

# 2009 A Year at CNRS

Scientific report



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The year 2009, which marked the 70<sup>th</sup> anniversary of CNRS, proved highly successful for our organization. A host of top-level scientific findings in every discipline bore witness to the dynamism and creativity of our research groups. To name but a few, these findings included the discovery of the remains of Nero's rotating banquet hall; the description of *Ardipithecus ramidus* and its environment, which was elected 'Breakthrough of the Year' by the journal *Science*; the identification of proteins that play a key role in the protection of neurons; the reconstruction in 3D of a 300-million-year-old fish brain; as well as significant progress in the field of tomorrow's digital memories.

These outstanding results were not only achieved in our own laboratories but also in the joint units (representing over 92% of CNRS's research units) that CNRS shares with universities, research bodies, *grandes écoles* and major businesses. They were made possible by men and women, researchers, academics and support staff, working side by side to contribute to the high quality of French research. Among these remarkable members of our staff, I would like to pay tribute to biologist Olivier Voinnet, recipient of the European Molecular Biology Organisation (EMBO) 2009 Gold Medal; chemist Patrick Couvreur, who was awarded the Galien Prize; mathematician Jean-Loup Waldspurger, rewarded with the prestigious Clay Prize 2009 at Harvard University; as well as physicist Serge Haroche, winner of the CNRS Gold Medal. I also wish to pay special tribute to Olivier Guillot-Noël, Ivan Lorgéré and Anne-Marie Wilhelm, three brilliant researchers who lost their lives in the crash of the Air France Rio-Paris flight.

In 2009, CNRS underwent reform. This resulted in the creation of ten theme-based institutes of national and international scope, covering every field of research: humanities and social sciences, biology, engineering, computer sciences, physics, particle physics, mathematics, chemistry, Earth sciences and astronomy, ecology and the environment. This reform also changed our governance, strengthened interdisciplinarity, and forged closer links with our partners, universities and research bodies. It is within this context that we will be working from now on, and we are fully committed to strengthening partnerships with universities moving towards greater autonomy.

We intend to help these universities organize themselves and unite in order to rapidly create a number of highly-visible academic centers that will emerge as serious competitors to their counterparts from abroad. We must and can help them, because collaborative research is one of our strengths. To do so, we will work together and propose a new alliance with Universities, whereby academic centers will apply common scientific policies that will take account of local scientific potential.

Finally, the year 2009 saw the setting up of the first Research Alliances, with the creation of AVIESAN (French National Alliance for Life and Health Sciences), ANCRE (National Alliance for Energy Research Coordination) and ALLISTENE (Digital Sciences and Technologies Alliance). Including ALLenvi (environment), a total of four Alliances now form part of the French national strategy for research and innovation. They provide a framework that will enable research bodies and higher-education institutions to mobilize their resources to tackle the issues facing society. CNRS is today a member of all these alliances.

2009 has seen the emergence of a new research policy in France. CNRS has a major structuring role to play at national level. It has a duty to be a major, open and innovative player, working with its partners to meet the knowledge challenge, which is crucial for France's future.

A handwritten signature in black ink, appearing to read 'A. Fuchs'. The signature is stylized and fluid, with a long horizontal stroke at the end.

**Alain Fuchs**  
President of CNRS

**1 074** RESEARCH UNITS, WITH **120** HIGHER EDUCATION AND RESEARCH INSTITUTIONS, AND OTHER NATIONAL AND INTERNATIONAL ORGANIZATIONS.

**25 584** PERMANENT STAFF  
**11 433** RESEARCHERS,  
**14 151** ENGINEERS AND TECHNICIANS  
 AND **8 234** TEMPORARY EMPLOYEES

ON 31/12/2009

**6 441** PH.D. STUDENTS,  
 POSTDOCTORAL FELLOWS  
 AND OTHER CONTRACT RESEARCHERS  
 IN 2009, INCLUDING **42 %** FOREIGN RESEARCHERS

**370** RESEARCHERS RECRUITED IN 2009,  
 INCLUDING **30 %** FOREIGN RESEARCHERS,  
 AND **478** ENGINEERS AND TECHNICIANS

A **3.2** BILLION EURO BUDGET, INCLUDING  
**744.5** MILLION EUROS FINANCED  
 BY CNRS-GENERATED INCOME IN 2009

**268** MILLION EURO INVESTMENTS IN 2009

**807,351** M<sup>2</sup> GROSS FLOOR AREA ACROSS **155** SITES

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## Neurocognition

### LEARNING TO READ BY TOUCH

The sense of touch facilitates the connection between sight and hearing, thus helping adults to learn to read. This has been revealed by a study carried out on thirty French-speaking adults, which corroborates results already observed in children. Although this work opens the way to improved methods for learning to read, the neuronal mechanisms involved in this multisensory learning process are still not fully understood.

**Published in** *PloS One*  
**Date** 16 March 2009



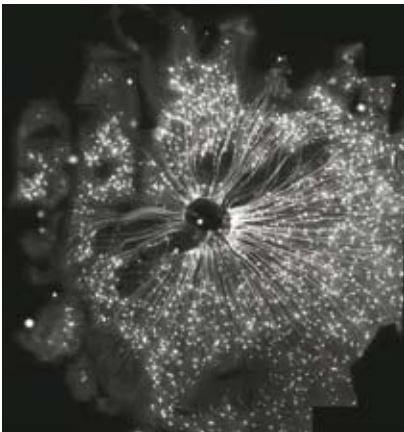
> Example of multisensory learning.

## Biomechanics

### FINGERPRINTS' GOOD VIBRATIONS

When we touch an object with our fingers, vibrations are created at the skin's surface and send a signal to so-called 'mechanoreceptive' nerve cells, thus enabling us to feel very fine structures. By making an artificial finger, researchers have discovered that fingerprints magnify some of these vibrations, probably making it easier for the skin's mechanoreceptive cells to detect them.

**Published in** *Science*  
**Date** 13 March 2009



> View of a mouse retina where ganglion cells sensitive to approaching motion have been marked.

## Neurophysiology

### SLEEPING HELPS THE MEMORY

'It's best to sleep on it': the saying was never more true. When we sleep, our neurons are constantly active, and our brain replays the day's events. It is well known that the hippocampus, a brain structure that plays a significant role in memory, is active while we sleep. Researchers have shown that rapid oscillations of the hippocampal neurons during learning, and their reactivation during sleep, are key to memory consolidation. In addition, another study carried out on rats has shown that not all information memorized is consolidated in the same way, and that only the information that is most relevant for behavior is stabilized. The work is a major step forward in explaining memory mechanisms and understanding neurodegenerative diseases such as Alzheimer's.

**Published in** *Nature Neuroscience*  
**Date** July 2009 and October 2009

## Neurogenesis

### YOUNG HYPERACTIVE NEURONS

Neurons born in the human brain first show hyperactivity, a property that they lose in just a few weeks. Moreover, only 50% of the new cells are incorporated into neural networks after two weeks. These findings could explain the failure of transplants, and suggest a therapeutic avenue that would consist in stimulating the brain's natural ability to produce neurons continuously.

**Published in** *Nature Neuroscience*  
**Date** 1 June 2009

## Visual detection

### NEW NEURAL CIRCUITS DETECTED IN THE RETINA

In the eye, the retina performs sophisticated processing of visual information and transmits a selective screening of this information to the brain. A study has revealed the existence in mice of a new functional type of neuron: these nerve cells are specifically sensitive to approaching motion, such as that of predators moving in on their prey, and could thus prove essential for survival.

**Published in** *Nature Neuroscience*  
**Date** 6 September 2009



### Archeozoology

#### PREHISTORIC GAME IN CYPRUS

Around 12,500 years ago, prehistoric humans crossed the Mediterranean to Cyprus and introduced wild boar, which they then hunted for food. Revealed by the discovery of the remains of small boars on the island, this early human presence shows that humans could already exercise some kind of control over populations of wild boar, a thousand years before their domestication.

**Published in** *Proceedings of the National Academy of Sciences*  
**Date** 22 September 2009

### Archeology

#### A DUGONG BONE SANCTUARY

On the island of Akab (United Arab Emirates), archeologists have uncovered the oldest known ritual site in the Arabian Peninsula. Dating from 3,500 BC, the sanctuary was dedicated to the dugong, a marine mammal related to the manatee. Around 10 m<sup>2</sup> in area and 40 cm high, the monument contains the carefully laid out remains of around forty dugongs, and provides the first-ever information about the rituals of prehistoric coastal societies of the Gulf.

**Published in** *Antiquity Journal*  
**Date** September 2009

### Evolutionary biology

#### OLDEST OR YOUNGEST SIBLING: IT MAKES A DIFFERENCE

Parental involvement is a decisive factor in children's survival and reproduction rates. By studying 577 Finnish families from the pre-industrial period, researchers have shown that natural selection influenced parents' behavior. For instance, eldest sons, who are at a particular advantage regarding inheritance, married earlier and had more children than their brothers.

**Published in** *PLoS One*  
**Date** 25 May 2009

### Telex

Part of a child's jawbone has been unearthed in Morocco, providing evidence for the existence of a population of *Homo rhodesiensis* (immediately before *Homo sapiens*) in the region half a million years ago.

### Evolution

#### DID HUMANS ORIGINATE IN ASIA?

Could Asia be the birthplace of the common ancestor of humans and apes? The discovery in Myanmar (formerly Burma) of part of the lower jaw of a new primate fossil lends weight to this hypothesis. The 37 million-year-old animal, dubbed *Ganlea megacanina*, had disproportionately-large canine teeth which enabled it to open and eat seeds in the same way as some monkeys in South America today. Paleontologists therefore place it in the family of anthropoid primates, to which humans and the great apes belong. In addition, other research carried out in Algeria brought to light remains of the skull and teeth of *Algeripithecus*, a small 50 million-year-old primate weighing just 75 grams, which was considered until now to be the oldest African anthropoid known. However, paleontologists have shown that it belongs to a more primitive group, the lemuriforms, thus strengthening the theory that anthropoid primates originated in Asia.

**Published in** *Proceedings of the Royal Society B (Biological Sciences)*  
**Date** 22 September and 7 December 2009



# Research is an open book

Every year, CNRS scientists write a host of books on a wide variety of topics. From Barack Obama's election to the crisis, the authors share the fruit of their research with us.

## Books

### **OBAMA FACE À LA CRISE (OBAMA AND THE CRISIS)**

Barack Obama was elected just as the most serious economic crisis since the Great Depression was getting under way. Would he be able to overcome the downturn that helped him to win in 2008? Just like Roosevelt arriving at the White House in 1933, he had 100 days to convince public opinion that his plan of action could save the planet.

**Authors** François Durpaire and Olivier Richomme  
**Published by** Demopolis  
**Publication date** January 2009

### **MANAGEMENT DES ENTREPRISES ET SANTÉ DES SALARIÉS (COMPANY MANAGEMENT AND EMPLOYEES' HEALTH)**

To what extent does the involvement of employees in the running of companies affect their state of health? This inquiry explores the relationship between human resources management and occupational health through the impact of the social climate. The notion of environmental nuisance is tackled in terms of social relationships, i.e. from a psychosocial, rather than a material point of view.

**Authors** Patrick Guiol and Jorge Muñoz  
**Published by** Presses universitaires de Rennes  
**Publication date** March 2009

### **FIN DE MONDE OU SORTIE DE CRISE ? (END OF A WORLD OR END OF A CRISIS?)**

The economic crisis has been rife for nearly two years now, and we are facing a key question: is this simply a passing classic economic cycle, or are we in the middle of a profound crisis of civilization that will give rise to a new economic order? The authors provide a coherent picture of these two possible interpretations of the crisis, as a contribution towards finding relevant and effective solutions.

**Authors** Pierre Dockès and Jean-Hervé Lorenzi  
**Published by** Perrin  
**Publication date** April 2009

# Under cover of light

Researchers master the properties of light and matter  
with evermore astonishing inventions. They can even make  
objects invisible in the microwave band.

## Atomic optics

### TAMING MATTER WAVES

Although physicists have been manipulating light waves since the nineteenth century, they are now seeking to develop optics for matter waves, which describe the motion of atoms in the quantum regime. By simulating the propagation of metastable argon atoms in an appropriate environment, a team has demonstrated the possibility of focusing matter waves onto an extremely precise point. This result holds out great promise in nanolithography for example.

Published in *Physical Review Letters*  
Date 9 April 2009

> A silica optical fiber gradually brightens under the effect of a powerful laser.





- 1. Enamelled goblet attributed to the late fifteenth-century Venetian school in Venice.
- 2. Light blue 'Venetian style' glass goblet from the sixteenth or seventeenth century, thought to have been made in the Netherlands. The intensity of the spectrum of the light blue upper part shows a signature that is typical of the nineteenth or twentieth century, thus calling into question its authenticity.

### Spectroscopy

#### PIERCING THE SECRETS OF ENAMEL GLASSWARE

Like many works of art, enamelled glassware are high-tech objects, due to the complexity of the materials used and the way in which they are combined. Researchers have used a novel non-destructive method based on Raman analysis. This spectroscopic technique has enabled them to penetrate the secrets of the manufacturing, production or restoration of several colored-glass goblets.

**Published in** *Journal of Raman Spectroscopy*  
**Date** June 2009

### Fluid mechanics

#### COMING TO THE RESCUE OF ENDANGERED WORKS OF ART

Researchers have modelled evaporation phenomena in porous media using a very simple model structure, i.e. a capillary tube of square cross-section. Evaporation in it is much faster than in a tube of circular cross-section, due to the transport of liquid films by capillary action along the inner 'corners' of the tube. This has many potential applications for the protection of ancient monuments and works of art.

**Published in** *Physical Review Letters*  
**Date** 16 September 2009

## Exhibition

### IN COSMETICS, ART AND SCIENCE GO HAND IN HAND

What was the composition of make-up and hair coloring in Roman times, or of perfumes in the Middle Ages? The result of a partnership between CNRS, L'Oréal Recherche and the Musée de Cluny, the exhibition 'The Bath and the Mirror – Body Care and Cosmetics from Antiquity to the Middle Ages' combines scientific research with historical and archeological information, and recounts the history of beauty care and the origins of the cosmetics industry.

From 20 May 2009 to 21 September 2009  
 Musée de Cluny – Musée national du Moyen-Âge, Paris



> A cosmetics jar and an X-ray photograph of it. This object contained make-up or eye lotion and was discovered in a cellar used as a dump at the end of the third century at Grand (Vosges, France).

### NANO-MASTERPIECES ON SHOW AT THE LOUVRE

Inspired by archeology, Michel Paysant's exhibition at the Louvre Museum reinvents original works on novel scales, and raises questions about how much we can know about a work of art from mere retinal perception. A research project between art, science and technology, OnLAB (le laboratoire d'œuvres nouvelles – the new works of art laboratory) presents, among other objects, micro- and nano-sculpture copies of ancient works or maps of archeological sites that are scarcely visible to the naked eye. Paysant worked with CNRS scientists, who produced the objects with a liquid resin deposited on a rotating silicon wafer and used electronic lithography to reproduce the drawings, whose lines

are scarcely a hundred nanometers wide!

From 26 November 2009 to 1 March 2010  
 Musée du Louvre

## Exhibition

# Opening the way to green energy

Hydrogen, lithium-ion batteries, water electrolysis and solar cells are all promising avenues towards new sources of energy. And energy is something CNRS researchers have in plenty when it comes to investigating them!

## Renewable energies

### A BRIGHT FUTURE FOR ORGANIC SOLAR CELLS

To supply devices that consume little energy (such as handheld game consoles, mobile phones, pacemakers, flexible screens, etc) with electricity, research is now looking at organic solar cells. Scientists have recently obtained record efficiency with these cells, which offer a whole host of advantages, especially in terms of cost and environmental impact.

Published in *Journal of Materials Chemistry*  
Date 2009

## Energy

### LATEST-GENERATION BATTERIES

Predominant in the mobile electronics market until now, lithium-ion batteries are taking up a strong position in the booming electric vehicle market, mainly for reasons of cost and safety. A new step forward in improving the performance of this type of battery has been taken with the synthesis of a new material, lithium iron fluorosulfate ( $\text{LiFeSO}_4\text{F}$ ). With enhanced ionic and electronic conduction properties, this compound facilitates the flow of lithium ions from one electrode to the other, and thus the production of electric current. By also bringing down the manufacturing cost of batteries,  $\text{LiFeSO}_4\text{F}$  opens up new prospects for the storage of electrical energy, especially for transportation.

Published in *Nature Materials*  
Date 29 November 2009 online



## Plate tectonics

### WHAT'S HIDING UNDER THE ROOF OF THE WORLD?

Tibet continues to fascinate, and there is still a great deal to be learned about this geological object that came into existence around 55 million years ago. The Hi-CLIMB (Himalayan-Tibetan Continental Lithosphere during Mountain Building) experiment undertaken by an international team has collected seismological data from a hundred seismometers scattered over a distance of 800 kilometers, and produced a continuous image of the lithosphere, which reveals the deep structure of the collision between the Indian plate and Eurasia.

**Published in** *Science*  
**Date** 11 September 2009

## Global warming

### THINNING ICE SPEEDS ARCTIC BREAK-UP

Researchers have examined the paths of nearly 600 buoys embedded in the Arctic pack ice over the last thirty years. They have observed that the speeds at which the ice drifts (+10% every 10 years) and the pack ice deforms (+ 50% per decade) have greatly increased, due to the thinning of Arctic ice. In return, these effects could contribute to accelerating the thinning of the ice.

**Published in** *Journal of Geophysical Research*  
**Date** 14 May 2009

## Mantle

### STRESSED OLIVINE LINES UP

Olivine, the main mineral in the Earth's upper mantle (50-70% of its volume), has an unusual property: its deformation is highly anisotropic, in other words the speed at which it deforms varies according to the direction of stress. When the mantle deforms, olivine crystals tend to line up. To better understand the complex processes at work, researchers have developed numerical models to simulate the deformation of tectonic plates and predict changes in the orientation of the crystals. Their models have shown that plate deformation occurs in regions where the lithosphere has already been deformed. By driving the reactivation of pre-existing structures (such as mountain chains and rift valleys), olivine deformation controls the deformation of tectonic plates.

**Published in** *Nature Geoscience*  
**Date** June 2009



> Setting up station T0040 (3,700 meters altitude), a few kilometers north of the village of Kharta, located to the West of the Ama Drime range.

## Telex

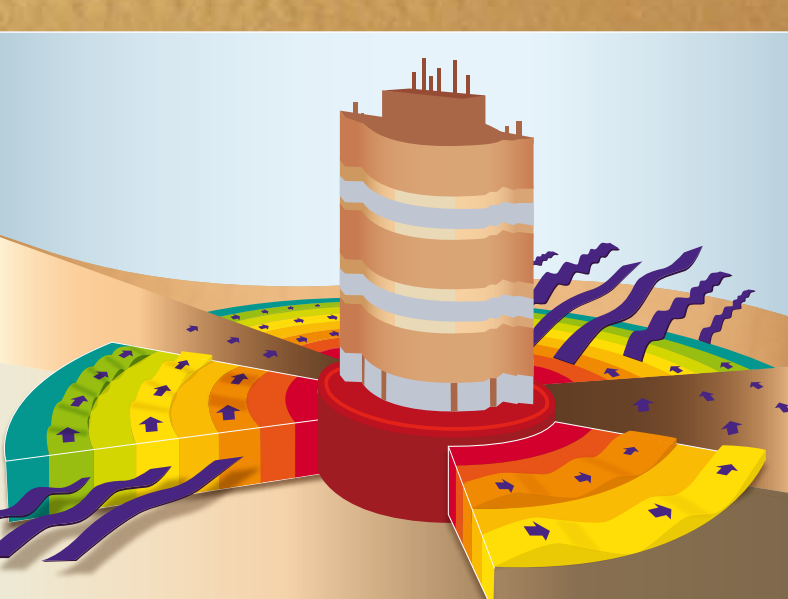
The MARMESONET oceanographic campaign south of Istanbul: first outing for BOB (Bubbles OBServatory module), a monitoring system for gas bubbles on the ocean floor.

## Waves

### AN ANTI-SEISMIC INVISIBILITY CLOAK

Imagine schools and hospitals made invisible to the most devastating seismic waves so as not to feel the effects of an earthquake: designed on the basis of mathematical models, this still experimental 'invisibility cloak' is a thin plate with a structure controlling the propagation of certain waves so as to deflect them from an obstacle. Before this system is put to use, it will be necessary to work with geologists to adapt it to specific ground conditions.

**Publié dans** *Physical Review Letters*  
**Date** 10 July 2009



> Artist's impression showing the principle of an anti-seismic invisibility cloak.

# The heart of the **matter**

**Higgs boson, neutrinos, nucleons: researchers handle these particles in order to penetrate the secrets of nuclear reactions and solve the mysteries of the Universe. Their eyes are riveted on Geneva and on forthcoming data from the LHC, the world's most powerful particle accelerator.**

## Prize

### GARGAMELLE REAPS TOP AWARD

The European Physical Society has awarded its High Energy and Particle Physics Prize to the Gargamelle collaboration for its observation of weak neutral currents in 1973. Two CNRS laboratories were involved in this major discovery, a central pillar in our understanding of the unification of electromagnetic and weak interactions, the key to which may lie in the discovery of the Higgs particle at the LHC.

### Telex

Michel Spiro, director of IN2P3-CNRS, is appointed President of the CERN Council.

LHC ends the year with a flourish: the world's most powerful particle accelerator successfully concludes its first complete scientific run.



> The LHC tunnel.



## Tribute

### CLAUDE LÉVI-STRAUSS HAS PASSED AWAY

Claude Lévi-Strauss passed away on 30 October 2009 and a flood of tributes praising the father of modern anthropology has poured in ever since. He had celebrated his hundredth birthday in November 2008 and on that occasion, a prize had been established in his name to recognize and promote French research excellence in the humanities and social sciences. The first Claude Lévi-Strauss Prize has been awarded to Dan Sperber, recognized for his work at the crossroads of anthropology, philosophy, linguistics and psychology.



## Medal

### BIOINFORMATICS PIONEER

He builds mathematical models by devising sophisticated computing methods that are applied to such disciplines as molecular phylogeny, a leading tool for the reconstruction of evolution through the analysis of DNA sequences and proteins. The author of publications at the frontier of computer science, mathematics and biology, Olivier Gascuel has been awarded the 2009 CNRS Silver Medal.



## Medal

### MODELING THE IMPACT OF CLIMATE CHANGE

Her intention was to study marine mammals, but she ended up doing research into plants. Isabelle Chuine, winner of the 2009 CNRS Bronze Medal, relies on experimental work and modeling to assess the impact of climate warming on the distribution of plant species. Aged 36, she works on the ecological and genetic constraints of plants' adaptation to climate, basing her work on the study of seasonal rhythms in particular.



## Award

### TROPHY FOR A MASTER GLASS-BLOWER

For over 26 years Marc Thilloy has been blowing glass. The instruments that equip the chemist's lab bench hold no secrets for him, whether they be purifiers, extractors, condenser coils or bubblers. The recipient of the 2009 CNRS Crystal prize creates unique, specially-designed equipment. This prize rewards his creativity, technical skill and sense of innovation.

## Telex

The renowned physicist, **Michèle Leduc**, who actively promotes women in research, has won the 2009 Irène Joliot-Curie 'Woman Scientist of the Year' award.

The young mathematician, **Artur Avila**, has been awarded the 2009 Jacques Herbrand Prize of the French Academy of Sciences for his outstanding work on the theory of dynamical systems.

A specialist in random matrices, **Alice Guionnet** has won the 2009 Loeve Prize, which is awarded for exemplary work by young researchers in probability theory.

**Anne Houdusse's** passion for molecular motors has won her the FEBS/EMBO 'Women in Science' award.

**Olivier Voinnet** has received the 2009 EMBO Gold Medal, the highest European award in molecular biology, for his research into RNA silencing mechanisms in plants.

For the vitality of his work in the field of computer security combined with outstanding cooperation with industry, **Jean-Claude Laprie** has been awarded the Grand Prize in Informatics of the French Academy of Sciences.



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