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International conference on one-dimensional nanomaterials

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Fabrication, Nanoelectronics, Photonics, Spintronics, Sensors, Hybrid structures, Energy storage and conversion. Transverse subjects such as modelling and advanced characterization techniques will also be addressed.
Editorial

BY MARK ASCH, MATHEMATICS & HPC SCIENTIFIC OFFICER AT THE FRENCH MINISTRY OF HIGHER EDUCATION AND RESEARCH

Big Data is a new scientific discipline with enormous societal challenges (including genomics, health, global warming, smart cities) that acts as a driving force for research. In this sense, data can be considered to be a shared infrastructure facilitating research at national, European, and international levels. The European Commission has recently funded four pilot projects within the framework of the European Strategy Forum on Research Infrastructures (ESFRI) to form “data clusters” in the life sciences, environmental sciences, and particle physics. The Research Data Alliance is an attempt to federate these efforts around digital information at the international level. The aim is to set up working groups and a plenary that will advise on certification, standards, and best practice.

CNRS plays an active role in the “Big Data revolution.” In May 2012, it launched Mastodons, a dedicated interdisciplinary grand challenge planned to run for five years, which will fund crosscutting research projects that tackle the emerging field of large data masses, its methods and applications.

With its far-reaching multidisciplinary expertise, CNRS is uniquely positioned to take up the challenge. As such, we expect to become a world leader in this exciting albeit complex domain.
Earth Sciences Summit

On November 29, 2012, government representatives from 13 European countries met at CNRS headquarters to endorse the concept of the future European Plate Observing System (EPOS), an infrastructure dedicated to the Earth sciences. The objective is to give researchers easy access to data from numerous observation systems (seismological networks, volcano observatories, etc.), digital simulations, and experimental analytical systems across Europe. To do so, EPOS seeks to integrate data from facilities that are both geographically and thematically distant into a single European-wide resource. The French contribution, overseen by CNRS's INSU, involves numerous infrastructures, notably Resif, the French seismological and geodesic network. The EPOS preparation phase should be completed by 2014.

FURTHER INFORMATION
- www.mudam.lu
- www.michelpaysant.fr

Root Growth

The emergence of lateral roots in the plant Arabidopsis thaliana is regulated by aquaporins, the membrane channel proteins that facilitate water movements within cell membranes. This result, obtained by an international team associating French researchers from CNRS and Inra, to labs from Germany, Spain, and the UK, may help optimize root growth.

FURTHER INFORMATION
- Institut national de la recherche agronomique
Serge Haroche, Nobel Prize in Physics 2012

On December 10, 2012, in Stockholm, Serge Haroche received the Nobel Prize in Physics, jointly with the American physicist David Wineland, for their work in quantum physics.

Haroche, 68, a researcher at the Laboratoire Kastler-Brossel (LKB) and a professor at the Collège de France, specializes in atomic physics and quantum optics. He is one of the pioneers of cavity quantum electrodynamics, which consists in studying the interactions between a single atom and a few photons contained in a “box,” or cavity. “The Nobel laureates have paved the way for a new era of experimentation in quantum physics by demonstrating the direct observation of individual quantum particles without destroying them,” said the Nobel Committee. “Through their ingenious laboratory methods, Haroche and Wineland—together with their research groups—have managed to measure and control very fragile quantum states considered inaccessible for direct observation.”

In fact, it was maths that Haroche first studied, before specializing in physics at the École Normale Supérieure (ENS) in Paris, which he joined in 1963. After leaving the ENS, he began his career at CNRS, where his research played a significant role in reconciling the microscopic quantum world with the macroscopic classical world. During the 1970s and 1980s, he developed new laser spectroscopy methods based on the study of quantum beats and superradiance. He then became interested in Rydberg atoms, giant atomic systems whose sensitivity to microwaves makes them particularly well suited to fundamental research into matter-radiation interaction.

In 2009, when Haroche was awarded the CNRS Gold Medal, France’s most prestigious scientific distinction, he modestly explained that “despite the complexity of the set-up, the underlying physical theory is actually very simple,” albeit difficult to express without using equations. “You need a basic grasp of maths,” he admitted.

Haroche’s own words best illustrate the common thread running through his career: “I have always endeavored to carry out experiments involving atoms and photons in ‘exotic’ situations not usually found in nature. I have tried to make use of these situations to decipher fundamental phenomena, and to develop new tools to investigate matter and radiation.”

Haroche’s work, enabled by ongoing technological advances, has made it possible to experimentally verify certain postulates of the physics of the infinitely small by drawing inspiration from the thought experiments devised by Albert Einstein and Niels Bohr.

For CNRS President Alain Fuchs, this Nobel Prize rewards “pioneering work carried out over the long term, combining fundamental understanding with experimental skills.”
On January 22, 1963, German Chancellor Konrad Adenauer and French President Charles de Gaulle signed the Elysée Treaty, the official document codifying post-war Franco-German reconciliation. How did it come about?

Corine Defrance: The Elysée Treaty was a bilateral treaty of rapprochement between France and Germany, setting objectives for increased cooperation between the two countries. The term “reconciliation” is not used in the text itself, but is mentioned in the joint declaration issued by Adenauer and De Gaulle. After nearly a century of rivalry and three wars, the resentment between France and Germany was stronger than ever in 1945, and each country saw the other as a “hereditary enemy.” To ensure lasting peace in Europe, this image needed to be dispelled once and for all. But first, groundwork needed to be done in both countries to prepare public opinion. It was only after the state visits of 1962—by Adenauer to Rheims in July and De Gaulle to Germany in September—that a project of French-German cooperation was proposed. De Gaulle’s tour of Germany was a triumph, and his speeches in German—the “language of the enemy” that he had learned as an officer—made a strong impression. Memoranda were exchanged in the autumn of 1962. Just three days before signing the final document, Adenauer suggested to De Gaulle that they make it a full-fledged diplomatic treaty, a much more binding agreement that would have to be ratified by the parliaments of both countries.

Does this mean that there had been little to no Franco-German cooperation before 1963?

C.D.: The notion that everything started with the Elysée Treaty is part of the “De Gaulle myth.” But a number of initiatives had begun immediately after the war, including by the French military government in Germany. In 1950, the Schuman Plan was a historic step towards closer political and economic ties between France and the new Federal Republic of Germany (FRG), and the blueprint for a European community. In civil society as well, actions to admonish lasting resentment were taken by various mediators, including many former French Resistance fighters who had kept contact with the German
democracy activists they had met as co-prisoners in concentration camps. Through associations like the French Committee for Exchanges with the New Germany and BILD (International Liaison and Documentation Bureau), they published reviews and organized conferences to present their respective countries. Town twinning also predated the Elysée Treaty, starting in 1950 with Montbéliard and the German city of Ludwigsburg, where De Gaulle delivered his famous address to Germany’s youth on September 9, 1962.

The Treaty was signed only a few months later. Which specific areas of cooperation did it cover?

C.D.: The treaty itself was a short document. The first section established the principle of regular consultation in the form of bi-annual Franco-German summit meetings. Initially, these involved heads of state and a few ministers, but they would later include all levels of the two governments. Cooperation was limited to three areas: foreign policy, defense/security, and education and youth. At first, the youth programs were the only ones that produced visible results. The Franco-German Youth Office (OFAJ), founded at the first summit meeting in July 1963, brought more than a million young people together in just five years. As of today, 8 million youths from all social backgrounds have benefited from these programs.

What about other cooperative efforts?

C.D.: The first decade proved a difficult one, but the era of Valéry Giscard d’Estaing and Helmut Schmidt, immediately followed by the François Mitterrand-Helmut Kohl period, ushered in a phase of close relations. This led to the substantial development of cooperation in the areas of education and culture, which were not included in the original treaty. The idea of a Franco-German television network, Arte, was proposed in 1986, and its first broadcast was in 1992. Cooperation in higher education and research took off in 1988, with the development of integrated Franco-German degree programs, which now involve 180 establishments and more than 5000 students on both sides of the border. Joint research organizations like the Marc Bloch Center in Berlin were also established. As for secondary education, the so-called “Abi-bac” classes were created in the early 1990s, to help students prepare for the final high-school exam baccalauréat/Abitur in both countries. Finally, European classes, in which subjects like history and geography are taught in the partner’s language, were created.

There seems to have been much less progress in areas like defense or international relations...

C.D.: Things got off to a slow start due to basic differences in how the countries operated. During the Cold War, the FRG had very close ties with the US and NATO, while France was more independent. Yet there was cooperation in certain areas, like armament or joint military exercise, and some highly symbolic initiatives were undertaken, such as the creation of the Franco-German Brigade in 1989, bringing together nearly 5000 troops. A turning point came in 2003, when the two countries expressed their opposition to the invasion of Iraq. As a result, France and Germany decided to hold special celebrations for the 40th anniversary of the Elysée Treaty. The French and German parliaments thus met for an extraordinary session in Versailles. The partners decided to establish the Elysée Fund, which finances Franco-German cultural projects in other countries. Starting in the 1970s, the two nations laid the foundations for the European Monetary System, initiated by Giscard d’Estaing and Schmidt, and later the euro, which was promoted by Mitterrand and Kohl. In fact, it seems that Mitterrand made the common currency a condition for German reunification.

How can the Franco-German relationship be defined today? And what is the future of this cooperation within the “Europe of 27”?

C.D.: There is now a real paradox. On the one hand, Franco-German relations are at risk of being taken for granted. The younger French generations who grew up with this close cooperation see no reason to strengthen ties with Germany rather than with Greece or Italy, for example. On the other hand, the Franco-German powerhouse has never been more vital to Europe’s well-being. In these highly unstable economic times, I can’t think of any other countries that could play this role.

01. Named after French Foreign Minister Robert Schuman
02. UMI/FRE (joint unit of French research institutes abroad) involving CNRS and the French Ministry of Foreign and European Affairs
03. Identités, relations internationales et civilisations de l’Europe (CNRS / Universités Paris-I and –IV)
Writing with your Eyes

BY EDDY DELCHER

Eye writing systems that let users select letters and symbols on a screen have existed for years, but EOL, short for “Eye OnLine,” goes much further. The system, developed by Jean Lorenceau and his team at the CRICM, allows subjects to draw with their eyes as if using a pen on paper. The main challenge in creating such a device lies in the eye’s inability to generate smooth trajectories in front of a static background, resulting instead in saccadic movements. This is where the optical illusion, known as reverse-phi, comes into play.

Reverse-phi is achieved when an image and its negative are shown in rapid succession, creating the optical illusion of movement. Lorenceau found this technique could be used to create a seemingly smooth eye movements possible. In his system, several hundred disks flickering at a frequency of 10 to 15 Hz are displayed on a screen. Any eye movement produced while looking at it triggers the illusion and tricks users into believing the screen is moving with their eyes. An oculometer tracks pupil movements, which software recreates on a computer screen. Three to five 30-minute training sessions are needed to control eye movements and write letters. “It takes some effort as one must first see and select the illusion as a support for the eyes before attempting to draw letters. The concentration required can also be tiring, and difficult actions, such as crossing the letter ‘t’, may not be correctly processed by the computer at this early stage,” explains Lorenceau. But with enough training, users can develop automatisms to ease the process and reach handwriting speeds.

The system will soon be tested by amyotrophic lateral sclerosis patients. It could help people affected by limb paralysis express themselves in a more independent manner through personalized writing and signatures. It could also help dyslexic children become more aware of their eye movements when reading, in turn providing a better understanding of how dyslexia works to fight it more effectively.

“We are still at an early stage of development, as several technical issues have to be resolved before an eye-controlled tablet is produced, but it is theoretically possible. In the future, surgeons could use eye control as a third hand, for example, or tennis players could use it to better track a ball,” concludes Lorenceau.

1. Centre de recherche de l’institut du cerveau et de la moelle épinière (CNRS / UPMC / Inserm)

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Environment
Citizen Science

BY FUI LEE LUK

In 2010, ordinary citizens teamed up with naturalists from the CERSP1 and the OPIE2 to launch the Photographic Survey of Flower Visitors (SPIPOLL). This citizen science project is France’s first country-wide observatory on pollinators, insects that help fertilize plants. Crucial to biodiversity and crop production, pollinators need to be monitored as urbanization and intensive farming threaten their habitats. SPIPOLL’s first findings, recently analyzed by CERSP-OPIE researchers, suggest ways to boost insect populations.
Chemistry

Taming Nitrenes

BY MARK REYNOLDS

Nitrenes are the giant squids and snow leopards of chemistry—so elusive that they are almost mythical in statute. They exist only briefly as transitional molecules during certain chemical reactions, and have solely been observed at extremely low temperatures. “Stabilizing highly-reactive nitrenes at room temperature is like taming wild animals,” explains Joint Research Chemistry Laboratory director Guy Bertrand, whose team was responsible for a recent breakthrough. “Nitrene has been postulated to be involved in thousands of reactions as a key intermediate that usually reacts further. You cannot stop reactions at the nitrene step,” he adds.

Because nitrenes are important to so many chemical processes—like the production of ammonia, 45,000 tons of which are manufactured each year—they are of obvious interest to chemists.

To stabilize nitrenes, Bertrand and his team bonded them with a phosphorous fragment, which computer modeling had predicted would serve as an appropriate electron “donor.” This formed a strong bond and reduced the intermediate’s instability. The resulting phosphonitrene retains some of the reactivity of nitrenes, but remains stable in the solid and liquid states at room temperatures.

The new compound might serve as a nitrogen reagent, able to transfer nitrogen atoms to organic substances, thus allowing the creation of a new family of chemicals. The precedents are promising. Bertrand’s stabilization of carbenes two decades ago led to a thousand-fold increase in carbene-related papers and patents published each year.

While the applications of nitrene stabilization are impossible to predict, the satisfaction of having achieved it for the first time is easy for Bertrand to describe. “It feels like being the first man to walk on the moon: it’s extremely exciting.”

Project Surveys Pollinators

Showcasing the power of citizen science, SPIPOLL volunteers—numbering 897 to date—contribute photos of insects sighted on flowering plants. The long-term goal is to track the way these populations evolve over time. However, the data has already pinpointed how pollinators are spread across France, via an index on their affinity with three land-use types: urban, agricultural, and natural.

Insects of the Hymenoptera order (including ants and bees) prove to be the only pollinators active on all three land types. The other orders observed—Coleoptera (beetles), Diptera (flies and mosquitoes), and Lepidoptera (moths and butterflies)—are more suited to agricultural and natural zones. SPIPOLL also shows that the rarer the insects, the more they favor natural areas over urban ones.

The study further contradicts the idea that “agricultural regions are poor in insect diversity,” notes Nicolas Deguines, from the CERSP. Indeed, such areas, which cover more than 40% of the European continent, hold strong insect-hosting potential and should be a focus for pollinator-friendly practices, according to the researchers. Strategies include growing flower strips around fields to provide nectar and pollen for pollinators or organic farming with fewer pesticides and herbicides to nurture flower bloom.

This would not only benefit pollinators, but also the crop they visit—a win-win solution.

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Astronomy

New Cosmic Rays Identified

BY TOM RIDGWAY

A century ago, physicist Victor Franz Hess discovered that high-speed particles—atomic nuclei or electrons—were reaching the Earth from the Milky Way. These “cosmic rays,” as they were later called, are believed to be supercharged with kinetic energy by the shockwaves of supernovae explosions, which allows them to pass through solar winds and penetrate the inner Solar System. Cosmic rays with lower energy levels—less than half a billion electron-volts—have proved harder to find and study as they never reach our System. Now, Vincent Tatischeff and his colleagues from the CSNSM have discovered the first hadronic low-energy cosmic rays (LECRs) of galactic origin, enabling researchers to start looking into their chemical composition, flux, and effects on the interstellar medium.

To find a source of LECRs, Tatischeff and his team needed to build a theoretical model of what LECR-created X-ray emissions in the interstellar medium would look like, and compare it with the data gathered by XMM-Newton since its launch in 1999. They thus identified a source of LECRs in the vicinity of the Arches cluster of young stars, about 100 light years from the center of the Milky Way. “The particles there are accelerated in the bow shock created by the cluster’s own motion, thus generating a characteristic X-ray emission by irradiating the ambient gas cloud, which we were able to identify using our model,” says Tatischeff. The discovery of these LECRs is particularly important since it proves that particles can be charged with kinetic energy not only by supernovae explosions but also by the simple movement of stars.

“New observations at radio and infrared wavelengths could enable us to study this colossal flux of LECRs and its physicochemical effects on the dense gas in the interstellar medium,” says Tatischeff. “This should prove interesting in light of these LECRs’ possible influence on star formation.”

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TEETH FOSSILS KEY TO DIETARY EVOLUTION

BY FUI LEE LUK

Eating habits say a lot about people. They can even reveal biological and social traits of our extinct ancestors, as geochemists from the LGL and biologists from the AMIS lab have shown. By studying teeth fossils from South Africa’s Cradle of Humankind site, the team has reconstructed the diets of hominins, unlocking details on the early humans. Vincent Balter of the LGL likens “teeth to trees that produce rings as they grow, telling a person’s history.”

Using an innovative laser ablation technique exposing growth prisms on dental enamel, the team traced the lifelong habitat and dietary changes of individuals. Remarkably, the technique also keeps the teeth relatively intact: the tiny holes made by the beams are invisible to the eye.

Three hominin genera were examined: *Australopithecus africanus* (2 to 3 million years old), *Paranthropus robustus* (1.2 to 2.5 million years old), and early *Homo* (*Homo sapiens’* precursor dating back 2.3 to 2.4 million years ago). Using strontium isotope analysis, the team tracked a specimen’s habitat by matching levels of water and plant strontium absorbed in enamel, to those found in surrounding bedrock. The scientists deduced that the hominins shared the same home range area, close to the caves where their bones were excavated. To detect their dietary content, the team measured the enamel’s barium and strontium concentrations, known to decrease as a mammal goes up the food chain and starts eating meat.

So what did our forbears chew on? *Australopithecus* had the most varied diet, scrounging anything from animal remains to plant matter. The later two groups derived from this common
Researchers have devised a new method for designing more reliable electronic tongues that can even “visualize” tastes.

Electronic Tongues that Can See Taste

BY EDDY DELCHER

Electronic tongues are devices capable of recognizing dissolved substances. They have many applications, from assessing foods’ freshness to detecting harmful substances in wastewaters. The receptors of conventional electronic tongues consist of complex molecules known to bind with particular chemical compounds. The large number of complex molecules required to create an array of receptors usually makes developing electronic tongues time-consuming and arduous.

A team of researchers bridging several laboratories has managed to speed up the process by using lactose and sulfated lactose—two small and easily accessible molecules—as building blocks to design receptors. Taking inspiration from the heparan sulfates’ ability to bind with proteins, the team mixed negatively-charged sulfated lactose and neutral lactose molecules to create droplets of varying concentration ratios, each displaying different binding properties. The droplets were then deposited on a gold-layered optical prism, where they formed an array of receptors. Bindings between receptors and chemical compounds were measured via Surface Plasmon Resonance imaging (SPRi), an optical detection technique never used before in this field. Each time a compound binds with a receptor, electron oscillations (plasmons) change. This in turn alters the way light is reflected on the prism’s surface, each alteration being measured optically.

“Using this real-time monitoring technique, a 3D landscape can be drawn for each analyte. In other words, our system allows us to see tastes,” explains Yanxia Hou-Broutin, from the SPrAM laboratory, who has been leading the project for the past four years. “Unlike previous systems, our method allows all receptors to be linked,” she adds. “This enables us to identify defective receptors and eliminate any abnormal signal. It can be compared to our brain’s ability to reconstruct an image from a screen, even when defective pixels are present.”

The new tongues are also cheaper to develop, and can be re-used and/or kept for months. “We are now exploring the analysis of complex mixtures such as beer, wine, and milk. While still under development, our system can already differentiate between the three, and determine whether a milk sample is spoiled just by looking at its 3D landscape,” concludes the researcher.

01. Laboratoire Structures et propriétés d’architectures moléculaires (CNRS / CEA / Université Joseph Fourier Grenoble) ; Institut de chimie moléculaire et des matériaux d’Orsay (CNRS / Université Paris Sud) ; Institut de biologie structurale (CNRS / CEA / Université Joseph Fourier Grenoble)
Nanotechnology  A nano-machine cluster producing coordinated contraction and extension movements brings us closer to mimicking human muscle.

CNRS Team Flexes Muscles

BY FUI LEE LUK

Reproducing muscle movements is a challenging issue for scientists, with major applications at stake. For the first time, chemists from the ICS1 have synthesized an assembly of nano-machines capable of muscle fiber-like motion,2 a breakthrough validated experimentally by physicists from the MSC.3

Living organisms consist of molecular machines where groups of molecules like proteins control key biological tasks including muscle contraction. It is the joint action of these tiny molecules that extends their scope. This is the case of protein nano-machines in muscle tissue: individual myosin proteins can only move a few nanometers along actin filaments, but grouped by the thousands in a sarcomere (the basic muscle unit), their concerted movement can cover one micrometer, allowing muscle contraction on a normal scale. Inspired by nature, chemists have artificially synthesized nanomachines since the 1960s, but have never been able to coordinate sets of nano-machines in time and space.

The puzzle has now been solved. The ICS’s biomimetic feat began with a 13-step synthesis to produce a target nanomachine: “a basic molecule coded to contract and expand,” explains team leader Nicolas Giuseppone. The next objective was to create “a big enough assembly to trace movement.” About 3000 molecules were joined together to form polymers (compounds made up of repeated units) linked by supramolecular bonds, strong but dynamic. This technical trick allows better incorporation of the machines within the long and complex polymer chains. Simultaneous response from the nano-machines was triggered by changing the pH of the environment, causing the entire chain to contract or extend. While each nanomachine can only move one nanometer or so, the movement of the whole chain is amplified by 10,000, covering about 10 micrometers. This echoes the model of the myosin/actin-driven sarcomere in muscle fiber. The finding was verified by measurements taken via light and neutron scattering experiments run by Eric Buhler’s team at the MSC. This polymer chain breakthrough represents an important first step towards a range of long-term applications. These

Astronomy

Exoplanet Closest to Earth

BY EDDY DELCHER

A team of European astronomers has just detected a planet with a mass similar to that of Earth, orbiting Alpha Centauri B.1

Not only is Alpha Centauri B—the “b” designating the first planet found in orbit—the lightest planet found to date around a Sun-like star, it is also the closest to our Solar System. Alpha Centauri B is 4.3 light years away, a relatively short distance considering that our galaxy stretches over some 100,000 light years.

Yet the new planet orbits too close to its parent star for water, if present, to be liquid, and therefore does not qualify as an Earth twin—i.e., a planet similar to Earth in size and mass, and orbiting in a star’s habitable zone. “It is an important discovery nonetheless, as 80% of light planets are part of multi-planetary systems. So there is a good probability we will find Earth twin candidates in that area,” explains François Bouchy from the IAP,2 who participated in the study. The team found Alpha Centauri Bb by detecting tiny changes in its parent star’s radial velocity, caused by the orbiting planet’s gravitational pull. These changes, of less than 2 km/h, were picked up using the HARPS3 instrument on the 3.6 meter telescope at the ESO’s La Silla Observatory in Chile. While HARPS offers the highest accuracy available for radial velocity measurements, it does have its limitations. “We can only observe very bright stars such as Alpha Centauri, and still lack the precision required to find Earth twins,” explains Bouchy. The arrival of the high-precision spectrographs ESPRESSO4 and SPIRou5 in late 2016, should make it possible to discover Earth twins within the next 10 years.
include medical devices such as artificial muscles, but also information storage and processing tools in molecule-based computers. They also cover microbots and new substances with novel properties, such as “sponge-like materials that can contract,” adds Giuseppone. The team’s next objective is to “bundle several fibers together to further amplify their movement” and “integrate other movements such as rotations.”

01. Institut Charles Sadron (CNRS / Université de Strasbourg)
03. Matière et systèmes complexes (CNRS / Université Paris-VII)

When Scarring Cells Overdo It

BY CLÉMENTINE WALLACE

→ Scarring tissue of skeletal muscle after an injury. The ADAM12+ cells (green with blue nucleus) produce excess collagen (red).

→ CNRS researchers have identified cells involved in scarring that may play a significant role in fibrosis, a pathological healing process which can be lethal when it affects internal organs.1

When an organ is injured, the healing process involves several factors. Among these, collagen-producing myofibroblasts make up the scar, which is usually eliminated once the tissue regenerates.

Yet in certain chronic diseases, the scarring process persists, leading to fibrosis, with collagen-producing myofibroblasts accumulating to the point of impairing organ function.

The origin and regulation of myofibroblasts are still unclear. “We knew that a transmembrane protein called ADAM12—which is expressed physiologically during embryogenesis—is often overexpressed in pathologies with a fibrotic component, such as muscle and liver disease or scleroderma. However the role of ADAM12 cells was not known,” explains Lucie Peduto,2 principal investigator of the study.

To find out more about their function, the team developed transgenic mice that produced a fluorescent protein when ADAM12 was expressed. Upon injury in the muscle and the skin, the researchers observed that expression of ADAM12 was rapidly induced in a subset of peri-vascular cells, albeit transiently. These cells also expressed high levels of pro-inflammatory cytokines and growth factors.

By labeling ADAM12 cells genetically, the scientists tracked the cells as they moved and multiplied over the entire process of tissue repair. The cells specifically gave rise to collagen-overproducing myofibroblasts during the scarring process. Furthermore, specific elimination of ADAM12 cells was sufficient to decrease collagen accumulation.

“In acute injury, the development of ADAM12 cells is only transient. But in certain chronic fibrotic diseases, they are generated continuously, which might play a role in excess collagen deposition,” says Peduto, who hopes this might help design novel therapeutic approaches to fibrosis.

02. Unité de développement des tissus lymphoïdes (CNRS / Institut Pasteur)
Biology Two recently-published results, one exploiting the HIV machinery, the other involving a new cytoskeleton inhibitor, could lead to better cancer treatments.

Fighting Cancer on All Fronts

BY CLÉMENTINE WALLACE

Using the human immunodeficiency virus (HIV) to cure cancer patients would provide a sense of victory over one of humanity’s greatest villains. And this is exactly what a team of CNRS researchers have in mind. “HIV is capable of producing a number of molecules that don’t exist naturally, much like a mutant factory,” explains team leader Matteo Negroni, from the IBMC. “So we tried to use this to our advantage.”

The IBMC team knew that researchers had long been trying to develop a more potent version of a human enzyme called deoxycytidine kinase (dCK), key to the effectiveness of anticancer drugs once they enter the organism. “If dCK can be improved to better phosphorylate anti-cancer drugs, their effectiveness could be enhanced,” he explains.

In their experiments, the researchers inserted a copy of the dCK gene into the HIV genome, and let it replicate in a culture of human cells. The team then collected the produced mutants, and tested them along with anticancer drugs in a culture of human tumor cells. By doing so, they eventually identified a variant capable of boosting the efficiency of anti-cancer drugs 60-fold, as compared to the wild-type dCK.

The second study concerns an alternative anti-cancer treatment for cells resistant to conventional chemotherapy. The LIM kinase (LIMK) enzyme, which is overexpressed in cancer cells, had already been identified as a potential new therapeutic target. LIMK plays a central role in regulating the dynamics of the cytoskeleton microtubules and actin filaments and the cell’s overall motility. However, very few selective LIMK inhibitors have been explored to date.

Now, a collaboration of researchers from France, Australia, and the UK say they have discovered the long-sought agent. They used an automated high-throughput screening tool to analyze more than 30,000 molecules, selecting those capable of acting on microtubules, a phenomenon that can be visualized by using specific markers.

Going a step further, they investigated whether their selection contained an agent capable of specifically inhibiting LIMK. “With the help of luck, it did,” as principal investigator Laurence Lafanechère puts it. The team called this agent Pyr-1. In vitro analysis then revealed that Pyr-1 was toxic to several cancerous epithelial cell lines, including ones that are resistant to current therapies.

“By blocking LIMK, Pyr-1 targets an enzyme involved in several physiological pathways: it blocks cell multiplication and motility. Pyr-1 is not only a new anti-tumor agent, it’s also potentially anti-metastatic,” says Lafanechère, outlining that 90% of cancer deaths are generally caused by metastases.

01. Institut de biologie moléculaire et cellulaire (CNRS) (Team Architecture et réactivité de l’ARN)
04. Institut Albert Bonniot (CNRS / Inserm / Université Joseph Fourier) (Team 3 Polarity, Development and Cancer)
Physics

Bio-Inspired Computing Memory

BY BRETT KRAABEL

How long does it take your brain to recognize a face? Not long. Yet for computers, this is an extremely challenging task. Now, researcher Manuel Bubes and his colleagues at CNRS, Thales, and the University of Cambridge have mimicked nature by building electronic components called memristors that are inspired by the brain’s computational circuitry.

In our brain, neurons act as computing units, each of which is connected to a thousand other neurons by synapses. But synapses also serve as memory, which contrasts starkly with the design of computers, where memory is a separate entity from the computing unit. A much more glaring difference is that neurons communicate through voltage pulses rather than direct current (DC) voltages. The result is that the brain is far more powerful and energy-efficient than any man-made computer.

Memristors mimic synapses in that they act as wires whose electrical resistance depends on the previous voltage pulses sent through them, giving them memory. The first memristor, produced in 2008, was based on the diffusion of ions through a thin film, a phenomenon poorly understood and difficult to control. To overcome this difficulty, Bubes and his collaborators have built memristors based on ultrathin ferroelectric films sandwiched between metal electrodes.

Ferroelectric films provide an answer because they retain an electric polarization after being exposed to an electric field (i.e., a voltage). “This lets them store information, much like ferromagnets in magnetic hard disks,” explains Bubes. When placed between metal electrodes, the polarization of the ferroelectric film determines the electrical resistance of the memristor. In this way, the resistance of the device depends on its voltage history, permitting memory storage.

In contrast to conventional memory circuits, which store only two bits, the resistance of ferroelectric memristors can be finely tuned, allowing them to contain much more information. This is possible because the film becomes polarized in nm-sized chunks, called domains. By varying the voltage applied across the film, the density of polarized domains can be precisely controlled, allowing the resistance to be tuned between a minimum value and a maximum value 300 times greater.

Another advantage of ferroelectrics is that they have been studied for decades, so the mechanisms of domain formation and interaction are well understood. The team now plans to use this knowledge to build a “neural network” with 10 electronic neurons and 100 memristor synapses.

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02. Treatment of a model cancer cell line (Hela) with LIMK inhibitor Pyr-1 increases stable microtubules content (green) without affecting dynamic microtubules (red).

03. Stabile microtubules

04. Using a non-invasive and mobile Raman spectroscopy technique on four ancient lamps, researchers have revealed the secrets of Mamluk Sultanate enamellings (Egypt and Syria: 1250-1517).

05. The Tuquztimur lamp, one of the Mamluk objects analyzed by Raman spectroscopy.

06. Blue light proved as effective as coffee to keep drivers alert during long journeys at night. Although the positive effect of blue light on nighttime alertness was known since 2005 for simple tasks, it had never been tested on highly-complex tasks like driving. The study, conducted by teams from France and Sweden, could lead to the development of electronic anti-sleep systems built into vehicles.
Biodiversity  In August 2012, a pluridisciplinary research team initiated an exhaustive inventory of the species inhabiting Madagascar’s Namoroka National Park.

Treasure Trove in Madagascar

Created in 1927, the Tsingy de Namoroka, a 223-km² national park in northwest Madagascar, is one of the world’s earliest nature reserves. With its striking karst landscapes, the area is an exceptional hotspot of biodiversity harboring a multitude of species, some still unknown.

That is until a few months ago, when an international team of scientists, led by botanist Thomas Haevermans of the OSEB laboratory, headed to the island with an ambitious objective: to undertake the first complete inventory of plants and wildlife in Tsingy.

Because the area’s dirt and bumpy roads make the reserve difficult to access during the rainy season, the region has hardly been explored and is therefore very well preserved. The latest scientific expedition dates back to the early 20th century.

In August last year, taking advantage of the dry season, a convoy of seven four-wheel drive vehicles and one truck set off from Mahajanga. Aboard, more than 20 scientists, specialists in plant biology, entomology, paleoentomology, and herpetology brought research equipment, but also food and water rations for a 3-week expedition.

After crossing two bays and continuing on dirt roads for two days—sometimes not exceeding 5 km/h—the researchers finally reached Namoroka and its spectacular limestone formations. A camp was set up in an open-roof cave, with electricity generators, computers, and a temporary lab.

The hunt for new species started each day before sunrise, with the help of experienced local guides. Plants and animals, including reptiles and insects found in the field, were systematically geolocalized with GPS technology to precisely map their distribution across the area, before being collected, photographed, and preserved. “Once collected, plants were dried overnight, then tightly pressed together in bundles, and finally kept in plastic bags,” explains botanist Lucile Allorge. Various plant species, such as ferns, euphorbs, and orchids were sampled over more than 400 harvests.

Entomologists not only worked in the daytime but also at night, setting up traps around the camp to lure insects. They managed to gather around 4100 specimens of Hemipterans, hundreds of different types of moth and beetle species, and a host of eco-ethological data like insect host-plants, biotope descriptions, and insect sound recordings. “For the first time, we were able to record the planthopper Typhlobrixia namorokensis, a cave-adapted insect never collected since its discovery in 1952,” explains OSEB entomologist Thierry Bourgoin.

Several new genera and species have already been identified and analyses are still underway, but one expedition is not enough. “An exhaustive inventory would require an entire year on site,” explains Haevermans. “We now have a better idea of the kind of specimens we can find in this highly endemic area.” The results of the mission will also help the government of Madagascar establish future conservation strategies.
Diabetes

Novel Bioelectronic Sensor

BY JEAN-PHILIPPE BRALY

Every day, and several times a day, millions of people have to prick their fingers to check their blood glucose level, and self-inject a dose of insulin because they suffer from type 1 diabetes. This illness is caused by the destruction of pancreatic β cells which normally secrete insulin and control blood glucose levels.

Implantable glucose sensors connected to insulin pumps have been on the market for several years, but they have limitations, particularly in terms of sensitivity and reaction times. Therefore, researchers from the Bordeaux-based laboratories CBMN¹ and IMS² are working on a new bioelectronic sensor that could overcome these drawbacks by fixing β cells onto an electronic chip. “Fashioned by evolution, these cells constitute the most sophisticated tool for determining insulin requirements,” explain CBMN researchers Jochen Lang and Bogdan Catargi. “They actually adjust their electrical activity according not only to the level of glucose, but also to a variety of nutrients and hormones.” This electrical activity, which is directly correlated with the insulin needs of the body, is measured using microelectrodes on the chip. The bioelectric sensor is able to calculate in real time the quantity of insulin required and when it should be delivered.

The researchers have recently succeeded in culturing β cells on an electronic chip capable of measuring these electrical variations in real time over several weeks, something that had never been done before. The team has filed an international patent to protect its invention. “First of all, we hope to be able to use this technology to test the effect of candidate drugs on β cells,” explains Sylvie Renaud, of IMS. A first prototype is scheduled for 2014.

PicoSeq

New Sequencing Method Pinned Down

BY GREGORY FLECHET

Researchers have designed a new DNA sequencing method that could be both cheaper and more precise than those in use. It is being developed commercially by the start-up PicoSeq, launched in June 2012. The technology overcomes some of the main drawbacks linked with existing techniques. “Current methods involve multiplying in large numbers the DNA sequence to be analyzed. Yet this procedure often induces bias,” explains Vincent Croquette, biophysicist at the LPS.¹ The strategy developed by the scientist and his team involves carrying out sequencing from single DNA molecules. This recently published innovative approach² is based on the “mechanical” opening of the double strand of DNA to be decoded. To do this, it is necessary to give the DNA a hairpin structure, using a complementary DNA fragment and a ligase enzyme. Placed in solution, this “DNA hairpin” is then attached to a magnetic bead by one of the two branches of the hairpin, while the other is securely fastened to a glass plate. Using magnets to pull on the beads, the double-stranded molecule can then be opened up like a zip. Small fragments of synthetic nucleic acids—oligonucleotides of random sequence such as CTG, AGG, GAG—are added to the solution and thus hybridize through complementarity with the single-stranded DNA. A CTG sequence always pairs with GAC, AGG with TCC, and so on. “When the force exerted on the DNA hairpin is released, the molecule closes, but pauses each time it encounters one of these small fragments,” explains the researcher. The analysis of the temporary blockages generated by each of these oligonucleotide fragments provides a faithful imprint of the sequence of the initial DNA molecule, based on the laws of DNA complementarity. This method also has a key advantage over available sequencing techniques: unlike these, it enables scientists to map certain types of repeated sequences involved in serious genetic pathologies such as Huntington’s disease. This advantage could allow PicoSeq to find a niche in the highly competitive market of genetic sequencing.

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Portrait  The anthropologist Philippe Descola was awarded the 2012 CNRS Gold Medal, France’s most prestigious scientific distinction.

Philippe Descola
Human Natures

BY STEPHANIE ARC

Philippe Descola, 2012 CNRS Gold Medal recipient and director of the LAS, had braced himself for the whirlwind of media attention that inevitably accompanies any distinction of this caliber. As he welcomes us into his office, his calm and professional demeanor is unshaken.

Now in his sixties, with a trim white beard and sparkling blue eyes, this specialist in the native tribes of the Amazon surveys a collection of photographs retracing his career: “In this one, taken at the Collège de France, you can see Claude Lévi-Strauss, in my opinion the preeminent thinker in the social sciences of the 20th century. Here’s another one with Maurice Godelier, the man who made me realize that I could make anthropology my profession.”

Seventeen years after winning the CNRS Silver Medal, Descola is surprised to have joined his two illustrious mentors, who were awarded the CNRS Gold Medal in 1967 and 2001 respectively. “I didn’t expect to see anthropology honored like this yet again. On the other hand, it’s a discipline that studies human beings from every angle—cultural, moral, mental and physical—and addresses our society’s uncertainties about the future of humanity.”

AN INNOVATIVE VISION

“I knew at a rather young age that I wanted to become an anthropologist, but I didn’t really know how to make it happen,” Descola recalls. While studying philosophy at the École Normale Supérieure of Fontenay-Saint-Cloud in the late 1960s, Descola developed a keen interest in Rousseau, and in Maurice Godelier’s classes on economic anthropology. A brilliant student, he decided to pursue a double major, earning a degree in ethnology (1972) as well as a teaching certificate in philosophy (1974). He then submitted a thesis project on the Amazon region to... Claude Lévi-Strauss.

“Unlike the African societies, which were already well understood, the Amazon Basin populations attracted me for their mystery,” Descola explains. “It was impossible to comprehend what constituted society for these Amerindians, living in small scattered groups, with no leader, no apparent history, and always at war.”

With funding from CNRS, he and his wife Anne-Christine Taylor, herself an anthropologist, went to do fieldwork among the Achuar people of Ecuador between 1976 and 1978. “Understanding these peoples’ relationship with ‘nature’ was what mattered most to me,” the researcher adds.

AMONG THE ACHUAR

Descola undertook a systematic study of the techniques and representations through which the Achuar make themselves part of their environment. His conclusions contradicted the prevailing viewpoints of the time, especially in the US, which held that these cultures were solely determined by environmental factors, such as the quantity and distribution of game animals.

“Afther observing the Achuas’ hunting practices, I had to conclude the opposite,” he explains. “They consider animals to be non-blood relatives and, conversely, see cultivated plants as blood relatives to be pampered. The Achuar believe that plants and animals are imbued with a soul, and converse with them in dreams or through incantations. Far from the traditional Western standpoint of seeing nature and culture as opposites, the Achuar see them as a continuity.”

Enriched by his travels and on-location experience, the anthropologist returned to France where he was hired as a lecturer at the EHESS® in 1984. “Working in the field transforms you,” he says. “Experiencing such different ways of living and of perceiving the human condition gives you critical perspective. It’s like being suspended between two worlds.”
THE FRONTIERS OF MAN
His ethnographic work led him to adopt a comparatist line of thinking. He began to reflect on the types of relationships that populations cultivate with their environment, first in the Amazon Basin and then in societies everywhere.

Descola identifies four ontologies—anism, totemism, analogism, and naturalism (see box)—four ways of detecting the limits between self and non-self in human societies and discusses the cosmologies that arise from them.

Today, the anthropologist continues his research in parallel with his work at the LAS. He is also hard at work on a new book on images, “which, even before verbalization, evince the ways of conceiving the relations and contrasts between people and the other components of their environment.”

COSMOLOGY
A representation of the organization of the world characteristic of a given culture and based on a specific ontology (anism, totemism, analogism, or naturalism).

PHILIPPE DESCOLA’S FOUR ONTOLOGIES
In his essay Beyond Nature and Culture, Philippe Descola distinguishes four primary systems through which people perceive their relationships to the environment (objects, plants, animals, other people) and make distinctions between “humans” and “non-humans.”

→ In anism, non-humans have the same attributes of interiority (intentionality, subjectivity, reflexivity, affects) as humans (moral continuity), but differ in their physical and corporeal characteristics (physical discontinuity). This system can be found among the Indians of South America and the Arctic regions of North America, as well as the Pygmies and certain populations of Southeast Asia.

→ In totemism, in particular among the Australian Aborigines, humans and non-humans are grouped together in a single totemic class; despite their difference in form, they are considered to possess identical moral and physical qualities (moral and physical continuity) derived from an ancestral prototype.

→ In analogist cultures, all beings are seen as singular, dissociated in every aspect (moral and physical discontinuity). These are the models of the classic Chinese and Indian cultures, the Andes, much of West Africa, and Europe until the Renaissance.

→ In naturalism, by which our Western culture is structured, only man has a soul, an intentionality, and the capacity to express it, even though he shares his physical characteristics with non-humans (moral continuity but physical discontinuity).

01. The University of Chicago Press books, in press, June 2013

FROM THE AUTHOR:
The BIG DATA REVOLUTION

From the Internet to large-scale research facilities, the amount of digital data generated today is growing exponentially. Data producers and users alike need to devise better ways to cope with this deluge of information. How can it be classified, stored, made relevant? CNRS International Magazine examines the bits and bytes that are reshaping our world.

BY FABRICE DEMARTHON, DENIS DELBEÇQ AND GRÉGORY FLÉCHET

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Coping with a Data Deluge 24
Data Storage: a Teething Problem 26

"Every two days, we create as much information as we did from the dawn of civilization up until 2003," said Google CEO Eric Schmidt at a conference in the US in 2010. And this observation illustrates a burning issue for scientists and economists worldwide: how to cope with such unprecedented amounts of data? “We are faced with a real deluge of data,” says Christine Collet, head of the DB team at the LIG and full professor at the Grenoble Institute of Technology. Numbers speak for themselves. Every second, one hour of video is uploaded to YouTube and more than 1.5 million emails are sent across the globe. Scientists are no less productive. In eight years (2000-2008), the Sloan Digital
Sky Survey, a large astronomical observation program, recorded 140 terabytes of images (see table of scales). But its successor, the Large Synoptic Survey Telescope (LSST)—a project involving teams from CNRS’s IN2P3—will collect much information every five days once operational. Each year, the Large Hadron Collider (LHC) gathers almost 15 petabytes of data, the equivalent of more than three million DVDs. Today, mankind generates around one zettabyte of data each year—nearly as many bytes as there are stars in the universe.4

**AN ECONOMIC PRIORITY**

The **Big Data** phenomenon, as it is dubbed by specialists, continues to expand, driven by the success of the digital economy, the widespread adoption of mobile devices, the boom of social networks, the opening of several databases to consumers (“Open Data”), and the development of large-scale international scientific programs. “We are witnessing a full-fledged democratization of data,” adds Collet. “Data is everywhere and it is generated, sold, and consumed like any other manufactured good.” These massive volumes of information have taken on such economic, industrial, and scientific importance that governments and businesses are making massive investments in this field. In March of last year, US President Barack Obama announced a Big Data plan...
BIG DATA IN THE HUMANITIES AND SOCIAL SCIENCES

“Big Data has revolutionized the work of specialists in the humanities and social sciences,” indicates Bertrand Jouve, mathematician and deputy scientific director at the CNRS’s Institute for Humanities and Social Sciences (INSHS). He sees Big Data as a great opportunity for his peers. “Online databases now provide a single entry point for accessing knowledge that was previously scattered across many locations,” he adds. “Internet-based surveys, for example, have not only made the work of sociologists easier, but also given their research more reach.” Despite his enthusiasm, Jouve is also aware of the many difficulties facing users today. “The problem is how to process the raw data,” he explains.

“Big Data has revolutionized the work of specialists in the humanities and social sciences,” indicates Bertrand Jouve, mathematician and deputy scientific director at the CNRS’s Institute for Humanities and Social Sciences (INSHS). He sees Big Data as a great opportunity for his peers. “Online databases now provide a single entry point for accessing knowledge that was previously scattered across many locations,” he adds. “Internet-based surveys, for example, have not only made the work of sociologists easier, but also given their research more reach.” Despite his enthusiasm, Jouve is also aware of the many difficulties facing users today. “The problem is how to process the raw data,” he explains.

When the information is not collected directly by the researcher, it is difficult to know how the data was processed before its inclusion in the database. LiG researcher Sihem Amer-Yahia believes this to be Big Data’s Achilles’ heel. “Raw data processing is often a black box, completely opaque to the user,” she explains, “yet it is a known fact that common manipulations can delete a large part of the information.”

The emergence of very large data volumes and the all-digital world raises other issues, albeit less technical. “Big Data is inevitably a cause for epistemological concern,” notes Sandra Laugier, deputy scientific director at INSHS. “What does it mean to have access to more information than a human mind can fathom? How will such uncontrollable exhaustiveness impact our relation to knowledge?”

There are a number of other concerns, such as data ownership, usage rights, the right to be forgotten, or ethics. Researchers in the humanities and social sciences must address these issues, in collaboration with other disciplines, in order to serve the public interest and avoid the possible stranglehold by private interests.

SCIENTIFIC CHALLENGES AHEAD

“Big Data is a considerable scientific challenge that can only be met by a combination of basic science and engineering,” explains Mark Asch, scientific officer for Mathematics and High Performance Computing at the French Ministry of Higher Education and Research. This prompted CNRS to launch the Mastodons program last summer (see box p. 21). The idea is to support interdisciplinary projects that will identify the problems involved in the management of very large amounts of scientific data. “What is the best way to store and preserve data? How can it be processed, analyzed, viewed, and interpreted? How should it be protected, in particular from abusive use, and how can it be permanently deleted? All issues that need to be addressed, and for which we have few answers,” says

COMPARATIVE SCALE OF BYTES

<table>
<thead>
<tr>
<th>Basic unit of measurement</th>
<th>One page of text</th>
<th>A piece of music</th>
<th>A two-hour film</th>
<th>6 million books</th>
<th>A stack of DVDs as tall as a 55-storey building</th>
<th>All the information generated up to 2003</th>
<th>All the data recorded in 2011</th>
<th>Storage capacity of the NSA datacenter (92,000 m², 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 B</td>
<td>30 KB</td>
<td>5 MB</td>
<td>1 GB</td>
<td>1 TB</td>
<td>1 PB</td>
<td>1 PIB</td>
<td>1 EB</td>
<td>1,8 ZB</td>
</tr>
</tbody>
</table>

**Byte**

1B

**Kilobyte**

KB 1000 Bytes

**Megabyte**

MB 1000 KB

**Gigabyte**

GB 1000 MB

**Terabyte**

TB 1000 GB

**Petabyte**

PB 1000 TB

**Exabyte**

EB 1000 PB

**Zettabyte**

ZB 1000 EB

**Yottabyte**

YB 1000 ZB
Mokrane Bouzeghoub, deputy scientific director of the INS2I, which coordinates Mastodons. “At the heart of these issues are algorithms, methodologies, but also High Performance Computing (HPC) infrastructures.”

UNANSWERED QUESTIONS

Farouk Toumani, LIMOS researcher and head of the Petasky project within Mastodons, shares the same point of view. “A telescope like the LSST, which should go live in 2020, will be able to save a 3 billion-pixel image of the sky every 17 seconds,” he explains. At the end of the program, astronomers will have a 140-petabyte database containing hundreds of characteristics for each object in the sky. At present, even the most efficient data mining algorithms would take dozens of years to explore the database and answer certain questions raised by researchers. LSST program scientists already know that some of their more complex interrogations will remain unanswered. Nevertheless, such a database is an ideal field of application for further fundamental research into Big Data, which is exactly what researchers on the Petasky project are involved in. “In order to overcome the obstacles inherent to the handling of very large volumes of data, we will certainly need to improve storage and processing technologies, as well as come up with new ways to process data,” notes Toumani. Sihem Amer-Yahia, social network specialist at the LIG, agrees. “The Big Data revolution, driven by the explosion of social networks where citizens themselves provide the content, has overturned the traditional data storage and processing structure.”

RADICAL UPEHVAL

Everybody is concerned. From biologists to astrophysicists, from Facebook to the tax office: no one can escape the Big Data phenomenon or the problems it spawns. This is an urgent issue: the amount of digital information generated worldwide doubles every two years, and this pace is accelerating. “Data is at the heart of both the digital economy and the information society,” concludes Collet. “It represents a basic ingredient with high-added value: nothing will happen without it.”
Today, the amount of information exchanged over the Internet represents five million times that contained in all the books ever written. How can this ever-expanding mass of information be analyzed? Marie-Christine Rousset, computer science professor and LIG1 member, is among those in the scientific community attempting to structure the continuous flow of data across the Web. “The pages we look at every day are part of the text-based Web, which contains billions of interconnected documents,” she explains. “These pages cannot be used as a genuine knowledge base since they were designed to be read by humans, not machines.” In other words, when entering a query in a search engine like Google, all it does is provide a list of thousands of documents likely to match it. It is then up to the user to laboriously search for the most relevant response. Given the dizzying rate at which documents are published on the Web, this type of search model may soon prove inefficient to manage such large amounts of data. The alternative is to upgrade the existing Web to a data Web: “This approach is based on adding metadata to the URL addresses that identify Web pages. It aims to simplify the Web by organizing its information, thus granting end-users easier access to knowledge,” explains Rousset.

This development is already underway through W3C, the international

**VISUALIZATION TO IMPROVE UNDERSTANDING**

The profusion of data now available to researchers is not always an advantage: the more information available, the harder it is to interpret. At the Bordeaux Computer Science Research Laboratory (LABRI),1 David Auber and his team are trying to make this deluge of information more legible using analytical visualization methods. “Our approach is to apply mathematical tools like algorithms to sift through this raw data and extract the most pertinent information,” explains the researcher. Using this method, stock prices, communications systems, chemical processes in cell metabolism, and geographical or social networks can be translated into visual metaphors.

Such representations enable researchers to analyze the structure of these masses of information both quickly and efficiently. Although exponential growth in computing power has generated a considerable quantity of data over the past ten years, our brain’s ability to process that information lags far behind. “Our short-term memory prevents us from analyzing more than seven things at once,” Auber stresses. The principle of analytical visualization—via interfaces to help with data analysis—may soon become essential to bridge the gap.

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Coping with a Data Deluge

In recent years, new technologies drastically changed practice in one scientific field: biomedical research. In the US, the Alzheimer’s Disease Neuroimaging Initiative (ADNI) has become one of the largest public image databases dedicated to a single pathology. It compiles Magnetic Resonance Imaging (MRI), nuclear medicine examinations, and spinal taps for cerebrospinal fluid. ADNI already contains more than 5000 MRI images from 2000 patients.

“With the advent of digital technologies, the amount of information from biomedical imaging has considerably increased over the past decade,” says Johan Montagnat, CNRS senior researcher at the 13S’ laboratory in Sophia Antipolis. He is also Mastodons coordinator for the Credible project, designed to federate distributed data and knowledge in biomedical imaging.

The Credible project has an opposite approach to that of ADNI. While ADNI centralizes biomedical information before analyzing it, Credible federates the data scattered across a number of French hospitals. “Sooner or later, the strategy of centralizing huge amounts of medical data will be limited by available storage capacity,” explains Montagnat. “Furthermore, the proliferation of data acquisition devices in hospitals makes it impossible to prevent the scattering of information across various storage sites.” But this federated approach is also prone to technical difficulties.

Two types of data must be federated: raw data (images, treatment results, etc.), and so-called “symbolic” data, which describes this raw information (the context in which it was collected, the anatomical or pathological characteristics extracted from an image, etc.). “One of the Credible project’s main challenges is to develop a semantic representation of this symbolic data to give it scientific meaning,” he continues. Once harmonized, these usually very heterogeneous databases can be used for a single national or even international clinical study. Analysis of biomedical resources on that

HIGH PERFORMANCE COMPUTING

The US is still the undisputed leader with regard to High Performance Computing (HPC). In 2012, the country boasted 252 of the world’s 500 most powerful supercomputers, about half of the total computing power available worldwide—estimated at 120 petaflops (PFlops). With 22 of these 500 supercomputers representing a total of 6.4 PFlops, France ranks 6th in terms of computing power dedicated to HPC. At CNRS, the IN2P3 computing center plays a key role in this field by developing computing grids dedicated to the Large Hadron Collider (LHC) experiments and to biomedical and industrial applications. “More than 2500 researchers and academics are involved in high performance computing at CNRS, making us one of the largest multidisciplinary communities in Europe,” points out Michel Daydé, director of the CNRS HPC Orientation Committee (COCIN). But the number of hours allocated either to national centers or European projects does not always satisfy the community’s growing HPC needs. “In order to meet the demand, we must keep increasing the overall capacity of supercomputing power in the country, and associate it to a suitable organization (urbanization) of computing and data infrastructure.

WELL-DISTRIBUTED DATA

In recent years, new technologies drastically changed practice in one scientific
scale would provide researchers with a new way of addressing today’s healthcare challenges.

COVETED DATA
It is easy to get lost in the depths of Big Data. Its analysis needs to be handled by experts: data mining specialists, who need to bring to the surface the knowledge buried under the mass of digital information. “This difficult algorithmic work is similar to sifting through a draughtboard with billions of rows and columns to identify a handful of repeated patterns,” explains Jean-François Boulicaut, researcher at the LIRIS in Villeurbanne. With his team, he is currently applying this expertise to the analysis of large volumes of urban and environmental data (the Amadouer project). This project explores the databases of the greater Lyon area to collect information on road traffic, energy, and pollution. Once analyzed, this data may be used to devise, for instance, a new transportation policy for the city center. There is however a downside: this type of information is of great interest to the private sector, which would like to use it for commercial purposes, sometimes at the expense of the scientific community. “Twenty years ago, a company wanted to buy the rights to the digital photos held by the association of French museums,” notes Boulicaut. “As the quality of digital pictures could not rival that of film-based photography at the time, the Ministry of Culture almost agreed, before deciding against it.” Today’s politicians will hopefully be as clear-sighted with respect to the Big Data gold rush.

BLOOMING DATACENTERS
Datacenters housing these massively parallel computing and storage systems are cropping up all over the world. “This is particularly true in colder regions since all these machines require continuous watercooling, which becomes expensive,” adds Valduriez. These centers are accessed via a private network or the Internet. The system, known as “cloud computing,” makes it possible to rent storage space or even computing time, either temporarily or permanently (see figure below). This is the model used for Amazon’s “Elastic Compute Cloud,” a service mainly targeting businesses, or

The constant generated flood of data must be stored somewhere. The obvious solution is to multiply the number of storage units like hard disks on computers or memory chips on mobile devices (see box). While this general principle can apply to massive amounts of data, its implementation is not yet well defined. “Think of storage as a construction site,” says Patrick Valduriez, Inria senior researcher at the LIRMM. “Speeding up operations means hiring more workers. But coordinating their activities also becomes more complex.” In other words, piling up storage systems is not enough: the way they work together must also be optimized. This is all the more difficult as, in addition to being plentiful, the data is heterogeneous and dynamic.

Hence the emergence of new ways to store information, notably driven by Internet giants like Google which need to keep track of billions of Web pages. “With huge amounts of data, we have seen the advent of specific massively parallel solutions which involve dividing the task so that many machines address specific parts,” explains Valduriez.
Magnetic hard disks remain the most widespread medium for storing the exponential flow of data. A hard disk drive contains a set of glass or metal discs spinning at high speed (usually 7200 RPM) inside a sealed case. Each disc is covered with a magnetic layer where the data is recorded. Today, commercial hard disks store around 25 gigabytes per square centimeter, a figure that may double by 2016. Besides, hard disks offer much better performance than either optical discs (CDs and DVDs) or “holographic optical” discs which are struggling to enter the mass market. Meanwhile, hard disk prices have plummeted. When IBM presented its first incarnation in 1956, it cost €8 million to store one gigabyte, compared to a few euros today. As a result, magnetic tape, which is ten times cheaper, is the only technology that can compete on price.

Tapes have a major drawback, however: they are slow and therefore can only serve to store infrequently-used data. Finally, flash memory, the storage technology found in most mobile devices, is becoming increasingly popular. It reads data faster than hard disks, and its price/performance ratio is shrinking fast.

STORAGE SOLUTIONS

for Google Apps and Apple’s iCloud, designed for consumer services such as computers, tablets, or smartphones. This solution is cost-effective for consumers, who only pay for what they need. But it also has a drawback: “These services may be attractive to companies for non-strategic data, but it is difficult to fully trust the system. Amazon has already had a failure so massive that data could not be recovered,” Valduriez points out.

HIGH SECURITY NEEDS

These concerns are slowing the development of cloud computing. “Many companies are reluctant to use it for confidentiality reasons,” explains Véronique Cortier of the LORIA. “Most of the time, servers store data in a legible format, making it accessible to any employee who manages the server.” To solve this problem, data must be encrypted on the client system before it is sent to the cloud. “Research is underway to develop such a solution. But it makes data access more complex and increases calculation time—and cost.”

There is another weakness: clouds provide a central point of entry making them vulnerable to piracy. “Since many sites use a single access control for all their services (email, calendars, documents), a successful attack can cause a lot of damage,” notes Hubert Comon-Lundh, who works on computer protocol security at the LSV in Cachan. To counter this threat, research has focused on detecting attacks before they occur and on creating data silos to compartmentalize information. In Europe, the issue of data security and confidentiality is all the more important since suppliers such as Amazon and Google are American corporations and therefore subject to the Patriot Act. This law, adopted by the US Congress following the September 11 attacks, gives the federal government the right to access data hosted on the server of any American company, wherever the server is located. This extra-territorial right of access is worrisome and seems to be holding back European users. The European Union is on a completely different tack: “The EU recently initiated legislative reform to reinforce protection of data pertaining to its businesses and citizens,” notes Valduriez. This political choice could well help Europe catch up with the Americans in the cloud.

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Preservation  For 50 years, France’s prestigious center for heritage preservation has been hard at work, using cutting-edge technology to protect some of the world’s oldest remaining documents.

Preserving Ancient Documents

BY VAHE TER MINASSIAN

The fifth and sixth floors of the Grande Galerie de l’Évolution building, located in Paris’s Jardin des Plantes, are home to one of the country’s main institutions for heritage preservation: the CRCC, a Mecca for conservation. Here, chemists, physicists, and microbiologists combine their efforts to study how graphic material and other documents deteriorate over time. The Center was founded in 1963 to analyze the mold that had ravaged libraries during the Second World War. A better understanding of the phenomenon would enable scientists to slow it down and, eventually, contain it.

Since its creation, the CRCC has obviously evolved and extended its scope of research. In Paris, most of its premises now house specialists in a variety of fields, such as leather and parchment, photo-
01 The CRCC team specializes in iron gall ink, used in manuscripts for centuries.

02 When it was established in 1963, the laboratory focused its research on the preservation of collections damaged by molds, such as those that have proliferated on this old entomology plate.

03 04 Researchers are looking at a certain type of stain called foxing, which appears on old books.

05 The stains of a single book may contain more than one hundred species of mold, which are identified by molecular biology techniques.

06 Microbiologist Malalanirina Rakotonirainy analyzes library mold samples sent by a curator.

07 Here, scientists are studying the brown lines that form at the wet-dry interface when paper is moistened. The project, called Tidelines, aims to provide alternative treatments for restoration teams, who often use water.

graphs, plastic, natural history specimens, as well as issues regarding lighting and art display. In Champs-sur-Marne, east of Paris, the CRCC’s recently-affiliated partner laboratory, the LRMH, deals mainly with stone, stained glass, concrete, and decorated caves.

“The CRCC’s diversification has by no means been detrimental to its work on graphic documents,” stresses the center’s director Bertrand Lavédrine. Indeed, microbiologist Malalanirina Rakotonirainy is happy to show off the laboratory’s carefully refrigerated fungus collection. With its 120 strains of molds and yeasts that regularly plague libraries, the collection is key to the consulting services provided by the researcher and her team to curators, who send samples for analysis. It is also used for advanced molecular biology research on stains such as the reddish-brown foxing that often affects old books.

On the floor below, scientists are working on so-called “tide lines.” Researcher Anne-Laurence Dupont and her colleagues are involved in an extensive international program to study the brown lines that appear at the wet-dry interface when paper comes into contact with water. They are also investi-
gating a new solvent-based process, which uses compounds called aminoalkyl alkoxysilanes, to strengthen papers significantly weakened by time-induced acidification. As an example, Dupont slides one such document out of a drawer—an old newspaper in a plastic sleeve, which would crumble if handled directly.

Newspapers are not the only treasures hidden in the conservation center’s cupboards. Researcher Véronique Rouchon has just finished examining one of the oldest pieces of paper in the world, a 2000-year-old sample discovered by ArScAn researchers Jean-Paul Desroches, Guilhem André, and their team during a French archeological mission in Mongolia in 2006. It has been carefully preserved in a polystyrene box ever since. Rouchon and her colleagues also study iron gall ink. “In Western Europe, from the Middle Ages to the 19th century, most writing was made with this type of ink. Containing ferrous sulfate, gum arabic, and oak galls, it poses a recurrent problem for librarians,” the scientist explains. “Over time, it diffuses through the paper, browns the back and damages the cellulose, creating splits and holes.” Once researchers had established that the iron(II) sulfate contained in the ink was the main culprit for this chemical degradation, they artificially reproduced the effect in order to determine the most effective treatment for severely damaged documents. This important study, which lasted approximately 10 years and was partly conducted at the SOLEIL synchrotron facility, south of Paris, enabled scientists to propose novel treatments that simply require contact with an interleaved sheet impregnated with active products, rather than complete immersion in a solution. This result perfectly reflects the CRCC’s mission of preserving the past through innovation.

08 CRCC specialists need to evaluate restoration processes for paper damaged by old inks. To do so, they take samples from old documents to study their behavior.

09 Other research focuses on the preservation of old manuscripts. New paper is impregnated with ink and subjected to different environments to analyze its behavior. Using this methodology, researchers were able to develop a new technique to stabilize badly damaged paper.

10 Some old documents made from unpurified wood pulp fall victim to acidification and are difficult to handle. The CRCC is developing treatments to simultaneously strengthen and de-acidify the paper, whose mechanical properties are then tested by scientists, as shown here.

01 Centre de recherche sur la conservation des collections (CNRS/MNHN/MCC)
02 Laboratoire de recherche des monuments historiques (MCC)
03 Laboratoire Archéologies et sciences de l’antiquité (CNRS/Université Paris-Ouest-Nanterre-La Défense / Université Paris-IX-Panthéon-Sorbonne / MCC)

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Environment  Following the recent French ban on shale gas extraction by hydraulic fracturing, CEREGE1 researcher Bruno Goffé assesses progress on alternatives.

Shale Gas Extraction: Alternatives Needed

By Charline Zeitoun

Based on current knowledge, there is no certainty that extraction of shale gas and oil by hydraulic fracturing poses no significant threat to health and the environment,” said an official statement by France’s President François Hollande in September. Since this technique, now banned by French authorities, is the only known extraction method, recent applications for permits in France have all been rejected.

Fracturing Rock

“Shale gas is trapped in low porosity rocks located at depths of 2000 to 3000 meters, and it doesn’t rise to the surface on its own, unlike commonly exploited natural gas,” explains geologist Bruno Goffé. To extract it, the most obvious solution is to fracture the rock in order to let it seep through. This is done by drilling into the source rock and setting off small explosions to pierce the wall of the tube inserted into the wellbore. Hundreds of cubic meters of water mixed with sand and gelling agents are then injected into the wellbore at high pressure to create and propagate cracks in the rock, and ensure that they remain open. “By decompression, the gas is then brought to the surface, together with the injected water and that contained in the rock,” Goffé explains.

Causes for Concern

“In Switzerland, France, and the UK, this technique has been known to trigger earthquakes, albeit of little magnitude (2-3 on the Richter scale). And these risks can be controlled,” Goffé points out. The issue of ground water contamination by shale gas, chemicals mixed with water, or subsequently-added solvents, has also been raised. “This has in fact happened, but it isn’t due to the extraction process in itself,” he adds. “It stems from bad practice, especially in countries where public standards are not as rigorous as in France, leading to poorly-sealed wellbores or the improper use of hazardous products that are sometimes directly discharged into watercourses.”

Alternative Techniques

“First of all, the chemicals used for hydraulic fracturing can be replaced by environmentally-friendly products, such as gelling agents used in food processing,” Goffé explains. “Using microporous minerals called zeolites as a model, it should be possible to design novel blends which, once pumped in, crystallize as a porous material that lets the gas through, while keeping pollutants in.” But there’s more. Other techniques could potentially be used that have not yet been tested. One of these is the thermal method, which consists in heating the rock so as to force the water up to the surface and bring the gas with it. “Lastly, it is essential to improve our knowledge of the underground by carrying out basic research. This is where public research comes in. It would enable us to identify and anticipate problems, adapt our legislation, and undertake monitoring and observation in the long run,” says Goffé. These studies would also make it possible to get a clearer picture of France’s underground resources, whether renewable or not.

1. Centre européen de recherche et d’enseignement de géosciences et de l’environnement (CNRS/ Aix-Marseille Université /IRD /Collège de France).

Bruno Goffé

A specialist in geological resources, he is a scientific representative at CNRS’s National Institute for Earth Sciences and Astronomy (INSU), and a senior researcher at the European Center for Research and Teaching in Environmental Geosciences (CEREGE).

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Each year, some 200,000 students from China, India, and Malaysia—not to mention Canada and the US—enroll in Australian and New Zealand universities. In the past few years, Australia has become the world’s third-largest host country for foreign students, after the US and the UK, outranking France, now in fourth place. What draws so many young scholars to these countries?

Australia’s key to success is its remarkably dense education network, with some 40 universities across the country, 19 of which were ranked among the world’s best in 2012. These establishments, mostly public, are based on the British model and interconnected through well-organized scholastic networks, such as the Group of Eight, a coalition of universities that includes the University of Melbourne and the Australian National University in Canberra.

There are, of course, close links between education and research, and Australia also champions the latter through a forward-looking policy that has placed the country in the world’s top 15 for R&D spending, number of researchers, scientific production, and patent filing. While the continent-nation is aware of its assets—80% endemic flora, Great Barrier Reef, proximity to the South Pole—it also has its weaknesses—vulnerability to natural disasters, environmental imbalances, and geographic isolation—and hopes to benefit from innovative research to meet its many challenges. Its national research agency, the CSIRO (Commonwealth Scientific and Industrial Research Organization), includes 12 research divisions and 5 innovation precincts. It has undertaken 11 Flagship programs which are priority thematic areas for the country, including adaptation to climate change, energy transformation, the food supply of the future, and preventive health.

As a result, Australia and the 27 members of the European Union are on par with regard to several disciplines, such as the Earth sciences, plant and animal sciences, and physics. The country is at the forefront in fields like clinical medicine, ecology, mathematics, and space sciences. For example, Australia will host, together with South Africa, the antennas and receptors of the Square Kilometer Array (SKA), which will be the largest and most sensitive radio telescope of its kind ever built.

A GREEN NEIGHBOR
Two thousand kilometers to the south-east, New Zealand enjoys a scientific reputation founded on “Green Growth,” sustainable development, and biosafety, stemming from a long tradition of environmental protection. The country’s research network comprises eight universities—five of which are included in the 2012 Shanghai rankings—competing for...
top-level native and foreign students. It also includes the Crown Research Institutes, eight centers of excellence of world repute. The island nation has developed internationally-recognized expertise in fields like climate change, Antarctica research, ice and rock drilling, and paleoclimatology.

Drawing strength from their differences, Australia and New Zealand are both closely involved in the EU-funded Framework Programmes (FP). For example, four research platform projects have been developed with the two countries as part of the bilateral science and technology cooperation (BILAT) agreements initiated to promote partnerships between the EU and various countries. CNRS is involved in most of these collaborations, and also in health, the environment, and astronomy.

Through the EU Seventh Framework Programme (FP7), France has become a close partner with both countries, playing an active role in 80 of the 120 projects with Australia and 20 of the 30 programs set up in partnership with New Zealand. CNRS is participating in 25 European projects involving Australia, especially in the information and communication sciences and technologies (ICST), but also in health, the environment, and astronomy. It is also part of a network of excellence with the University of Auckland in New Zealand.

Moreover, the two countries have initiated bilateral support programs called Hubert Curien Partnerships with France to facilitate researcher mobility. Between 2009 and 2012, some 40 projects associating France and Australia or New Zealand involved CNRS, mainly in ICST.

These collaborations have made France the sixth most important scientific partner of Australia and New Zealand in terms of international co-publications, of which 50% involve CNRS laboratories.

**CNRS COMMITTED TO THE REGION**

Emblematic of the close cooperation between CNRS and Australia, a specific agreement was signed in 2011 for the establishment of a center of excellence in the Earth sciences at the Macquarie University in New South Wales. It brings together teams from CNRS and Australian universities, as well as from Canada, the US, Germany, and China.

Seven CNRS structuring initiatives are also underway with the two countries, including the “Biodiversity of Coral Reef” International Research Network and the recently-founded International Associated Laboratory “TransOceanik” (see box). Five fruitful cooperation projects are currently active, four with Australia, (three in biomedicine and one in cryptography), and one with New Zealand (in plant biodiversity). Other operations will follow in 2013, confirming CNRS’s commitment and capacity to forge international scientific partnerships, whatever the distance.

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01. Interactive research, mapping, and creative agency in the Pacific, the Indian Ocean, and the Atlantic.
02. Laboratoire d’anthropologie sociale (CNRS / EHESS/ Collège de France).
03. TransOceanik research at the 2012 Festival for Pacific Arts, which brings together 33 countries every 4 years.

**TRANSOCEANIK: ASSESSING THE IMPACT OF COLONIALISM**

The first French Australian International Associated Laboratory (LIA) in the humanities and social sciences was set up in January 2012. TransOceanik’s aim is to compare the social, cultural, and political creative responses of different ethnic and regional groups from the tropical belt to the various types of discrimination they face as a result of colonialism. The LIA brings together 13 French anthropologists from the LAS, an interdisciplinary team from James Cook University (JCU), as well as 20 PhD students and postdocs. It is co-directed by LAS professorial researcher Barbara Glowczewski and professor Ton Otto from the Cairns Institute (JCU).
Materials Science  The first International Joint Unit (UMI) between CNRS and MIT studies multi-scale porous materials from an energetic and environmental standpoint.

Global Issues  Joint Response

BY ARBY GHARIBIAN

Many of the pressing challenges facing governments today transcend national borders and require new and deeper forms of international collaboration. Hence the decision by CNRS and MIT to form an International Joint Unit (UMI MIT-CNRS), a laboratory that brings together researchers from both institutions on MIT’s campus at Cambridge (US). Last June, MIT President Susan Hockfield and CNRS President Alain Fuchs inaugurated the UMI “Multi-Scale Materials for Energy and Environment” (MSE), and indicated that it would mark the beginning of a broader partnership between the two organizations in the areas of education, training, and research.

“MSE expands on the important work undertaken by MIT teams at the Concrete Sustainability Hub and the X-Shale Hub research centers,” explains Roland Pellenq, senior research scientist at CNRS and at MIT, and co-director of the UMI with MIT professor Franz-Josef Ulm. The laboratory will study structurally-complex porous substances such as cement, shale gas, and nuclear fuels using the so-called “bottom-up” method. This involves holistic analysis over length (from nanometers to microns) and time (from nanoseconds to hours) scales to acquire essential knowledge of materials’ behavioral properties, which vary depending on life span and molecular level.

“The recent disasters in Japan and the Gulf of Mexico have emphasized the need for novel technology in civil engineering,” adds Pellenq. “By using fundamental physics to investigate molecular structure, we can produce materials and energy sources that are more durable, more stable and, ultimately, more sustainable.”

For example, the production of concrete, the ubiquitous building material, contributes approximately 5 to 10% of the world’s CO₂ emissions. Scientists and private sector R&D departments have long tried to formulate better versions with little success, primarily because the main component, calcium silicate hydrate (CSH), resisted traditional forms of investigation. Combining neutron and X-Ray scattering, electron microscopy, and nano-indentation with computational physics, MIT researchers working in collaboration with Pellenq were able to model CSH nanoscale texture and modify it to make longer-lasting concrete with a lighter ecological footprint.

Another exciting application is in the production of shale gas, a cleaner-burning alternative to coal or petroleum. MSE’s multi-scale approach looks at shale formations all the way down to the level of the nanopores where the methane is stored, to understand why the gas is sometimes retained rather than released. This knowledge can help render extraction techniques like hydraulic fracturing less intrusive and more efficient.

In the wake of the Fukushima disaster, nuclear fuels will also be re-assessed taking into account tighter safety regulations. One concern is that the uranium bars used in reactors tend to form pockets of rare gases. Predicting the multi-scale fracture mechanisms of nuclear fuel with such gas inclusions can make reactors safer.

“We are encouraged by the promising leads and applications of our joint research,” concludes Pellenq. “We look forward to partnering with industry both in France and the US to quickly bring these innovations to global markets.”

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**INDIA**

- A new French-Indian International Joint Unit (UMI) in mathematics was set up in cooperation with the Indian Ministry of Science and Technology. The Indo-French Center for Applied Mathematics (IFCAM), which will be based at the Indian Institute of Science in Bangalore, will provide a joint platform for applied mathematics projects in numerous fields including computing, statistical physics, and biology. French partners include CNRS, the Ecole Polytechnique, ENS Paris, Inria (National Institute for Research in Computer Science and Control), and the universities of Nice-Sophia-Antipolis and Paul-Sabatier in Toulouse.

**CHINA**

- The Sino-French program for environment and sustainable development (SEED) held its 5th annual seminar, focused on key environmental issues for marine coastal ecosystems, in Montpellier (France) last October. More than 80 people attended the two-day event, which was jointly organized by CNRS and the Chinese Academy of Sciences (CAS).

  Created in 2008, SEED is a pluridisciplinary program that aims to federate French-Chinese cooperation for the environment and sustainable development.

  The laureates of the 2012 France Talent Innovation program—developed by the French Embassy in China to identify potential partners—took part in the event.

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**ALTO**

**Exotic Nuclei in Action**

**BY VAHÉ TER MINASSIAN**

- In its shielded cave at the heart of the TANDEM accelerator building, at Orsay’s Institute of Nuclear Physics (IPNOrsay),1 the ALTO facility is already up and running. Twenty-four hours a day, operators seated at two consoles control its first production of extraterrestrial nuclei. These elements, also known as exotic nuclei, which are too unstable or radioactive to exist on Earth in the natural state, are found in stars and supernovae.

  Research into exotic nuclei has long been limited by the fact that these isotopes could only be produced in minute quantities. ALTO represents a decisive step towards solving this problem. By using a type of “gun” to bombard streams of electrons onto uranium-238 pellets heated to over 2000°C, the accelerator generates the nuclei in the form of a radioactive ion beam. Enough nuclei are produced to enable specialists, using two sets of measuring instruments, to determine their fundamental properties, including structure, lifetime, and other characteristics.

  This morning, the operators are working on silver-128 nuclei, a “very neutron-rich isotope involved in certain stellar processes,” explains ALTO’s lead scientist David Verney. The accelerator—practically the only one of its kind—paves the way for tomorrow’s physics of exotic nuclei. Funded to the tune of €1 million by a number of French public entities,2 the installation is scheduled for inauguration in March 2013. Not only will it provide physicists with a wealth of eagerly-awaited results, it should also give them valuable expertise in the techniques to be used in next-generation facilities like SPIRAL2, currently under construction at the Ganil Laboratory in Caen.

  Each year, some 50 physicists and astrophysicists will be invited to work at the laboratory headed by Faïcal Azaiez, in an effort to advance our understanding of exotic nuclei—especially of new neutron-rich nuclei, several dozens of which will be studied by ALTO for the very first time.

1. Institut de physique nucléaire d’Orsay (IN2P3-CNRS/Université Paris Sud).
2. The Île-de-France region, the Essonne département, the French Ministry of Research, and CNRS.

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Emerging Science  Focused on the manipulation of fluids at the sub-millimeter scale, this new discipline is finding applications in a variety of fields.

Microfluidics: A Free-Flowing Revolution

BY KHEIRA BETTAYEB

Microfluidics is one of the ten technologies that will change the world, according to the prestigious Massachusetts Institute of Technology (MIT). At the interface of biology, chemistry, physics, and microfabrication, this new science investigates fluids and their manipulation on a very small scale, from one to a few dozen micrometers (10⁻⁶ m). It has already revolutionized a number of fields, from chemistry to biotechnology. And the best is yet to come: most of its potential applications are still in the research phase—including at CNRS, where some 40 teams are working on microfluidics. First developed in the early 1990s, the discipline proved to be of great value in genomics, which required new bioanalytical tools that could perform several thousand analyses simultaneously. But the discipline’s real boom came with the introduction of LOC, for “lab-on-a-chip.” a single chip measuring a few square centimeters integrating an entire analysis chain that normally requires large-scale laboratory equipment.

A RANGE OF APPLICATIONS

European researchers are at the forefront of this emerging science. Indeed, they developed the first devices based on microscopic fluid flow channels. “Not only do these tools make high-throughput analyses possible, they also reduce their duration and require smaller amounts of sample materials and reagents, thus cutting costs,” explains Anne-Marie Gué of CNRS’s LAAS² in Toulouse, and co-director of the Micro-nanosystems and Micro-nanofluidics research network (GDR). LOC systems, some of which are already available on the market, are key to the discipline’s expansion. The objective is to apply this technology to fields like medicine (especially for diagnoses), the food industry (e.g., for the detection of contaminants), or environmental protection (identifying pollutants in water, etc.). Microfluidics has also proved highly effective for the synthesis and structuring of innovative materials, such as nanoparticles. These materials can be used to generate specific optical properties or to create multiple emulsion systems (droplets encapsulated in other droplets) which offer better control of the drop size, for example to delay the release of an active ingredient in a skin-care formula.

MAKING STRIDES

In parallel, microfluidics also advances theoretical knowledge of small-scale fluid flows. Fluids in micrometric—or even smaller—systems behave according to distinct physical principles with a range of previously unknown effects. What are the physical characteristics of microfluids that are in contact with solids? How do they flow on the nanometric scale? How can a drop or bubble be manipulated within a maze of channels? These are some of the intriguing questions that the researchers hope to answer. Recent breakthroughs in the discipline include the discovery that light, under certain conditions, can spread a droplet of water across a Teflon-lined silicon surface,² or that water flows much faster than predicted in carbon nanotubes due to reduced friction inside the tubes.¹ Unexpected properties like these could further expand the applications of this promising new discipline.

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Technology Transfer

The 45 Pillars of Innovation

With more than 4400 patents, 743 joint ownership agreements, several dozen framework agreements with businesses, and 670 spin-offs created since 2001, CNRS is an active player in technology transfers. But its Innovation and Business Relations Department (DIRE) aims much higher. In order to encourage new industrial partnerships, the DIRE recently disclosed a list of 45 Strategic Pillars of Innovation (“Axes stratégiques d’innovation” or ASI), namely existing areas of research at CNRS with a strong economic potential. These range from virtual reality to gene therapy, as well as pollution clean-up, finance, spintronics, imaging, and carbon dioxide capture. The DIRE has identified the leading researchers and their laboratories for each discipline, along with the number of patents, contracts, publications, and particular expertise of each unit.

This project, which was initiated in 2011, identifies the research domains where CNRS is at the forefront, in terms of human resources (internationally-renowned teams), facilities (cutting-edge equipment), and knowledge (patents, publications, know-how, etc.). “ASI are open-ended and they will be frequently updated according to our strategic objectives and activities monitoring,” says DIRE director Pierre Gohar.

These research areas already serve as the basis for scientific cooperation between CNRS and large corporations such as Air Liquide, EADS, or Renault, enlightening all potential partners about the benefits that CNRS expertise could bring to their projects.

ASI offer other advantages for CNRS, starting with enhanced visibility in the ever-changing world of scientific innovation. “We wanted to make our assets more visible, easier to comprehend, and more attractive to R&D stakeholders, especially potential industrial partners,” adds Gohar. “This is essential at a time where rapid development of open innovation pushes businesses to set up partnerships to carry out their research projects.”

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GERMANY

On November 9, 2012, an agreement was signed towards the creation of a new International Associated Laboratory (LIA) that will focus on the study of a signaling pathway involved in the immune response of both the drosophila and the insect Anopheles gambiae, the vector of malaria. The ultimate goal is to breed insects that are resistant to Plasmodium falciparum, the parasite responsible for the disease. Created for 4 years, it will bring together a German team from the Max Planck Society and a French lab from CNRS and Inserm.¹

⁴ Réponse immunitaire et développement chez les insectes (CNRS/Inserm)

RUSSIA

On November 29, 2012, a scientific cooperation agreement was signed in Moscow for the creation of a French-Siberian training and research center. French partners in the project include CNRS, Inserm (French National Institute of Health and Medical Research), Inalco (French National Institute of Oriental Languages and Civilizations), and 18 universities, while Russian partners consist of the Siberian branch of the Academy of Sciences and 14 universities. The agreement is intended to increase scientific collaboration and high-level training in various disciplines including chemistry, the Earth sciences, biology and ecology, to name but a few.

CNRS OFFICE IN THE US

The CNRS office in Washington has a new management team. Xavier Morise, CNRS researcher, was appointed director, and Jean Thèves, research engineer, fills the newly-created position of deputy director in charge of reinforcing CNRS’s actions in the US, Canada, and Mexico.
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.

CNRS Facts and Figures

Founded in 1939 by governmental decree, CNRS is the largest fundamental research organization in Europe.

- CNRS is involved in all scientific fields through ten specialized institutes dedicated to:
  - Life sciences
  - Physics
  - Nuclear and Particle Physics
  - Chemistry
  - Mathematics
  - Information technologies
  - Earth sciences and Astronomy
  - Humanities and Social sciences
  - Environmental sciences and Sustainable development
  - Engineering

CNRS research units are either fully funded and managed by CNRS, or run in partnership with universities, other research organizations, or industry. They are spread across France, and employ a large number of permanent researchers, engineers, technicians, and administrative staff.

The CNRS annual budget represents one-quarter of French public spending on civilian research. This budget is co-funded by the public sector and by CNRS, whose revenue streams include EU research contracts and royalties on patents, licenses, and services provided. **CNRS’s 2013 budget is €3.4 billion.**

CNRS employs some 34,000 staff, including 11,400 researchers and 14,200 engineers and technicians. About 93% of its 1200 research units are joint laboratories with universities and industry.

DERCI, an office dedicated to European and international collaborations.

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

  The European Research and International Cooperation Department (Direction Europe de la recherche et coopération internationale) coordinates and implements CNRS policies in Europe and worldwide, and maintains direct relations with its institutional partners abroad.

  To carry out its mission, the DERCI relies on a network of 11 representative offices abroad, as well as on science and technology offices in French embassies around the world.

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> www.cnrs.fr/derci

**KEY FIGURES**

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Wild vs Mutant

By Isabelle Tratner

→ Are these strange creatures huddling or fighting each other? They actually belong to the plant kingdom, and more precisely to the species Arabidopsis thaliana, a plant model widely used in molecular biology. The photograph (propidium iodine staining and confocal microscopy) shows plant embryos that were dissected out of the seed coat that protects them, to see the effect of the mutation of the major plant cell cycle regulator CDKA. While the absence of the homologous enzyme is lethal in mice, mutant plant embryos can germinate and develop into mature but severely compromised and sterile plants. Remarkably, the mutant embryos (right), although composed of much fewer cells, reach the same size as wild-type ones (left) with a width of approximately 200 µm, highlighting the tremendous developmental plasticity of plants. This image was obtained by Arp Schnittger’s team, who specializes in plant cell cycle at the IBMP laboratory.1

01. Institut de biologie moléculaire des plantes (CNRS).

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