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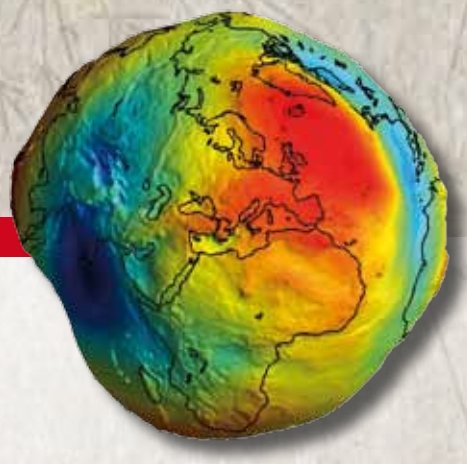
150 YEARS ON,

# The World According to DARWIN



ON LOCATION

**GOCE Mission**

Determining the Real Shape of Earth

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→ AWARDS

# France on the Move

**Anne Houdusse**[1] has been awarded the "FEBS/EMBO Women in Science" prize, given every year to a woman who has made an exceptional contribution to the life sciences. **Gérard Férey**, from the Institut Lavoisier[2] has won the ENI prize for the protection of the environment, awarded by the eponymous Italian petroleum company, for his work on large-scale sequestration of $CO_2$. And **Michel Dyakonov** from LPTA[3] received the American Physical Society's "Beller Lectureship Award."

**Sébastien Candel**, from the EMC2 Laboratory,[4] has been elected as a foreign associate of the US National Academy of Engineering, while **George Calas**, from IMPMC[5] has been made a Fellow of the Geochemical Society and of the European Association for Geochemistry.

Last but not least, **Gérard Mourou,** head of LOA[6] and professor at the Physics Department of the Ecole Polytechnique, has been elected to the physics section of the prestigious Academy of Russian Sciences. Mourou has made major contributions to the invention of the laser amplification technique, which has paved the way for new fields in optics and physics.

1. Motilité structurale (CNRS / Institut Curie).
2. CNRS / Université Pierre et Marie Curie.
3. Laboratoire de physique théorique et astroparticules (CNRS / Université Montpellier-II).
4. Energétique moléculaire et macroscopique, combustion (CNRS / Ecole Centrale Paris).
5. Institut de minéralogie et de physique des milieux condensés (CNRS / Université de Versailles Saint-Quentin).
6. Laboratoire d'optique appliquée (CNRS / Ecole polytechnique / ENSTA / Université Paris-XI).

## Abel prize

The French-Russian mathematician **Mikhail Leonidovich Gromov**, aged 65, was awarded the Abel Prize 2009 for "his revolutionary contributions to geometry." A French citizen since 1992, Gromov was born in Boksitogorsk in the Soviet Union. Since 1982, he is a permanent professor at the Institute of Advanced Scientific Studies (IHES), near Paris. The third French mathematician to win this award since its creation in 2003, Gromov "has produced deep and original work throughout his career and remains remarkably creative," commented the Abel Committee.

© J.-F. Dars/CNRS Photothèque

→ **4th**

**is CNRS' global position in the Webometrics ranking of the most visible research and higher education institutions on the internet. Drawn up by the Cybermetrics Lab (Consejo Superior de Investigaciones Cientificas) in Spain, the ranking is based on popularity indicators of sites as well as on the number of publications available online. CNRS takes top place among European research organizations.**

## A New Director for Humanities and Social Sciences

© T. Haberbusch/AEFC

Bruno Laurioux has been appointed scientific director of Humanities and Social Sciences at CNRS as of February 1st, 2009. He had been acting director since September 1st, 2008. He will be entrusted with setting up CNRS' new Institute of Humanities and Social Sciences.

→ ERC ADVANCED GRANT

## CNRS Takes First Place

Sixteen CNRS researchers were chosen as recipients of the first "Advanced Grant" competition put out by the European Research Council (ERC).[1] Twelve of them are hosted at CNRS and four in other institutions in France or abroad. CNRS thus takes top place among host organisations in Europe. The objective of these grants is to give backing to internationally-recognized and experienced researchers of all nationalities hosted in laboratories in the European Union or associated countries. Three major fields were covered: physical sciences and engineering, life sciences, and humanities and social sciences. Interdisciplinary projects were also selected. The winners can be funded to the tune of as much as €3.5 million over a period of five years.

1. http://erc.europa.eu/





# editorial

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**Françoise Gaill**
Scientific Director,
Institute of Ecology and Environment (INEE).

# 150 Years of **Darwin's Evolution**

The year 2009 marks the bicentennial anniversary of Charles Darwin's birth. This great English naturalist, the father of the theories of evolution and natural selection, has forever changed our understanding of how life unfolded. There can be no doubt that Darwin lies at the origin of modern biology's most important conceptual framework, which is based on the incredible variety of life forms on Earth. Evolution is key to our understanding of the world we live in, and is indeed one of the great puzzles of modern science. Why do so many species coexist? How are they shaped? Why do they come in such a variety of forms, structures, patterns, and complexity? How did they come about? All these questions are at the heart of extensive research carried out at CNRS.

Any attempt at understanding the origin, organization, and preservation of biodiversity necessarily means studying the mechanisms of evolution. Ever since the 1992 Rio de Janeiro conference, biodiversity–because it is a key component of the stability of ecosystems–has also become a social issue and one of the major challenges for sustainable development. This is why the study of the history and dynamics of biodiversity is a priority for the Institute of Ecology and Environment (INEE) at CNRS.[1] In this field, CNRS has helped set up several international research networks focused on various regions of the world, especially French Guiana, the French Overseas Departments and Territories, southern Africa, and Asia.

It is also towards the mechanisms of evolution that we turn when we try to understand the adaptive responses of living organisms affected by extreme conditions or by a rapidly changing environment–like that resulting from global warming. And these similar mechanisms will also help us analyze how populations and species respond to the countless pollutants produced by human activity.

Evolutionary processes act at every level, from genomes to ecosystems, via individuals, populations, and species. Such processes are varied in nature: they may be molecular, physiological, morphological, behavioral, etc. Furthermore, they are usually slow, and must be studied over long periods of time–spanning anything from a few generations to hundreds or thousands of years, or even on geological time scales. Attempting to understand the origin of evolutionary novelties and reconstruct the tree of life is no easy task. Meeting such challenges is a genuine obsession for many researchers at CNRS and elsewhere. But despite considerable progress, much remains to be done. CNRS and its dedicated institute (INEE) are very active in the field of paleoenvironment and paleontology. Recent findings have led to considerable progress in the history of human origins, pushing the dawn of human lineage much further back into the past, from 3.5 to 7 million years ago. Recently, to make further progress in this area, CNRS initiated an international research network in paleontology, bringing together France, Chad, and the US.

CNRS and the INEE have placed the evolutionary sciences at the heart of much of their research. For the Institute, the study of current and past biodiversity cannot be dissociated from actions in the areas of conservation, environmental management, and development. Its other priorities are human-environment relations and ecological analysis, which take into account the relations between life and its environment, and require detailed knowledge of the functional aspects and dynamics of ecosystems. In this way, CNRS is taking a firm stand against the return to Europe and France of currents of thought that oppose evolution, like creationism and Intelligent Design. Evolution is a scientific theory that has been extensively supported by indisputable evidence, and many CNRS labs are working hard to fully understand its mechanisms and its full breadth.

1. Which evolved from the Environment and Sustainable Development (EDD) department created in 2006.

AERONOMY

# Keeping a Close Eye on the Sky


Though its scientists are busy studying the atmospheres of celestial bodies or tracking down extraterrestrial life, the Service d'aéronomie (SA)[1] has its feet firmly on the ground. Celebrating its 50th anniversary this year, we get an exclusive peek at what goes on behind the doors of this prestigious lab.

"Which planet shall I take you to?" is the first question we're asked by Christian Malique, in charge of the technical department at SA's site in Verrières-le-Buisson (Essonne), near Paris. We're standing at the entrance to a maze of underground corridors that house experimental labs with mysterious-sounding names, like "PHEBUS," "PAMPRE," or "MOMA." The site itself is surprising enough–an old military fort dating back to 1875 nested in a deep forest–but now we're off to an even more exotic destination: Titan, one of Saturn's moons. Behind the door, the silhouettes of three young researchers–of the 140 or so people currently working at SA–can be made out in the dim light. In the center of the lab lies a mesmeric pink glow. "This color is caused by a plasma, an ionized gas.[2] It simulates the physical chemistry found on Titan," explains Guy Cernogora, the researcher in charge of the PAMPRE project. "This reaction leads to the formation of fine organic particles, like the ones observed by the Huygens spacecraft. We're studying them closely, since they might give us clues about the origin of life on Earth."

Above and below: researchers reconstruct Titan's atmosphere in a plasma chamber to study the fine organic particles which form there. These may provide some clues about the origin of life on Earth.

© Photos : P. Virgnaud/CNRS Photothèque

Above right: assembling the prototype of PHEBUS, an ultraviolet spectrometer designed to study Mercury's atmosphere. It will equip a satellite due to reach the planet's orbit in 2020.

But we are already being rushed off to our next destination, which turns out to be Mercury. Other lab, other atmosphere: A young engineer wearing white gloves, Pierre-Olivier Mine, is busy assembling the prototype of PHEBUS, an ultraviolet spectrometer for a spacecraft that will be launched in 2013 and reach Mercury seven years later, in 2020. "This instrument will enable us to describe the composition and processes of Mercury's exosphere, the outermost layer of its atmosphere,[3]" Mine explains. Excited by solar radiation, the atoms in the exosphere emit photons, whose characteristic wavelength will be picked up by the spectrometer.

We've hardly left the lab when we come face to face with the nose cone of a Soviet M 100 rocket from the Second World War. But our real destination is the MOMA lab. Here, David Coscia and his colleagues are developing a gas chromatograph. "This device will be looking for traces of life on Mars. It'll do this by analyzing samples of soil taken by the European Exomars spacecraft, whose launch has just been pushed back from 2014 to 2016," Coscia explains before taking us into the clean room. The air in the room, whose walls are entirely made of glass, is permanently filtered to prevent any contamination. On a table in the middle of the room are five small coils. "If needed, these chromatographs can replace the ones we provided NASA with for the American MSL mission, a mission similar to Exomars which will reach Mars in 2011," says Coscia. During these missions, the challenge will lie in the analysis of real samples, "which is trickier to do than taking measurements by remote sensing from a satellite," adds Franck Montmessin, the young researcher in charge of one of the Exomars instruments.

## KEEPING AN EYE ON OZONE

"Remote sensing" is the term that best sums up what has made SA's international reputation, bolstered by its famous "lidars." "A lidar is a pulsed laser," explains SA Director Alain Hauchecorne. "When it comes into contact with the various atmospheric constituents, it is sent back at wavelengths that are characteristic of these constituents. By analyzing these wavelengths, we can determine and quantify the constituents present along the laser's path." Lidars from this lab now not only equip observatories all over the world,[4] but also a number of planes, like the one used for the Polarcat[5] mission in the Arctic in 2008. The main goal is to monitor global stratospheric and tropospheric ozone, and the lab is coordinating the French contribution to this mission. "By combining these results with measurements made by spectrometers on the ground and in various types of balloons, we measured a 3% fall in the global quantity of ozone between 1991 and 2001," says Philippe Keckhut, in charge of coordinating ground-based lidar measurements. "The figure even fell by as much as 50% at the poles during some winters!"

These data also help validate the measurements provided by observation satellites, such as Envisat and its GOMOS instrument. In his office, layered with stacks of files bearing evocative names like Mars Express, Venus, or NASA, Jean-Loup Bertaux tells us how it works. "GOMOS measures the spectrum of light emitted by a star. By comparing it with the spectrum of the same star as it sets behind the horizon, when its light travels through the Earth's atmosphere, we can infer the light absorption characteristic of the constituents of the Earth's atmosphere, among which is ozone." It's as easy as that. Using this "star occultation" technique, as it is called, GOMOS has carried out no fewer than 400 profiles per day since 2002, and this work is set to continue until 2011. The aim is to map the concentration of ozone and other constituents of the Earth's atmosphere at an altitude of between 15 and 100 kilometers, to obtain a 10-year trend. "Another two of our instruments are currently in orbit studying the atmospheres of Mars and Venus. We're also making use of the second instrument by pointing it towards Earth and acquiring practice at measuring bioindicators, like ozone and chlorophyll, to search for life on exoplanets," enthuses Éric Villard, as he shows us a spare model of the instrument.

## MEASURING OR MODELING?

The major strength of the SA obviously lies in its know-how for developing ever more sophisticated and miniaturized measuring instruments. "Whereas its mathematical modeling will evolve, a well performed measurement will endure!" used to say SA founder Jacques Blamont, whose photos line the walls of the building. But even if measurements are the "lifeblood of science," as Montmessin likes to put it, Slimane Bekki, one of the lab's modelers, is more cautious: "You can't launch a measurement campaign today without knowing ahead of time how the results will be used," he says. To avoid the accumulation of results in under-utilized databases, his team has developed models that assimilate all these data to simulate the transport and chemistry of major gases in the Earth's stratosphere (ozone, methane, nitrogen oxides, etc.). One of these models, REPROBUS, will be used by the International Panel on Climate Change (IPCC) for the forthcoming predictions in the "chemistry" section. This program has even been adapted to the atmospheres of Mars and Venus.

DR

DR

Left: At the Haute Provence observatory, two lidars from the lab are used to study the ozone content of the atmosphere (blue beam) and the components of the wind (three green beams). Right: In 2000, inflating an SA balloon equipped with a spectrometer to measure the ozone and nitrogen dioxide content of the stratosphere.

## EVER FURTHER OUT

But SA isn't restricting itself to planetary atmospheres. Its research extends to the atmosphere of comets, through participation in missions onboard the European Rosetta spacecraft and through experiments in the lab, and even to the Sun's atmosphere through "on site" research.

For this, the lab has provided the International Space Station with a triple spectrometer, and is also taking part in the PICARD mission, which will be taken up on a satellite in 2009. Going even further, the team has started investigating the interplanetary and interstellar media. "Based on measurements provided by the SOHO satellite, we were the first to reveal a distortion of the heliosphere around the Sun," explains researcher Rosine Lallement. "The discovery was subsequently validated by the American Voyager space probes, which were the first to cross the frontier between the heliosphere and the interstellar medium." This interstellar medium is now the subject of Lallement's research, as she maps it using observations not only from ground-based telescopes, but also from satellites.

Time to bid farewell to this place full of wonders. A place that SA's researchers will be leaving in 2010 to join up with some of their colleagues from CETP,[6] in Guyancourt (Yvelines), forming the new LATMOS lab.[7] There, they will be gathering forces to elucidate more of our sky's mysteries.

**Jean-Philippe Braly**

1. CNRS / Université Paris-VI / Université Versailles St-Quentin. The laboratory was headed by Gérard Mégie, CNRS president from 2000 to 2004.
2. A plasma is a fourth state of matter: an ionized gas which is in particular a very good conductor and which emits electromagnetic radiation (well-known phenomena like lighting or the aurora borealis).
3. Mercury's atmosphere is so tenuous that it is usually referred to as an exosphere.
4. Haute Provence (France), Dumont d'Urville (Antarctica), Alomar (Norway), and the Réunion island (France).
5. Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, of Climate, Chemistry, Aerosols, and Transport. www.polarcat.no/polarcat
6. Centre d'étude des environnements terrestres et planétaires (CNRS / Université Versailles St-Quentin / Université Paris-VI).
7. Laboratoire Atmosphères, milieux, observations spatiales (CNRS/ Universités Paris-VI and Versailles-Saint-Quentin).

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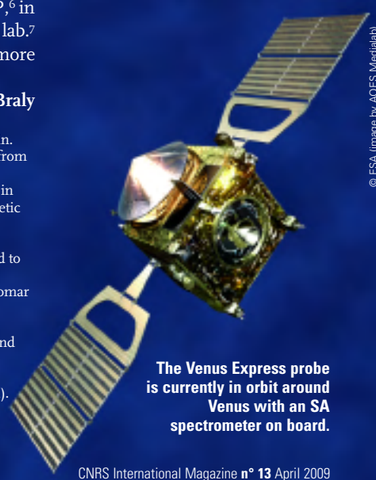


© ESA (image by AOES Medialab)

The Venus Express probe is currently in orbit around Venus with an SA spectrometer on board.

PALEONTHOLOGY

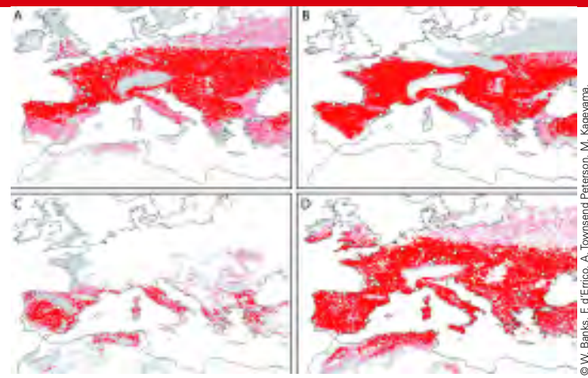
# How Neanderthals Became Extinct

Having inhabited Europe for over 200,000 years, Neanderthals became extinct about 35,000 years ago, and the reasons behind their disappearance have been the source of considerable debate.

The scientific community has long been split between those blaming Neanderthals' inability to cope with dramatic climatic change–in particular a cold period about 39,000 years ago called Heinrich Event 4 (H4)–and those who consider competition with anatomically modern humans (AMH) as a more likely cause. Yet a recent study[1] by a multidisciplinary Franco-American research team, featuring experts in archeology, ecology, and paleoclimatology should put the debate to rest. It demonstrates that competitive exclusion, not climate change, is indeed responsible for Neanderthal extinction.

Using an algorithm called GARP, initially developed to predict the impact of climate change on biodiversity, the team showed that Neanderthals and AMH were exploiting almost identical ecological niches before and during the cold period. "The algorithm uses a host of data–carbon dating, geographic information, and climate history across Europe–and matches it to the paleoenvironmental features shared by known archeological sites (belonging to either Neanderthals or AMH) to predict where these populations might have lived at any given time," explains archeologist William Banks from the PACEA laboratory,[2] who led the research.

According to GARP's calculations, Neanderthals should have continued to occupy the majority of Europe during Greenland Interstadial 8 (GI8), the warmer period that followed H4. "But when we look at the actual sites dated to GI8, we see that the regions occupied by Neanderthals had shrunk to southern Spain," Banks adds. The algorithm results also showed that AMH' niche had expanded during GI8, thus making competition between the two groups–and AMH' superior adaptation–the likely drivers behind Neanderthal extinction.



© W. Banks, F. d'Errico, A. Townsend Peterson, M. Kageyama, A. Sima, M.-F. Sánchez-Goñi / PLoS ONE, Dec. 2008

**The distribution of Neanderthals (A,C) and anatomically modern humans (B, D) before (A, B) and after (C, D) Heinrich event 4 (approx. 39,000 years ago), during the last glacial period.**

While several past studies have attempted to gauge the impact of climate change on human populations, the multidisciplinary approach made possible by GARP constitutes a significant breakthrough. As stressed by Francesco d'Errico, co-author of the study, "GARP combines archeological, chronological, and climatic data in a unique computational architecture."

**Fabien Bulliard**

1. W. E. Banks et al., "Neanderthal extinction by competitive exclusion." *PLoS ONE*, 2008. 3(12): e3972.
2. De la Préhistoire à l'Actuel: Culture, Environnement et Anthropologie (CNRS / Université Bordeaux-I).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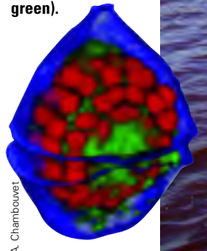
MICROBIOLOGY

# Curbing Red Tides, Naturally

**Non-toxic red tide in Elorn Bay in Brittany (France, 2004).**

© L. Guillou

**A dinoflagellate (blue) infected by its specific parasite (nucleus in red, and cytoplasm in green).**



© A. Chambouvet

Researchers have discovered a parasite that can fight the toxic red tides caused by the dinoflagellate *Alexandrium minutum*, a micro-alga capable of proliferating uncontrollably, to the point where it can taint coastal seawater to a characteristic murky-red. These algae produce toxins that accumulate in shellfish, making the latter hazardous for human consumption.

By the late 1980s, the emergence of red tides in the coastal waters of France's Britanny region led to the frequent closure of aquacultural farms. Yet, without apparent reason, no single "bloom" has been observed since 2003. The subject of her doctoral thesis at the SBR,[1] Aurélie Chambouvet, under the supervision of Dr. Laure Guillou has demonstrated the regulating action of a marine parasite that specifically infected *Alexandrium minutum*, but not only. In fact, each species of dinoflagellate observed in this ecosystem had a parasite that was genetically very specific.

The use of new molecular tracing methods has shed light on how this type of infection occurs. These new generation tracers are strings of DNA coupled to fluorescent markers. When they latch onto the target cell's ribosomic RNA, they turn its whole cytoplasm fluorescent. "We found that each micro-alga host has a corresponding strain of parasite that can infect, proliferate, and destroy its host in just a few days," says Guillou, adding that this rapid decline then benefits another species of dinoflagellates which can proliferate until attacked in turn by its own specific parasite.

Red tides seem to result from an imbalance between the host alga and its natural parasite. This balance can be upset by human activity like ships carrying a strain of dinoflagellate to a new environment, or environmental factors such as global warming, since abnormal temperatures may lower the virulence of a parasite. "Host and parasite constantly try to outdo each other, and when parasites lag behind, biocontrols are absent which results in an unabated proliferation of host algae," Guillou explains.

So far, the human introduction of parasites in bloom situations is not on the agenda. "We need to learn much more about upstream processes, and whether or not other host algae could be impacted. We will rather focus on studying the parasites' molecular mechanisms, know more about them and their capacity to act as biocontrols against red tides," concludes Guillou.

**Stéphane Malhomme**

1. Station biologique de Roscoff. Adaptation et diversité en milieu marin. (CNRS / Université Paris-VI).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NANOTECHNOLOGY

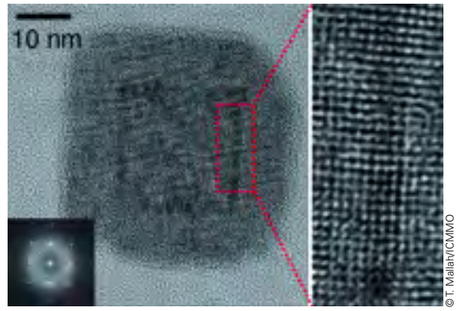
# Magnetic Nanoparticle Networks


Electronics, computers, communications, optical and biomedical engineering... these crucial areas of research and many more stand to gain from core-multishell structures for nanoparticles. CNRS has actively been exploring this novel avenue of research.

Core-multishell structures can act as building blocks of high technology, whereby desirable properties can be blended on a mix-and-match basis. This innovation stems from the pooled expertise of three CNRS-partnered laboratories.[1] Previous experimentations with Prussian Blue pigment and its analogs (PBAs), characterized by transition metal[2] cores bridged to other atoms by cyanide ligands, had led to the discovery that PBA-based nanoparticles could spontaneously stabilize and regroup into coordination networks where components were magnetically bound into ordered arrays. Subsequent tests on PBAs spawned the first successful synthesis, in 2008, of core-multishell particles.

The technique consists in stabilizing charged cores in water so that particle surfaces are more apt for coordination networking, before solutions are added to grow shell networks around the cores.[3] Its great boon is that the core of a given network can be surrounded by shells of differing chemical compositions. Moreover, the stacking of shells can be monitored "at the nanometer scale," specifies Talal Mallah from ICMMO,[1] simply by adjusting the solution content added to cores. In short, any type of shell can be grafted onto any desired core, at whatever thickness needed.

Most remarkably, when different shell types are combined, the various physical properties present then act in synergy. The lure of PBAs lies in their strikingly diverse physical properties, such as magnetism, photomagnetism,[4] piezomagnetism,[5] electrochromism,[6] and spin crossover.[7] Mallah points out that assorted properties can be harnessed for the production of one–or possibly several functions.




© T. Mallah/ICMMO

**High resolution electron-microscopy images of a core-multishell nanoparticle (left), showing the perfect alignment of the networks assembled (right).**

Indeed a huge step ahead for the tiny nanoparticle, as the accumulation of properties opens up a new world of possibilities for devices requiring versatile and compact components.

More specifically, the team foresees producing nanoparticles with magnetic or conductive properties, for example, that will respond to electric, magnetic, temperature, light, or pressure stimuli, and can serve as models for information storage, signal processing, or signal transformation. Electrochrome nano-objects may further be exploited in biological detection tags or captors. When on the other hand core-multishell nanoparticles that unite disparate metallic cores are decomposed, metallic alloys otherwise impossible to synthesize may be isolated, something highly valuable for the development of catalysts or high-density computer memories. The new technique's potential is yet to be fully exhausted. Mallah indicates that the team is now looking to create core-multishell structures from particles other than PBAs in the hope of producing "new metallic particles containing metals which, in standard conditions, do not associate with one another."

**Fui Lee Luk**

1. Institut de Chimie Moléculaire et des Matériaux d'Orsay (ICCMO: CNRS / Université Paris-Sud), Laboratoire de Physique des Solides (CNRS / Université de Strasbourg), and Institut de Physique et Chimie des Matériaux de Strasbourg (CNRS / Université de Strasbourg).
2. Metallic elements with an incomplete inner electron shell.
3. L. Catala et al., "Core-multishell magnetic coordination nanoparticles: toward multifunctionality on the nanoscale," *Angew. Chem. Int. Ed.*, 2009. 48: 183-7.
4. Where magnetism is modified by light.
5. Where magnetism is modified by strain.
6. The capacity to change color reversibly when energy is applied.
7. Whereby light irradiation modifies a compound's electronic spin state.

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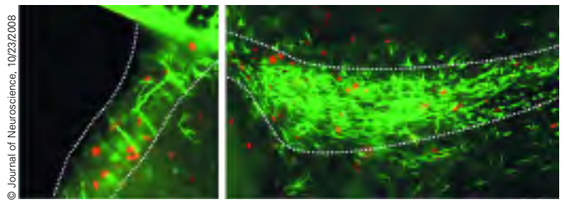
NEUROBIOLOGY

# Glial Cells Get Center Stage

For a long time, glial cells were overshadowed by neurons. Originally viewed as ordinary caretakers, their importance is now slowly emerging. In this context, two recent studies show how they participate in the brain's self-repair and communication systems.



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**After a chemical lesion of the olfactory epithelium in mice, stem cells from the subventricular zone (left, red) migrate through the rostral migratory stream (right) to reach the olfactive bulb.**

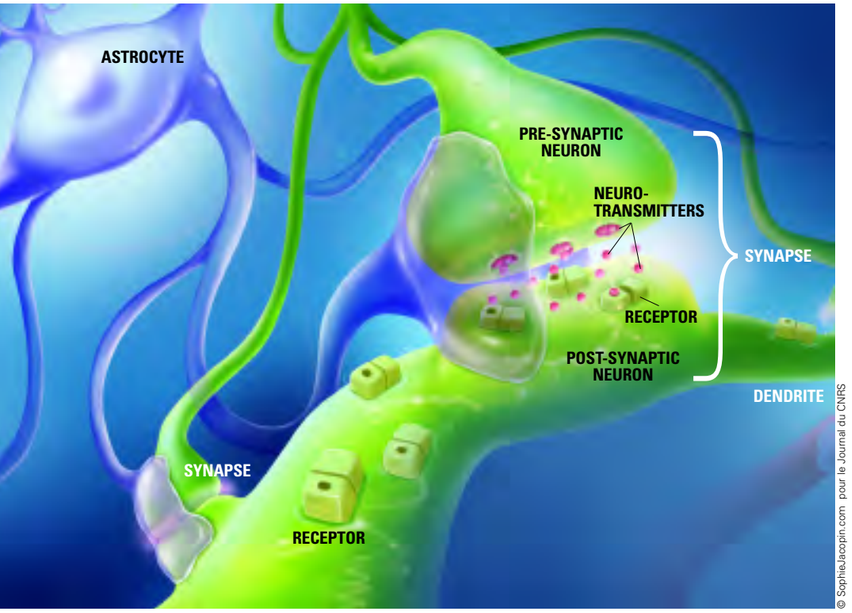
Glial cells play crucial roles in the central nervous system, where they outnumber neurons 10 to 1. In mature organisms, they provide physical support and transfer energy from the blood circulation to the nerves. They are also known to have a protective role by enabling the clearance of leftover ions and neurotransmitters from the synaptic cleft. More surprisingly, glial cells have also been shown to actively participate in synaptic transmission.

As if this wasn't enough, another major role has emerged in the last decade: Glial cells inside a specific brain region–the subventricular zone–have the ability to transform into neurons. This finding contradicted a long-established dogma, which stipulated that the adult brain could not produce new neurons.

Now, a team led by CNRS researcher Pierre-Marie Lledo[1] has demonstrated that glial cells inside another area–the olfactory bulb–could also transform into neurons.

As described in their study,[2] the researchers spent two years creating a fluorescent viral-vector aimed at the neuron-producing cells–a particular type of glial cells called "astrocytes" (star-shaped cells that make up the "cement" between the neurons). The vector enabled them to locate astrocytes on mouse olfactory bulb slices. Using electrophysiology, they observed that fluorescent astrocytes developed the hallmarks of neurons. When the scientists damaged parts of the tissue, they witnessed a six or seven-fold increase in neuron production from astrocytes in that region, demonstrating that a lesion triggers neurogenesis. "It's interesting to note that the two brain regions where this phenomenon takes place are involved in memory formation," says Lledo. "We are now trying to discover if this inherent self-repair mechanism could be extended to other parts of the brain, when subject to lesions, trauma, or strokes."

**Astrocytes and neurons are organized in parallel networks whose mutual interaction is essential for functional synaptic communication within the brain.**

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At a more fundamental level, another interesting finding concerns the mechanism by which astrocytes communicate among themselves and with neurons. According to CNRS researcher Christian Giaume,[3] when neurons are active, their need for energy is passed on to neighboring astrocytes, which stimulate an entire network of astrocytes to route nutrients from the blood circulation towards these nerves. In a recent study,[4] Giaume and colleagues demonstrate that the network organization is key to an interactive loop between neurons and astrocytes.

Working on mouse hippocampus slices, the scientists injected fluorescent glucose inside an astrocyte, and visualized its transmission to neighboring astrocytes. When the junctions linking astrocytes were pharmacologically blocked, nutrients could no longer travel to the nerves, whose activity weakened, according to electrophysiology recordings. Vice versa, the size of the astrocyte network decreased when researchers blocked neuronal activity; when neurons were over-stimulated, the size of the network increased. "When studying interactions between astrocytes and neurons, whether it be in a metabolic context or in a context of synaptic communication, researchers should realize that it is probably not just a single astrocyte that is involved, but an entire network, just like neurons," concludes Giaume.

**Clémentine Wallace**

1. Perception et mémoire (CNRS / Institut Pasteur).
2. M. Alonso et al., "Turning astrocytes from the rostral migratory stream into neurons: a role for the olfactory sensory organ," *J. Neurosci.*, 2008. 28: 11089-102.
3. CNRS / Inserm / Collège de France.
4. N. Rouach et al., "Astroglial metabolic networks sustain hippocampal synaptic transmission," *Science*, 2008. 322: 1551-5.

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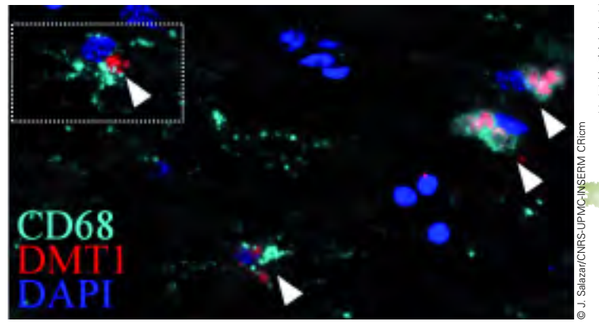
NEUROBIOLOGY

# Iron and its Transporter in Parkinson's Disease

Limiting the level of iron in dopaminergic neurons could help fight Parkinson's disease (PD). This is what CNRS researcher Etienne Hirsch[1] together with a team at INSERM-UPMC[2] have recently demonstrated.[3] Iron plays an integral role inside neurons as a co-factor for enzymes that produce dopamine–the neurotransmitter found lacking in a specific region of the brain in PD patients. But while some iron is needed for dopamine production, too much results in oxidative stress and cell death. To elucidate the role of the iron transporter DMT1 in the development and evolution of Parkinson's disease, and to see whether the mechanism may represent a therapeutic target for neuroprotection, Hirsch and his co-workers used rodent animal models.

First, they observed that the induction of the disease in mice was correlated with a doubling of the level of expression of DMT1, leading to an increase of iron within dopaminergic neurons, and the expected ensuing oxidative stress and cell death.

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**Microglial cells, labelled for a specific marker (green) and DNA (blue), show an increased expression of the metal transporter DMT1 (red) in the brain of a patient with Parkinson's disease.**

Then, they used a mice strain called "microcytic" where the DMT1 iron transporter was impaired, the result of a spontaneous mutation. When injected with a toxic chemical specific to dopaminergic cells, these mice showed a 20% neuronal cell death rate compared to the 40% in wild-type animals. A functional DMT1, with the resulting iron increase inside cells, thus seems to contribute to neuronal cell death, whereas a dysfunctional iron transporter confers protection from degeneration.

"While there is now relatively good symptomatic treatment for Parkinson's disease, that consists in restoring the missing dopamine, we have no treatment to slow down the progression of neurodegeneration which evolves over decades," says Hirsch. "We found that we could protect half of the dopaminergic neurons from degeneration by decreasing iron in the cells."

His main concern with targeting this transporter therapeutically is that it could prevent required levels of iron from entering the cells. "It is therefore important to achieve the right balance and prevent dysregulation," he concludes.

**Karen Dente**

1. Unité 975 (Inserm / CNRS / UPMC).
2. Université Pierre et Marie Curie.
3. E. Hirsch et al., "Divalent metal transporter 1 (DMT1) contributes to neurodegeneration in animal models of Parkinson's disease," *PNAS*, 2008. 105, 47: 18578-83.


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PARTICLE PHYSICS

# Calculating the Mass of a Proton

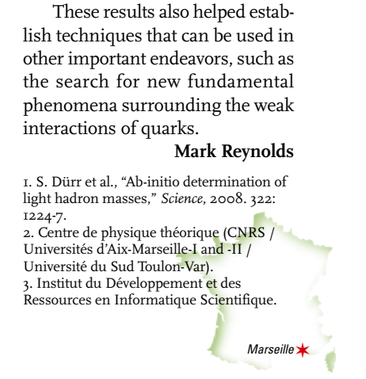
Scientists have known how much a proton weighs for the better part of a century. But it took a pan-European team of theoretical physicists, building upon decades of research by scientists from around the world, to work out precisely how its mass comes about.[1] Led by Zoltan Fodor from the University of Wuppertal and Laurent Lellouch from the CPT in Marseille,[2] the team's results confirm that Quantum Chromodynamics (QCD), the fundamental theory of quarks and gluons, correctly describes the interactions which bind these elementary particles together to form hadrons. As Lellouch explains, a proton's main components are two "up" quarks and one "down" quark, which are held together through the exchange of gluons. Yet the masses of the individual constituents do not add up to the mass of a proton, a disparity which had been known for a long time. A full quantitative understanding of this disparity had to wait until last year. "We realized that the different techniques needed were coming together, and that the necessary computing power was now available," explains Lellouch. The researchers used IBM Blue Gene supercomputers from the Forschungszentrum Jülich in Germany and CNRS' IDRIS,[3] applying their ability to perform over 100 trillion calculations/sec.

Though the only parameters of the calculation are the quark masses and the overall strength of the interaction, describing quark and gluon behavior in four-dimensional space-time requires an infinite number of variables. This is where a technique known as lattice QCD comes in. It allows a numerical simulation in which continuous space-time is viewed as a succession of increasingly finer four-dimensional lattices, each composed of sites spaced along rows and columns. After roughly $10^{20}$ computer operations, the theorists determined the mass of the proton and of other light hadrons with a precision of a few percent, finding excellent agreement with laboratory measurements and thus confirming that most of it comes not from the masses of the hadron's quark and gluon constituents, but rather from the energy generated by the interactions between them.

These results also helped establish techniques that can be used in other important endeavors, such as the search for new fundamental phenomena surrounding the weak interactions of quarks.

**Mark Reynolds**

1. S. Dürr et al., "Ab-initio determination of light hadron masses," *Science*, 2008. 322: 1224-7.
2. Centre de physique théorique (CNRS / Universités d'Aix-Marseille-I and -II / Université du Sud Toulon-Var).
3. Institut du Développement et des Ressources en Informatique Scientifique.

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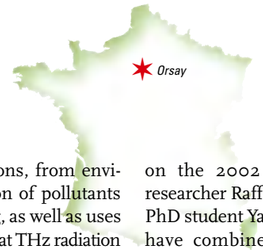
PHYSICS

# THz Lasers Are Cool




THz quantum cascade lasers are a relatively new family of semiconductor lasers which emit in the terahertz frequency range ($10^{12}$ Hertz). Because of the lack of compact radiation sources between 1 and 10 THz, scientists call it the "THz gap." Since the first development of the quantum cascade laser family–in 1994 at the US' Bell Labs–physicists and engineers have been trying to narrow this gap.

If they succeed, THz lasers promise distinct advantages. Since THz waves can penetrate through skin (but are non-ionizing, unlike x-rays), clothing, paper, wood, cardboard and plastic, they offer wide potential applications, from environmental detection of pollutants to medical imaging, as well as uses for security, given that THz radiation could detect hidden drugs or weapons at airports.

Before 2002, lasers in the THz gap were big, bulky, gas-based ($CO_2$ and methanol), and inefficient. But in 2002, an Italian-British collaboration began shrinking their size, and with it, the THz gap. And if today's lasers are as small as a tie clip, or a typical silicon chip (200 microns x 2 mm), they have two main weaknesses: the relative divergence of their beam, and the difficulty of extracting radiation from the chip's surface. Following up on the 2002 discoveries, IEF[1] researcher Raffaele Colombelli and PhD student Yannick Chassagneux have combined small photonic crystal structures with the laser creating a system that not only emits THz waves, but also enables control of the output beam.[2] "It now diverges very little," Colombelli says.

The researchers are still trying to boost the lasers' temperature and power. One obstacle is that THz quantum cascade lasers operate at a maximum temperature of 178K (-95°C). The researchers believe they can reach 240K (-33°C) by redesigning the laser's active regions. This will make it viable for a range of applications, since this warmer temperature is compatible with today's commercially available coolers. Anything cooler than 240K demands a cryogenic system. "Today, when industrialists call and ask 'what temperature are you at?' and I say 'still 178K,' they just answer 'we'll call back later.' We still have 62K to go."

**Joshua Jampol**

1. Institut d'Electronique Fondamentale (CNRS / Université Paris-XI).
2. Y. Chassagneux et al., "Electrically pumped photonic-crystal terahertz lasers controlled by boundary conditions." *Nature*, 2009. 457: 174-8.

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ENVIRONMENT

# Ancient Forests Do Trap Carbon


Old-growth forest–with its multiple layers of vegetation and great biodiversity–traps between 0.8 and 1.8 billion tons of carbon a year. This is the surprising result of a study dispelling the belief that old-growth, pristine forests could not store carbon after a certain age. The discovery makes for more accurate "full carbon accounting" and smarter incentive programs to curb carbon emissions.

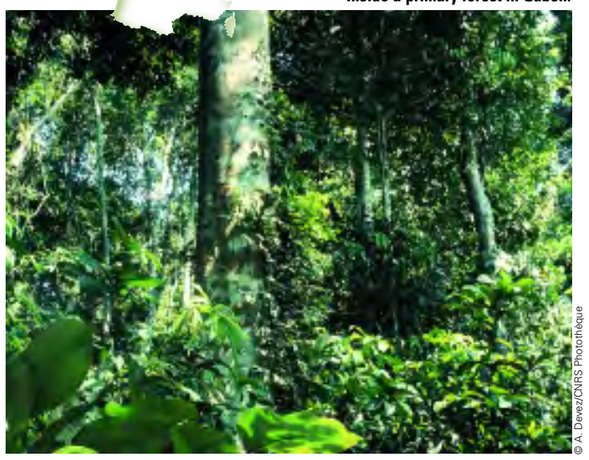
Ecologist Eugene Odum hypothesized in the 1960s that forests over 150 years old reached a neutral balance between storage and emissions of $CO_2$. A majority of scientists initially accepted this paradigm, even though it had not been backed by scientific evidence. "Odum's rationale was that forests could not grow eternally, and had to reach an equilibrium between storage and emissions," says Philippe Ciais, senior researcher at LSCE[1] who contributed to this recent study published in *Nature*.[2] Because of this, old-growth forests have so far been ignored by the Kyoto protocol. A team of international researchers, with the participation of LSCE, have made, compiled, and analyzed measurements in old forests throughout the world, from the Siberian taiga all the way to the Amazon rainforests. Their results countered Odum's theory: Ancient forests do continue to store carbon. This entails that the previously ignored 15% of total forest area is in fact responsible for trapping 10% of overall carbon sink.

"In theory, Odum's hypothesis made sense. After a while, a tree had grown so much that it simply could not add biomass. From 10,000 saplings of the young forest, mortality over 150 years had left 300-400 huge trees that harvested most sunlight, but could not carry water up their branches–limiting their maximum size. Yet on closer inspection, our biometric measurements of roots, trunks, branches, and leaves showed that they continued to add biomass, and therefore, store carbon," says Ciais. One possible explanation is that rising $CO_2$ levels or global warming induce longer growing seasons and foster carbon uptake beyond Odum's expectations.

"One perverse effect of Kyoto 1 is that a country can clear-cut an ancient forest with no penalty, sell the wood, then re-plant and cash in the carbon credits for a younger forest which does not contain as much carbon because it is regularly managed by foresters," says Ciais. "We should therefore also give a bonus to countries that protect their ancient forests," he concludes.

**Stéphane Malhomme**

Inside a primary forest in Gabon.



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1. Laboratoire des Sciences du Climat et de l'Environnement (CNRS / CEA / Université de Versaille).
2. S. Luyssaert et al., "Old-growth forests as global carbon sink," *Nature*, 2008. 455: 213-5.

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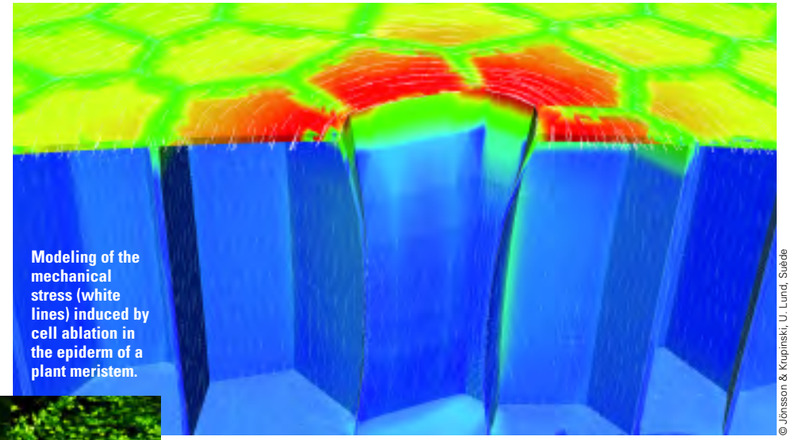
MOLECULAR BIOLOGY

# Mechanical Pressure as Gene Regulator

A central question in developmental biology is how non-genetic phenomena such as mechanical forces regulate growth. Here are the most recent findings on the role of such forces in the development of diametrically different tissues: human tumors, and plants.



Modeling of the mechanical stress (white lines) induced by cell ablation in the epiderm of a plant meristem.

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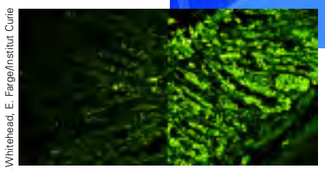
For almost half a century, scientists believed that all the events that occured during the development of an organism were the sole product of what was written in its genes. The postulate began loosening up only a decade ago, as biologists started demonstrating that non-genetic phenomena also affected development.



© J. Whitehead, E. Farge/Institut Curie

Myc oncogene expression (green fluorescence) is induced in colon cells submitted to mechanical pressure (right) in an APC mutated background.

In this context, researchers led by Emmanuel Farge[1] at the Curie Institute in Paris have been studying the influence of mechanical pressure on genetic expression and cell proliferation during embryonic development, and more recently during tumor formation.

Working on embryos of fruit flies, the team first demonstrated that the forces generated by migrating cells during early embryonic development influence the expression of genes in neighboring cells. "The growing tissues and the genes responsible for the body's architecture are in close communication," says Farge. "It's a sort of feedback loop indicating where genetic activation should be launched." At the molecular level, they discovered that such mechanical pressure triggers the relocation, inside cells, of a protein called ß-catenin (involved in both cell adhesion and gene activation) from the external membrane to the nucleus, where it activates the transcription of developmental genes. This protein thus acts as a messenger transferring mechanical information to the genes.

In humans, it is only during tumor formation that ß-catenin can be found inside the nucleus of adult cells. This phenomenon can occur when cells lack one or two copies of a gene called adenomatous polyposis coli (APC), whose physiological role includes clearing the excess of intracellular ß-catenin. APC mutations are known to pre-dispose to certain cancers such as colon cancer. When ß-catenin enters the nucleus, it activates the transcription of oncogenes–which are often identical to the developmental genes involved in embryogenesis. "This similarity is what led us to investigate whether mechanical forces might also come into play in the development of some cancers," says Farge.

In recent experiments,[2] the team applied controlled mechanical pressure on tissues of healthy mice colon cells, and on tissues of mice colon lacking one copy of the APC gene. Using fluorescence, they observed that pressure on healthy tissues did not induce the relocation of ß-catenin. However, in APC-deficient tissues, this protein did travel to the nucleus. "Mechanical pressure can thus contribute to the activation of oncogenes in cells genetically pre-disposed to cancer," says Farge. "In these cells, one copy of the APC gene is not sufficient to counter the mechanically-induced ß-catenin relocalization."

The team also noticed that the relocation occurred when the pressure applied equaled at least that of bowel movements inside the colon. "We still have to elucidate whether the pressure generated by bowel movements can initiate tumor genesis in APC deficient cells, or if pressure is only involved in the amplification process–cells of a growing tumor pressuring a pre-disposed neighboring cell, thereby feeding a chain reaction."

On the other side of the realm of developmental biology, researchers have discovered the role of mechanical forces in plant development. An international team of researchers including CNRS scientists[3] showed that the mechanical constraints generated by growing tissues determine the orientation of growth in neighboring cells.[4] "Before that, we knew growing cells exert pressure on their neighbors, but we didn't know how this pressure was integrated as a message," says lead author Olivier Hamant.

Working on tissues of plant meristem–a pool of undifferentiated cells found in zones where growth takes place–the team showed that intracellular components called microtubules react to external forces. Microtubules are known to control the direction of cell expansion. Using fluorescent live imaging, the team followed the organization of microtubules inside these tissues. In some cells, the microtubules appeared oriented in one direction. In other cells, they were disorganized. When the researchers applied different pressures on the tissue, they observed that the microtubules oriented themselves parallel to these forces, reorganizing themselves according to the maximum constraint. "This proves that mechanical constraints contribute to determining the direction of growth," says Hamant.

The team now hopes to study the interactions between mechanical forces influencing direction and other parameters such as growth speed and genetic pre-disposition.

**Clémentine Wallace**

1. Inserm UMR 168 (CNRS / Institut Curie / Inserm).
2. J. Whitehead et al., "Mechanical factors activate ß-catenin-dependent oncogene expression in APC1638N/+ mouse colon," *HFSP J.*, 2008. 2: 286.
3. Reproduction et développement des plantes (Université de Lyon / CNRS / ENS / INRA).
4. O. Hamant et al., "Developmental patterning by mechanical signals in arabidopsis," *Science*, 2008. 322: 1650-5.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GEOLOGY

# Molten Carbonates Fill the Gap


Scientists have discovered that carbonatite melts are responsible for the mantle's conductive properties. And this research has far-reaching implications in environmental sciences, from mapping out volcano carbon emissions to developing clean energy.

Lodged between the Earth's crust and core is the mantle, where solid nether regions are topped by molten magma- and lava-producing areas. For the past 30 years, we have known that natural electrical currents occur in the Earth's upper mantle at depths of 70 to 350 km–this despite the fact that olivine, the iron- and magnesium-rich mineral silicate that makes up most of the layer, is nonconductive. So what is it that causes the mantle's conductivity? And furthermore, why does this conductivity vary from one part of the mantle to another?

Led by Fabrice Gaillard from the ISTO,[1] an Orléans-based research team–also representing the CEMHTI laboratory[2]–has succeeded in identifying the source of the mantle's conductivity: small quantities of molten carbonates–also called carbonatites–that are found between loose rocks.[3] The researchers link the conductivity of the oceanic asthenosphere, or upper ductile mantle, to the presence of an average volume of 0.1% of carbonatite melts, confirmed by the $CO_2$ content of mid-ocean ridge basalts.

Using laboratory measurements conducted on mantle components, the team demonstrated the high conductivity of these carbonates, as compared with other substances to which conductivity had formerly been attributed: three and five orders of magnitude higher than molten silicate and hydrated olivine, respectively. This explains why varying concentration of carbonates throughout the mantle can cause divergences in conductivity.

While geologists have lacked proof for their longtime suspicions on the mantle's significant carbon content due to its scarcity in samples, the team's findings have allowed an initial estimate on this figure: an average of 0.03% $CO_2$ by weight–a seemingly small proportion, yet enough to account for 80% of the $CO_2$ emitted by volcanoes. Figures are to be confirmed in an upcoming project, Electrolith, also led by Fabrice Gaillard, in which measurements will be taken at Ol Doinyo Lengai, in Tanzania, the only volcano in the world to produce lava containing liquid carbonates. Elsewhere, the mantle also holds carbonates, but they are dissolved in basalt lava and released as $CO_2$ gas when the lava reaches the Earth's surface.

Various research areas have opened up in response to the findings, some offering substantial environmental prospects. The discovery advances clean energy by aiding the development of carbonates like lithium carbonate to be used as electrolytes in high-temperature fuel cells. "Having found the correlation between conductivity and carbonatites, we can now also 'map out' carbon levels in magma source regions to quantify the carbon footprint of terrestrial volcanism," says Gaillard. In other words, by detecting conductivity in the mantle roots of volcanic areas, carbon content can be ascertained and the contribution made by volcanoes to the greenhouse effect pinpointed at various locations.

Lastly, these carbonatites are not only a source of conductivity, but also believed to play a role in the asthenosphere's viscosity, enabling the shifting of tectonic plates. This hypothesis paves the way for studies on the behavior of liquid carbonates in solids, and possible effects on viscosity.

**Fui Lee Luk**

1. Institut des Sciences de la Terre d'Orléans (CNRS / Université d'Orléans / Université François-Rabelais).
2. Conditions Extrêmes et Matériaux: Haute Température et Irradiation (CNRS).
3. F. Gaillard et al., "Carbonatite melts and electrical conductivity of the asthenosphere," *Science*, 2008. 322: 1363-5.

**Ol Doinyo Lengai (Mali) is the only volcano in the world to produce lava containing liquid carbonates.**



© Photos : Hannes Matsson, ETH Zurich

**At the summit of Ol Doinyo Lengai, small explosions produce carbonatite-rich lava characterized by a very low viscosity.**

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CANCER

# Fighting Leukemia at the Root

Acute promyelocytic leukemia (APL) is a rare disease that affects 100 people each year in France. Concerned patients have a chromosomal translocation giving rise to a fusion between the promyelocytic leukemia (PML) gene, normally encoding a transcription factor and tumor suppressor, and the retinoic acid receptor α gene. The resulting protein known as PML-RARA blocks differentiation of blood precursor cells, leading to the accumulation of malignant cells in the bone marrow and blood of affected patients.

For the past decade, Professor Hugues de Thé and his team[1] have been searching for drugs that would interact with the PML-RARA protein and destroy patients' cancer cells. Two drugs, retinoic acid and arsenic trioxide, have been shown to be clinically effective, sometimes sending APL in complete remission. So far, it was believed that the eradication of the disease was mainly due to the "renewed" differentiation of leukemia cells. Now, working on a mouse model of the disease,[2] de Thé's team has shown for the first time that retinoic acid and arsenic trioxide also induce complete disappearance of the small subpopulation of stem cells responsible for the permanent production of leukemia cells. The complete eradication of leukemia stem cells is due to the degradation of PML-RARA in these cells. De Thé's team was able to uncouple the effects of the two drugs. Retinoic acid alone brings about differentiation of APL cells but not stem cells clearance or disease remission, which requires the synergic action of both drugs.

These findings have "very exciting implications for cancer therapy," de Thé explains, not only for improving APL treatment, but also because "the concept of destroying a disease-causing protein in cells that have acquired stem-cell characteristics might help treat other cancers in the future."

The efficiency of the combined use of these drugs in humans has now been demonstrated through a clinical trial led by the group of Zhu Chen at the Rui Jin Hospital in China. De Thé now wants to investigate the pathways involved in the loss of the leukemia stem cells in greater detail. Such advances in the field of cancer research hold great promise for the development of improved and more specific treatments.

**Juliette Gray**

1. Pathologie et virologie moléculaire (CNRS / Université Paris-VII).
2. R. Nasr et al., "Eradication of acute promyelocytic leukemia-initiating cells through PML-RARA degradation," *Nature Medicine*, 2008. 14: 1333-42.

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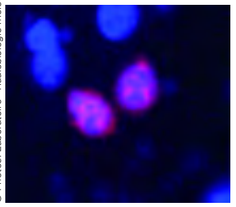
IN BRIEF

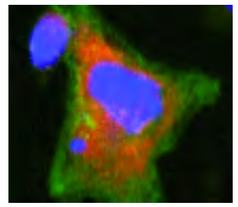
## All Roads Lead to BRCA1

**BRCA1, one of the proteins whose mutation is responsible for hereditary breast cancer, might also be involved in the other type of breast cancers, non-hereditary, called sporadic. These represent 85 to 90% of all cases of breast cancers and are actually less understood than their hereditary counterpart. Because the protein kinase AKT1 is overexpressed in half of sporadic breast cancers, a team of researchers[1] investigated whether AKT1 might act through regulation of BRCA1 activity. Their results[2] indeed show that this is the case. In tumor cells, overexpression of AKT1 results in BRCA1 retention in the cell cytoplasm. This protein, normally involved in DNA repair and in regulation of gene expression in the cell nucleus, is thus unable to perform its functions. In particular, BRCA1 can no longer play its role in homologous recombination, a mechanism that helps maintain DNA stability. This same function is the one that is impaired in hereditary breast cancer, through BRCA1 mutations. These results show that both hereditary and non-hereditary cancers result from the impairment of the same molecular mechanism, homologous recombination, essential to maintain DNA integrity.**

1. From CNRS, CEA, and Hôpital Saint-Louis.
2. I. Plo et al., *Cancer Res*, 2008. 68: 9404-12.

> **Contact: Bernard Lopez,** Bernard.lopez@cea.fr



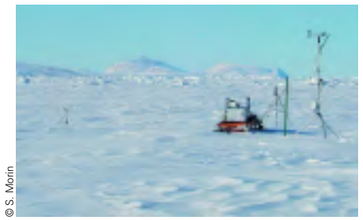


© Photos: Laboratoire "Radiobiologie moléculaire et cellulaire"

**In a non-pathological situation, BRCA1 (red) is located in the cell nucleus.**

**In the presence of AKT1 (green), BRCA1 (orange) is kept out of the nucleus (blue).**

# Nitric Arctic



© S. Morin

**Instruments for chemical and meteorological measurements on Arctic pack ice covered by snow (Alert, Canada, Spring 2004).**

One third of all nitrates present in the Arctic atmosphere in spring come from the melting of the snow cover. This worrying news was published by a team led by Samuel Morin,[1] after quantification of a process already known, the "travelling" of nitrate around the planet. Nitrogen oxides produced by natural phenomena like lightning and forest fires, but also by human activity, such as combustion and industrial activity, are rapidly oxidized to nitrate. Incorporated into atmospheric particulate matter, nitrate is transported by air currents towards distant ecosystems, like the Arctic, where it is deposited onto the snow cover during autumn, winter, and early spring. When the snow is exposed to solar radiation, the nitrate turns into nitrogen oxides that are emitted into the atmosphere. By measuring the isotopic composition of the atmospheric nitrate collected in the Canadian Arctic, researchers have shown that it comes in a large proportion from the "recycling" of nitrate from the Arctic pack ice. This study once more demonstrates the need for a global approach when it comes to environmental problems, due to the close links between the climate system (ice and snow-covered surfaces, temperatures, and solar radiation) and the presence of highly-reactive pollutants in the atmosphere (nitrogen oxides, ozone, and particulate matter).

1. S. Morin, et al., *Science*, 2008. 322: 730-2.

> **Contact: Samuel Morin,** samuel.morin@lgge.obs.ujf-grenoble.fr

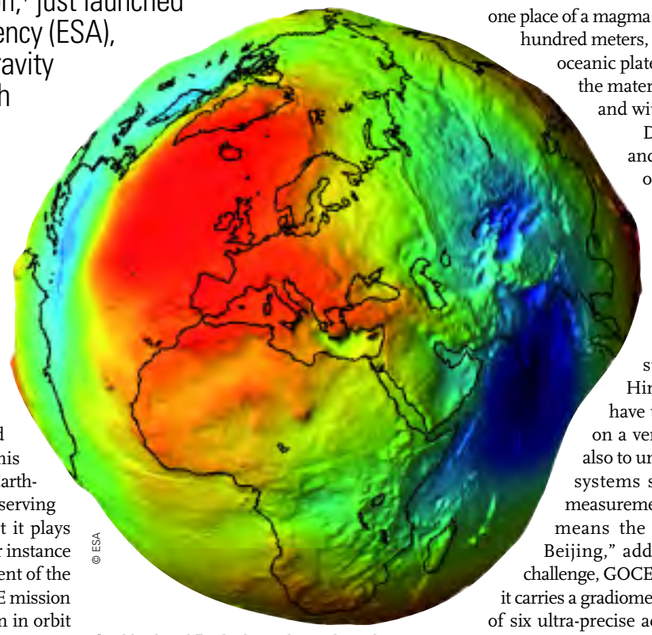
GOCE MISSION

# The Real Shape of Earth

The job of the GOCE mission,[1] just launched by the European Space Agency (ESA), is to measure the Earth's gravity field at every point and with unrivalled accuracy. This fundamental yet poorly known data will help determine the true shape of Earth.

If Man first believed the Earth was flat, then round–we might be in for yet another surprise: its shape is actually that of a lumpy potato.[2] There's a hollow off South America, a bump to the north of Australia, and various lumpy bits here and there. This distorted shape is invisible both to the Earth-bound traveler and to the astronaut observing the blue planet in its atmosphere–yet it plays havoc with a host of measurements, for instance those of ocean currents or the movement of the Earth's crust. It is what makes the GOCE mission so important. This satellite will remain in orbit for 20 months. It will measure the gravity field, the cause of deformities, with the same precision (one part in a million) all over the surface of Earth, at a resolution of about a 100 km. Researchers from several CNRS labs[3] are getting ready to process the data and include them in their models.

The quantity known as g (the acceleration due to gravity) is what relates mass to weight, and gives the Earth its shape. And if our planet isn't a smooth sphere, it is because g doesn't have exactly the same value all over the surface of Earth: Mass is not equally distributed inside the planet, and every point on its surface is not subjected to the same attractive force.



© ESA

**On this virtual Earth, the regions where the gravity field is weakest are shown in blue, and the regions where it is strongest in red.**

To get a better picture of the variations of g at the Earth's surface, scientists use an imaginary Earth called the "geoid." It is important to note that this lumpy image of our planet corresponds to the mean level the ocean would have at rest. "If the whole of the Earth were covered with water, its surface would be the same as that of the geoid," explains Michel Diament, of IPGP.[4] "This means ocean level extends beneath the continents and is used as a reference for altitudes. For instance, the Mont Blanc summit is 4807 meters above the geoid." So why do the world's oceans at rest show such hollows and bumps? The answer lies in the entrails of the planet. "If the Earth was immobile and made of just one material–i.e., if it was homogeneous–the geoid would be a sphere," Diament says. "But our planet rotates, which gives it a flattened shape, and it is made of materials of different densities. The presence in one place of a magma reservoir at a depth of a few hundred meters, and in another of a sinking oceanic plate means that the density of the material beneath our feet varies, and with it the value of g.

Determining these hollows and bumps–with differences of up to a 100 meters–with the same precision all over the planet is no easy task. Indeed, local ground measurement can give the value of the gravity field with accuracy of one part in a billion, but for a large structure such as the Himalayas, it is necessary to have this type of high precision on a very large scale. "The aim is also to unify international reference systems so that, for example, the measurement of the altitude of a point means the same thing in Paris or Beijing," adds Diament. To meet this challenge, GOCE is well equipped: on board, it carries a gradiometer, an instrument made up of six ultra-precise accelerometers built by the French Aerospace Lab Onera,[5] completed by a GPS receiver. To preserve high resolution, GOCE was placed in a low orbit, at an altitude of 265 kilometers. At this distance, friction with the residual atmosphere makes it constantly lose altitude. The satellite therefore has to compensate for this by firing small ion thrusters. "This is a top notch Earth observation satellite," says Diament admiringly. In fact, it was thought up nearly 30 years ago–in particular by Georges Balmino, today a researcher at CNES who has at last seen the fruits of his labor.

**Azar Khalatbari**

**The GOCE satellite (artist's rendition), should be able to measure the gravity field with unprecedented precision and resolution on a global scale.**

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1. Gravity Field and Steady-State Ocean Circulation Explorer. www.esa.int/SPECIALS/GOCE/
2. http://ganymede.ipgp.jussieu.fr/frog/objectifs.htm
3. IPGP (CNRS / Universités Paris-VI and VII / Université de la Réunion); Locean (CNRS / Université Paris-VI / MNHN / IRD); Observatoire de la côte d'Azur; Observatoire Midi-Pyrénées.
4. Institut de physique du globe de Paris (CNRS / Universités Paris-VI and VII / Université de la Réunion).
5. Office national d'études et de recherches aérospatiales.

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CLAIRE VOISIN

# Artist of the Abstract

Making algebraic geometry speak "volumes," Claire Voisin has become a reference for specialists of the Hodge theory. But it is her work on Kodaira's conjecture that won her the Clay Research award in 2008.

Very quickly, words no longer suffice. Claire Voisin goes to the board, eraser in one hand, chalk in the other, and draws geometrical figures side by side with complicated calculations. Voisin, a senior researcher at the Institut de mathématiques de Jussieu[1] in Paris is a specialist in algebraic geometry. More specifically, she works on the study of the "topology of complex algebraic varieties."

To introduce her field, she sketches a sphere that she cuts up in three-dimensional triangles with curved edges, as if they had been shaped by the rounded surface. The result is that you can cover a sphere with triangles, which are themselves the "faces" of a pyramid, for example. "Topologically speaking," Voisin explains, "a sphere and the surface of a pyramid are therefore identical–though saying something like that is an absurdity from the point of view of algebraic geometry," she immediately points out. According to her, "this is also possible with an inner tube that has one or more holes." If "triangulated," the result is a skeleton made up of triangles stuck together along their sides. A metric induced by the ambient space then gives rise to a complex structure, hence to a Riemann surface, which turns out to be a purely algebraic object, a projective curve. And in higher dimensions, the problem becomes even more complex. To get from one figure to the other therefore involves a mathematical trick, the precise details of which are very difficult to grasp for a non-specialist, involving such words as homeomorphism, simplex, Riemann surface, transcendental functions, etc. But the general idea is clear: moving between the "topological," the "algebraic," and "complex geometry," the result is a"multiplicity of perspectives of one and the same object" using different mathematical approaches. "What's exciting about my work is this constant moving back and forth several geometries and several types of tools to prove results in one field or another," Voisin continues.

She resembles the typical mathematician as we often imagine them, with a particular ability for abstract thinking. In fact, though mathematics came easy to Voisin both at school where she was already boning up on final year courses, then at the École normale supérieure and while doing her PhD, she knows that for all intents and purposes, she speaks a language that is foreign to most ordinary people. It's not easy to follow what she says. That's true even for the students studying for their Masters in mathematics, to whom she teaches a few courses a year, attempting to "explain these superb ideas." Yet they often drop out, discouraged by the complexity of the field. "It's very frustrating not to be able to get across all the things that mean so much to me in my work and research," says Voisin regretfully. She remembers the six months during which she was an assistant professor, before she got a CNRS position, as being "hellish." "Joining CNRS saved my life!" she jokes.

© C. Lebedinsky/CNRS Photothèque

Becoming a full time researcher at the age of 24, she could at last devote herself entirely to algebraic geometry, the study of the properties of sets defined by algebraic equation systems, which is at the heart of the most abstract mathematics. "There is creative drive in mathematics, it's all about movement trying to express itself," Voisin confides. Nothing to do with the "boring, dead, and dry" mathematics taught in secondary school, where the courses go through an endless series of "definitions, properties, and theorems" using a method that is "always under control, as if on tracks," and which is applied to "simple exercises in logic."

After her doctoral thesis, she became fascinated by a tool that is well known to topology specialists, Hodge theory, which can also be used to tackle complex algebraic geometry. Published in 2003, her book on the subject has rapidly become a reference. She won a number of prizes and awards, such as the CNRS bronze (1988) and silver (2006) medals, and the Clay Research Award (2008) from the Clay Mathematics Institute,[2] for her work on Kodaira's conjecture, another problem in complex algebraic geometry. As an editor of several mathematical journals, she always keeps an eye on the development of her discipline. In her private life, she is also a mother of five, and her eldest daughter started studying mathematics. "But her field is far removed from mine and that of my husband–also a mathematician–so as to avoid any family 'pressure,'" she explains. "In any case," she adds, "we never talk maths at home!"

**Charline Zeitoun**

1. CNRS / Université Paris-VII. Voisin is currently seconded to the Institut des hautes études scientifiques, in Bures-sur-Yvette.
2. An American private foundation set up in 1999 whose aim is to promote mathematics.

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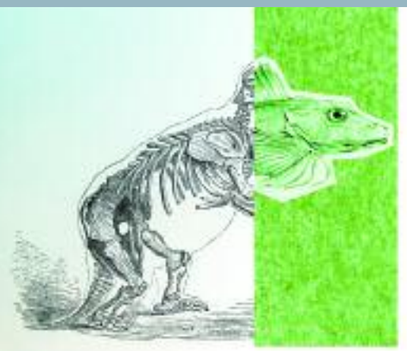
150 YEARS ON,

# THE WORLD according to DARWIN







One of Darwin's many collections of insects, which gave him the opportunity to carry out extremely detailed real-life observations.

The year 2009 marks both the bicentennial of Darwin's birthday and the 150-year anniversary of the first publication of his famous work *On the Origin of Species*. Throughout the year, the world will celebrate the English naturalist who revolutionized the story of life with his theories of evolution and natural selection. And this is a well-deserved tribute. Indeed, his work laid the foundations for all the fundamental research carried out since then, to establish the relationships between species and understand their evolution over millions of years. But this celebration also responds to a need to reassert a number of scientific facts, at a time when Darwin's critics, led by the creationists, seem to be making up lost ground. So just how did Darwin construct his theories? And how have they developed since then? Which new avenues are his followers exploring in their labs? CNRS International Magazine has been finding out.



## The Origins of a Theory

As the surrealist Belgian writer Louis Scutenaire humorously noted, "the death of celebrities is always commemorated, but never their birth." Yet at least 2009 will be an opportunity to celebrate in truly worthy fashion the bicentennial of the birth of this giant of modern science, Charles Robert Darwin. By a fortunate coincidence, it will also be the 150th anniversary of the first edition of his seminal work, *On the Origin of Species by Means of Natural Selection*.

It is hardly surprising that there is so much enthusiasm about Darwin today. His theory of the evolution of species has been constantly enriched, perfected, and fleshed out by generations of researchers on the basis of a huge amount of experimental work carried out both in the field and in the lab. What's more, it now appears to have no serious rivals. So just what did Darwin state back in the mid-19th century? Basically, that living organisms were constantly evolving, due in particular to the phenomenon of natural selection, which meant that within one species, the individuals that were best adapted to their environment reproduced in greater numbers than the others. But Darwin went further, inferring that all species (including humans) descended from one or more common ancestors. This was in complete contradiction with the traditional Christian view that prevailed at the time, namely that all the different kinds of creatures that inhabited the planet were the work of divine creation, and were forever unchanging and unrelated to each other.

For Hervé Le Guyader, director of the SAE[1] laboratory, "the theory of evolution in the Darwinian meaning of the term is currently the best conceptual framework that we have for a rational understanding of the instability of living organisms and for thinking about an essentially dynamic natural world."

### THE FUNDAMENTAL PRINCIPLES OF EVOLUTION

The explanation of the mechanisms of biological evolution formulated by Darwin and his successors is based on four fundamental principles. The first, as Guillaume Lecointre, a team leader at SAE explains, is that "among individuals that recognize each other as potential sexual partners, there exist variations (physical, genetic, in ability, etc.). Consequently, whatever the cause of such variation, living species have a natural ability to vary." The second is that every species can be selected for. Horticulturists, who for instance create new varieties of roses by crossing older varieties, or dog breeders, who in a mere 11,000 years have produced dachsunds from wolves, know this only too well. "The simple fact that humans can change the morphology of a species at will shows that it can be 'molded,' as it were, and that it has the ability to be altered," Lecointre points out.

The third principle is that all species reproduce as long as they can find food resources and optimum habitat conditions. They keep on reproducing so as to always reach the limits of these resources, or until they come up against other limits, like predation by other species. "There is therefore a natural capacity for overpopulation that can be observed, for instance, when non-native species suddenly invade a closed environment such as an island," >

Darwin only published his theory of natural selection relatively late in life– when he was 50 and already an internationally renowned naturalist.

George Richmond's 1840 portrait of Charles Darwin, seen here not as the bearded patriarch immortalized for posterity, but as a young and slim man.

> continues Lecointre. The best example of this occurred in Australia when rabbits were first introduced. They went on to overrun the country destroying plants and crops. Yet the planet is not dominated by a single hegemonic species, but, as Lecointre explains, "it is on the contrary populated by millions of species living in coexistence, despite the natural capacity for overpopulation that each of them has. So each species acts as a limit for the others, by occupying their space, by exploiting them (predation and parasitism), or by sharing the same resources. In short, the other species all act as constraints that play a role as selective agents."

The fourth and last principle is that the success of a species' growth and reproduction depends on optimum conditions, both physical (temperature, humidity, sunshine, etc.) and chemical (pH, odor molecules, toxins, etc.). "These factors all act as constraining factors," says Lecointre. "If they change, the genetic variants[2] that carry a selective advantage won't be the same."

So there are a host of factors, within the physical, chemical, and biological environment a species inhabits, that lead to natural selection in each generation, resulting in "differential reproductive success." Put into plain language, this means that within the same species, individuals that carry a heritable variation that is temporarily advantageous in the conditions of the environment at that time will produce more offspring. "If those conditions are maintained for long enough," Lecointre adds, "the variant with a selective advantage will end up having a frequency of 100% in the population. The species will then have changed." The outcome is that no species is stable over time.

## DARWIN'S FORERUNNERS

Although it fell to Darwin to put forward two big ideas–descent with modification and the key role of natural selection in the adaptation of living organisms, and therefore in evolution–they were not purely incidental. The ground had been prepared by, among others, the French naturalist Jean-Baptiste de Monet, better known as Chevalier de Lamarck, and the Scottish geologist Charles Lyell. Indeed, the first volume of Lyell's *Principles of Geology* traveled with the young Darwin when he set sail from Plymouth in late 1831 on a voyage round the world on board the famous Beagle. This was to be a very long voyage of exploration of natural history, during which Darwin landed on the Galápagos Islands, home to giant tortoises, iguanas, fur seals, and above all, the well-known finches. Although their morphologies showed striking similarities, they differed in various details, such as the shape and size of their beaks, from island to island. Darwin realized that the isolation of the finches on the different islands had caused the single species that had arrived from the mainland to diverge and show variations that were probably connected to differences in their ways of life and feeding habits. Over 20 years of work were to follow before the publication of *On the Origin of Species*. These were two decades during which, according to Michel Veuille, from EPHE,[3] Darwin "wrote to correspondents from all over the world, questioned them, asked them for statistics, found out about the taxonomy of the species he observed, and took this into account in his analysis. It is as if he already realized that the study of adaptations needed to rely on the principle that species descend from common ancestors."

While many Darwinists consider the 1859 publication of *On the Origin of Species* the key scientific event that raised biology to the status of a historical science, the epistemologist André Pichot, from LPHS,[4] minimizes the importance of Darwin in the history of science. For him, "Darwinism in 1859 scarcely consisted of anything more than natural selection. But that wasn't really a novel idea in the mid-19th century. The concept can be found, for instance, in 1813 in the work of William Charles Wells, and then in 1831 in that of Patrick Matthew, who accused Darwin of plagiarism. We also know that Alfred Russel Wallace had developed a similar version at the same time as Darwin. And we shouldn't forget the minister, geologist and political scientist Joseph Townsend, whose ideas in the matter were almost entirely copied by Darwin." Pichot points out that the idea of selection was already around at that time, and if it made Darwin so successful, it was because the timing was right: "The second half of the 19th century saw the triumph of economic liberalism,[5] and Darwin's ideas lent great weight to this notion by giving it a natural basis."

Pichot's interpretation makes Darwinists see red. "Darwin's innovative idea wasn't so much natural selection as descent with modification, in other words the fact that species have a history and are related," Le Guyader points out. The now famous meeting organized in June 1860 in Oxford by Bishop Samuel Wilberforce concerned this point. Wilberforce, attacking the Darwinist Thomas Huxley, asked him if it was "on his grandfather's or grandmother's side that [he] claimed descent from an ape," and received the no less famous reply: "Better to descend from an ape than from a man who uses his great gifts to obscure the truth."

## GENETICS TO THE RESCUE

Darwin's theory, while upsetting the traditional Christian view of the world, suffered from a major handicap: the causes and laws of heredity, as well as the true nature of its material basis, were still unknown. Although his theory maintained that natural selection was the main mechanism of evolution, Darwin also believed that characters acquired during an organism's existence could be handed down to its offspring.

"Darwin's theory of natural selection plunged into obscurity after his death in 1882," says Veuille. After the rediscovery of Mendel's laws on hereditary transmission[6] in 1900, a new science, "population genetics," was to rediscover the importance of the notion of natural selection. The mathematical models[7] proposed by Fisher, Haldane, and Wright were accepted by the scientific community in 1932. It was only then that researchers were able to turn population genetics into a practical discipline.

The years 1940-70 saw the merging of population genetics with zoology, botany, and paleontology, which had hitherto ignored each other, giving rise to the "synthetic theory of evolution." As Lecointre explains, "its instigators attempted to unravel the mechanisms that gave rise to biodiversity, using the mechanisms described by population genetics enriched by what naturalists had discovered about natural geographical variations within species and about speciation.[8]"

## DARWIN'S DESCENDANTS

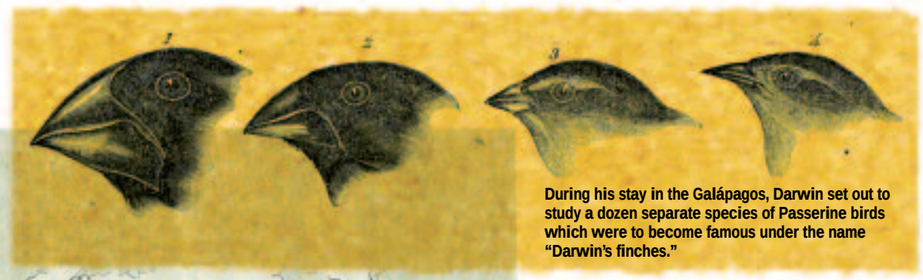
Another modification of the theory of evolution was provided by the so-called "neutral" model of the Japanese geneticist Motoo Kimura. "Kimura believes that most changes observed between the genomes of various species are due to chance, which imperceptibly alters the frequency of variations from one generation to the next, rather than to natural selection, whose existence he nonetheless recognizes," Veuille explains. Over the last few decades, many other researchers have added weight to the synthetic theory of evolution and helped refine it, starting with the paleontologists Stephen Jay Gould and Niles Eldredge. Their new model, the "punctuated equilibrium," explained why in the fossil record, species seem to happen in spurts interspersed with long periods of stagnation. During an event of population separation, a small group of "marginal" organisms becomes cut off from its original population when it occupies a new environment. The original population is stable in morphology while the marginal one changes at a faster rate. As time passes, the marginal population accumulates divergence. If it is successful, it extends its territory and may replace the original population through interspecific competition, as happened with the trilobites (marine arthropods) during the Paleozoic era. "This would explain why, in an unbroken sedimentary sequence, a species that has been stable for several million years is suddenly replaced by another species related to it," Lecointre explains.

Working with Richard Lewontin, Gould subsequently corrected the overly optimistic view of the synthetic theory. Gould and Lewontin pointed out that variants with a selective disadvantage continue to appear all the time, which led evolutionary scientists to put into perspective their impression that nature was a perfect construct," Lecointre explains. "Furthermore, they show that certain structures that could be deemed as a handicap (like the fact that spotted hyenas give birth through the clitoris, which results in death for some of the newborns) are in fact biologically connected to other structures which provide decisive advantages (in this case, the aggressiveness of females), which is why these structures are maintained."

Another key stage in the ever-increasing sophistication of the synthetic theory was the method developed in the 1950s by the German entomologist Willi Hennig for reconstructing the evolutionary history of species–i.e., identifying their degree of kinship and constructing the tree of life–and its associated classifications–as well as its computerized applications from the 1970s onwards. This total shake up of taxonomy (the science of the classification of organisms), later coupled with the large-scale sequencing of genomes, made it possible to "place on the same 'tree of life' and at the same time fungi, bacteria, animals, etc., whereas until then we were only able to classify vertebrates and plants relative to one another," says Le Guyader. >

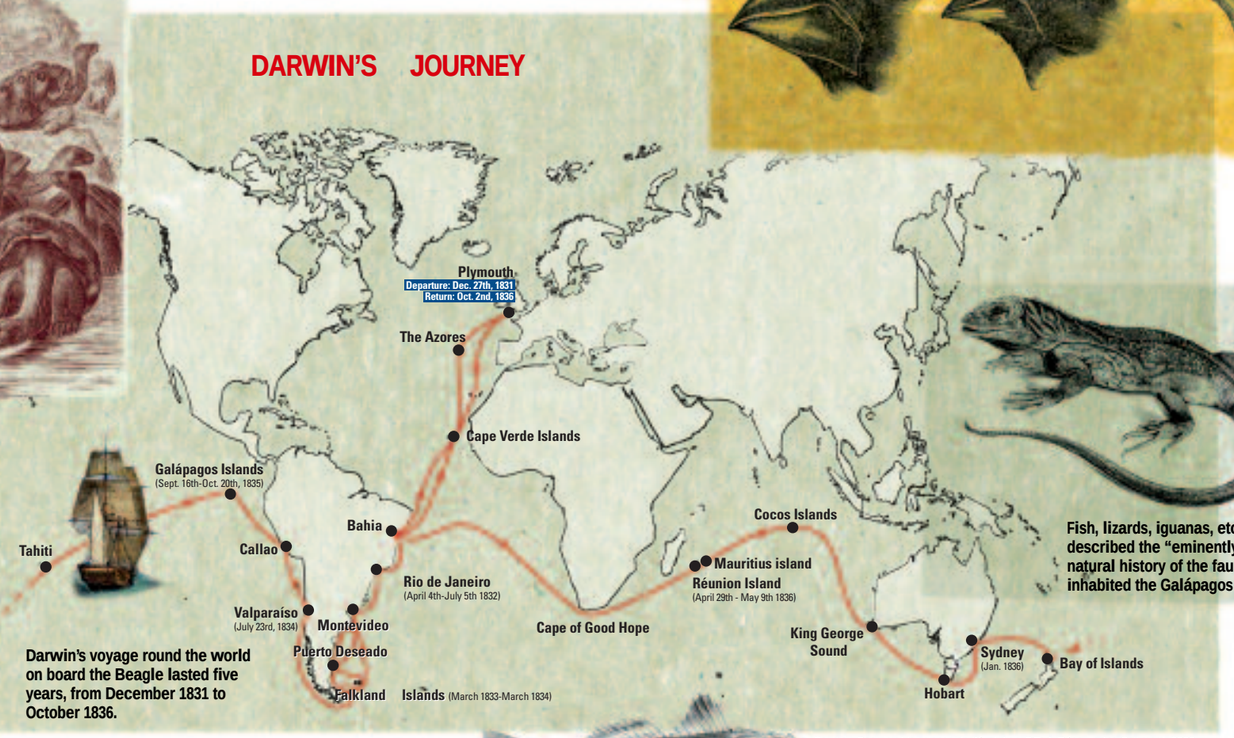
In September 1835, Darwin was able to observe giant tortoises and turtles in the volcanic Galápagos Islands on the equator.

Jean-Baptiste de Monet, Chevalier de Lamarck, helped introduce the idea of evolution into the scientific thinking of the early 19th century. There appears to be an obvious connection between his ideas and those of Darwin.



During his stay in the Galápagos, Darwin set out to study a dozen separate species of Passerine birds which were to become famous under the name "Darwin's finches."

## DARWIN'S JOURNEY



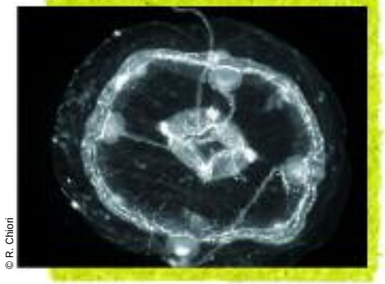

Darwin's voyage round the world on board the Beagle lasted five years, from December 1831 to October 1836.



Fish, lizards, iguanas, etc.: Darwin described the "eminently curious" natural history of the fauna that inhabited the Galápagos Islands.

Source : *Darwin et la science de l'évolution*, P. Tort, Découvertes Gallimard, 2000

Comparing the nervous system of jellyfish with the more complex systems of other animals helps us understand how this cellular network developed during evolution.



© R. Chiori

## THE CONTRIBUTION OF EMBRYOLOGY

The latest boost to the theory of evolution has been provided by the rapid development of evolutionary developmental biology–informally known as "evo-devo"–a discipline focused on the identification of the genes behind embryonic development, the study of their distribution within the animal world, and their comparison. This should help to better interpret organ similarities between large groups of animals. As Le Guyader points out, "Darwin would have been delighted with this encounter between embryology (in which he was very interested) and genetics, which thrusts development and its associated genes into an evolutionary framework."

All these areas of research show that the pioneering ideas of the great English naturalist were greatly enriched throughout the 20th century. "Today, evolutionary specialists can play with a wide range of models and mechanisms to explain evolutionary phenomena," says Michel Morange.[9] "Their objective isn't to prove Darwin's theory wrong," but rather to test the different models derived from his theory.

Philippe Testard-Vaillant

1. Laboratoire Systématique, adaptation, évolution (CNRS / Université Paris-VI / MNHN / IRD / École normale supérieure Paris).
2. Variants are individuals that carry a different genotype from other individuals in a population.
3. Ecole pratique des hautes études. Research Network Génomique des populations et génomique évolutive.
4. Laboratoire de philosophie et d'histoire des sciences–Archives Henri Poincaré (CNRS / Université Nancy-II).
5. The economic liberalism that established itself in 19th century Victorian England lent weight to the idea that free competition between companies and freedom of work and trade should not be hindered.
6. Formulated by Johann Mendel, who as a monk was known as Gregor Mendel (1822-1884), these laws stated that genes (whose existence Mendel knew nothing about) from each parent contribute in equal share to the offspring.
7. These models showed that genes with a small selective advantage could reach a frequency of 100% in the population.
8. Differentiation of species during the course of evolution.
9. Professor of biology at the University of Paris-VI and Ecole Normale Supérieure. Laboratoire Régulation de l'expression génétique (CNRS / École normale supérieure Paris).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- **Michel Morange,** morange@biologie.ens.fr

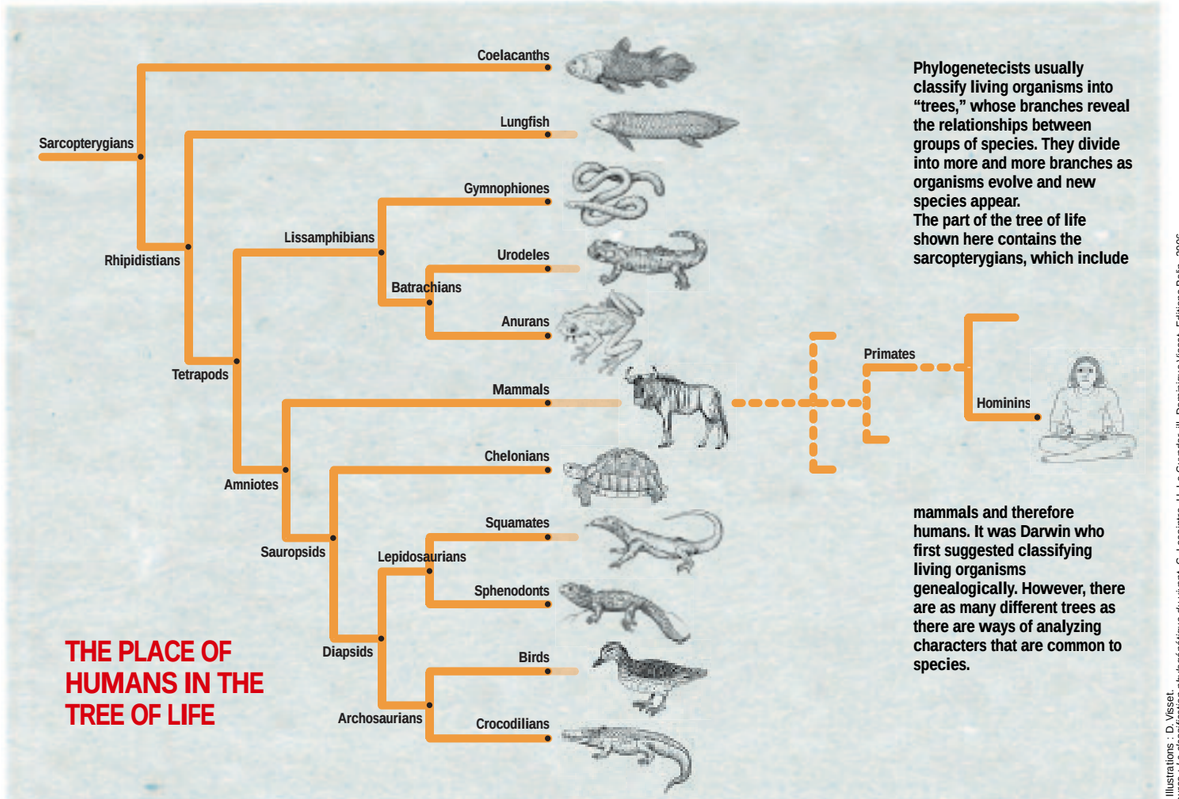

## A DANGEROUS CRUSADE AGAINST DARWIN

**"I'm not a knight in shining armor fighting creationism, although the subject does need to be addressed," answers Pascal Picq, paleoanthropologist at the Collège de France, slightly irritated that he has once more been asked to comment on the harm caused by the crusade currently waged by fundamentalist evangelical circles in the US.**
**"These Churches, which teach that the Universe and the Earth were created by a god around 6000 years ago, are constantly gaining ground, and their goal is nothing less than to establish a theocracy," he explains.**
**"Europe is vulnerable. The revival of creationism that we're seeing today is a real threat to secularism and democracy."**
**Another current of thought which has a knack for making evolutionary scientists angry is that of "Intelligent Design," a neo-creationist belief that claims to be a science and states that certain evolutionary facts (such as the formation of complex structural and functional features like the eye) can never be explained by science, and that we should therefore seek non-natural causes for their appearance. "Intelligent Design invokes the existence of a 'superior intelligence' to explain the incredible diversity of life," Picq explains.**
**So, what can be done to fight off the onslaught of creationism and Intelligent Design? Most suggest the reestablishment of the fundamental concepts of evolution in school curriculums as a starting point.**

**P.T.-V.**

**CONTACT: Pascal Picq,** pascal.picq@dbmail.com

## THE PLACE OF HUMANS IN THE TREE OF LIFE




**Phylogenetecists usually classify living organisms into "trees," whose branches reveal the relationships between groups of species. They divide into more and more branches as organisms evolve and new species appear.**
**The part of the tree of life shown here contains the sarcopterygians, which include mammals and therefore humans. It was Darwin who first suggested classifying living organisms genealogically. However, there are as many different trees as there are ways of analyzing characters that are common to species.**

© Illustrations : D. Visset.
Source : *La classification phylogénétique du vivant*, G. Lecointre, H. Le Guyader, ill. Dominique Visset, Editions Belin, 2006.

# Research in Evolution

It is no surprise that scientists from every discipline are still unable to explain all the facts of evolution. How could it be otherwise, given that only a few decades have gone by since the discovery of DNA and the fundamental molecular mechanisms of life. Yet facing the complexity of the task, researchers are using all the means at their disposal to unravel the events set off 2.5 billion years ago. "Such questions form one of the most far-reaching and exciting scientific fields. Moreover, beyond its academic and practical interest, studying evolution provides us with the keys we need to forecast the impact of current global change on organisms and ecosystems," says Jean-Christophe Auffray, director of ISEM[1] in Montpellier.

## ON THE TRAIL OF BIODIVERSITY

Trying to understand how biodiversity emerges and maintains itself is Nicolas Galtier's specialty at ISEM. "Evolution can be studied at different levels of organization," he explains. "It can be studied on the scale of ecosystems, of species, of organisms, or of genomes, which is what I do. I 'watch sequences of DNA evolve,' both within current populations and between species that are very far apart, such as bacteria and mammals, knowing that certain genes–like those that regulate the transcription of DNA into RNA and the translation of RNA into proteins–are common to all living organisms." This is the art of making genes "talk," to decipher the relationships that unite all living things and to reconstruct the evolutionary history of species.

However, why is it that the genomes of some species (human, for instance) evolve at a slower pace than others (like the fruit fly)? Nobody knows. Such a differential evolution rate between species remains largely unexplained. "Several possibilities are beginning to emerge," Galtier explains, "involving various parameters such as the spontaneous appearance of genetic changes from one generation to another, the efficiency of repair of damaged DNA, the average life span of a generation of organisms, or even the ability of different species to eliminate deleterious–disadvantageous–mutations."

Working on the methods and mechanisms of evolution can also entail studying mimicry, as does Mathieu Joron, from the OSEB laboratory.[2] This adaptive phenomenon causes species that are genetically very far apart to resemble each other morphologically. "I have shown that, for the tropical butterfly Heliconius numata, variation in wing color is controlled by a single locus (a precise spot on a chromosome)," he says, "whereas for other closely related species, variation in the same trait is controlled by four or five loci located on different chromosomes, and involves more genes. I am attempting to understand the evolutionary aspects of these differences in 'genetic architecture.'"

© M. Joron

These images show mimicry between different species of butterfly that are genetically relatively far apart.

© Photos : E. Permi/CNRS photothèque

The insectarium at ISEM, where thousands of mosquitoes are bred and available at different stages in their life cycle. This is a valuable tool, especially for studying the mechanisms that enable common mosquitoes to acquire resistance to insecticides.

## NEW DISCOVERIES IN THE LABS...

Uncovering the secrets of the evolution of living organisms also means finding out its impact on biodiversity. To tackle this issue, the ecologist Nicolas Mouquet, who works at ISEM, has been working with the bacterium Pseudomonas fluorescens. The experiment he carried out >

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By following the diversification of the bacterium Pseudomonas fluorescens for over 500 generations, researchers have revealed a connection between the complexity of the environment and the biological diversity that can take place there through evolution.

> together with Patrick Venail, Thierry Bouvier, and Michael Hochberg "consisted in creating in the laboratory, using plastic micro-culture plates, various environments made up of several sources of carbon[3]–based on glucose, fructose, amino acids, etc. We put bacteria that were strictly genetically identical into each of the 96 wells of the micro plates, and we left them evolve freely for over 500 generations (i.e., around 50 days), at the same time moving a small fraction of them from one well to another." And what were the results? The effect of this cocktail, which combined spatial heterogeneity of available resources and dispersion, accelerated the diversification of the genotypes of the Pseudomonas fluorescens communities and boosted their ability to create biomass. "This work shows that there exists a positive relationship between the complexity of the environment and the biological diversity that can emerge from it through evolution," explains Mouquet. It also indirectly shows that the increasingly uniform terrestrial ecosystems resulting from human activity could eventually reduce life's ability to diversify.

Another "experimental evolution" assay is being carried out at ISEM on phytophagous mites (which feed on plants). Populations of Tetranychus urticae mites are placed in environments containing different host plants (cucumber, tomato). "We let each population evolve, sometimes on just one single substrate, sometimes on one substrate and then on another, and sometimes in an environment containing a combination of these substrates," explains Isabelle Olivieri, who leads the experiment. The aim is to test the predictions of the mathematical models that describe the processes of adaptation and specialization according to the heterogeneity of the environment. They will be able to tweak the parameters of these models to better understand the mechanisms of what is known as "adaptive speciation," especially in a context of increasingly fragmented habitats. "The results obtained until now show that, even after 400 generations on one single host plant, the populations still exhibit a very large genetic diversity, enabling them to adapt to new environments," Olivieri says. "This evolutionary potential enables them to live on new host plants. Eventually, we would like to discover the genes involved in this process. In particular, we wish to determine to what extent adaptive mechanisms are repeated. Is a given specialization process always genetically performed in the same way, or do the genes recruited differ from one population to another for the same selective environment?"

## ... AND IN THE FIELD

To study the evolutionary mechanisms that led to current biodiversity, Hervé Le Guyader, back at SAE, is scouring the sea floor. It provides food and shelter for an extraordinary fauna that live around hydrothermal vents or get their energy supply from organic matter that trickles down from the surface (the dead bodies of large cetaceans, for example). "We have discovered that the organisms found in these deep

## LACTASE EVOLUTION

**If there's one example that shows that cultural differences can lead to biological alterations and affect the genetic diversity of Homo sapiens, it is that of lactase, an intestinal enzyme that makes it possible to digest the lactose (a sugar needed for children's growth) present in milk. "This enzyme," explains Évelyne Heyer, from MNHN,[1] "is generally inactivated in mammals after weaning, which makes them unable to digest milk when they become adults. "However, in certain human populations, especially in Northern Europe (Sweden) and in East Africa (the Tutsis), a high proportion of adults (as many as 90%) have active lactase." So what do these groups have in common? All of them are made up of herdsmen or descendants of herdsmen, and milk has played a major role in their diet for several thousand years. Heyer explains that "when these populations began to drink large quantities of fresh milk, individuals who were able to digest it possessed a selective advantage (better absorption of calcium, better resistance to dehydration, etc.). The tools of population genetics even enable us to date the moment when this mutation began to increase in frequency." The European mutation's age is estimated to be approximately 8000-9000 years old, dates which are consistent with what archeology tells us about the domestication of livestock.**

**P.T.-V.**

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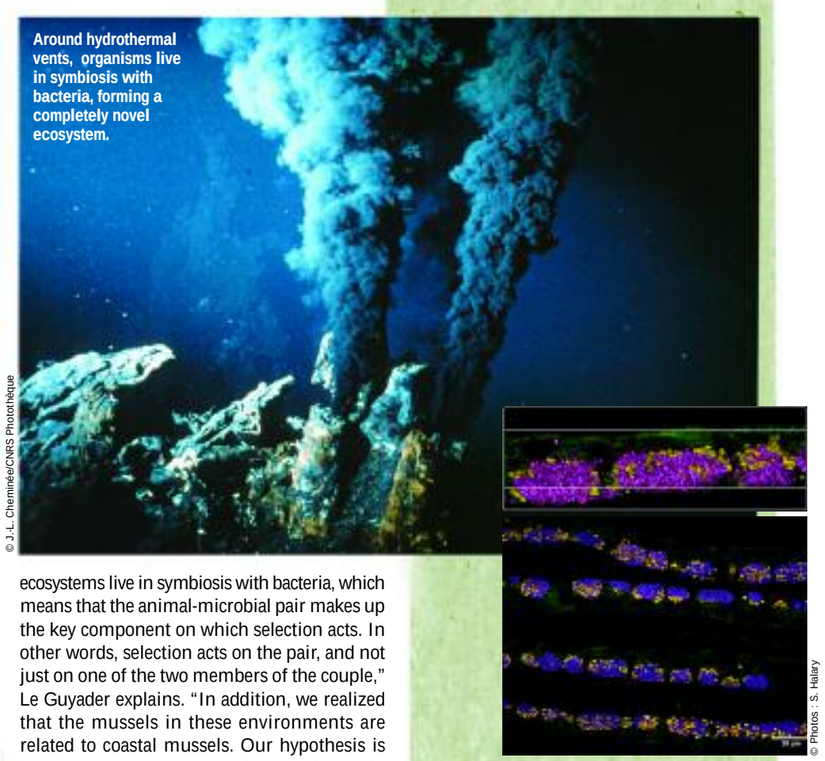

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Around hydrothermal vents, organisms live in symbiosis with bacteria, forming a completely novel ecosystem.



© Photos : S. Halary

Above, bottom: gill filaments of a hydrothermal vent mussel, where it is possible to make out the cells containing its symbiotic bacteria. Top: 3D view of a detail of this image.

ecosystems live in symbiosis with bacteria, which means that the animal-microbial pair makes up the key component on which selection acts. In other words, selection acts on the pair, and not just on one of the two members of the couple," Le Guyader explains. "In addition, we realized that the mussels in these environments are related to coastal mussels. Our hypothesis is that 'sunken wood' (torn out trees sent down to the ocean floor during hurricanes) could have been a colonization vector for surface organisms which over thousands of years adapted, some of them to whale carcasses, others to hydrothermal vents." Le Guyader also works in the field of "evo-devo,"–i.e., connected to the genetics of development. He is comparing sponges, which lack a nervous system, with both jellyfish, which have a simple nervous system, and mammals, which possess a complex nervous system, to try to understand the evolutionary origin and the function of the genes specialized in the organization of neurons.

Meanwhile, over at CEFE,[4] scientists are working on evolutionary ecology, focusing on the interactions between genes, individuals, populations, and variations in their environment. Thierry Boulinier is endeavoring to understand a peculiar adaptive process observed on an arctic bird, the black-legged kittiwakes. The females of these birds pass on to their chicks, via the yolk of their eggs, antibodies against a bacterium transmitted by a tick to which the chicks are likely to be exposed. "This adaptive process raises a lot of questions," explains Boulinier. "Does the ability to transmit antibodies vary among females? Are the chicks effectively protected against the parasites? Is the investment costly for the mother? Does this process play a role in the dynamics of emerging diseases? We are combining various approaches to tackle these questions, from modeling to experiments in the field and in the lab."

## 100% VIRTUAL ORGANISMS

But why not create entirely virtual organisms from scratch using computer programs, and observe "live" all the events that take place during their evolution? This is the exciting idea that Guillaume Beslon is trying out at LIRIS[5] and IXXI.[6] Whereas phylogeny reconstructs "retroactively" the stages of evolution of real species that have survived until today or that have left fossil remains, "we do just the opposite," Beslon explains. "Instead of looking back to the past, we follow over thousands of generations the evolution of artificial organisms, each one possessing simplified virtual DNA based on bacteria, which we bring together as populations. By introducing biologically plausible mutation and selection mechanisms, we can observe the 'real' evolution of artificial organisms!" >

## POLLUTION'S IMPACT ON EVOLUTION

**What is the impact of air pollutants from road traffic on female fertility and, therefore eventually, on the evolution of the human species? A study, dubbed Atmos-Fer (Atmospheric Pollution and Human Fertility), in which CNRS researcher Lyliane Rosetta is taking part,[1] should help shed more light on the question. A thousand French women aged 18-44 not using contraception and attempting to become pregnant took part in the survey. "We asked the women to send us urine samples collected every other day during a complete menstrual cycle," Rosetta explains. "We are currently determining the hormonal profiles of estradiol (a hormone secreted in large amounts just before ovulation) and progesterone (secreted after ovulation) in the biological samples." The same women were also asked to provide a sample of hair to determine the quantity of pollutants it contained. The aim is to find out whether the cycles of these women were disturbed, and if so, to what extent this anomaly could be linked to air pollution in their immediate environment.**

**In terms of evolution, Rosetta says, there is every reason to think that "if air pollution does affect, and actually decreases the overall pregnancy rate, more fertile women will have a distinct advantage over less fertile ones, for whom it will be harder to reproduce." The definitive results are expected to be available in 2010.**

**P.T.-V.**

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**The effect of air quality on human reproduction is of increasing interest to scientists.**

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> This makes it possible to monitor all the events the organisms undergo during an experiment, including those that phylogeny would have lost track of. "In fact, although we produce all the mutation algorithms, they occur at random. We don't decide ourselves in which part of the genome they will occur, nor when," points out Carole Knibbe, a bioinformatics scientist working on this project. Researchers have already obtained unexpected results. For instance, they were surprised to observe that the frequency of spontaneous mutations has a strong influence on the size of the evolved genomes." In particular, we have discovered a connection between the proportion of non-coding sequences[7] in a genome and the mutation rate it undergoes," the scientists explain. A result that could help us better understand the role of such non-coding DNA in *in vivo* evolutionary phenomena.

This is only some of the research currently carried out to shed some light on the development of evolutionary mechanisms. Research that agrees with the words of the Russian-American geneticist Theodosius Dobzhansky (1900-1975): "Nothing in biology makes sense except in the light of evolution."

Philippe Testard-Vaillant

1. Institut des sciences de l'évolution de Montpellier (CNRS / Université de Montpellier-II).
2. Origine, structure et évolution de la biodiversité (CNRS / MNHN).
3. Carbon is at the root of metabolism in bacteria.
4. Centre d'écologie fonctionnelle et évolutive (CNRS / Universités Montpellier-I, II, and III / Ensa Montpellier/ Cirad / École pratique des hautes études).
5. Laboratoire d'informatique en images et systèmes d'information (CNRS / Insa Lyon / Universités Lyon-I and II / École centrale de Lyon).
6. Institut Rhône-Alpin des systèmes complexes. Its partners include CNRS, INRIA, IRD, ENS Lyon, Insa Lyon, Université Joseph Fourier, and many others.
7. DNA sequences that do not code for proteins.


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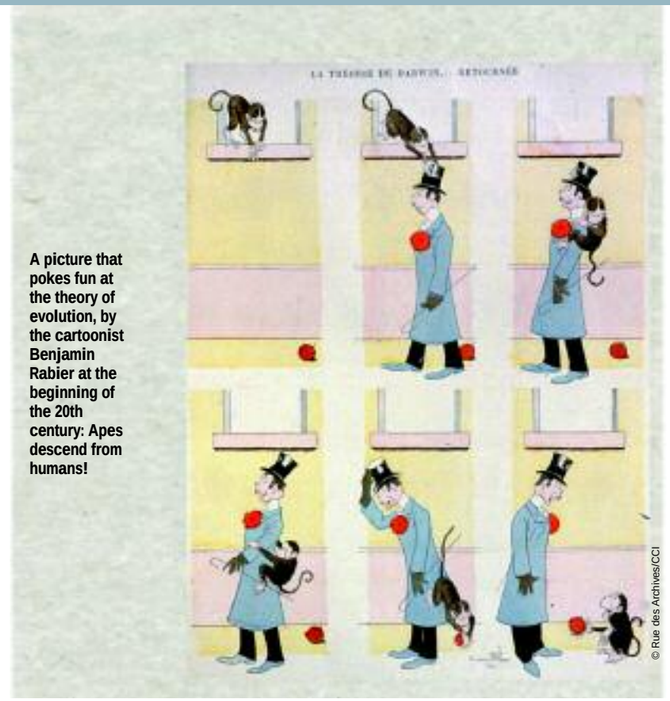
# When Controversy Rages

A number of evolutionary theories have attempted to apply Darwinism to human societies. Born in the ferment of debate between the life sciences and the social sciences in the second half of the 19th century, the proponents of "social Darwinism"–which sees human society as an animal species whose "health" requires the elimination of the most unproductive individuals, such as criminals, alcoholics, the disabled, etc.–are a source of endless controversy. At issue is the exact role played by Darwin's ideas in the emergence of detestable ideologies like eugenics, which calls for "artificial selection" of human beings. The philosopher Patrick Tort, the founder and director of the international Charles Darwin Institute[1] and a tireless defender of Darwin, categorically denies that the British naturalist had anything to do with the emergence of such ideas (see box below).

André Pichot, however, is far less charitable to Darwin and begs to disagree. "Darwin was neither more nor less racist, sexist, or a supporter of slavery than his contemporaries," Pichot claims. "But Darwinism gave rise to all sorts of sociological and political theories that made competition, war, and mass slaughter the explanatory principles of societies and their evolution. You only have to read what was being written before and during the First World War, right up to the 1930s! Darwin never protested against the eugenic and racist ideas of his cousin Galton. And his own son, Major Leonard Darwin, was for years the chairman of the International Federation of Eugenics Organizations." The issue looks set to remain controversial.

Nonetheless, according to Dominique Guillo, from GEMAS,[2] whatever the truth of the matter, the social sciences, after having been initially closely connected to biology and its offshoots, progressively severed their links with the life sciences and became an independent discipline at the beginning of the 20th century. Admittedly, social, eugenic, racist, and imperialist ideas derived from Darwinism continued to proliferate, acting for example as a source of inspiration for the horrors of Nazism. But for many decades, "on the whole, academic sociology and anthropology kept their distance from biology, hiding behind the principle of an insurmountable barrier between nature and culture," Guillo explains.




**A picture that pokes fun at the theory of evolution, by the cartoonist Benjamin Rabier at the beginning of the 20th century: Apes descend from humans!**

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## FROM NATURE TO CULTURE

This separation was questioned in the mid-1970s by neo-Darwinian theories of culture, especially as propounded by the American entomologist Edward O. Wilson, whose *Sociobiology: The New Synthesis*, triggered tremendous controversy in western intellectual circles. In its most radical version, sociobiology's reasoning can be boiled down to one simple and very succinct proposition: Much social behavior is governed by genetic mechanisms and by the principle of natural selection, not only in animals, but also in humans. "Wilson sought to adapt the foundations of Darwinian logic to a whole series of human social and cultural phenomena: moral codes, religion, the division of labor between men and women, etc.," says Guillo. For Wilson, social norms, such as the avoidance of incest, are the biological tendencies rooted in genes that were probably selected for in our ancestors, throughout prehistory, for the advantages they conferred.

The reductionist determinism formulated by human sociobiology gave rise to another, apparently "softer" version: evolutionary psychology. The instigators of this ideology admit that things do get a bit complicated with regard to the human species, where it isn't possible to disregard the complexity of cerebral mechanisms and the importance of cultural and social transmission. But the basic principle remains the same. "For these theoreticians," Guillo insists, "behavior in animal and human societies is in the final analysis governed, more or less directly, by specific genes retained by natural selection."

Another even more distant cousin of sociobiology, to which it is even totally opposed on certain points, is memetics, which emerged from the work of the English ethologist Richard Dawkins. This line of thinking, which has many followers in the US, applies the evolutionary mechanisms modeled by Darwinism to human societies, but solely as an analogy. For Dawkins, Guillo explains, "there exist basic ideas–he calls them memes–that are specific to each culture: the idea of God, a song, a certain way of cooking, etc. These memes work like genes. They jump from one brain to another, spreading out through populations and multiplying, competing with each other to 'colonize' the maximum number of brains. They mutate when someone introduces a technical innovation in an industrial process, or invents a new style of clothing, etc. Such mutations can either disappear rapidly (as in the case of fashions), or establish themselves long-lastingly (such as the meme of the idea of God)." In other words, memes, like genes, undergo a process of selection. In memetics, Guillo points out, "human culture therefore appears to be disconnected from biological evolution, the evolution of genes."

At the junction between the two aforementioned theories, another neo-Darwinian model of culture, "gene-culture co-evolution," attempts to sit on the fence by seeking to estimate the respective influence of biological and cultural factors in human evolution. "This tendency reviews the various scenarios," says Guillo, "from the recognition that genetic factors are involved in some human practices, to situations in which cultural evolution is totally independent of genes." For the American anthropologist William H. Durham, cannibalism, which is given great cultural value by the Fore people of New Guinea for the warlike virtues that can be obtained from an enemy killed in combat, illustrates this latter point, since such practices probably ended up triggering the appearance of a lethal neurophysiological disease called kuru, which is a variant of mad cow disease.

Philippe Testard-Vaillant

1. www.darwinisme.org
2. Groupe d'étude des méthodes de l'analyse sociologique (CNRS / Université Paris-IV).


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## FOR FURTHER INFORMATION

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## RACISM: DARWIN CLEARED

**Was Darwin a racist? Can his theory of evolution be accused of bolstering the racist undercurrents that would lead to the horrors witnessed during the 20th century? For the philosopher Patrick Tort, the answer is certainly no. "Racism glorifies the inherent qualities of the 'race' and condemns mixed marriages, which is totally opposed to Darwin's ideas," he says. Darwin fought racism as a result of family tradition, personal outrage after visiting Brazil, and because of his own theoretical convictions."**

**Was the British naturalist such a convinced opponent of slavery?**

**Yes, he was, "absolutely and constantly," says Tort. To all those who maintain that Darwin was at the root of the obnoxious distortions of his theory, Tort reminds us that *The Origin of Species* was first published in 1859. So as not to damage the chances of his ideas being accepted, "Darwin refused to make any public statements on the subject of humans for over a decade. And yet it was precisely during those ten years that the English philosopher Herbert Spencer developed his 'system of synthetic philosophy,' which led to a social theory that celebrated the triumph of the 'deserving,' as well as the refusal to help the poor." During the same period, Darwin's young cousin, Francis Galton, invented eugenics.**

**Referring to Darwin, both Spencer's and Galton's theories "converged" towards the principle of the necessary elimination of the weak. "Yet Darwin saw the protection of the poor as an indication of the degree of 'civilization,' and irrevocably dismissed Galton's eugenics in Chapter 5 of 'The Descent of Man,'" says Tort. "Which is why it is necessary," Tort concludes, "to finalize the unexpurgated French translation of this work. This is currently being undertaken by the Slatkine publishing house."**

**P.T.-V.**

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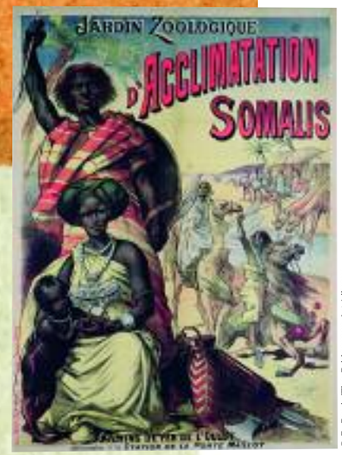
**At the end of the 19th century, for the supporters of social Darwinism, "human zoos" justified the distinction between "primitive" and "civilized" races.**

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ETHNOLOGY

# The Century of CLAUDE LÉVI-STRAUSS

Claude Lévi-Strauss celebrated his centennial on November 28, 2008. This renowned anthropologist, a tireless social theorist and founding father of structuralism, has had considerable influence on contemporary thought.

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**3** He studied several Amazon tribes, including the Nambikwara. Unusually for South American Indians–who invented the hammock–members of this tribe sleep on the ground.

**4** Among the Nambikwara, the men take care of their bodies just as much as the women.

**5** The "mariddo," a Bororo Indian dance, was performed during a complex funeral rite that also included a ritual hunt.

**6** The village of Nalike in the Serra Bodequana was the capital of the region of the Caduveo Indians. Claude Lévi-Strauss made two documentaries about it, filmed in 1935.

**7** Lévi-Strauss and Dina, his first wife, in their camp in Amazonia. They had both graduated in philosophy and she actively participated in the ethnographic research trips.

**8** For Lévi-Strauss, the Bororo Indians formed a "knowledge-based" and extremely hierarchical society. It was divided into two rival "moieties," the Cera and the Tugare, each of which was subdivided into four hierarchical clans. Here, a Cera wears a ceremonial dress.

**9** This hairpin, 62 centimeters in length, made from a twig to which large red and blue ara feathers are attached, was brought back from Amazonia by Lévi-Strauss. It is part of the Lévi-Strauss collection at the Paris Quai Branly museum, which includes 1478 items.

**10** While in exile in New York during the Second World War, Lévi-Strauss, along with André Breton and his Surrealist friends, bought several items made by the Indians of the American northwest and by the Inuit, including this decorative item made of carved wood and green mother-of-pearl.

**1** Claude Lévi-Strauss was born in Brussels in 1908. After studying in Paris, he was successively a professor of philosophy, sociology, and finally anthropology.

**2** Lévi-Strauss, shown here with his second wife, Monique, was elected to the Académie française in May 1972.

© W. Karel/Gamma/Eyedea Presse

2

Those who have crossed his path have never run out of praise: "a man with an exceptional flair for ethnology," "a lively, modest personality, with a great sense of humor," "the author of one of the greatest contributions to 20th century French thought." Winner of the CNRS gold medal in 1967, he has made throughout his career an indelible mark on ethnology and anthropology. "His body of work has fertilized major studies in the human sciences–those of Foucault, Deleuze, and Bourdieu," notes Frédéric Keck of the Institute Marcel Mauss in Paris,[1] who was involved in the publication of his major works in the "Bibliothèque de la Pléiade" edition, a collection of great works of literature and philosophy. "His work has had a spectacular influence internationally."

Lévi-Strauss, a professor at the Collège de France, the author of more than 20 books, including the famous *Tristes tropiques* (1955), *La pensée sauvage* (1962, *The Savage Mind*, 1966), and *Mythologiques I-IV* (from 1964 to 1971), and founder in 1960 of the Laboratory for Social Anthropology[2] is best known for having introduced structuralism, a method borrowed from linguistics, into the field of anthropology. Social phenomena such as kinship systems or myths are no longer to be studied as independent entities each with their own significance, but rather as part of an organized system where connections are revealed by differences, not commonalities, exposing at the same time the structures of unconscious thought that are common to all human beings. "Structuralism provided a way out of a kind of determin- >

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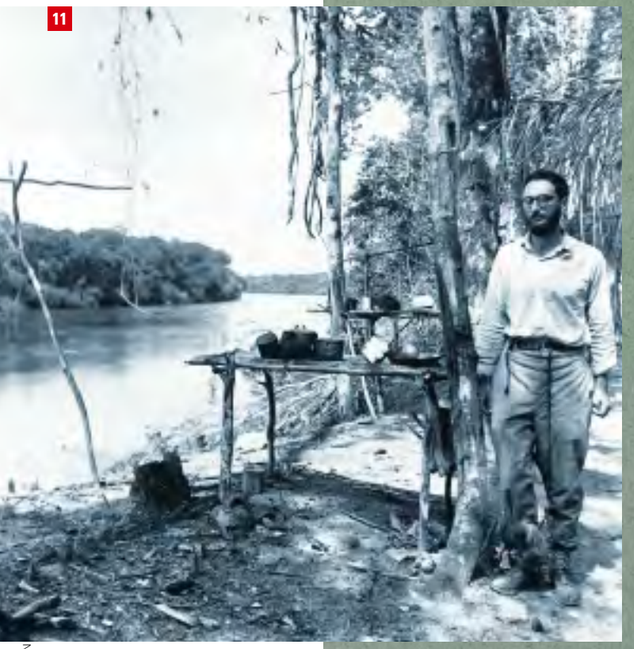

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**11** **Lévi-Strauss during his research visit to Brazil. He explains that Lucinda, the little monkey that lived with him, had made a habit of clinging to one of his legs.**

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**12**

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**13**

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**14**

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**15**

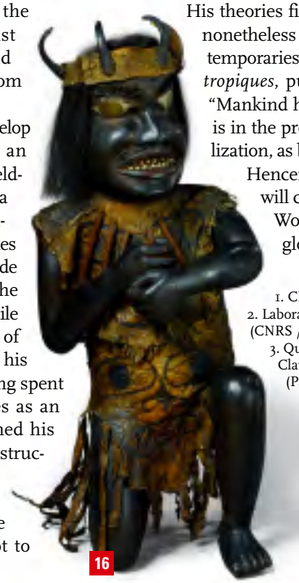
**12 13 14 15** **Claude Lévi-Strauss and his wife Dina took many portraits of indians, such as the Caduveo (12) and (13), the Nambikwara (14) or the Guarani (15). These photographs show how diverse their arrays and jewels can be: body paint, lip and nose ornaments, headdresses...**

> ism that saw societies' traditional practices and bodies of knowledge as simply responses to the natural or social environment," explains Pierre Deléage of LAS. "Levi-Strauss was able to show that universal structures of thought were at least of equal importance in the formation of these practices and bodies of knowledge." He pulled together these structures into the concept of "the savage mind," an alternative to the "primitive mindset" that prevailed at the time, as a symptom of the supposed superiority of colonialist scholars over the practices and mentalities of societies different from their own.

How did Claude Lévi-Strauss develop his theories? "Oddly enough for an ethnologist, he did relatively little fieldwork," acknowledges Michel Izard, a former member of LAS. In fact, Lévi-Strauss' theories originated in the series of ethnographic research trips he made between 1935 and 1938 to study the Amazon Indians of Mato Grosso, while he was a professor at the University of São Paulo in Brazil. It was not until his return to France in 1948, after having spent the war years in the United States as an academic refugee, that he published his doctoral thesis on "the elementary structures of kinship," along with a complementary thesis on the family and social life of the Nambikwara Indians. He was not to return to Brazil until many years later, in 1985, after his retirement.

Lévi-Strauss, then, is not a fieldwork specialist. He admits that he does not have "the meticulousness and patience" for it.[3] Yet as a theoretician, he is a genius. "All his articles, all his books have consistently inspired true anthropological thinking," Izard observes. "When I was just a student, I attended his seminars at the Sorbonne University in Paris. His theories filled us with excitement." He nonetheless kept a critical eye on his contemporaries, and still does today. In *Tristes tropiques*, published in 1955, he wrote: "Mankind has opted for monoculture; it is in the process of creating a mass civilization, as beetroot is grown in the mass. Henceforth, man's daily bill of fare will consist only of this one item." Words which, in the new age of globalization, ring terribly true.

**Fabrice Demarthon**



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**16** **On bended knee, this Tsimshian shaman statue is adorned with a garment made of painted skins. On its head sits a leather diadem with upward bear claws. It was part of Lévi-Strauss' North American collection, and is now displayed at the Quai Branly museum.**

1. CNRS / EHESS.
2. Laboratoire d'anthropologie sociale (LAS) (CNRS / Collège de France / EHESS).
3. Quoted from De près et de loin, by Claude Lévi-Strauss and Didier Eribon (Paris: Odile Jacob, 1988).

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HEALTH AND ENVIRONMENT

# First Joint Unit in Africa

Pollution, global warming, urbanization... the world is facing major environmental challenges. An ambitious French-African research group has just been formed to study these phenomena and their consequences on health.

On January 16th, the first ever international joint unit (UMI) between CNRS and Africa was signed into existence. This UMI, which goes by the name "Environnement, santé, sociétés,"[1] brings together researchers from France, Burkina Faso, Mali, and Senegal to work in a high-priority field: environmental change and its impact on health. "Through this first major initiative for CNRS in Africa, our goal is to set up a strong, balanced partnership between researchers from the North and South," stated CNRS president Catherine Bréchignac during the ceremony. Joining her were the heads of the three other founding organizations: Senegal's Université Cheikh Anta Diop in Dakar (UCAD), Mali's University of Bamako, and Burkina Faso's National center for scientific and technological research (CNRST).

The researchers have their work cut out for them. Their primary goal is to investigate the relationship between environmental changes and health. For example, the way that pollution brings about new respiratory illnesses, or the precise role that global warming plays in the diffusion of epidemics, or in food crises. But they will also look at the sanitary problems raised by migrations, and at demographic evolutions, including aging. Finally, they will evaluate how hospitals and health centers function, to improve medical care. All these topics will be studied at the local level in Africa, but also on a world scale.

"With global warming, for instance, diseases currently present in southern countries may very well spread to northern countries," says Gilles Boetsch, UMI director and president of CNRS's scientific board. "The issues that this group will tackle are therefore global and relevant to researchers all over the world." And these issues involve many scientific fields: the five main research topics (*see box*) will rely on 40 or so specialists in environmental science (climatologists, ecologists), health sciences, as well as in the humanities and social sciences (anthropologists, sociologists...). This type of interdisciplinary research is essential, according to Yannick Jaffré, from CNRS,[2] who will be one of the five deputy directors of the UMI.[3] "Everyone knows how important the life sciences are to studying malaria in Africa. But it is very difficult to tackle the subject seriously without looking into local sanitation systems, seeing how patients are treated in health clinics, investigating the use of mosquito nets, or even taking into account city politics–known to contribute to the spread of malaria. In other words, the social sciences are crucial to these issues."

Apart from their recognized scientific expertise, the UMI's researchers have another asset: almost all of them know each other, some quite well. "Most of the teams making up this UMI have already worked together for several years," says Abdou Salam Sall, president of UCAD. This is because a number of African researchers and UMI team leaders first pursued research in CNRS labs, and, once back in their home countries, continued to work together. Their collaboration needed to be formalized, and this took some work. "It's tricky enough forming a lab involving just two countries, so imagine one involving four...," adds Boetsch. But the work has paid off, and the UMI has been created for four years (renewable) at four geographical sites: Marseille (France), Ouagadougou (Burkina Faso), Bamako (Mali), and Dakar (Senegal). "This is like the embryo of a global lab," says Basile Guissou, delegate general of CNRST. "It will enable us to share infrastructures, but also to be everywhere at once, so to speak." Another undeniable advantage of the lab is its visibility, useful for responding to important international calls for proposals. The rector of Bamako's university, Ginette Siby Bellegarde, has an optimistic outlook: "Each partner brings his own skills to the mix, his desire to work with others on unifying topics. I have no doubt that the results of our work will be up to our expectations," she enthuses, confiding that she hopes that the project will be extended to neighboring countries.

**Matthieu Ravaud**

## FIVE TOPICS OF RESEARCH

- → **Pollution, health and society**
- → **Environment, cognition and society**
- → **Pathocenosis, social dynamics, prevention and society**
- → **Technical care spaces and society**
- → **Ways of life and health, influence of migration and demographic transition**


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**Traffic jam in Dakar (Senegal). Researchers will study the effects of pollution on health.**

1. Environment, Health, Society.
2. Laboratoire "Anthropologie bioculturelle" (CNRS / Université Aix Marseille-II / EFS Alpes Méditerranée).
3. With Lamine Gueye and Nicole Chapuis for Senegal, Ogobara Doumbo for Mali, and Blaise Sondo for Burkina Faso.

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# Marcello Solinas

## Research Addict

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"I am interested in everything, as long as something is at stake behind the work," enthuses Marcello Solinas. His aim is to understand drug addiction, its pathophysiology and the influence that the environment plays on it. It's an ambitious challenge but the results are already coming in. With his colleague Mohamed Jaber, Solinas has recently shown[1] that a positive and stimulating environment helps defeating cocaine addiction. And the 34-year-old Italian scientist, who arrived 5 years ago at the IPBC[2] in Poitiers, has absolutely no intention of stopping such promising research.

Interestingly, his encounter with both neuroscience and France was totally unpredictable. Attracted to languages and history, the young Sardinian chose classical studies, "ideal for developing a sound reasoning mental structure." But at 18, he changed course. His family owned a pharmacy so he opted for a doctorate in the field at the University of Cagliari. This gave him the opportunity to meet Professor Gaetano Di Chiara, a world-renowned specialist in drug addiction and dopamine. "I only discovered how famous he was later on. But he impressed me with his lectures on the cerebral circuitry common to natural rewards and drugs, and on how the brain suffered from addiction." This rapidly evolving sector of neuroscience gave Solinas ample avenues for exploration. He subsequently wrote a dissertation on the changes in dopamine[3] neurotransmission in the brain areas linked to addiction. In 2000, with his doctorate in hand, he had one goal: to cross the Atlantic. He landed in Baltimore at the National Institute on Drug Abuse (NIDA). It is there that he embarked on four years of research on subjects ranging from the mechanisms of action of caffeine to the role of the human brain's "endogenous cannabinoid system." Counting several molecular entities, this system is involved in pain inhibition, coordination, and even appetite control. Cannabis acts on the same system, excessively mimicking the effect of the molecules secreted by the brain. "Like cannabis, this system can regulate the activity of the brain's dopaminergic systems but without producing the sensation of pleasure, therefore without risks of addiction." This explains the growing interest in therapeutic use of newly developed cannabinoid tools, capable of providing only the positive effects without abuse liability. The goals are to treat eating disorders and depression–characterized by low motivation–or facilitate weaning someone off cannabis as shown by the scientist's results published in May 2007.[4]

Meanwhile, Solinas and his French wife decided to move back to the "old continent," though career opportunities were rather uncertain there. Yet he was soon recruited as a guest researcher in Poitiers in 2004. One year later, he joined CNRS in his newly adopted city. Different lab, different challenge: While pursuing his work on cannabinoids, Marcello started using rodents to investigate "the influence of living conditions on the effect of drugs." He built this activity from scratch, including finding available financing and buying the latest equipment. This strategy is paying off, "we are finally starting to be competitive and our work is now accepted for publication in prestigious journals." "France has offered me great professional opportunities despite my handicap with the language," he adds with a smile. The next step will be to consolidate the neurosciences in his region and make his laboratory world-class.

**Patricia Chairopoulos**

1. M. Solinas et al., "Reversal of cocaine addiction by environmental enrichment." *Proc Natl Acad Sci USA*, 2008. 105: 17145-50.
2. Institut de physiologie et biologie cellulaires (CNRS/Université de Poitiers).
3. Our endogenous molecule linked to reward.
4. M. Solinas et al., "Nicotinic alpha 7 receptors as a new target for treatment of cannabis abuse." *J Neurosci.*, 2007. 27: 5615-20.

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### WORKING IN A FRENCH LAB, PRACTICAL INFORMATION:

**Fondation nationale Alfred Kastler (FNAK):**
Helps foreign researchers settle in France and maintains contact after their departure.
→ www.fnak.fr

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

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

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

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

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

# Nathan McClenaghan

## Molecular Language

How can two apparently solitary neighboring molecules be made to communicate together? This was the challenging idea raised by young chemist Nathan McClenaghan, a recent recipient of the CNRS Bronze Medal. With his "COMMOTION" project, for which he has been awarded a European grant, he is indeed trying to establish communication links between certain molecules, simply by using light.

Just 35, he understands the full scope of this particularly innovative type of research, and takes it in stride. In fact, Brussels has just granted him a total of €1.25 million over a five-year period, to build his team and develop his project in the context of the ERC young researchers program.[1] CNRS, the Aquitaine Region, and the University of Bordeaux-I are also providing strong support for the project.

And this son of a Northern Irish engineer is confident, having nurtured the idea for a long time. During his thesis work in Belfast, where he worked on developing light-sensitive (photosensitive) molecules, he already had his eye on mainland Europe, and particularly the work by French teams based in Bordeaux.

Following an initial postdoctoral stay in Italy, he moved to France, the country where he would later meet his wife. He rapidly mastered the French language and pursued his research in a Bordeaux chemistry laboratory where he focused not only on isolated molecules, but also on supramolecular architectures based on self-assemblies of fullerenes (comprising carbon atoms ordered in the shape of a football). Then, in 2003, this young scientist decided to settle at the ISM[2] in Bordeaux in the Nanostructures Organiques (NEO) group, and started his initial research on molecular language. To establish inter-molecular communication, his current methodology involves pointing a light source directly at the molecules, forcing them to modify their molecular and electronic structure. This action can release ions, which act as messengers that are then caught and gradually released by other molecules. "This process is inspired from living organisms," explains McClenaghan. "Vision is a good example: When your eye is exposed to light, photons are absorbed by retinal pigments which change their shape and trigger the gradual release of ions to the brain, which in turn records the message. This is a simple but efficient form of communication. I am now trying to determine the extent to which this can be reproduced and used, at the nanometer scale, in the laboratory." And this time, using light-driven ions and small designer molecules. This is molecular communication that can be followed in real-time using photosensitive molecules whose properties adapt during the "conversation," thus enabling small-scale computation or even the instantaneous diagnosis of certain diseases that are mainly based on defective communication. This could be accomplished, for example, by investigating the transport of calcium or potassium ions, or other types of ions that are responsible for certain serious disorders like osteoporosis, tetanus, and various nervous diseases. In the long run, one possibility might be to treat certain diseases by photo-activating defective channels. The COMMOTION team is now being formed, and should bring together about a dozen students and CNRS researchers, specialists in the fields of chemistry, biology, and physics. We shall certainly be hearing a lot more about this very ambitious project in the near future.

**Séverine Duparcq**

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1. European Research Council. http://erc.europa.eu/
2. Institut des sciences moléculaires (CNRS / Universités Bordeaux-I and IV / ENSCP Bordeaux).

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## GRANTS/ FELLOWSHIPS

### 4TH STIC-AMSUD PROGRAMME

Calls for submission of research-development projects in all topics related to Information and Communication Sciences and Technologies were just issued. Projects must include at least two participating South American countries, and one team of French scientists.
→ **Deadline:** May 15th, 2009
→ **www.sticamsud.org**

### CNRS-DENMARK AGREEMENT

CNRS and the Danish National Research Foundation (DNRF) have concluded an agreement to strengthen scientific cooperation between France and Denmark. It includes a mobility program that provides support for travel expenses, accommodation, and running costs. Applications can be submitted throughout the year three months prior to the intended date of travel.
→ **www.dg.dk**

### EURAXESS

This portal provides information on grants, fellowships, or positions available throughout Europe as well as practical information (accommodation, childcare and schools, healthcare...) for each country.
→ **http://ec.europa.eu/euraxess/index_en.cfm?l1=0&l2=0&l3=0**

### ÉGIDE

Égide is a non-profit organization that manages French government international mobility programs. Many funding opportunities are listed. Most content is in English.
→ **www.egide.asso.fr**

### MARIE CURIE ACTIONS

This EU program provides numerous fellowships and grants facilitating research mobility in Europe.
→ **http://europa.eu.int/comm/research/fp6/mariecurie-actions/indexhtm_en.html**

# Scientific Revival


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Monte Fitz Roy, located in the Southern Patagonian Ice Field.

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Argentina, which produced two Nobel science prize-winners in the 20th Century, is a country with huge potential: It is the second biggest country in South America and one of the continent's largest economies, with an educated workforce and considerable natural resources. Yet its troubled past, including several military dictatorships and public finance bankruptcies, prompted a significant brain drain among the neglected scientific community. The government now wants to encourage their return. It has placed R&D at the heart of the current program for national development, together with improving the resources and pay of researchers.

This budding renaissance also centers around a strong development of international scientific cooperation in which France is a major partner. "There is a long tradition of French presence in Argentina," comments Claire Giraud, deputy director of International Relations at CNRS. "Argentines represent the majority of CNRS researchers of Latin American origin, and they now lead many of our joint projects." The current revival followed one of the country's worst crises; in December 2001, the economy collapsed due to record debt defaults and currency devaluation, leading to violent social unrest. But following the election of president Nestor Kirchner in 2003, the country witnessed a remarkable turnaround, due to a combination of audacious internal economic policies and a favorable international economic climate. The recovery has largely continued under the current president, Cristina Fernández de Kirchner, who succeeded her husband in 2007.

Many problems remain, but the baseline figures are impressive: Argentina has enjoyed relative political stability and greatly improved finances with its debt restructured and partly repaid. By 2008, the Argentine economy was the third fastest-growing in South America, with a public debt level brought down to 51% of its GDP and unemployment reduced to 7.8%–down from 20% in 2002.

In 2006, the Argentine government announced the launch of a 10-year plan to double the proportion of GDP spent on scientific and technological R&D, from 0.5% to 1%. One of Mrs Kirchner's first moves was the creation of the Ministry of Science, Technology and Productive Innovation (MINCyT), which devises and leads national research policies. Significantly, she appointed a scientist, Dr. José Lino Barañao, to run it. Mrs Kirchner, who described science as "key to the nation's economic future," also set aside funds to increase researcher salaries by 30%, and boost public funding of competitive research grants by 40% in 2009.

At a national level, the National Council of Scientific and Technical Research (CONICET), headed by the MINCyT, manages the financial organization of specific research activities. Created in 1958 and based on the same organizational structure as CNRS, it currently has a yearly budget of about €110 million and employs researchers in both its own and associated research centers–many of whom conjointly hold university posts.

Research is centered around five major fields: agronomy; engineering and materials; biology and health; natural and exact sciences; and human and social sciences. Under the terms of a development plan launched in 2005, the CONICET annually provides 500 permanent positions (300 newly-created and 200 replacements). It also manages 1300 grants for doctorate and post-doctorate research studies.

Academic research is seated among the country's 79 universities, of which 41 are privately-funded, and which total some 1.54 million students. The leading research universities are those of Buenos Aires, La Plata, Cordoba, and Rosario.

## IN FIGURES

- **39.9** million inhabitants (source: UN 2008)
- **6 636** US$ GDP per capita (source: UN 2007)
- **0.5%** R&D spending as a percentage of GDP, in 2006
- **32,000** researchers in 2006
- **3.8%** state funding in education, as a percentage of GDP (source: UNESCO 2004)
- **1.54** million students in higher education in 2006

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**Above: The fly larvae that infect domestic bees are the subject of one of the cooperative research programs. Left: Researchers collect bees' larvae for their work.**

Finally, separate to the MINCyT structure is the National Atomic Energy Commission (CNEA), a government-run body responsible for management, research, and development of all the country's civil nuclear activities. Placed under the authority of the Energy Secretariat and the Ministry for Federal Development, Public Investment and Services, the CNEA has several research centers at its disposal. These include the Centro Atomico Constituyentes near the capital Buenos Aires, involved in fundamental and applied technology, and the Centro Atomico at Bariloche, in Patagonia, which enjoys a longstanding history of cooperation with the CRTBT,[1] a CNRS lab based in the French city of Grenoble.

The CNEA provides Argentina's contribution to the country's largest single international research cooperation project: the Pierre Auger Observatory (named after French physicist Pierre Victor Auger). Based in the Mendoza Province of western Argentina, this unique international observatory of ultra-high energy cosmic rays brings together 253 researchers and engineers from 17 different countries. This includes a French team of 32, which is principally represented in the project by CNRS. In 2008, France contributed 12% (€3 million) of the Observatory's budget.

The National Agency for Scientific and Technological Promotion (ANPCT), placed under the MINCyT, encourages both national and international research cooperation agreements. On the basis of research papers published in Argentina in 2007, France was Argentina's fourth-placed international partner (behind the US, Spain, and Brazil), accounting for 260 co-publications (of which 160 involved CNRS).

"Joint scientific activities with France and other major European partners offer Argentina better access to research in Europe-wide structures, like the EU Framework Program for Research and Technological Development, which the EURALINET program aims to stimulate," explains Jean-François Marini, who represents CNRS and the French IRD[2] in Argentina.

In 2007, CNRS researchers carried out 250 mission visits to Argentina, mainly involving sciences of the universe (almost 30%), engineering sciences and technologies (19%), physics (15%), and social and human sciences (12%). Several CNRS researchers were also involved in year-round projects in the country.

Across all its joint projects based in Argentina, CNRS counts five International Program for Scientific Cooperation (PICS), involving biology, mathematics, genetics, and social and human sciences; two International Research Networks (GDRIs), one involving extreme energy observation at the Auger Observatory, and another focused on water governance and access in the Americas; as well as an International Associated Laboratory (LIA) in nanotechnology.

CNRS is currently involved in negotiations with the MINCyT to establish two Joint International Units (UMIs), one focused on technologies, astro-particles and sciences of the universe based at the Auger Observatory, the other involving climate studies, which would be located at the University of Buenos Aires.

Rooted in an agreement signed in 1985, CNRS and the CONICET together fund a yearly average of 15 cooperation projects, mainly in the fields of physics, mathematics, materials, information and communication technologies, and history, centered at the universities of Buenos Aires, La Plata, and Rosario.

Finally, this year marks the 10th anniversary of the ECOS program (orientation and evaluation of scientific cooperation) under which France's Ministry of Foreign and European Affairs and Ministry of Higher Education and Research fund some 15 joint lab projects in Argentina, of which about 60% involve CNRS teams. These currently include research in bioinformatics, architecture, and mathematics.

**Jason Brown**

1. Center for Research into Very Low Temperatures.
2. Institut de Recherche pour le Développement.

© J. M. Villacide

**Pine trees in a Patagonian plantation, infected by the woodwasp *Sirex noctilio*. Researchers study the parasitoids used in the biological control of this major pest.**

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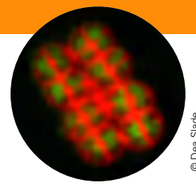
DEINOVE

# Second Generation Biofuels


© Des Slade

**Bacterial membranes (red) and DNA (green) labelling of a small colony of *Deinococcus radiodurans* (8 bacterias).**

Producing second generation biofuels from residual agricultural and forest biomass is now seen by many as an environmental priority. That is because first generation biofuels–such as bioethanol obtained by fermenting corn with brewer's yeast (*Saccharomyces cerevisiae*)–stress food resources. But to be successful, second generation biofuel production needs to break down polymers, namely cellulose, hemicellulose, and lignin, more complex than glucose and saccharose, which Saccharomyces feeds on. This may soon be possible, thanks to the biotechnology company Deinove, specialized in research into a family of superbacteria, namely Deinococcales. *Deinococcus radiodurans* for example, first identified bacteria of the genus, can resist ionizing rays, UVs, solvents, and drought, among other things. "It is very efficient at repairing its DNA after radiation damage. This property makes it easier to insert genes into its genome, such as enzyme genes which are of interest for sugar degradation or fermentation. Some of these bacteria can also withstand high temperatures, which results in less water consumption when cooling the vats during fermentation under industrial conditions," says Jean-Paul Léonetti, of CPBS[1] in Montpellier.

The team of Miroslav Radman,[2] a member of the French Academy of Sciences, had for a long time been carrying out cutting-edge research on DNA repair in Deinococcus. It was after a meeting with Truffle, a venture capital firm, that Deinove was created two years ago, also involving CNRS and the Toulouse branch of the engineer school Insa.

"Three patents have been filed," says Jacques Biton, Deinove's CEO. "The first patent protects a smart research tool, the second one is protecting applications for the production of biofuels, and our last patent protects other potential industrial applications. Within two and a half years, we hope to set up a large scale pilot fermentor, with the help of an industrial partner." The latest move was the May 2008 creation of Deinolab, a cooperative lab between Deinove and CNRS in Montpellier. Thousands of Deinococcus strains have been collected since then all over the country–mostly in the hotsprings the bacteria are fond of. "We are now screening these strains on parameters such as sugar assimilation or solvent resistance, in order to identify one or several candidates. We will soon start their fermentation profile to generate a hyper-producing strain within 18 to 24 months," explains Léonetti.

**Jean-François Haït**

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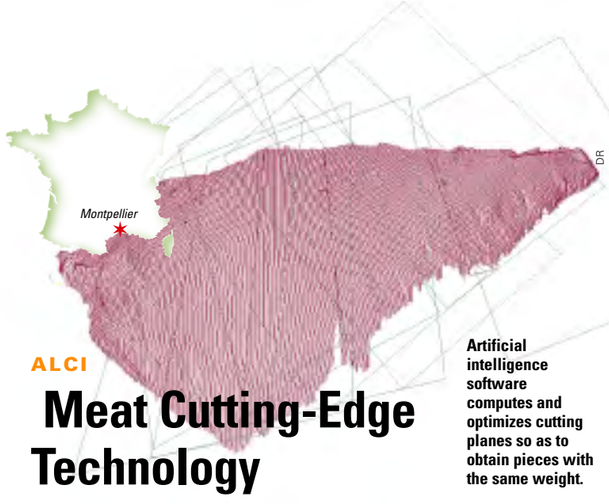

DR

**Artificial intelligence software computes and optimizes cutting planes so as to obtain pieces with the same weight.**

ALCI

# Meat Cutting-Edge Technology

Somewhere, at a supermarket's fresh food counter, a customer is picking up a tray of vacuum-packed beef. He's not thinking too much about the weight because after all, the pieces have been graded, and they all weigh roughly the same. But although we take this for granted, it wouldn't be at all possible without the hard–sometimes deemed unrewarding–work of butchers working in a chilly 5°C and 80% humidity environment, and striving to cut meat into pieces with identical weights. Yet in the near future, this job could be handled by robots. All thanks to the pioneering work achieved by Alci, a new company set up in 2007 in Montpellier by Hervé Turchi and David Barra (two PhD students at LIRMM[1]).

A meat-cutting robot is a pretty unusual idea–and a world first–admits Turchi as he remembers the day when this idea first came to him: "Someone I know actually pointed out to me how little automation there was in the food processing industry." Little by little, a business plan took shape, and the project got off the ground with the arrival of the third team member, Mickaël Sauvée, an engineer in machine vision. They weren't long in producing a prototype robot at LIRMM, which continued to host their experiments, resulting in two technological patents. In 2005 and 2007, their initiative won awards in the innovation competition organized by the French Ministry of Research. In short, Alci has been something of a success story. "We did benefit from a very favorable context, especially through business development grants," the two Alci founders admit.

Their goal was to have their robot cut uniform slices from pieces of meat of varying shape and size. To design it, the team made the most of what they had learnt at LIRMM. A profilometer, consisting of a laser and a camera, is used to obtain an image of the muscle that is to be cut. Then, artificial intelligence software developed by the team calculates the optimum cutting angles required to obtain pieces with identical weights. Finally, a robot arm slices the piece of meat at the angles indicated by the software. The prototype is able to cut 250 kg of meat per hour, with a 5% margin of error, compared to the current rates of butchers–100 kg/hour with a 10% margin of error. Despite its high cost, the improved quality and productivity provided by this robot has already won over one customer, who will have operational machines in early 2009. But the team doesn't intend to stop there. The researchers are already talking to the vegetable and fish industries, and other projects to develop new robots are already under study. By the end of the year, they're hoping to hire three people and obtain ISO 9001 certification, which defines the requirements for quality management systems.

**Caroline Dangléant**

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AGROCHEMISTRY

# The Strength Lies in the Plant

Toxicity, water table pollution, soil degradation... The list of harmful effects of chemical treatments used by farmers still sends shivers down the spine. Although for many years, numerous research groups have been focusing on the development of clean alternatives, they have never been able to achieve the combination of sustainable development and intensive agriculture. This problem is nonetheless crucial, especially in viticulture where the use of plant health treatments can harm the image of renowned vineyards. A novel plant health protection strategy has now been developed on the lab benches of IBMM[1] in Montpellier: Rather than combating the pathogen, as do pesticides, new biodegradable and non-toxic compounds can preventively stimulate the natural defenses of plants against bacteria, viruses, and fungi. The new patented product was presented last June at the European Research and Innovation Exhibition, and in 2007 the team had received the INPI trophy for innovation in the Languedoc-Roussillon region.

How exactly does this new treatment work? "The aim is to supply the plant with a substance that acts as a signal to stimulate its natural defense mechanisms, in other words, an 'elicitor'peptide," explains Florine Cavelier, researcher at IBMM. As initiators of the project, Cavelier, together with Jean Martinez, also from IBMM, had first of all observed this effect in a family of peptides synthesized by Trichoderma fungi. But they were difficult to produce and thus too costly to use as an agrochemical. "We then looked at this compound as an object rather than a complex chemical structure. We sought to produce a simplified peptide with a structure as close as possible to that of natural peptides, so that they would nonetheless keep the ability to stimulate the plant's defenses," explains Cavelier.

As a result, the team produced a compound they called "Lapp 6," which was first tested in the laboratory at low doses on melon and cucumber plants and young vines. These trials showed that Lapp 6 was able to stimulate the natural defenses of the plants tested, as shown by the detection of two early markers of the natural defense pathway. The substance was then improved to enhance the control of specific attacks from powdery and downy mildew, that mainly affect vines. Finally, in 2005, open-field trials were authorized on sections of three vineyards in the Burgundy, Loire-Atlantique, and Languedoc regions. The treatment, applied by spraying the leaves, enabled a significant protection of grapes, despite less marked efficacy on leaves.

The IBMM team had decided to patent this process as early as 2001, and the patent was extended worldwide in 2003. Today, this innovation belongs to both CNRS and the company De Sangosse in Agen (France), specialized in plant health solutions. But the work is not complete yet: "we need to analyze the stability of this product over time, its interaction with the surrounding environment, and its precise formulation," adds Cavelier. In any case, some of Lapp 6's properties have already ensured that it will be able to enter the integrated farming market: it is easy to synthesize, active at very low doses, non-toxic, and biodegradable.


© Photos : F. Cavelier

**Top: Grape attacked by downy mildew. Bottom: Grapes treated with Lapp 6, at a rate of 1.5 g per hectare, remain healthy.**

**Aude Olivier**

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FLUOPTICS

# Making Tumors Fluorescent

Coloring malignant cells could be of great help to surgeons when removing tumors. And this is exactly what Fluoptics is working at. The product of a close-knitted collaboration between researchers at different French organizations,[1] Fluoptics is set to offer a complete imaging solution to surgeons.

Whereas current methods of cancer detection require the injection of radioactive molecules into the organism, Fluoptics uses patented fluorescent markers which are capable of targeting cancerous cells responsible for the vascularization of tumors (angiogenic). And these markers are cheaper, have fewer constraints, and no side effects.

"We have brought together two independently developed innovations: biomarkers, and a portable optical device designed by CEA,[2] to visualize pathogenic zones," explains Odile Allard, one of the project leaders. The principle behind the two prototypes used in laboratory-based preclinical tests is simple: The fluorescent tracer is injected intravenously the night before the operation. During the surgical procedure, a camera lights up the operation site by infrared, and captures the fluorescent light emitted in response by the markers affixed to the tumors. This means the surgeon is able to visualize the extent of the tumor from the beginning of the procedure, and can ensure that the ablation is complete.

Conscious of the great public health interest in this technology, the French Ministry for Research and Industry selected last June the Fluoptics project leaders as winners of a national competition for innovative business creation assistance (€450,000 to launch a start-up). Fluoptics' technology had also received recognition at the European level with a first prize at the European Innovation Hopes.

After being incubated at the Grenoble Alpes Incubation structure in summer 2007, and then at EM-Lyon from April 2008, Fluoptics was created at the beginning of 2009. The next stage, according to Allard, is "to manufacture and industrialize this technology."

**Aude Olivier**

1. CNRS, CEA-Léti, and Université Joseph Fourier.
2. Commissariat à l'énergie atomique.


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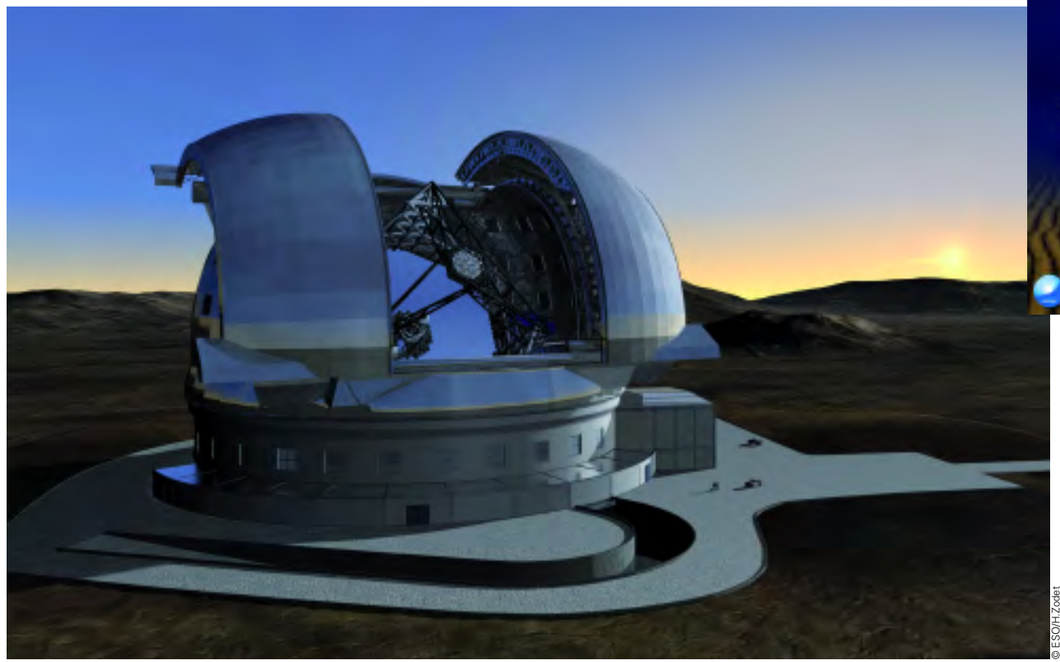
ASTRONET

# Europe's Space Bound Program

Building on significant advances in the past 50 years, Europe looks set to keep its lead in space science with the Astronet program, a roadmap for the next two decades.

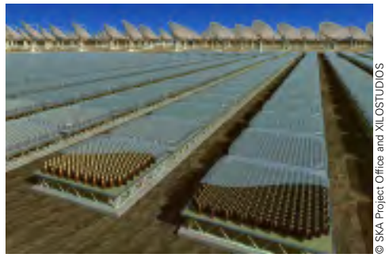


© ESO/H.Zodet

The E-ELT will be mounted on a central concrete pier that ensures a minimum clearance of 10 m above the ground.

Is there life elsewhere? How did the galaxies, stars, and planets form? What is the nature of dark matter? Just some of the fascinating questions astronomers worldwide are trying to find answers to. To consolidate and reinforce Europe's leading position in astronomy, the Astronet program was created in September 2005. Supported by 28 countries, the Astronet consortium is coordinated by CNRS' French National Institute for Sciences of the Universe (INSU). "The aim was to establish a long-term plan for the development of European astronomy, including every observation approach, from space or from Earth, and covering radiation studies on all wavelengths," explains CNRS researcher Jean-Marie Hameury, coordinator of Astronet. The strategic plan, which puts forth a detailed Astronet roadmap, was released in November 2008 to funding agencies. This roadmap was written by 60 European experts regrouped in five panels. They reviewed over 100 tools and infrastrucutures, examined computing facilities and data archiving, and analyzed human resources including education, recruitment, public outreach and industrial involvement.

Astronet's major role is to define priorities ensuring that the goals of the scientists meet those of the funding agencies. Two ground-based infrastructure projects emerge as top priorities: the European Extremely Large Telescope (E-ELT) and the Square Kilometre Array (SKA). The first, a very ambitious project driven by ESO (European Space Observatory), is already in an advanced stage of study, whereas the SKA–comprising thousands of antennas making the total collecting area close to a million square meters–is still in early stages of development. Other projects, which operate on smaller budgets, were also classified top priority, such as the European Solar Telescope (EST), the Cherenkov Telescope Array (CTA), and the underwater neutrino detector KM3NeT.



© SKA Project Office and XILOSTUDIOS

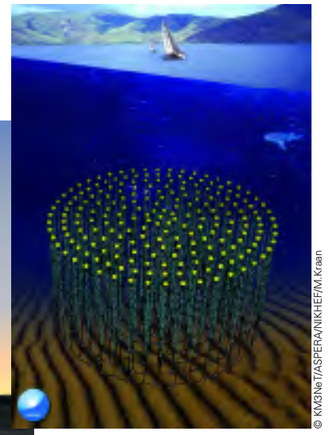
The SKA's collecting area (around a million square meters) will be distributed over a number of groups of antennas, or "stations"–perhaps as many as a few hundred.

Future space missions are obviously on the agenda with large-scale missions like the gravitational-wave observatory LISA and the X-ray observatory XEUS/IXO first on the list, followed by the search for giant planets with TandEM or LAPLACE, and ExoMars. The highest priority medium-scale projects include Gaia data analysis and processing (Milky way mapping), EUCLID (Dark Energy), or the Solar Orbiter, a mission devoted to studying the Sun. All these space missions are driven by the European Space Agency (ESA).

The role of existing observational facilities, in space or from the ground, is also considered in the roadmap, recommending the prolongation of the most successful space missions, and the review of all ground-based telescopes. A scientific group has already begun assessing the existing small to medium-size optical telescopes throughout Europe, with the objective of overall coordination and ensuring all these facilities (approximately 30) are useful.

"The roadmap also focuses on training and education," adds Jean-Marie Hameury. But it will also deal with public communication and will establish greater ties with European industry. Indeed, technological readiness is a limiting factor for many of these projects and a vigorous R&D program is needed, in concert with industry, to ensure technology transfer. This coherent plan should also be a strong asset in negotiating international partnerships for the largest projects. "To define a roadmap is the first step, but putting it into action is what really matters," concludes Hameury. European astronomy now has a clearer view of where it's going.

**Samantha Maguire**



© KM3NeT/ASPERA/NIKHEF/M.Kraan

The KM3NeT neutrino telescope, immersed in the Mediterranean sea, will be unique in sensitivity and resolution.

## EUROPEAN TRAINING ON BLACK HOLES

**A black hole is a region of space in which the gravitational field is so powerful that nothing (not even light) can escape it once inside. Black holes are therefore "invisible" by nature–but not to astronomers, who detect events happening close by. "For instance, they eject powerful jets of plasma," explains Stéphane Corbel, from the AIM laboratory.[1] He is also the French coordinator of a new "Marie Curie training network," the Black Hole Universe Consortium–part of the 7th Framework Programme (FP7). For four years, it will associate leading astronomy institutions across Europe in order to train a new generation of space scientists. "We will train students, who are usually specialized in one or the other wavelength (X, Gamma, radio...), to be multi-scale oriented," says Stéphane Corbel. A necessary skill when working on the two types of black holes: the stellar ones, produced in massive star explosions, and their heavy counterparts, a billion times more massive, found at the center of galaxies.**

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UK

## Focus on the Thalamus

A key component of the brain, the thalamus plays a role in many physiological functions (sensory information processing, sleep, etc.) as well as in various pathologies. To better understand how it works, CNRS, the Pierre et Marie Curie University, and Cardiff University (UK) have set up the European Associated Laboratory (LEA) "Thalamic function in health and disease states-THD." It brings together the Neurobiology of Adaptive Processes laboratory (CNRS / Université Paris-VI) and the Cardiff School of Biosciences.

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POLAND

## Joining Forces on Exotic Nuclei

The France-Poland European Associated Laboratory (LEA) COPIGAL (COPIN-GANIL cooperation on the physics of exotic nuclei) was launched November 26th, 2008. It brings together CNRS' National Institute of Nuclear and Particle Physics (IN2P3), the French large heavy-ion accelerator (GANIL), the French Atomic Energy Agency (CEA), and the Consortium of Polish Institutions for research in the field of nuclear physics (COPIN). Although the teams involved have long worked together on exotic nuclei–those of chemical elements that do not exist in a natural state on our planet–COPIGAL will encourage the joint use of infrastructures and the promotion of long-term strategies.

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IRELAND

## Biological Imaging

A cooperation agreement on biological imaging and "translational research," a link between fundamental research and clinical research, was signed in Paris on January 26th. It brings together the Institute of Functional genomics[1] and the Royal College of Surgeons.

1. CNRS / Inserm / Universités Montpellier-I and II.

→ **Contact : Anne-Marie Brass,**
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ISRAEL

## Strengthening Scientific Cooperation

On March 18th, in Jerusalem, CNRS President Catherine Bréchignac and Menahem Megidor, the president of the Hebrew University of Jerusalem, signed an agreement for the creation of a European associated laboratory (LEA), the France-Israel Laboratory of Neuroscience (FILN). It brings together CNRS, the Victor Segalen University in Bordeaux, the Descartes University in Paris, and the Hebrew University of Jerusalem. It takes over, in renewed form, from the first France-Israel laboratory set up in 2005, the France-Israel Laboratory for Neurophysiology and Neurophysics of Systems. The FILN is dedicated to fundamental and clinical studies of the brain. Just beforehand, March 16th, the LEA NanoBio Science (NaBi) was inaugurated in Rehovot in the presence of Catherine Bréchignac and Daniel Zajfman, president of the Weizmann Institute. This LEA brings together for a duration of four years seven CNRS-affiliated laboratories and the departments of chemistry and physics of the Weizmann Institute. Research will focus on nanotechnology, photonics, and biological imaging.

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CZECH REPUBLIC

# CEFRES in Prague

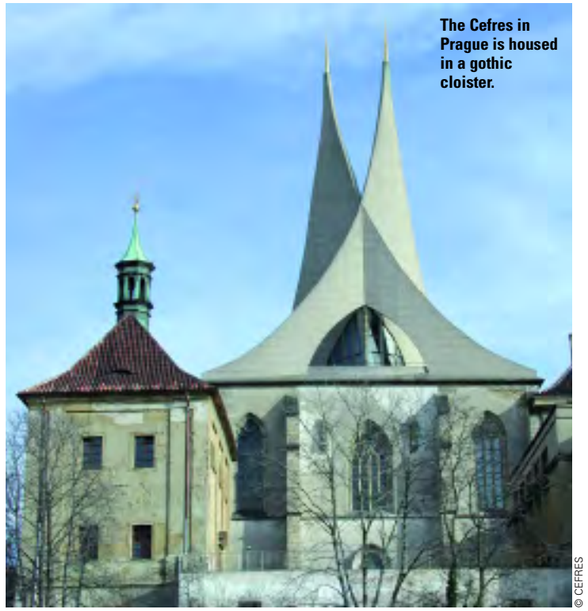
At the forefront of French research and with direct ties to the world's major cultural areas, the UMIFREs (French Research Institutes Abroad) act as both vehicles for knowledge and springboards for scientific collaboration. We interviewed Marie-Claude Maurel, director of the French Center for Research in Social Sciences (CEFRES) in Prague.

**The Czech Republic took over the presidency of the European Union in January. How has this affected the activities of a research center like CEFRES?**

**Marie-Claude Maurel:** CEFRES is extremely active. On top of our research work, this year we're taking part in publishing a journal which will present the Czech Republic in all its different aspects (historical, social, sociological, cultural, etc). We're also organizing two conferences so that the scientific, economic, and political players in the rest of Europe learn more about this country.

**What is CEFRES' overall mission?**

**M.-C.M:** To take part in the development of scientific networks in Eastern Europe. Although we work in Prague, we maintain very close links with our neighboring countries–especially Slovakia, Hungary, and Poland. These countries have a joint heritage in the cultural, political, and administrative fields, which justifies the presence of a center like ours. This unit, which is a true research and service platform, is constantly tied to local French embassies, universities, and research institutions. We host approximately 20 fellowship students, researchers, and assistant professors. Every year we organize conferences, talks, and training workshops open to French-speaking researchers.



The Cefres in Prague is housed in a gothic cloister.

© CEFRES

**What research are you carrying out and with what means?**

**M.-C.M:** We are involved in an International program for scientific cooperation (PICS) entitled 'Local players faced with the European model.' Another of our projects, funded by the French National Research Agency (ANR), is concerned with the sound archives of the Soviet Gulag. Lastly, we are initiating a study–also funded by the ANR–on 'Local action and territorial development in Central Europe.' For the first time, it brings together approximately 20 French, Polish, Czech, Hungarian, Slovakian, and Lithuanian researchers.

**Séverine Lemaire-Duparcq**

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## NEW IMPETUS FOR FRENCH CENTERS ABROAD

**On January 29, CNRS reasserted its backing to the directors of the 26 French centers abroad gathered together at the organization's headquarters in Paris. CNRS President Catherine Bréchignac announced that this spring, special funding would be made available, aimed in particular at improving "the dissemination of information between the various areas of culture" and at encouraging the emergence of thematic networks. In addition, an agreement should be signed this year between the centers' two supervisory authorities, CNRS and the French Ministry of Foreign Affairs, to more clearly define the missions of these centers, the duties of their directors and their responsibilities. With clear objectives, this "road map" should help instigate a strict and constructive evaluation policy by 2010.**

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ASIA

# Closer Ties

**New international associated laboratories (LIAs) have been set up in the last few months with China and Hong Kong. The Functional Organophosphorus Materials (MOF) laboratory, bringing together the University of Rennes-I and the University of Zhengzhou, will be dedicated to the synthesis of new phosphorus compounds for plastic electronics. The France-China Catalysis laboratory, with Claude-Bernard University in Lyon, the Dalian Institute of Chemical Physics (DICP), and a Chinese industrial group–the Research Institute of Petroleum Processing (RIPP)–will focus on catalysis for energy and water treatment.**

**Lastly, the first LIA with Hong Kong is now underway. Called "Role of calcium in cellular determination and differentiation," it brings together, for a period of four years, CNRS, the Hong Kong University of Science and Technology (HKUST), and Toulouse-III University. This LIA is the fruit of more than 10 years of collaboration between researchers from the Center for Developmental Biology in Toulouse, and a Hong Kong team that specializes in calcium's role in gene expression during development.**

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MATHEMATICS

# Paris, City of Maths

With approximately 1000 researchers, the Fondation Sciences Mathématiques de Paris (FSMP) is one of the world's largest breeding grounds for mathematicians. And it's not only the numbers that are impressive. The prestigious medals and prizes that the Foundation has chalked up over a few years testify to its level of excellence.

With four Fields medals, two Abel prizes, three of the eleven prizes awarded at the most recent European congress, fourteen members of the French Academy of Sciences and 120 winners of both French and international awards, the Fondation Sciences Mathématiques de Paris (FSMP) backs up its success with numbers. Launched at the end of 2006, it is made up of six teaching and research organizations[1] and brings together nine labs in Paris with no fewer than 1000 researchers, making it the largest group of mathematicians in the world. CNRS is one of the founding members and accounts for a quarter of its staff. The Foundation was set up to federate Paris's mathematicians and to improve the visibility and attractiveness of their labs in France and abroad. Another of its distinctive features is that it covers the entire range of pure and applied mathematics, as well as fundamental computer science. A choice justified by a fact that is borne out again and again: There is no such thing as an insurmountable barrier between theory and its applications. As FSMP Director Jean-Yves Chemin likes to point out, "mathematics first emerged 5000 years ago to manage the production and distribution of goods. It doesn't get much more applied than that!"

## THE APPLICATION FACTOR

And the scope is far-reaching: climatology, seismology, and a host of other disciplines all need mathematics. One example is cryptography, which has become essential for secure online banking transactions. "The number theory that it relies on is an edifying example of how abstract mathematics can be used for a practical application. There can be no doubt that mathematics play a vital role in our everyday life. This is why the FSMP encourages collaborations between researchers and business and industry. Its goal is to play a key role in helping companies identify their medium and long-term needs, and then recruit the mathematicians most qualified to answer them.

## ATTRACTING THE VERY BEST

Though the French capital already enjoys great credibility when it comes to mathematics, maintaining it will require a major effort. "There are other cities in the world lying in wait, like Beijing and Mumbai, where the number of mathematicians is constantly growing," Chemin warns. Therefore, the Foundation is investing considerable means to attract the world's top mathematicians. For instance, it recently created a chair of excellence intended for world-class researchers, the only individual chair in France entirely dedicated to mathematics. Fifteen postdoctoral researchers from other countries can also be hosted every year, which makes this the only post-doc program for mathematics and fundamental computer science on this scale in the country. "To recruit them, we advertise the positions in 2000 institutions around the world," Chemin explains.


© Laetitia le Saux for the CNRS magazine

And there are other ways to attract talent. The Foundation Prize can sponsor for up to one year a promising young mathematician–who could one day become a leader in the field–and the world's greatest mathematicians can also be invited for two to three-month stays in Paris. "Funds can also be rapidly made available to host an exceptionally talented PhD student from abroad," adds Chemin, citing the example of a young Australian prodigy who recently picked the FSMP over other tempting offers.

## A TASTE FOR MATHS

Fostering general interest in mathematics is also one of the Foundation's objectives–though its main role lies in research. While Paris universities are not as affected, the overall shortage of math students has become a worrying trend. This has encouraged the FSMP to launch a "Paris Graduate School of Mathematical Sciences," with grants for both Masters and PhDs. "Our goal is to host 20 foreign students at 'Master 1' level at the beginning of the 2010 academic year, and then increase this to 50 students," Chemin explains. Similarly, the Foundation is also committed to making science more accessible to the general public, through its website and various public lectures, like those that were held during its launch in 2007–hoping that a growing number of students also add up.

**Jean-Philippe Braly**

1. CNRS / Ecole Normale Supérieure / Université Paris-Diderot / Université Pierre et Marie Curie / Université Paris-Dauphine / Collège de France.

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# CNRS in Brief

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

## Facts…

**Founded in 1939 by governmental decree, CNRS has the following missions:**
- ➔ To evalulate and carry out all research capable of advancing knowledge and bringing social, cultural, and economic benefits to society
- ➔ To contribute to the application and promotion of research results
- ➔ To develop scientific communication
- ➔ To support research training
- ➔ To participate in the analysis of the national and international scientific climate and its potential for evolution in order to develop a national policy

**CNRS research units are spread throughout France, and employ a large body of permanent researchers, engineers, technicians, and administrative staff. Laboratories are all on four-year, renewable contracts, with bi-annual evaluations. There are two types of labs:**
- ➔ **CNRS labs:** fully funded and managed by CNRS
- ➔ **Joint labs:** partnered with universities, other research organizations, or industry

**As the largest fundamental research organization in Europe, CNRS is involved in all scientific fields, organized into the following areas of research:**
- ➔ Life sciences
- ➔ Physics
- ➔ Chemistry
- ➔ Mathematics
- ➔ Computer science
- ➔ Earth sciences and Astronomy
- ➔ Humanities and Social sciences
- ➔ Environmental sciences and Sustainable development
- ➔ Engineering

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

**The CNRS annual budget represents one-quarter of French public spending on civilian research. This funding comes from various sources:**
- ➔ Government and public funding
- ➔ CNRS funds, primarily from industrial and EU research contracts and royalties on patents, licenses, and services provided

## … And Figures

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

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

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

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

## DAE AND DRI, TWO OFFICES DEVOTED TO INTERNATIONAL RELATIONS

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

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

**IN NUMBERS:**

**Exchange agreements:** 85 (with 60 countries)

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

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

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

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# AMAZING IMAGES

## Tentacles of Thought

Electric seaweed? A mysterious creature of the underworld? Not quite. What you are looking at is a rat's neuron at the moment neuronal communication occurs. In this picture, a research team from the PCS[1] lab in Bordeaux used fluorescence microscopy (a labeling method using colored antibodies) to highlight the terminals of the pre-synaptic neuron (blue), and the post-synaptic neuron (red for a post-synaptic marker, green for glutamate receptors, and yellow for the nucleus). They observed an accumulation of neurotransmitter receptors at the tip of the dendritic spines–visible as white labeled dots, the result of colocalization of blue, red, and green fluorescence. The team believes these receptors' mobility plays a vital role in the passage of nerve impulses from one neuron to another, and thus controls the reliability of data transfer. Their results[2] pave the way for new therapeutic targets for Parkinson's, Alzheimer's, OCD, and other disorders that are caused by poor neuronal communication.

**Lucille Hagège**

1. Physiologie cellulaire de la synapse (CNRS / Université Bordeaux-II).
2. M. Heine et al., "Surface Mobility of Post-synaptic AMPARs Tunes Synaptic Transmission," *Science*, 2008. 320: 201-5.

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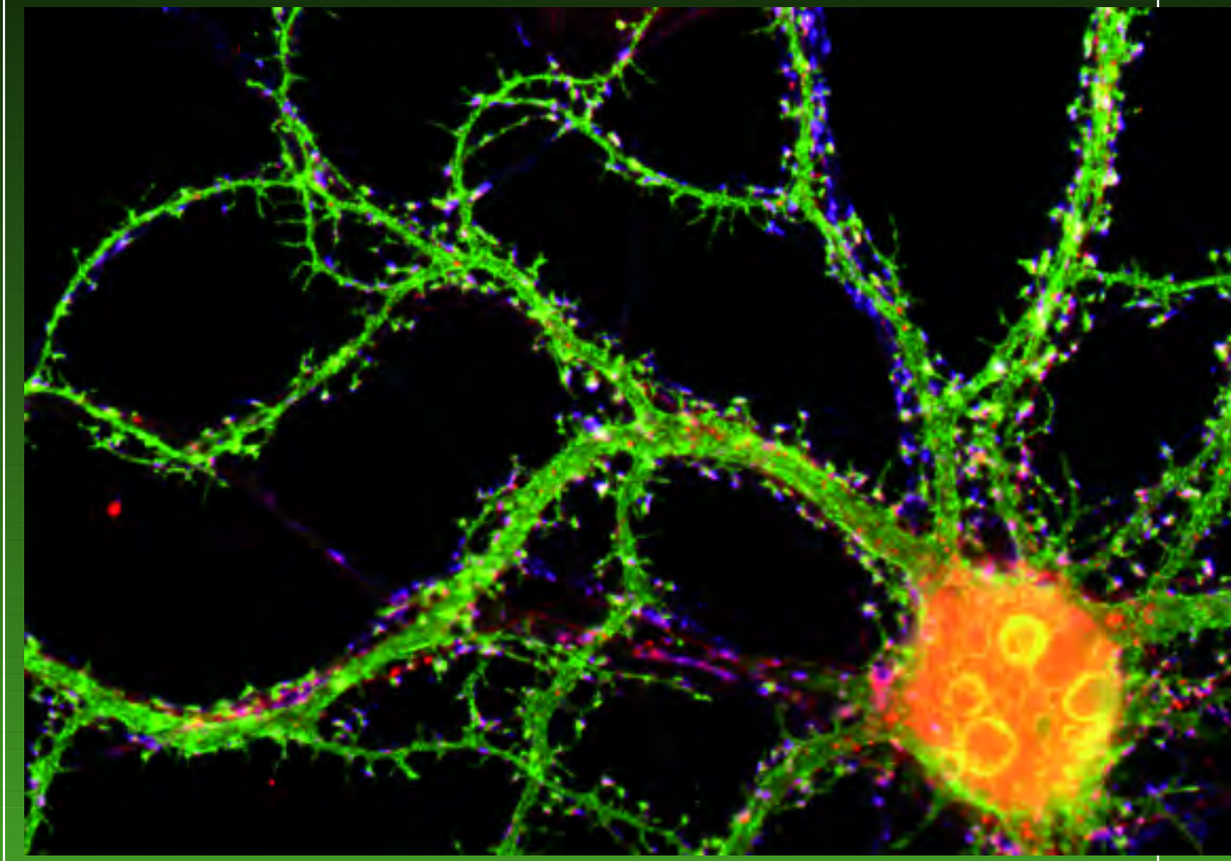
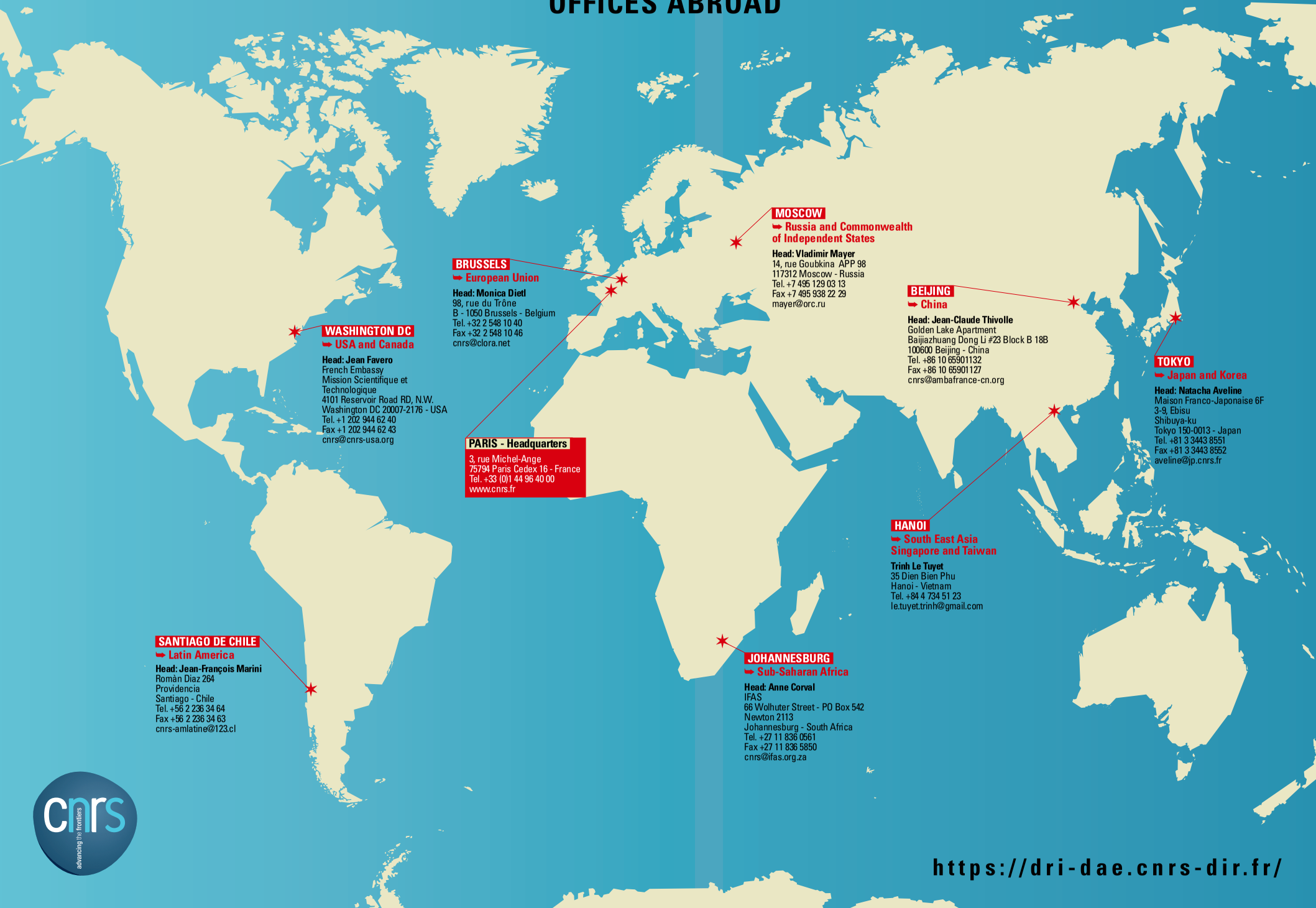


# FRENCH NATIONAL CENTER FOR SCIENTIFIC RESEARCH

## OFFICES ABROAD



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cnrs advancing the frontiers

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