In 2016, CNRS is recruiting permanent researchers in all scientific fields:

- life sciences, chemistry, environmental sciences and sustainable development,
- humanities and social sciences,
- computer sciences, engineering, mathematics, physics, nuclear and particle physics,
- Earth sciences and astronomy.

CNRS International Magazine was launched exactly 10 years ago to bolster the long-standing internationalization strategy of one of the world’s leading science agencies. The magazine’s objective was always three-fold: showcase the latest scientific results (representing 35,000 publications a year) from our more than 1000 laboratories; support the efforts of our international offices, which continue to secure strong partnerships with high-caliber scientific institutions in all four corners of the world; and more generally, disseminate knowledge to the public and promote French research abroad.

On all counts, CNRS International Magazine has been a resounding success. Attracting growing interest in foreign universities and research centers, it is today read in more than 140 countries. Yet as a quarterly print magazine, its format has become less adapted to a more mobile and fragmented readership, but more importantly, to the increasingly fast pace of scientific discoveries and innovation. It is perhaps therefore fitting that this magazine be reborn on its 10th anniversary. To continue its international expansion, increase its visibility to a larger audience, be more current, and more accessible to you, the reader, CNRS International Magazine becomes cnrsnews.fr, a fully interactive and updated online news site dedicated to the latest CNRS research.

Available on all platforms, cnrsnews.fr will deliver the same in-depth features, interviews, special reports, and scientific excellence you have come to expect, but also videos, full image galleries, live updates, and much more. This website, specifically tailored for an international audience, will become the English counterpart of lejournal.cnrs.fr, which was launched in 2014 for a domestic readership.

Above all, we would like to thank you for your support, your feedback, and mostly, your commitment to science and unfailing interest in research carried out here at the CNRS and across the world. We hope that you enjoy our last print issue and invite you to continue the conversation with us online: cnrsnews.fr

By Patrick Nédéléc,
Director of the CNRS European Research and International Cooperation Department (DERCI).
IN DEPTH 20

SPECIAL REPORT | World Climate Change Conference: Action Required ................................. 20
PORTFOLIO | A Glacier under Surveillance ................................................................. 32

IN THE SPOTLIGHT 5

2015 CNRS Gold Medalist Eric Karsenti ................................................................. 5

SCIENCE AT WORK 6

FOCUS | Plan B in Outer Space .................................................................................. 6
LAB WATCH | Invertebrates, the Bellwether of Extinction ................................................... 8
A Burning Issue ........................................................................................................ 9
Turning Natural Poisons into Drugs ........................................................................ 10
Rise of a Giant ........................................................................................................... 12
Exoplanet Hunter .................................................................................................... 12
Ragweed Pollen to Soar .......................................................................................... 13
Is there a Hacker on Board? .................................................................................... 14
Seeing The Trees for the Forest ................................................................................ 16
Viagra May Slow Malaria Transmission .................................................................. 16
Photovoltaics: the Perovskite Rush ......................................................................... 17

INNOVATION | The Rise and Fall of Innovation ................................................................. 18

WORLDWIDE 38

PARTNERSHIP | E2P2L: Sustainable Solutions for Tomorrow’s Chemicals ........................................ 38
NEWswire | International Agreements ............................................................................... 40
AlgoSolis: Microalgae in Focus ................................................................................. 41
CNRS China Office Celebrates 20-Year Anniversary ............................................... 42

CLOSE-UP 43

An Eagle’s Nest for Science ...................................................................................... 43
IN THE SPOTLIGHT

CNRS exceptional grade senior researcher Ludwik Leibler has received the European Inventor Award 2015 in the “Research” category. This distinction recognizes his work on vitrimers, novel organic materials with promising applications in industry.

Aged 63, the physical chemist is director of the MMC laboratory and associate professor at ESPCI ParisTech. He has been a member of the French Academy of sciences since November 2014. A multi-talented researcher, he has designed a new class of recyclable and repairable materials, which can be shaped at will and without breaking. Their resistance, insolubility, lightness, and low manufacturing cost make them particularly attractive for the aviation, automotive, building, and electronics industries.

In collaboration with Didier Letourneur, from the LVTS, Leibler has also developed an easy-to-use gluing method, which has been successfully tested on rats to repair soft-tissue organs and replace surgical stitches. Consisting of applying adhesive silica nanoparticles contained in an aqueous solution on biological tissue, the technique closes wounds in seconds, while providing aesthetic healing.

In 2013, Ludwik Leibler was awarded the CNRS Innovation Medal in recognition for his outstanding contributions to groundbreaking innovations. He has registered 47 patents and published 177 scientific articles.

Eric Karsenti
2015 CNRS Gold Medalist

The 2015 CNRS Gold Medal, France’s highest scientific distinction, has been awarded to the cell biologist Eric Karsenti for his exceptional career and extensive work on cell cycle regulation. “I share this award with all the excellent scientists from all fields who contributed to the projects I led: without their work and expertise nothing would have been possible,” he stated following the announcement. Born in 1948 in Paris, Karsenti began his career at the Institut Pasteur’s immunocytochemistry laboratory, where he defended his PhD thesis in 1979. He was recruited by the CNRS in 1976, and did his post-doctorate on temporary assignment to the University of California, San Francisco (US), between 1981 and 1984. On his return, he led a unit in the department of cell biology at the EMBL in Heidelberg (Germany), which rapidly became one of the most influential teams in the then booming field of cell cycle research. Their work helped determine how an enzyme – kinase cdc2 – triggers and regulates cytoskeleton dynamics during mitosis, the stage of cell division.

It was the first time that scientists were able to elucidate how complex functions emerge from the collective behavior of cell components. In 1996, Karsenti set up the EMBL’s department of cell biology and biophysics, pioneering interdisciplinary approaches in cell biology by combining measurements of forces and mathematical modeling with synthetic biology and cutting-edge imaging techniques. From 2001 to 2003, he headed the Institut Jacques Monod in Paris with the same objective in mind. In 2009, the biologist, whose love for sailing and the sea never faltered, embarked on a new project to study microscopic organisms in the oceans: Tara Oceans.

During a 140,000 km voyage spread over four years, this expedition gathered 35,000 samples of plankton from around 210 representative sites in a number of the world’s seas. Dried and refrigerated, these samples make up the largest database of its kind ever collected almost simultaneously.

Karsenti, now a senior researcher emeritus at the CNRS, is currently assigned to the Institute of Biology at the Ecole Normale Supérieure, while remaining director of Tara Oceans and a visiting researcher at the EMBL. Laureate of the CNRS Silver Medal, he has been a member of the French Academy of Sciences since 1999 and is a “Chevalier de la Légion d’honneur” (Knight of the French Legion of Honor).

Eric Karsenti onboard the schooner Tara in March 2012.

Image gallery available online: www.cnrs.fr/cnrsmagazine

Ludwik Leibler
European Inventor of the Year

The film Mitosis and Spindle can be viewed online: www.cnrs.fr/cnrsmagazine

Eric Karsenti on the schooner Tara in March 2012.
Plan B in Outer Space

Engineering. Operating some of the most complex machinery ever built can be a daunting task for the best of engineers. Especially when something breaks down hundreds of millions of kilometers away.

BY SAMAN MUSACCHIO

Yes, my hands were shaking a little,” recalls Jean-Yves Bonnet. Engineer at the LATMOS, he is in charge of the gas chromatograph (SAM-GC), an instrument on board NASA’s Curiosity Rover used to analyze atmospheric and solid samples on Mars. On May 10th, following a long data crunching session, he and his colleagues from the GSFC uploaded new instructions to reconfigure the device, located a “mere” 350 million kilometers away.

Curiosity call home
Three months earlier, one of SAM’s six chromatographic columns—each dedicated to a different family of chemical components—had broken down. “We found an anomaly in column 5, the most used with 27 analyses already completed. The helium that carries the samples inside the column wasn’t passing through normally. We actually had a rock sample in there and lost part of the data,” explains Bonnet.

All the researchers had to find the root cause were pressure and temperature measurements, as well as readings from two detectors inside the device.

This is why the process took three months: first, to identify the problem, then write the repair code that would re-establish the carrier gas flow in the chamber, and finally test it on the replica of the instrument located at the GSFC in Washington, before sending it to Curiosity. “Since you only get one shot at this, you have to make sure the code doesn’t generate more problems, or renders the instrument useless.”

At the same time and still on Curiosity, ChemCam, a set of sensing instruments capable of taking both high-resolution images of soil samples (RMI) and determining elemental composition using a laser beam (LIBS) also experienced a malfunction. The component used to focus the laser had stopped working. “The ChemCam team’s solution was somewhat more complex, as it involved rewriting the operating system of the instrument entirely in order to use the high-resolution camera to determine the targets of the laser module,” adds Bonnet. On May 11th, data came back from Curiosity indicating that all systems were fully operational, much to the relief of teams back on Earth.

Known unknowns
“Such ‘remote’ fixes become even more complex when you add extraordinary time constraints,” explains UPMC.
professor and comet specialist Anny-Chantal Levasseur-Regourd, also from the LATMOS. She speaks from experience, as a co-investigator of several instruments on the Rosetta mission and on its lander Philae, whose landing on comet 67P a year ago captured the world’s attention. Concerning the Rosetta mission, the only glitch had to do with a thruster and harpoon malfunction on Philae, preventing it from securely anchoring itself to the planned landing site. “Instead of one landing, we got three for the price of one. This was of course one of the scenarios that had been explored. The worst-case had the lander completely bouncing off the comet, lost in space,” she explains.

Many instruments were operational during those rebounds, gathering data from three different areas.7 “Once we figured out that Philae had ended up in a dark and cold place, we needed to act very fast to ensure that all this data would be uplinked to Rosetta before its batteries ran out—about 60 hours,” she continues. “With very little information available, the engineers managed to make a last-ditch effort to change Philae’s orientation—known as attitude—to get this data transferred. This was definitely not business as usual.”

Little maintenance ahead

The main reasons that make communication in space so complex are no secret: poor data rates (the equivalent of a 56k modem for NASA’s New Horizons), huge distances (time delays for reception), and complex alignment (Philae, Rosetta, and Earth, for example).

This is why engineers continue to make these space probes and spacecraft more autonomous and resourceful, often with built-in contingency plans. Some researchers, like the ISIR8 team in Paris, are exploring surprising avenues. “We’re working on a code that allows machines to autonomously discover alternative behaviors when they partially break down,” says Antoine Cully, lead researcher on the project. His team has created a system that allows a robot to test its physical capabilities and overcome various failures.9 In this case, the researchers used a 6-legged robotic insect, whose objective was to keep on moving forward. “It’s a two-step process. The first consists in running a simulation sifting through all the possible ways it can articulate its legs—1047 possibilities in all—using an evolutionary algorithm selector. Following this virtual test period, the algorithm was by itself able to find 13,000 efficient methods of walking,” explains Cully. Researchers then proceeded to “damage” the device by taking off one, then two limbs, replacing a “foot” by a piece of wood, etc. “We made 5 different permutations, and each time, after loading up this code, the robot took less than 2 minutes to find a way to keep moving,” Cully says. The most vivid example occurred within the simulation when all the “feet” were removed. “The machine flipped itself over, and continued ‘crawling’ on its knees,” enthuses Cully, who is now working on adapting this technique to multi-purpose robots. Although currently focused on industrial applications, the scientists are aware that such “adaptive” robots could prove extremely useful for rescue missions in hostile environments, or anywhere they need to operate without human intervention. “There is no reason why we shouldn’t think that future space exploration rovers or spacecraft could be given similar self-recovery code to continue operating for longer periods, or deal with time-critical situations,” he adds.

Levasseur-Regourd is more reserved. “Space missions are not like earth-bound laboratory testing that you can repeat over and over again,” she concludes. “They represent a unique opportunity, which we can only have if we try to do something that is truly exceptional—at the very limit of technical feasibility. Of course there will be glitches, but as we have seen, the overwhelming majority of these incredible projects are successes.”

**Biology.** Reassuring though they may seem, official extinction figures mostly reflect the status of a few “charismatic” species, concealing the extent of total biodiversity loss.

**Invertebrates, the Bellwether of Extinction**

As the planet is claimed to be experiencing its sixth period of mass extinction, up to 7% of the Earth’s plant and animal species could already be lost. This percentage, which translates to approximately 130,000 extinctions, far exceeds the 1.3% listed by the International Union for the Conservation of Nature (IUCN) in its annual “Red List” of threatened or extinct species.

While most of the data used by the IUCN derives from studies on vertebrates, especially mammals and birds, a pluridisciplinary team of researchers from the Paris-based ISYEB, and French conservation think tank CESCO, working in collaboration with colleagues from various laboratories, and the University of Hawaii (US), shifted the focus on invertebrates, which make up 70% of all known biodiversity.

**Dual approach**

Based on a random sample of 200 land snails, the scientists used a two-pronged approach to evaluate the conservation status of these less charismatic species, which are nonetheless prone to extinction. They first asked 35 experts from around the world to determine whether the mollusks were extinct, still extant or whether lack of data did not allow their situation to be assessed.

Because this method relies on interpretation—and therefore involves a degree of subjectivity—the researchers built a probabilistic mathematical model in parallel. To do so, they used all available information drawn from the scientific literature of the past two centuries, as well as data from museum and expert or amateur collections to estimate the chances of extinction for each species.

**Deceptive charisma**

The modeling and expert approaches proved consistent, showing that

---

1. Institut de systématique, évolution, biodiversité (CNRS / MNHN / UPMC / EPHE).
2. Centre d’écologie et de sciences de la conservation (CNRS / MNHN / UPMC).
3. Evolution Paris Seine (CNRS / UPMC); Atelier de bioinformatique (UPMC); Centre interdisciplinaire de recherche en biologie (CNRS / INSERM / Collège de France); Laboratoire de probabilités et modèles aléatoires (CNRS / UPMC / Université Paris-Diderot / Fondation sciences mathématiques de Paris / Fédération de recherche en mathématiques de Paris centre / RDMath Ile de France).
overall levels of extinction are grossly underestimated. This is due to the emphasis—and wealth of information—on terrestrial vertebrates, which also concentrate the bulk of conservation efforts. On the contrary, data acquisition lags behind for invertebrates, which are practically excluded from extinction rate projections. “Not only are invertebrates highly sensitive to the modification or disappearance of their habitat, but they are left out of protection schemes,” says Claire Régnier, lead author of the study.

Although the IUCN Red List does reflect the fact that species are disappearing faster than under normal evolutionary conditions, results are skewed by the success of conservation initiatives aimed at charismatic vertebrates. Hence the need for a complementary approach to get an accurate picture of the ongoing biodiversity crisis and its potential impact on human societies. “Consequences can be economic, with the extinction of species that provide ‘ecosystemic services’ for example,” Régnier emphasizes. “More generally, it means a loss of natural heritage, as a species that disappears is lost forever.”

Yet researchers hope that targeted protection measures will be taken to help slow down—if not stop—what could be the Earth’s worst extinction event of the past 66 million years.

Why is the Sun’s corona, its outer gaseous layer, 200 times hotter than its surface? Using hefty numerical models, scientists from the CPHT and AIM have cracked a puzzle that has perplexed astrophysicists for nearly a century. In defining the energy flows behind the phenomenon, the team advances our understanding of stars, especially the one that governs our Solar System.

While the Sun’s core is a fiery 15 million degrees Celsius, its surface drops to 6000°C. Logic would imply that temperatures fall further with distance from the center—and yet its corona can top 1 million degrees. To find out why, the team simulated the mechanisms at work in various solar layers, running their models on computers at the CPHT and the IDRIS.

Crucially, the presence of a thin layer of boiling plasma—an electrically conducting fluid—was inferred just underneath the Sun’s surface. Heated by the core below, this layer acts like a shallow pan whose sizzling contents bubble up. Being electrically charged, their movement creates a dynamo effect that “builds and also sustains energy reserves in the form of magnetic fields.”

To release these buildups, energy erupts via “tangled networks of magnetic fields, like mangrove roots,” that sprout from the Sun’s surface. It is when magnetic waves, generated by such eruptions, carry energy along vertical “trunk-like” magnetic fields above the “roots” that the corona overhead heats up. The team posits that this phenomenon occurs in many other stars.

The Sun’s magnetic field exiting towards the surface (salt and pepper spots).

© T. AMARI/CENTRE DE PHYSIQUE THÉORIQUE ET S. HABBAL / M. DRUCKMÜLLER

Turning Natural Poisons into Drugs

BY JEAN-PHILIPPE BRALY

Biology. Nature abounds with species capable of producing harmful toxins to humans. Scientists believe some of these could be turned into useful allies.

What do a bacterium that causes ulcers, a venomous snail, and a microorganism that contaminates and poisons canned food have in common? They all produce potent toxins that are often lethal to humans. Yet by manipulating these poisons, researchers are now able to redirect their toxicity toward therapeutic purposes.

A microbial toxin to replace aspirin?

For several years, scientists have been focusing their efforts on Buruli ulcer. Caused by the Mycobacterium ulcerans bacterium, this tropical disease results in the necrosis of skin tissue. Strangely enough, affected patients exhibit no symptoms of pain or fever. This lack of fever was first found to be due to the anti-inflammatory activity of mycolactone, a toxin secreted by the bacterium. This toxin acts by inhibiting the functioning of certain white blood cells, causing an immunosuppressive effect. In June 2014, researchers discovered that mycolactone also exerts an analgesic effect by binding to certain neural receptors.¹ Hence the idea of exploiting these properties for therapeutic use.

In this context, chemists and biologists screened the different active sites in mycolactone to identify those responsible for its analgesic and anti-inflammatory effects. The chemistry team, led by Nicolas Blanchard, senior researcher at the LCM,² then synthesized a truncated mycolactone containing the “useful” active sites. When tested on human cells by Caroline Demangel, senior researcher at the Institut Pasteur, and her team, this compound displayed the same beneficial effects as natural mycolactone, but with reduced toxicity. The protective efficacy of truncated mycolactone was then tested on mice suffering from chronic skin inflammation and inflammatory pain. As a result, these symptoms regressed markedly in the rodents, and with no adverse effects.³

¹ E. Marion et al., “Mycobacterial Toxin Induces Analgesia in Buruli Ulcer by Targeting the Angiotensin Pathways,” Cell, 2014;157 (7):1565-76.
² Laboratoire de chimie moléculaire (CNRS / Université de Strasbourg).
⁴ Institut des biomolécules Max Mousseron (CNRS / Université de Montpellier / ENSCM Chimie Montpellier).
⁵ Institut des neurosciences cellulaires et intégratives (CNRS / Université de Strasbourg / NeuroPôle Strasbourg-Neurex).
Unlike opioids, these conotoxins do not cause addiction,” explains the biochemist. “Another important advantage is that these are small protein molecules, which are easy to synthesize in the laboratory. They can also be administered orally, provided their structure is slightly modified to avoid being degraded by digestive enzymes.”

The list of potential applications is continually increasing. Specifically, the scientists have obtained promising initial results in animals, after discovering conotoxins that could block other molecular receptors involved in epilepsy or myocardial infarction.

**Botox treats more than wrinkles**

Last but not least, botulin neurotoxin is no doubt the most famous of toxins for medical use. Better known under its commercial name of Botox, it is produced by Clostridium botulinum, a bacterium that can contaminate canned food. Causing fatal paralysis, it is one of the most dangerous toxins. It acts by preventing the release of acetylcholine, the neurotransmitter that triggers contractions at the neuromuscular junctions. Today, botulin toxin is prescribed to correct abnormal muscle contractions.

It has therefore been used since the late 1970s to correct strabismus (by injecting very small doses into certain eye muscles). Its indications have considerably broadened since then, and not just to smoothing out wrinkles by paralyzing subcutaneous muscles. Indeed, it also corrects blepharospasm (involuntary closure of the eyelids), some types of torticollis, writer’s cramp... or even the contraction of certain muscles in the limbs (spasticity) following a stroke.

Botulin toxin has also proved effective for unexpected indications. For example, it is used to treat excessive perspiration or to reduce the production of saliva (thanks to its inhibitory action on the nerve endings in the glands that produce bodily fluids), to control bruxism (excessive contraction of the jaws, which notably causes nighttime teeth grinding), or even some types of incontinence due to an overactive bladder.

“The possibility of using it as an analgesic has also been envisaged, since it has been observed that the so-called dystonic pain associated with torticollis may be relieved independently of the contraction of the muscle,” explains Bernard Poulain, CNRS senior researcher at the INCI. “Since then, studies have shown that botulin neurotoxin also blocks the release of the neurotransmitters involved in carrying the nociceptive information at the origin of the pain. Yet its analgesic effect through its action in the central nervous system remains to be demonstrated.” Pain, contractions, inflammation, neurodegenerative diseases, cancer, blood disorders—the number of conditions poisoned by toxins continues to rise. II
Construction recently began on the Large Synoptic Survey Telescope (LSST) at Cerro Pachón in the Chilean Andes. A partnership between Chile, US institutions, including the National Science Foundation, and the CNRS,¹ the telescope should achieve first light in 2019, and become fully operational in 2022. By then, "the 20 billion galaxies and 17 billion stars visible from the LSST site will be photographed more than 80 times a year," says Pierre Antilogus,² lead scientist for the LSST-France collaboration. "These will be used to construct a 3D, six-color film of the sky in the southern hemisphere," which will be added to a new database throughout the 10-year lifespan of the project.

At the heart of the new telescope will be a 3.2-billion-pixel camera, the world’s most powerful, on which CNRS researchers have worked since its conception, as well as an innovative three-mirror system that provides greater observational flexibility. "The LSST is extremely compact for an 8.4-meter-diameter telescope," says Antilogus. "This allows it to move quickly across each section of the sky we are observing," and take images of moving and changing objects, such as exploding supernovae and asteroids. "By precisely reconstructing changes in the Universe over time, we will also be able to work out the influence and physical properties of dark energy and dark matter, its fundamental components," adds the researcher.

Around 800 panoramic images—some 30 terabytes of data—will be produced every night by the LSST, amounting to approximately 500 petabytes by the end of the project. The massive task of processing that raw data will be split between the US National Center for Supercomputing Applications (NCSA) and CC-IN2P3, the CNRS computing center near Lyon (France). "A system is already in place that will allow us to test what will become the most complete—ever database of the Universe," Antilogus concludes. II

¹ Nine CNRS laboratories are involved in the LSST project: APC, CC-IN2P3, CPPM, LAL, LMA, LPC Clermont, LPNHE, LPSC, LUPM.
² Laboratoire physique nucléaire et hautes énergies (CNRS).

Exoplanet Hunter

In operation since June 2014, the Spectro-Polarimetric High-contrast Exoplanet REsearch instrument (SPHERE), attached to one of the four mirrors of the Very Large Telescope (VLT) in Chile, was designed for the direct observation of extrasolar planets. Light reflected by exoplanets is much fainter than that of their neighboring stars, making direct detection very difficult. SPHERE combines a number of technologies to obtain extremely high-contrast images in the area around the star to identify these weak glows.
Ragweed Pollen to Soar

Airborne concentrations of ragweed pollen in Europe are expected to reach unprecedented heights, calling for EU-wide strategies.

**Palynology.** Airborne concentrations of ragweed pollen in Europe are expected to reach unprecedented heights, calling for EU-wide strategies.

BY VALERIE HERCZEG

Ragweed pollen counts could quadruple in Europe by 2050 and become a serious health issue. Native to North America, common ragweed (Ambrosia artemisiifolia), is an invasive species in the Old Continent. Also present in Australia, East Asia, and South America, it could spread in infested regions and invade non-infested areas, as a result of climate and land use change, and seed dispersal.

Researchers from French institutions, including CNRS laboratories, working in collaboration with several European bodies, have succeeded in quantifying the likely increase in airborne ragweed pollen concentrations over the 2041-2060 period. Two numerical models made this possible: the first one simulated climate change based on rising CO₂ levels resulting from human activity in the coming years, while the other incorporated ragweed pollen production, release, and dispersion to assess future concentrations.

These models allowed long-term projections to be made for the first time and determined that ragweed pollen is likely to increase by a factor of 4-4.5 in the next 25 to 35 years. Seed dispersal—whether naturally occurring or anthropogenic—will be responsible for a third of this rise. The remaining two thirds will be due to climate and land use change which, by increasing CO₂ and its fertilizing effect on plants, will boost pollen production. “This is of concern as ragweed pollen is a strong allergen, even at very low concentrations,” says Lynda Hamaoui-Laguel from the INERIS, who led the study. “And average concentrations may largely exceed tolerance thresholds in the future,” she warns.

Hence the need to launch public awareness and uprooting campaigns to map ragweed distribution and density, and, mostly, Europe-wide programs, as this invasive species threatens most of the continent, Hamaoui-Laguel advocates.

1. Laboratoire des sciences du climat et de l'environnement (CNRS / CEA / UVSQ); Laboratoire de météorologie dynamique (CNRS / Ecole Polytechnique / UPMC / ENS); Centre d’écologie fonctionnelle et évolutive (CNRS / Université Montpellier / Université Paul Valéry Montpellier / EPHE / SupAgro Montpellier / INRA / IRD); Institut national de l’environnement industriel et des risques (INERIS); Réseau national de surveillance aérobiologique (RNSA).

© P. HUGUET-DUBIEF/BIOSPHOTO

© L. HAMAOUI-LAGUEL
Is there a Hacker on Board?

**Information technology.** The increasing prevalence of electronics and software in transportation—from cars to airplanes—makes research on better cybersecurity systems an urgent necessity.

Hard times for computer security. Last April, US cybersecurity specialist Chris Roberts told the FBI that he had hacked into the computer systems of airplanes he had boarded on about 20 occasions—and even managed to change the thrust of a jet engine. In recent months, a number of studies published by the US government also highlighted the vulnerability of planes and cars to attack by hackers. In all cases, incidents come down to one flaw: by providing passengers with a WiFi, Bluetooth, or Internet connection, the multimedia systems in vehicles can become a Trojan horse for malicious infractions.

Should this be a cause for concern? For Abdelmalek Benzekri, a specialist in communications security, the possibility that a hacker can connect to the in-flight entertainment (IFE) system from an Ethernet port using a cable or a USB key is doubtful to say the least. The researcher, who heads the Network Administration and Services Integration team at the IRIT,¹ believes that the success of such an attack is unlikely. “Security solutions for each port have been available for 20 years: when a laptop, for example, is connected to the plane’s computer network, port-based access controls verify its IP address, and determine whether it is authorized or not.”

Yet Benzekri agrees that “anything can be hacked, for example by forging a false address using what is called ARP spoofing,” which tricks the access control software into believing that the intruding computer is legitimate. Once this obstacle is overcome, hackers still have to prove their identity by means of a fake security certificate, and must bypass different security measures that prevent sending data or connecting to critical systems. So if Roberts’ hacking went as he claims, “this would mean that the system he attacked lacks the most basic security mechanisms,” says a bewildered Benzekri.

**Detecting malicious intrusions**

Yet the threat of hacked airplane computer networks is very real. So much so that for a number of years already, aircraft manufacturers like Airbus and their suppliers—including Rockwell Collins, which sells an IFE system—have been collaborating with CNRS laboratories in Toulouse on intrusion detection systems. As Philippe Owezarski, a researcher from the LAAS,² observes, protection is all the more necessary as equipment providers, such as Thales Avionics, have been asked by airplane manufacturers to explore solutions for extending the use of the air control link (between the aircraft and control towers) to passengers in the cabin who want to access the Internet. This would be done using the same antenna and network to save costs and not burden the aircraft. Yet there is a problem: by carrying vital systems information on a channel that is also available to passengers, ground-based hackers could eventually log into it and send data to disrupt navigation or even take control of the aircraft.

A solution would be to teach the computer system to differentiate between normal data traffic and an anomaly indicative of piracy. This is the subject of a recent thesis by research engineer Silvia Gil-Casals of the INSA Toulouse,³ supervised by Owezarski with the support of Thales.

---

¹ Institut de recherche en informatique de Toulouse (CNRS / INPT / Universités Toulouse-III Paul Sabatier / Toulouse-I Capitole / Toulouse-II Jean-Jaurès)
² Laboratoire d’analyse et d’architecture des systèmes (CNRS / Université Toulouse-III Paul Sabatier / INSA Toulouse / INP Toulouse)
³ Institut national des sciences appliquées de Toulouse

© TNS/ZUMA/REA
© K. YOLSHIN/FOTOLIA.COM

benzekri@irit.fr
owe@laas.fr
istudnia@laas.fr

If not fully secure, in-flight entertainment systems can become an entry point for potential hackers.
Avionics. Unlike other network traffic diagnostic tools, this semi-supervised analysis method mostly focuses on the density of different kinds of data received by computer equipment. “Without knowing the nature of the attack that will hit the network, this strategy makes it possible to automatically detect suspicious elements in the state of its traffic,” explains Owezarski. For instance, this would happen when the on-board computer that manages some of the plane’s critical hardware receives more information than usual—or none at all. Moreover, the software analyzes the headers of each data packet, or parts of the code that indicate the nature of the information, the protocol used (TCP/IP, Ethernet), the values conveyed, as well as the origin and destination of the data.

As Thales Avionics only gave access to a small fraction of the data being exchanged between the cockpit and the control tower, the intrusion detection system was unable to demonstrate its effectiveness. Yet Owezarski is convinced that this tool “gave better results than those that can be found in today’s on-board systems. To know whether a batch of data should be accepted or not by the network, some of the technologies available on the market are even less effective than a simple random process.”

The autonomous car, an easy target?
Analyzing traffic in a computer network is also at the heart of the research conducted by Ivan Studnia, who works in a team dedicated to information security at the LAAS. Except that the young PhD student is not working to secure airplanes, but cars. The growing computerization of automobiles, which are increasingly equipped with multimedia systems connected to the Internet, combined with the emergence of autonomous vehicles such as the Google car, make the risk of a hacker taking control increasingly likely.

Zeplin researchers had succeeded in hacking the computer system of a car. They had forced it to accelerate even though its anti-collision radar had detected the presence of a wall—and brake violently regardless of the security of its potential passengers. A month later, the automobile manufacturer Chrysler recalled 1.4 million cars following the discovery of a software vulnerability in the dashboard computers of one of its models.

Like the diagnostic tool developed for planes, Studnia’s work aims to teach the car’s computer system to detect intrusions. “The issue is to determine, among all the messages circulating, those that are legitimate and those that are not.” A software probe connected to the computer network that manages the car’s different functions—brakes, steering, dashboard display, communication systems—will give it a kind of “immune system that detects symptoms of illness,” in this instance the differences between the normal state of traffic and an anomaly. Yet at this stage, there is no mention of combatting the intrusion itself: “It’s already something to detect the problem and alert the driver,” admits Studnia. “It is only a first step, we can then think of countermeasures, such as blocking data or forcing the car to stop.”

But whether it is to protect a connected car or an aircraft, Benzekri, Owezarski, and Studnia will tell you the same thing: manufacturers should stop using “commercial solutions developed for the Internet,” i.e., the widely-available universal devices known as COTS (short for “components off the shelf”), which are then adapted to one’s specific needs—and thus all the more hackable. There is no doubt in the researchers’ minds: rather than favor the low cost of such software, it is essential to revert to “techniques and instruments specifically developed for aviation” or the automobile sector. This is the only way, as Owezarski says, “to be a step ahead of the hackers, for once.”
Biogeochmistry

Seeing The Trees for the Forest

BY ARBY GHARIBIAN

A

lthough the Amazon forest plays a crucial role in the global carbon cycle through its enormous capacity to capture and store atmospheric CO₂, scientists are still trying to gain a better understanding of the phenomenon’s inner workings. A new study, conducted by the RAINFOR forest monitoring network with the participation of CNRS researchers, has provided a much clearer picture of the mechanisms at play by demonstrating that a mere 1% of the Amazon’s 16,000 tree species traps half of the carbon stored in the forest.

“Current modeling methods for forest ecosystems only distinguish a handful of vegetation types, such as deciduous and evergreen species,” explains Jérôme Chave, who was involved in the study. “They do not account for the trees’ highly variable carbon-trapping capacity, or physiology.”

By analyzing data from more than 500 forest plots, including 200,000 trees and 3600 species, scientists were able to determine that the forest’s carbon sink effect is concentrated in approximately 200 species, called “hyperdominant” due to their inordinate contribution to the carbon cycle.

“Focusing on this much smaller number of hyperdominant species will enable us to take more detailed samples and measurements, such as of tree physiology, photosynthesis, and tolerance to drought. This new-found precision will allow us to provide much more accurate models for forest behavior, a key tool for predicting whether tropical forests will remain net carbon sinks in the face of continuing climate change, or whether they could potentially represent a new and considerable source of carbon,” the researcher concludes.

Biology

Viagra May Slow Malaria Transmission

BY EMMA WALTON

From failed heart medication to panacea for erectile dysfunction, Viagra has become one of the world’s most successful drugs. Now a team of Paris-based CNRS researchers shows that this powerful pill may also help to control the spread of malaria.

The malaria parasite has a complex life cycle. Current treatments target the asexual, disease-causing form of the parasite, but not the sexual form (called gametocytes), which infects red blood cells (RBCs) and is transmitted to uninfected mosquitoes when they feed on infected individuals. “Stopping the transmission of drug-resistant parasites is a priority,” says study co-lead author Gordon Langsley. “People cured of malaria still carry gametocytes and contribute to the spread of the disease,” he adds.

The key to stopping transmission via gametocytes may lie in one of the body’s own quality control systems: the spleen. RBCs must be flexible to pass through capillaries without rupturing, so the spleen filters out old, stiff blood cells. When gametocytes first infect RBCs, these localize to the bone marrow and are stiff. But following their release into the bloodstream, they become flexible and pass easily through the spleen.

“For a long time we had been studying levels of a small molecule called cAMP in the parasite,” explains Langsley. “We realized that CAMP levels decrease when cells become flexible, so we decided to test whether the molecule controls this switch.”

“We used a bead filter, which acts like an artificial spleen,” says Lavazec. “Stiff cells get stuck in it, whereas flexible ones go through.” To increase cAMP levels, the team treated infected cells with Viagra, which blocks the enzyme that breaks down cAMP. Ironically, Viagra made the infected RBCs stiff, thus blocking their passage through the filter.

These findings provide “proof of concept” that drugs controlling cAMP levels may constitute a new class of antimalarials, although more research in humans is needed. Viagra is already known to be safe and is taken by millions of people across the world. Researchers are hoping to test a derivative without erectile effects in the near future.

2. Laboratoire de biologie cellulaire comparative des apicomplexes, Institut Cochin (Inserm / CNRS / Université Paris Descartes).
3. Laboratoire de biologie de la transmission de plasmodium, Institut Cochin (Inserm / CNRS / Université Paris Descartes).

© PHOTOS: RAMDANI ET AL.

© R. SALAMÃO

© F. LANGSLEY

05 jerome.chave@univ-tlse3.fr
gordon.langsley@inserm.fr

catherine.lavazec@inserm.fr
Photovoltaics: the Perovskite Rush

**Chemistry.** A new type of materials with a specific crystalline structure could find a wealth of applications, notably in photovoltaics.

*BY JONATHAN RANGAPANAIKEN*

They have made the headlines of all the major scientific journals, and dedicated conferences are so crowded that participants sit on the floor. Like graphene and carbon nanotubes before them, perovskites have triggered a surge of interest among researchers the world over. Yet when they first appeared in the field of photovoltaics in 2012, no one could have predicted that they would break all records for efficiency: 10% in 2012, 15% in 2013, and 20% in 2014—not far from the 25.6% currently achieved with silicon. And who knows how high this will go?

Perovskites are a family of materials with a specific crystalline structure. Those used in solar energy production are known as “hybrids,” comprising both organic and inorganic compounds. The result of research in organic photovoltaics, perovskite solar cells are an attractive alternative to silicon cells, which dominate the market but have well-known limitations (performance, inflexibility, etc.).

**Unsuspected qualities**
The discovery of perovskites’ photovoltaic qualities is due to the work of two experts in the field: Michael Graetzel of the École Polytechnique de Lausanne and Henry Snaith of the University of Oxford. “From their very first trials in 2012, the cells developed by Graetzel and Snaith delivered better performance levels than any other emerging technology,” reports Daniel Lincot, director of the IRDEP, a French solar energy think tank.

Perovskites displayed unsuspected qualities that enabled them to achieve impressive efficiency. Their good charge separation and mobility came as a “nice surprise,” especially since “the electronic properties of these materials were not fully understood when the first results came in—and still aren’t today,” explains Emmanuelle Deleporte, a physicist at the LAC, who has been studying these compounds for the past 10 years. Their good charge mobility is combined with high sunlight absorption, low production costs, and the possibility of applying them in the form of an ink, making it easy to coat large surfaces.

**Toward hybrid solutions**
Are perovskites destined to be the technology of choice for the future of photovoltaics? “I don’t think that any one technology will become the be-all and end-all,” Lincot cautions. “Perovskites have gained considerable momentum in the photovoltaics community and are still very promising, but they also have serious drawbacks, like their poor stability and low resistance to water. In addition, those record yields were achieved using demonstration cells with surfaces of only a few square millimeters. We have years of research ahead of us, even though solar panel manufacturers have already shown a keen interest.”

Although this “miracle material” has not revealed all its secrets, it could soon be on the market. Snaith, with his startup Oxford Photovoltaics, hopes to commercialize perovskite solar cells as early as 2017. The rush is likely to continue.

---

1. Institut de recherche et développement sur l’énergie photovoltaïque (CNRS / Chimie Paristech / EDF).
2. Laboratoire Aimé-Cotton (CNRS / Université Paris Sud / ENS Cachan).

© G. COOK/VISUAL UNLIMITED/CORBIS
The Rise and Fall of Innovation

What does the videophone have in common with disposable underwear and pickle-flavored toothpaste? They are all flops. Or rather novelties that never caught on. “In the industrial world, seven to nine innovations out of every ten are expected to fail,” notes Bernard Darras, a semiotician at the Institut ACTE. Some 20 researchers from the ACTE Institute are collaborating to create a documentary database of these “by-products of modernity” from the late nineteenth century to the present day. The CNRS-sponsored project, entitled “Archaeology of Abandoned, Neglected or Resurgent Innovations,” involves a description of each object, along with its history, photos, videos, and analyses by researchers and engineers. It aims to examine the notion of modernity—and give innovators in every field an unbiased perspective on failure.

The Bi-Bop: a textbook case
Yet failure is not easy to define. “Sales or usage figures can be an indicator, but the history of innovations should also be taken into account: can they be called failures when they are initially abandoned but re-emerge later, in the same or a different form?” ponders Norbert Hillaire, theoretician of technologies and researcher at the ACTE Institute. Darras would rather see them as “tries that need to be converted,” to use a rugby metaphor.

Indeed—and as entrepreneurs like to say—being right too early is the same as being wrong. And examples abound, like Apple’s Newton, a personal digital assistant launched in 1993, met with irony and discontinued in 1998, before being reintroduced in 2007 in a much-improved version under the iconic name of “iPhone.” In a similar vein, France has had its own emblematic communications flop with the Bi-Bop, the country’s first cell phone. Launched in 1991, it operated on a specific network of radio antennas that were set up in city centers. Users could receive and make calls, as long as they were close to one of these antennas, much like Wi-Fi works today. But a limited network of terminals (whose faded blue, green and white-striped stickers can still be spotted in Paris) and the advent of GSM cell phones in 1997 led to its demise.

“In our classification, we distinguish between ‘premature’ or ‘resurgent’ innovations and those that proved inadequate and doomed to failure,” say the researchers. The high-speed moving walkway in the...
Montparnasse-Bienvenüe Metro station in Paris falls into the latter category. Accelerating to the breakneck speed of 11 kilometers per hour, it was supposed to shave 90 precious seconds off the user's average travel time, but was finally abandoned in 2009, after seven years of repeated breakdowns and falls.

The need for failure

“Most interesting, in my opinion, are innovations that are disregarded for some time, and eventually make a comeback,” Darras adds. The monocle, for example, fell out of favor in France after the Franco-Prussian War for being too reminiscent of the enemy. “Yet it seems to have reappeared in high-tech form in the 2010s as Google Glass, whose headsets have a single optical zone with a camera,” the semiotician points out. Revival was short-lived though, as production was suspended in January 2015 due to deterring prices and hostile public reaction. Still, the Wall Street Journal hints that the device may soon rise from its ashes.

“It is often a matter of time: how long does it take for a failure to become a success, and can it fail again?” Darras asks. Hence the choice of “archaeology” of innovations as a name for the project, championed with the CNRS by Richard Conte, director of the Institut ACTE.

In fact, the fear of failure seems to be more daunting in France than in other countries. For many French people, it is “the equivalent of social suicide, whereas in the US… failure is a learning experience,” asserts Jefte Dedijer, former marketing director of Ikea France. “The problem in France is that the educational system condemns failure, leaving engineers reluctant to take any risks,” Darras explains. “Our documentary database seeks to break the mold and show that success often results from a string of trials and dead ends. We hope to change people’s attitudes.”

Darras and his colleagues are not alone. “Conferences dedicated to the sharing of entrepreneurial failures” have been held in France in the past few years in order to “learn from the mistakes of others,” points out the entrepreneur Boris Golden. Often cited as reference is the versatile manufacturer Bic, which brought ballpoint pens, disposable razors, and lighters into every household, but suffered a severe setback with low-priced perfume. Another indicator of change is that, since 2013, France’s central bank has only indexed fraudulent bankruptcies, whereas its “blacklist” used to include all entrepreneurs who had filed for bankruptcy in the previous three years, no matter the reason.

A philosophical challenge

Do the ACTE researchers also seek to reduce the seemingly inevitable 70-90% failure rate for innovations by “predicting” the non-starters? Are they hoping to rationalize the development process in order to prevent failure? “On the contrary,” Darras explains, “I believe in serendipity, which in 1928 allowed Sir Alexander Fleming to discover penicillin in a ruined lab sample. For similar reasons, Chinese researchers systematically reproduce experiments performed elsewhere in the world in the hope of discovering something scientists may have missed the first time around!” The researcher firmly rejects the idea of intellectualizing everything in an attempt to increase chances of success—experience and failure are part of the scientific process. “It’s a political and philosophical challenge,” Hillaire concludes. “We need to break away from the positivist view of the history of modernity, which tends to disregard failures instead of analyzing them.”

Yet the ACTE project does not involve building a museum devoted to innovation fiascos, such as the one opened in Tokyo by Kenichi Masuda to display his own personal collection. Exhibits include a strange plastic sheet which, placed in front of a black and white television screen, gives the impression of seeing the images in color. Not to mention a running toaster, literally speaking. II

---

**SERENDIPITY**

The act of making a relevant discovery while looking for something else.


© X. D. STOR/LAIF/BEPA

---

© B. DOPPAGNE/BELGA/AFP

© WITT/SIPA

---

Bernard.darras@gmail.com
In the run-up to the UN COP21 Climate Conference in Paris, governments, citizens and scientists join forces to propose solutions for the future of our planet.
Joseph Fourier infers that the Earth should be considerably colder if only warmed by the Sun: certain particles in our atmosphere must be conveying energy back to Earth.

The estimated level of carbon dioxide (CO₂) in the atmosphere is 290 parts per million (ppm), according to ice measurements made in the 20th century.

Understanding Climate Change

Many events, whether scientific, climatic, or cultural, have shaped and brought about international mobilization around climate change over time.

Mean global temperature 13.6°C

1824

Joseph Fourier infers that the Earth should be considerably colder if only warmed by the Sun: certain particles in our atmosphere must be conveying energy back to Earth.

1850

The estimated level of carbon dioxide (CO₂) in the atmosphere is 290 parts per million (ppm), according to ice measurements made in the 20th century.

290 ppm
400 parts per million. This is the highest concentration in the past 800,000 years, as shown by CNRS researchers in 2008 when they analyzed gases trapped in the Antarctic ice, as part of the EPICA ice coring project.

The effects of global warming are already being felt. As a result of melting glaciers and ice sheets, coupled with thermal expansion of the oceans, sea levels are now rising by 3.3 mm each year, as compared with 1-2 mm over the past few millennia. In addition, 30% of arctic sea ice has melted since 1980. Heat waves are becoming more frequent: extreme temperatures that only affected 1% of the Earth's land surface now impact nearly 10%. And the oceans are acidifying faster than at any time in the past 300 million years due to excess CO₂ dissolving in surface waters, with little known but worrying effects on marine organisms (see p.25).

If emissions continue at their current rate, temperatures are likely to rise by 2.6-4.8°C (with a mean value of 3.7°C) compared with the period 1986-2005, and by 0.3-3.1°C with alternative scenarios. These figures are based on predictions by 27 global numerical models of the Earth system, two of which involve the CNRS, at the Institut Pierre-Simon Laplace (IPSL) and at the CNRM-CERFACS. In addition, according to the last IPCC synthesis report, the worst-case scenario predicts sea levels to rise by nearly one meter by the end of the century.

**National efforts for joint solutions**

To bring humankind back on track and curb the effects of climate change, the 195 UNFCCC Parties have developed a novel approach: before the Conference, each country must submit an Intended Nationally Determined Contribution (INDC) in which it publicly states the action it intends to take to contribute to the global effort. A synthesis report on INDCs will have been presented by November 1. By September 8, 2015, 58 countries responsible for 60% of greenhouse emissions in 2012 had submitted their contributions. For example, the EU member states have set a target of a 40% emissions reduction by 2030, from 1990 levels. This sets them on track to achieve an 80–95% cut by 2050. “On that basis, the best we can hope for is a treaty laying down fundamental principles and a global target, ...
Various emission scenarios have been used by the IPCC to estimate temperature rise in relation to CO₂ concentrations in the atmosphere over the century.

... as well as a document taking up the contributions from the Parties,” says Sandrine Maljean-Dubois, of the CERIC. “Ideally, this would be a flexible, incentive agreement allowing contributions to be revised upwards over time.”

Fundamentally, what is the 2°C figure based on? “It is a necessary political symbol,” admits Hervé Le Treut, director of the IPSL. But there is more to it: “It is also the limit beyond which the Earth will actually become a different planet, whose dangers are difficult to assess at this stage.” The more temperatures rise, the more the physical processes involved in the climate system might exceed thresholds beyond which the whole mechanism could spin out of control—inhibiting deep ocean ventilation, destabilizing the Arctic polar ice cap, preventing the oceans from absorbing more carbon as they become warmer, for example, with equally uncontrollable and irreversible consequences on the environment. “These thresholds will not necessarily be exceeded if average temperatures rise by more than 2°C,” Delecluse points out. “But beyond this limit, the climate will be set on an irreversible path.” Jean-Louis Dufresne of the LMD adds: “The higher the warming, the more uncertain the climate and the lesser our ability to predict, and therefore anticipate, such upheavals.” In other words, the climate will spiral out of control.

Staying below target
In any event, keeping the increase below 2°C is an ambitious goal in light of the situation. To give just one figure, human-induced carbon dioxide emissions must not exceed a total of 3 trillion tons to meet the target. Yet 2 trillion tons have already been released since the industrial revolution. “We don’t have much leeway,” Joussaume emphasizes. “By 2050, we will have to reduce our global emissions by 40-70% compared with 2010 to stay below 2°C—and achieve carbon neutrality by the end of the century.” For Philippe Ciais of the LSCE, “taking into account the uncertainties in models of climate sensitivity to greenhouse gases, and the ability of the land and oceans to reabsorb some of the emitted carbon, this target—which means reducing our emissions by 3-6% annually throughout the century—gives a probability of more than 70% of staying below a 2°C rise.” This is possible, even though the amount of carbon released by human activity now reaches 40 billion tons each year, compared with 1-2 billion in 1950, as Le Treut points out.

Theoretically, this target, which constitutes the mitigation component of the future Paris agreement, can be met. As shown in the latest IPCC report, climate stabilization is achieved in 60% of the economic scenarios studied. However, this is only possible if drastic action is taken immediately, with the 2°C threshold being temporarily exceeded at times. It also implies a macroeconomic cost of 4% of GDP over the century, equivalent to a year of delayed growth. Yet as Franck Lecocq, director of the CIRED,9 points out, “these projections are based on strong assumptions, including large-scale CO₂ capture by mid-century, and massive reforestation.” However, carbon capture is still in its infancy, despite the research carried ...

Give the Oceans a Voice

By Françoise Gaill, Coordinator of the scientific board of the Ocean & Climate Platform

The oceans cover 70% of the Earth’s surface, absorb 25% of the CO₂ released each year into the atmosphere as a result of human activity, and as much as 90% of the surplus heat caused by the greenhouse effect. And yet the oceans do not even feature on the agenda of the 21st Conference of the Parties (COP21). Some 200 delegations will be taking part, together with thousands of decision-makers and politicians who will hopefully take suitable initiatives to ensure a viable future for our planet’s land surface. But are they aware that the oceans contain 50 times more carbon than the atmosphere, and that their ability to store heat far exceeds that of the atmosphere, and that their impact and variability of these processes are not yet known, and scenarios need to be drawn up about their effects on coastal regions, such as erosion, flooding, subsidence, or even the sinking of islands.

The oceans, which are the largest ecosystem on Earth, are impacted by global warming in other ways. A third of all identified marine species live in coral reefs. Yet above a certain threshold, one extra degree is enough to cause coral bleaching and the potential loss of these reefs. Current estimates indicate that half of them could disappear by 2050, which would directly affect the subsistence of half a billion people throughout the world. Another significant risk lies in the fact that increasing CO₂ emissions lead to ocean acidification, threatening marine ecosystems. Finally, dead zones—areas with little oxygen that asphyxiate any living organism unfortunate enough to enter them—are also on the rise as a result of human activity. Yet the real impact of climate change remains largely unknown. The good news is that the results of the Oceanomics project’s first large-scale expedition of the 21st century should help shed new light on the issue. For the first time, a comprehensive number of the microscopic inhabitants of the surface layers of the world’s oceans has been identified by scientists working on the schooner Tara, using cutting-edge techniques. This will make it possible to monitor the state of health of the plankton ecosystem and find out more about changes in the biological carbon pump or, more generally, about the response of marine organisms to climate variations.

A priority for society
The Oceans Round Table (“Grenelle de la Mer”) held from 2009 to 2012 in France identified a number of priorities for society. This was followed by attempts to make the oceans central to environmental strategies, with the creation of bodies such as the French National Coastal and Ocean Council. The scientists got down to work, maritime stakeholders made proposals, the high seas were discussed—only to come up against a nagging question: which sea is this all about? The sea is everywhere and nowhere; above all, it is never mentioned, as if the oceans were too large, too abstract and too distant to be acknowledged by our societies, which prefer to stay on the edge. And yet everyone flocks to the coast in summer, and two thirds of the world’s population will live in coastal regions within a decade. Not to mention the fact that 90% of world trade goes by sea.

Healthy oceans will help save the climate, which indeed depends on them. Will politicians eventually realize this? In their time, some of them were scientists, sailing the oceans and charting the Gulf Stream simply by measuring the temperature of the water, like Benjamin Franklin. So perhaps we should take them on board, just as the UN Secretary General set sail on Tara, to convince them that the ocean is our future and that this future, is blue. II

Sign the petition “Together, let’s give the Ocean a voice!”
www.change.org/oceanforclimate
Learning from History

Emmanuel Garnier, a climate historian who specializes in extreme events and their effects on ancient societies, describes how society could draw on past experiences to adapt to the increasing risks posed by climate change.

Your field uses archival data (crop yields, observations, etc.) to study past climates. How does this data tie in with that of the ‘hard sciences’?

Most of the data is made up of written public records. Other sources are more unusual, such as captains’ logbooks and the private diaries of peasants and dignitaries. Historians can also study the climate in images, in the form of ex-votos, small religious pictures relating climate disasters. The reconstruction of old meteorological records enhances climatologists’ models. At the Paris Observatory for instance, the first instrumental observations began in the 1650s. History is also invaluable when it comes to studying extreme weather events. Moreover, historical information provides climatologists with a much finer chronological resolution than pollen or tree ring studies.

In your opinion, what extreme weather events helped raise public awareness of climate change?

Paradoxically, the link between the two is very recent. Although the first climate research programs were launched in the late 1960s (GARP, WCRP), it wasn’t until the disasters of the 2000s that politicians and the general public began to connect the two phenomena. For example, in Europe, very few media related the Lothar and Martin windstorms in December 1999 to climate change.

And although things began to evolve with hurricane Katrina in August 2005, the real turnaround occurred in October 2012, when hurricane Sandy hit New York, especially Manhattan. The unanimous decision to raise nearly a billion dollars to protect the city from flooding is clear evidence of a wake-up call for all those concerned.

You feel that our view of climate change-related issues is too global, and that a more local analysis is required.

Indeed, the climatologists I work with admit that they have trouble working at the local scale. Since I take part in European projects, I know that people are more prepared to listen to us when we can place our research in the context of their region. Such mediation through history has enabled us to rediscover, for example, seeds of plants known by the elders as anhydro (‘without irrigation’), on the island of Syros (Cyclades, Greece). These tomatoes, melons, and other plants can grow on arid plateaus and need no irrigation. Some regions of Europe could reintroduce these seeds to counteract aridity as it moves further north as a result of global warming. Examples like this show that history should be considered from a dual perspective, that of improving climate models, and that of enhancing adaptation strategies by making use of the feedback it provides.

An interdisciplinary challenge

To be met, these many challenges require the mobilization of every scientific discipline. “This is essential if we are to make the transition from a science that identifies problems to one that offers solutions,” says Sébastien Treyer of the IDDRI. The success of the conference “Our Common Future under Climate Change” illustrates this commitment. The CNRS played an active role in this international forum, which was held at UNESCO on July 7-10, 2015, at the initiative of the French scientific community (see p.29). Inaugurated by French Minister of Ecology Ségolène Royal as a prelude to the COP21 Conference, the event brought together 2200 researchers and highlighted the wide spectrum of disciplines now addressing climate concerns. "It..."
enabled us to clearly spell out to decision-makers not only the scope of the challenges we are faced with, but also the involvement of the entire scientific community in finding solutions to reduce global warming and adapt to its effects,” Treyer says.

Above all, it is essential to be able to fully grasp the situation in which humankind finds itself. “This is a turning point: humans are now clearly part of the causal chain that alters nature, and climate change presents us with a challenge so huge that at first, we feel that there’s nothing we can do about it,” explains Sandra Laugier, a philosopher and deputy scientific director at the CNRS Institute for Humanities and Social Sciences (INSHS). “Moreover, it is now obvious that progress can no longer consist in finding radical solutions, but rather in coping with change. From this point of view, philosophy can help reduce this global situation to individual ones that can be understood and therefore possibly dealt with.”

The social sciences can also contribute to investigating the complexity of these new parameters: “We act as if humanity was facing a common future but our interests widely differ, especially due to the significant environmental, economic, and social inequalities between countries. To a certain extent, social sciences help us remain realistic, even though it is easier to think about the end of the world or a global disaster in a hundred or in a thousand years’ time than tackle immediate problems in all their diversity,” Laugier adds.

At the other end of the disciplinary spectrum, climatologists must be able to refine their predictions so that they can look into countries’ proposals over time, and ensure that these are compatible with the desired mitigation or ...
... adaptation pathways. There are a number of areas where this needs to be done. For instance, data remains insufficient, especially about the Arctic and tropical regions. In addition, “it will take a lot of effort to format all the global data and make it compatible,” says Ciais. Modeling of processes also needs to be further refined. Take ice sheet dynamics for example. “Twenty years ago it was thought that they would take 100,000 years to melt and affect the climate. However, satellite and field observations have shown that they are breaking up far more quickly, hence the importance of understanding and depicting these processes so that they can be better implemented in numerical models,” Delecluse explains. The same goes for the carbon cycle: “At present, half of the emissions are absorbed by the land, vegetation, and oceans. We know that this proportion will decrease due to rising temperatures, but cannot tell to what extent as yet.” Finally, climatologists are seeking to improve and validate numerical weather prediction models. With more reliable forecasts and better spatial resolution, these models will be able to produce accurate data for each country, as well as provide detailed information over time about the occurrence of extreme weather events—such as tropical cyclones—at the local level.

In fact, a refined analysis of the effects of climate change is an utmost priority if humanity is to get on the road to sustainable adaptation. For example, because of the impact of rising sea levels, small island states are generally looked on as the first victims of global warming, which will affect them in the very short term. Yet a synthesis of observations of hundreds of coral islands shows that, over the past 30-100 years, three-quarters of them have maintained their area or even seen it increase. “At this point, the main factor of change is the ability of coral reefs to supply these islands with sediments, rather than sea level rise,” explains Virginie Duvat, of the LIENSs.12 Not that this result means that no action should be taken, on the contrary. But it does show that sustainable adaptation to rising sea levels on any of the world’s coasts should under no circumstances lead to the construction of sea defences such as dykes and seawalls, which actually prevent sediment supply. More generally, “this argues in favor of robust, flexible adaptation processes that will need to be spread out over long periods of time, responding to changing impacts,” Duvat adds. Treyer agrees: “Science has definitely entered the era of detailed analysis.”

Means and resources
To implement these methods, scientists will need versatile resources—economic and financial to start with. At ...
“Governments Have their Backs to the Wall”

One of the main organizers of the conference “Our Common Future under Climate Change” at UNESCO last July, French climatologist Jean Jouzel\(^1\) relays the importance of this event.

**BY LAURE CAILLOCE**

---

Pre-COP scientific conferences are rare. Why organize one this year?

Jean Jouzel: The last conference was held in 2009 before the Copenhagen Convention. Organizing one this year was essential because 2015 is the deadline that governments set to make pledges for the post-2020 period. The Kyoto Protocol, whose parties agreed to cut global CO\(_2\) emissions by 5% compared with 1990, covered the 2008-2012 time lapse. Focused on the 2013-2020 period, Copenhagen was a semi-failure: governments did not commit to reduce emissions, but agreed to limit long-term warming to 2°C. Now they have no alternative but to design and implement the right strategies to meet this objective.

What must be done to stay below a 2°C rise?

J. J.: To stay below 2°C, we have 800 billion tons of CO\(_2\) left to emit until the climate stabilizes—that’s less than 25 years of emissions at the current pace. We need to cut CO\(_2\) increases by 15-20% by 2020, halve our emissions between 2020 and 2050, and aim for zero emissions by 2100. This will require a complete overhaul of current development methods to aim at low-carbon, less energy-hungry societies.

What do you think of the pledges that have been made for the COP21?

J. J.: Europe has announced a 40% reduction by 2030, in relation to 1990 levels. The US have committed to curbing emissions by 26% by 2025—this time, in relation to 2005. And China, which has become the planet’s largest emitter, has promised to reach its emission peak by 2030... meaning that we still have a long way to go. But this will be a negotiation, so positions may change. In fact, and this is very important, it is the first time that emerging countries will make commitments to reduce their emissions. This could be a turning point in the fight against climate change. \(II\)

---

1. Laboratoire des sciences du climat et de l'environnement (CNRS / CEA / UVSQ-IPSL).
… present, the Paris agreement is supposed to determine how adaptation to climate change will be funded. In 2009, developed countries committed themselves to mobilizing US$100 billion from public and private funding each year until 2020, to enable developing countries to combat global warming and embark on sustainable development. However, as Lecocq points out, “much more will be needed, and in a tight budgetary situation.” This is why economists are striving to propose innovative funding mechanisms that will encourage investment in low carbon projects. Lecocq also mentions an innovative concept called a co-benefit: “for example, air pollution produced by burning coal and gas generates significant costs in terms of health and agricultural productivity, especially in India and China. The latest IPCC report shows that reducing greenhouse gas emissions would provide a ‘co-benefit’ of around 0.6% of GDP.” As a result, cutting emissions would not only benefit the climate but also the country’s economy.

Public policies also have a key role to play in adaptation, as they determine the creation of large infrastructures and influence individual behavior. Antoine Bozio, director of the Institute of Public Policies (IPP), calls for a change in the role of taxation. “Because of the need to fight global warming, part of taxation should no longer be considered as a source of income but rather as a means of keeping the balance between ‘winners’ and ‘losers.’” This is the condition for a change in human behavior, he says.

And it is this behavior that needs to change. “It doesn’t just boil down to turning the tap off while you clean your teeth,” says Le Treut. “It is a question for sociologists,” Treyer explains. “What is it in a society that brings about a change in behavior, such as the one we witnessed when smoking was banned in public places?” According to Laugier, “it is also

---

13. Adopted on March 22, 1985, the Montreal Protocol bans the use of chlorofluorocarbons (CFCs) and other substances that deplete the ozone layer. It has now been signed by 197 countries, making it the first ever environmental protocol to achieve universal ratification.
an issue for historians, who can identify tipping points similar to the one we are confronted with." (see p. 26)

At the other end of the chain, the scientific community is endeavoring to open up new prospects in terms of multilateral negotiations and international governance. Maljean-Dubois points out that decision-makers now have a wide range of legal instruments at their disposal if they wish to go further. “In addition to a universal agreement, there could be enhanced cooperation between groups of countries, or else sectoral agreements.” This specialist in international and European environmental law also points to the shortcomings of global governance. “In areas such as biodiversity, the economy and social affairs, global governance is highly fragmented. For instance, it does not help that the Montreal Protocol on ozone is separated from climate agreements, or that the latter have no connection with the World Trade Organization, which has control over intellectual property issues related to clean technology. Academic research is increasingly focusing on such obstacles and ways of getting round them.”

With many observers highlighting the inadequacies of a large number of countries’ INDCs, will the planet really be ready when the Paris negotiations begin in December? “We’ve studied the proposals that are already available,” says Ciais. “As things stand, the chances of meeting the 2°C target are slim but not nil.” For Le Treut, “in many countries, these proposals have given rise to a heated debate. It is not easy for a country to make a 15-year commitment, and the effort that it implies should be emphasized. Whatever the objectives listed in the future agreement, it should be assessed on its ability to create a dynamic.” In any case, one thing is certain: scientists are in the starting blocks for the November event.

The CNRS at the forefront

The CNRS is involved in a growing number of initiatives aimed at the general public, and will be present at a host of forthcoming regional and national events. On December 4-10, the organization will be at the Grand Palais in Paris, where an important exhibition is being organized during the COP21 negotiations. “This will be a multi-stakeholder event focusing on solutions to climate change. It will bring together businesses, NGOs, local authorities and, of course, scientists. Armed with proposals and innovative ideas, researchers from the CNRS and other institutions will be present, with the backing of the French Ministry of Higher Education and Research,” says Agathe Euzen, scientific delegate at the CNRS Institute of Ecology and Environment (INÉE) and COP21/CNRS coordinator.

In parallel, the CNRS is about to publish a book entitled Penser les solutions au changement climatique (“Finding solutions to climate change”). “Bringing together contributions from around 50 scientists and other stakeholders, the book aims to provide the facts needed to understand climate change-related issues, and to propose economic, environmental, social, technical, and legal solutions,” Euzen explains. “Through a number of events held across France, more than 2000 researchers will seek to raise society’s awareness of climate change and its implications,” adds Stéphanie Thiebault, director of the INÉE.

In addition, on the occasion of the COP21, the CNRS has initiated a participative science project in collaboration with the French Natural History Museum’s (MNHN) Centre for Ecology and Conservation Sciences (CESCO) and the Vigne-Nature participative observation program. The aim is to develop new biodiversity observatories in relation to climate change. The project is innovative in that it stems from the questions and suggestions of a group of citizens using the “Open Space” approach, which is based on self-organization. “We extend their participation ahead of observation by encouraging future observers to produce their own questions and design their own protocols,” explains the MNHN’s Denis Couvet.

Hurricane Sandy on the eastern coast of the US is the country’s second-costliest in history.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean Global Temperature</th>
<th>CO₂ Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>14.6°C</td>
<td>393.82 ppm</td>
</tr>
<tr>
<td>2013</td>
<td>14.6°C</td>
<td>396.48 ppm</td>
</tr>
<tr>
<td>2015</td>
<td>14.6°C</td>
<td>396.48 ppm</td>
</tr>
</tbody>
</table>

The COP21’s objective is to limit the average increase in global temperature to below 2°C compared with pre-industrial levels.
Antarctic Glacier under Surveillance

Glaciology. Melting Antarctic glaciers could raise sea levels by nearly a meter before the end of the century. The Astrolabe Glacier in East Antarctica has been under constant monitoring over the past four years via a network of GPS receivers measuring its flow rate towards the ocean.

BY AUDREY DIGUET
PHOTOS BY NASA, IPEV, THIBAUT VERGOZ/IPEV/LGGE/CNRS PHOTOthèque, BRUNO JOURDAIN/IPEV/CNRS PHOTOthèque, EMMANUEL LE MEUR/IPEV

1. Nine GPS beacons were installed on the Astrolabe Glacier. Evenly spread over 10 km², they have to withstand the harsh Antarctic winter and its high winds.

2. The glacier’s motion has been continuously recorded over the last four years, with a view to deciphering the physical processes underlying this movement.
3. Every austral summer, glaciologists travel the length and breadth of the Astrolabe, repositioning and repairing the network of beacons. Helicopters are essential due to the weight of the equipment.
As it flows towards the ocean, the glacier adapts to the underlying relief, strongly deforming the ice and giving rise to deep crevasses (that can exceed 40 meters). This makes it difficult for the researchers to access the GPS receivers.

4.5. In some places, the Astrolabe Glacier, together with its network of receivers, moves at speeds of up to 600 meters per year. The changing GPS position of each beacon over time makes it possible to determine the flow rate.
6. Holes are drilled into the ice to reinstall the masts that support the structure of each GPS station (representing in total 300 to 400 kilograms of equipment).

7. The masts will have to withstand the next austral winter. Here, a researcher is securing the solar panels that ensure the energy self-sufficiency of the GPS stations.
8. The data stored in the receivers is recovered each year. It will take another decade to establish a general trend. Researchers hope to determine in particular whether the glacier flow is speeding up.

9. An acceleration of the flow would increase the amount of ice discharged into the sea. Since other glaciers in the region are presumably following the same pattern, this could affect sea level rise.
To ease the strain on the planet’s limited resources and face the undeniable threat of climate change, researchers in a variety of disciplines are working towards more efficient and environmentally-friendly transformations, with chemistry playing a key role in providing alternatives. The ever-growing importance of chemicals in everyday products is an incentive to focus on sustainable or green chemistry. This involves improving existing solutions by offering better application properties, reducing environmental impact through the creation of new bio-sourced molecules (rather than petroleum-based ones), and by cutting energy consumption, CO₂ production, and waste in manufacturing processes.

The E2P2L,¹ created in 2011 as an International Joint Unit (UMI), is located at the Shanghai Research and Innovation Center of Solvay, a worldwide active chemical company headquartered in Belgium. Along with the CNRS and Solvay, it brought together a leading French chemical laboratory (ENS Lyon),² a Chinese University (ECNU),³ and, since 2013, a mirror site at the UCCS⁴ in Lille as well as another Chinese partner (Fudan).⁵

An eco-efficient future
“Collaborating with China was a logical choice,” says E2P2L director Armin Liebens, “given the country’s strong growth, the concentration of scientific talent, and the government’s commitment to standing up to pressing environmental challenges. An intellectual property agreement was drafted, whereby patents are registered in China in Solvay’s name, with the CNRS as co-owner where applicable.” The laboratory encompasses all aspects of chemistry—from organic to inorganic, physical to theoretical, fundamental to applied—and uses advanced catalysis to tackle various challenges, with emphasis on bio-engineered plastics, bio-surfactants, and CO₂ valorization.

“Our goal is to meet the challenges of the 21st century by designing innovative solutions for eco-efficient processes and products with positive environmental effects on the global scale,” explains Liebens. “One example is the development of specialty molecules from renewable biomass such as lignocellulosic (plant) waste material. Such molecules can replace less sustainable solvents and surfactants used in chemical processes, thus reducing their environmental footprint. At the same time, we integrate economic parameters such as operating costs and feasibility to ensure the competitiveness and marketability of any new discoveries.”

Jean-Marc Clacens, the E2P2L deputy director, emphasizes that 90% of the 200 million tons of plastic produced globally every year are petroleum-based. “We are therefore conducting research on alternative solutions.”

In brief

CHILE

On June 9, 2015, during the state visit of Chilean president Michelle Bachelet to France, the CNRS and its Chilean partners formalized the creation of the International Associated Laboratory (LIA) MINES for “Mining systems in the Atacama Desert.” This LIA will focus on mining through all its typological variety (metallic and non-metallic, above or below ground, small or large scale), from pre-Inca settlements to the present day. On this occasion, the International Joint Unit (UMI) “Mathematical Modelling Centre,” created in 2000 with Universidad de Chile, was also renewed for four years.

SINGAPORE

A Memorandum of Understanding was signed between CNRS president Alain Fuchs and Bertil Andersson, president of Singapore’s Nanyang Technological University (NTU) on May 18, 2015. This agreement, which was signed in Paris in the presence of the two countries’ heads of state, will lead to the creation of a joint International Research Network (GDRI) dedicated to renewable energies. Research will focus on smart grids, power systems, energy storage, marine and wind energy, photovoltaics, as well as intelligent and sustainable buildings.

Novel alternatives

A milestone was the creation of bio-based alternatives for petroleum surfactants (surface active agents), the substance used as a performance additive to reduce surface tension (between two liquids or between a liquid and a solid) in chemical processes, such as the production of paint, dyes, detergents, or adhesives. This process, like many of ours, blends scientific advancement with an industrial production perspective to help bring these products to market.

molecules prepared from bio-based feedstock such as cellulose,” he explains. Bio-refineries can then use these molecules to create monomers for engineering greener plastics. Another initiative involves the creation of amines—widely used in producing materials or detergents—from biomass-based alcohols. “This process, like many of ours, blends scientific advancement with an industrial production perspective to help bring these products to market.”

Researchers looking at an NMR tube within the research premises.

The Gingko Building, part of the Research and Innovation Center Shanghai (RICS) of Solvay, houses the E2P2 headquarters.

Researchers looking at an NMR tube within the research premises.

bio-surfactants, although current production processes involving glycerol are costly. “Laboratory teams have achieved a significant breakthrough in this field,” explains Jean-François Tassin, deputy director of the CNRS Institute of Chemistry. “They are using ‘surfacting’ silica nanoparticles to make ethylene glycol react with a fatty aldehyde (as a model reaction), thus mixing the two compounds without resorting to a solvent or surfactant. This eco-efficient process has the added benefit of offering good catalytic yields, and the nanoparticles can be recaptured and reused with no loss in effectiveness.”

Another focus area of the laboratory is CO₂ valorization, which aims to capture the abundant greenhouse gas, before storing and potentially using it as a chemical raw material. Yet CO₂—being highly stable and not very reactive—requires large amounts of energy to be transformed into fine chemicals. Researchers are addressing this hurdle by conducting fundamental research on carbon-carbon bond formation under electrocatalytic reaction conditions, in order to show that carbon molecules can be activated at low cost and with little energy. To learn more about this basic chemical building block, researchers are developing tools and advanced computer modeling methods that can help accelerate experimental development across the laboratory’s range of activities. II

Left to right: NTU president B. Andersson, Singapore head of state T. Tan, CNRS president A. Fuchs, and French head of state F. Hollande.

1. In Chile: Universidad Católica del Norte, Universidad de Chile, Universidad Arturo Prat, and Universidad Academia de Humanismo Cristiano, in France: Université Rennes-I, Université Paris Ouest Nanterre La Défense, and Université Paris III-Sorbonne Nouvelle.
LIA ARTEMIR
Prehistoric Art

An agreement for the creation of the International Associated Laboratory ARTEMIR, for “Multidisciplinary Research on Prehistoric Art in Eurasia,” was signed between the CNRS and its partners in May 2015. The new LIA will be dedicated to research on 3D imaging of prehistoric art in southern Siberia. It will enable researchers to study exceptional Russian collections and sites that have been difficult to access until now.

Photogrammetric model of a Paleolithic pearl found in the Denisova Cave (Altai Krai, Russia).

Researcher taking photomicrograph images of petroglyph details on the site of Kalguty (Republic of Altai, Russia).

GDRI EMAE
Alums of Europe

The GDRI EMAE1 for “alums Mediterranean Europe in the late Middle Ages / Exploitation of Mediterranean Alums of Europe” has just been signed. Its objectives are to gain new knowledge on the characteristics of products sold during the Middle Ages. In particular, it will study the manufacturing process and commercialization of potassium alum. For most historians, this commodity is linked to the industrial, commercial, and scientific development of the Western world.

Battery of four roasting furnaces in the “allumiere” of Monteleo (Monterotondo, Italy) dating back to the turn of the 16th century.

MEXICO During the state visit of Mexican president Enrique Peña Nieto for the July 14, 2015, celebrations in Paris, 13 scientific cooperation agreements were signed during an “Academic and scientific strategic partnerships Mexico France” meeting at the Maison de l’Amérique latine. Around 30 scientific and academic agreements had already been signed during a French-Mexican forum on research organized on July 8-9 by the French Ministry of Research. Two of these involve the CNRS: a letter of intent to create a UMI in Mathematics1 and another to collaborate in the space program SVOM (Space-based multi-band astronomical Variable Object Monitor).2

CHINA Since 2012, China is the CNRS’s first scientific partner in Asia in terms of copublications. Some 17 International Associated Laboratories (LIAs) are currently operating in the country, covering almost all scientific fields, including the humanities. One of the main goals of the recent mission of the CNRS in China was to create a new LIA: the “G-quadruplex-HELI – Helicase-mediated G-quadruplex DNA unwinding and genome stability,” which will focus on the structures and interactions of nucleic acids. This agreement was signed in Beijing on May 29, 2015, between the CNRS, the École Normale Supérieure de Cachan (ENS Cachan), and the Institute of Physics of the Chinese Academy of Sciences. During this meeting, the LIA “Monocl”3—which addresses the variability of the Southeast Asian monsoon and the exchange of water masses in nearby oceans—was also renewed.

1. Novosibirsk State University / Institute of Archaeology and Ethnography of the Siberian Branch of the Russian Academy of Science / Institute of Automation and Electrometry of the Siberian Branch of the Russian Academy of Science / Université de Bordeaux / Université Savoie Mont Blanc / Ministère français de la culture et de la communication.

AlgoSolis: Microalgae in Focus

Synthetic biology.
A new platform promises to make microalgae more accessible to industry.

For most people, it’s just scum. For scientists and businesses in the know, microalgae are natural wonders whose vast industrial potential has yet to be tapped. To foster investigations into these unicellular aquatic plant species, the AlgoSolis R&D Facility was inaugurated in Saint-Nazaire last June as France’s first public microalgal research platform. AlgoSolis is backed by the 25 years of microalgal study notched up by its founding laboratory, the GEPEA, which remains in charge of the facility’s operations.

Towards mass exploitation
With this new platform, academic and industrial players in microalgal development now have access to cutting-edge infrastructures essential for nurturing mass production of an underused green resource with global prospects.

Microalgae have much to offer industry. Not only are their proteins, lipids, sugars, and pigments useful in diverse areas ranging from human nutrition, animal feed, cosmetics, and health to biofuels or green chemistry, but they are also particularly effective as bioremediators. These are organic waste-management agents that remove pollutants—from wastewater. Thriving on little more than light, water, and CO₂, they grow easily year-round and also act as carbon sinks. For now, however, their industrial use is limited: sustainable and economical methods for farming them on a large-scale intensive basis have yet to be defined.

The goal of AlgoSolis is precisely to “unlock the bolts that hinder mass exploitation,” says its director Jérémy Pruvost from the GEPEA. By supporting strategies to optimize microalgal biomass production and its conversion into usable products, the platform seeks to make the field truly viable, both financially and environmentally. A path well worth exploring, for Pruvost calls microalgae “a high-potential bioresource of the future.”

Attracting the world
Concretely, the platform proposes to advance microalgal research through its offer of hi-tech facilities including exclusive revolutionary equipment designed and patented by the GEPEA-CNRS-Université de Nantes. Open to public, private, or collaborative projects, the 2500 m² facilities cover the full spectrum of microalgal exploitation: culture and analysis rooms, production areas with more than 20 cultivation lines, and a downstream unit for microalgal biomass harvesting and refining. Production stages can be tested separately or in combination, with the aim of enhancing the overall chain.

From its site on the western coast of France, AlgoSolis stands to become a focal point of innovation that will spread the benefits of microalgae throughout the world. The platform will focus in particular on cross-border partnerships, namely with the US, Australia, and Japan, for “projects with long-term global impacts such as biofuel development,” notes Pruvost.

1. CNRS / Université de Nantes. 2. Laboratoire Génie des procédés - environnement - agro-alimentaire (CNRS / Université de Nantes / ONIRIS / Ecole des Mines de Nantes).
CNRS China Office Celebrates 20-Year Anniversary

Cooperation. Looking back at the CNRS’s historical ties and thriving collaborations with China, now a key global player in scientific research.

Two decades ago, when the CNRS established an office in Beijing, the reasons for doing so were not nearly as clear as they would be today. At the time, Japan was the scientific powerhouse of Asia, hence the CNRS presence there as of 1994. “The relationship with China began more modestly,” explains Antoine Mynard, current director of the CNRS Office in China. “A scientific cooperation agreement signed in the late 1970s initiated the process, with smaller-scale researcher exchange and cooperative links continuing for the next decade.”

A long time in the making
A first substantial initiative came during the early 1980s, as the CNRS and a number of Chinese research organizations, including the Chinese Academy of Sciences and the Ministry of Geology, launched an ambitious bilateral geological research program exploring the Earth’s crust and the upper Himalayan mantle. The project involved more than 60 researchers over several years, and resulted in the characterization of tectonic dynamics, which had a huge echo in the international Earth sciences community.

“Despite this initial success, scientific cooperation remained less extensive compared with other countries,” Mynard adds. “It was only in the late 1980s, following a staff reshuffle that the French embassy sought a ‘science attaché’ in 1995 to address the lack of scientific dialogue. Given its early and leading role in collaborating with China, the CNRS accepted the French government’s suggestion to propose a scientist, able to act both as attaché and CNRS representative in China.”

Today the situation is very different, even if the CNRS remains instrumental in scientific cooperation between the two countries. China has now become a prime location for research collaboration, with R&D budgets growing even faster than the economy, and expenditure exceeding 2% of GDP since 2014. Yet the issue of why and how to collaborate remains to be addressed—a mission entrusted to the office’s three staff members, located in the premises of the French Embassy in Beijing since 2011, without being subordinated to it. “Globally, we help both the CNRS adjust its collaborative policy with China, and individual researchers develop partnerships by negotiating with Chinese institutions, formalizing bilateral agreements, and finding Chinese sources for co-financing. We also promote CNRS activities and emphasize the ‘hands-on’ work carried out in joint projects through various channels, such as the quarterly magazine Le CNRS en Chine, published in French and Chinese in the two countries.”

Looking to the future
The CNRS now has a substantial collaborative research portfolio, with numerous laboratories and research networks, as well as two joint research units, including the successful E2P2L1 International Joint Unit in Shanghai, which explores green chemistry processes in partnership with the Solvay corporation and two prominent local universities. “Great progress has clearly been made, yet many opportunities are up for grabs,” concludes Mynard. “Our mission is to help our community of researchers seize them by developing tools and policies to promote collaboration.”

1. Eco-Efficient Products and Processes Laboratory (CNRS / Solvay / ENS de Lyon / East China Normal University / Fudan University / Université de Lille-I).

To subscribe to the CNRS China regional magazine (Chinese or French editions):
- antoine.mynard@cnrs-dir.fr
Nestled 2160 m above sea level, the OPAR’s “Piton Maïdo” facility was completed in 2012, making it the highest of the three atmospheric observation stations on Reunion island, in the south-western Indian Ocean. The station has four operational Lidars, only two of which can be seen by the human eye (green beams). Lidar technology, which consists in firing a laser at an object and analyzing the reflected light (called “backscattering”), allows scientists to determine a variety of atmospheric measurements. “Using this facility, we can obtain data on temperature—up to 100 km above ground—water vapor, wind, as well as tropospheric and stratospheric ozone,” explains Guillaume Payen, OPAR’s technical lead. “But what makes the Maïdo facility so special is not only its altitude, which eliminates contamination (from pollution, humidity, and lights), but its latitude. There aren’t that many stations close to the Equator, making it an ideal candidate for observing stratospheric transport across the globe—an essential parameter of climate change,” the researcher adds. Following a first test period last May, the facility is scheduled to soon join the NDACC, an international network of 70 monitoring stations.

guillaume.payen@univ-reunion.fr

ON NOVEMBER 1ST 2015
OUR QUARTERLY PUBLICATION CNRS INTERNATIONAL MAGAZINE BECOMES CNRSNEWS.FR
VIDEOS / INTERVIEWS / IN-DEPTH FEATURES
LATEST RESULTS / LIVE UPDATES
FULLY INTERACTIVE / ALL PLATFORMS
100% ONLINE

www.cnrsnews.fr

Stay connected to the CNRS on social media