1. Laboratoire neurophysiologie et nouvelles microscopies (CNRS / Université Paris-V).
2. Non-linear optics makes use of the intense electric fields produced by lasers to alter the optical properties of the medium they pass through.
3. The use of highly focused laser beams as optical tweezers to manipulate cells or small objects.

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GRANTS/FELLOWSHIPS

MARIE CURIE ACTIONS
This EU program provides numerous fellowships and grants facilitating research mobility in Europe.
➔ **http://cordis.europa.eu**

ÉGIDE
Égide is a non-profit organization that manages French government international mobility programs. Many funding opportunities are listed on the website, and most content is in English.
➔ **www.egide.asso.fr**

EURAXESS
This portal provides information on grants, fellowships, or positions available throughout Europe as well as practical information (accommodation, childcare and schools, healthcare...) for each country.
➔ **http://ec.europa.eu/euraxess/**

SEE-ERA.NET PLUS
A joint call for European research projects in ICT and agrofood was just launched. Retained projects will be funded for one or two years up to €150,000. The applicants must consist of at least two partners from the Western Balkan countries and one from other participating countries.
➔ **Deadline:** November 3, 2009.
➔ **http://plus.see-era.net/pjc**

CNRS AGREEMENT WITH DENMARK
CNRS and the Danish National Research Foundation (DNRF) have concluded an agreement to strengthen scientific cooperation between France and Denmark. It includes a mobility program that provides support for travel expenses, accommodations, and running costs. Applications can be submitted throughout the year, three months prior to the intended date of travel.
➔ **Deadline:** December 31, 2009.
➔ **Contact Information:** anne-marie.brass@cnrs-dir.fr or vs@dg.dk
➔ **www.dg.dk**

EUROPEAN RESEARCH COUNCIL
This entails a number of calls for proposals by the European Research Council (ERC) for both starting and advanced grants in Physical Sciences and Engineering, Life Sciences, and Social Sciences and Humanities.
➔ **Deadline:** Various closing dates between October 28, 2009 and April 7, 2010.
➔ **http://erc.europa.eu (grant section)**

WORKING IN A FRENCH LAB, PRACTICAL INFORMATION:

The Kastler Foundation (FNAK): Helps foreign researchers settle in France and maintains contact after their departure.
➔ www.fnak.fr

Foreign embassies and consulates in France:
➔ www.diplomatie.gouv.fr/annuaire/

French embassies and consulates abroad:
➔ www.expatries.diplomatie.gouv.fr/annuaires/annuaires.htm

Association Bernard Gregory: This association helps young PhDs from any discipline make the transition into business.
➔ www.abg.asso.fr

France Contact will help you plan and arrange your stay in France:
➔ www.francecontact.net

Edufrance: Information on France's higher education programs–course enlistment, grant and fellowship applications.
➔ www.edufrance.fr

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This balloon will gather atmospheric data above the Franco-Italian Concordia station at Dome C.

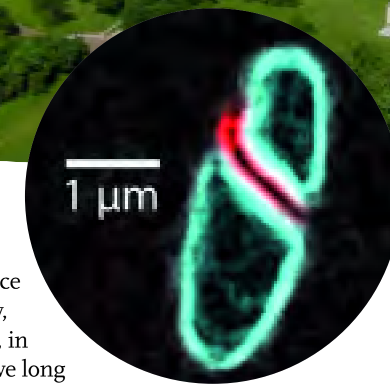
© J.-P. Brun CNRS-EFR / Centre Jean Bérard

At the Cumae site near Naples, researchers are unearthing a wall of a mausoleum dating back to the first century BC.

Muraz/CNRS Photothèque/LPSC

Part of the large electromagnetic calorimeter (EMcal) that will measure the energy of electrons and photons at the LHC.

© Courtesy of Sincrotrone Trieste



D. Lacour/CNRS Photothèque

Top: Aerial view of ELETTRA, the Trieste synchrotron facility.

Above: Magnetic tunnel junction (MTJ) image observed using the XPEEM microscope.

The Italian Paradox

© CNRS

IN FIGURES

- **59** million inhabitants (2008)
- **82,489** researchers (2005)
- **16.835** billion euros spent on R&D in 2006 (1.13% of GDP)
- **4856** CNRS missions to Italy in 2008
- **1706** scientific co-publications with CNRS in 2007

Statistics on scientific research in Italy reveal a striking contradiction. While the country's R&D ressources significantly lag behind those of other major economies, its output, in terms of scientific publications, is not only one of the most prolific in the world, but also highly recognized in several fields.

In recent years, Italy's annual R&D spending, has averaged around 1.13% of GDP, compared with a European Union average of 1.84% (2004-2006). With 51%, the public sector is the largest contributor to R&D funding, compared to the private sector's 48%–an uncommon occurrence in major world economies.

The country counts an average of just 3.4 researchers per 1000 people employed, against 8.2 in France. Yet between 1998 and 2008, Italy produced 371,205 scientific publications, putting the country in eighth position worldwide and fourth in Europe. The predominant fields are medical science, space science, mathematics, and physics.

Over this same period, Italian publications were the seventh most cited internationally (4.16 million) particularly in the fields of molecular biology and genetics, immunology, space science, and neuroscience and behavior–illustrating researchers' proficiency in these fields.

Young Italians have been the second most successful scientists in obtaining European Research Council grants, awarded on highly selective criteria of scientific excellence and creativity.

R&D organization and funding are essentially directed by the Ministry for Education, Universities, and Research (MIUR) in consultation with the scientific community, local government, and private enterprise. MIUR-led research policy is set in three-year plans, called the National Program for Research (PNR). Applied sciences receive almost half the annual research spending, while the rest is evenly split between development and basic research.

The country's 61 public and 26 private universities, comprising a total of 1.8 million students, employ 67,000 researchers and receive about 30% of all state R&D spending.

In addition to overseeing university research, the MIUR also manages most major research agencies, including the National Research Council (CNR, the largest Italian research organization with approximately 4000 researchers), the energy and environment agency (ENEA), and the national institutes of mathematics (INdAM), astrophysics (INAF), and nuclear and particle physics (INFN).

In 2007, foreign cooperation projects accounted for almost 40% of the 45,241 Italian scientific publications produced. France was the second most active partner (after the US), involved in 3363 co-publications, half of which with CNRS, mostly in physics (39%), space science (30%), chemistry (16%), and fundamental biology (12%). Conversely, Italy was the fourth most active partner in CNRS co-publications. This close collaboration is illustrated in the almost 5000 CNRS research trips to Italy in 2008. Furthermore, Italians make up the largest foreign contingent among CNRS researchers.

The numerous informal transalpine collaborations are a breeding ground for a large number of structured cooperation projects between CNRS and Italy.

Three European Associated Laboratories (LEAs) were launched in chemistry, knowledge systems, and nuclear physics–the latter involving the Normandy-based Spiral 2 particle accelerator in collaboration with nine other international teams. Other international cooperations involve 18 European/International Research Networks (GDREs/GDRIs) mainly in human and social sciences, mathematics, and chemistry, and 13 International Projects for Scientific Cooperation (PICS) in space science, chemistry, biology, and physics. Mathematics, in which Italy and France have long histories of excellence, is the subject of three GDREs linking CNRS and INdAM, involving around 600 researchers from both countries.

Besides, under a 1971 bilateral agreement (renewed in 2007), CNRS and the CNR fund short-term exchanges between partner laboratories, involving between 30-40 researchers from each country every year.

Among major projects, CNRS went into partnership with the INFN in 1994 to build and operate a gravitational wave detector called VIRGO, based at the European Gravitational Observatory near Pisa (*see box*). Three CNRS laboratories (IN2P3) and two from the INFN (Frascati and Catania) currently collaborate in the design and construction of modular components for a powerful electro-magnetic calorimeter, ALICE EMcal, based at the Large Hadron Collider at the European Laboratory for Nuclear Research (CERN). The project, which also includes three US labs, will study interacting matter at extreme energy densities, with the hope of observing the formation of quark-gluon plasma, a new phase of matter.

Since 2003, CNRS has also been involved in a major Franco-Italian project for developing X-ray Photo Emission Electron Microscopy (XPEEM) at the Trieste synchrotron facility ELETTRA. The studies using the XPEEM microscope significantly strengthened ties between French and Italian research into X-ray microscopy. This instrument is scheduled to be transferred to the French synchrotron SOLEIL in 2010.

A series of archaeological and historical studies into the ancient Greek colonies in southern Italy led by the CNRS Naples-based Centre Jean Bérard, affiliated to the Ecole Française de Rome, have also meant close collaboration with researchers from Naples' Federico II and Orientale universities, and with Italy's Superintendence of Archaeological Heritage.

Finally, the Concordia research station in Antarctica, operated by French (IPEV) and Italian (PNRA) polar research programs, is one of just three international inland Antarctica bases. At an altitude of 3233 meters, the surrounding atmosphere and long nights make it an exceptional site for astronomy–yet in a rather harsh environment. Concordia has hosted several joint studies by CNRS (INSU) and INAF, and a European project for deep ice core drilling (EPICA) in partnership with ENEA and INFN. This provided the first data on greenhouse gas evolution over the past 800,000 years, and furthered the understanding of the mechanisms of rapid climate change.

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LOOKING BACK WITH VIRGO

Jointly financed by CNRS and INFN, the VIRGO gravitational wave detector is a Michelson laser interferometer made up of two perpendicular arms, each three kilometers long.

Operational since May 2007, VIRGO is expected to detect the presence of gravitational radiation produced by supernovae explosions or from the merging of cosmic binary systems (black holes or neutron stars). It is capable of "observing" thousands of galaxies and weakly luminous bodies at a distance of up to 300 million light years, thanks to its extreme sensitivity that allows measuring variations in the path of a laser beam to the order of one hundredth of a billionth the size of an atom. "Gravitational waves are a consequence of Einstein's theory of general relativity," explains Benoît Mours from LAPP.[1] "If a mass is accelerated, it will radiate deformations of space which will spread around. These are called gravitational waves." To test this theory, VIRGO's data will be analyzed in conjunction with those provided by similar detectors in the US and Germany. So far, however, gravitational waves have not yet been detected and VIRGO, like its international counterparts, will be made significantly more sensitive. Beyond this fundamental test, VIRGO is intended to become a permanent observatory to further astrophysics and cosmology research, with the potential of directly capturing information about the first moments of the Universe.

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One of VIRGO's many ultra-high vacuum tubes. VIRGO, located near Pisa (Italy) is expected to detect gravitational waves.

Immersed in a world of swashbucklers, players will need to use French to communicate with other players and make progress in the game.

HUMANITIES AND SOCIAL SCIENCES

Gaming Your Way to Better French

A team from the Strasbourg C&SE laboratory[1] is developing a Massively Multiplayer Online Game (MMOG) to help people learn French. Patrick Schmoll, the sociologist behind the project, tells us about his revolutionary educational game dubbed Thélème.

What exactly is Thélème?

Patrick Schmoll: Thélème is an online application that helps you learn French as a foreign language. After creating their own characters, the players are immersed in a world of swashbucklers. They then interact in real time with other non-French players like themselves with whom they have to communicate in French through a text-based chat system. They also meet French speakers attracted by the game itself, with whom they can improve their language skills. The players' scores are based on the quantity and quality of the French they use. We are also planning to have teaching modules based on virtual non-player characters who will entrust players with specific tasks–finding somewhere to live, looking for a job, solving a criminal investigation–using French as the only means of communication.

What are the advantages of this new learning method?

P.S.: Thélème should be the first method that combines immersion, simulation, and interactivity among thousands of users. Its concept is based on the ever-increasing enthusiasm for video games and persistent virtual worlds like World of Warcraft and Second Life. Such games generate virtual communities in which users spend a lot of time, the key to learning a foreign language. Compared to current online or even offline teaching methods, like CDs and DVDs, our concept will be able to evolve and thus have a longer lifespan. It will be cheaper and it needs neither a state-of-the-art computer, nor an ultra-high speed Internet connection.

Where did the idea come from?

P.S.: Thélème is the result of our work on virtual communities, which showed how social bonding is generated through situations of conflict. In multiplayer online games, the competition leads to both conflict and dialog, because in the end, for long-term quests, you simply cannot win without the help of others. All interactions to exchange information, help one another, create groups and alliances, and build common strategies are opportunities to speak a common language: French in the case of Thélème.

How far have you come in its development?

P.S.: The playable prototype, which belongs to CNRS and the University of Strasbourg, was completed at the end of February for a budget of €298,000. We are now seeking other sources of funding. We need €500,000 so that Almédia, the company that we set up at the end of February, can develop the game under license until we have a marketable product.

What are the next steps?

P.S.: A free version of the prototype was made available to French teachers in September for two years,[2] during which we hope to set up a community and get feedback to improve the product. The full version could be accessible by 2011 with a subscription fee of €5/month. At that price, the company would break even with just 10,000 players, out of a potential market of 290 million people worldwide. What's more, the game could rapidly come out in German and Spanish versions, and we are also planning to add voice recognition modules.

Interview by Jean-Philippe Braly

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2. www.theleme-lejeu.com

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ELECTRONICS

Microfluidics Shrinks Fuel Cells

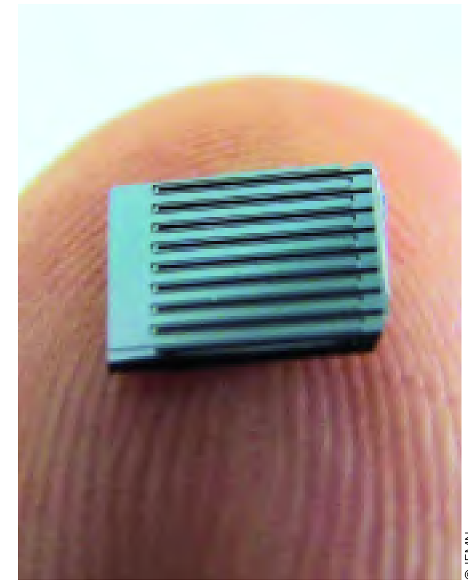
A Franco-Japanese consortium has just revealed that it is possible to make fuel cells the size of a microchip. The prototype fuel cell weighs less than 100 milligrams and has been developed by Steve Arscott's team at IEMN[1] in Villeneuve d'Ascq, working in collaboration with the electronics company Sharp. With a power of 50 milliwatts per cubic centimeter, it is the smallest and most efficient fuel cell in the world. Its size would make it ideal for future portable electronics.

So far two patents have already been registered in Japan in partnership with CNRS for this technological marvel. Like all fuel cells of this type, a current is produced from an electrochemical reaction: the oxidation of a fuel. Specifically, in this case the reaction takes place between methanol and air. The device is based on a thin plastic membrane sandwiched between two silicon wafers etched with microchannels. Methanol from a reservoir outside the fuel cell circulates through these fine grooves, together with the air needed for the reaction. "The microchannels, which are no deeper than the diameter of a single hair, were etched using semi-conductor technology," Arscott comments, "and they are the key to the fuel cell's performance." The microchannels make it possible to precisely control the flow of methanol so as to obtain an optimal chemical reaction, leading to an efficiency of 75% at room temperature.

This new battery obviously has a promising future in the portable electronics sector. By stacking several cells, several hundreds of milliwatts of power and an infinite lifespan are envisaged (as long as it's refueled with methanol). The micro fuel cell could be used to power low-consumption devices, such as MEMS (Micro-Electro-Mechanical Systems)-type microsensors, currently developed all over the world. These could in particular be used as warning systems in the event of fire or chemical pollution. And in five to ten years' time, Arscott and his colleagues hope to combine several of these tiny fuel cells into one that could power more familiar electronic devices, such as mobile phones.[2]

Xavier Müller

1. Institut d'électronique, de microélectronique et de nanotechnologie (CNRS / Université Lille-I / Université de Valenciennes / Isen Recherche).
2. A. Kamitani et al., "Improved fuel use efficiency in microchannel based DMFC using a hydrophilic macroporous layer." *J. Power Sources*, 2009. 187: 148-55.



A silicon chip (5 mm x 3.6 mm) with microchannels through which methanol circulates in the micro fuel cell.

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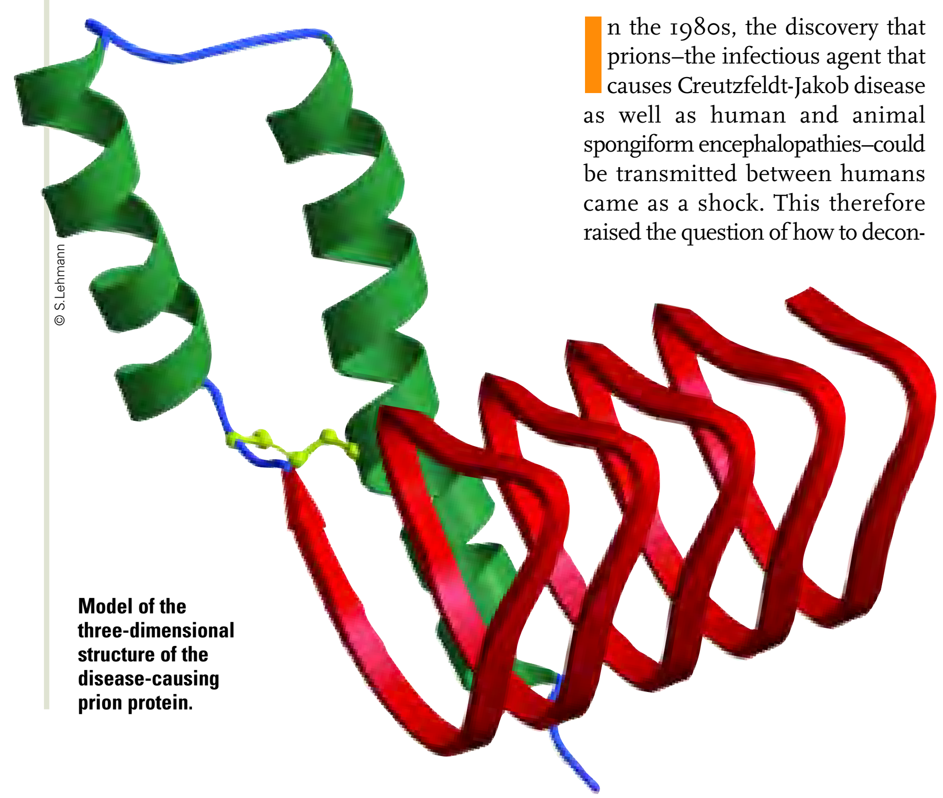
PATENTS

A New Weapon against Prions



Model of the three-dimensional structure of the disease-causing prion protein.

In the 1980s, the discovery that prions–the infectious agent that causes Creutzfeldt-Jakob disease as well as human and animal spongiform encephalopathies–could be transmitted between humans came as a shock. This therefore raised the question of how to decontaminate medical equipment. Because of the prion's powerful physical and chemical resistance, no fully satisfactory solution had been found until now. A new product–the result of research carried out at the Institute of Human Genetics (IGH)[1] in Montpellier–has just been marketed under the name Actanios Prion by the firm Anios.[2] It is able to destroy prions without damaging fragile medical equipment like endoscopes.

It was while studying the non-pathogenic form of prions[3] that researchers at IGH observed that it could be destroyed by the combined action of copper and an oxidizing agent such as hydrogen peroxide. Until then, decontamination methods that worked against prions were either extremely aggressive (caustic soda, concentrated bleach, or autoclave), or not very effective (peracetic acid). "Of course, we immediately wondered whether this chemical cocktail would be efficient against pathogenic prions," says Sylvain Lehmann, group leader at IGH and professor at the university and hospital of Montpellier. The answer wasn't long coming: The combination of copper and hydrogen peroxide was indeed able to destroy the abnormal protein and its infectious nature. "We knew very well the importance of this finding, so we registered a patent in 2004 and contacted the firm Anios, with the objective of developing a marketable decontamination product."

A scientific collaboration with an exclusivity option on the patent began in 2005 between IGH and Anios, and given the importance of this new method, international patent coverage was also sought. This was followed by four years of work in order to adapt the formulation to hospital practice and to medical equipment, which requires specific cleaning precautions, and to validate the effectiveness of the solution against not only prions but also bacteria, viruses, and parasites. With this now out of the way, a license has finally been granted, and Actanios Prion is at last available on the market.

Caroline Dangléant

1. Institut de Génétique Humaine (CNRS).
2. Anios is a subsidiary of Air Liquide, and is the market leader–both in France and the world–in the field of hospital decontamination.
3. The prion protein exists in two forms: a normal, non-pathogenic form, and an abnormal, pathogenic one.

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OPTICS

Knowledge on All Scales

Optics are central to a number of fields, including telecommunications, astronomy, the life sciences, or fundamental physics. Following a key meeting in Lille last July between academia and industry, we take a closer look at this branch of physics whose many applications are as diverse as they are unexpected.

A scientific and technical field that deals with physical phenomena and technologies connected with the emission, propagation, manipulation, detection, and use of light." This official definition of optics conceals a host of applications that the general public can scarcely imagine. But in one field at least–telecommunications–optics has brought about a highly noticeable revolution. "Internet wouldn't be what it is today without the progress that's been made in the field of optical fibers and lasers that carry millions of messages in the form of beams of light," points out Christian Chardonnet, deputy scientific director at CNRS' Institute of Physics in Paris. "A revolution in which our researchers have played a significant part."

Optics not only helps transmit data, it also makes it readable, as shown by the laser scanners we use every day. They let us read information stored in increasingly compact form on media like CDs and DVDs. But what will be the next revolution? It will probably deal with the manipulation of photons, which, amazingly, can now be produced and detected individually. This could pave the way for emerging applications like quantum cryptography, which would make data exchanged on the internet impossible to hack. And it could even lead to the holy grail: a quantum computer, with hugely increased computing power.

Whether pointing to the Earth or to the stars, optics is providing high-performance observation tools. Teams at CNRS are developing pulsed lasers called lidars, which are used to study the composition of the Earth's atmosphere. Astronomy is also benefiting from the progress being made in adaptive optics. "Developed by astronomers, this method makes it possible to correct the distortion that starlight undergoes when it passes through the layers of the atmosphere," Chardonnet explains. "In practice, the surface of the telescope is modified in real time so that it compensates exactly for the distortion, and optimizes the quality of the images. This is the case for the Very Large Telescope in Chile, which our scientists are working on." This technique has subsequently been introduced in biology for so-called "biophotonics" applications, to eliminate the disturbance caused by biological fluid during tissue observation.

In medicine also, optics has become an essential tool, used in laser eye surgery, endoscopy, or imaging, to mention just a few. "The development of ultra-intense lasers should make it possible to generate laser-accelerated protons for proton therapy, a technique that targets cancer tumors far more effectively than radiotherapy," adds Chardonnet.

Such ultra-intense lasers are also of great importance to study the quantum vacuum in fundamental physics. In the European ELI project, for example, researchers plan to build a laser that will deliver a pulse of around 200 petawatts[1] for a duration of approximately 10^{-15} seconds."Yet at these levels of power, there are still many technological obstacles that we need to overcome," warns Chardonnet.

Far more compact lasers, with a power of a few milliwatts, can be used to cool down atoms which, in turn, stabilize other lasers: The entire set-up constitutes an atomic clock that is 1000 times more accurate than those used in the well-known GPS system. But lasers have many other applications, in telemetry, navigational aids, the control of chemical reactions, and even the cleaning of historical monuments. "Optics is a discipline that spills over into every field, and it's also an area in which France is a front runner, thanks to its optics research clusters[2] and to the excellence of CNRS laboratories," Chardonnet concludes.

Jean-Philippe Braly

1. 1 petawatt = 10^{15} watts.
2. Opticsvalley, Popsud, Alpha, and Route des lasers.

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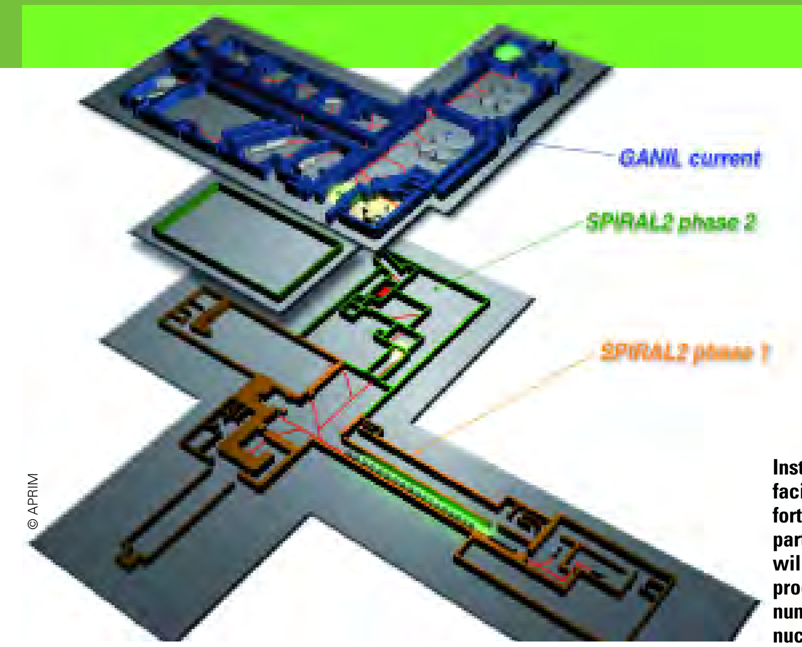
A scientist controls the polishing of a toroidal mirror that will equip the Very Large Telescope in Chile.



Installed at the GANIL facility in Caen, the forthcoming Spiral 2 particle accelerator will be able to produce a large number of exotic nuclei.

NUCLEAR PHYSICS

Spiral 2 Weaves its International Web

Specialists in nuclear physics will soon have new objects to study: "Exotic" nuclei that do not belong to the list of the 300 or so stable elements that currently exist in our universe. These nuclei should be produced in abundance as of 2012 using a new instrument, called Spiral 2,[1] installed at France's GANIL (National Heavy Ion Accelerator Laboratory) site in Caen.

This large-scale facility will be built under the joint supervision of CEA and CNRS, with the support of numerous European and international partnerships. In fact, Sydney Gales, deputy scientific director of IN2P3/CNRS[2] and director of GANIL, has opted for a series of targeted bilateral partnerships each focused on one aspect of Spiral 2, rather than seeking to team up with partners ready to commit to the project as a whole. Polish and Italian teams have already set up European Associated Laboratories (LEAs), Japan and India have confirmed the creation of International Associated Laboratories (LIAs),[3] and Memoranda of Understanding (MoUs) have been signed with American laboratories. "We also have similar agreements with Germany, Russia, Romania and Bulgaria, and we are in discussions with Spain, the UK, and the Czech Republic. Only South America is currently missing from our global partnership network," explains Gales.

Each participating laboratory within this star-like network is committed to part of the funding for at least four years, the planned lifetime of the LEAs and LIAs. Over that period, the objective is to associate the various partners into a consortium in 2012-2013, the planned start-up date of Spiral 2. "GANIL has made use of the wide range of European and International partnership tools provided by CNRS to weave an international web based around Spiral 2," explains Francesca Grassia from CNRS'Office of European Affairs. This type of organization could serve as a model to build and fund other large-scale European scientific facilities of common interest.

Virginie Lepetit

A GENERATOR OF EXOTIC NUCLEI

Fifty meters long and ten meters wide, Spiral 2, installed in a tunnel eight meters underground, will be a small particle accelerator. Yet it will provide GANIL physicists with a wide range of exotic nuclei beams, created by uranium fission. The stakes are considerable, because such exotic nuclei no longer exist. Formed in the cosmic cauldrons during the birth or death of stars, their existence was short-lived since they quickly recomposed into the now familiar stable elements. Their study will doubtless help to reconstitute the pathways that produced the heavy elements of our universe, and to explore a new, unknown world of nuclear physics.

V.L.

1. Second Generation On-Line Production of Radioactive Ions System.
2. Institut National de Physique Nucléaire et de Physique des Particules du CNRS.
3. LEAs and LIAs are "open" laboratories that formalize and structure close collaboration between teams. These four-year partnerships can be renewed for a further term.

CONTACT INFORMATION

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→ **Francesca Grassia**
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INTERNATIONAL COOPERATION

MAGHREB

Mathematics

A number of French scientific institutions, including CNRS, in partnership with laboratories from Algeria, Morocco, and Tunisia, have created the Franco-Maghreb International Associated Laboratory (LIA) in mathematics and their interactions (LF2MI). This LIA follows on a long-standing collaboration in mathematics between France and these North African countries. Besides multiplying collaboration on specific research projects, the partners want to organize a number of events (conferences, doctoral schools, etc.) to develop the field and encourage an exchange of knowledge in mathematics.

CHILE

Inorganic Chemistry

An International Associated Laboratory (LIA) was created on September 3rd in the field of inorganic chemistry. Called "Functional Inorganic Materials," it reinforces a 20-year collaboration between teams from Rennes (Brittany, France)[1] and Chile. The aim is to continue and strengthen the existing partnership in research on chemical synthesis, spectroscopic, structural, and theoretical analyses, as well as to investigate the properties of new materials. The LIA will concentrate particularly on the creation of smart materials to respond to the strong demand for high performance and low polluting materials that could find applications in the fields of health, energy, ecology, transport, and information storage.

1. Laboratoire Sciences chimiques de Rennes (CNRS / Université Rennes-I / École nationale supérieure de chimie de Rennes / Insa Rennes).

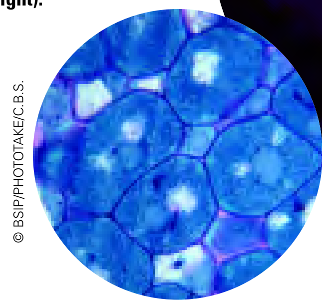
> **Contact: Jean-René Hamon, jean-rene.hamon@univ-rennes1.fr**

Mr. Muga (Catholic University of Valparaiso), Mr. Migus (CNRS General Director), and Mr. Pérez (University of Chile).

GENOMICS

Exploring the Soil's Genetic Biodiversity

The international TerraGenome consortium, led by a French team, is coordinating efforts towards the complete sequencing of the genome of all soil micro-organisms. An enormous task, but one that could open up countless new possibilities.



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Soil contains a multitude of bacteria, such as those that fix nitrogen for plants, like *Rhizobium leguminosarum* (below), and *Sinorhizobium meliloti* (right).

© NIBSC/SPL

The bacterium *Escherichia coli* is used for cloning huge collections of DNA fragments from soil bacteria, which can then be sequenced.

Is it possible to completely sequence the genomes of the tens of thousands of bacteria, archaea, and fungi that inhabit a single gram of soil? "A few years ago, such a project in metagenomics–the analysis of the genomes of all living organisms in an ecological niche–would have been unimaginable. But progress in microbiology, sequencing, robotics, and bioinformatics now make it possible," explains Pascal Simonet, from the Ampère Laboratory.[1] And this is how TerraGenome–the international consortium for soil metagenomics–was born in December 2008, as an extension of Metasoil, a French research initiative dedicated to the sequencing of all microorganisms in a reference soil. With a budget of €2.2 million over three years, Metasoil brings together a number of French labs[2] and is coordinated by researchers from the Ampère Laboratory. TerraGenome is set to help scientists from other countries cooperate with the Metasoil project.

© P. Simonet

The soil of the Park Grass plots at the Rothamsted Experimental Station (UK), was selected as a reference for the complete sequencing of the genomes of the various micro-organisms present in a soil, the objective of the international TerraGenome project.

Soil is the biggest biodiversity reservoir on the planet. "It contains bacteria and fungi which are a source of enzymes and other molecules with considerable industrial and pharmaceutical importance–in fact 70% of the antibiotics currently on the market are derived from soil bacteria," Simonet explains. "However, most of the total bacterial biodiversity is still unexplored, and makes up an almost inexhaustible reservoir of novel bioactive molecules, largely exceeding anything that could ever be synthesized."

On average, every gram of soil contains a billion bacterial cells, but it is still impossible to define the number of species present. "Partly because less than 1% of these micro-organisms can be grown *in vitro*," adds Simonet, "and partly because the soil is complex and heterogeneous: Some areas are like overpopulated megacities hardly accessible to research, while others are genuine microbial deserts. In addition, most of these species only comprise a few individuals."

This is why scientists opted for a metagenomic approach. It consists in directly extracting bacterial DNA without previous isolation of bacterial strains on culture media. "Once extracted and purified, the overall DNA can be either directly sequenced, or cloned as fragments of around 40 genes (40 kilobases) before sequencing. The first approach makes it possible to obtain an initial catalog of the genes present in the bacterial community, whereas the second approach gives more precise information, such as how genes interact with one another."

Launched last January, the Metasoil project is focused on analyzing the soil from one of the world's oldest agricultural research stations: Rothamsted (UK). A large amount of information about this soil is available: the climatic conditions, the crops grown, the treatments applied, etc.–and all this over the past 150 years. "Our sampling method will consist in taking around 20 samples distributed throughout various periods of the year. The first molecules of metagenomic DNA extracted at Rothamsted are already being sequenced, and the first million clones will be produced by the end of 2009," Simonet explains.

Rothamsted's biological resources will be made available to the international scientific community, which, through TerraGenome, will be given the job of completing the sequencing and analysis of the two million clones in the Metasoil DNA bank. "Two US labs have already applied for funding to collaborate on our project," Simonet adds enthusiastically. The work carried out on the reference soil should help us understand bacterial mechanisms of adaptation and evolution, and complete the inventory of bacterial functions. Such information will be very valuable to agriculture and industry, in particular to the pharmaceutical industry.

Marie Lescroart

A CENTER FOR BIODIVERSITY IN 2014

Aware of the many threats to biodiversity, a number of partners, from both the public and private sectors,[1] have come together to create the Research center for biodiversity and marine biotechnologies. CNRS will be involved through the National Institute for Earth Sciences and Astronomy (INSU) and the National Institute for Ecology and Environment (INEE). With an initial budget of €11 million, this center located on France's southern "Côte Vermeille" (bordering Spain), should be operational by 2014. A number of research projects are already on the agenda. The private company Pierre Fabre, associated to Paris-VI University and CNRS, will actively search for natural active substances that could be used in therapeutics and cosmetics. Other projects involve the development of biosensors to evaluate the health of ecosystems, detect toxic species or the presence of pollutants. Space will be allocated for the transitory housing of start-ups in the field. The center will also have a public information mission, with the creation of the "biodiversarium." This unusual aquarium, there to teach the general public about ecology and biodiversity, will recreate Mediterranean biotopes with local species. Approximately 110,000 visitors are expected in this tourist area.

I.T.

1. Pierre Fabre Laboratories, France's national, regional, departmental, and municipal administrative divisions, the city of Banyuls, Paris-VI and Perpignan Universities, and CNRS' INSU and INEE.

CONTACT INFORMATION

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1. Laboratoire Ampère (CNRS / École Centrale de Lyon / Insa / Université Lyon-I).
2. The Ampère Laboratory, the Genoscope in Evry, Libragen, and a group of bioinformatics scientists coordinated by researchers at the Biometrics and Evolutionary Biology Laboratory in Villeurbanne.

INTERNATIONAL COOPERATION

SINGAPORE

Nanotechnologies

The International Joint Unit (UMI) CINTRA was created on october 7, 2009, between CNRS, the Nanyang Technological University of Singapore, and Thales, one the main industrials in the field of nanotechnologies for electronics and photonics. This private/public sector association demonstrates the willingness of the partners to foster, by concrete actions, the cooperation between research, higher education, and the industrial players in both France and Singapore. CINTRA activities will be focused on the integration and interconnection of nanotechnologies, such as carbon nanotubes, semiconductor nanowires, and semiconductor nanowaveguides for applications in the fields of nanoelectronics, nanophotonics, and microwaves. This UMI represents a major asset for bridging science and technological breakthroughs with industrial innovation.

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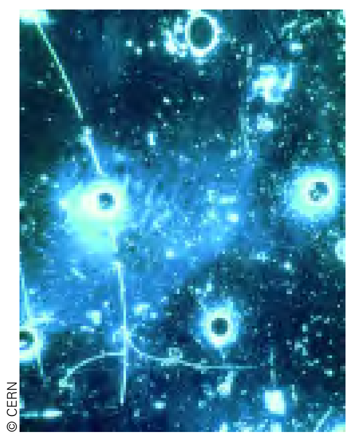
PRIZE

Gargamelle Collaboration Rewarded



© CERN

The first example of the leptonic neutral current. An incoming muon-antineutrino knocks an electron forwards, creating a characteristic electronic shower with electron-positron pairs.

This year, the European Physical Society has awarded its prestigious High Energy and Particle Physics Prize (HEPP) to the Gargamelle collaboration for the "observation of the weak neutral current interaction"–interactions that involve no exchange of electric charge between the particles concerned. The Gargamelle experiment took place at CERN (European Organization for Nuclear Research) in the early seventies. It was carried out by a collaboration of seven European laboratories, including CNRS labs,[1] as well as guests from Japan, Russia, and the US.

The HEPP prize is awarded every two years for an outstanding contribution to High Energy Physics in experimental, theoretical, or technological areas. It is the first time that the prize is awarded to a large collaboration. The prize was collected on behalf of the joint collaboration at the EPS HEP 2009 Conference in Krakow (Poland), and the medal will be attached to the Gargamelle bubble chamber, on display at CERN.

1. Laboratoire de l'accélérateur linéaire (CNRS-IN2P3 / Université Paris-XI) and Laboratoire Leprince-Ringuet (CNRS-IN2P3 / École polytechnique).

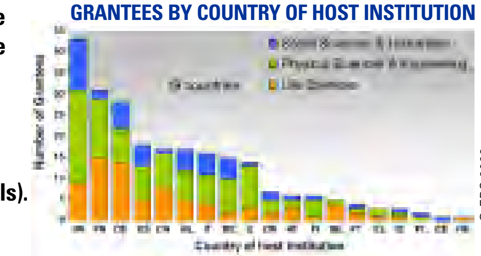
IN BRIEF

ERC Starting Grants Attributed

Of the 2503 applications received, 219 researchers were selected as recipients of the European Research Council's (ERC) second call for Starting Grants, and an additional 24 researchers are on a waiting list. The total budget is estimated at €325 million, which could bring the total number of confirmed grants to approximately 240.
Among the 219 grantees, 26 work in French institutions, including 9 researchers at CNRS (6 in life sciences, 2 in physics and engineering, and 1 in social sciences and humanities). Five other French researchers are currently on a waiting list. Altogether, France is second-ranked in number of grantees (after the UK), and ranks first in the life sciences with 16 grantees (14 on the main list, and 2 on the waiting list). The average age of grantees is 36 and around 23% are women (with large variations between the different research areas and panels). The grantees are of 33 nationalities and will be working in host institutions in 19 different countries. Nine grantees currently based outside Europe are moving to an EU Member State or associated country to take up their Starting Grant, thus fulfilling one the project's main objective: attracting top researchers to Europe.

> http://erc.europa.eu

GRANTEES BY COUNTRY OF HOST INSTITUTION



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CNRS in Brief

The **Centre National de la Recherche Scientifique** (National Center for Scientific Research) is a government-funded research organization under the administrative authority of France's Ministry of Research.

Facts...

Founded in 1939 by governmental decree, CNRS has the following missions:

- ➔ To evalulate and carry out all research capable of advancing knowledge and bringing social, cultural, and economic benefits to society
- ➔ To contribute to the application and promotion of research results
- ➔ To develop scientific communication
- ➔ To support research training
- ➔ To participate in the analysis of the national and international scientific climate and its potential for evolution in order to develop a national policy

CNRS research units are spread throughout France, and employ a large body of permanent researchers, engineers, technicians, and administrative staff. Laboratories are all on four-year, renewable contracts, with bi-annual evaluations. There are two types of labs:

- ➔ **CNRS labs:** fully funded and managed by CNRS
- ➔ **Joint labs:** partnered with universities, other research organizations, or industry

As the largest fundamental research organization in Europe, CNRS is involved in all scientific fields, organized into the following areas of research:

- ➔ Life sciences
- ➔ Physics
- ➔ Chemistry
- ➔ Mathematics
- ➔ Computer science
- ➔ Earth sciences and Astronomy
- ➔ Humanities and Social sciences
- ➔ Environmental sciences and Sustainable development
- ➔ Engineering

CNRS conducts some twenty interdisciplinary programs in order to promote exchange between fields, ensure economic and technological development, and solve complex societal problems.
➔ www.cnrs.fr/prg/PIR/liste.htm

The CNRS annual budget represents one-quarter of French public spending on civilian research. This funding comes from various sources:

- ➔ Government and public funding
- ➔ CNRS funds, primarily from industrial and EU research contracts and royalties on patents, licenses, and services provided

... And Figures

Budget for 2009
€3.36 billion of which €607 million comes from revenues generated by CNRS contracts

Personnel
32,000 employees: 11,600 researchers, 14,400 engineers and technical staff, and 6000 non-permanent employees

Organization

- > 9 thematic institutes
- > 19 regional offices, ensuring decentralized direct management of laboratories
- > 1100 research units–90% are joint research laboratories with universities and industry

Industrial Relations (2007)

- > 1680 contracts signed by CNRS with industry in 2007
- > 30 current agreements with major internat-ional industrial groups
- > 3103 patent families
- > 729 licenses and other financially remune-rating active acts
- > €58.2 million in royalties
- > 394 companies created between 1999 and 2008

DAE AND DRI, TWO OFFICES DEVOTED TO INTERNATIONAL RELATIONS

CNRS carries out research activities throughout the world, in collaboration with local partners, thus pursuing an active international policy.

The Office of European Affairs (DAE) and the Office of International Relations (DRI) coordinate and implement the policies of CNRS in Europe and the rest of the world, and maintain direct relations with its institutional partners abroad. The DAE and the DRI promote cooperation between CNRS laboratories and foreign research teams through a set of structured collaborative instruments developed for this purpose. At the same time, they coordinate CNRS actions with those of other French and international research organizations as well as the activities of the Ministries of Research and Foreign Affairs.
To carry out their mission, the DAE and the DRI–with head offices in Paris–rely on a network of eight representative offices abroad, as well as on the science and technology offices in French embassies around the world.

IN NUMBERS:
Exchange agreements: 85 (with 60 countries)

Foreign visiting scientists: 5000 (PhD students, post-docs, and visiting researchers)

Permanent foreign staff members:
> About 1700 researchers of whom more than 1200 come from Europe

> International Programs for Scientific Cooperation (PICS): 363
> International Associated Laboratories (LEA + LIA): 89
> International Research Groups (GDRE + GDRI): 90
> International Joint Units (UMI): 18

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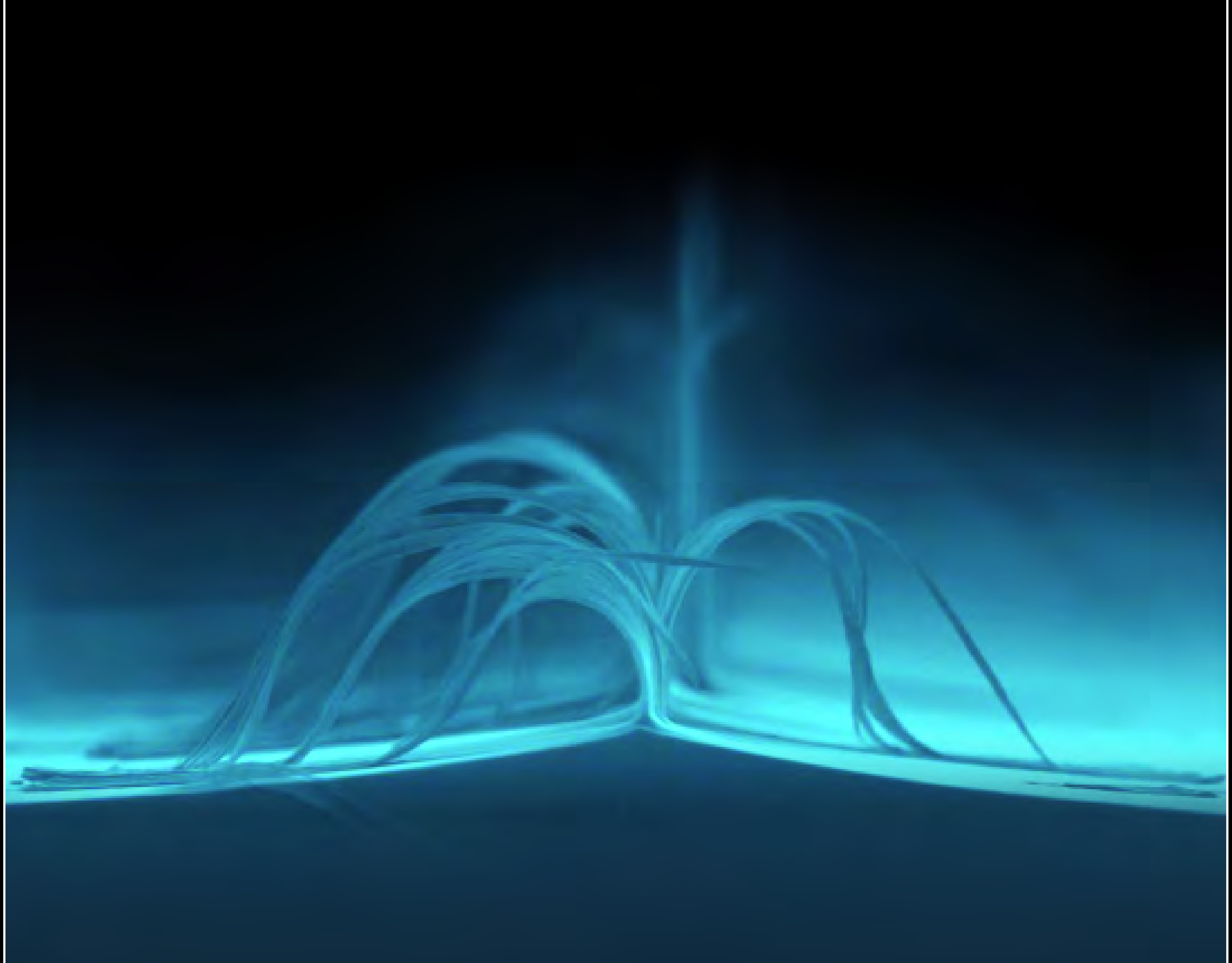
AMAZING IMAGES



Optical Nanosource

What could pass for a shredded piece of paper or string cheese is actually a 100-nanometer-wide vertical wall that has lost its rigidity. Made of a Gallium Arsenide (GaAs) semiconductor, these "threads" show what happens when a nanowall–an extremely thin wire approximately 100 nm wide and 3 μm (microns) high–attains the physical limits of dimension reduction, explains Maïté Volatier, a PhD student at CRN2[1] in Sherbrooke, Quebec. Compared to "classic" semiconductors, which are mainly used in microelectronics, GaAs-based semiconductors have the ability to confine and conduct light. Such nanostructures are then used to design and produce ultra-compact optical sources in the near- and mid-infrared ranges. This picture won the 2nd prize in a photography contest organized during the LIA-LN2[2] symposium last July. This international laboratory, created by CNRS in 2008, brings together teams from France and Quebec. It aims to encourage collective research projects in the fields of nanotechnologies and nanosystems.

Marie-Hélène Towhill

1. Centre de Recherche en Nanofabrication et Nanocaractérisation (Université de Sherbrooke, Quebec).
2. Laboratoire international associé en nanotechnologies et nanosystèmes (www.labn2.ca).

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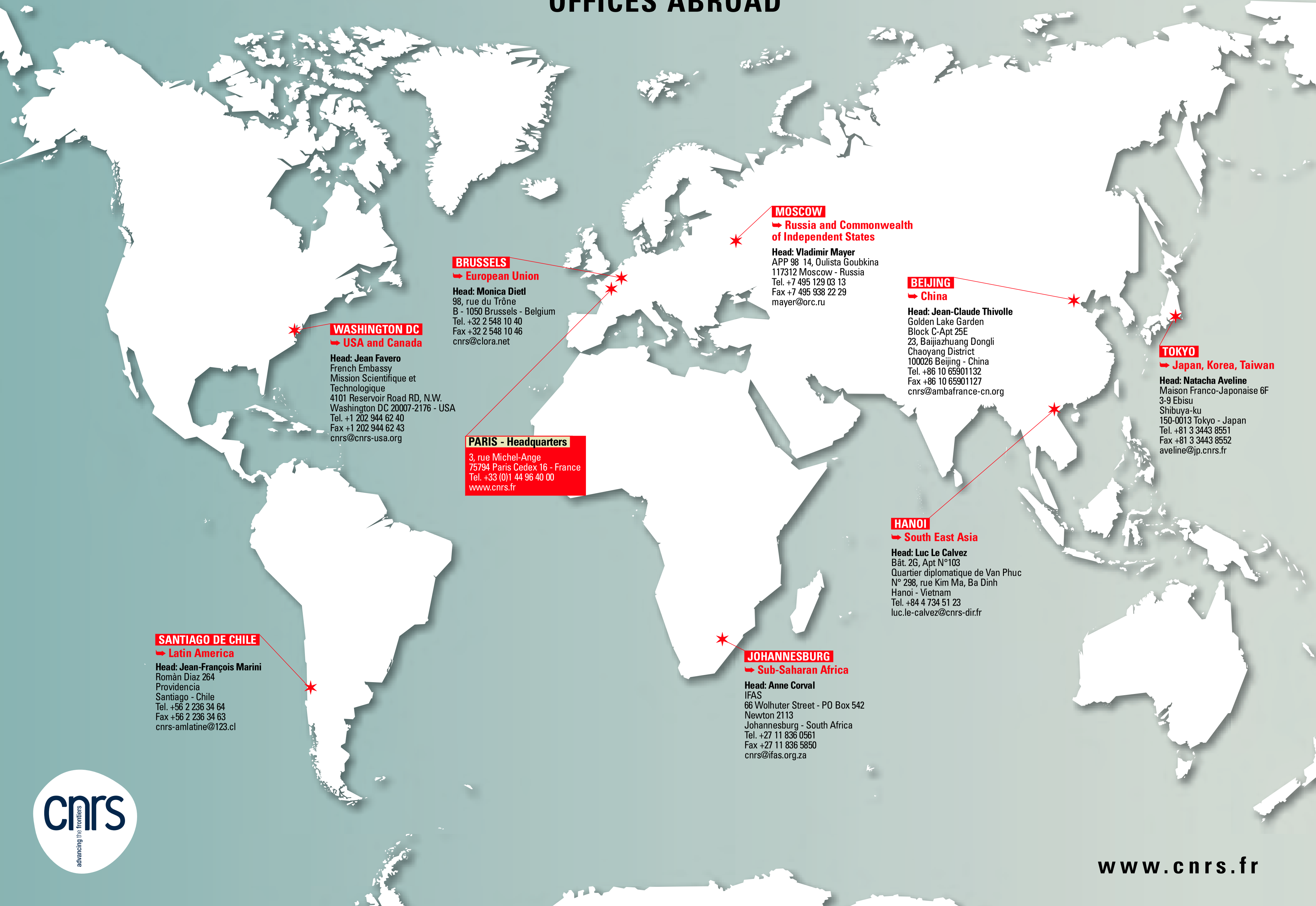
FRENCH NATIONAL CENTER FOR SCIENTIFIC RESEARCH

OFFICES ABROAD



www.cnrs.fr