



2010 A year at CNRS

Scientific Report



www.cnrs.fr

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Brochure printed by **Imprimerie Ménard** on paper from sustainable forests.

Legal deposit	July 2011
ISSN	1776-2154



In 2010, I was proud and honored to be appointed president of Europe's top research organization, which has reaped sixteen Nobel prizes and eleven Fields medals since it was founded a little over 70 years ago.

In accordance with the new decree defining the organization of CNRS, which came into force in November 2009, I am also responsible for the general management of the institution. I have appointed two chief executive officers to implement my policies: Joël Bertrand, chief research officer, and Xavier Inglebert, chief resources officer.

When I took up my new position, I discovered a recently reformed organization in good working order, with ten scientific institutes covering the whole range of disciplinary fields. Above all, I was delighted to meet the administrative staff and the teams of highly qualified researchers, engineers and technicians, keen to carry out first class research in every disciplinary field within our laboratories. Their remarkable work, a selection of which is presented in this report, bears witness to this, and is often the result of collaborations with our partners - universities, research organizations, and Grandes Ecoles, as well as businesses and foreign research institutions. Among this wealth of research results, I should like to single out sight recovery in mice suffering from retinitis pigmentosa, the use of carbon-14 dating to establish an absolute chronology of dynastic Egypt, a new, extremely accurate measurement of the size of the proton, the discovery in Gabon of traces of multicellular life dating back 2.1 billion years, and the first proton collisions at record energy levels generated by the LHC, the most powerful particle accelerator on the planet.

Among the many men and women who work hand in hand in CNRS laboratories, helping to maintain top-quality research in France, our mathematicians stand out. Cédric Villani and Ngô Bao Châu were awarded the Fields medal, the highest international distinction in mathematics. A third French mathematician, Yves Meyer, won the 2010 Gauss Prize. I would also like to pay tribute to Alain Aspect, laureate of the Wolf Prize in Physics, Bernard Derrida, recipient of the Boltzmann Medal, Alessandra Carbone, who was awarded the 2010 Irène Joliot-Curie 'Woman Scientist of the Year' award, Julia Kempe, who received the 'Trophée Femme en Or' in the 'research' category. And finally, my very special congratulations go to CNRS 2010 Gold Medal recipient Gérard Férey.

In 2010, the French research and higher education landscape underwent major changes, which included the creation of two new research alliances: ALLENI, the National Research Alliance for the Environment, and ATHENA, the National Alliance for the Humanities and Social Sciences. CNRS is a founding member of both alliances and will have the privilege of chairing ATHENA for two years.

Considerable funding was also set aside by the Government, with nearly €22 billion earmarked for investments for the future. CNRS took this opportunity to contribute to the development of a dozen world-class research and higher education centers that are essential to our country's future. Throughout the year, in every region, CNRS has joined forces with its partners to answer calls for projects aimed at giving French research new impetus. I have no doubt whatsoever that CNRS will meet the research and innovation challenges ahead and that it will play a key role within these high-quality teaching and research universities, while pursuing its national and international coordination mission.

Alain Fuchs
President of CNRS

A handwritten signature in black ink, consisting of a stylized 'A' followed by a series of loops and a long horizontal stroke.

CNRS, key figures...

AN AVERAGE OF **28,500 PUBLICATIONS** EACH YEAR, OF WHICH OVER HALF ARE CO-AUTHORED
WITH AT LEAST ONE LABORATORY ABROAD

4,382 PRIMARY PATENTS,
OF WHICH **495** WERE PUBLISHED IN 2010

864 ACTIVE LICENCES BY LATE 2010

59 COMPANIES SET UP IN 2010

PARTICIPATION IN **676** EUROPEAN PROJECTS WITHIN THE 7TH FRAMEWORK
PROGRAM FOR RESEARCH

39 'STARTING GRANTS' RECIPIENTS
AND **13** 'ADVANCED GRANTS' RECIPIENTS
OF THE EUROPEAN RESEARCH COUNCIL

PARTICIPATION IN **67** COMPETITIVENESS CLUSTERS
THROUGH **300** RESEARCH UNITS

FOUNDING MEMBER OF **12** ADVANCED
THEME-BASED RESEARCH NETWORKS (RTRA)

32,000 MENTIONS OF CNRS
IN THE FRENCH MEDIA IN 2010

> Levitation of a magnet placed above a disk of superconducting cuprate cooled down to -196°C in liquid nitrogen.

1,053 RESEARCH UNITS AND 96 SERVICE UNIT, INCLUDING NEARLY 93 % IN PARTNERSHIP
WITH **HIGHER EDUCATION AND RESEARCH INSTITUTIONS** AS WELL AS NATIONAL AND INTERNATIONAL ORGANIZATIONS

25,630 PERMANENT STAFF
11,450 RESEARCHERS,
14,180 ENGINEERS AND TECHNICIANS
AND 8,400 TEMPORARY EMPLOYEES
ON 31/12/2010

AROUND **6,700 PH.D. STUDENTS,**
POSTDOCTORAL FELLOWS
AND OTHER CONTRACT RESEARCHERS IN 2010,
INCLUDING **45 % FOREIGN RESEARCHERS**

400 RESEARCHERS RECRUITED IN 2010,
INCLUDING 27,5 % FOREIGN RESEARCHERS
AND 500 ENGINEERS AND TECHNICIANS

3,7 BILLION EURO BUDGET,
INCLUDING 762,41 MILLION EUROS FINANCED
BY CNRS-GENERATED INCOME IN 2010

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Fresh impetus for CNRS

Interview with Joël Bertrand, Chief research officer

Appointed Chief research officer by CNRS President Alain Fuchs in February 2010, Joël Bertrand reviews the highlights of CNRS's scientific policy in 2010 and outlines the institution's goals for the coming years.



What are the key scientific events that stood out in 2010?

First of all, I would like to recall the key event that took place in late 2009. The new agreement on objectives between CNRS and the French Government was signed on 19 October 2009. It set out CNRS's scientific priorities for the following four years, and overhauled its organization, in particular by setting up ten Institutes. It

was on that basis that we started work in 2010 to give fresh impetus to CNRS. We took a number of structural steps to help us make progress on the 56 scientific objectives agreed with the Government. These measures included setting up research groups, funding exploratory projects, organizing conferences and new collaborations, and acquiring facilities. This Scientific Report sets out a few examples.

I would also like to pay tribute to our research teams and to our researchers, engineers and technicians. They have obtained remarkable results in the disciplinary fields covered by CNRS. I wish to single out Cédric Villani and Ngô Bao Châu who have been awarded the Fields Medal.

Talking of which, French mathematics was particularly successful in 2010.

Two French mathematicians receiving the

world's highest distinction in mathematics was certainly one of the highlights in this field, but it wasn't the only one. For instance, in June, the Institut Henri-Poincaré and the Clay Mathematics Institute (CMI) jointly organized an international conference to celebrate the resolution by Russian mathematician Grigoriy Perelman of the Poincaré conjecture, one of the seven problems of the Millennium. Along with these achievements, the organization of mathematical research has been overhauled in a major shake-up. For example, CNRS's Institute for Mathematical Sciences (INSMI) has now been entrusted with missions at the national level. Its objectives are to coordinate and promote research in France, develop international collaborations, facilitate mathematics' interaction with other disciplines as well as with business and society, and maintain the excellence of the French mathematical community.

By creating the Institute for Computer Sciences (INS2I) at the end of 2009, CNRS wished to assert its role as a major player in the field. Did this strategy continue in 2010?

Yes indeed. Computer science, one of the key components of the National Research and Innovation Strategy (SNRI), is one of our priorities. Progress in this field has led to a digital revolution whose spectacular developments have profoundly transformed our everyday lives. And the resulting scientific and everyday uses constantly raise new, fundamental questions. As part of its

research, the Institute naturally seeks to collaborate with the universities, Grandes Ecoles and of course, the French National Institute for Research in Computer Science and Control (INRIA). Over 60% of INRIA's teams work jointly with our own units. A framework agreement was also signed in 2010 with INRIA. This agreement highlights the research strategy shared by the two organizations, which are founding members of ALLISTENE, the Digital Sciences and Technologies Alliance.

How much importance does CNRS give to the humanities and social sciences?

They lie at the heart of our scientific policy. As part of the National Research and Innovation Strategy, they represent one of the key pillars of France's scientific development, at the interface between all major fields of research. The year 2010 was particularly fruitful in this sector. It saw the emergence of the fifth French research alliance, the National Alliance for the Humanities and Social Sciences (ATHENA). CNRS, one of its founding members, will be chairing it for two years. The success of our research groups was illustrated by their participation in five award-winning 'Facilities of Excellence' projects in 2010, and by the continuing development of highly effective tools such as the Very Large Facilities ADONIS, CORPUS and the Digital Scientific Library. It is obvious that the humanities and social sciences are playing an increasingly important role in our global research organization, and that they are essential to our strategy of close collaboration with the universities.

While we're on the subject, could you outline the features of this enhanced partnership?

This enhanced partnership, which is part of our scientific policy, is in line with the national approach that seeks to promote the emergence of a dozen major French univer-

sities onto the world stage. In this respect, we have signed a framework agreement with the Conference of University Chancellors, which reaffirmed our joint role as supervisory authorities over Joint Research Units and our will to shape tomorrow's research landscape together. CNRS's national dimension and its strong regional presence are valuable assets, which enable our organization to play a major role in a new policy that aims to create major higher education and research clusters. The groundwork undertaken by designated Scientific Directors and Regional Representatives will enable us to develop scientific policies based on joint research sites. We will also encourage our partners to make full use of our tools in the fields of international relations and technology transfer. Site agreements will therefore gradually replace the bipartite agreements that we formerly had with higher education and research institutions.

'CNRS's national dimension and its strong regional presence are valuable assets, which enable our organization to play a major role in a new policy that aims to create major higher education and research clusters.'

On 20 October a prospective workshop on competitiveness clusters was held. What ties does CNRS have with them?

Our collaboration has been a success. Slightly over 300 CNRS units are involved in 67 of the 71 existing clusters. In all, 1,269 contracts certified by competitiveness clusters have been signed over the past five years with a total value of €217 million. One of CNRS's strengths is that it can gain a foothold in most industrial sectors since it is the only public research organization that covers every field of knowledge. Encouraged by this success, we wish to strengthen our position with regard to competitiveness clusters. This could be achieved through establishing a list of the skills and technologies that our laboratories can provide to in-

dustry, and by encouraging visiting researchers and engineers from industry, while facilitating the secondment or consultancy of their CNRS counterparts. We will also play an increasingly important role by improving technology transfer to businesses. This will be one of the missions of the Office for Innovation and Relations with Business (DIRE) that we set up in 2010.

Finally, this year has also been a busy one for CNRS on the international stage.

It certainly has. In 2010, we created the European Research and International Cooperation Office (DERCI). Its objective is to coordinate all activities carried out by CNRS, with a view to reinforcing the European Research Area and developing international cooperation with the rest of the world. To do this, DERCi relies on its network of offices abroad to structure collaboration with 41 countries and manage researchers' mobility. In 2010, DERCi prepared the opening of three offices in countries of great importance to CNRS: India, Malta and South Africa. As an emerging country, India is a strategic partner. However, due to its history, it tends to lean more naturally towards English-speaking countries.

Our New Delhi office should help us to strengthen our presence there. As for our office in Malta, it will act as a bridgehead to the countries of the Mediterranean. And our new South African office in Pretoria, run jointly with the French Research Institute for Development (IRD), will reinforce the Johannesburg office. CNRS's international activities enhance its influence and, more generally, that of French research. CNRS flies the French flag abroad, and its actions seek to make our country more attractive to students and researchers throughout the world.

Life sciences: goals and initiatives

Research in the 21st century will have to meet major challenges in the field of life sciences.

Gaining better understanding of the complexity and diversity of living organisms, improving living conditions, especially healthcare, implementing sustainable development: these are all issues that CNRS pledged to move forward when it signed the 2009-2013 agreement on objectives with the French Government.

Here are just some of the structural initiatives launched in 2010.

Computer modeling

NEW LAB BRINGS TOGETHER MODELERS AND EXPERIMENTALISTS

Computer modeling of biological systems and of biomolecule functionality, one of the key strands in the agreement on objectives, requires very close collaboration between modelers and experimentalists. This prompted CNRS to set up the Benthic Ecogeochemistry Laboratory (Laboratoire d'Ecogéochimie des Environnements Benthiques (LECOB)) in partnership with UPMC (Université Pierre et Marie Curie). LECOB is a multidisciplinary component of the Oceanography Observatory at the Banyuls marine research station, carrying out research using complementary approaches that combine observation, modeling and experimental work in coastal and deep water environments.

Medical instrumentation

A WORKSHOP TO IDENTIFY TECHNOLOGICAL OBSTACLES

Research networks (groupements de recherche (GDR)) are also in charge of moving forward the scientific initiatives laid down in the agreement on objectives. The workshop organized by the ISIS and STIC-Santé research networks in 2010 was entitled: 'Transmission and storage of medical images and videos: issues and problems caused by applications of current and future medicine', and allowed progress to be made in the 'development of healthcare instrumentation', one of the initiatives included in the agreement. The workshop provided an opportunity to take stock of the theoretical and/or technological obstacles connected to such applications, and the emerging solutions proposed by research.

Chemical ecology

INTERNATIONAL CONFERENCE TAKES STOCK

One of the scientific initiatives agreed consists in identifying and understanding the mechanisms that govern the development of organisms. With this in mind, CNRS held an international conference on chemical ecology from 31 July to 4 August 2010 in Tours. This discipline studies the role of molecules in mediating biotic interactions. The conference provided specialists in chemical ecology from France and abroad with the opportunity to share knowledge about topics such as intraspecific communication mechanisms and the evolutionary aspects of chemical communication.



> Tortoise beetle (*Charidotella egregia*). The beetle turns red when attacked.

Evolution, a history of life

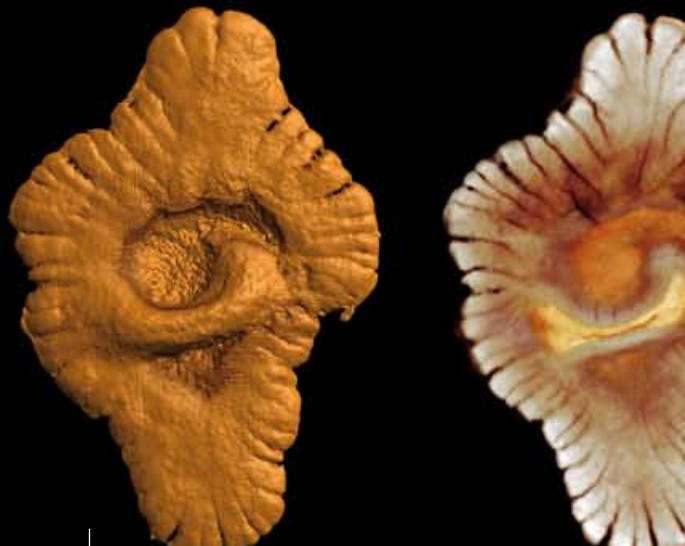
Research into fossils, transitions between geological periods, and the appearance of major groups of animals adds to existing knowledge of evolutionary scenarios and sometimes radically changes them.

Origins of life

MULTICELLULAR LIFE OLDER THAN PREVIOUSLY THOUGHT

What happened between the appearance of the first traces of single-celled life, 3.5 billion years ago, and the sudden proliferation in the number of living species around 600 million years ago? The discovery in Gabon of over 250 fossils aged 2.1 billion years helps to fill in this gap in the history of life. Detailed analysis of the fossils shows that multicellular organisms existed at that time, which is 1.5 billion years earlier than generally believed. Reconstruction of samples in three dimensions using an X-ray microtomograph shows the diversity of these organisms, some of which, paleontologists believe, lived in colonies in a shallow marine environment. This complex life form may have appeared due to a temporary increase in oxygen concentration in the atmosphere a little over 2 billion years ago.

| Published in *Nature*, 1 July 2010



> Virtual reconstruction using microtomography of the external (left) and internal (right) morphology of a 2.1-billion-year-old organized, complex multicellular macrofossil.

Metabolism

MARINE REPTILES WERE WARM-BLOODED

Researchers analyzed the oxygen isotopic composition of the tooth enamel of three groups of marine reptiles from the Mesozoic (251-65 million years ago) and compared it with that of the remains of fish living in the same period. They found that, unlike cold-blooded animals whose isotopic composition reflects the temperature of the ocean, the body temperature of the reptiles was constant whatever the water temperature. The reasons for such endothermic metabolism remain to be determined.

| Published in *Science*, 11 June 2010



Biostratigraphy

EVOLUTION TAKES ITS TIME

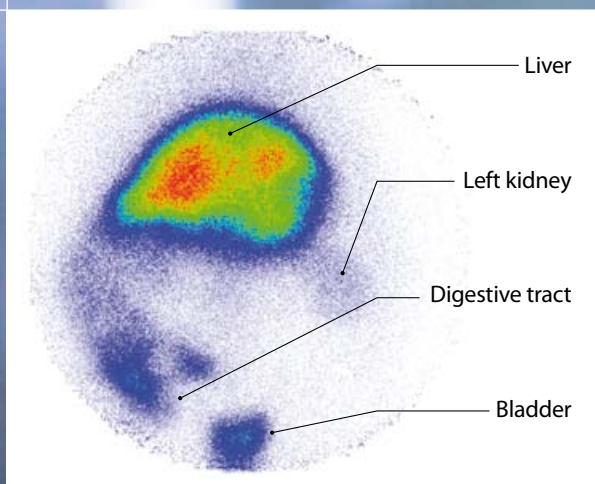
The Cambrian (542-488 million years ago) was characterized by the rapid emergence of all the major animal groups. The geological period that followed it, the Ordovician (488-444 million years ago), was marked by a major diversification of these groups. The discovery in Morocco of a deposit from the Lower Ordovician containing the remains of marine organisms that are typical of the Cambrian upsets evolutionary scenarios and reveals a gentle transition between the two periods.

| Published in *Nature*, 13 May 2010

> *Furca* sp., a marrellomorph. This emblematic group of primitive arthropods is found in exceptionally well-preserved deposits of the Lower and Middle Cambrian.

Understanding and diagnosing diseases

Whether caused by genes or the environment, human diseases are ever better detected thanks to progress in medical research.



> After 60 to 90 minutes, a decrease in the liver binding capacity of LACTAL is observed. The degradation products are partly eliminated by the kidneys and partly via biliary excretion before they end up in the digestive tract.

Scintigraphic imaging

LACTAL FACILITATES MONITORING OF LIVER ACTIVITY

A new radioactive tracer developed by a French team to improve the diagnosis of certain liver diseases has been successfully tested on mice. Once injected, LACTAL accumulated in the mice livers in less than ten minutes and at rates exceeding 90%. This highly specific targeting, which makes it possible to determine the distribution of healthy liver tissue, could be used to improve the detection of liver tumors for surgical removal.

| Published in *Bioconjugate Chemistry*, 4 March 2010

Biotechnology

A BIOCHIP TO DETECT VIRUSES

Researchers have developed a DNA chip that can detect a known virus or bacterium, or one of their emerging variants, from a very wide range of infectious agents. Its advantage is that it is highly discriminating, even in the presence of a mixture of viruses, which makes it possible to do without traditional sequencing techniques. Used during the A(H1N1) flu epidemic of 2009, the biochip revealed the presence of the virus in clinical samples tested in just 24 hours.

| Published in *Nature Biotechnology*, 10 January 2010



Autism

DISCOVERY OF NEW GENES INVOLVED IN AUTISM

Researchers from the international consortium for genetic research on autism, the Autism Genome Project, which includes French scientists, have analyzed the entire genomes of 1,000 people who present symptoms related to autism, together with those of 1,300 control individuals. This enabled them to discover insertions and deletions of gene sequences. These segments, known as 'copy number variants', have made it possible to identify previously unknown genes involved in autism through their action relating to the synapses or to cell proliferation. The researchers also showed that more of these rare copy number variants affected the genes of subjects suffering from autism than those of the control individuals. They also noticed that a large number of these mutations tend to affect genes already associated with autism or intellectual disabilities.

| Published in *Nature*, 10 June 2010



> *Aedes albopictus*, the vector of chikungunya.

Clinical studies

INHERITED DIABETES

Two surveys carried out on around 150,000 Europeans have made it possible to identify new genes that increase the risk of higher blood glucose levels and type 2 diabetes. During the first survey (involving 101,000 individuals), nine genes that regulate fasting blood glucose were discovered, several of which may also cause type 2 diabetes. The second survey (45,000 individuals) describes three genes that increase glycemia after meals, one of which codes for a receptor for an intestinal hormone.

| Published in *Nature Genetics*, 17 January 2010

Chikungunya

VIRUSES PLAY HIDE-AND-SEEK

During the Chikungunya epidemic in Reunion Island in 2005-2006, doctors noticed that the symptoms of this infectious disease persisted long after the acute phase of the infection. Researchers now know why. Study of the disease's development in rhesus monkeys, whose physiology is close to that of humans, showed that the virus took refuge in macrophages, from where it could subsequently infect the rest of the body.

| Published in *The Journal of Clinical Investigation*, 22 February 2010

Therapeutic progress

While certain diseases are on the increase, their treatment is also improving.
New therapeutic prospects, especially for cancer, are emerging.



Nanotechnology DESTROYING A TUMOR BY ILLUMINATING IT

Glioblastoma multiforme is the most aggressive brain tumor. In order to gain access to it and treat it, some researchers rely on photodynamic therapy. They have developed multifunctional nanoparticles that enhance the MRI signal, thus making it possible to guide the insertion of the optical fiber. These nanoparticles are selective with respect to the tumor's vascular network, and deliver the photoactivable molecule that is essential to the therapeutic action of light. In vivo trials have validated this treatment based on MRI-guided light using such multifunctional nanoplateforms.

| Published in *Current Medicinal Chemistry*
in November 2010

Leukemia

THE ORIGIN OF BLOOD STEM CELLS REVEALED

All blood and immune cells in the organism are derived from hematopoietic stem cells (HSC). By using a real-time, high-resolution imaging technique, researchers have for the first time succeeded in observing their formation in the embryo of the zebrafish. The images obtained show that certain cells can detach from the aortic wall and form HSCs, without affecting the integrity of the aorta. This discovery is proof that already specialized cells can reprogram themselves and become stem cells with a host of potential uses. This work, which is still at a fundamental stage, hints at the possibility of personalized treatment to restore healthy immune and blood systems in patients suffering from leukemia.

| Published in *Nature*, 14 February 2010

> This machine uses positron emission imaging coupled with an X-ray scanner to carry out anatomic and functional imaging.



Innovations

GREATER PRECISION FOR TMS

Transcranial magnetic stimulation (TMS) consists in using a magnetic probe to beam magnetic pulses into the brain in order to treat certain neurological disorders. Robotics researchers have designed a robotic system that moves the probe with high precision over the surface of the patient's skull. The device, guided in real time by a neuro-navigation system based on a 3D reconstruction of the cortical sulci, is currently being tested prior to clinical validation.



> The 'Stick and Donut' swimmer is particularly efficient.

Microsurgery

SWIMMING NANOROBOTS

At the microscopic scale, what is the most effective way of swimming? Using a battery of algorithms, mathematicians have carried out numerical simulations involving robots with two, three or four arms in order to define the systems that make the best swimming strokes. They have succeeded in coming up with a number of models that are more efficient than existing ones. This could eventually open the way to miniature robots that can carry out surgical operations without incision, or undertake repairs at the microscopic scale.

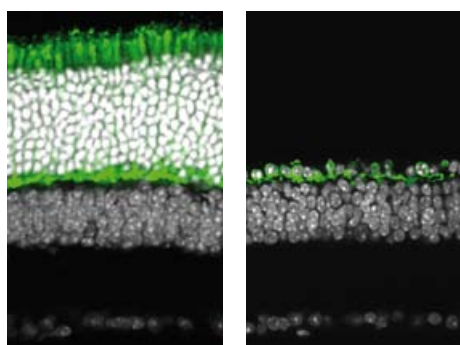
| 2010 *La Recherche* Prize, category 'Sustainable mobility'

Oncology

ARSENIC IS GOOD FOR YOU

Prescribing arsenic to fight acute promyelocytic leukemia isn't as ludicrous as it sounds. Biologists have uncovered arsenic's mechanism of action: it induces oxidative stress, which triggers bond formation between the oncoproteins involved in the onset of this cancer, causing them to clump together. The formation of these bonds then favors binding of a peptide, SUMO, and sets off the breakdown of the abnormal protein clumps.

| Published in *Cancer Cell*, 13 July 2010



> Cross-section of a healthy retina (left) and of a retina affected by retinitis pigmentosa (right), on which there only remains a single layer of photoreceptors.

Gene therapy

MICE RECOVER SIGHT

Retinitis pigmentosa is the most frequent cause of blindness in human beings of average age. The disease is caused initially by the degeneration of the photoreceptors responsible for night vision. Subsequently, the photoreceptors involved in daylight vision become insensitive to any light stimulation, although they are not destroyed. They can therefore be artificially activated, allowing partial restoration of sight. This remarkable feat was accomplished in mice by introducing a protein able to couple light stimulation to an ion transporter. The scientists have thus recreated a genuine biological photoelectric system. The effectiveness of this novel therapeutic approach has been confirmed in vitro on human retinal cultures.

| Published in *Science*, 24 June 2010

Telex

CNRS and Archade have joined forces to improve the efficiency of carbon ion hadrontherapy, a novel method for the treatment of X-ray-resistant cancers.

Deep into the cell

The cell, where gene expression takes place, still holds many secrets. Scientific exploration deep into the heart of this extraordinary machinery reveals the mechanisms at work in the transcription of DNA to RNA and during embryogenesis.

Intestinal flora

DIVERSITY OF MARINE ORIGIN?

Without intestinal flora, humans cannot break down the polysaccharides in their diet. Porphyrin, one of the polysaccharides present in the cell walls of a red algae used particularly in the preparation of sushi, is broken down specifically by an enzyme called porphyranase. This enzymatic activity has been identified in marine bacteria and, surprisingly, in the bacteria that populate the gut of the Japanese. A transfer of genes between bacteria must have enabled the microbiota of the Japanese to take over all the 'machinery' required to digest the algae in which sushi is wrapped. The association of food and marine bacteria may therefore help to acquire new enzymes, which would explain the diversity of human intestinal flora.

| Published in *Nature*, 8 April 2010

Bioinformatics

VARNA ALL THE RAGE

VARNA is a Java applet, a computer application that can be used to draw the secondary structure of an RNA molecule in a web browser. This software has been chosen from a dozen other applications by the Rfam database, a global reference website for the structures of RNA families. Thanks to VARNA, Rfam can now offer scientists who use the site a rapid and interactive display of the RNA sequences listed in its databases.

Eukaryotes

RIBOSOME STRUCTURE REVEALED AT LAST

The ribosome is a large intracellular molecule that carries out protein synthesis on the basis of genetic information. For the first time, its atomic structure in a non-bacterial organism, a yeast in this case, has been determined using crystallography, with a very high resolution of 0.415 nanometers, i.e. at the atomic scale. The researchers also revealed the oscillatory dynamics between the two ribosomal subunits, behind the protein synthesis mechanism.

| Published in *Science*, 26 November 2010

> Close-up of nurse cell nuclei in an ovarian chamber of the fruit fly, *Drosophila melanogaster*. The nuclei are shown in green and the cell membranes in red.

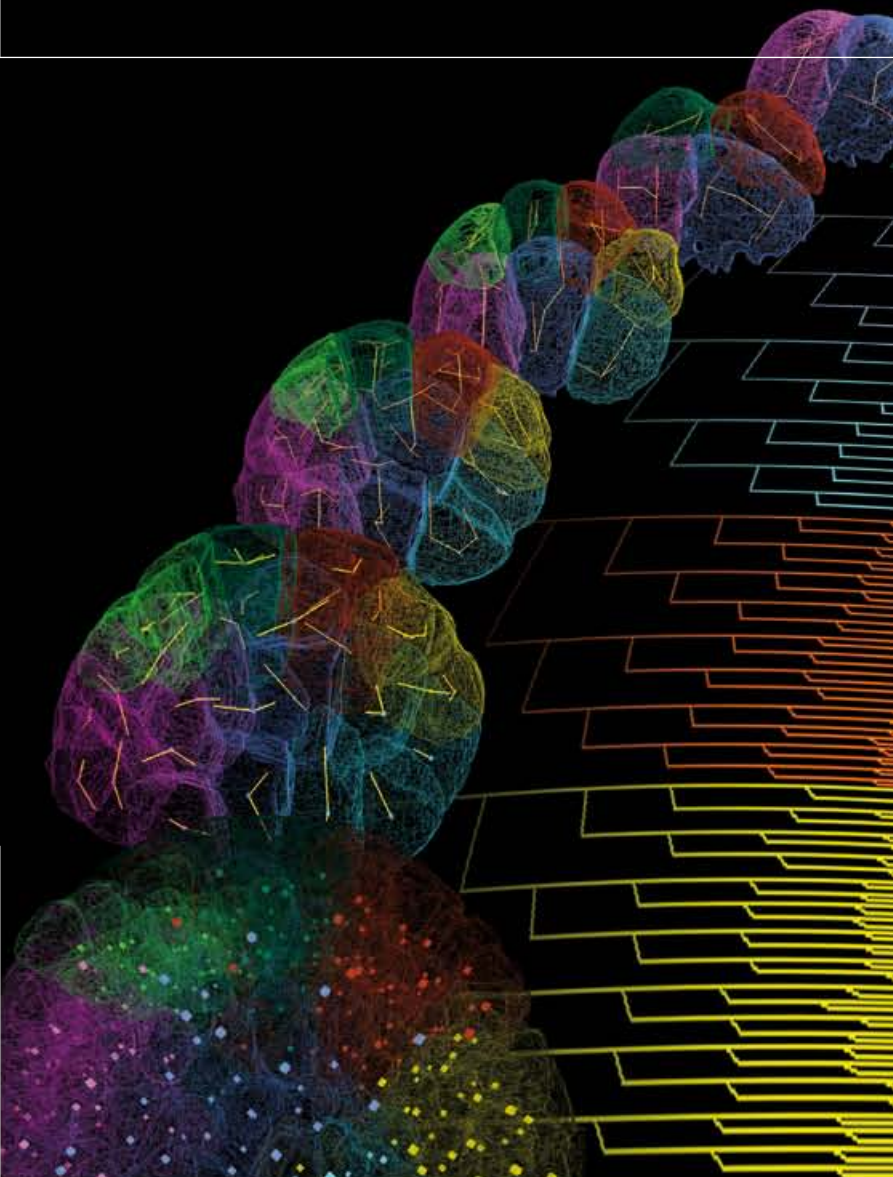
Imaging

SHEDDING NEW LIGHT ON EMBRYOGENESIS

An interdisciplinary team has proposed a new imaging strategy that makes it possible to observe and reconstruct in their entirety and with unequalled precision the early stages of development of the zebrafish embryo. Their method is based on the nonlinear optical properties shown by certain cell structures. Illuminated by an infrared pulsed laser, the mitotic spindles generate red light, which provides a precise temporal marker for the cell cycle. Meanwhile, the cell membrane and the nuclear envelope generate blue light, allowing cell positions and boundaries to be precisely defined. The images obtained enabled the researchers to reconstruct the cell lineage of six embryos from the first cell to the thousandth. This work reveals the spatial and temporal dynamics of cell division.

| Published in *Science*, 20 August 2010

> 2D and 3D spatio-temporal development of the first division cycles of a zebrafish embryo.



Transcription

INITIATION FILMED IN 3 DIMENSIONS

The expression of a gene begins with the transcription of its DNA into RNA by an enzyme, RNA polymerase. By analyzing the transcription complex using electron cryomicroscopy, a technique that makes it possible to observe a molecule in a hydrated state similar to its natural state, scientists have succeeded in photographing, image by image, the first stages of the transcription of DNA into RNA, thereby shedding light on part of the mechanisms of this process.

| Published in *Nature*, 17 June 2010

Structural biology

LOOKING INTO THE HEART OF GIANT MOLECULES

Researchers have designed a new isotopic labeling protocol that improves the sensitivity of nuclear magnetic resonance imaging. Based on the incorporation of methyl groups into certain amino acids in the protein, this process made it possible to study a protein ten times larger than those traditionally observed by deciphering its details. The improved sensitivity provided by this technique also enabled the researchers to detect, for the first time, hydrogen bonding within biological macromolecules.

| Published in *Angewandte Chemie International Edition* and *Nature Chemistry*, 15 February and 2 May 2010



Turning the spotlight on neurons

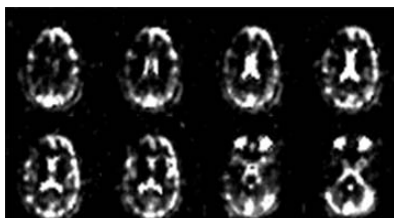
The brain, the human body's on-board computer, is a fruitful target for scientific research. By investigating how neurons work, researchers are also opening up new avenues in terms of detection and therapeutic applications with regard to certain diseases.

Parkinson's disease

A NEW TYPE OF NEURON INVOLVED

At an advanced stage of Parkinson's disease, patients suffer from gait disorders that resist traditional treatment with dopamine. Researchers investigated the pedunculopontine nucleus, a brain structure composed of neurons that use acetylcholine instead of dopamine as a chemical messenger. By combining functional MRI on healthy subjects and analysis of post-mortem tissue from diseased subjects, they demonstrated the involvement of this structure in gait control, opening up therapeutic avenues for equilibrium disorders.

| Published in *The Journal of Clinical Investigation*, 12 July 2010



> In vivo sodium MRI brain scan of a healthy subject. Sodium appears in white in the images.

Sodium MRI

IMPROVED DETECTION OF NEUROLOGICAL DISORDERS

Researchers have developed a new magnetic resonance imaging (MRI) technique that differs from the traditional method as it is based on the excitation of sodium atoms rather than hydrogen nuclei. This is no mean feat, since the sodium signal is 20,000 times weaker than the hydrogen signal. It therefore proved necessary to develop innovative systems to recover the transmitted signal as well as specific algorithms to process it. This method makes it possible to map the distribution of sodium in the human brain in vivo and non-invasively. The stakes are high, since the abnormal accumulation of sodium in the axon plays a role in a number of neurodegenerative diseases, such as multiple sclerosis and Alzheimer's. The technique should eventually enable scientists to gain a better understanding of the processes involved in such pathologies, and perhaps make them easier to detect.

| ANR program: 'Neurological and psychiatric disorders'.




Awards

ETHICS IN ACTION REWARDED

Anne-Marie Ergis, a specialist in the neuropsychology of ageing, is joint laureate of the special prize 'Éthique en acte', one of the 2010 Pierre Simon-Ethics and Society awards. The distinction was awarded to Ergis, who is a teacher, researcher and clinician, for her original work on the design and validation of new tests aimed at assessing cognitive disorders caused by Alzheimer's disease in Amerindians in French Guiana.

This work was supported by the CNRS interdisciplinary research program 'Longevity and Ageing'.

> Explants of granule neuronal cells from a mouse cerebellum. The neuron nuclei, shown in blue, contain DNA. The fine hairs in green are made up of axons, or nerve fibers.

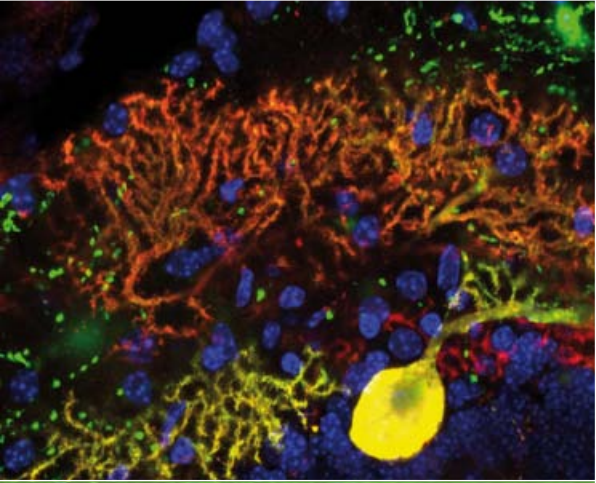


Spinal cord

IMPROVING THE LIFE OF PARALYZED PEOPLE

Three quarters of paraplegic and tetraplegic patients suffer from hyperactive reflexes and muscular stiffness. This disorder, called spasticity, is caused by a dysfunction in the activity of inhibitory neurons, whose origin is unknown. A study carried out on rodents shows that this dysfunction may be linked to a drop in the levels of a membrane protein called KCC2 in the motor neurons located below the spinal cord lesion.

| Published in *Nature Medicine*, 28 February 2010



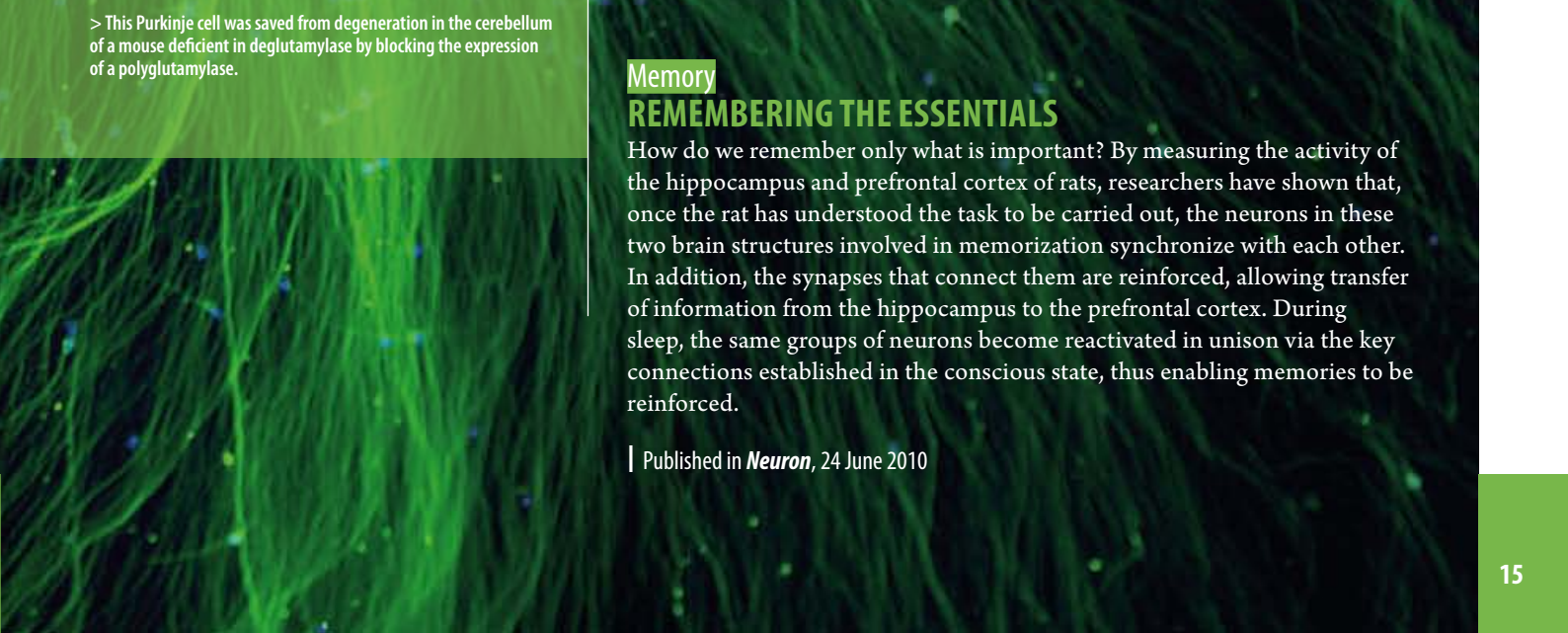
Neurodegeneration

DISCOVERY OF A NEW FAMILY OF ENZYMES

Biologists have discovered a family of enzymes, called deglutamylases, which remove glutamic acid side chains attached to tubulin, a protein involved in the transport of constituents in the neurons. Moreover, by studying a mouse deficient in one of these deglutamylases, they showed that precise control of the level of tubulin glutamylation is critical for neuronal survival. This work thus establishes a link between the integrity of the tubulin and the mechanisms of neuron degeneration or survival.

| Published in *Cell*, 12 November 2010

> This Purkinje cell was saved from degeneration in the cerebellum of a mouse deficient in deglutamylase by blocking the expression of a polyglutamylase.



Memory

REMEMBERING THE ESSENTIALS

How do we remember only what is important? By measuring the activity of the hippocampus and prefrontal cortex of rats, researchers have shown that, once the rat has understood the task to be carried out, the neurons in these two brain structures involved in memorization synchronize with each other. In addition, the synapses that connect them are reinforced, allowing transfer of information from the hippocampus to the prefrontal cortex. During sleep, the same groups of neurons become reactivated in unison via the key connections established in the conscious state, thus enabling memories to be reinforced.

| Published in *Neuron*, 24 June 2010

Impacting the genome

Carrying the genetic information inherited from the preceding generation through the subtle action of meiosis, the genome is impacted by a host of factors. Research results point to the complexity of its structure.

Meiosis

A PROTEIN THAT DETERMINES THE GENETIC MAP

During meiosis, the special type of cell division that gives rise to the formation of reproductive cells, the exchange of genes between homologous chromosomes inherited from both parents contribute to maintaining the genetic diversity of the species. Geneticists have identified a gene called *Prdm9*, which codes for a protein of the same name that can bind to numerous sites in the genome and cause chromatin alterations. Such alterations allow the 'recruitment' of recombination proteins, which determine the location of genetic exchange during meiosis in humans. Deciphering this mechanism, which defines gene mapping in mammals, opens the way to a better understanding of the transmission of heritable traits.

| Published in *Science*, 12 February 2010

Chronobiology

LIGHT RESETS THE BODY'S CLOCK

How are circadian clocks able to synchronize themselves accurately to the day/night cycle without taking account of light fluctuations over the course of a single day or from one day to the next? The mathematical analysis of the activity profiles of two central genes of the circadian clock of a microscopic green alga reveals that the circadian clock is only sensitive to light if it is out of sync and needs to be reset.

| Published in *PLoS Computational Biology*, 11 November 2010

Structural genomics

A DASH OF BACTERIA IN OUR DNA

A quarter of our genome is made up of introns. These sequences, which contain no genetic information, were probably transferred into our genome by bacteria that lived in symbiosis inside the ancestors of our eukaryotic cells several hundred million years ago. New weight has now been lent to this hypothesis by the discovery, against expectations, of abundant and highly mobile introns in *Wolbachia*, an endosymbiotic bacterium present today.

| Published in *Molecular Biology and Evolution*, 6 September 2010

Embryology

PEPTIDES TAKE CONTROL

A major part of the genome produces large RNAs that are reputedly non-coding and whose function remains mysterious. Researchers have now revealed the vital role of one of these RNAs, called Pri, in the transcriptional program that causes morphological differentiation of the epidermis in *Drosophila*. Pri produces four small peptides that control the activation of a transcription factor. It is not yet known whether other genes perform their functions by producing similar peptides.

| Published in *Science*, 16 July 2010

Awards



MATHEMATICIAN WINS 'WOMAN SCIENTIST' AWARD

The mathematician Alessandra Carbone has won the 2010 Irène Joliot-Curie 'Woman Scientist of the Year' award. Head of the Laboratory for Genomics of

Microorganisms, and a professor at Université Pierre et Marie Curie (UPMC), Carbone led the Décrypton's HCMD (Help Cure Muscular Dystrophy) project. By using the computing power of thousands of Internet users' computers, HCMD should help to rapidly increase our knowledge about the role played by numerous proteins in muscular dystrophy.

> Artist's impression of the DNA double helix.

Biodiversity, an endangered treasure

Celebrated throughout 2010, biodiversity is a masterpiece in peril.
The scientists investigating its state of health are witnesses not only to the threats
it faces but also to Nature's fascinating adaptation capabilities.

Subalpine forest

AN ECOSYSTEM MADE MORE VULNERABLE BY FIRES

How does a mountain forest grow back after a fire? By analyzing charcoal and sub-fossil plant remains contained in French and Italian mountain lake sediments, researchers have accurately determined the vegetation of this environment over the past 8,000 years. Using statistical tools, they modeled trends in vegetation dynamics during that period of time. It appears that subalpine forests take at least 150 years to recover from the effects of a fire. At the end of that cycle, the arolla pine, the dominant species in the ecosystem, is still not as abundant as before the fire. The study therefore concludes that if fires break out at intervals of less than 150 years, these slow-growing forests lose their ability to recover completely. Priority should therefore be given to their protection at the European level.

| Published in *PLOS ONE*, 30 August 2010

> Mixed subalpine forest of arolla pine and larch near Lanslevillard, 2010. Located at an altitude of 2,100 meters, it has burnt three times over the past two hundred years.

Dispersal of species

SHOULD I STAY OR SHOULD I GO?

Within the same species, some individuals can travel a long way before settling down, while others stay in their home territory. Ecology experts have developed a model showing that these 'nomadic' or 'sedentary' lineages emerge naturally when the environment consists of a few large territories bordering on many small ones. These findings could rekindle the debate about the size and distribution of nature reserves set aside for biodiversity conservation.

| Published in *Evolution*, 12 October 2010

Biodiversity

LIZARDS UNDER THREAT FROM CLIMATE CHANGE

An international team has analyzed a large database of over 200 species of lizards across four continents (Africa, America, Australia, Europe). The researchers reckon that 4% of local populations have become extinct since 1975. On the basis of a model that in particular incorporates the impact of rising temperatures on the physiology of lizards, they predict that 20% of species will have disappeared by 2080.

| Published in *Science*, 14 May 2010



> Male *Gonatodes humeralis*. These small lizards are relatively common, although shy. In woodland, they can usually be seen on the buttress roots of trees or on fallen trunks and stumps.

Carnivorous plants

FRAGRANT LEAVES ATTRACT PREY

Nepenthes rafflesiana is a carnivorous plant from northern Borneo whose pitcher-shaped leaves enable it to capture small insects. To better understand how this leaf trap works, researchers analyzed the volatile compounds given off by the plant. They found that the upper pitchers released substances that were identical to those produced by flowers. Such fragrant traps could provide inspiration for programs to combat disease carriers such as mosquitoes.

| Published in *Journal of Ecology*, 28 April 2010

Reproduction

THIRD GENDER IDENTIFIED IN CLOSE RELATIVE OF THE OLIVE TREE

Geneticists have discovered a novel reproductive system in the species *Phillyrea angustifolia* L. based on the coexistence of two hermaphrodite plants: members of the first group can only reproduce with those of the second. Therefore, the pollen of each hermaphrodite can only fertilize one in two individuals. This work shows for the first time that a transition from hermaphroditism to separate sexes is possible over the course of evolution.

| Published in *Science*, 26 March 2010



> A young Houbara bustard, *Chlamydotis undulata*. The females are highly receptive to the males' courtship displays.

Ethology

SEXY COURTSHIP DISPLAYS LEAD TO HEALTHY OFFSPRING

By studying the behavior of female Houbara bustards, North African birds that are highly receptive to courtship displays, researchers discovered that the fertility rate and hatching success were greater in females that had been stimulated by highly displaying males. The amount of energy that the females are willing to invest in reproduction therefore depends on the attractiveness of the males.

| Published in *Proceedings of the Royal Society B*, 9 June 2010

Nature's cunning strategists

Rather than competing with each other, some species prefer to join forces. Others have more destructive relationships. The interactions between animals and plants involved in the symbiosis and parasitism mechanisms bear witness to these often astonishing strategies.

Mutualism

MÉNAGE À TROIS IN THE TROPICAL RAINFOREST

A tripartite relationship between an ant, a fungus and a plant has been described for the first time by researchers. They have shown that ants build a trap using hairs from the plant as well as from a fungus that they specifically cultivate in order to build the galleries of their insect trap. They also showed that filaments from the fungus enter the cells of the plant, providing them with minerals derived from the ants' waste. The nutritional advantage provided by the fungus apparently encourages the persistence of this type of symbiosis.

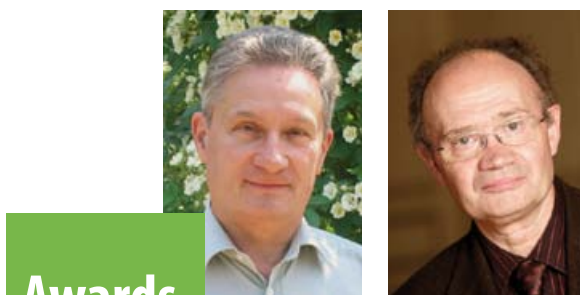
| Published in *Biology Letters* et *Journal of Ecology*, 17 November 2010 and 7 December 2010

Ecological communities

STABILITY DEPENDS ON THE TYPE OF INTERACTION

After drawing up a theoretical model that could determine the stability of species communities, researchers compared these predictions with the architecture of 34 real mutualistic networks ('who pollinates who') and 23 trophic networks ('who eats who'). They concluded that to be stable, mutualistic networks need to have a nested architecture, whereas the stability of trophic networks is provided by a compartmented architecture.

| Published in *Science*, 13 August 2010



Awards

TOP AWARD FOR TWO ECOLOGY EXPERTS

Robert Barbault (left) and Bernard Delay have been awarded the 2010 Grand Prix of the Société Française d'Ecologie for their action in promoting scientific ecology and biodiversity. Barbault, a professor at Université Pierre et Marie Curie (UPMC), Paris, is a pioneer in the study of biodiversity in all its complexity. Delay, who set up and led the 'Department of Environmental Sciences and Sustainable Development' at CNRS (which has since become the Institute of Ecology and Environment), now heads the Foundation for Research on Biodiversity.



Hosts-parasites

A NOT-SO-STEADY RELATIONSHIP

In order to understand how host-parasite communities react to changing environments, researchers took samples from the natural environment of bacteria associated with the viruses that infect them. They then measured in vitro the properties of the interaction network in environments with varying productivity. They thus showed that as resources become scarcer, the system becomes increasingly vulnerable and prone to extinction.

| Published in *Biology Letters*, 20 October 2010

Interdisciplinary program

TREES AND ANTS STICK TOGETHER

In the rainforest of French Guiana, ants of the genus *Azteca* frequently live in symbiosis with the *Cecropia* tree, also known as trumpet tree. By studying the symbiotic relationship between the species *Azteca andreae* and the tree *Cecropia obtusa*, an international team has discovered a surprising hunting strategy. The worker ants hide side-by-side beneath the leaf margins, waiting for prey to alight. In this position, they use their claws to firmly cling onto the long hairs found on the underside of the leaves. Using this Velcro®-like system, an ant can hold onto as much as 5,000 times its weight without being pulled off. In this way, a group of worker ants can capture very large prey, the biggest observed by the scientists being a grasshopper 13,350 times heavier than a single worker.

This work was funded in 2010 by the interdisciplinary programs 'Interface physique-chimie-biologie physique, biologie et chimie : soutien à la prise de risque' and 'Amazonie'.

| Published in *PLoS ONE*, 25 June 2010

> Horsefly captured by *Allomerus decemarticulatus* ants in French Guiana. They live exclusively on the plant *Hirtella physophora*. Nouragues Station, French Guiana.



> A hawkmoth caught by one of its wings on the lobe of a leaf. On the right, worker ants are ready to attack their prey.

Societies and networks: action !

Science makes it possible to analyze the changes affecting today's society and adapt accordingly. It contributes to improving everyday life, especially with regard to the security and reliability of communication networks. Such concerns are among the main priorities of the agreement on objectives signed with the French Government and due to run until 2013, as illustrated below by some of the initiatives undertaken in 2010.

Intensive network computing

COMPUTING GRIDS WILL BOOST SCIENTIFIC PRODUCTION

Since September 2010, the 'France Grilles' scientific interest group (GIS), led by CNRS's Grids Institute (Institut des Grilles), has coordinated the technological resources of eight institutional partners to make them available to all research laboratories. Every user will therefore have access to considerable resources both in terms of computing power and data storage, via a simplified interface. This GIS, which has obtained the 'Very Large-Scale Research Infrastructure' label from the French Ministry of Research, is the French component of the European Grid Infrastructure (EGI), providing over 17% of EGI's resources. France Grilles is making a significant contribution to moving forward the agreement on objectives and is set to become a major scientific production facility in years to come.

Language theory

A NEW ANALYTICAL TOOL

In 2010, projects involving the digitization of language corpuses and the elaboration of tools for the development of theories of language, both of which are included in the agreement on objectives, bore fruit. After five years of work, a project for the dissemination of Mediterranean island languages and cultures has given rise to a multimedia DVD dubbed In Corsu +. In addition, the international MarqSpat project has led to the development of a cross-validation method for the analysis of variation in structural elements of three sign languages (used in the US, France and Quebec), of the surrounding spoken languages and of their coverbal gestures.

Document preservation

RECOMMENDATIONS FOR LONG-TERM PRESERVATION OF HUMANITIES AND SOCIAL SCIENCES (SHS) ARCHIVES

Operational since February 2010, the ArchiSHS network provides a concrete response, in the field of humanities and social sciences, to the objective laid down in the agreement with the Government to 'support shared initiatives for document preservation and methodologies for long-term storage of archives'. Acting as a forum for reflection and as a source of expert knowledge, this multidisciplinary thematic network aims to reflect on the status of SHS archives (administrative and scientific records, and public surveys) and to draw up recommendations for a preservation policy. The program, which brings together social sciences researchers, archivists and legal experts, will subsequently be supported by document management professionals and IT specialists, thereby taking on an international dimension.

> Optical fibers.

Digitizing for posterity

The manuscripts of the past, as well as present and future scientific publications, are invaluable testimonies of our history. Digitization and electronic archiving are essential to keep them safe and accessible to all.

Restoration

MANUSCRIPTS RISE FROM THE ASHES

In 1944, an air raid set fire to the 2,000 manuscripts in the municipal library in Chartres. Although a thousand of them were saved, they were torn apart and scattered by the fire as well as by water from fire hoses. Funded by ADONIS, a CNRS Very Large Facility, the Chartres project aims to restore and digitize 450 medieval manuscripts to make them available to the scientific community.

> Opuscles on medicine dating from the tenth century, Chartres municipal library.



> Loading wood in a Gulag camp.

European history

GULAG SURVIVORS REMEMBER

From the very first moments of Stalin's reign until his death in 1953, nearly one million Europeans were deported to Soviet labor camps. The testimonies of 160 survivors from thirteen European countries, collected by researchers from all backgrounds in partnership with Radio France Internationale (RFI), today constitute the first sound archives of 'European Memories of the Gulag'. These recordings are genuine historical documents that bear witness to the effect of these deportations on the national identity of the European countries of the former Soviet bloc.

Scientific archives

LONG-TERM VISIBILITY

The multidisciplinary open archive HAL, aimed at facilitating the dissemination of research results, will now be stored for a minimum period of thirty years at the Centre Informatique de l'Enseignement Supérieur (French Higher Education Computing Center). HAL, which was set up in 2000, collects and provides free access to over 2,000 new scientific articles a month from laboratories and teaching and research institutions in France and abroad.

Telex

Fontes Historiae Iuris is a single portal providing access to digitized resources on the history of law and justice. Inaugurated on 1 February 2010, the site is especially aimed at facilitating documentary research for scientists working in this field.

Set up on 3 February 2010, MédiHAL is an open archive of scientific images and illustrated scientific documents, which relies on voluntary filing of these documents by researchers.

Initiated in April 2010, the Michel Foucault portal is organized in three sections (digital archives, bibliography and education), and provides hitherto unpublished data and resources in relation to the French philosopher's work.

Retracing history

From the port of Narbonne to ancient Egypt or the salt mines of the Caucasus, archeologists travel the world in a bid to interpret the remains of bygone civilizations.

Archeology

SALT MINE IS A MINE OF INFORMATION

By analyzing a large number of remains buried at the site of Duzdagi, Azerbaïdjan, archeologists have discovered that this rock salt mine is the oldest known to date (4500 BC), and that it was exploited intensively. Studying the techniques used to exploit raw materials should help to shed light on the needs and complex organization of past civilizations, such as those that emerged between 4,500 and 3,500 BC in the Caucasus.

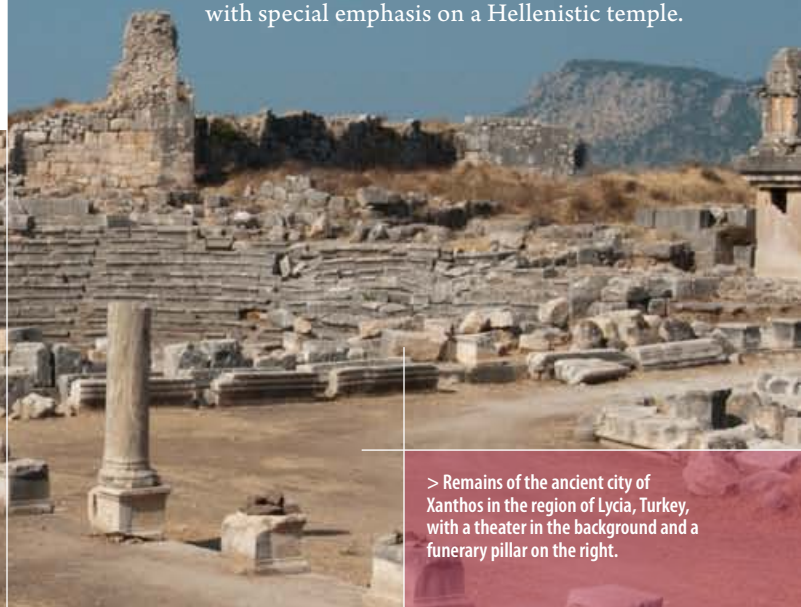
| Published in *Tüba-ar*, 1 December 2010



Mission

MAJOR CIVILIZATION IN ASIA MINOR

As they do every summer, researchers traveled to the site of Xanthos in southern Turkey, retracing the history of Lycian civilization, which was present in the region from the seventh century BC. The discovery of a banqueting hall on the site of a sanctuary sheds light on this society of farmers, herdsmen and sailors. The latest excavations went hand-in-hand with an intensive restoration program, with special emphasis on a Hellenistic temple.



> Remains of the ancient city of Xanthos in the region of Lycia, Turkey, with a theater in the background and a funerary pillar on the right.

Practices and customs

CANNIBALS AMONG OUR FOREBEARS

Excavations at an early Neolithic site at Herxheim, Germany, have unearthed a village with pits containing a large number of human remains. Detailed study of the bones show numerous traces of alterations of human origin (incisions) that show similarities with butchery practices in use at that time. The findings provide evidence of cannibalism and researchers believe the victims may have been eaten at the end of sacrificial rites.



Roman Empire

THE IMPORTANCE OF THE PORT OF NARBONNE CONFIRMED

Archeologists have revealed new structures in the port of Narbonne that had lain hidden under a layer of sediment until now. The remarkable remains uncovered include a canal for the transport of wine, two jetties used to unload goods, and intact wooden structures, such as wharfs, anchorage for lifting equipment and over 200 piles. All these discoveries confirm Narbonne's status as the second most important Western port in the Roman Empire.



Analytical methods

A NEW CHRONOLOGY FOR ANCIENT EGYPT

How is it possible to establish an absolute chronology of the kings who succeeded each other to the throne of Dynastic Egypt? An international team of researchers used carbon-14 to date numerous samples of Egyptian artifacts that are archeologically attributed to a specific Egyptian reign or period. This data, combined with the known or supposed duration of each reign, has made it possible to determine the first complete and accurate chronology of ancient Egyptian dynasties. Although this is consistent with most previous findings, it will lead to some reappraisals of Egyptian history. The chronology will help to establish a more accurate time frame for neighboring civilizations such as Nubia or the Near East.

| Published in *Science*, 18 June 2010



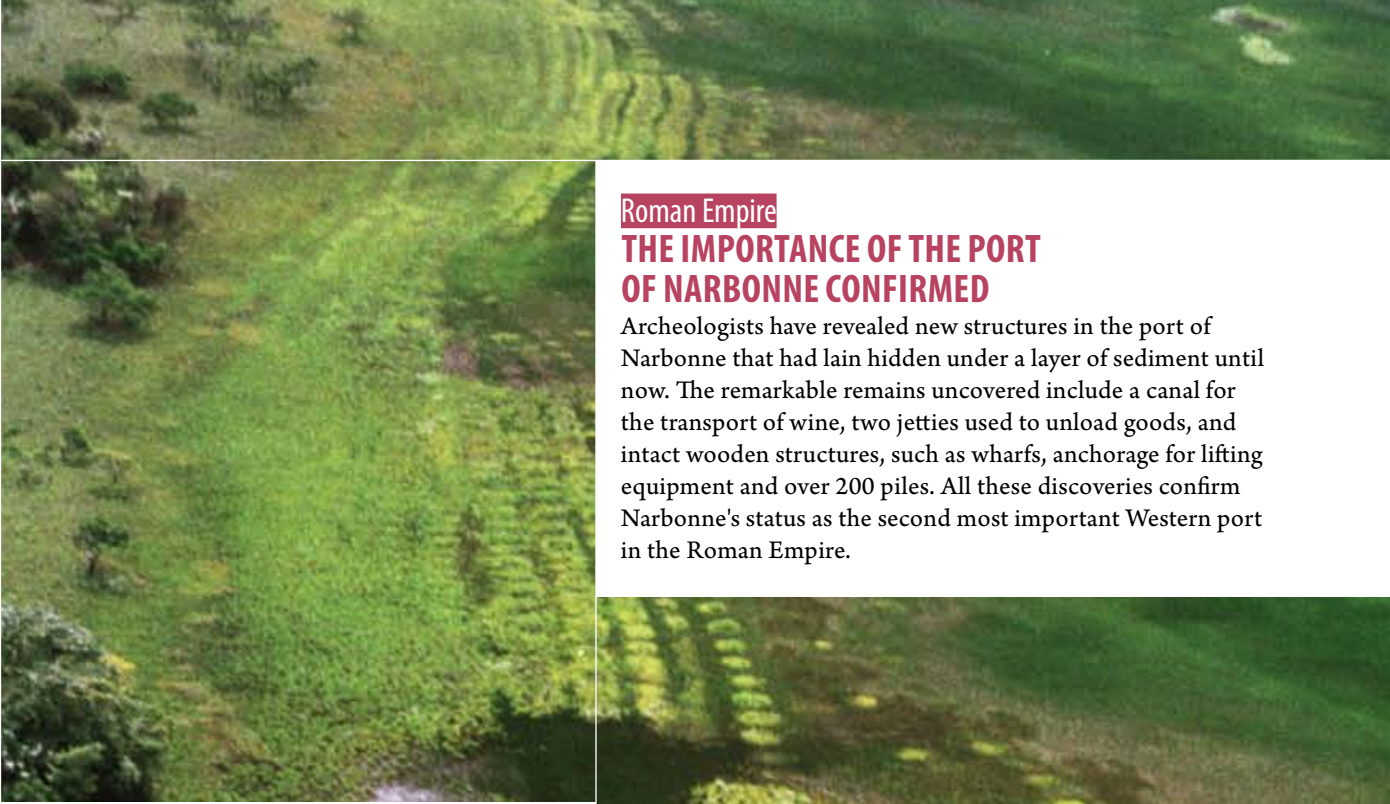
Interdisciplinary program

A HIGHLY SUSTAINABLE ECOSYSTEM

Mysterious mounds along the coast of French Guiana were once well-drained, raised fields laid out by pre-Columbian Amerindians to withstand seasonal flooding. It was the plants and insects which colonized them that contributed to the remarkable preservation of these almost one-thousand-year-old drainage systems. In return, the mounds provided them with ideal living conditions. This discovery could be a source of inspiration for ecologically intensive agricultural systems.

This work was funded by the 'Amazonia' interdisciplinary research program.

| Published in *Proceedings of the National Academy of Sciences*, 12 April 2010



> Aerial view of French Guiana's savannah. The remains of pre-Columbian raised fields can be seen clearly.

Science serves art

Science and art get on famously: the latest innovations in modern electrochemistry and in spectroscopic analysis are used to discover the medicinal virtues of ancient Egyptian eyeliner, and to reveal the secrets behind the production of a painting or a violin.



Music

SECRETS OF MASTER VIOLIN MAKER'S VARNISH REVEALED

The mystery surrounding the unequalled tone of the violins designed by Antonio Stradivari is beginning to clear. Scientists have developed an array of spectrometric analysis techniques in order to gain access to the stratigraphic structure and organic and inorganic composition of the varnish of five violins made by the famous Italian violin maker. They showed that the varnish was always composed of two layers with similar organic composition. The deeper of the two is based on a siccative oil, a substance that makes varnish dry more quickly. In the surface layer, the same substance is combined with a resin from trees of the pine family. These findings go some way to filling a gap in our knowledge since, until the end of the eighteenth century, no known historical source describes the materials, tools and methods used to varnish these instruments.

| Published in *Angewandte Chemie International Edition*, 4 January 2010

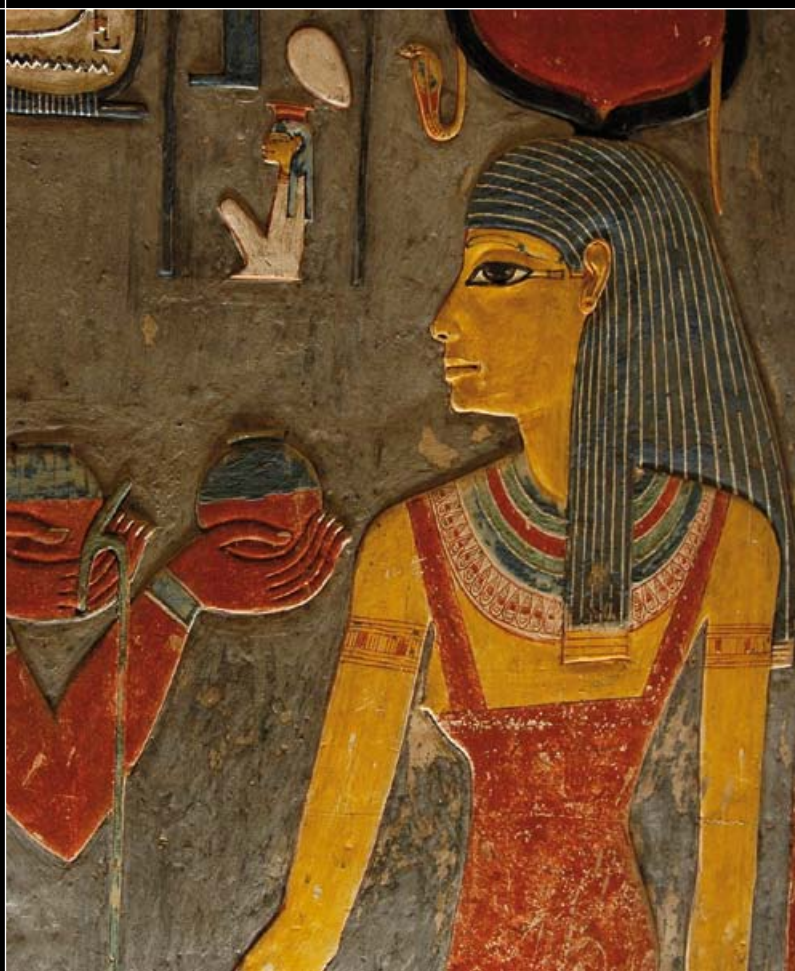
Rock art

STUDYING PAINTINGS ON SITE

Raman spectroscopy consists in projecting a laser beam onto a sample in order to determine its composition and structure from the scattered light. This non-invasive method was tested for the first time in situ on rock paintings of the San peoples of South Africa. This research made it possible to obtain information not only about the pigments used by the painters of the time, but also about the state of conservation of the paintings.

| Published in *Journal Of Raman Spectroscopy*, 6 May 2010

> Spectrometric analysis of tiny fragments of varnish from old violins sheds light on the varnishing techniques used by violin makers in the eighteenth century.



> Offering by King Horemheb to the goddess Hathor. Antechamber of Horemheb's tomb, Valley of the Kings, Thebes West Bank, Egypt.

Egyptology

EYELINER AS AN EYE PROTECTOR

The ancient Egyptians used to enhance their eyes with a thick layer of eye-black. However, this eyeliner was more than just cosmetic. Made from lead salts, it also had medical properties. This has been confirmed by a study on laurionite, a lead chloride that was used in Egyptian make-up. Using ultramicroelectrodes, the researchers studied the chemical reactions taking place in a skin cell placed in contact with a solution of laurionite. They observed a sharp increase in the production of nitrogen monoxide, a chemical compound known to stimulate the immune system. The Egyptians' eyeliner thus triggered a defence mechanism, which in the event of an eye infection limited the proliferation of bacteria.

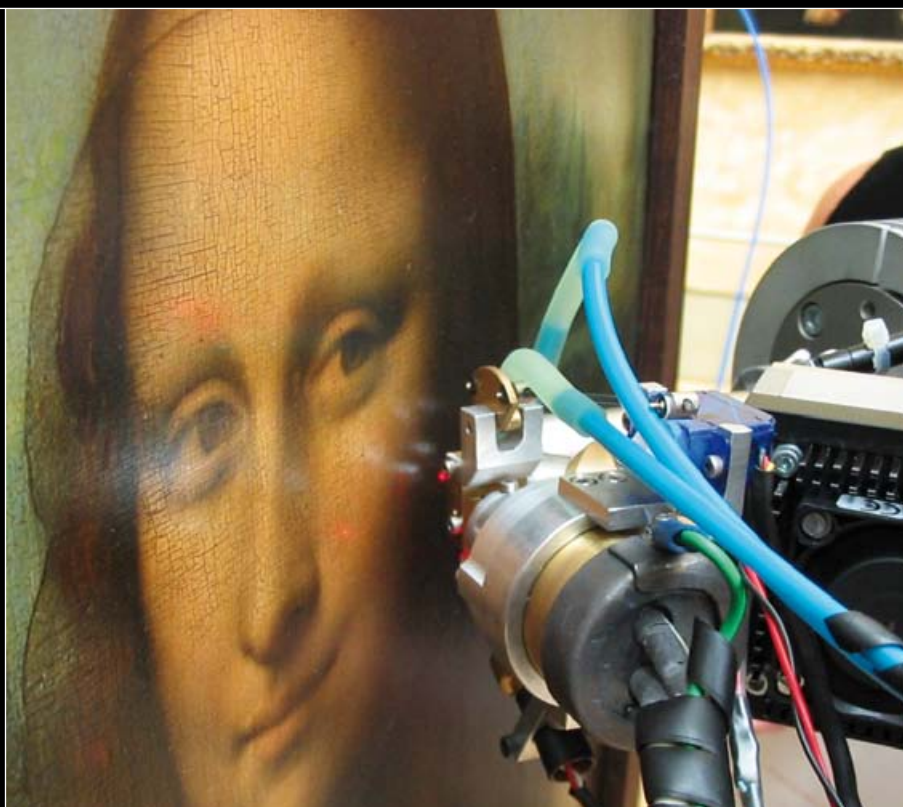
| Published in *Analytical Chemistry*, 15 January 2010

Sfumato

A PICTORIAL TECHNIQUE UNVEILED

Researchers were lucky enough to be able to analyze, directly inside the Louvre Museum and without taking any samples, the composition and thickness of each layer of material laid down by Leonardo da Vinci on seven of his paintings, including the Mona Lisa. This enabled them to reveal the secrets of the sfumato, a pictorial technique used by da Vinci to paint shadows on faces. It appears that the application of several dozen 1-2 micrometer-thick layers of paint, as well as the nature of the pigments, played a major role in breathing so much life into da Vinci's work.

| Published in *Angewandte Chemie International Edition*, 14 July 2010



> Photograph taken during a series of measurements on the Mona Lisa: X-ray fluorescence spectrometry is being used directly on the works of the Louvre Museum.

Society in motion

Keeping a close eye on our way of life, sociologists and economists decipher society's evolution in order to better anticipate future change.

Gender

IMPROVING THE STATUS AND ACCESSIBILITY OF GENDER STUDIES

French research into gender and/or women lacks visibility. In light of this, a national census of male and female researchers working on the subject was launched at the beginning of 2010. It aims to assess the current situation of French research through a database available on the Internet, and make this work accessible to the scientific community. A book and a conference are also being prepared.

Opinion poll

THE FRENCH DON'T TRUST THEIR POLITICIANS

During the 2007 presidential election in France, political trust played a key role in the dynamics of the campaign and in voters' choices. In preparation for the 2012 elections, a 'Barometer of political trust' has been launched. It aims to measure the various aspects of political trust (personal, institutional, media), and will be used to closely monitor trends in this central feature of the electoral and civic process. The first polls reveal a general distrust of politicians and their ability to improve their fellow citizens' prospects. They also show that the French are generally quite satisfied with their lives and with public services more specifically, and that they rely on themselves to defend their interests.



Awards

FRENCH ECONOMIST REAPS FRESH AWARD



Winner of the 2007 CNRS Gold Medal, the economist Jean Tirole was awarded the Claude Levi-Strauss Prize in 2010 for his internationally acclaimed research into game theory and information theory. The prize, created in November 2009 to commemorate the centenary of the renowned French anthropologist's birth, seeks to promote the excellence of French research in the humanities and social sciences.

Monetary policy

TOO MUCH TRANSPARENCY UPSETS THE MARKETS

Today, the stock markets react instantly and strongly to decisions by the central banks on monetary policy. Such decisions have a dual effect: for instance, an increase in interest rates stabilizes the economy by reducing inflation. But at the same time, it tells the markets that inflation figures are poor, and that adverse economic conditions prevail. A study shows that if the central banks wish to optimize their monetary policy and play their stabilizing role, they should take account of the informational role played by their instruments (in this case, interest rates), and adopt a suitable communication strategy.

| Published in *Journal of Monetary Economics*, September 2010

Telex

The National Alliance for the Humanities and Social Sciences (ATHENA), which was set up in June 2010, seeks to improve coordination between players in these disciplines in France, and undertake long-term analysis to meet society's expectations. This fifth research alliance brings together CNRS, the Conference of Grandes Ecoles (CGE), the Conference of University Chancellors (CPU), and the National Institute for Demographic Studies (INED). It will be chaired by the President of CNRS for a duration of two years.

Of robots and men

Signal processing, miniaturisation and robotics are gradually entering our everyday lives. Whether designed to transport passengers, assess the quality of a fabric, or perfectly imitate bipedal locomotion, will robots make life any easier?



Robotics

USING HUMANS AS A MODEL

Robots designed according to conventional robotics techniques may take strange positions to perform simple tasks such as fetching an object. To put this right, the researchers in artificial intelligence working on robot HRP2 studied human behavior in similar situations in order to model the 'invariants' of an action. When these models are incorporated into the motion planning algorithms, it becomes possible to calculate positions that are much more natural.

| **Best Paper Award** at the IEEE BioRob Conference, Tokyo (Japan), 26-29 September 2010

Interdisciplinary program

MEASURING UNDER EXTREME CONDITIONS

Coatings in industrial environments are exposed to increasingly harsh conditions, such as high temperature or corrosion. At present, no instruments can provide information about the behavior of these coatings in such situations. Researchers have developed a miniaturized sensor to measure electrical resistivity. It is made of alumina and tungsten, which are both resistant materials in the working environment of coatings and could be used in a wide variety of fields, such as power electronics, the nuclear industry, turbines, etc.

This research was funded by the CNRS 'Materials' interdisciplinary research program.

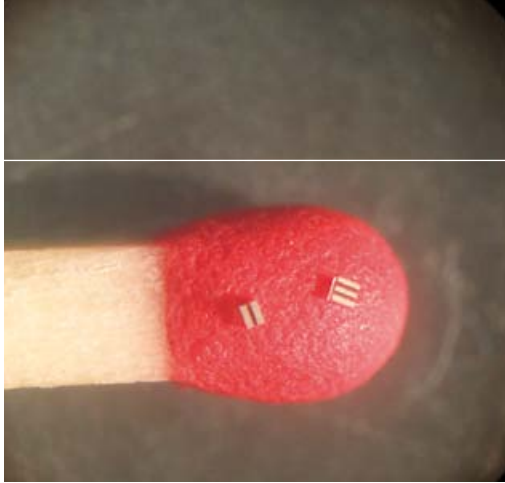
Signal processing

DETECTING LEAKAGE IN DIKES

Although fiber optics associated with temperature-measuring devices is already being used for the monitoring of earth dikes, it could not be applied on a large scale due to the lack of a reliable data interpretation method. Signal processing systems that combine the use of statistics and source separation techniques have been developed to analyze temperature variations in the ground at the base of the dikes. These act as indicators of internal damage caused by leaks and infiltration.

| **72nd Meeting of European Association of Geoscientists and Engineers**, Barcelona (Spain), 14-18 June 2010

> The HRP-2 robot can pick up an object from the ground without losing its balance.



> World microrobot speed champion MagPieR, seen here in two versions: 388x388x240 μm^3 and 300x388x240 μm^3 .

Microrobotics

WORLD SPEED CHAMPION IS FRENCH

Hurrah! It took a mere 28.1 milliseconds for the MagPieR microrobot developed by a CNRS team to run the length of the two millimeter-long track, easily winning the Mobile Microrobotics Challenge two-millimeter dash organized in May 2010 in Anchorage. MagPieR is composed of two distinct materials enabling it to be activated at a distance by a magnetic field and the piezoelectric effect.

| International Conference on Robotics and Automation, Anchorage (Alaska, United States), 3-8 May 2010

> The HandTouchTissue® system can be used to assess the feel of fabrics objectively. This novel approach could find applications in other industrial fields, such as paper, leather, plastics, etc.



Patents

A TACTILE ROBOT

To evaluate the quality of a fabric, textile manufacturers traditionally touch and handle it, making use of the human sense of touch. However, this subjective approach does have its limitations. In order to assess the feel of fabrics objectively, researchers have developed an 'artificial hand' able to measure their vibration and stiffness. This makes it possible to classify them on the basis of their sensory perception. This system, known as HandTouchTissue®, is already being used by an operator in the luxury silk industry.

| Patent registered 19 March 2010

Autonomous vehicles

BIRTH OF A SMART CAR

The result of a collaboration between a CNRS laboratory, an R&D company named Apojee, and the French car manufacturer Ligier, the VIPA (which stands for Véhicule Individuel Public Autonome, or autonomous public individual vehicle) was given a preview at the 2010 Paris Motor Show. This driverless vehicle navigates, adjusts its speed and avoids obstacles autonomously. Its secret is a visual memory relying on an enhanced GPS system coupled to a wide-angle video camera. The many tests already carried out have shown that this electric vehicle can reliably follow the same path within a margin of less than 10 centimeters. An important point is that it requires no ground guidance system, such as rails or magnetic studs. The VIPA is designed to drive people around very large facilities such as hospitals, airports and amusement parks.

> The VIPA, previewed at the 2010 Paris Motor Show, is an autonomous vehicle suitable for a wide variety of uses.



The future ^{is} digital

In the constantly-evolving field of computing, researchers have made significant breakthroughs concerning data security and electronic components' reliability.

Start-ups

SMARTPHONES BRING PEOPLE CLOSER

An increasing range of applications captures the interest of the ever-growing number of smartphone users. Riding on this wave, the ClosyCom project aims to use the relative positions and orientations of smartphones to build a spontaneous, self-organized network for information exchange with co-located devices. This technique won the 2010 French national contest for the support of innovative start-ups in the 'emerging projects' category.

Software

MAKING SECURITY TOKENS MORE SECURE

Security tokens, which resemble USB keys or smart cards, are used by major groups to manage secure access to sensitive data in computers. The configuration of these cryptographic keys may however lead to security flaws. A new software called 'Tookan' provides a solution. By identifying ten 'cryptographic vulnerabilities' in eighteen models of security tokens, the software has already proved its effectiveness.

| Published at the **Conference on Computer and Communications Security**, Chicago (United States), 4-8 October 2010



> Development in a virtual scene of new, easy-to-learn interactions. By simply moving a stylus, it is possible to select one area of the object and choose a viewpoint.



A MAN OF NETWORKS

At the interface of fundamental and applied research, the scientific work of Jean-Claude Bermond, CNRS senior researcher, has been rewarded by two successive prizes: the 2010 EADS Enterprise Foundation Prize and the Prize for Innovation in Distributed Algorithmics awarded by the Sirocco conference. These two distinctions acknowledge

Awards

Bermond's visionary work in the field of optical and wireless telecommunications, and in the design of interconnection networks and communication protocols.

Information processing

NEURO-INSPIRED COMPUTERS

The synapse transmits an electrical message from one neuron to another, adapting the message according to the incoming signal. Researchers have managed to mimic these functions using just one electronic component that combines an organic transistor and gold nanoparticles, as opposed to the seven conventional transistors required until now. Used as neuro-inspired computers, these transistors are able to perform complex functions, such as visual recognition.

| Published in *Advanced Functional Materials*, 22 January 2010

Language processing

YOUR COMPLAINTS DIGITALLY SCREENED

With Feedback Analytics, the thousands of messages sent by customers of large companies can now be deciphered in real time. First marketed in early 2010 by the French start-up Viavoo, the software, developed by computer linguists, has cutting-edge semantic and syntactic analytical tools, artificial intelligence algorithms and an automatic natural language processing engine. This enables Viavoo to 'understand' most of the messages and extract the relevant information they contain.



> Needle probe station for components, chips and microelectronic circuits.

Formal methods

IMPROVING MICROCHIP RELIABILITY

Microchip manufacturers must check their products' reliability before marketing them. To do so, they carry out numerical simulations, a time-consuming process that is applied only to the most frequent situations likely to be encountered when using the chips. Over the past three years, researchers have been working on a more complete chain of verification relying on formal methods, starting with chip description at the transistor level. The advantage of this system is that it validates more scenarios in a shorter period of time. In 2010, the chain was successfully trialled from end to end on the SPSMALL chip marketed by the STMicroelectronics company, one of the world leaders in the semiconductor market.

Mathematical demonstration

Two Fields Medals and the Gauss Prize were the highlights of a highly successful year for French mathematics.

Fields Medal

A MAN WHO COUNTS

Cédric Villani may look like a nineteenth-century dandy, but don't let that

fool you. Behind the elegant clothing and the lavalliere cravat lies one of the most gifted mathematicians of his generation. At the age of 37, he is one of the winners of the 2010 Fields Medal, the equivalent of the Nobel Prize in mathematics. Villani, a renowned researcher and director of the Institut Henri-Poincaré in Paris, didn't always see himself untangling inextricable mathematical problems. In fact, as a schoolboy he wanted to become a paleontologist. However, he found his vocation for mathematics in 1992 when he joined the Ecole Normale Supérieure in Paris. There he met Pierre-Louis Lions, winner of the 1994 Fields Medal, who supervised his doctoral thesis. Villani was awarded the Fields Medal for his recent work which proved the validity of Landau theory, known as Landau damping, on the convergence of plasma to equilibrium without increasing entropy. His results have theoretical and practical applications, especially in astrophysics.

Kinetics

WHEN GEOMETRY CONTROLS CHEMICAL REACTIONS

Does the rate of a chemical reaction depend on the initial position of the reactants? By calculating the time taken by reactants to come into contact with each other in various situations, physicists have shown that, unlike in dilute solutions, where the reaction rate is independent of the initial position of the reactants, in confined and congested environments such as living cells the spatial location of the reactants plays a key role in kinetics.

| Published in *Nature Chemistry*, 18 April 2010

Algebraic structures

PRIME NUMBERS REVEAL A FEW MORE OF THEIR SECRETS

A prime number is a natural integer that cannot be expressed as the product of two smaller numbers. Many arithmetical problems concerning prime numbers remain unsolved today. Two researchers have made a major breakthrough by demonstrating that there are on average as many prime numbers for which the sum of decimal digits is even as those for which it is odd. This finding could lead to applications in numerical simulation and cryptography.

| Published in *Annals of Mathematics*, May 2010

Fields Medal

THE FABULOUS DESTINY OF A MATHEMATICIAN

With a physicist for a father and a doctor for a mother, Ngô Bao Châu was spurred on from an early age by the intellectual ferment of his family environment. As a young man, he quickly developed remarkable analytical skills. At 17, he had already won two gold medals, in 1988 and 1989, at the International Mathematical Olympiad. It was at that time that he left Vietnam and pursued his studies, first at Université Pierre-et-Marie-Curie and then at the Ecole Normale Supérieure. A researcher at CNRS from 1998 to 2004, Ngô Bao Châu became a professor at Université Paris-Sud 11 in 2004. He was awarded the 2010 Fields Medal for his proof of a conjecture, the 'fundamental lemma', which is part of the Langlands program, formulated in 1967 by the famous mathematician of the same name. This theory establishes fundamental links between two distinct fields of mathematics, namely arithmetic and group theory. Granted French citizenship in 2010, Ngô Bao Châu recently joined the University of Chicago, where he continues his research into automorphic forms and representations.

Awards

FEMALE RESEARCHER GOES FOR GOLD

Every year, the Trophée des Femmes en Or is presented to exceptional women from a wide variety of backgrounds. In 2010, Julia Kempe was awarded the prize in the 'research' category. A Berliner of Russian descent, Kempe, who won the CNRS Bronze Medal in 2006, is a computer scientist whose work lies at the interface between physics and mathematics. She is currently working on algorithms for quantum computing.

Awards

FROM THEORY TO PRACTICE

Yves Meyer has been awarded the 2010 Gauss Prize for applied mathematics, not only for his contributions to number theory, operator theory and harmonic analysis, but also for his leading role in the development of wavelet theory and multiresolution analysis, now used in digital coding and image and video compression. Professor emeritus at the Ecole Normale Supérieure in Cachan, Meyer has also developed new algorithms for image compression used by the Herschel space mission.

Telex

INSMI, formerly known as Institut des Sciences Mathématiques (Institute for Mathematical Sciences and their Interactions) has now acquired a national dimension and becomes Institut National des Sciences Mathématiques et de leurs Interactions (National Institute for Mathematical Sciences, INSMI). It is henceforth in charge of missions involving mathematics at the national level.

Action plan for materials

Nanosciences, quantum information and sustainable energy are major development sectors where future scientific initiatives have been identified and included in the agreement on objectives.

Here are just a few projects that CNRS pledged to move forward in 2010.

Quantum information

A NATIONAL LABORATORY WITHOUT WALLS

'Strengthening the development of technologies based on quantum information' is one of the goals set out in the agreement on objectives. It is also the objective of the new research network (GDR), 'Quantum information: foundations and applications'. Created in 2010, this research network, which brings together over fifty laboratories throughout France, has set itself two goals: establish a common knowledge base, and use this as a platform to achieve new scientific advances. This laboratory without walls devoted to quantum information will have a real national dimension.

Alternative energies

MAKING FUEL CELLS SHINE

Launched in 2010, the 'Fuel cell-Systems' research network (PACS GDR) aims to 'explore alternatives to materials produced from scarce raw materials', as laid down in the agreement on objectives. Combining the efforts of 150 researchers from around sixty teams, the mission of the PACS GDR is to elucidate the problems related to the operation of fuel cells and the systems that make use of them. Research focuses in particular on the components of the fuel cell core and of the electrolytic cells (electrolyte, electrodes, etc).

> Grooves on the surface of a monocrystalline gallium arsenide wafer. Seen through a metallurgical microscope in polarized light.

Energy saving

HIGH-LEVEL JOINT RESEARCH

The creation in 2010 of the CNRT Materials (CNRT Matériaux) Joint Service Unit made it possible to combine and strengthen high-level joint research carried out by three laboratories in the specific fields of thermoelectric materials and composite materials, with the aim of saving energy. The creation of the Unit testifies to CNRS's commitment to step up interdisciplinary research into improved energy saving methods, a target laid down in the agreement on objectives.

Nanomaterials reveal their secrets

Although the making of carbon nanotubes holds no secret for scientists, many of their properties remain unsuspected. Here's a brief selection of some recent discoveries.

Molecular dynamics

NANOTUBES' SNAKE-LIKE MOTION

In an environment full of obstacles, long, flexible filaments move forward by using horizontal undulatory progression. But what about stiff or semi-stiff fibers, which can hardly bend to avoid obstacles? To find out, scientists decided to observe the motion of single-walled carbon nanotubes, used as a model for stiff polymers, in aqueous gels. After measuring the rigidity of each nanotube, they filmed its motion at high speed. They concluded that flexibility, however small, plays a vital role in the filament's motion. The filament's undulations due to thermal agitation cause a wriggling effect, considerably accelerating its motion in a crowded environment.

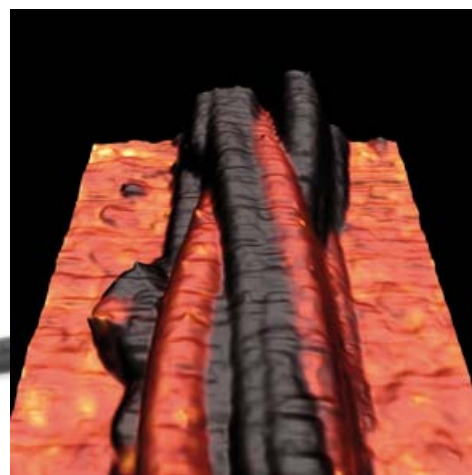
| Published in *Science*, 24 December 2010

Nanofluidics

NO FRICTION BETWEEN WATER AND NANOTUBES

Nanotubes have surprising properties when it comes to transporting water. A team of physicists have discovered why water flows through carbon nanotubes of very small diameter without any friction. These findings, which explain the ultra-rapid flow of water observed in carbon nanotube membranes, open the way to a host of applications in fields such as desalination, ultrafiltration and energy conversion.

| Published in *Nanoletters*, 16 September 2010



> Bundle of carbon nanotubes seen by using scanning tunneling microscopy. The semiconducting tubes (in black, low conductivity) and metallic tubes (in red, high conductivity) can be clearly distinguished. The metal substrate is also shown in red.

Conductivity

SUBSTRATES DON'T TAKE A BACK SEAT

Are carbon nanotubes conductors or semiconductors? Until now, measurements of their conductivity were contradictory. Recent studies using scanning tunneling microscopy on nanotube bundles show that in fact the metal surface on which they rest affects their properties: they are conductors when in contact with the surface, but become semiconductors when separated from it. This fact will need to be taken into consideration when inserting nanotubes into electronic components.

| Published in *Nature Materials*, 17 January 2010

> Newly-formed carbon nanotube fiber in an aqueous solution. It has very strong adsorption properties and good electrical conductivity.

What's new in the **nano** world?

There seems to be no limit to nanotechnologies' applications.
Ecological lubricants and digital coding are just two of many possibilities.

Tribology

TOWARDS THE LUBRICANT OF THE FUTURE

Certain fullerene nanoparticles could be a serious alternative to today's lubrication additives, provided that their behavior can be elucidated. Using the tip of an atomic force microscope mounted on a transmission electron microscope, researchers were able to observe in real time the behavior of an isolated nanoparticle in a dynamic contact. This enabled them to obtain information about its lubrication mechanism: the behavior of the particle varied from a sliding to a rolling motion depending on the applied force and the intrinsic characteristics of the particle.

| Published in *Tribology Letters*, January 2010

Hypersound

PROBING NANOSTRUCTURES INSIDE MATERIALS

Ultrarapid sound waves, also called hypersound, can be used to probe nanostructures inside materials. For the first time, physicists have succeeded in generating, controlling and detecting this type of wave at the nanometer scale by reproducing Bloch oscillations, a physical phenomenon never observed in sound waves before, in a 0.881 micrometer-thick acoustic super-network of fifteen periods. This result could lead to the development of sources of sound pulses with controllable parameters.

| Published in *Physical Review Letters*, 13 May 2010

Interdisciplinary program

MASS PRODUCTION OF GRAPHENE COMES A STEP CLOSER

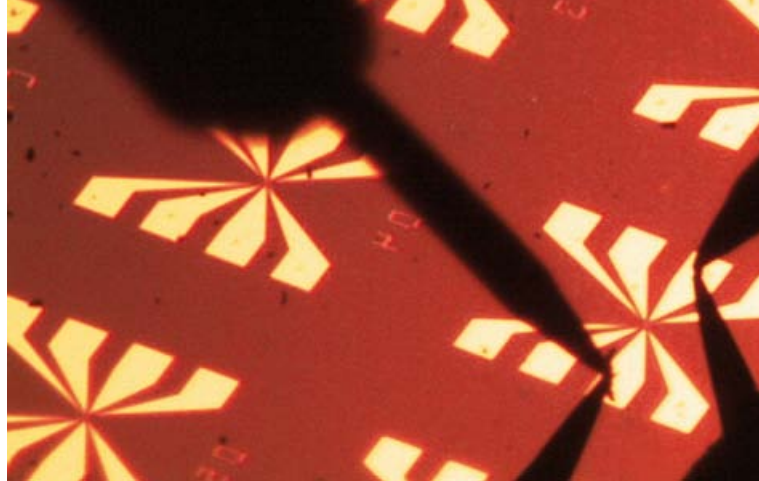
A nanomaterial with a huge number of potential applications, graphene takes the form of sheets of carbon atoms arranged in the same plane in a honeycomb pattern. It is difficult to produce in large quantities, which hinders its use. Researchers have designed, manufactured and tested a prototype that uses microwaves to produce graphene in quantities of around a hundred grams.

This research was funded by the CNRS 'Materials' interdisciplinary research program.

| Published in *Nano Research*, February 2010



> Colorized view of a crumpled sheet of graphene seen through a scanning electron microscope. The discovery of graphene earned Andre Geim and Konstantin Novoselov the 2010 Nobel prize in Physics.



> Optical microscope image of a nanoelectromechanical system (NEMS) in an ultra-high vacuum probe station.

Acoustics

NANOTUBE DEMODULATOR

Detecting radio waves involves recovering the wanted signal contained in the carrier wave. To carry out this so-called demodulation stage ultrasensitively and at very high speed, researchers have designed a nanoelectromechanical system whose active component is a single nanotube. This mechanism naturally produces 'zero' or 'one' signals, which are essential for digital coding, and can reach a data-transfer rate exceeding the GSM mobile phone standard.

| Published in *Small*, 7 May 2010

Technical innovation

NANO-COATINGS IN A SPRAY APPLICATION

Invented around fifteen years ago, a so-called 'layer by layer' technique for depositing nano-materials makes it possible to design nano-coatings with extremely varied properties. However, this method required successive dippings and long deposition times. Chemists and physical chemists have now made this technique more powerful and easier to apply. By using bottles, they can spray two liquids simultaneously on the surface to be coated. The potential advantages in terms of time saving and logistics are considerable. Better still, this technique can be applied to completely new types of materials, such as purely inorganic films. The introduction of biologically active molecules into these films opens the way to medical applications, such as implant biocompatibility, pharmaceutical carriers, etc.

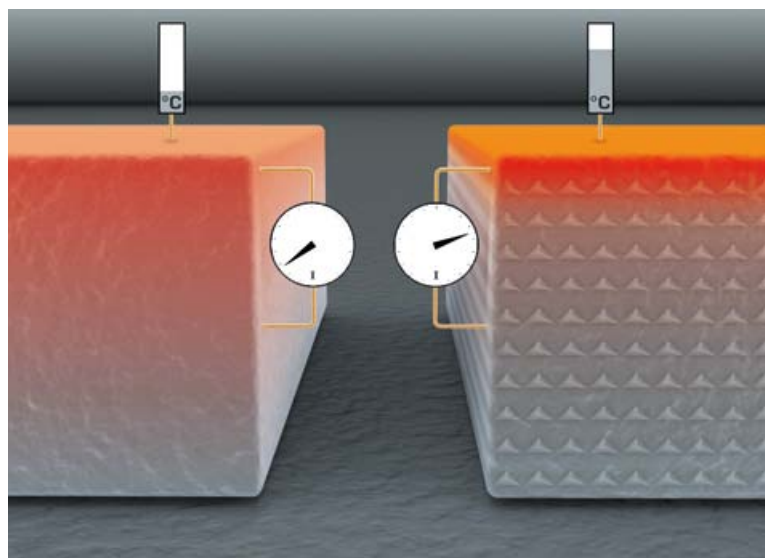
| Published in *Angewandte Chemie International Edition*, 23 November 2010

New materials

BIRTH OF A SUPER-INSULATOR

Good thermal insulators are always good electrical insulators. However, for certain applications, it would be useful if these two properties could be separated. Scientists have taken a decisive step in this direction by developing a thermal super-insulator that can conduct current. The new material, which was developed using nanostructuring, is made up of a silicon matrix enriched with a network of germanium 'nano-islands'. These nano-islands increase the thermal insulating performance of the silicon a hundredfold without altering its electrical conductivity. Such materials could facilitate the production of electricity from a heat source, for instance by generating current from the heat released by a car exhaust pipe, thus reducing its fuel consumption.

| Published in *Nature Materials*, 2 May 2010



> Artist's impression of a new nanomaterial (right), made up of a silicon matrix enriched with a network of germanium nano-islands, which make it a good thermal insulator. On the left, conventional silicon.

Optics looks ahead

Fiber optics has revolutionized telecommunication networks. Further revolutions such as quantum optics and ultra high-speed imaging are underway.

Information processing

OPTICAL INFORMATION PROCESSING GETS CLOSER

Using micrometer-sized 'photonic wires', physicists have managed to condense polaritons, hybrid particles that are half light and half matter, into a single quantum wave. In addition, these light-matter condensates are able to interact. This brings the development of polariton circuits one step closer, which could lead to ultrafast, entirely optical information processing.

| Published in *Nature Physics*, 29 August 2010

> Scanning electron microscope image of photonic wires in which polariton condensates are generated. An artist's impression of examples of measurements showing the formation of extended condensates is superimposed along the edges of the wires.

Radiation

TERAHERTZ WAVES EASY TO DETECT

Quantum cascade lasers (QCL) have great potential as new sources of terahertz (10^{12} hertz) waves, a radiation with a huge number of potential applications. Yet, detecting these waves rapidly and sensitively at room temperature remains tricky. By coupling a QCL to a femtosecond (10^{-15} second) laser, researchers have managed to show that detection similar to that of radio waves, i.e. in the megahertz range, can be extended as far as the terahertz range.

| Published in *Nature Photonics*, 20 June 2010



Theoretical physics

WHEN LIGHT MAKES LIGHT OF OBSTACLES

Superfluidity, which has been known for about a century, is a state of matter in which obstacles have no effect on the flow of a fluid. Theoretical physicists have shown that, under certain conditions, this effect can apply to the propagation of light, if it takes place in a non-linear medium where the refractive index depends on light intensity. In addition, this novel 'superfluid light' effect can easily be shown using a photonic crystal.

| Published in *Physical Review Letters*, 14 October 2010



Miniaturization

REVOLUTION IN ULTRA-HIGH-SPEED IMAGING

First developed in the 1950s, streak cameras, which are able to measure ultra-high-speed luminous phenomena and display them as a function of time, have reached maturity but remain expensive and bulky. Now, scientists have succeeded in miniaturizing them. They worked on specific sensor structures that can replicate the functionality of a conventional streak camera on an integrated circuit. They demonstrated the feasibility of the concept by developing demonstrators, using cheap standard CMOS technologies. Performance has been extremely promising, with a spatial resolution of 20 micrometers and a temporal resolution of less than a nanosecond. This opens the way to potential marketing prospects for this technology, which has scientific, medical and industrial applications.

| Published in *Measurement Science and Technology*, 6 October 2010

Photons

BRIGHT FUTURE FOR ENTANGLEMENT

At the heart of applications such as quantum cryptography lies a phenomenon known as 'entanglement'. Two photons are entangled when the properties of one depend on those of the other, whatever the distance separating them. Now, researchers have developed a light source of entangled photons twenty times brighter than any existing systems, using a novel 'photonic molecule' system, which traps each of the photons in the pair and makes it possible to collect them efficiently. This could pave the way for faster quantum communication.

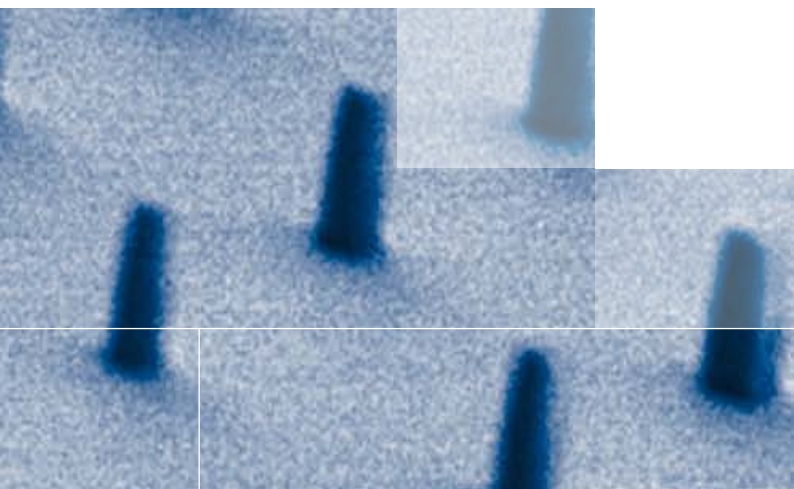
| Published in *Nature*, 8 July 2010



Awards

SPOTLIGHT ON QUANTUM OPTICS

Alain Aspect, a renowned specialist in quantum optics and 2005 CNRS Gold Medal laureate, is one of the winners of the 2010 Wolf Prize in physics. This prestigious award recognizes in particular the fundamental research carried out in 1982 by Aspect and his team. Their work confirmed the revolutionary nature of quantum entanglement, intuited by Einstein forty-seven years earlier.



Into the heart of matter

Using ever more sophisticated analytical methods, scientists can now observe unstable molecules never described before, or detect infinitesimal amounts of matter.

Entrapment

A RECIPE FOR STABILIZATION

Quinones are organic molecules with unusual physical and chemical properties. Their sulfur and selenium analogs are so unstable that they had never been isolated before. For the first time, chemists have succeeded in stabilizing them. To do so, they developed a novel method of synthesis that uses organometallic fragments as ligands to trap these reactive compounds. The chemists are now faced with the challenge of developing chiral versions of these new molecules in order to enhance their anti-tumor activity.

| Published in *Angewandte Chemie International Edition*, 4 October 2010

Molecular dynamics

MOVING MOLECULES INSIDE GLASS

Although it has long been known how to bring about the motion of molecules in solids such as photochromic glass, it was not yet clear why or how they moved. It is now. Using molecular dynamics simulation, researchers have shown that the light-induced diffusion of matter in these glasses is similar to that occurring in the liquid state. In order to move, every molecule has to wait for one of its neighbors to travel. Cooperative motion, where all the molecules move together, is then observed.

| Published in *Journal of Chemical Physics*, 23 July 2010

Molecular structure

REVEALING THE INDESCRIBABLE

By using a specially adapted nuclear magnetic resonance (NMR) technique, researchers have succeeded in rapidly and effectively characterizing organic compounds present in tiny amounts on the surface of organic-inorganic hybrid materials. Based on the fifty-fold NMR signal amplification of carbon-13 atoms, this revolutionary process makes it possible to gain access to the molecular structure of surface compounds without prior labeling.

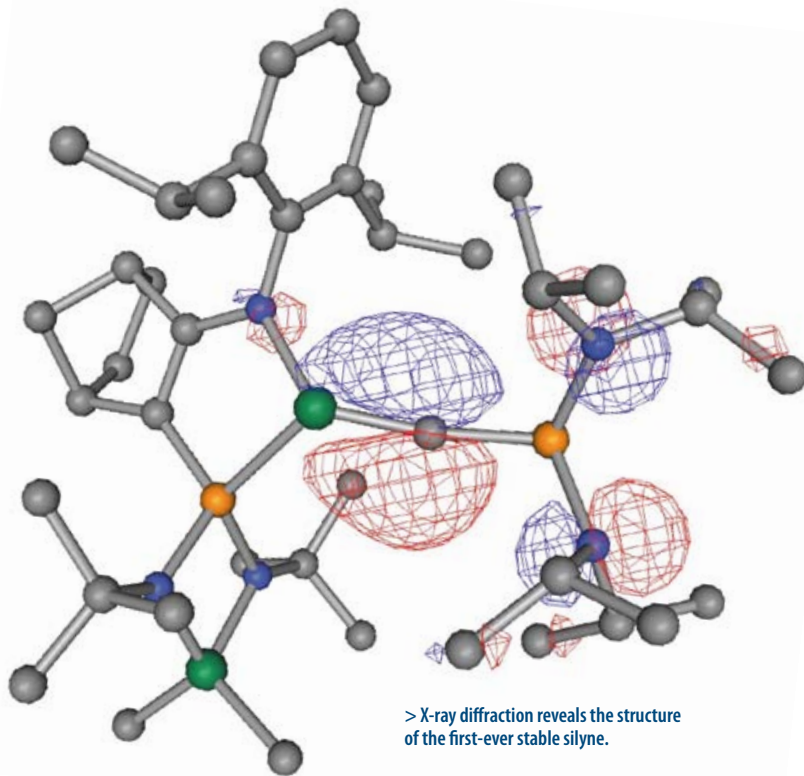
| Published in *Journal of the American Chemical Society*, 10 September 2010

Chemical reactivity

SYNTHESIS OF THE FIRST STABLE SILYNE

A product of silicon chemistry, silynes have a silicon-carbon triple bond that makes them highly unstable. Until now, they had only been observed under extreme conditions. By using a phosphine ligand to stabilize the triple bond, researchers have managed to isolate the first-ever stable silyne and characterize its molecular structure by using X-ray diffraction. An added bonus is that carbon atoms bonded to silicon in this way show unusual reactivity.

| Published in *Angewandte Chemie International Edition*, 30 July 2010



> X-ray diffraction reveals the structure of the first-ever stable silyne.

Self-organization

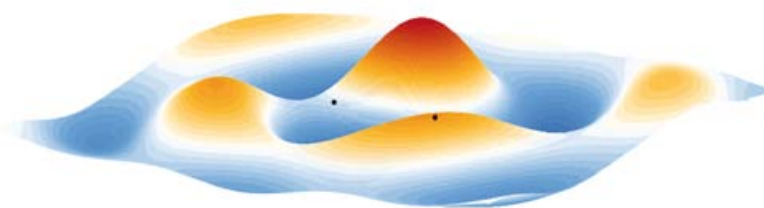
THE STRUCTURE OF CYCLOBUTADIENE REVEALED AT LAST

Cyclobutadiene is highly reactive: once synthesized, it instantly combines with itself or with other similar molecules. Because of its extremely unstable nature, its crystal structure had never been determined directly. Researchers have now developed a supramolecular self-organization technique aimed at designing cyclobutadiene 'traps' that do not disturb X-ray analysis. This enabled them to stabilize the molecule long enough to reveal its square and rectangular structures. This work shows that a suitable matrix could make it possible to trap unstable molecules and control their reactivity, which would allow chemical reactions that cannot be obtained at this stage.

| Published in *Science*, 19 November 2010



> Sectional view, seen through a scanning electron microscope, of a laser diode produced using molecular-beam epitaxy, chemically etched to obtain a column-shaped laser.



> Spatial distribution of a valence electron in a dinitrogen molecule, $1\,500 \pm 300$ attoseconds after being excited by a powerful laser. The dots show the position of the nitrogen atoms within the molecule.

Quantum chemistry

IMAGES OF ELECTRONS IN MOTION

Most of the methods used to measure the distribution of electrons in an atom or a molecule do not allow their motion to be observed. Is this because they move too fast to be seen? Not quite. Physicists have now taken the first-ever 'snapshot' of electrons in motion inside a molecule. The image was obtained by analyzing the X-rays emitted by molecules excited by an intense laser pulse.

| Published in *Nature Physics*, 1 March 2010

Matter in all its states

Self-propelling micro-objects, electronic synapse, molecular-scale information storage: when researchers tame matter, mind-boggling discoveries are at hand.



> Due to the phenomenon of supercooling, water doesn't freeze inside clouds even though the temperature is below 0 °C. The reason for this is probably related to the way atoms are arranged in liquids.

Phase transition

WHY DOESN'T WATER FREEZE INSIDE CLOUDS?

Water in clouds doesn't freeze because of supercooling, a state of matter in which liquids do not solidify even though they reach a temperature below their freezing point. The usual explanation for this is that the atoms in such liquids are arranged in pentagons, a structure that cannot be repeated periodically to fill up an entire space. As a result, they cannot form crystals. This hypothesis has now been confirmed in the laboratory by using synchrotron radiation to study a silicon-gold alloy in the liquid state.

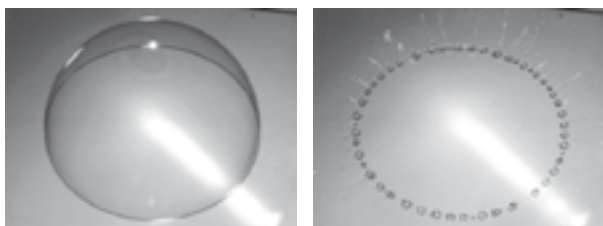
| Published in *Nature*, 22 April 2010

Superconductivity

A MAGNETIC ORIGIN?

Before becoming superconductors, certain so-called 'high critical temperature' materials go through an intermediate phase, which shows novel magnetic properties. One theory postulates that this phase results from the spontaneous formation of tiny loops of electric current below a certain temperature. Physicists have now confirmed this theory by observing hitherto unsuspected magnetic excitation that only exists in the intermediate phase.

| Published in *Nature*, 11 November 2010



> Instead of simply disappearing, a bubble that bursts on a solid surface breaks down into a ring made up of many smaller-sized bubbles.

Physical mechanisms

HOW DO BUBBLES BURST?

By using a high-speed camera to film the bursting of bubbles in contact with a liquid/gas or solid/gas interface, researchers have discovered and modeled the mechanism: the liquid film retracts, leading to the formation of a curved tube closed in on itself. This structure is unstable and breaks down into a ring made up of bubbles that are smaller than the initial bubble, which in turn leads to a cascade of bursting bubbles. This work could benefit industrial processes such as glass production.

| Published in *Nature*, 10 June 2010

Information processing

TOWARDS A MOLECULAR HARD DISK

Researchers have long dreamt of storing binary information, as on hard disks, at the molecular scale in order to increase storage capacity. The dream has come true, thanks to a molecule made up of iron and cobalt atoms which, via light- and temperature-induced electron transfer, can exist in two distinct, stable magnetic states. One step closer to the hard disks of the future.

| Published in *Angewandte Chemie International Edition*, 21 April 2010



Awards

STATISTICAL PHYSICS TAKES PRIDE OF PLACE

Awarded every three years, the Boltzmann Medal, the highest distinction in statistical physics, was bestowed in 2010 upon the physicist Bernard Derrida for his whole career. His best-known work focuses on disordered systems known as spin glasses, which are metallic alloys containing a small number of randomly distributed magnetic impurities, and for obtaining exact solutions for non-equilibrium prototype models.



Molecular machines

A PROPULSION SYSTEM BASED ON SELF-REGENERATION

Using a novel approach called bipolar electrochemistry, researchers have managed to induce directional motion of metallic micro- and nano-objects. When an electric field is applied to the objects, their ends become oppositely charged. This polarization is high enough to bring about opposing redox chemical reactions on each side. The metal structure is oxidized and dissolves at one end, while at the other end the object expands by reduction, forming a metal deposit. This sort of continuous self-regeneration causes the object to move at a speed of the order of a hundred micrometers per second. The technique, which does not require a conventional fuel to induce the motion, opens up new prospects in various fields, ranging from micromechanics to nanomedicine.

| Published in *Journal of the American Chemical Society*, 21 October 2010

> Example of propulsion of a zinc dendrite.

The energy of the future

In order to reduce consumption of fossil fuels in our societies, scientists are constantly breaking new ground in fields such as photovoltaics, biofuel cells and the recycling of nuclear waste.

Photovoltaic cells

TOWARDS CHEAP, MORE EFFICIENT CELLS

Making solar cells competitive means improving the efficiency of conversion of solar energy into electricity, which remains poor. By using low-temperature plasma processes, researchers have developed silicon nanowire radial junction solar cells. They consequently increased the efficiency of this technology from 1% to 6%, opening the way to the development of cheap, high-efficiency cells.

| Published in *Solar Energy Materials and Solar Cells*, 10 July 2010

Rapid storage

BREAKING THE CHAINS OF MOBILE ELECTRONIC DEVICES

Researchers have developed new electronic components for on-chip energy storage by deposition on gold microelectrodes of pure carbon nano-onions, allowing extremely rapid ion exchange. The power of these fingernail-sized micro-supercapacitors is up to 4,000 times greater than that of commercially available miniaturized batteries, although they have an equivalent storage capacity. They should help to meet the demand for greater autonomy of mobile electronic devices.

| Published in *Nature Nanotechnology*, 15 August 2010

Awards

BETTER MANAGEMENT OF RENEWABLE ENERGY USE

The RIDER project (Réseau et Interconnectivité

Des Energies classiques et Renouvelables—Conventional and renewable energies network and interconnectivity) is an innovative information system aimed at optimizing the energy efficiency of a group of buildings. The system will allow exchange of energy between different buildings by integrating various types of energy, both conventional and renewable. The system, which won the Digital Green Growth Prize in the 'Research' category in November 2010, will soon be tried out at three pilot sites.



> Solar panels.

Telex

GUINEVERE, the model of the world's first demonstrator of Accelerator Driven Systems (ADS) for the incineration of nuclear waste, was inaugurated in March 2010 in Mol, Belgium.



Awards

AWARD-WINNING SCIENTIST MAKES SPARKS FLY

The Combustion Institute's Ya B. Zeldovich Gold Medal, the highest international distinction

in the field, was awarded to Sébastien Candel at the 33rd International Symposium on Combustion, held in Beijing in August 2010. Candel, who is a professor at the École Centrale de Paris and at the Institut Universitaire de France, and winner of the 1993 CNRS Silver Medal, has worked for over thirty years on understanding the dynamics and structure of flames.

Energy storage

PUSHING BACK THE FRONTIERS OF MINIATURIZATION

Using processes that are compatible with microfabrication techniques, chemists have formed, on the surface of a titanium carbide sample, a film of porous carbon with a very large specific surface area. The energy density stored in one-micrometer-thick films is multiplied threefold in comparison with conventional supercapacitor electrodes. These results pave the way for the production of micro-supercapacitors with high energy densities that will be easier to incorporate into miniaturized electronic systems.

| Published in *Science*, 23 April 2010

Renewable energy

THE MOST POWERFUL BIOFUEL CELL EVER MADE

Improving the performance of biofuel cells requires the development of electrodes that are not only small, in order to reduce transport of matter, but that also have a very large surface area. Current research thus faces the challenge of increasing electrode porosity, which means extending electrodes' reactive surface area without changing their dimensions. The challenge has been taken up by chemists, who have designed microelectrodes from highly-porous carbon nanotube fibers. By using them as both the anode and cathode of a glucose/O₂ biofuel cell, they have obtained the smallest and most powerful biofuel cell ever developed: it generates an electric current with a power of 740 $\mu\text{W}/\text{cm}^2$. These novel electrodes could be incorporated into future devices such as the biofuel cells used to power medical sensors.

| Published in *Nature Communications*, 12 April 2010



> Insertion of a biofuel cell into a living plant, in this case a euphorbia. Made up of two enzyme-modified electrodes, it operates by using the products of photosynthesis: glucose and dioxygen (O₂).

Cascade of collisions

The international physics community pursues its research into particles, in a bid to understand the fundamental laws that govern the Universe. A milestone was reached in 2010 when the Large Hadron Collider (LHC) was ramped up to its experimental operation phase and carried out its first high-energy collisions.

High-energy physics

FIRST HIGH-ENERGY COLLISIONS AT THE LHC

2010 has been a busy year at the Large Hadron Collider (LHC). The main goal was to collide two beams of very high-energy particles traveling at enormous speed and in opposite directions around the huge ring. Mission accomplished on 30 March: the world's most powerful particle accelerator produced its first proton collisions at the record energy level of 7 TeV. This takes scientific research into hitherto unexplored areas of the fundamental laws that govern the Universe. Very high energy research aims to obtain experimental data that might fill in some of the gaps in the Standard Model, the theory describing the interactions between the elementary particles that make up matter. Then on 4 November 2010 collisions between heavy ions (lead ions) got underway. By producing a tiny amount of the primordial matter known as a quark-gluon plasma, the scientists are hoping to get a glimpse of matter as it existed in the very first instants of the Universe. This could help them to understand how it evolved into the matter that makes up the Universe today.

> View of the CMS detector at the LHC.

Nuclear physics

A SPECTROMETER OF UNRIVALLED PERFORMANCE

The AGATA demonstrator, a next-generation gamma-ray spectrometer, was inaugurated in Italy in April. The demonstrator, whose purpose is to validate the technical aspects of the instrument, consists of five triple clusters of detectors made of ultra-pure germanium, making up around 10% of the number of detectors in the final spectrometer once completed. The spectrometer should be up and running at GANIL in two or three years' time. With a much greater sensitivity than current equipment, AGATA will be used to study the behavior of nuclei in extreme states and the structure of so-called 'exotic' nuclei, which are very unstable.

OPERA

DETECTION OF THE FIRST TAU NEUTRINO?

The OPERA experiment, located in Italy, has probably detected its first tau neutrino. It could result from the transformation, during their 730 kilometer journey, of one of the many muon neutrinos beamed from CERN. The observation of several events of this kind could represent long-awaited direct evidence of neutrino oscillation, thus opening the way to new physics beyond the Standard Model.

Quantum physics

SIZE OF THE PROTON REVISED DOWNWARDS

A new, extremely accurate measurement of the radius of the proton could challenge certain predictions of quantum electrodynamics. The measurement was obtained by using muonic hydrogen, in which the electron that normally orbits the proton is replaced by a muon. According to the laws of quantum physics, the muon should orbit two hundred times nearer the proton than an electron does. This makes it much more sensitive to the size of the proton. By measuring the binding energy of the muon in the atom with a specially-designed infrared laser, researchers were able to calculate the radius of the proton ten times more accurately. They obtained a result of 0.8418 femtometers (10^{-15} meter), as compared to 0.877 femtometers using electrons. The challenge now is to explain this discrepancy.

| Published in *Nature*, 8 July 2010

Telex

The very latest results of experiments in high-energy physics were unveiled at the prestigious ICHEP 2010 international conference, held from 22-28 July in Paris by the French scientific community. The French head of state addressed the conference on 26 July.

Particle physics

LOW MASS FOR THE HIGGS BOSON?

The Higgs boson remains the only particle predicted by the Standard Model that has never been observed to date. According to the latest measurements carried out by researchers studying proton-antiproton collisions at the Tevatron in Chicago (over 500,000 billion collisions since 2001), the Higgs boson, if it exists, should have a mass lying most probably somewhere between 114 and 158 GeV/ c^2 .

| International Conference on High Energy Physics (ICHEP), 26 July 2010

Neutrinos

T2K STARTS TO COLLECT DATA

On 24 February, the Super-Kamiokande detector, based on the west coast of Japan, detected its first muon neutrino, which had traveled all the way from JPARC, situated 295 kilometers away on Japan's east coast. This event marks the beginning of physical data collection for the T2K experiment, which aims to study neutrino oscillations.

> Artist's impression of a hydrogen atom. The nucleus is made up of a proton (in pink), around which orbits an electron (green wavy line). By replacing the electron with a muon, the researchers were able to measure the size of the proton more accurately.

Probing the Universe

Elucidating the subtle mechanisms at work on our planet, exploring the Universe, and understanding the origins of life requires not only to use research results from space missions but also to develop both ground-based and space-borne large observation instruments. The agreement on objectives concluded with the French Government sets out a number of priority areas in these fields. Here is just a small selection.

Wide field telescope

VIEWING THE UNIVERSE AT HIGH RESOLUTION

CNRS is actively involved in the design of the Large Synoptic Survey Telescope (LSST), scheduled for launch in Chile in five years' time. In 2010, the public-private sector international consortium responsible for funding this wide field telescope validated the French proposal to design a series of electronic components for the camera that is to be mounted at the prime focus of the telescope. Another significant French contribution to the project is the design and production of validation chains for the matrices of the LSST's CCD sensors. This reflects CNRS's commitment to contribute to the design and launch of wide field telescopes.

Universe Sciences Observatories

UNRAVELING THE 'EARTH SYSTEM'

As well as carrying out research, the Universe Sciences Observatories (Observatoires des sciences de l'Univers (OSU)) support observation activities by ensuring the preservation of data resulting from these observations. They are therefore a useful tool for the development of integrative approaches aimed at elucidating the Earth System, one of the targets highlighted in the agreement on objectives. It was from this perspective that the OSU 'Earth-Humans-Environment-Time-Astronomy' (THETA) was inaugurated in May 2010, in the French region of Franche-Comté. It brings together various environmental themes.

Interdisciplinary program

UNDERSTANDING THE ORIGINS OF LIFE

By supporting research areas including the characterization of exoplanets, the study of life forms and of biological or prebiotic molecular systems, as well as modeling approaches, the 'Planetary Environments and Origins of Life' program (EPOV) contributes, as stipulated in the agreement on objectives, to the development of a scientific community focusing on deciphering the origins of life, both on Earth and on other planets. In 2010, 26 projects from a wide range of scientific communities, such as the epistemology of science, photochemistry, and the origin of terrestrial planets, were supported financially by CNRS to the tune of €300,000.

> Viewing extremely large images with the WILD platform (Wall-sized Interaction with Large Datasets).

Earth on the move

The earthquakes in Haiti and Chile in 2010 are still fresh to the memory. Such dramatic earthquakes are a reminder that the surface of the Earth is like a giant jigsaw, whose pieces move around or bump into each other, driven by plate tectonics.

Haiti

ANALYSIS OF A DEVASTATING EARTHQUAKE

On 12 January 2010, Haiti was struck by one of the most deadly earthquakes in history. Thanks to data from the GPS network set up in 2003 near Port-au-Prince, researchers knew that the Enriquillo-Plantain Garden fault that caused it had remained locked since the last major earthquake in the region, in 1751. Elastic deformation had built up since then, before suddenly giving way. In February, as part of a post-earthquake mission at sea, researchers deployed 21 seafloor seismometers off the Haitian coast. These made it possible to record the very low magnitude aftershocks that took place in the rupture zone area in the weeks that followed the earthquake. The seismologists were therefore able to pinpoint their characteristics and quantify the remaining risks over the next few years.

Expedition

INVESTIGATING AN UNUSUAL MID-OCEAN RIDGE

A new type of non-volcanic seafloor was discovered in the south-west Indian Ocean in 2003. The magma-poor mid-ocean ridge, which is described as being 'ultra-slow' since its spreading rate is a mere 15 mm/year, was studied from every angle during the SMOOTHSEAFLOOR campaign in October 2010. Scientists reached the conclusion that in this region of the planet, the mid-ocean ridge is characterized by a complex system of faults that lays bare the rocks of the mantle.

| Indian Ocean, 2 October-2 November 2010



Chile

A PREDICTABLE DISASTER

With a magnitude of 8.8, the Chile earthquake of 27 February 2010 struck the surroundings of the city of Concepción, on a seismic gap that had long been studied by French geophysicists. Shortly after the earthquake, the scientists arranged to come with their mobile observation equipment and lend a helping hand to their Chilean colleagues in the field. Crossed by a fault, the area was at high risk since it had experienced no major earthquake in the previous 175 years. During that period, the researchers estimated that 12 meters of deformation had built up along 400 kilometers of the fault, which led them to fear the worst.

> Setting up a GPS receiver and a seismic station equipped with an accelerometer at Cerro Negro, north of Santiago, Chile, after the earthquake of 27 February 2010.

Anatomy of the Earth

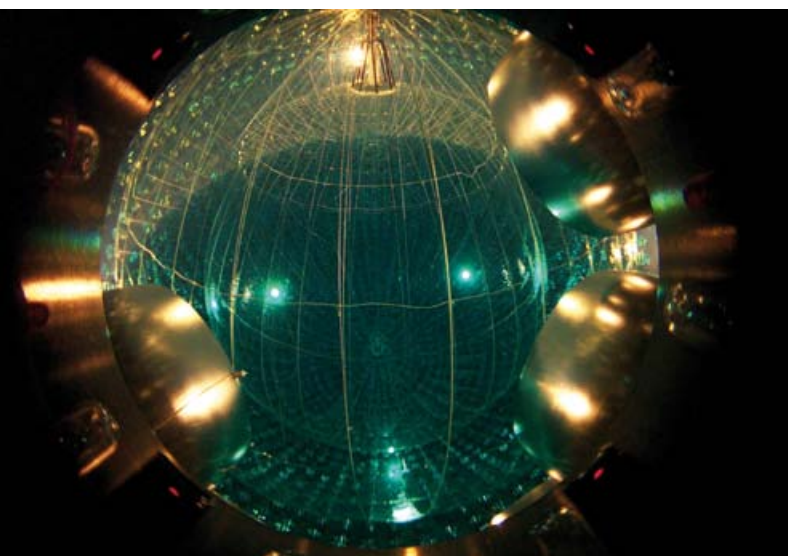
The internal structure of our planet still holds many secrets. Through widely varying approaches, such as combining numerical models with geophysical data or using cosmic-ray particles, researchers have managed to shed light on some of the processes at work.

Magnetic field

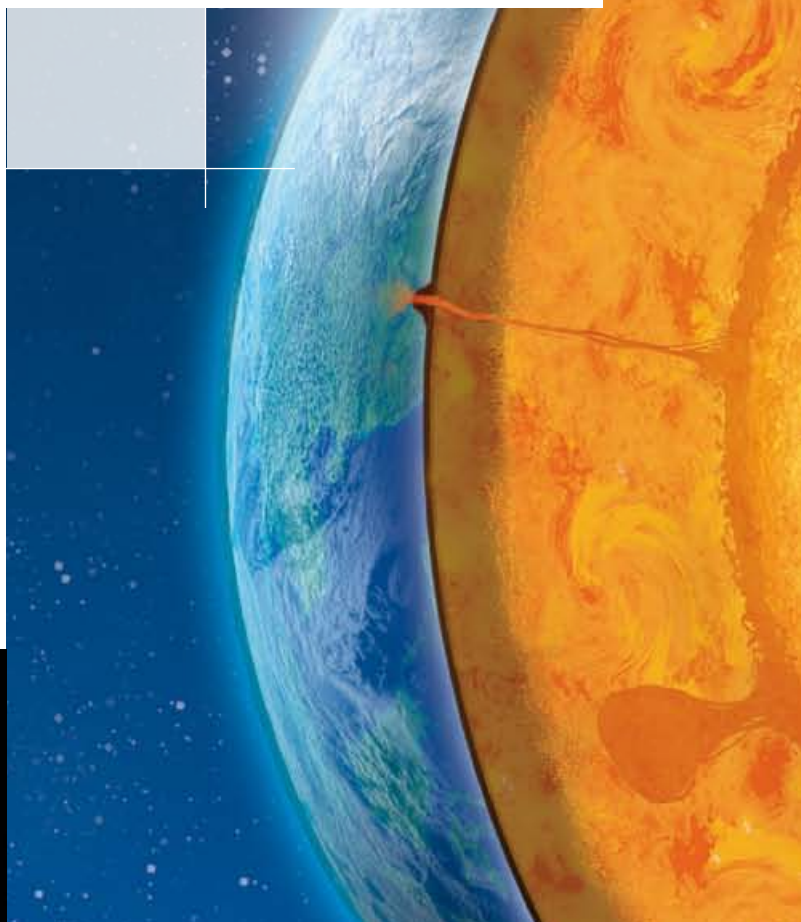
ACCURATE ESTIMATION OF EARTH CORE'S MAGNETIC FIELD GETS CLOSER

Although scientists know how to measure the magnetic field at the surface of the Earth, a reliable assessment of its intensity within the liquid outer core, where it originates, is an elusive goal. By combining numerical models and geophysical data in a novel approach that uses geomagnetic data assimilation, researchers have managed to reconstruct the flow in the liquid core. Their study reveals the existence of a fast torsional wave, which takes four years to travel from the edge of the solid inner core to the outer core equator. This time lapse can be used to estimate the strength of the magnetic field in the liquid core as being a few millitesla, which is in line with predictions. This value should make it possible to determine the Earth's energy budget more accurately.

| Published in *Nature*, 6 May 2010



> The detector of the international Borexino experiment, in the Italian Alps (Gran Sasso), has observed geo-neutrinos produced deep inside our planet.



Geothermal energy

NO CENTRAL HEATING IN THE EARTH'S CORE

The geo-neutrinos recently detected by the Borexino experiment have shed light on our planet's internal heating system. These particles are produced by decay of the uranium and thorium present in the Earth's successive layers. While their detection confirms the radioactive origin of a large proportion of the Earth's internal heat, it clearly rules out the hypothesis of a nuclear reactor at the center of the Earth.

> Anatomy of the Earth: the solid inner core lies at the center. Around it are the liquid outer core, the lower mantle and finally the upper mantle.



Interdisciplinary program

> The dome of La Grande Soufrière volcano, in Guadeloupe, seen from the volcano observatory. The dome, which first formed in 1530, is undergoing intense hydrothermal alteration that is threatening its stability.

A TELESCOPE THAT MONITORS VOLCANOES

Using cosmic-ray particles that penetrate into the Earth to scan volcanoes, just as X-rays are used to scan the human body, is the purpose of the DIAPHANE project. A first prototype telescope, set up near La Grande Soufrière volcano, in Guadeloupe, relies on cosmic-ray muons to monitor the magma in the volcano. The first tomographic image thus obtained will provide valuable clues about the zones of weakness in the volcanic dome.

The project is funded by CNRS's 'Particles and Universe: observation, data and information' interdisciplinary research program.

Inner core

SOLIDIFYING ON ONE SIDE, MELTING ON THE OTHER

The inner core, a ball of metal 2,400 kilometers in diameter, is surrounded by a layer that is denser than the liquid core in which it is immersed. A study has found that this dense layer is the result of a crystallization and melting process associated with thermal convection from west to east: the inner core crystallizes on one side and melts on the other, and the molten liquid spreads around the inner core forming the dense layer. The researchers have also shown that the latter does not completely mix with the liquid outer core.

| Published in *Nature*, 5 August 2010

Experimental geophysics

UNVEILING THE DEEP MANTLE

What goes on at the Earth's core-mantle boundary? Geophysicists are inclined to believe that partial melting of the mantle takes place there. They have now verified this hypothesis by exposing representative microsamples of the mantle to the temperature and pressure conditions that exist at the core-mantle boundary, 2,900 kilometers below the Earth's surface. Using X-ray diffraction at the synchrotron facility in Grenoble, they have shown that under these conditions, partial melting of the mantle occurs when temperatures reach 4,200 kelvins, which corroborates the hypothesis of a deep magma ocean.

| Published in *Science*, 17 September 2010

Protecting the environment

Helping to design cleaner car engines, making some manufacturing processes less polluting, or predicting the extent of major flooding: these are just some of the challenges that researchers are taking up in order to win the battle of the environment.

Plastics

AN ENVIRONMENTALLY FRIENDLY CATALYST

Hydrocarbon polymerization reactions, which form the basis of plastics production, require catalysts that are either toxic or expensive. Now, researchers have developed a new catalyst based on alumina, a widespread, non-polluting material, and have deciphered how it works. This research represents another step towards new, cleaner and more efficient catalysts.

| Published in *Angewandte Chemie International Edition*, 30 September 2010

Awards

ECO-FRIENDLY BUSINESSES WIN AWARDS

This year, the Pierre Potier Prize was awarded to five businesses,

two of which work in close collaboration with CNRS laboratories. In the 'Processes' category, a prize went to Pierre Fabre Dermo-Cosmétique for a novel molecule used to treat atopic dermatitis, called Sélectiose®, which is the result of a long collaboration with a CNRS laboratory. In addition, Innoveox was awarded a medal in the 'Start-up' category for hydrothermal oxidation in supercritical conditions, an environmentally-friendly solution patented by CNRS for the treatment of hazardous waste.

Catalysis

IMITATING NATURE

Natural enzymes are generally able to directly synthesize the useful form of a molecule. However, the number of enzymes available to carry out reactions of industrial interest is limited. Conversely, chemical catalysts can be used to perform a large number of reactions, but often lack specificity. Hence the idea of creating artificial metalloenzymes, complexes made up of an inorganic catalyst and a protein, which can produce the required molecules at a lower environmental cost. This is what researchers have now done, subsequently using X-ray crystallography to observe the active site of their metalloenzyme. In this way, they managed to observe the key steps in oxygen activation, a process essential to life. This work should play a valuable role in the development of tomorrow's catalysts.

| Published in *Nature Chemistry*, 10 October 2010

> Underwater view of a red mangrove (root) *Rhizophora mangle* in the Xel Ha lagoon in the state of Yucatan, Mexico.



> 3D Lidar topographic images (raw data points) of the same part of the urban area of La Faute-sur-Mer, France. In the bottom view, the area in blue shows the flooding caused by sea levels, an event that occurs roughly every twenty years. The large number of flooded houses is clearly visible.

Climate hazards

ASSESSING RISKS OF FLOODING IN A COASTAL AREA

Using an airborne laser scanner acquired as part of the interregional CLAREC project, scientists have drawn up the most detailed-ever topographical map of part of La Faute-sur-Mer, one of the urban areas flooded in February 2010 during the Xynthia storm. With a map of this kind showing the tiniest details on the ground, it is possible, with the help of hydrodynamic models, to specify the extent of flooding, pinpoint flooded houses and estimate water depths for each dwelling.

Transport

TOWARDS CLEANER CARS

When it comes to curbing pollution, today's most promising engines, called HCCI (Homogeneous Charge Compression Ignition) engines, work by compressing a homogeneous mixture of fuel and oxygen, which ignites spontaneously. However, to design such engines, it is necessary to determine at what stage, in the chain of chemical reactions, the auto-ignition process occurs. By continuously injecting butane and oxygen into a reactor, chemists have reproduced the conditions that precede auto-ignition in an engine. Using equipment of their own making together with analytical chemistry methods, they have highlighted the key role played by a family of hydrocarbons, the keto-hydroperoxides, which form the foundation of the model used by theoreticians to describe combustion. This result could prove crucial for the future of the HCCI engine.

| Published in *Angewandte Chemie International Edition*, 19 April 2010

Telex

The French National Alliance for Environmental Research (AllEnvi), set up on 9 February 2010, now gathers twelve players in French scientific research, including CNRS, and focuses on food, water, climate and land-use related issues.

Greenhouse gases

under close

surveillance

Largely responsible for the enhanced greenhouse effect, the carbon dioxide (CO₂) produced by human activity is the subject of much scientific scrutiny. While certain farming strategies might mitigate greenhouse gas emissions, curbing CO₂ emissions in cities could lead to the creation of many new jobs.

Gold Medal

AN ARCHITECT OF MATTER WORKING FOR THE ENVIRONMENT

G rard F rey is an architect of the infinitely small whose achievements are best seen through an electron

microscope. A member of the French Academy of Sciences and Professor Emeritus at Universit  Saint-Quentin-en-Yvelines, F rey, a physical chemist, has been awarded France's highest scientific distinction for his innovative work in designing a new class of hybrid porous solids that combine organic and inorganic materials. F rey first became

interested in this cutting-edge field in 1996 when he set up the Institut Lavoisier in Versailles. By bringing together physics and chemistry, he and his team succeeded in designing crystallized porous solids with remarkable properties, such as MIL-101, whose nanometer-sized 'cages' can be used to store up to 400 times its volume of gas. This material, patented by CNRS, could in particular be used to trap the carbon dioxide emitted by factory chimneys.

Every year, CNRS also awards Silver Medals to experienced researchers and Bronze Medals to promising young researchers. The CNRS 'Crystal' Award honors engineers and technicians for outstanding contributions to the promotion of knowledge and scientific discovery.

All 2010 award winners are listed on www.cnrs.fr/fr/recherche/prix.htm

> MIL-101, developed by a team led by G rard F rey, is a porous material containing nanometer-sized cages like this one. It can trap 400 times its own volume of gas!



The carbon cycle

'PRIMING EFFECT' IS A MAJOR PLAYER

The priming effect, a mechanism by which the incorporation of fresh organic matter into soil finally leads to the release of CO₂, has long been underestimated. A study suggests that it could play a major role in regulating the carbon cycle, at play both in terrestrial and oceanic environments. Taking this mechanism into account in every environment therefore seems essential for improving predictions of changes in planet-wide and local biogeochemical cycles as a result of global change.

| Published in *Ecology*, October 2010

Geo-engineering

LESSONS FROM VENUS COULD HELP TO OFFSET THE GREENHOUSE EFFECT

Measurements carried out by the European Space Agency's (ESA) Venus Express spacecraft have enabled an international team to discover a layer of gaseous sulfur dioxide (SO₂) in the upper atmosphere of Venus. The gas is thought to be the result of evaporation, followed by decomposition by solar radiation, of the sulfuric acid present in huge quantities in Venus's atmosphere. Sulfur dioxide is also found on Earth, where it is released mainly by volcanic eruptions. At high altitude, it turns into tiny droplets of sulfuric acid that reflect part of the solar radiation back to space, which lowers surface temperatures. This is what prompted Nobel Chemistry Prize-winner Paul Crutzen to suggest that SO₂ should be massively injected into the Earth's atmosphere in order to offset the greenhouse effect. The international team's discovery may help to better understand the impact that such a geo-engineering initiative might have.

| Published in *Nature Geoscience*, 31 October 2010

Agriculture

MITIGATING GREENHOUSE GAS EMISSIONS

For the first time, an exhaustive and accurate analysis of carbon and greenhouse gas fluxes has been carried out on 14 highly varied agricultural plots, scattered from Denmark to Spain. It reveals that a more rational use of fertilizers and pesticides would have little impact on the reduction of greenhouse gas emissions caused by their use. A more promising approach would be to grow intermediate crops between two harvests, which would reduce the carbon losses that occur when the ground is bare.

| Published in *Agriculture, Ecosystems & Environment*, 5 November 2010

Economics

LESS CO₂ FOR MORE JOBS

If the French region of Ile-de-France decided to substantially reduce its CO₂ emissions, what effect would this have on jobs? According to various scenarios suggested in a recent prospective study, it could lead to the creation of 20,000 to 164,000 new jobs. The study integrates variations in three different parameters: in addition to the reduction in CO₂ emission levels defined by the Ile-de-France region, it also takes into account the sharp rise in oil and gas prices, and the level of debt that the region would be willing to accept in this domain.

> A T3 tram seen as it approaches the Porte de Vitry junction, in Paris (photomontage). According to one study, curbing CO₂ emissions in the Ile-de-France region would help to create thousands of new jobs.



The climate machine

Forecasting El Niño by observing the Indian Ocean, simulating the paths of volcanic ash plumes, or detecting ozone by satellite or stratospheric balloons: scientists' ingenuity knows no bounds when it comes to deciphering climate phenomena.

Concordiasi

BALLOONS LAUNCHED OVER ANTARCTICA

Nineteen stratospheric balloons were launched from America's McMurdo Station during the third campaign of the Concordiasi international program. Their mission is to fly over the Antarctic for several months to measure ozone concentrations and continuously analyze cloud formation processes in the stratosphere. The project aims to shed light on Antarctica's climate and on the mechanisms behind the annual formation of an ozone hole over the continent during the southern hemisphere's spring.

Photosynthesis

AN IMPROVED WORLDWIDE ESTIMATION

By combining theoretical models and observations from the Fluxnet network, which was launched in 2000, an international team has refined the worldwide estimation of carbon exchanges between the atmosphere and terrestrial ecosystems caused by photosynthesis. The study shows that for 40% of the planet's surface, ecosystems' photosynthetic capacity is mainly influenced by rainfall: tropical areas resist water stress better than expected, while temperate areas do less well.

| Published in *Science*, 5 July 2010

Chemical weathering

THE INFLUENCE OF VEGETATION COVER

Chemical weathering of continental surfaces consists in the slow dissolution of soil minerals by water. These reactions consume atmospheric CO₂, making this process a carbon sink. Researchers have now used numerical simulation to show that, in tropical environments, all the other factors (climate, soils, etc) remain constant, and that in the absence of significant physical erosion, vegetation cover controls chemical weathering by slowing water flow in the altered area. Remove the vegetation, and consumption of CO₂ by chemical weathering increases by over 70%!

| Published in *Global Geochemical Cycles*, 20 April 2010

Volcanic plume

GROUND OBSERVATIONS, MODELING AND AIRBORNE MEASUREMENTS

Following the eruption of the Icelandic volcano Eyjafjöll on 15 April 2010, scientists joined forces to collect information about the ash plumes in the atmosphere over the country. By using ground-based, satellite and airborne observation instruments, they were able to assess their spatial distribution, altitude, optical properties and particle content. Combined with good-quality weather forecasting, the simulation proved to be a reliable tool for predicting the path of ash dissemination.

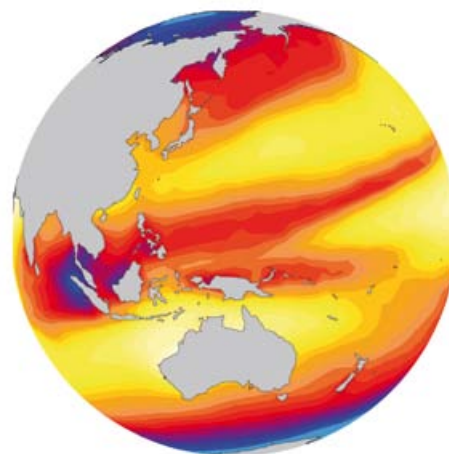


Tropospheric ozone

POLLUTION CAN BE DETECTED FROM THE SKY

Researchers have been able to study the seasonal cycle of tropospheric ozone concentrations above the cities of Beijing, Shanghai and Hong Kong by using data collected in 2008 by the French IASI instrument on board the European MetOp-A satellite when it flew over these three Chinese cities. The results confirm that satellite observation of ozone is possible even in the lower layers of the atmosphere, which opens the way to large-scale daily monitoring of this pollutant.

| Published in *Atmospheric Chemistry and Physics*, 23 April 2010



> Mean infrared radiation emitted by cloud tops in October. Colors show temperatures at the top of the clouds: from yellow (warmest), through red, to blue (coolest). This data shows the presence of very strong atmospheric convection in the eastern Indian Ocean.

Climate phenomena

ANTICIPATING EL NIÑO

The El Niño Southern Oscillation (ENSO), which consists of irregular episodes of warm (El Niño) and cold (La Niña) conditions in the Tropical Pacific Ocean, is the most spectacular fluctuation observed in the Earth's climate. Although the mechanisms that control the evolution of El Niño are fairly well understood, forecasting its occurrence remained a challenge until researchers recently established the role played by the Indian Ocean Dipole, which is the Indian Ocean equivalent of ENSO. By comparing thermal data for the two oceans over a period of 27 years, they showed that a negative Dipole, characterized by a fall in temperature in the west of the Indian Ocean and an increase in the east, heralds El Niño (and conversely for La Niña). This means that it is henceforth possible to predict El Niño 14 months before its peak, six months earlier than with the methods used until now.

| Published in *Nature Geoscience*, 21 February 2010



> Preparing a stratospheric pressurized balloon as part of the Concordiasi program.

Observing space from Earth

From France's Plateau de Bure to Chile's Atacama Desert, astrophysicists relentlessly probe the skies, on the lookout for the birth of a giant planet or for a new type of black hole.

Cosmology

ANDROMEDA FORMED BY VIOLENT COLLISION

The Andromeda galaxy, a giant spiral galaxy in our immediate cosmic neighborhood—the Local Group of galaxies—may have resulted from a violent merger between two smaller galaxies. This hypothesis is suggested by the numerical simulations carried out by an international team of researchers, who for the first time modeled the evolution and structure of Andromeda. This event occurred less than 6 billion years ago.

| Published in *The Astrophysical Journal*, 20 November 2010

Stellar formation

YOUNG UNIVERSE GORGED ON COLD GAS

Thanks to recent improvements in the performance of the interferometer run by the Institute for Radio Astronomy at Millimeter Wavelengths on the Plateau de Bure, researchers have obtained images of the cold molecular gas from which stars form in distant galaxies. The observations show that, several billion years after the Big Bang, massive star-forming galaxies contained five to ten times more of this cold matter than today's galaxies. This large quantity of cold matter directly explains the huge star production rate in the early Universe.

| Published in *Nature*, 11 February 2010

> Artist's impression of the extrasolar planet β Pictoris in orbit around its star.

Astrophysical objects

BLACK HOLES PULL THEIR WEIGHT

The data obtained by the European Southern Observatory's Very Large Telescope has confirmed the extreme luminosity of HLX-1, an X-ray source spotted in 2009 by the XMM-Newton satellite, and has made it possible to pinpoint its position. Located 300 million light years from Earth, HLX-1 is the brightest ultra-luminous X-ray source discovered to date. It may be home to so-called intermediate-mass black holes, which are around 500 times the mass of the Sun. Such black holes, which have never been detected, might be the fundamental building blocks of the super-massive black holes found at the center of most galaxies.

| Published in *The Astrophysical Journal Letters*, 8 September 2010

Exoplanets

FAST FORMATION OF GIANT PLANETS

Giant planets form much faster than previously thought, according to a team that has been observing the star Beta Pictoris since 2003. The images, obtained with the Very Large Telescope's adaptive optics system, provide evidence of a giant extrasolar planet in orbit around the star, which is a mere 12 million years old. This shows that a giant planet can form within the dust disk around a star in just a few million years.

| Published in *Science*, 10 June 2010

Interferometry

GETTING CLOSE TO A STAR

A European team has obtained the first-ever image of the region around a young star where planets form. To achieve this, the astronomers used the exceptional resolving power of the Very Large Telescope Interferometer (VLTI), combining the light coming from its eight telescopes. The data was then processed with complex mathematical algorithms. The images obtained have the same resolution as they would if seen through a 130 meter-diameter telescope.

| Published in *Astronomy and Astrophysics*, 8 September 2010

Satellites probe ^{the} far reaches of the Universe

Dedicated to hunting down exoplanets, the CoRoT satellite identified seven new celestial objects in 2010. Meanwhile, the European Planck satellite sent back its first image of the entire sky, the European Herschel space observatory was busy scrutinizing the furthest reaches of the Universe, and the tiny Robusta satellite will soon be testing electronic components in space.

CoRoT

DISCOVERY OF NEW CELESTIAL OBJECTS

Dedicated to hunting down extrasolar planets, the CoRoT satellite, operated by the French space agency CNES, makes use of the planetary transit method, which consists in observing a planet as it passes in front of its star. The observation of such transits is backed up by ground-based observations, especially with spectrographs, which makes it possible to obtain an accurate measurement of the size, mass and orbit of the newly-discovered planets. In 2010, CoRoT was able to identify seven new celestial objects, including a brown dwarf (an object sixty times greater than Jupiter, with a mass comprised between that of a giant planet and a star). CoRoT also made an even more unusual discovery: a temperate giant planet. The size of Jupiter and with an orbit similar to that of Mercury, this gas giant, dubbed CoRoT-9b, is quite similar to the planets in our own Solar System. Detailed analysis made it possible to determine the temperature of its gaseous atmosphere, which lies between -20 and +150 °C.

| Published in *Nature*, 18 March 2010

Dark energy

PAIRS OF GALAXIES HELP TO HUNT DOWN MYSTERIOUS FORCE

A force called dark energy, whose origin is still unknown, causes celestial objects to move away from each other at very large scales. Starting out from the hypothesis that dark energy leaves a measurable geometric imprint, researchers have analyzed 721 pairs of galaxies in orbit around each other in order to determine its abundance. Using solely observations of the angular distribution of the pairs, they found that dark energy makes up 60-80% of the energy content of the Universe.

| Published in *Nature*, 25 November 2010

Asteroseismology

A STAR WITH SUN-LIKE MAGNETIC ACTIVITY

Using data collected by the CoRoT observation satellite, a magnetic activity cycle has been detected in a sun-like star 100 light years away. This observation, derived for the first time from asteroseismology, a technique used to study the internal structure of distant stars, opens the way to hundreds of others. The aim is to understand how magnetic activity cycles differ from one star to another.

| Published in *Science*, 27 August 2010

> Artist's impression of CoRoT-9b.

Picosatellite

FEATHER-WEIGHT SATELLITE SET TO BLAST OFF

The result of a particularly successful synergy between training and research, ROBUSTA is a tiny cubic satellite that weighs just one kilogram. Designed and produced by students in Montpellier, it will be used to validate a laboratory test method, thanks to the results of an in-flight experiment on the deterioration of electronic components exposed to the space radiation environment. ROBUSTA will be launched in the next few months on board the European VEGA launcher.

Planck

A WEALTH OF DISCOVERIES

2010 was the year of discoveries for the European Space Agency's Planck mission. Designed to map the cosmic microwave background (CMB) radiation, the relic radiation from the Big Bang, Planck will provide the most detailed representation ever obtained of the primordial Universe. Its main asset is its ability to produce images of the sky in nine 'colors' in the millimeter wavelength range. In June 2010, Planck sent back the first of five complete surveys of the sky scheduled to be completed by 2012. This first spectacular image in the series highlights the two most abundant sources of microwave radiation in the sky, the Milky Way and the cosmic microwave background. Planck was also able to discover a supercluster of galaxies by analyzing their imprint on CMB photons. The largest known structures in the cosmos, galactic superclusters, formed in the early stages of the Universe and should help to chart its evolution. Finally, Planck also obtained images of clouds of dust in the form of filaments within our own Galaxy, revealing the structure of the interstellar medium of the Milky Way.



History of the Universe

ZOOMING IN ON FIVE GALAXIES

Using ESA's Herschel space observatory and ground-based observations, an international team of astronomers has measured the exact distance to five very distant galaxies, showing that the light from these galaxies must have traveled for around ten billion years before reaching the Earth. To obtain this result, they made use of a phenomenon known as gravitational lensing, a sort of cosmic zoom lens that magnifies the radiation from certain distant galaxies.

| Published in *Science*, 5 November 2010

> Artist's impression of the Herschel space observatory, which will provide an unprecedented view of the Cold Universe.

The scientific findings presented in this brochure are the result of research carried out at CNRS associated laboratories, in collaboration with our partners, including higher-education and research institutions, national and international research bodies, and businesses.

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> Protists and planktonic larvae. This plankton
was collected during the Tara Océans expedition.