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SPECIAL FEATURE

SEAS AND OCEANS: STUDYING EARTH'S FINAL FRONTIER

BIOLOGY AND MEDICINE

**EMPOWERING PATIENTS
AND IMPROVING TREATMENT
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EDITORIAL

by the editorial team

EXPLORING AND PRESERVING: MARINE SCIENTISTS' RACE AGAINST TIME

While it has often been argued that humankind's 'final frontier' is space, what we know — or rather what we don't know — about our seas and oceans makes them a serious contender. According to experts, an incredible 95 % of the world's oceans haven't been explored yet, despite covering over 70 % of the planet's surface. These figures contrast with the critical role oceans play in our lives, be it for fisheries, trade, transport or scientific discoveries.

Put in such a context, the issue of global warming really takes on a whole new dimension. Scientists are engaged in a race against time when it comes to both discovering the oceans' well-kept secrets and preserving them from the effects of climate change.

To celebrate World Oceans Day and shed light on the challenges currently being faced by researchers, this issue of the *research*eu results magazine* focuses on research conducted in or related to seas and oceans. The magazine's 'special' section contains 10 articles which can roughly be split into three topics: deep-sea exploration, preserving resources of the sea and better understanding the impact of climate change on marine ecosystems. Indeed we now know that CO₂ emissions not only drive climate change but also cause the worrying trend of

**'An incredible 95 % of
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ocean acidification as the oceans are forced to absorb man-made emissions — which is in turn threatening living organisms.

This month's interviews also reflect the diversity of ongoing sea and ocean-related research. Thanks to the CARBOCHANGE project, for instance, scientists recently made a giant leap forward in their understanding of the ocean's carbon uptake, future trends and their effects on marine habitats. The ECO2 project looked into a similar CO₂ leakage scenario but this time from below the

seabed, with a thorough monitoring of 'Carbon capture and storage' (CCS) installations in the North and Barents seas off Sweden.

The other two projects, LINKFISH and ARROWS, remained at seabed level but for very different purposes. LINKFISH studied the role of macroalgae in the conservation of fish populations in the Mediterranean, while ARROWS focused on lost man-made artefacts. With support from archaeologists, the team created a new generation of deep-sea exploration robots capable of inspecting every corner of ship wrecks and other lost testimonies of human history.

These articles are followed by our usual sections on biology and medicine, social sciences and humanities, energy and transport, the environment, IT and telecommunications, industrial technologies and physics and mathematics, along with a list of upcoming scientific events.

We look forward to receiving your feedback. You can send questions or suggestions to: editorial@cordis.europa.eu



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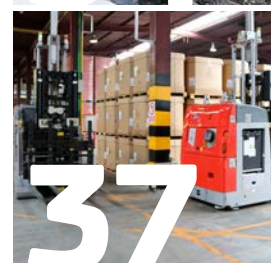
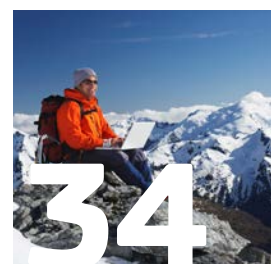
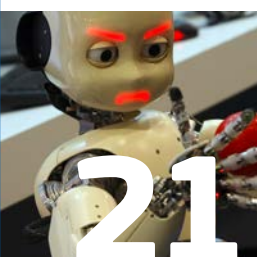
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SPECIAL FEATURE SEAS AND OCEANS: STUDYING EARTH'S FINAL FRONTIER

INTERVIEW

DEEP-SEA EXPLORATION WILL SOON BE AN OPTION FOR MOST ARCHAEOLOGISTS

With the ARROWS project, EU-funded researchers are turning deep-sea archaeological exploration from a risky and out-of-reach undertaking to a flexible and affordable solution.

When Plato first came up with the myth of Atlantis, he probably didn't expect that the mysterious island would keep stirring debates and feeding popular imagination for over 2000 years. Yet, Atlantis fantasies say a lot about the mysteries still surrounding Earth's seabeds: Whilst our seas and oceans are packed with inviolate submerged sites and shipwrecks, archaeological and scientific discoveries are still hindered by logistical and financial barriers, and low-cost, flexible solutions are desperately needed.

Aiming to boost research in this field, the EUR 4 million ARROWS (ARchaeological ROBOT systems for the World's Seas) project picks up where military security and offshore oil and gas technologies left off by creating underwater exploration vehicles tailored to the needs and expectations of deep-sea archaeologists. Since the project started in September 2012, the 10-partner strong consortium has developed three new 'Autonomous

underwater vehicles' (AUVs), including U-CAT, a highly manoeuvrable robot inspired by turtles and designed to penetrate shipwrecks. These AUVs and their dedicated components boast tantalising advantages such as reduced size and mission cost, higher versatility, lower weight and more ergonomic designs.

Benedetto Allotta, professor of Robotics at the University of Florence and ARROWS project coordinator, details the main selling points of the AUV technologies developed by the project team, explains the demonstration process with active participation of archaeologists and discusses the future commercialisation of ARROWS' brand new AUVs.

★ What are the main objectives of ARROWS?

Benedetto Allotta: ARROWS aims to adapt and develop low-cost cooperating AUV technologies to significantly reduce the cost of archaeological operations, covering the full spectrum of archaeological campaigns. The ARROWS

methodology involves identifying archaeologists' requirements in all phases of an archaeological campaign and proposing/demonstrating suitable technological solutions.

★ What was the role played by archaeologists in ARROWS?

On the one hand, archaeologists played a role of specification, with a view to identifying the requirements for the technologies to be developed. The requirements for the AUVs to be used in archaeology have been defined by the Archaeological Advisory Group, a board including European archaeologists from and beyond the ARROWS consortium.

On the other hand, archaeologists supported us in the choice of significant demonstration sites/scenarios.

★ Did you face any problems during the project and if so, how did you solve them?

Due to the absence of GPS underwater, one of the main problems in the use



BENEDETTO ALLOTTA

of AUVs for underwater archaeology is to correctly geo-reference images and sonograms taken from underwater sites. Accuracy requirements expressed by the archaeologists are in the range of one metre, which is a very challenging achievement. Another problem to be addressed and solved underwater in order to have a team of cooperating heterogeneous vehicles is communication. This has to be addressed by means of modern acoustic technology, which is much slower and less reliable with respect to airborne radio communication.

★ **What are the main strengths of the U-CAT compared to other underwater robots?**

The U-CAT has been designed by our Estonian colleagues with the ambition being to develop a robot capable of entering modern (metal) wrecks. The main strengths of the U-CAT lie in: its small size which enables it to go through small passages inside the wreck; its round shape with no protruding parts to minimise the risk of getting stuck; its low weight and ergonomic design to be operable from a small boat; and very good manoeuvrability to efficiently move in the rooms and corridors of the shipwreck. Moreover, the cost of the U-CAT is low enough to make it affordable to archaeologists and to reduce the economic risk in case of vehicle loss. The U-CAT is user friendly, requiring special training in robotics to be operated, and its possible use in Remote Operation (ROV mode) further extends the range of potential applications.

★ **Other technologies have been developed under the project. Can you tell us more about these?**

Two more vehicles have been developed within the framework of ARROWS.

The first one is 'Marine robotic tool for archaeology' (MARTA), a moderate-cost AUV designed by the University of Florence which features a modular electromechanical structure. Modular means that the vehicle can quickly — in a matter of minutes — be dismantled and assembled again with different sensor payload configurations (either sonar or optical payload). Battery packs can be replaced very rapidly as well. The vehicle is torpedo-shaped with a smaller diameter (177 mm) than existing, best-selling vehicles and has rather rich navigation sensor equipment in order to cope effectively with the requirements of accurate geo-referencing. The sensor payload includes two digital cameras and a forward-looking discovery sonar. However, other payload modules can easily be designed and deployed.

The other AUV is the A-Sized vehicle designed by Edgelab SRL, an Italian SME based in La Spezia. Edgelab's vehicle is torpedo-shaped as well, with a diameter even smaller than that of MARTA (150 mm). Edgelab's approach consists in developing a really cheap, 'sexy' and easily deployable vehicle albeit with reduced performance. The vehicle weight is in the range of 15 kg, making its logistics really simple. This vehicle represents a very interesting low-cost opportunity not only for archaeologists but also for scientists.

In addition to the vehicles themselves, components for AUVs have also been developed by other SMEs in the consortium. In particular, a soft cleaning tool, to be mounted on an existing, bigger AUV (the Typhoon vehicle developed by the University of Florence) has been jointly developed by NESNE (Turkey) and AMT (Spain) and will be tested in Sicily.

★ **Making your technologies affordable is one of the main project goals. How did you achieve this?**

We decided to address the problem of expensive vehicles through custom designs of innovative vehicles, including a minimum set of expensive navigation sensors. The A-Sized is an extreme interpretation of this concept, resulting in a really low-cost vehicle with reduced performance but major advantages in terms of logistics and deployability. The MARTA vehicle is more a compromise between cost requirements, geo-referencing accuracy, and ease of use, with the advantage of a modular electromechanical structure allowing different vehicle and payload configurations.

★ **You conducted tests in the Mediterranean and Baltic Seas. Are you happy with the results?**

Designing and building three new vehicles from scratch wasn't an easy task. The underlying but very important tasks of enabling communication and cooperation between a heterogeneous team of vehicles wasn't easy either.

"Designing and building three new vehicles from scratch wasn't an easy task."

So far, tests have been performed in Tuscany, Israel, Croatia and the Baltic. Preliminary results are encouraging. The final demos are now in preparation, and a campaign in the Egadi Archipelago (Sicily) is planned for 26 May to 6 June. More tests will be performed in Estonia in the second half of July. We are very optimistic about the success of the final ARROWS demos.

★ **When do you expect your technologies to be commercialised?**

We expect that at least some of the technologies and vehicles developed within the framework of ARROWS will be commercialised within the next three years.

ARROWS

- ★ Coordinated by the University of Florence in Italy.
- ★ Funded under FP7-ENVIRONMENT.
- ★ http://cordis.europa.eu/project/rcn/104294_en.html
- ★ Project website: <http://www.arrowsproject.eu/>

ACHIEVING BOTH HEALTHY AND PRODUCTIVE SEAS AND OCEANS

Our oceans contain vast opportunities for blue growth and jobs, but oceans, seas and coasts are under strong pressures from human activities and climate change. The Joint Programming Initiative on Healthy and Productive Seas and Oceans (JPI Oceans) was established to help address these pressures, and for almost three years now, the FP7-funded CSA Oceans project has been supporting JPI to become operational.



The main aim of CSA OCEANS (CSA Healthy and Productive Seas and Oceans) is to support JPI Oceans in its start-up phase so that it can move quickly towards implementation. Since September 2012, the CSA OCEANS team has been working towards this by proposing tools, procedures and structures for long-term governance and operational cooperation of the Joint Programming activities. Furthermore, the project team has been exploring best practices and innovative solutions to propose new ways of interaction between the member countries of JPI Oceans.

Thanks to the work of CSA OCEANS, in April of this year, JPI Oceans published its Strategic Research and Innovation Agenda (SRIA) which contains 10 strategic areas as priorities for marine and maritime research in Europe. Ranging from exploring deep sea resources to the effects of ocean acidification on marine ecosystems, the strategic areas now provide the basis for selecting and implementing joint actions. The Management Board of JPI Oceans is currently in discussion about which actions will be taken forward in the first phase of implementation.

In preparation for drafting the SRIA, CSA OCEANS project partners mapped the marine and maritime research landscape to identify gaps and overcome the key challenges. They also carried out stakeholder consultations and calibrated the input with a similar consultation of member countries on their key strategic priorities. This formed the basis for areas of possible alignment and action to be taken forward and which tools could be used, as described in the draft Implementation plan (Iplan).

The communication plan, website and promotional video featuring key European policymakers developed by CSA OCEANS' project partners also informed the development of the SRIA.

A number of pilot actions have also been developed to test out new tools to fit the purpose and to demonstrate the added value and alignment ability of JPI Oceans. These small-scale test cases will provide potential templates for activities to be developed at full scale as actions are taken forward.

Most recently, the CSA OCEANS team has also published a number of papers of interest including 'Foresight Exercise Test Run — Experiences from the field of Microplastics' and 'Mapping and preliminary analysis of the science landscape'.

CSA OCEANS

- ★ Coordinated by the Research Council of Norway.
- ★ Funded under FP7-TRANSPORT.
- ★ http://cordis.europa.eu/result/rcn/158607_en.html
- ★ Project website:
<http://www.jpi-oceans.eu/>
- ★  <http://bit.ly/1Hehy3i>

INTERVIEW

SCIENTISTS LIFT THE VEIL ON SUB-SEABED CARBON STORAGE IMPACT ON LOCAL ECOSYSTEMS

European seabeds are often scarred or fractured, yet oil industries in the North and Barents Seas are storing CO₂ below these seabeds to reduce their emissions. Is such sub-seabed CO₂ storage a viable solution? A team of EU scientists recently shed light on this matter.

With the objective of limiting global warming to +2°C by 2050 looking increasingly out of reach and with a new UN climate conference on the horizon, the EU and its international partners are under increased pressure. All suitable solutions to reduce CO₂ emissions have to be contemplated, and 'Carbon capture

and storage' (CCS) — a set of technologies preventing CO₂ from reaching the atmosphere by storing it in suitable underground geological formations — is one of them.

In its recent Communication for an Energy Union, the European Commission acknowledges the need for enhanced support for CCS. The

"We could not find any signs of leakage at the storage sites which are currently operated."

technology has so far failed to develop as initially expected, largely due to high investment costs and limited



© Klaus Wallmann

KLAUS WALLMANN

incentives as a result of low carbon prices. But there is another aspect of CCS that still leaves potential investors and decision-makers in the dark: the question of leakage, especially in sensitive storage locations such as seabeds.

For the past four years, a team of EU scientists have been monitoring existing CCS installations in the North and Barents Seas to determine the likelihood of a leakage scenario and its impact on local ecosystems. ECO2 (Sub-seabed CO₂ Storage: Impact on Marine Ecosystems) scientists identified possible pathways for CO₂ leakage, monitored seepage sites, traced the spread of CO₂ in bottom waters and studied the responses of benthic animals and plants to CO₂. In early May, the project compiled these observations into a guide for the selection and monitoring of storage sites and presented it to the European Union.

Klaus Wallmann, coordinator of ECO2, discusses the project's results and the team's plans for further research in the field.

★ **What pushed you to do research in this area?**

Klaus Wallmann: In Europe, most of the CO₂ captured at power plants will be stored below the seabed. It is thus important to understand whether CO₂ will remain in sub-seabed storage formations or will leak out to damage the ecosystem at seabed level.

★ **What would you say is the most innovative aspect of the project in this regard?**

The major new element of the ECO2 approach is the 'Propensity to Leak Factor' which has been developed by combining a compact description of the storage complex and heuristic techniques accommodating the large number of parameter uncertainties. Since it is not possible to simulate all relevant geological features, processes and events with the modelling software currently available, we found a way to realistically estimate how likely a leakage is at a specific CCS installation.

★ **At which locations did you conduct your research and why?**

We investigated real storage sites in the North Sea and Barents Sea off Norway where millions of tons of CO₂ have been separated from natural gas and stored in sub-seabed geological formations for many years.

★ **How did you proceed to detect leakage from these sites?**

A wide range of sea-going instrumentation was applied in the project to detect leakage. The instruments were deployed from research vessels but also from 'Remotely operated vehicles' (ROVs). Cutting-edge technologies used by the project include P cable 3-D seismic instrumentation for high-resolution imaging of pathways for fluid flow getting through the overburden covering the storage

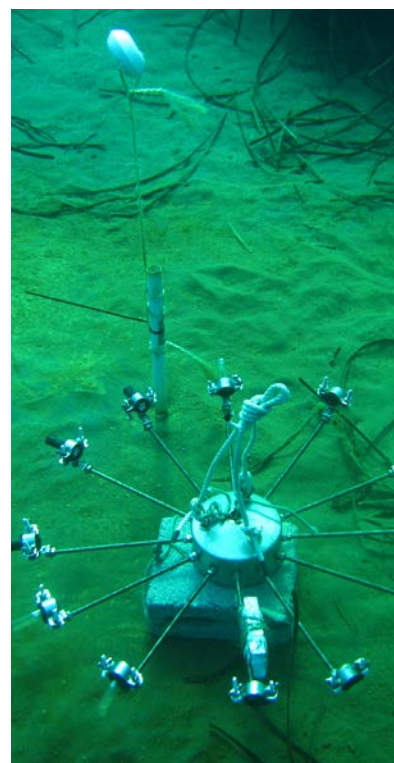
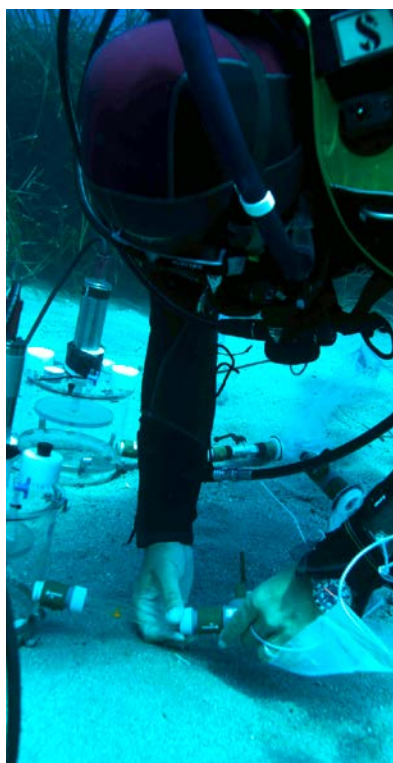
formations, hydro-acoustic methods to detect gas bubbles ascending from the seabed and chemical sensors to measure the levels of dissolved CO₂ in seawater.

★ **Have you identified potential room for improvement in storage techniques and technologies?**

Yes, we published a best environmental practice guide that can be downloaded at <http://oceanrep.geomar.de/28739/>. There we describe how sub-seabed storage sites should be selected and monitored.

Most notably, when selecting sites, we recommend avoiding geological structures that may serve as conduits for formation water and gas release, geological formations containing toxic compounds and low-energy hydrographic settings with sluggish currents and strongly stratified water columns. Also, storage sites should be established far enough from valuable natural resources or areas in which biota is already living at its CO₂ tolerance limits.

The guide also stresses that the overburden, seabed and water column should be monitored using 3-D seismic techniques, high-resolution bathymetry or backscatter mapping of the seabed, hydro-acoustic imaging of gas accumulations and outlets, video and photo imaging, and chemical detection of dissolved CO₂ in ambient bottom waters. Most of these technologies are either already available or will soon become state-of-the-art.



© ECO2

★ **ECO2 essentially focused on leakage impact on marine ecosystems. What are your conclusions?**

We learned that if leakage were to occur the impact on the marine ecosystem would be limited to the immediate surroundings of the leak. In this small area sensitive organisms would die and would be replaced by other, more resilient organisms. At a lateral distance of more than 100 metres from the leak, the impact would be very small and barely detectable since the leaked CO₂ would rapidly be diluted by bottom currents.

★ **Based on the results of the project, would you say that sub-seabed CO₂ storage is a viable technique?**

Yes, we could not find any signs of leakage at the storage sites which are currently operated. It is possible that leakage will occur should hundreds of new storage sites be opened and operated in the future. However, only a very small fraction of the stored CO₂ would leak out and the impact on the marine environment would remain small and local.

★ **What are your plans now that the project has come to an end?**

There is still a lot of work to do: We need to better understand how

leakage rates are controlled by geological structures and physical processes in the overburden. Moreover, monitoring techniques should be further improved to enhance their sensitivity and reduce operational costs.

ECO2

- ★ Coordinated by GEOMAR in Germany.
- ★ Funded under FP7-ENVIRONMENT.
- ★ http://cordis.europa.eu/project/rcn/98756_en.html
- ★ Project website: <http://www.eco2-project.eu/>

MAPPING MEDITERRANEAN DEEP-SEA HABITATS

Deep-sea habitats are increasingly under threat from the impacts of human activities such as trawling and pollution. European marine scientists have therefore investigated the relationship between seafloor geology and biodiversity to develop effective maps of deep-sea ecosystems.

The EU-funded GEO-HABIT (Geo-acoustic mapping of benthic habitat distribution) project, which ran from May 2012 to April 2014, set out with two main aims: to assess present-day natural resources and to characterise ancient conditions of deep-sea ecosystems.

The team adopted an interdisciplinary approach based on marine geology, seabed ecology and oceanography using geo-

"The work of GEO-HABIT will enable the accurate statistical prediction of the distribution of sensitive deep-sea ecosystems."

statistical analysis to study 'Cold-water coral' (CWC) communities. These communities are biodiversity hotspots in the deep sea. Researchers also investigated CWC mounds, carbonate

formations that can provide valuable information on the climate and environmental conditions from the ancient past.

Project partners wished to determine the main physical factors responsible for the development, maintenance and decline of CWC mounds in the Mediterranean Sea. They also investigated how detailed predictions of the occurrence of CWC communities can be made over large areas.

Research was conducted in the eastern Alboran Sea, which lies between Spain and North Africa, to acquire high-resolution geophysical data on CWC mounds. Scientists also studied their seafloor morphology, sedimentology, water column and biology.

A study of the newly mapped Cabliers Mound showed that it had a uniquely high level of biodiversity for the region. The mound was sampled using four gravity cores from 5 to 11 m long, which revealed that the Cabliers Mound is different to others in the region.

The data acquired will help give a better understanding of the evolution of the Alboran Giant CWC Mounds. In addition, a short documentary was produced that described the main sea-going tasks used to map the CWC mound habitats.

Different predictive habitat distribution models were tested to statistically predict the distribution of three CWC species in the Cap de Creus Canyon off the north-east coast of Spain. The models enabled a better understanding of the spatial distribution of habitats at the bottom of the Mediterranean, highlighting the relationship between a species and its environment.

Despite the differences between the three models, a common ecological pattern in coral distribution was identified. The outcomes of the three models were then combined to provide a better prediction for the three CWC species.

The work of GEO-HABIT will enable the accurate statistical prediction of the distribution of sensitive deep-sea ecosystems. This will help to create an efficient and cost-effective science-based method of mapping that will enable stakeholders to manage natural resources more effectively.

GEO-HABIT

- ★ Coordinated by the Natural Environment Research Council in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158563_en.html



BROWN SEAWEED, A SOURCE OF ATMOSPHERIC IODINE

Scientists have investigated how much iodine is released by seaweeds into the atmosphere to facilitate the development of better models of aerosol formation and atmospheric chemistry.

Brown seaweeds are excellent accumulators of iodine, which can be released into the atmosphere in the form of 'pure' molecular iodine, I₂, or as molecules called iodocarbons. These molecules are suspected to be the key to marine aerosol formation and consequently also influence the absorption of the Sun's energy by the atmosphere.

Therefore, knowing the magnitude and composition of gas containing iodocarbons or molecular iodine (I₂) emitted by brown seaweeds is essential for models that describe the formation of marine aerosol. However, obtaining data under realistic conditions is a difficult task.

The EU-funded ALMA-MATER (Absorption of light, macro-algae and the atmosphere) project was set up to identify, describe and study potential sources of gaseous iodine and other halogenated compounds.

Researchers used a new absorption spectroscopy technique to identify natural



sources of I₂ and iodocarbons. Therefore, the brown seaweed *Laminaria* (commonly known as kelp) was collected from the Irish coast and its gaseous emissions studied.

When *Laminaria* is put under stress at low tide, it releases I₂ together with a number of volatile iodocarbons. Researchers tested the hypothesis that seaweed is the source of iodocarbons in the marine boundary layer by studying gaseous emissions of seaweed in the laboratory. The marine boundary layer is the part of the lower atmosphere directly influenced by the ocean's surface.

Additional experiments were conducted to investigate the known emission of

I₂ from *Laminaria digitata* over six-hour tidal cycles. The aim was to study its ability to recover from external oxidative stress factors.

Work carried out by the ALMA-MATER consortium used a multidisciplinary approach to develop new spectroscopic techniques and answer longstanding questions regarding seaweed physiology and the atmosphere.

ALMA-MATER

- ★ Coordinated by University College Cork in Ireland.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159577_en.html

INTERVIEW

AN INSIGHT INTO FUTURE OCEAN CARBON UPTAKE

Seas and oceans are a key contributor to the absorption of CO₂ emissions into the atmosphere caused by human activities. But does this mean we can rely on this capacity to alter ongoing climate change? And, most importantly, where does the excess CO₂ from the atmosphere go to? The CARBOCHANGE project considerably advanced scientific knowledge and predictions on the matter.

With the help of a comprehensive network of buoys, floats and research vessels, the EU-funded CARBOCHANGE (Changes in carbon uptake and emissions by oceans in a changing climate) project aimed to provide the best possible quantification of net ocean carbon uptake now and in the future, under different climate change scenarios based on past and present ocean carbon cycle changes.

This research is key to understanding the Earth's future under changing climate conditions, as Earth's oceans are thought to have absorbed about one quarter of the CO₂ humans pumped into the atmosphere over the past 20 years. The flip side of this process is that, as they absorb CO₂, oceans also become more acidic with dramatic consequences for sea life. Even worse, oceans might not be able to cope with a future increase in man-made CO₂ emissions in the same way they have been doing this so far.

The project is now complete and its results not only provide researchers with invaluable data and a global carbon model, but they also improve scientific understanding of key biochemical and

physical processes, quantify them, shed light on the vulnerability of oceans to increased CO₂ intake, help predict future climate and are set to help policy makers in taking concrete actions.

Christoph Heinze, Professor in chemical oceanography at the University of Bergen and coordinator of CARBOCHANGE, details some of the key findings of the project.

★ What is your prediction model based on?

Christoph Heinze: Our work consisted in quantifying CO₂ transfer between the ocean and the atmosphere as well as carbon fluxes within the ocean itself, by means of a combination of observational datasets and models.

The observational datasets, which included sea surface data as well as water column data of the oceanic carbon system, were used in combination with predictive and diagnostic models. The Earth system models employed for projections based on emission scenarios are among the most complex and demanding computer programmes human brains ever created.



Since the marine carbon cycle is influenced by physics chemistry and biological action, an interdisciplinary team was needed to tackle the challenge of quantifying changes in the carbon budget under a changing climate.

★ **What are the main findings of the project, in terms of factors strongly affecting oceans' reduced carbon uptake?**

There is evidence of substantial regional and temporal variations of the air-sea CO₂ fluxes on various time scales, up to an order of magnitude of plus or minus 50% for certain oceanic domains. The same holds true for variations of oceanic uptake of human-produced CO₂ from the atmosphere.

However, a transient weakening in ocean carbon uptake in one ocean basin can be compensated by increased uptake at another location. All in all, the annual marine CO₂ uptake rates have been able to more or less keep pace with the increase in atmospheric CO₂ so far: The annual percentage of new human-caused CO₂ emissions taken up by the oceans globally is rather constant.

However, future projections with Earth system models, either fully fledged complex model systems or so-called Earth system models of intermediate complexity, reveal that this may change once emissions of CO₂ further accumulate in the atmosphere and climate change accelerates in the coming decades. A more sluggish ocean circulation in combination with a decrease in seawater buffering ability at high sea surface CO₂ concentrations will induce a weakening of the ocean CO₂ uptake efficiency. Exciting new results include the effect of increasing bacterial decomposition of organic matter in the ocean water column and the decrease in biogenic aerosol emissions to the atmosphere under rising temperatures. Both feedback effects will accelerate global warming.

★ **More generally, what would you say are the most groundbreaking achievements of CARBOCHANGE?**

The project team has achieved a series of key results. I will name just a few. First of all, the team has contributed to Earth system model projections as a basis for the assessment reports of the Intergovernmental Panel on Climate Change (IPCC), to the annual updates of the Global Carbon Budget issued via the Global Carbon Project, and to the most complete and highest quality observational ocean carbon data collections ever collected (SOCAT for the surface ocean and GLODAP for the three-dimensional ocean). CARBOCHANGE has thus been a key contributor to huge international research efforts, and this has been acknowledged by our colleagues worldwide.

Other results worth mentioning include the discovery that, in order to limit global warming, ocean acidification, ocean de-oxygenation, and land biomass loss, stronger CO₂ emission reductions are necessary in comparison to what it would take to

tackle only global warming. We also found that progressing ocean acidification is unequivocally affecting also the deep ocean as well, with potential biodiversity loss especially among vulnerable deep-sea organisms. Finally, we provided evidence that combined stressors for marine ecosystems will become increasingly critical in the coming decades, whereby the evolving hot spots can be estimated from models.

★ **Did you face any difficulties during the project and how did you resolve them?**

As scientists we are always operating at the boundaries of our abilities. This makes our profession both tiring and exciting at the same time. We had no major logistical difficulties during this project — the consortium worked extremely constructively. One emerging issue, however, was that the systematic combination of observational data sets with complex ocean models was even more difficult than we expected at the beginning of the project. We could achieve some important improvements of models and new insights into carbon uptake processes through such data assimilation procedures. But in order to use the observations of the present ocean to their full potential, one first would have to systematically calibrate Earth system models for a situation representing the unperturbed pre-industrial world. However, solving this problem will require repeated, highly expensive computer model runs. This is a challenge to be re-addressed in future work.

★ **How will seas and oceans be affected by the various climate change scenarios?**

Here it can clearly be said that smaller amounts of further emissions per year will result in better resilience of the oceans to anthropogenically-induced forcing. Ocean warming and CO₂ uptake from the atmosphere develop over long timescales, from decades to tens of millennia. Even if we immediately stopped emitting further CO₂ from fossil fuel burning, land use change and cement manufacturing into the atmosphere, the ocean would come back to a quasi-equilibrium both physically and chemically only after several tens of thousands of years.

But it is also important to note that projections on marine CO₂ uptake under so-called green emission scenarios (with strong, imminent reductions in human-caused CO₂ emissions) show that in this case, the remarkable buffer capacity of the ocean for CO₂ will come more effectively into play. If human societies could achieve emission levels foreseen in the RCP2.6 or at least the RCP4.5 scenario, damage to the Earth system could be limited. At present the world is still under the 'business as usual' RCP8.5 scenario — a development of serious concern.

★ **What do you hope will be the impact of your research?**

Human societies need to move quickly to a sustainable use of resources and a decarbonised energy production. Our research

helps find optimal pathways for climate mitigation to tackle global climatic and environmental change. The quantification of the marine carbon sinks and sources with respect to the atmosphere is also essential for keeping track of the fate of human-produced CO₂. Where is it ending up, what controls its cycling, have we overlooked key processes so far?

We have developed methodologies to observe and simulate the ocean carbon cycle over the long term with a suite of methods which complement each other. These techniques will have to be extended and applied in the future as well, as CO₂ emissions are still increasing strongly. Also, with respect to the verification of national greenhouse gas budgets, accurate knowledge of the ocean carbon sink is essential, as quantifications of air-sea CO₂ fluxes of larger areas can be done more precisely than for land areas. Therefore, if we want to understand continental changes, knowledge about the marine realm is key. The quantification of ocean carbon state variables under CARBOCHANGE through models and observations is key to acidification impact studies. Relevant communities now have a wealth of data available to scale their impact experiments.

★ **Do you have any plans for follow-up research now that the project has ended?**

We have concrete plans to continue with an extension of our research. This includes new and additional sensors on autonomous floats and gliders for CO₂ partial pressure, pH, oxygen and other variables, and also an extension and continuous support of routine carbon measurements from commercial ships. We are already busy upgrading our ocean models with improved process representations for the next round of climate projections for international assessments. New versions of the

international ocean carbon data syntheses are already on their way, and we also see great potential in developing new concepts for marine ecosystem modelling.

A key issue for the coming years will be to improve annual carbon budgets both globally, and also basin-wide and nationally. We are developing new approaches for optimally estimating the progressing CO₂ invasion into the ocean and also how the corresponding air-sea CO₂ surface fluxes vary. Bringing down uncertainties in these variables will contribute to a sound greenhouse gas budget verification system of high political relevance for the coming 10 years. Collaborative projects coordinated and carried out at EU level have proven an efficient means of pushing the limits in greenhouse gas research and optimally exploiting their results for a hopefully sustainable future.



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CHRISTOPH HEINZE

CARBOCHANGE

- ★ Coordinated by the University of Bergen in Norway.
- ★ Funded under FP7-ENVIRONMENT.
- ★ http://cordis.europa.eu/project/rcn/97547_en.html
- ★ Project website: <https://carbochange.b.uib.no/>

QUIETENING THE OCEANS

Researchers from a number of Member States have joined forces to investigate and mitigate the effects of underwater noise generated by shipping.

Cavitation is a noisy, vibration-inducing phenomenon where water 'cold-boils' at low pressure, causing shock waves when the cavitation bubbles collapse upon entering areas of higher pressure, resulting in noise bursts. This underwater noise, created by ever-increasing maritime traffic, may negatively affect large sea mammals and fish.

The EU-funded SONIC (Suppression of underwater noise induced by cavitation) project has been working for almost three years now to understand, map and minimise background noise caused by shipping.

SONIC has brought together world-leading hydrodynamic institutes, noise

experts, propeller designers, universities, European shipyards and marine biologists to develop guidelines for determining and mitigating the underwater noise emitted by shipping in the North Sea. The team has developed techniques to model cavitation noise computationally and experimentally at model scale.

Two full-scale observation trials have been carried out by the team. The first trials, successfully completed between August and September 2013, were carried out on two vessels supplied by the University of Newcastle in the UK. The most recent trials, completed in September 2014, were carried out by a team from the University of Newcastle (on-board measurements) and Southampton University (off-board measurements). The teams successfully conducted the noise emission trials covering a good range of speeds over a reasonable distance from the hydrophones, in some cases, using two different types of hydrophone deployments. The information from these trials will feed into the mapping exercise that the team is

carrying out on the spatial distribution of sound caused by a single ship (a noise footprint) and sets of ships in an area (a noise map). The measurements are also useful for studying various methods of measuring the underwater noise of shipping in general and ships specifically.

When the SONIC project is completed in September 2015, the cavitation noise models will have been validated, resulting in guidelines for determining and mitigating the underwater noise levels of ships. The European Commission can use the noise mapping methods to determine the underwater sound levels in European waters. Quietening the oceans in this way will improve the environmental status of European waters and the welfare of marine life.

SONIC

- ★ Coordinated by MARIN, the Maritime Research Institute Netherlands.
- ★ Funded under FP7-TRANSPORT.
- ★ http://cordis.europa.eu/result/rcn/158619_en.html
- ★ Project website: <http://www.sonic-project.eu/>

"When the SONIC project is completed, the cavitation noise models will have been validated, resulting in guidelines for determining and mitigating the underwater noise levels of ships."

INTERVIEW

DO MACROALGAE HABITATS HELP SUSTAIN FISH POPULATIONS IN THE MEDITERRANEAN?

Whilst the importance of phytoplankton (microalgae) as a primary producer for coastal ecosystems and thus fish production is well documented, the importance of macroalgae and seaweed in the preservation of fish stocks remains obscure. Thanks to the LINKFISH project, scientists now better understand how specific characteristics of macroalgae habitats can help populations of juvenile fish to thrive.

According to Dr Hilmar Hinz, Marie-Curie Fellow at the Spanish Institute of Oceanography, whose research is supported under the EU-funded LINKFISH (Investigating the link between sub-littoral algae habitats and fish communities in the Mediterranean Sea) project, the lack of scientific understanding of macroalgae ecosystems is the consequence of limited scientific attention. Most research efforts in the Mediterranean so far have concentrated on sea grasses or deeper demersal systems, while algae habitats have been less well studied despite being equally widespread.

To fill this knowledge gap and feed into the ecosystem approach to fisheries management — which aims to identify, conserve and restore habitats critical to fish in order to regenerate and sustain their populations — Dr Hinz has conducted in-lab research and Mediterranean scuba-diving to analyse these habitats, their productivity and the biodiversity of associated benthic fauna and to determine how energy is transferred from algae to juvenile fish.

Completed in May, the project focused on shallow water system habitats (*Cystoseira*) for its experimental work, due to its traceability, but also investigated two deep water systems (*Osmundaria* — *Phyllophora* and *Peyssonalia*) that occur widely in the Mediterranean. In this interview with the *research*eu results magazine*, Dr Hinz elaborates on the importance of his research and how it increases our understanding of the ecology of macroalgae habitats.

★ What are the main objectives of the project?

The main goal of the project is to understand the importance of macroalgae as an essential habitat for juvenile fish in coastal systems of the Mediterranean.

We know that most coastal ecosystems in the Mediterranean are oligotrophic, meaning that there are very few nutrients in the water and therefore the production of plankton (microalgae) is relatively low when compared to other areas such as Northern European Seas.

“The richer and more complex an algae community, the higher the density of prey and juvenile fish.”

Macroalgae and sea grasses represent the primary producers of organic matter and therefore the main source of biological production sustaining coastal

food chains. They are home to a diverse micro-fauna mainly consisting of tiny crustaceans which are a primary food source for juvenile and small fish, and they also provide structural shelter from larger predators.



DR HILMAR HINZ

Our research is trying to assess which algae species and which type of associated fauna may be particularly important for the transfer of energy to juvenile and small fish. Coastal algae habitats are currently under increasing pressure, and detailed understanding of their functional importance is thus far only sketchy. We hope that our project will be able to add some important details that may be useful in the future for the assessment of habitat quality in Mediterranean Europe's waters.

★ How do you explain the current lack of research dedicated to macroalgae habitats?

In the Mediterranean, research on coastal systems has mainly been focused on seagrass beds, deeper demersal systems and Marine Protected Areas. Rocky reef habitats where algae dominate, despite their proximity to the shore and intensive human usage, have not been as intensively studied in particular with regards to their importance for fish. This is because studying juvenile fish in rocky shores poses considerable logistical challenges: juvenile fish of 2-6 cm in size are not easily caught and traditional fishing methods with trawls or gillnets cannot be used.

★ What was your methodology for this research?

The project had various components. We have tried to combine observational studies in the field with laboratory experiments. The observational part of the study has been completed, while the experimental part is still ongoing and will be continued by the host institution after the end of my Marie Curie Fellowship funding.

Conducting the observational studies required several intensive field surveys with the collection of algae and fish samples by means of scuba-diving. *In situ* observations of

fish and algae were made along dive transects to identify the various algae habitats prone to the presence of juvenile fish, and the diet, condition and isotopic signature of different size classes of juvenile fish were determined for areas with distinct algae coverage.

In the laboratory experiments, we are now trying to test the patterns we observed on site in a more controlled manner, in order to get a better understanding of the mechanistic link between algae, their associated fauna and fish.

★ **What have you discovered with regards to juvenile fish dependency on macroalgae?**

The results are still very preliminary and we are still at the stage of analysis, but it appears that some algae types — especially algae that are long-lived and structurally complex such as *Cystoseira* — contain a higher density of prey compared to less structured algae morphotypes. This means that the feeding potential and thus habitat quality for juvenile fish is related to algae composition. So far, our observations seem to suggest that the richer and more complex an algae community, the higher the density of prey and juvenile fish. We still need to identify the mechanisms behind this fact, as algae may also serve as shelter for fish, and observed higher densities in these more complex habitats could also be associated with reduced predation. Hopefully the results of our ongoing laboratory experiments will shed some light on this.

★ **What about potential threats to these macroalgae?**

Macroalgae are predominantly found in the coastal rocky shore. Due to their proximity to human activities, they are under increased anthropogenic pressure and thus more likely to be affected by environmental changes. Some algae such as the above-mentioned genus *Cystoseira* are in decline and have disappeared from many coasts of the Mediterranean because of reduced water quality which is itself caused by an increased urbanisation of coastal areas.

Furthermore, algae communities are under pressure from the introduction of alien species in the Mediterranean. For example the rabbit fish, a herbivore fish with a huge appetite for algae, is able to transform areas of previously healthy algae cover into barren rock with only a thin layer of turf, with obvious consequences for other fish. The introduction of alien algae species also has consequences for the overall native composition of algae communities, with as yet unknown consequences for other ecosystem components.

★ **The project will be ending in May. How do you expect its results to impact the ecosystem approach to fisheries management?**

Hopefully we will be able to highlight the importance of certain algae habitats for juvenile fish. On the basis of this work, we might be able to classify coastal habitat quality for juvenile fish on a larger scale and incorporate this into spatial management plans. Through the promotion of this knowledge, we hope to be able to sensitise marine stakeholders and the general public to the value of these habitats and hopefully initiate conservation efforts that would help preserve these ecosystems and secure future fish production.

★ **What are your plans for future research, if any?**

I will remain in Spain to continue my research, as I successfully applied for a National fellowship funding scheme Ramón y Cajal. I am planning to pursue this new line of investigation which has opened up for me as a result of the Marie Curie Fellowship funding. Additionally I am planning to continue my involvement in fisheries-related EU projects and to pursue my research into the effects of fishing on benthic ecosystems.

LINKFISH

★ Coordinated by the Spanish Institute of Oceanography in Spain.

★ Funded under FP7-PEOPLE.

★ http://cordis.europa.eu/project/rcn/104077_en.html



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EXPLORING MARINE PROTECTED AREAS IN THE MEDITERRANEAN

The Mediterranean supports a rich diversity of marine life, which is the focus of conservation efforts. The EU-funded DEMARN project, which concludes towards the end of this year, is investigating how best to designate and manage these sites for marine conservation.

Many endangered species live in the Mediterranean Sea, including some that are completely unique to that area. The Mediterranean is almost totally enclosed, which exacerbates the problem of pollution, and its coastline is subject to unregulated development and over-exploitation.

Therefore, there is a great need for an enhanced set of 'Marine protected areas' (MPAs) which restrict human activities to conserve precious natural species and habitats.

Since the project began in November 2011, the DEMARN (Designation and

management of marine reserve networks) team has been studying MPAs off the coast of Israel and other Mediterranean countries. Researchers have explored the spatial character and conservation needs of MPAs and identified challenges posed by both society and institutions that are often

SPECIAL FEATURE

left out of the decision-making process.

Research conducted by DEMARN is divided in two main parts. The first involved mapping and analysing the context within which MPAs are established and designed. The second identified the factors that influence conservation planning outcomes from MPAs that fail to follow conservation planning best practice. The main decision-making support tool under focus in the project has been zoning.

"The project's findings will help support decision making about where efforts and finances should be directed."

A case study was conducted at the Rosh HaNikra Protected Area, which is a small reserve off the Israeli coast that is seeking to expand. The focus

was on the reserve's management regime, including proposed zoning, its ecological attributes and potential contribution to marine conservation in the eastern Mediterranean.

DEMARN has also been involved in researching the relationship between higher levels of protection for MPAs and factors such as conservation efforts and level of dependence on the maritime economy. In March 2015, DEMARN published a new paper on this topic in the Journal of Nature Conservation. Titled 'Conservation "Identity" and Marine Protected Areas Management: A Mediterranean case study', it examined the relationship between a country's 'protection level' (PL) score and its conservation efforts, economic conditions and human impact along the coast. The paper found that certain contextual factors — particularly economic dependence on the marine environment, efforts at terrestrial conservation and greater

human impact — were significantly associated with higher PLs among the northern littoral countries of the Mediterranean.

The work conducted by DEMARN is particularly important as all the world's seas, but especially those around Europe and North America, face increasing exploitation and development. The project's findings will help support decision making about where efforts and finances should be directed. This will encourage successful ecosystem management and integrated coastal zone management for marine reserves.

DEMARN

- ★ Coordinated by Technion — Israel Institute of Technology in Israel.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158494_en.html
- ★ Project website: <http://demarn.net.technion.ac.il/>

OPEN OCEAN BACTERIA AND ZOOPLANKTON

Marine scientists have compared the composition of a free-living bacterial community in the Atlantic Ocean with one associated with a type of zooplankton known as a copepod. The results offer valuable insights into the biological and geochemical processes that take place in the open ocean.

The EU-backed ROMEO (Role of crustacean zooplankton on prokaryotic community composition in the Mesopelagic Ocean) project combined zooplankton ecology with microbial oceanography. The aim was to investigate the influence of zooplankton on the composition and activity of the prokaryotic community in the open sea of the North Atlantic. Prokaryotes are simple single-celled organisms and comprise two main groups: archaea and bacteria.

Samples of small planktonic crustaceans known as copepods were collected during two research voyages in the North Atlantic Ocean. Scientists examined the gut content of different species of copepod to obtain a detailed picture of the composition of the prokaryotic community they contained. This was compared with the composition of the prokaryotic community in the surrounding water.

The data obtained was used to investigate the difference between the bacterial composition associated with the copepods and the bacteria community collected from the open ocean. The copepod and bacterioplankton samples were collected from the same location from boundary depth layers of about 750 m and 100 m.

Results showed significant differences between the bacterial communities associated with the dominant types of copepod and the surrounding water. *Bacilli* and *Actinobacteria* dominated the copepod-associated community, whereas *Alphaproteobacteria*, *Deltaproteobacteria* and *Synechococcus* dominated the free-living community.

However, the presence of shared bacterial DNA sequences known as operational taxonomic units between these two distinct habitats indicates an exchange of bacteria with seawater and copepods. These results support the hypothesis that the interior and exterior surfaces of copepods provide a specific ecological niche. This niche involves a strong selective pressure that favours bacteria.

ROMEO results provide greater knowledge of the interaction between zooplankton, the main food source for North Atlantic fish, and prokaryotes. Prokaryotes are the main drivers of the oceans' biogeochemical cycles. Therefore, the project impacts our understanding of how these different groups of organisms play a major role in open sea ecosystems.

ROMEO

- ★ Coordinated by the University of Vienna in Austria.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158636_en.html





BIOLOGY AND MEDICINE

EMPOWERING PATIENTS AND IMPROVING TREATMENT OF PARKINSON'S DISEASE

A personal health system helps Parkinson's patients manage their symptoms while providing doctors with a rich source of information from continuous monitoring.

More than 1 million people in Europe live with Parkinson's disease today and this number is expected to double by 2030 as the population ages, according to the European Parkinson's Disease Association.

The EU-funded REMPARK (Personal Health Device for the Remote and Autonomous Management of Parkinson's Disease) project promises to provide relief to Parkinson's patients and to help doctors improve treatment. Researchers are developing a patient health system that detects and records the current motor state of the patient and helps the patient restore nearly normal movement.

'Besides helping the patient manage their symptoms, the system also provides feedback to their doctor for more accurate follow-up of the disease,' says Professor Joan Cabestany, the project's coordinator and a member of the Department of Electronics Engineering at the Universitat Politècnica de Catalunya (UPC).

Recovering walking rhythm

The complete REMPARK system consists of a sensor worn at the waist, a smartphone acting as a gateway for sending and receiving information, a server receiving the data and communicating with medical staff, an auditory cueing system and a sensory functional electrical stimulation device. The sensor monitors the motor status of patients in real time and is able to identify the specific symptoms of Parkinson's. It evaluates patients' so-called 'ON/OFF/ Dyskinesia status'. 'ON' indicates that the patient is able to move almost correctly, while 'OFF' indicates that the patient is having trouble moving and may be experiencing the trembling or other involuntary muscle spasms that often characterise Parkinson's.

When a patient begins to have difficulty moving smoothly, an earphone connected to the system plays a rhythmic click much like a metronome. This gait guidance system helps the patient recover and perform daily activities.

Continuous information at your fingertips

Neurologists typically only see their Parkinson's patients a few times throughout the year, and thus only have access to a snapshot of the patient's status. With the REMPARK system, however, neurologists can view and analyse the disease's evolution. The patient's 'Body area network' (BAN) sends data to the server in the cloud via the patient's smartphone. This information can be accessed by the physician remotely to evaluate the state of the patient and monitor evolution of the disease. Using the system, the physician can then provide feedback to the patient.

'The system helps doctors identify trends,' explains Professor Cabestany. 'They can examine data over any time frame.'

'The sensor is a device that can be used right now to improve patient monitoring. Doctors can measure disease evolution over a whole day or any other period, in ambulatory conditions as the patient goes through a normal day,' says Professor Cabestany.

Using the insights gained from their analysis, neurologists can adjust patients' treatment regimes accordingly, and stay within the 'therapeutic window' where the desired effects of medications outweigh any adverse effects.

This availability of information is good for not only doctors, but also patients. 'When patients know how many hours they were ON/OFF, they can learn to manage their symptoms better by making adjustments in their daily routine or environment,' says

Professor Manuel Moreno, a colleague of Professor Cabestany's at UPC's engineering faculty.

Alerts

If a sufferer gets into difficulties without realising it, the system can prompt them via a message to their smartphone so that the patient becomes more aware of their body state and can react accordingly.

In case of an emergency, for example a fall, the system can alert the patient's family, physician or a call centre.

REMPARK ran from 1 November 2011 through to 30 April 2015 and received EU funding of EUR 3.3 million. The project conducted trials in ambulatory conditions with 43 patients from four medical centres in Spain, Italy, Ireland and Israel over the course of several months starting in September 2014.

REMPARK

- ★ Coordinated by the Polytechnic University of Catalonia in Spain.
- ★ Funded under FP7-ICT.
- ★ http://cordis.europa.eu/result/rcn/160040_en.html
- ★ Project website: <http://www.rempark.eu/>
- ★  <http://bit.ly/1yJEAou>

BRAINS WARP TIME TO GAIN INFORMATION

Professional baseball players often report feeling as if the ball slows as they are preparing to strike it with their bats. EU-funded researchers have conducted the first study that provides scientific data supporting this anecdotal observation.

Movies sometimes show an accident about to happen in slow motion so that the audience sees it mirrored on the actor's face as he or she prepares to try and avoid it. According to recent research by EU-funded scientists, it turns out that our brains in fact slow down or dilate time while preparing to act. The project ACTION AND TIME (Perception of time during action preparation) demonstrated that visual sensory perception is modulated by preparation for a movement related to that input.

Subjects were shown a visual stimulus, a white disk, on a computer monitor. They were asked to judge its duration as either short or long. Control subjects were not asked to do anything. In the experimental condition, the subjects were instructed to reach out toward a second disk that appeared on the monitor right after the white disk disappeared.

Results showed that the visual stimulus was perceived to have a longer duration only when an action was prepared. In addition, the amount of time dilation was related to the degree of motor preparation, manipulated by the uncertainty that an action would be required. Interestingly,

preparation for action not only dilated time perception but also slowed down the perceived frequency of a flickering stimulus. Experiments also showed that this slowing down was linked to an increased capacity for visual information processing.

As the first scientific study to support reports by baseball players that the ball seems to slow before they swing the bat to hit it, it received widespread media attention. The findings were broadcast by the British Broadcasting Corporation (BBC news), Le Figaro, the Austrian Broadcasting Company and CBS News in the United States.

In addition to its inherent value in the deeper understanding of nervous system function, the project's outcomes are relevant to many fields in which action in response to a stimulus is required. These include athletics, gaming, and just about every type of job involving manual labour or vehicle operation. Better understanding of related mechanisms can eventually help manufacturers to create better products, players to hone their senses and employee training programmes to have the most impact.



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ACTION AND TIME

- ★ Coordinated by University College London in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159630_en.html

UNVEILING THE AETIOLOGY OF INSULIN RESISTANCE

Obesity is considered the epidemic of the 21st century. Understanding the aetiology and pathophysiology of obesity should facilitate its prevention, diagnosis and treatment.

Insulin resistance is a common denominator in many metabolic-related diseases and obesity. However, the mechanism that causes insulin resistance is not completely understood. Emerging evidence indicates that the presence of certain pro-inflammatory cytokines such as 'Hepatocyte growth factor' (HGF) in adipose tissue is closely associated with obese subjects and the development of metabolic disease.

Although the role of HGF in the activation of glucose metabolism and in the inhibition of fatty acid oxidation is well established, little is known about its role in insulin resistance. Seeking to address this, the EU-funded HGF-INSR (Hepatocyte growth factor and insulin resistance) consortium generated transgenic mice expressing HGF in skeletal muscle and mice lacking the HGF receptor in skeletal muscle.

Looking at the impact of HGF in these mice, they observed reduced plasma insulin levels and improved glucose tolerance, despite similar body weight. The results were even more striking when HGF was overexpressed in the muscle of obese mice, with improved total body glucose metabolism and insulin sensitivity.

The consortium worked under the hypothesis that HGF improves insulin sensitivity. They also performed anthropometric measurements in normal and obese children to find an association between plasma HGF levels and insulin resistance in obese children. HGF levels were also higher in pre-term neonates, suggesting a potential role in foetal maturity.

To understand the association between maternal obesity and foetal metabolism, scientists measured the levels of HGF in amniotic fluid. Their findings clearly supported a mechanistic link between HGF with glucose and lipid metabolism in neonates. They suggest that HGF modifies the availability of nutrients to the foetus, thereby



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increasing the risk of metabolic diseases such as obesity and diabetes later in life.

Taken together, the results of the HGF-INSR study underscore the importance of HGF in insulin resistance and the development of metabolic diseases. Furthermore, they indicate that HGF could be reliably used as a diagnostic marker for predicting obesity or diabetes.

HGF-INSR

- ★ Coordinated by the University of Castilla-La Mancha in Spain.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159663_en.html

A MICRO LOOK AT EPILEPSY

Epilepsy, affecting millions of people globally, is a condition where spontaneous unpredictable seizures occur in the brain. This potentially dangerous condition occurs due to abnormal neuronal network communication in the brain.

Our knowledge about the role of neural microcircuits or hub neurons in epileptic activity is very limited. To identify what changes cause epilepsy, the EU-funded project HUBS IN EPILEPSY (Functional connectivity and the role of hub neurons in epilepsy) investigated their functional and anatomical structure in the brain.

Researchers aimed to identify the key elements in the neural microcircuitry that causes epilepsy. For this purpose, they employed *in vitro* and *in vivo* calcium imaging as well as histological investigation of epileptic tissue. The pilocarpine mouse model of temporal

lobe epilepsy was chosen for its similarity to human brain pathology.

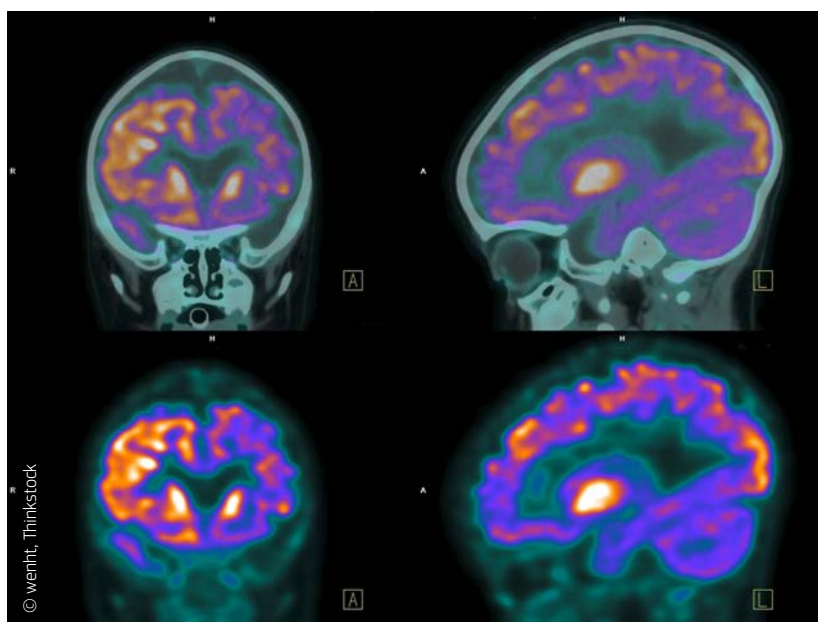
Results linked epileptiform activity to the co-activation of spatially localised neuronal assemblies. However, recurrent epileptic activity was found to be due to co-activation of different clusters of neurons rather than the same neuronal subsets.

Contrary to a previous hypothesis, GABAergic (gamma-aminobutyric acid) interneurons in the hippocampus play a key role in interictal bursts. Interictal bursts are the signals seen in the period between seizures or

“Recurrent epileptic activity was found to be due to co-activation of different clusters of neurons rather than the same neuronal subsets.”

epileptic episodes in the brain in an electroencephalogram.

To elucidate epileptogenesis — the transition of a normal brain into epilepsy — researchers employed immunohistochemistry on tissue samples from epileptic mice. Despite extensive



cell death during epileptogenesis, early-born GABAergic or glutamatergic neurons survived.

Project activities have shed novel insight into the mechanisms underlying epilepsy at the micro scale. Further research endeavours in this arena can now focus on characterising the role of GABAergic or glutamatergic neurons in epileptiform activity. These findings could also lead to the development of more effective therapies for this debilitating condition.

HUBS IN EPILEPSY

- ★ Coordinated by INSERM in France.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159662_en.html

LYMPHOCYTES VERSUS HEPATITIS B VIRUS: CAUGHT IN ACTION

For the first time ever, two ERC grantees, Prof. Luca G. Guidotti and Dr Matteo Iannacone, have observed *in vivo* how specific white blood cells, so-called cytotoxic T lymphocytes, identify, target and attack liver cells that are infected with the hepatitis B virus. To witness these immune cells in action in real time, the two scientists developed advanced, dynamic imaging techniques.

An estimated 240 million people are chronically infected with hepatitis B worldwide. This discovery, published recently in the scientific journal *Cell*, opens new horizons for the development of novel therapies.

Cytotoxic T lymphocytes are the armed soldiers of our immune system. They circulate throughout the body's blood vessels searching for infected or transformed cells, seeking

to destroy them. However, how these lymphocytes actually reach and attack liver cells infected by the 'hepatitis B virus' (HBV) has remained unknown for a long time. Prof. Guidotti and Dr Iannacone have now captured,

"The blockade of the fenestrae may inhibit the capacity of the tiny tentacles to reach target cells, thus reducing the efficiency of our immune system in tracking altered liver cells."

in real time and from the inside, the body's immune response during the various stages of an HBV infection of liver cells.

Crawling sentinels with lethal tentacles

In *Cell*, the researchers report how cytotoxic T lymphocytes are alerted by small blood cells, called platelets. These build a 'sticky mat' within the liver's smaller blood vessels (so-called liver sinusoids), in order to attract circulating lymphocytes where they are needed and to block their unhindered further patrolling in blood. After docking to platelets, the cytotoxic T lymphocytes start slowly crawling within the liver sinusoids, even against the bloodstream direction.

'As they crawl, the lymphocytes start deploying tiny tentacles — 10 000 times smaller than a millimetre each — slipping them through small natural holes in the vessel wall called fenestrae,' explain the two Italian scientists based at the San Raffaele Scientific Institute (SRSI) in Milan. 'Once identified, the same tentacles serve to inject deadly toxins into infected cells situated on the other side of the vessel wall, while the lymphocytes remain inside the blood vessel.'

Prof. Guidotti and Dr Iannacone's observations also help in explaining why liver fibrosis — a condition frequently observed during chronic HBV infection where the fenestrae are reduced in number and diameter — is such a predisposing factor for the development of liver cancer. The blockade of the fenestrae may inhibit the capacity of the tiny tentacles to reach target cells, thus reducing the efficiency of our immune system in tracking altered liver cells.

According to the most recent World Health Organisation estimations, over 240 million people are chronically infected by the hepatitis B virus, and each year approximately 780 000 people die from disease complications. These latest scientific findings open innovative and important scientific horizons that could help to develop new treatments against liver diseases, including cirrhosis and liver cancer.

The best equipment, back at home

'These results are the outcome of research started many years ago in the US. We then realised that we needed better technology to further understand how the disease progresses in the liver of mice. Back at home, the ERC grants helped us to develop the most modern high-resolution microscopes and state-of-the-art imaging methodology.

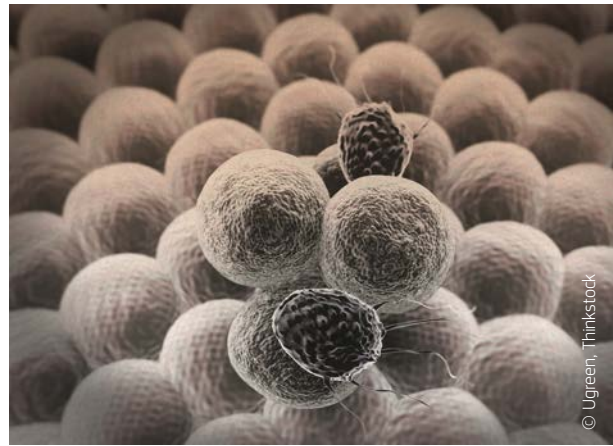
In Milan, we have now one of the best research facilities worldwide to film, record and analyse what happens live and *in vivo* at the level of a single cell,' say Prof. Guidotti and Dr Iannacone.

After almost 20 years as a faculty member at The Scripps Research Institute in La Jolla, California, Prof. Guidotti joined SRSI in 2009 as Head of the Laboratory of Immunopathology. Since 2013, Prof. Guidotti has also served as Deputy Scientific Director of SRSI.

Dr Iannacone was a member of Guidotti's research team in California between 2002 and 2007 and then joined Harvard Medical School in Boston, Massachusetts. He moved to SRSI in 2010 to head the Laboratory of Dynamics of Immune Responses.

Since arriving in Milan, these two independent scientists have worked together, supported by ERC grants.

'The ERC grant is the reason why we unexpectedly came back to Europe and a unique opportunity to carry out risky research,' conclude Prof. Guidotti and Dr. Iannacone.



LIVER IVM AND HBV

- ★ Coordinated by San Raffaele Hospital in Italy.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <http://erc.europa.eu/projects-and-results/erc-stories/lymphocytes-versus-hepatitis-b-virus-caught-action>

LOOKING INTO CELL DIFFERENTIATION

In vitro differentiation of embryonic stem cells is a field of immense importance for regenerative medicine. A high-throughput live cell imaging study has allowed for better understanding of differentiation dynamics.

Patients have a host of previously unavailable options thanks to *in vitro* generation of hepatocytes to treat liver failure or cardiomyocytes to address acute coronary disease. The EU-backed DIFFEBIMG (Differentiation dynamics in size-controlled embryoid bodies) project focused on 'embryoid bodies' (EBs), 3D aggregates of differentiating embryonic stem cells.

fluorescent embryonic stem cell markers. Scientists conducted several live imaging experiments to monitor the effect of focal signalling on early mesodermal differentiation.

The system developed for wild type and interventional monitoring and analysis of spatiotemporal developmental changes in 3D tissue is a unique tool. Studies into differentiation and

signalling events will help to elucidate connections between signal and cell fate.

DIFFEBIMG

- ★ Coordinated by Tel Aviv University in Israel.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159656_en.html

"Scientists developed two types of growth assays for EBs, one using microfluidic devices and another in microwell arrays."

Scientists developed two types of growth assays for EBs, one using microfluidic devices and another in microwell arrays. Microfluidic devices allowed for monitoring interactions between the isolated pairs of cells. Formation of uniform-size EBs containing patches of cardiomyocytes took place within the microwell arrays. Growth and differentiation were observed over two weeks.

A two-photon laser scanning microscopy system helped to unravel the relation between the signalling events and differentiation decisions using



SLIDES THAT IMPROVE OPTICAL PROPERTIES

Real-time imaging of live cell and tissue samples provides an important tool that can be used to link structures and signalling pathways to functions. A novel nano-structured microscopic slide enhances resolution and efficiency, and could provide a new window on cellular mechanisms.

Techniques that support wide-field high resolution, good contrast, and high-data-acquisition rates and signal processing are required for real-time cellular imaging. Important advances in fluorescence-based microscopy have not been able to achieve both high-speed capture of images and high spatial resolution simultaneously for a truly real-time molecular dynamics imaging platform.

Fluorescence techniques suffer resolution issues due to the wave nature of light. EU-funded scientists developed biocompatible artificial mesoscopic structures and nanostructures with fundamentally new optical properties. Within the project SMARTS (Super-resolution fluorescence microscopy based on artificial mesoscopic structures), scientists developed materials that can be used as microscopic slides to study live cellular processes.

The novel artificial material has been optimised and characterised, including testing for biocompatibility. Nanofabrication methods were demonstrated to be simple and cost effective. Culturing of live cells was straightforward following common protocols and resulted in an amazing axial resolution of approximately 10 nm. Furthermore, the advanced technique eliminates the need for scanning, greatly minimising image acquisition and processing time. Results have been published in the prestigious

peer-reviewed journal *Proceedings of the National Academy of Sciences* (PNAS).

Researchers exploited their nano-structured material in a study of 'Förster resonance energy transfer' (FRET). This is a fluorescence imaging technique exploiting a donor fluorophore and a receptor fluorophore. It is an excellent sensor at very short distances, but not useful at all for longer distances. The team showed that, through a quantum mechanical effect (the ability of the nanostructure to support surface plasmon modes), their nanostructures can amplify a very low FRET signal. This is a very important finding because most other techniques shown to 'boost' FRET have not been biocompatible.

The end of the SMARTS project does not signal the end of the technology development. The team fully plans to incorporate the materials and techniques into a functional imaging platform within the next two years. Collaboration with a prominent lab studying cellular signalling via FRET promises to accelerate optimisation and commercialisation.

SMARTS

- ★ Coordinated by the University of Würzburg in Germany.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159641_en.html

BLOOD: THE FORCE OF DEVELOPMENT

The complex molecular and cellular interactions that take place during development are poorly understood. Using zebrafish as a model organism, European researchers have studied how blood flow affects embryo development.

In the developing embryo, it is well established that cells divide, migrate and differentiate in response to environmental cues. However, it remains unclear how biological systems sense their environment and how positional information is associated with geometrical constraints.

The first functional organ in the developing embryo is the heart, underscoring the importance of the cardiovascular system and blood flow in growth. The scope of the EU-funded FLOWBUILT (Biological flows and embryonic development) project was

to delineate the role of blood flow early on in development and identify the molecular pathways it activates. Scientists were mainly interested in studying vessel formation during embryogenesis.

For this purpose, they chose zebrafish as the model organism, mainly due to its optical transparency and ease of genetic manipulation. In addition, zebrafish embryos do not need heart function during the first five days of development, making them excellent models for addressing the roles of flow forces during angiogenesis.

By combining novel imaging methods and blood flow modelling, researchers were able to characterise blood vessel biomechanics during vessel formation. The models of the entire zebrafish vascular network indicated that the stress in newly formed vessels is significantly influenced by red cells in the blood. At the molecular level, blood flow was also discovered to impact on endothelium maturation. Through the study of heart valve mutants, the consortium elucidated the effect of blood flow on certain cellular

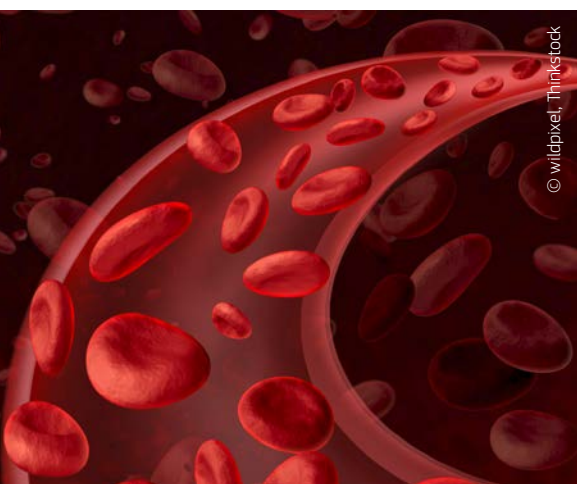
rearrangements that take place during valve formation.

Considerable effort was devoted to identifying mechanisms in the developing endothelium that can sense the blood flow. Scientists discovered that cell protrusions known as cilia extend from endothelial cells during angiogenesis and serve as detectors of the flow forces. This finding led to elucidation of the role of blood flow during heart development in health and disease.

Taken together, the results of the FLOWBUILT project provide fundamental insight into some key mechanisms that drive embryo development. The data generated emphasises the role of blood flow in vessel formation and heart growth, and could be used to understand congenital cardiomyopathies.

FLOWBUILT

- ★ Coordinated by CERBM in France.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159644_en.html



SOCIAL SCIENCES AND HUMANITIES

POSTURE AFFECTS INFANTS' CAPACITY TO IDENTIFY OBJECTS, STUDY FINDS

The iCub robot has helped advanced scientific understanding of word-object mapping, thanks to joint efforts from the ITALK and POETICON++ projects.

Generally taken for granted, our capacity to immediately recognise, name and associate thousands of objects with memories — under various viewing conditions — still remains a mystery. It is well-known that top-down knowledge arising from previous experience with our environment plays a key role in this process. But what if there is no such knowledge, such as when infants suddenly start mapping words to objects? Is the learning process strictly relying on repeated word-object associations, or do things like spatial location and body posture have an impact as well?

To find out, scientists at Indiana University teamed up with two EU-funded projects — ITALK (Integration and Transfer of Action and Language Knowledge in Robots) and POETICON++ (Robots need Language: A computational mechanism for generalisation and generation of new behaviours in robots) — to run tests on a humanoid robot model and later verify the results in new infant studies. Various experiments were conducted on the robot, including one with two different objects being placed on its right- and left-hand side — in a way that forced the robot to position itself differently to view one or the other. Once the robot turned left, the name of the left-hand object was pronounced, and the other way around.

After repeating the two object presentations several times, the team proceeded with no object in view, and then with objects visible but not being named. Finally, the locations of the two objects were changed, and the robot kept making the right name-object association in 71% of tests. When the body variable was removed from all experiments, however, this score only reached 46%. Tests on infants showed very similar results.

'This study shows that the body plays a role in early object name learning, and how toddlers use the body's position in space to connect ideas,' said Linda Smith from Indiana University, who conducted the study. 'A number of studies suggest that memory is tightly tied to the location of an object. None, however, have shown that bodily position plays a role or that, if you shift your body, you could forget.'

The robot used for this study is none other than iCub, a humanoid robot developed under the EU-funded project ROBOTCUB and adopted by over 20 laboratories worldwide. The robot, which is characterised by its highly realistic body movements, is also central to the ITALK and POETICON++ projects, which provided it with the capacity to acquire complex cognitive and behavioural skills based on infant-inspired language learning.

'The creation of a robot model for infant learning has far-reaching implications for how the brains of young people work,' Smith concludes. Whilst additional research is needed to determine whether the link to posture for learning is limited to infants, this link has potentially wide-ranging implications. Many problems related to motor development are tied in with cognitive developmental disorders, and this relationship remains poorly understood. It is hoped that the study will help to advance scientific knowledge in this field.

POETICON++

- ★ Coordinated by the Italian Institute of Technology in Italy.
- ★ Funded under FP7-ICT.
- ★ http://cordis.europa.eu/news/rcn/122663_en.html
- ★ Project website:
<http://www.poeticon.eu/>
- ★  <http://bit.ly/1E9i7nG>

RECONSTRUCTING PERSEPOLIS

Renewed reflections on an ancient urban landscape have been made possible, revealing archaeological information in the process.

Persepolis is a Unesco World Heritage Site in Iran; the city was built by King Darius I (520–486 BC). As a result of modern-day human pressure and intensive cultivation, what landscape does remain of the Achaemenid period is disappearing over time. Remnants of ancient settlements are hard to locate. Thus, the only way to do so while still preserving the ancient remains is to embark on studies that combine archaeological survey methods.

“The field surveys have led to the discovery of numerous previously unknown sites.”

That was precisely the aim of the EU-funded SELOPERSE (Settlement and landscape organisation of the Persepolis region) project, along with defining the layout of what appears to be an uncommon, loose and very

open plan of the ancient city. A joint Iranian–Italian expedition was set up to carry out the work. Intensive survey methods such as field walking and geophysical surveys, as well as excavations in certain areas, were used to prove the hypothesis of the ancient urban landscape.

One of the main results was uncovering sections of a monument from the early Achaemenid period, which helped provide details on the city’s development. Our works also allow us to estimate the surface area of the Persepolis Royal Precinct, as a result of discovering a new monumental complex. Furthermore, surveys on the foothills in the area revealed quarry remains. These provide evidence for marking out the boundary between the city and its territory.

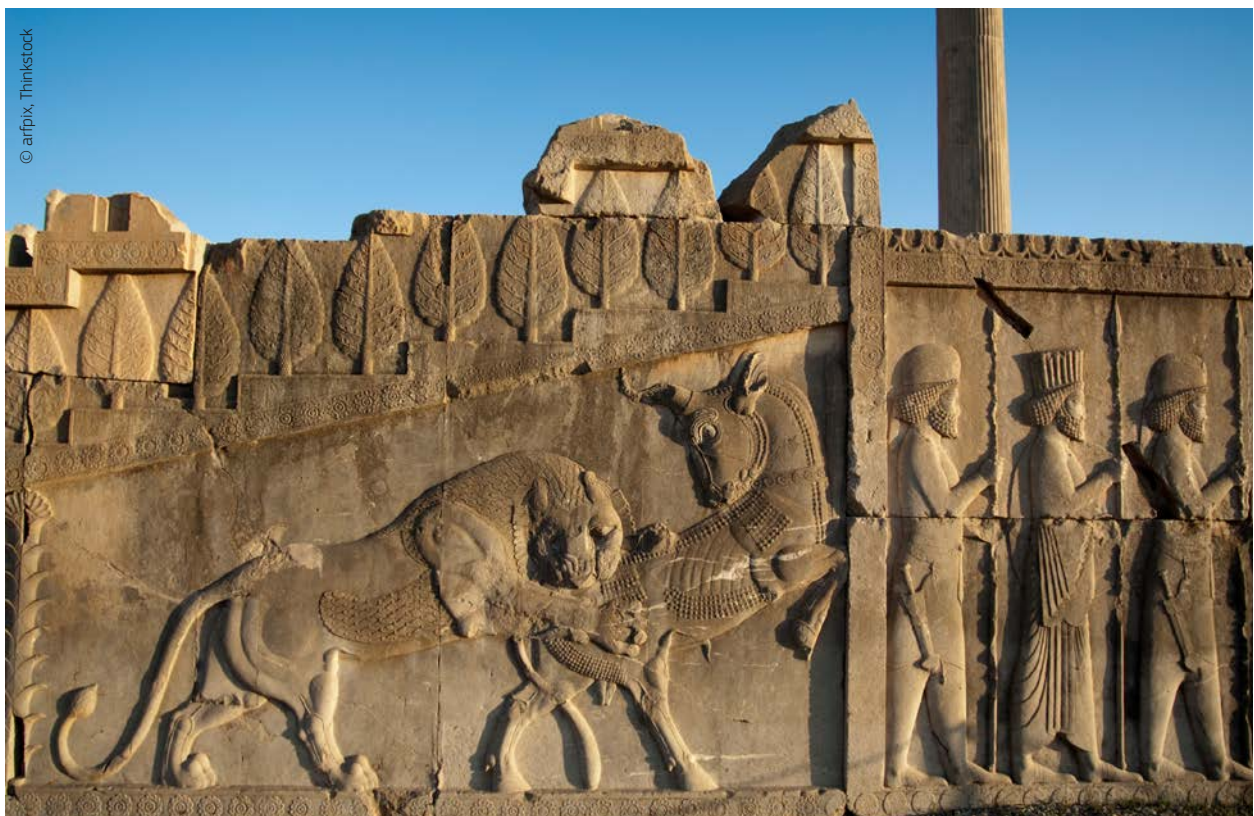
Fieldwork also provided a way of testing new methods for surveying landscaped areas by developing adaptations of field strategies using prototype instruments. For example, focusing on the magnetic properties of soil provides a way of tracing

ancient human activity. Researchers investigated many dozens of hectares via large-scale sampling. The maps obtained reveal part of the mosaic of interwoven built and unbuilt areas that shape Persepolis city.

With the project findings, new directions in research have emerged that can be useful for planning international programmes on the Achaemenid settlement system over the entire ancient Near East.

SELOPERSE

- ★ Coordinated by the University of Bologna in Italy.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158612_en.html



EXPLORING NON-URBAN ROMAN SETTLEMENTS

Decentring urban centres of ancient Rome as the only place of societal and cultural development sheds new light on the traditional notion of Roman colonies.

Non-urban settlements during the time of Roman colonial expansion, namely the 4th to 2nd centuries BC, have until now not been widely identified and studied due to scholarly bias. Therefore, a major challenge presents itself for scholarship in this field today.

An innovative approach has been applied by the EU-funded WORLDVIL (A world of villages: dispersed settlement and colonial expansion in Central-Southern Italy under the Roman Republic (c. 4th-2nd centuries BC)) project to compare colonial settlement organisation with contemporary non-colonial control areas of the Roman Republic in central and southern Italy. Special emphasis was placed on non-urban settlements.

Through an intensive archaeological field survey and geophysical analysis, the project set out to examine a new concept of early Roman colonisation not based on an urban model. The team reviewed archaeological data of two colonial territories to systematically compare settlement patterns in two similar landscapes that were not colonised. The field surveys have led to the discovery of numerous previously unknown sites.

Based on promising results, an expansion of the project is planned for the future. A research group was created to target a much larger scope that expands to the regions of Molise and



Basilicata. Results have been disseminated in Europe and the United States via presentations, reports and publications.

WORLDVIL

- ★ Coordinated by the University of Glasgow in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159706_en.html

COPING WITH A MULTITUDE OF UNCERTAINTIES

Groundbreaking research has linked the relationship between the simultaneous occurrence of poverty, violent conflict and natural disaster, and the effect it has on household well-being.

People in developing countries often face a multitude of uncertainties such as climatic shock and violent conflict, which can happen simultaneously. Being economically vulnerable while also politically

political violence and drought have on child nutrition. Andhra Pradesh, a state in southern India, was used as a context for the analysis.

Two important results were found. One is that drought has negative effects on child nutrition, but only in communities affected by violence. The other is that political violence has major negative effects on child nutrition due to reducing the ability to cope with drought conditions.

An interesting finding was that during a ceasefire period the effects of drought reversed. Furthermore, the isolation that households face due to conflict has consequences on how well they can cope, since access to public goods and services is restricted.

Another aspect the project examined is how economic expectation is impacted. First, individuals in conflict areas perceive bad outcomes to be much more likely than individuals in

low- or non-conflict areas. Second, even after 40 years of violent conflict, people are still sensitive to changes in the configuration of conflict patterns. This suggests that short-term recovery could be possible and that negative effects on outlooks on life and hopelessness are (at least partially) reversible.

Important lessons can be learned from the findings in terms of how to cope with the impact of conflicts and uncertainties at the household level.

“Drought has negative effects on child nutrition, but only in communities affected by violence.”

insecure and facing natural disasters can devastate people's overall livelihood. Just how communities and households cope under such circumstances has not been fully examined.

In light of this, the EU-funded POVCON (Poverty in the face of conflict) project delved into how armed conflict can impact ways in which people cope with levels of uncertainty. More specifically, it looked at the effect that

POVCON

- ★ Coordinated by the Institute of Development Studies in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158585_en.html

THE IMPACT OF EMPLOYMENT SYSTEMS ON CAREERS

Researchers have studied how alternative work systems and organisational practices affect an individual's career development path.



The current employment system is in a state of transformation. Organisations have moved towards a more decentralised model of decision-making, empowering their lower-level employees to make decisions that before were left up to the managers. In addition, there has been a dismantling of 'Internal labour markets' (ILMs) which has led to a new model of career development between organisations. Companies have moved towards a model of distributed workforce and it is not uncommon to find people working on the same team but across different geographical boundaries. Relevant research is needed to investigate how these transformations have changed the traditional model of career advancement.

The main research goal in the EU-funded WSCA (Work systems and career advancement) project was to investigate how new work systems and organisational practices have affected individuals' career advancement.

The first study within the WSCA used a United States matched employer-employee representative sample to investigate how giving more voice and decision-making power to employees affected employee promotions. This study found that individuals who are in jobs with high-involvement practices obtain more opportunities for promotion.

Another study examined whether the dismantling of ILMs has also affected the career patterns of successful executives. The study found that current executives have shorter tenure, hold shorter-duration jobs, are less specialised and hold more graduate degrees than their equivalents three decades ago. This suggests executives have migrated towards a model of external careers.

"Having the manager separated from the worker may actually improve performance in some cases."

A further study investigated how the movement towards a mediated labour market, for example via head-hunters and online job boards, has affected career outcomes, specifically wages and access to employment. One important finding is that these intermediaries replicate some of the biases that already existed in organisations, and in some cases they may even have exacerbated them. Finally, another study looked at an aspect of work distribution, manager-worker separation, and found that having the manager separated from the worker may actually improve performance in some cases.

Dissemination of the study's results has taken place through academic and practitioner publications. The information is relevant for use in literature on careers and management. Furthermore, it can contribute to debates on participatory work systems and on income and opportunity inequalities.

WSCA

- ★ Coordinated by the IE Foundation in Spain.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159705_en.html



ENERGY AND TRANSPORT

SUGAR AND JUTE AEROPLANE PANELS

The aerospace industry is committed to reducing the environmental impact of its activities. An innovative EU-funded project focused on the use of biodegradable biocomposites rather than the more commonly addressed reduction in emissions.

Stringent requirements for certification and the harsh environments to which composite materials are subjected pose formidable challenges to the use of natural materials. Through the EU-funded project BME CLEAN SKY 027 (Development of an innovative bio-based resin for aeronautical applications), scientists met these challenges with novel epoxies that can replace conventional mineral oil-based plastics.

Researchers set out to synthesise resins from sugars obtained from sources that do not compete with foods. In order to meet aerospace requirements, they planned to integrate natural fibres to improve mechanical properties and apply a surface treatment to reduce flammability. Component synthesis was conducted according to principles of green chemistry, energy efficiency, environmental and health safety, and scalability.

Scientists prepared multifunctional epoxy resins using glucose as a starting

point. The team then synthesised three types of flame-retardant compounds using environmentally friendly agents that produce the harmless by-product ethanol. Four epoxy resin systems were fully characterised and one — based on 'glucofuranoside' (GFTE) — was selected for up-scaling.

Investigators then compared a variety of natural fabrics, including three types of hemp, three types of jute, two types of linen and a hemp-linen mix. Based on strip tensile test results and availability, a plain jute fabric was chosen to reinforce the epoxy resin and improve mechanical properties.

The flammability of natural fabrics is an important issue. Two types of eco-friendly flame-retardant surface treatments (ammonium phosphate and aminosilane) were investigated in isolation and in combination. The combination provided the best balance of reduced

flammability and increased thermal stability.

Foam-core sandwich panel composites were manufactured from the bio-based GFTE matrix. Test results to determine utility as internal floor panels demonstrated that the panels significantly outperformed the conventional synthetic matrix sandwich structures. BME CLEAN SKY 027 has thus paved the way to use of eco-friendly biocomposites in lieu of carbon fibre-reinforced synthetic plastics in a variety of aeroplane interior applications.

BME CLEAN SKY 027

- ★ Coordinated by Budapest University of Technology and Economics in Hungary.
- ★ Funded under FP7-JTI.
- ★ http://cordis.europa.eu/result/rcn/158628_en.html

WIRELESS SENSING UNDER THE HOOD

'Wireless sensor networks' (WSNs) in cars could reduce costs, weight and fuel consumption while enhancing performance. Researchers have used advanced experimental and simulation tools to address their technically challenging implementation.



Electronic control units' (ECUs) in cars are increasing in number and complexity. The complexity and weight of their associated wiring harnesses for transmission of data and power to all the distributed sensor and actuator components is also increasing. WSNs could be the solution.

However, designers must ensure the same level of reliability, latency and data rate in transmitting real-time sensing data. Doing so within the highly dynamic environment of vehicles and with limited available energy is no easy task. Scientists developed an experimental platform and mathematical descriptions of behaviours with EU funding of the project IWWSN (Intra-vehicular wireless sensor networks). They used them to measure and analyse the physical layer channel characteristics at various sensor locations within an intra-vehicular WSN.

Having selected 'ultra-wideband' (UWB) wireless radio frequency technology, scientists then sought to fill gaps in current knowledge. Most UWB channel measurement campaigns have been conducted in non-vehicle applications

or with a focus on the passenger compartment or trunk for vehicle tests. In addition, none addressed small-scale fading, the changes caused by small changes in transmitter or receiver positions with minimal changes in the environment around them.

IWWSN developed a physical layer model accounting for both small-scale and large-scale fading. The latter is caused by significant changes in the position of the transmitter or receiver and/or in the environment around them. The detailed channel model was applied to a UWB channel beneath the chassis and within the engine compartment. Scientists were thus able to investigate for the first time ever small-scale fading characteristics and the effect of vehicle motion on large-scale and small-scale parameters.

For the medium access control layer, scientists developed a new scheduling algorithm to provide the maximum level of adaptability. It accommodates changes in transmission time, retransmissions due to packet losses and additional messages. Further, it does so while satisfying packet generation period, transmission delay, reliability and energy requirements. Scheduling was optimised for both one-ECU and multiple-ECU cases.

IWWSN has significantly advanced our understanding of the behaviours of intra-vehicular WSNs. Implementation of WSNs will lead to major reductions in the costs, complexity and weight of vehicular ECUs with enhanced performance.

IWWSN

- ★ Coordinated by KOC University in Turkey.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159658_en.html

EFFICIENT SOLAR CELLS MAY SOON BE CHEAPER

An EU-funded project carried out an in-depth characterisation of hybrid 'solar cells' (SCs) using advanced spectroscopic techniques. Project activities are enabling the design of custom-made organic-inorganic heterojunctions for high-performance SCs.

Displacement of energy-related carbon dioxide emissions crucially depends on developing low-cost and widely accessible routes

to clean energy generation. From all renewable energy sources, solar energy has by far the greatest potential. However, the inorganic solar cells available on the market are currently too expensive to compete with conventional power sources.

Hybrid inorganic-organic SCs are an emerging technology holding great potential for cheap fabrication. Based on a nano-structured junction, they combine cheap and abundant organic materials with the advantages of inor-

ganic materials in terms of stability and charge transport. The EU-funded project CHOIS (Characterisation of hybrid inorganic-organic solar cells by advanced spectroscopic methods) sought to further enhance understanding of the hybrid SC's working mechanisms to ultimately achieve high conversion efficiencies.

Initially, scientists characterised a state-of-the-art hybrid 'cadmium sulphide' (CdS)-polymer system through

"CHOIS contributed to further enhancing understanding of the mechanisms of hybrid SCs and determining a way to fabricate efficient ones."

transient absorption spectroscopy. Results showed that excitations in CdS have a longer lifetime, leading to the conclusion that charge generation is not limited to small domain sizes. Scientists also found the main loss processes limiting charge generation in the polymer used.

The next step was to use an inorganic material with a broader absorption spectrum to harvest more of the solar spectrum. Given their broader absorption spectra, antimony and bismuth sulphides were identified as promising alternatives to CdS, with the former exhibiting higher conversion efficiencies. Its minimised energy losses were attributed to charge separation.

Based on these findings, scientists proposed new material combinations to produce more efficient hybrid SCs. Dense layers of antimony sulphide were fabricated and tested in SCs with a polymer as a hole conductor, demonstrating efficiency of above 3%. Given that the inorganic material was the main active component, such SCs were classified as solution-processed inorganic SCs.



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CHOIS contributed to further enhancing understanding of the mechanisms of hybrid SCs and determining a way to fabricate efficient ones. This should promote development of hybrid SCs with a solution-processed heterojunction, paving the way to producing alternative and inexpensive SCs.

CHOIS

- ★ Coordinated by the Imperial College of Science, Technology and Medicine in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159595_en.html

A BETTER FOLDABLE BIKE

Imagine an extremely lightweight bicycle that folds and unfolds and has optional electrical assistance. Researchers have designed this personal vehicle as a pleasurable individual urban mobility tool, to be used in conjunction with all other types of transportation.



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Thanks to the EU-funded BIKE INTERMODAL (THE INTERMODAL BIKE - Multi-modal integration of cycling mobility through product and process innovations in bicycle design) project, the better foldable bicycle is here. Many foldable models have already been produced, but within the established standards of the bicycle industry. These standards prevented the foldable bicycle from coming of age.

With a nod to global warming, small two-wheeled vehicles, bicycles, electric bicycles, scooters and the like are the solution for individual urban transport.

The new design is modern and vertically integrated with an automotive-type supply chain. It is economically efficient and scalable, while being environmentally certified, technologically reliable and low maintenance.

Researchers overcame the volume and weight problems that affect all other folding bicycles currently on the market. The resulting folded bike package is just slightly bigger than a briefcase (40x50x15 cm). Folded, it occupies just 30 litres as compared with 90 litres, the most

“CHOIS contributed to further enhancing understanding of the mechanisms of hybrid SCs and determining a way to fabricate efficient ones.”

compact model on offer in the global market. Unfolded, it is a normal bicycle height, suiting cyclists ranging from 155 to 192 cm in height. The personal vehicle can be equipped with a powerful, miniaturised motor, a welcome option for many urban users.

It has been designed in a way that makes it easy to update individual parts of the main system. The integrated design, hierarchical assembly and lean manufacturing have reduced the materials and parts list, and halved the material per product unit. The number of parts needed to construct this personal vehicle is one fifth of the number needed to construct a traditional foldable bicycle.

BIKE INTERMODAL's technological advancements have provided a newer, better and higher-performing product for, among others, urban commuters and fleet services

(car rentals, cruise ships, hotels) and for emergency mobility. The bicycle created by this project appeals to royals and workers, young and old alike. The personal vehicle will now be mass-produced and widely marketed.

BIKE INTERMODAL

- ★ Coordinated by Trilix in Italy.
- ★ Funded under FP7-TRANSPORT.
- ★ http://cordis.europa.eu/result/rcn/159593_en.html
- ★ Project website:
<http://www.bike-intermodal.eu/>
- ★  <http://bit.ly/1IFAvLq>

AFRICAN BIOFUELS COME AT WHAT COST?

A recent project has looked at how biofuel crops influence ecosystem services and human well-being in Sub-Saharan Africa (SSA).

Biofuel crops like jatropha and sugarcane are increasingly cultivated worldwide for their economic value. However, there is little understanding of the overall impact of biofuel crops on ecosystems and the socio-economic status of people relying on those ecosystems.

The EU-funded ABIOPES (Rapid assessment of biofuel potential and impact on ecosystem services) project used

an ecosystem services framework to judge the direct and indirect impacts of biofuel production.

“Jatropha, sugarcane and oil palm cultivation negatively affect food and fodder provision, water availability, biodiversity and soil erosion.”

Researchers began by reviewing the literature around biofuel crop production,

and categorising the impacts based on effects on ecosystem services. They found that jatropha, sugarcane and oil palm cultivation negatively affect food and fodder provision, water availability, biodiversity and soil erosion.

These changes in turn impact on income, food/fuel security, access to land and public health. Overall, biofuel production led to major trade-offs in these areas for communities within an ecosystem.

In another part of the ABIOPES project, scientists surveyed two jatropha projects in southern Africa: a large plantation and a smallholder project. They found that the major effect of these plantations was a decrease in land available for food production. Researchers did note a small positive impact through increased income for farmers and labourers.

Finally, ABIOPES produced a policy report highlighting the impacts of biofuel production on human well-being in SSA. This project will bring clarity to the debate around biofuels policy in a changing world.



ABIOPES

- ★ Coordinated by the University of Oxford in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159586_en.html

ENVIRONMENT AND SOCIETY

ENZYMES — A NEW WEAPON IN THE WAR ON DRUGS IN WATER

Conventional water treatment technologies do not remove all of the pharmaceutical residues currently found in wastewater. Helping to eliminate a potential health threat, an EU-funded project has shown that enzymes can be used to neutralise these drugs when treating wastewater.

Pharmaceuticals — synthetic or natural chemicals used in human and veterinary drugs — are a great boon to society. However, as humans and livestock naturally excrete these chemicals after ingesting them, they eventually end up in wastewater.

Conventional wastewater treatment technologies are currently unable to remove all of these chemicals, and small amounts end up accumulating in Europe's rivers, lakes and ground water.

Some of these chemicals have been detected in drinking water, though at tiny concentrations 'very unlikely' to pose an immediate risk to health, says the World Health Organisation (WHO).

Even so, the best strategy is to remove all pharmaceuticals from wastewater, preventing them from entering the water system in the first place. The EU-funded ENDETECH (ENZymatic DEcontamination TECHnology) project, which ended on 31 January 2015, has shown the way by demonstrating that a purification system using enzymes — proteins that act as catalysts for chemical reactions — could be developed to

neutralise potentially harmful pharmaceuticals — antibiotics, hormones and endocrine disruptors.

'ENDETECH demonstrated in the lab that such a system could work,' says project coordinator Pierre-Alain Bandinelli of Da Volterra in France. 'Enzymes could be a natural way of removing pharmaceuticals from wastewater. While the technology is still in early stage development and needs to be scaled up, it should be considered as part of the arsenal of approaches used in treating wastewater.'

Targeting endocrine disruptors

ENDETECH began by developing tests or assays that identified new enzymes able to inactivate four antibiotics that are not easily captured by conventional water treatment technologies — tetracycline, erythromycin, sulfamethoxazole and ciprofloxacin.

The project's researchers then developed a way to incorporate these enzymes on beads and filtering membranes.

In the ENDETECH concept, wastewater would flow along the beads or through the membranes, where the enzymes would neutralise the targeted pharmaceuticals.

The researchers also identified enzymes to neutralise tetracycline, an important and commonly used antibiotic for humans and livestock. Lab tests on wastewater samples showed the enzymes removed some of the tetracycline traces after one day — a sign that ENDETECH's research was on the right track.

The project also tested other enzymes against endocrine disruptors. This class of drugs can interfere with the endocrine systems of humans and animals, potentially leading to diseases such as cancer, birth defects and other health problems. Endocrine disruptors are also known as 'gender benders', as they can suppress the testosterone hormone in males, leading to abnormalities.

The lab tests showed that ENDETECH's technology reduced endocrine disruptors in wastewater — a 'promising result', says Bandinelli.

Next steps

ENDETECH's research has provided researchers with a method for searching for and pinpointing enzymes that neutralise specific pharmaceuticals. The project also developed a method for incorporating these enzymes in beads and membranes for use in treatment plants.

"While the technology is still in early stage development and needs to be scaled up, it should be considered as part of the arsenal of approaches used in treating wastewater."

More research is needed to make the technology more effective and to scale it up for use in treatment plants, says Bandinelli. Since the project has just ended, the partners involved have not yet made a decision on the way forward and are considering further development of the technology.

He adds: 'Taking action to remove this type of environmental pollution is becoming a necessity as European and national regulations are becoming stricter to ensure water remains safe to drink and to protect the environment.'

ENDETECH

- ★ Coordinated by Da Volterra in France.
- ★ Funded under FP7-ENVIRONMENT.
- ★ http://ec.europa.eu/research/infocentre/article_en.cfm?artid=34456
- ★ Project website: <http://www.endetech.eu/>

CONTROLLING FLOWERING TIME IN PLANTS

A recent research project has found key proteins that control flowering time in plants, resulting in an unprecedented understanding of this economically important process.

The process by which plants change from a vegetative to a reproductive state has intrigued horticulturalists and agrarian researchers for decades. Recent

evidence suggests that chromatin-modifying proteins control this switch in biological states. Chromatin is the complex of DNA, RNA and proteins found in cell nuclei.

With EU funding, the FLOWERING CHROMATIN (Control of flowering time by chromatin remodelling) project aimed to elucidate the control of this important biological function using several different biochemical and molecular biology tools.

Researchers focused on two chromatin-remodelling complexes, SWR1 and NuA4, which are common to most plants, animals and fungi. Specifically, FLOWERING CHROMATIN investigated proteins SWC4 and YAF9 (common to both SWR1 and NuA4 complexes in yeast) in *Arabidopsis thaliana*, a model flowering plant.

Studies of these proteins confirmed that they did indeed form part of a chromatin-remodelling complex in *A. thaliana*. Researchers found that both proteins regulate the expression of key genes that control flowering.

Scientists studied the mechanism of action further, finding that these flowering genes are controlled by altering the chromatin structure. Known as histone deposition, this alteration of chromatin leads to a large increase in gene activity in a particular area of the genome.

The findings of FLOWERING CHROMATIN will be useful in the search for improved crop performance in the face of global climate change. Further, this work improves scientists' understanding of chromatin regulation and remodelling in plants.

FLOWERING CHROMATIN

- ★ Coordinated by INIA in Spain.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159592_en.html



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VOLCANO ROCKS SHED LIGHT ON ERUPTIONS



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Researchers have compared rocks formed inside and outside of volcanoes to better understand how and when eruptions occur.

Magma can form two types of rock: plutonic rocks are formed when magma cools underground, and volcanic rocks are formed when lava cools above-ground. Comparing volcanic and plutonic rocks may hold clues to the timing and magnitude of volcanic eruptions, but this is currently difficult to do.

The EU funded the IMAPS (The pluton-volcano connection: Integrating processes, volumes and time scales in magma plumbing systems) project to compare juxtaposed volcanic and plutonic materials from exposed volcanic systems in the United States. Researchers aimed to use this comparison to shed light on processes that occur kilometres below the surface of the Earth.

IMAPS selected three exposed calderas in the United States where plutonic and volcanic rocks are found in the same region. Samples of both types of rocks were collected from these sites.

Researchers then undertook an extensive laboratory analysis of these samples using state-of-the-art geochemical techniques. In particular, they studied the composition, texture, crystal structure, presence of trace elements and changes in the rocks over time.

Scientists working on the project found that plutonic rock close to the surface is responsible for most violent volcanic eruptions. Perhaps more important, they found evidence of

a 200 000-year cycle of activity in these volcanoes up until activity stopped for no discernible reason.

By comparing different types of igneous rocks, IMAPS has given scientists a better understanding of volcanic activity. This will contribute to long-term predictions of volcanic eruptions, which may potentially save thousands of lives.

IMAPS

- ★ Coordinated by the University of Durham in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159657_en.html

“Scientists working on the project found that plutonic rock close to the surface is responsible for most violent volcanic eruptions.”

SCREENING FOR ENVIRONMENTAL CONTAMINANTS

Water is essential to life, but every year millions of chemicals produced, together with their reactants and by-products, enter the water cycle. Many of these chemicals currently remain unidentified, and the risk posed to human health and the environment cannot be fully determined.

Awareness is growing over the presence of organic contaminants in the water cycle, but current monitoring strategies focus on a limited selection of priority pollutants. However, recent advances in high-resolution liquid chromatography mass spectrometry have enabled previously undetectable organic contaminants to be detected.

The EU-backed CONTAMINANTID (Integrated Computational Techniques for Non-Target Screening of Environmental Contaminants using High Resolution Mass Spectrometry) project improved the identification of organic contamination in water by developing an automated procedure that searches compound databases. Current database searching strategies were explored to produce more efficient and user-friendly identification efforts during routine monitoring.

As database searching does not always deliver the right answer, researchers also developed identification strategies based on structure generation. This considered all possible molecules, not just those in the database. The result is a far more effective workflow, which incorporates the latest identification procedures

from the environmental and metabolomics fields.

Compounds known as benzotriazoles are among the most highly concentrated contaminants in wastewater effluent. An investigation was therefore conducted using structure generation to identify the transformation products of benzotriazoles. The results of this work were published in the journal *Environmental Science and Technology*.

The search for improved identification and comparability of identification methods also led to the founding of the CASMI project. The idea behind CASMI is to initiate an open contest regarding the identification of small molecules from mass spectrometry data. This has encouraged the exchange of ideas between metabolomics, environmental science and other fields.

CONTAMINANTID therefore promoted the exchange of information on metabolomics and environmental science, and its results have applications in the pharmaceutical, medical and forensic fields. Project outcomes will also improve quality of life for EU

citizens by protecting their health and the environment.

CONTAMINANTID

- ★ Coordinated by Eawag in Switzerland.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159709_en.html



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WASTEWATER IMPACTS ON FISH

Fish populations are declining in many of Europe's inland waterways, partly as a result of exposure to aquatic pollutants such as from wastewater treatment plants.

The aim of the FISHMETABOLOME (Fishing for markers of effluent exposure using metabolomics) project was to find an array of biochemicals that can identify markers for exposure of fish to wastewater effluent and the effects of this effluent on fish. In particular, researchers investigated changes in fish blood plasma metabolites and identified marker metabolites for use in monitoring fish exposure to toxic contaminants.

Sexually mature roach (*Rutilus rutilus*) were exposed either to water contaminated with effluent from wastewater treatment works or to a clean water control. After 15 days, the fish were anaesthetised and the plasma and tissues removed and analysed.

The plasma samples were extracted using techniques developed as part of the project and the samples were profiled by mass spectrometry. Chemical and biochemical markers for effluent exposure were identified and

compared with mass spectra from databases or from pure standards.

Results showed distinct differences between the control fish and those exposed to effluent for plasma, gonads, kidney and liver samples. This indicated significant changes in the tissue chemistry of effluent-exposed fish.

Contaminants identified as accumulating in fish tissue included endocrine disruptors and a mixture of many pharmaceuticals. Analyses of metabolites showed disturbances in eicosanoid, steroid, serotonin, bile acid, carnitine and sphingosine pathways.

"The non-targeted approach could be extremely useful for investigating the health effects and contaminants found in fish exposed to wastewater effluent"

Some of these metabolite disruptions could be linked to the presence of chemical stressors in the fish tissue.

FISHMETABOLOME showed that sensitive non-targeted chemical profiling techniques can be used to detect mixtures of contaminants and the disruption of key metabolic pathways in fish tissue. Exposure to effluent resulted in disturbances to several fundamental signalling pathways in fish, including ion transport, immune function and reproduction.

A reduction in androgen and an increase in serotonin metabolites were also observed, indicating potential effects on the reproduction and nervous system of exposed fish. Therefore, the non-targeted approach could be extremely useful for investigating the health effects and contaminants found in fish exposed to wastewater effluent.

The work carried out by FISHMETABOLOME can provide tools and techniques for investigating the impact of a contaminated environment on aquatic organisms. It showed

that fish in effluent-contaminated waters are highly vulnerable to exposure to several pharmaceuticals, which can affect behaviour, the immune system and reproduction.



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FISHMETABOLOME

- ★ Coordinated by the University of Sussex in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159740_en.html

HOW DUST IMPACTS HIGH-ALTITUDE ENVIRONMENTS

EU researchers have examined mineral dust deposited on Mount Elbrus in southern Russia to identify its properties, source, and the conditions for its transportation and deposition. The aim was to increase understanding of how mineral aerosols are transported in the atmosphere and their impacts on climate change.

Glaciers around the world are shrinking due to climate warming. They are also affected by the presence of mineral dust, which makes them darker and increases melt rates. The dust can originate locally or from thousands of kilometres away, and is transported in the atmosphere before being deposited on glaciated and snow-covered areas.

Dust such as that from deserts can also affect the geochemical cycles found in high-altitude environments. This is because the minerals that it contains supply oxides of iron and other nutrients to the streams, rivers and lakes fed by melting snow and glaciers.

The EU-backed DIOGENES (Dust impacts on glaciated environments) project investigated the twin threats of glacier shrinkage and impact of dust on the climate system. Field work was conducted on Europe's highest peak, Mount Elbrus in the western Caucasus mountains. The elevation of 5 642 m above sea level and its proximity to the Sahara and the Middle East makes it ideal for trapping dust.

Ice cores and cores taken from compacted snow are the best archives of desert dust deposition events. Scientists therefore extracted two

cores from Mount Elbrus and analysed them for the presence of mineral dust, chemical composition and particle size distribution.

The cores were also dated to determine when deposition of the dust occurred and to identify its original location. This was achieved using a new technique developed by DIOGENES based on satellite imagery and meteorological data. Results showed that desert dust deposition was highest between March and June. Snow melt starts in the Caucasus in May/June, therefore the timing of the dust deposition maximises its impact on glacier melt.

Methodologies developed by DIOGENES can be applied to other high-altitude regions of Europe with extensive snow cover. In addition, data on the reflectance of dust will enhance glacier and hydrological models. Knowledge of the impact of desert dust on the geochemistry of high-altitude environments has also been significantly improved.

DIOGENES

- ★ Coordinated by the University of Reading in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/157743_en.html



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IT AND TELECOMMUNICATIONS

SWITCHING EUROPE ONTO THE NEXT MOBILE GENERATION

EU-funded researchers have developed the world's first 5G radio channel model; an innovation that will help set future mobile industry standards.

While the next mobile network generation — 5G — is yet to be fully realised, the EU has committed itself to ensuring that European businesses and services are able to take full advantage when this new wave of technology arrives. Industry predicts that the speed and capacity of 5G will open the door to new applications in Cloud Computing, the 'Internet of things' (IoT)

and 'Machine-to-machine' (M2M) communications, to name but a few.

To ensure that European industry and technological

endeavour fully benefit, however, Europe must play an influential role in designing 5G infrastructure. The EU-backed METIS (Mobile and wireless communications Enablers for Twenty-twenty (2020) Information Society) project is a shining example of the serious European investment being made in 5G.

The project, which has received EUR 15.9 million in EU funding, used its final meeting in March 2015 in Turin to herald a significant breakthrough — the delivery of industry-first 5G radio channel models. These models are based on realistic end-user scenarios and requirements, and are mapped to a range of options. As 5G will support a broad

range of applications, different channel models are likely to be required.

Researchers and developers of new technologies and products will benefit from the proposed 5G radio channel models in several areas, not least in enabling them to characterise the performance of early 5G designs. For example, the models will enable technologists to run laboratory tests to predict how devices will work in real-world conditions.

The models will also allow for system performance evaluation, system optimisation, radio interface simulation, R&D testing and final product approval, ensuring that Europe will have a major say in what 5G technology will look like.

Consortium members have also been careful to ensure that the proposed radio channel models address a very wide frequency spectrum, from relatively low frequencies in the current cellular frequency bands to centimetre and millimetre wave frequencies. Some technology firms believe that new channel models will be needed for 5G — in 2020 mobile and wireless traffic volume is expected to increase a thousand-fold compared to 2010 figures — and it has been acknowledged that limited work has been done on understanding how millimetre wave systems will work in practice.

"The models will enable technologists to run laboratory tests to predict how devices will work in real-world conditions."

These models will therefore help speed up development of the next generation of wireless technology, and ensure that European business and know-how are very much in the driving seat. METIS has also helped to lay the foundation for a European — and indeed global — consensus on the future of mobile and wireless communications, providing a valuable contribution to pre-standardisation and regulation processes.

A key reason for the success of the METIS project has been the strength of its European consortium, complemented by selected non-European partners to ensure global harmonisation. The consortium brought together leading

telecommunication stakeholders, vendors, operators and academic researchers, along with a new partner from the automotive industry to provide new insight.

METIS

- ★ Coordinated by Ericsson AB in Sweden.
- ★ Funded under FP7-ICT.
- ★ http://cordis.europa.eu/news/rcn/122710_en.html
- ★ Project website: <https://www.metis2020.com/>

PLATON SUCCEEDS IN USING PLASMONICS FOR NEXT GEN ROUTING APPLICATIONS

PLATON's new 'Silicon-on-insulator' (SOI) solution combines plasmonics and silicon photonics for faster and more energy-efficient computing.

While the so-called big data revolution is still not so obvious to the general public, it is certainly happening. In 2009, global data generation amounted to some 0.79 zettabytes (1 trillion gigabytes). With the continued development of cloud computing, the increase in numbers of connected devices and the advent of the Internet of Things, this figure is expected to reach 73.5 zettabytes by 2020 — a 4 300% growth.

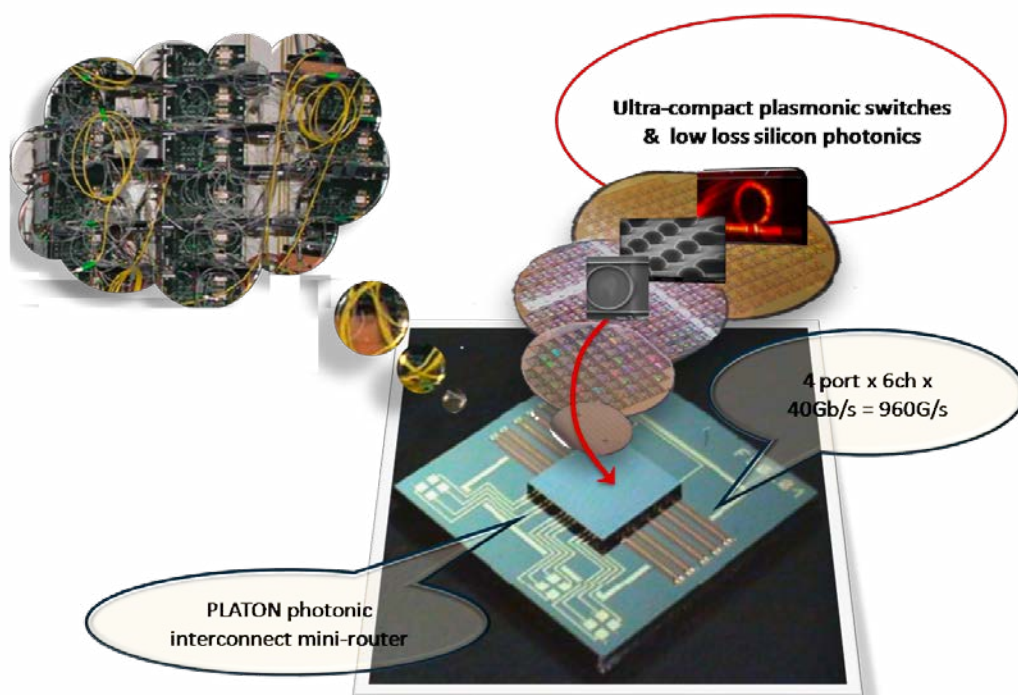
One thing that isn't changing much, however, is the way this data is stored and transferred, and this is becoming

more and more of a problem: bandwidth-limited electrical interconnects have reached their limits, and the 10 Pflops benchmark for computer performance has only been reached at the expense of excessive power consumption. While researchers generally agree that replacing electrical interconnects with optical ones is the best option, photonic devices are faced with their own limitation: they cannot reach the level of compactness of their electronic counterparts.

Completed in late March, the EU-funded PLATON (Merging Plasmonic and

Silicon Photonics Technology towards Tb/s routing \nin optical interconnects) project successfully overcame all these problems by demonstrating a new SOI platform with integrated nanophotonic, plasmonic and microelectronic components. Not only is such a combination of photonics with plasmonics a first, but it also allows for further reductions in circuit size, 'Terabit per second' (Tb/s) optical routing and increased energy efficiency.

Two years ago, PLATON researchers had already generated interest among the specialised press by demonstrating active plasmonics in a



'Wavelength-division-multiplexed' (WDM) data switching application. They had developed the smallest-ever 'Dielectric loaded surface plasmon polariton' (DLSPP) switches, capable of routing real data for BladeServer and backplane optical interconnects with a very small footprint, very low power consumption and negligible latency thanks to a novel material called Cyclomer.

"Combined with their small footprint, these devices pave the way for a new 'beyond silicon photonics' era in integrated photonics."

'Plasmonics is introduced for the first time in WDM switching applications,' Nikos Pleros, professor at Aristotle University of Thessaloniki and PLATON project coordinator, told LaserFocusWorld at the time. 'Combined with their small

footprint, these devices pave the way for a new "beyond silicon photonics" era in integrated photonics, where circuit designers can choose at will the best solution for IC performance optimisation between electrical and optical signals. Continuing progress in plasmonic technology may lead to the necessary broadband, ultra-small, and low-energy network-on-chip solutions required by computing environments.'

These WDM switches have now been used as building blocks on the 'Complementary metal-oxide semiconductor' (CMOS)-compatible SOI manufactured by project partner AMO. This also features a cavity as an interface for the integration of the plasmonic devices and two 8x1 MUX/DEMUX structures yielding a record performance of 40% in terms of high-bandwidth versus channel density ratio.

All in all, PLATON results ideally blend the small size and low power switching capabilities of plasmonics with the low

loss of silicon and processing capacity of electronics to provide miniaturised and power-efficient Tb/s photonic interconnect routers for ultra-performance data communications.

The project ran from January 2010 to March 2015. It was coordinated by the Greek Centre for Research and Technology Hellas. Other partners included Fraunhofer in Berlin, Syddansk Universitet Denmark, the University of Burgundy in France, the Institute of Communication and Computer Systems in Greece and AMO GmbH, based in Aachen.

PLATON

- ★ Coordinated by the Centre for Research and Technology Hellas in Greece.
- ★ Funded under FP7-ICT.
- ★ http://cordis.europa.eu/news/rcn/122683_en.html
- ★ Project website: <http://www.ict-platon.eu/>

REDUCING DATA UNCERTAINTY

An EU team has developed data systems that use statistical and probabilistic reasoning to reduce uncertainty. The project helped to merge such methods with conventional databases, in part by developing scalable algorithms and a variety of new tools.

Various software applications must manage and make decisions using data with high levels of uncertainty. While certain tools can fill in the gaps to some degree, such tools are generally simplistic and limited.

The EU-funded HEISENDATA (Heisendata - towards a next-generation uncertain-data management system) project aimed to improve matters. The team planned to design and build new 'Probabilistic database systems' (PDBSs), supporting statistical models and probabilistic reasoning in addition to conventional database structures. The project set out to address the challenges involved in supporting such a novel union, including the redesign of key system components. HEISENDATA ran for four years, ending in February 2014.

Project work covered three main branches: new probabilistic data synopses for query optimisation, new PDBS algorithms and architectures, and scalable algorithms and tools.

The data synopses involved defining and creating algorithms for building histograms. For various error metrics, the new algorithms constructed optimal or near-optimal histograms and wavelet synopses. Further work introduced probabilistic histograms, which allowed a more accurate representation of the data's uncertainty characteristics.

Additionally, the team addressed problems related to unstructured text containing units of structured information. The solutions further extended a leading 'information extraction' (IE) model, by developing two query approaches. The efficiency and effectiveness of the approaches were compared using real-life data sets. The result was a set of rules for choosing appropriate inference algorithms under various conditions, yielding up to 10-fold speed improvements.

The project also devised a framework for scaling any generic entity resolution algorithm, and demonstrated the framework's effectiveness. Further work helped to integrate the IE pipeline with probabilistic query processing.

HEISENDATA found new statistical methods for processing data with high uncertainties, and integrated the methods into conventional database structures. The work addressed a topic of interest to the academic and commercial sectors.



HEISENDATA

- ★ Coordinated by the Technical University of Crete in Greece.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158643_en.html

INDUSTRIAL TECHNOLOGIES

AUTOMATING LOGISTICS FOR THE FACTORY OF THE FUTURE

Mass production and packaging in factories is already highly automated these days, but the same cannot be said for logistics. Movements of raw materials and finished products still depend heavily on manual labour. However, EU-funded research on 'Automatic guided vehicles' (AGVs) means this is about to change over the next decade — and could create thousands of new jobs.

Moving raw materials and final products around factories and warehouses is a labour-intensive process, mainly using forklift trucks. It is traditionally error-prone, costly, inefficient (from both a planning and energy consumption perspective) and the cause of many accidents. Bottlenecks are a common occurrence at even the most automated factories, which complicates Just-In-Time delivery and inventory management.

The PAN-ROBOTS (Plug And Navigate ROBOTS for smart factories) project, comprising six partners in five EU

countries and supported by EU funding of EUR 3.33 million, was charged with providing innovative technologies for automating logistics operations in the so-called 'Factory-of-the-future' (FoF).

'AGVs used in factories today are still at an early stage of development. The companies using them get their Return on Investment quite rapidly, but these systems can be improved immeasurably by using on-board cameras, laser scanners and 3D mapping of facilities,' explained Dr Kay Fürstenberg, from German sensor company SICK AG which is coordinating the project.

A robot that can see round corners

PAN-ROBOTS focuses on four main work areas: exploration systems for 3D-mapping of the plant; advanced perception systems on-board the AGVs; a modern control centre for monitoring them; and cooperative infrastructure laser scanners distributed about the facility.

The most innovative technology in the project is a stereo camera with 'fish-eye' lenses, mounted on top of the AGV. It uses 3D images to constantly look out for obstacles.

The camera's 360-degree field of view ('3D perception') and safety laser scanners ('2D safety') ensure the robot has no blind spots and guarantee safety for the people who still work in the factory or warehouse. The vehicle can reverse with full vision and stops before, and navigates around, obstacles in its path. The perception system can even 'see' round corners by interacting with laser scanners at intersections.

"The advanced AGVs developed also use 50% less energy compared to manual forklifts and they are many seconds faster per operation than current AGVs."

PAN-ROBOTS underwent early tests at Coca-Cola's bottling plant in Madrid. Now the team is preparing the soft drink maker's Bilbao factory for real-world validation and a final

demonstration as the project ends in October this year.

'The results are very exciting,' said Dr Fürstenberg, 'and by trying it out at two plants, we are proving that the technology adapts to different facilities.' Results include an innovative contour-based self-localisation technology, which relies on the identification of natural landmarks in the warehouse rather than installed reflectors, saving 90% on the installation costs of a reflector-based landmarking system.

The advanced AGVs developed also use 50% less energy compared to manual forklifts and they are many seconds faster per operation than current AGVs, meaning that, in the future, fewer vehicles can do the same job. Additionally, the PAN-ROBOTS system can be installed in two instead of six months, saving on factory outage time.

First products being readied for market

Now the partners are discussing several products with existing customers.

These have a chance of being launched on the market within the next few years. Because other systems will need more effort for industrialisation, the partners are looking to launch the camera and other systems within a medium-term perspective.

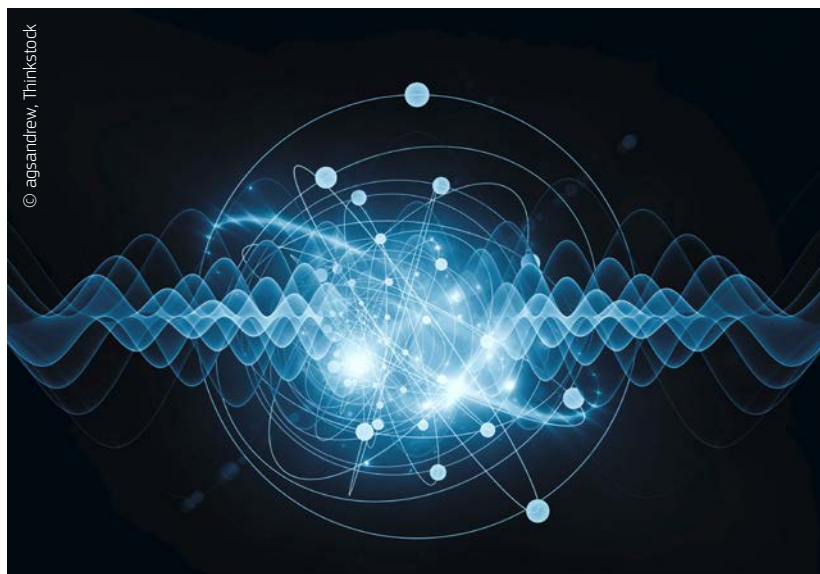
There is a good chance that half of all European factories will be operating with AGV fleets by 2030, Dr Fürstenberg believes, potentially creating thousands of new jobs at robot manufacturers and their suppliers over the next decade.

PAN-ROBOTS

- ★ Coordinated by Sick in Germany.
- ★ Funded under FP7-ICT.
- ★ http://cordis.europa.eu/result/rcn/160857_en.html
- ★ Project website: <http://www.pan-robots.eu/>
- ★  <http://bit.ly/1ELiJx>

PHOTOTECHNOLOGY THAT HITS THE BULL'S EYE

A new EU-funded research project has combined two cutting-edge technologies for major enhancements in cost-effective photodetector technology. Applications abound, from digital photography through to biomedical imaging.



The EU-funded project PEQUHOT (Plasmonically-enhanced quantum dot photodetectors) was launched to break down the barrier and demonstrate the potential. It combined two novel technologies, a type of nanostructured (quantum dot) photodetector and a plasmonic antenna.

"Scientists employed a plasmonic bull's eye structure that consists of periodically arranged concentric metal grooves."

Novel materials with unique properties drive the evolution of numerous fields and the development of exciting new devices. A new class of materials, plasmonics, exploits the interaction of light with composites

consisting of metals and dielectrics to produce optical properties not seen in nature. These metamaterials are expected to enhance the performance of many optoelectronic devices but applicability has remained elusive.

The team chose photodetectors, as detection of optical signals is critical to numerous applications. Low-cost, solution-processed quantum dot photodetectors are gaining interest. However, there has been a trade-off between speed and sensitivity. Minimising the electrically active area increases speed but the optically

active area must be large enough to capture a lot of photons. Plasmonic antennae concentrate light at the nanoscale, providing the impetus for the project.

Scientists employed a plasmonic bull's eye structure that consists of periodically arranged concentric metal grooves. The grooves concentrate and focus the light into the centre or bull's eye, enhancing transmission through a sub-wavelength hole there. They

thus reduced the electrically active area of the photodetector but maintained its optically active area with a plasmonic antenna. Experiments demonstrated that the performance of the quantum dot photodetectors was improved. In fact, the plasmonic bull's eye photodetector outperformed both references.

PEQUPHOT has provided compelling new evidence that plasmonics can enhance the performance of

optoelectronic devices. The project has made a major contribution to a growing field and strengthened the EU's competitive position.

PEQUPHOT

- ★ Coordinated by the Institute of Photonic Sciences in Spain.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/157569_en.html

QUANTUM OPTICAL DEVICES

'Photonic crystals' (PhCs) are periodic optical structures that confine or control the emission and propagation of light. Scientists have developed a way to place individual 'quantum dots' (QDs) in them for exciting new applications in photonics.

Confining photons has important applications in laser and light-emitting diode technologies because spontaneous emission in microcavities can be greatly enhanced compared to that in free space. The phenomenon can also be exploited in telecommunications and memory devices, and even in sensors for biomedicine.

Controlled placement of nano-emitters such as QDs in PhC cavities could provide an approach to real-time, ultrafast control of radiative processes, including spontaneous emission. It is expected to propel the field of nanophotonics, paving the way to realisation of complex photonic circuits, including PhC routers, switches and delay lines.

EU-funded scientists have exploited new methods for fabrication of site-controlled nano-emitters and PhC cavities through work on the project SITLEITE (Deterministic coupling between SITE-controlled, dilute nitride-based Light Emitters and tailor-made photonic-crystal structures). The final goal is integration of the PhC structures with the light emitters.

The first step was to optimise the process for producing site-controlled nano-emitters via spatially selective hydrogenation of dilute nitride semiconductor materials. Dilute nitrides have unique properties distinct from those of conventional semiconductors, including a strong dependence of the band gap on nitrogen content, making them important in applications from long-wavelength optoelectronics to photonics.

Researchers improved the properties of QDs fabricated by the process, also called in-plane band gap engineering, achieving single-photon emission. A simplified one-step application process now yields a finished mask immediately after electron-beam lithography, and facilitates a significant increase in successfully processed samples.

Further investigations on strain properties modulated by spatially selective hydrogenation of dilute nitrides point the way to control of polarisation extent and direction of wire-like structures. This was accomplished via the creation of a strongly anisotropic H-induced strain field in the plane of the sample. The same approach is under development for the realisation of tailor-made X-ray photonic structures.

Scientists then developed a simple, knowledge-based method for the design of PhC cavities, eliminating the



"Fabrication of the first set of passive PhC devices is near completion."

trial-and-error procedures currently hindering optimisation and further development. Fabrication of the first set of passive PhC devices is near completion and a series of ordered QD arrays ready for integration is currently undergoing detailed spectroscopic measurements.

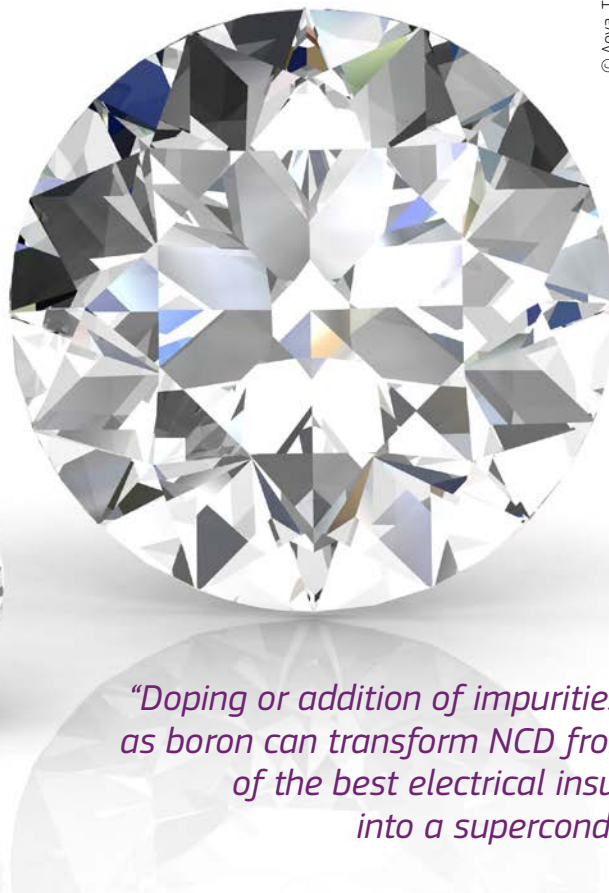
SITLEITE outcomes have been published in major peer-reviewed scientific journals. Placing single quantum objects at arbitrary points of a PhC structure promises to usher in a new era of photonic devices. Potential applications in fields from optoelectronics and biomedicine through to energy abound.

SITLEITE

- ★ Coordinated by the University of Rome in Italy.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158639_en.html

DIAMONDS ARE MICROELECTRONICS' BEST FRIEND

Diamonds do not have to be large to be valuable, at least to scientists. 'Nanocrystalline diamond' (NCD), superior to silicon for use in 'microelectromechanical systems' (MEMS), has been exploited in novel MEMS devices, attracting large industrial investment.



© Aeva, Thinkstock

"Doping or addition of impurities such as boron can transform NCD from one of the best electrical insulators into a superconductor."

The resistance of diamond to elastic (reversible) shape changes under loading (high Young's modulus) makes very-high-frequency resonators with high-quality factors possible. Conveniently, NCD is also compatible with silicon complementary metal oxide semiconductor technology, a key advantage over many other MEMS materials.

Scientists launched the EU-funded project DIAMEMS (Microelectromechanical systems from nanocrystalline diamond) largely to optimise NCD growth and planarisation. The ability to produce smooth and continuous NCD covering large areas and exhibiting bulk diamond properties could significantly reduce the price of current applications relying on bulk diamond. It could also open the door to new applications outside the MEMS field, such as tribological coatings.

Optimised nucleation and chemical vapour deposition at relatively low temperatures (400 degrees Celsius) led to uniform NCD films with thicknesses of 30 nm. Planarisation to very-low-roughness values via chemo-mechanical polishing resulted in a high-profile publication.

Integration of 'aluminium nitride' (AlN), a ceramic widely used in microelectronics, was accomplished in two different ways. The first more traditional method of growing AlN on the polished NCD surface led to surface acoustic wave devices (often used as high-frequency filters or oscillators) operating at frequencies in excess of 15 GHz. As high-precision pressure sensors capable of withstanding harsh environments, their presentation resulted in investment by

a very large telecommunications company. This approach resulted in three more publications.

The second method manipulated the voltage difference between the surface of the NCD seeds and the bulk deposition solution (zeta potential). Removing the planarisation step reduces costs considerably. This approach led to demonstration of high-frequency MEMS. A total of six publications resulted from work on AlN and NCD.

Doping or addition of impurities such as boron can transform NCD from one of the best electrical insulators into a superconductor. Investigations exploiting this phenomenon with MEMS led to demonstration of a superconducting nanoresonator and yet another publication.

DIAMEMS fully demonstrated the utility of nano-scale diamond in electronic devices, opening the door to major cost reductions in a number of fields. As seen by major industrial investment in continued development, the outcomes will have a significant socioeconomic impact.

DIAMEMS

- ★ Coordinated by Cardiff University in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158463_en.html

“Scientists made significant steps toward manipulating the electron spin in conventional metals and organic materials.”

PHYSICS AND MATHEMATICS

ORGANIC MATERIALS SHOW THEIR MAGNETIC NATURE

EU-funded scientists have explored a new route to spintronics by investigating spin transport in organic semiconductors. Project findings are marking a new era in which spintronics is turning organic, impacting on future information processing and storage technologies.

With ‘Complementary metal-oxide semiconductor’ (CMOS) technology nearing the limit of scaling, several new technologies are being investigated as potential replacements. Spintronics — an emerging technology exploiting the electron spin in addition to its charge — seems to be a promising direction for the post-CMOS era. Long-distance spin transport without loss of polarisation and spin manipulation are fundamental factors underpinning the design of innovative spintronic devices.

Due to their tunable mobility and low spin-orbit coupling, organic semiconductors are considered ideal materials for spin transport, potentially representing a breakthrough in spintronics. With EU funding of the project ITAMOSCINOM (Injection, transport and manipulation of spin currents in new organic materials), scientists provided further insight into their spin transport properties and spin manipulation.

Initial work focused on growing and characterising organic materials on top of ferromagnetic ones and vice versa. This allowed scientists to obtain optimised organic vertical spin valves and study spin coherent length and its transport mechanism. Through more complex spintronic devices such as metal-based transistors or nanometric field effect transistors, ITAMOSCINOM achieved deeper understanding of the spin decoherence mechanisms in organic materials.

Focus was also placed on studying spin injection and transport in metals and ferromagnets using lateral spin valves. These fascinating devices hold great promise for spintronic applications as they allow for producing pure spin currents. The spin-flip mechanism in the spin transport of simple metals received particular attention.

Scientists took significant steps toward manipulating the electron spin in conventional metals and organic materials. As such, they achieved more sophisticated understanding of

spintronics, including the spin-orbit interaction that is crucial to achieving spin manipulation through an external electric field.

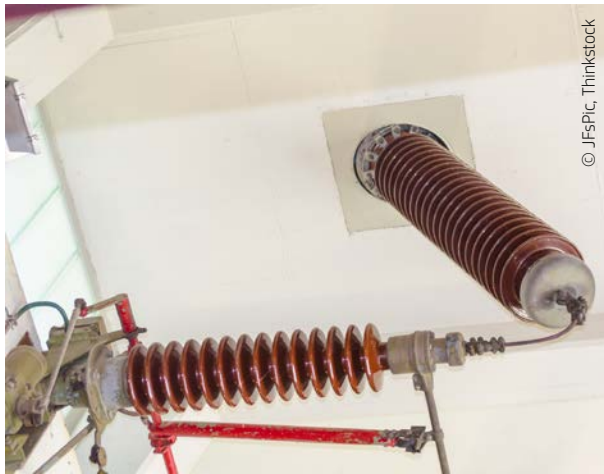
ITAMOSCINOM succeeded in studying materials with optimised spin transport properties that should enable spintronics to become a viable alternative to conventional electronics. Project findings regarding spin manipulation are paving the way to developing advanced spintronic devices such as a spin transistor.

ITAMOSCINOM

- ★ Coordinated by CIC nanoGUNE in Spain.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159650_en.html

THE TOPOLOGY OF INSULATING MATERIALS

Topological phases of matter are remarkable for their mathematical description and for the richness of physical phenomena they describe. The recent discovery of topological insulators spurred EU-funded researchers to explore how new topological phases of matter emerge and how they can be classified.



Topological insulators are materials that are electrical insulators in the bulk, but conduct electricity on their surface — a feature not seen in ordinary insulators. The two different phases of matter coexist in heavy elements like bismuth and antimony, holding the key to future spintronics and other electronics applications.

Most analyses of these materials have relied on highly simplified models in which electrons inside the solid were treated as though they do not interact with each other. Researchers working on the QETPM (Quantum entanglement and topological phases of matter) project performed a more detailed analysis.

The internal structure of topological insulators was approximated by a system of quantum particles interacting on a lattice in the presence of magnetic fields. Such systems are experimentally realised with ultracold atoms, but for

QETPM researchers offered the most suitable theoretical description of topological insulators.

They conducted theoretical experiments to establish the relationship between the basic states of this so-called Hofstadter problem and topological insulators. The team also examined whether the same rules that govern the formation of quantum Hall states for multiple interacting lattice systems apply to systems of coupled superconductors.

At very low temperatures and in the presence of a strong magnetic field, thin films of semiconducting materials display the phenomenon known as quantum Hall effect. The same state, where electrons flow with no energy loss, can be achieved in the newly discovered topological insulators as well.

QETPM researchers found a wide variety of quantum Hall states formed in lattice systems with different inter- and intra-layer interactions. In addition, they derived the excitation spectra of these multi-layer systems and predictions for new topological orders.

Different phases of matter are found to be distinguished by their internal structures, which scientists call orders. The new topological orders found within the QETPM project are expected to extend and deepen our understanding of known phases of matter. They can also guide us to new phases of matter and explain exactly how a normal material can become a topological insulator.

QETPM

- ★ Coordinated by the National University of Ireland Maynooth in Ireland.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/158613_en.html

STRONG GRAVITY BEYOND GENERAL RELATIVITY

Since its introduction 100 years ago, the theory of general relativity has been proven to be an accurate description of gravity. Recently, physicists posited that Einstein's equations aren't the whole story and searched for what corrections are needed to describe matter around black holes.

Physicists working on the EU-funded ASTRONGR (Strong curvature corrections to General Relativity: consequences for astrophysics and for particle physics) project sought to probe strong gravitational fields where deviations from general relativity may appear. They used black holes as 'cosmic laboratories' to test the so-called strong-field regime of Einstein's theory. The structure of these compact objects was investigated using different theories of gravity, the scalar tensor theories.

Although the current theoretical model of black holes is consistent with general relativity, it may not be consistent with these extensions of Einstein's theory. Indeed, the ASTRONGR scientists carried out a series of calculations for black holes surrounded by matter. They uncovered different mechanisms through which black holes become unstable as a result of perturbations around them.

In the future, observations from instruments that can record gravitational waves could back up the

ASTRONGR scientists' findings. Existing astronomical observations of spinning black holes also helped them test a fundamental aspect of the Standard Model. This allowed the

"They ruled out the possibility that dark matter is made up of these black holes formed when dense regions of the early Universe collapsed gravitationally."

researchers to establish the most stringent constraint on the mass of photons, estimated to be a hundred billion billion times smaller than the neutrino mass.

In addition, ASTRONGR scientists set theoretical constraints on the fraction of dark matter hidden in primordial black holes. Specifically, they ruled out the possibility that dark matter is made up of these black holes formed when dense regions of the early Universe collapsed gravitationally.

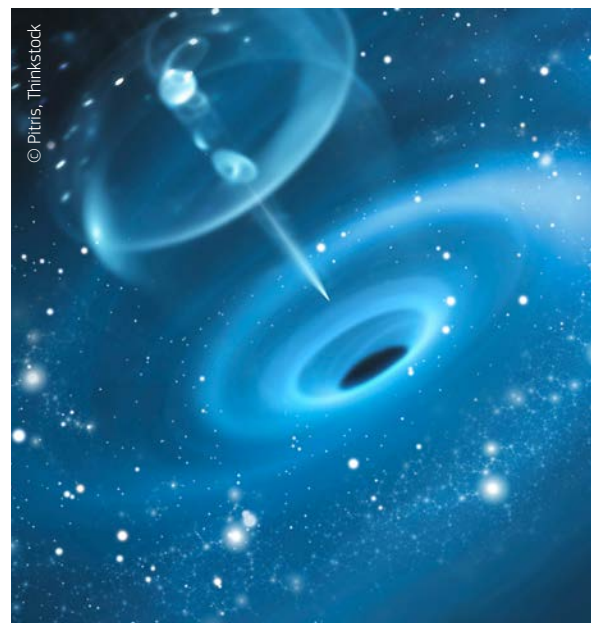
Their multiple discoveries are described in 22 papers published in international peer-reviewed journals, including the prestigious Physical Review Letters and Physical Review D. ASTRONGR scientists also presented their findings at major scientific

conferences held in Canada, Italy and Japan.

The ASTRONGR project has broadened our knowledge of the origins of gravity. Black holes and other compact objects such as neutron stars not only carry the imprint of possible corrections to general relativity, but also reveal an elusive link between gravity and quantum mechanics. Motivated by the advent of gravitation always astronomy, the ASTRONGR project has paved the way for new studies.

ASTRONGR

- ★ Coordinated by Instituto Superior Técnico in Portugal.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159718_en.html



HADRON STRUCTURE AND STRONG COUPLING

Since early models of the atom nearly 100 years ago, new discoveries and developments have greatly enriched descriptions of the particle nature of the Universe. EU-funded researchers have once again expanded understanding of particles and their interactions.

The Standard Model of particle physics now states that there are 12 elementary matter particles, a Higgs boson and four force carrier particles. Hadrons, like protons and neutrons, are not elementary particles, but made up of the elementary matter particles called quarks. The quarks are bound by gluons, elementary force particles that mediate the strong interaction that, among other things, is responsible for holding like-charged protons in the nucleus.

Scientists used Monte Carlo simulations to unveil the structure of hadrons and to provide precision measurements of the strong coupling constant with EU funding of the project PRECISION LATTICEQCD

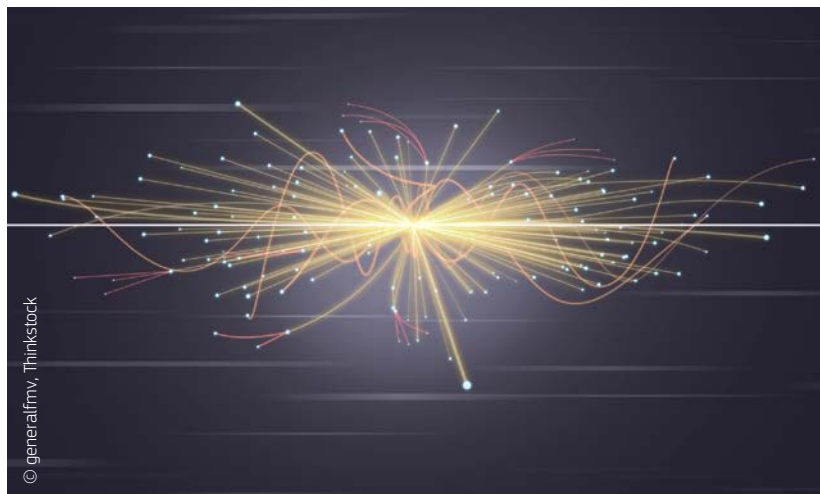
(Precision lattice QCD calculations). Monte Carlo simulations, only possible since the advent of supercomputers, rely on repeated random sampling. They stochastically solve the path integrals of QCD using many different input sets of random numbers (typically more than 10 000).

Monte Carlo simulations have been very important in providing estimates of quantities inaccessible or difficult to measure with experiments, and the field of 'quantum chromodynamics' (QCD) is no exception. As part of the Standard Model, QCD is the theory of the strong interaction between quarks and gluons. At large energies, QCD can be treated perturbatively. However,

outside this realm, QCD becomes much more complicated and predictions are difficult.

Enter lattice QCD, a 'digitised' QCD where discrete points exist in Euclidean space-time (the lattice). There are no assumptions or approximations and well-established and powerful Monte Carlo simulations can now be used. Exploiting lots of time on different parallel supercomputing systems, the team assimilated a wealth of lattice data for hadronic structure functions and the strong coupling constant. They introduced a new method to treat certain artefacts (hypercubic lattice artefacts) inherent in many of these and other lattice observables that will make future analyses and conclusions less uncertain and more accurate.

Results will impact numerous physical problems in elementary particle physics. They could help power searches for physics beyond the Standard Model, and they will certainly support new experiments in reaching beyond the physically measurable to the physically possible.



PRECISION LATTICEQCD

- ★ Coordinated by the University of Regensburg in Germany.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159649_en.html

EXCITON-PHOTON DYNAMICS IN GRAPHENE

An EU-funded project studied the physics underpinning light-matter interaction in two-layered graphene with a band gap. Project findings will pave the way to developing pioneering optoelectronic devices.

Excitons — neutral quasiparticles that exist in semiconductors — demonstrate strong coupling with light. Embedding bilayer graphene with a band gap in optical microcavities allows for controlling interaction that can lead to a strong coupling regime. Such an interaction results in the formation of a new kind of quasiparticle known as exciton-polariton that is a half-light and half-matter bosonic quasiparticle.

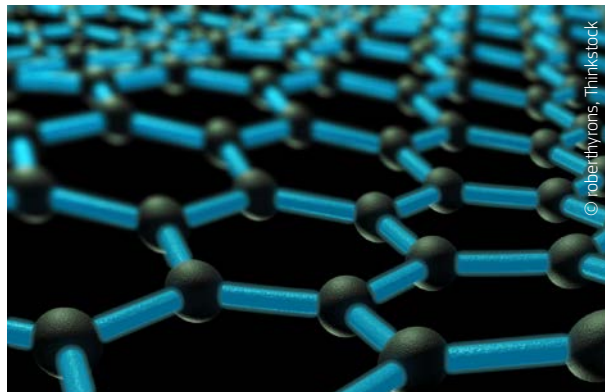
With EU funding of the project BIGEXPO (Bilayer graphene exciton polariton), scientists sought to enhance understanding of the bilayer graphene coupling to the photonic field of a microcavity. Based on a non-perturbation approach, BIGEXPO focused on studying the phenomena taking place when a dipole layer such as a graphene sheet

interacts with an electromagnetic field.

Study findings demonstrated that the Purcell effect breaks down — counter-intuitively, the spontaneous emission rate plummets in a strong coupling

regime. Furthermore, scientists concluded that current approximations to photonic emissions have to be modified.

Another task was to develop a microscopic theory describing the coupling between excitons in bilayer graphene and photons. Once completely developed, this theory should provide a comprehensive description of the underlying



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physics of light-matter interaction. The coupling non-perturbative nature should account for extraordinary physical effects.

BIGEXPO sought to enhance understanding of the physical processes governing the exciton-photon dynamics in microcavities. Considering its large excitonic dipole moment, the graphene microcavity system could push back the frontiers of research into solid-state cavity quantum electrodynamics. Not only will it allow for observing a novel, strongly correlated light-matter coupling regime, it will also lead to a new generation of terahertz and mid-infrared super-efficient optoelectronic devices.

BIGEXPO

- ★ Coordinated by the University of Southampton in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/result/rcn/159578_en.html

TOWARDS QUANTUM TELEPORTATION

By enhancing quantum control of mechanical devices, EU-funded scientists have opened the door to linking quantum physics laws to the macroscopic everyday world.

Controlling microscopic physical systems has already been demonstrated successfully in numerous

experiments, in particular in the field of quantum optics. Current research interest focuses on achieving quantum-mechanical control at the macroscopic scale as well.

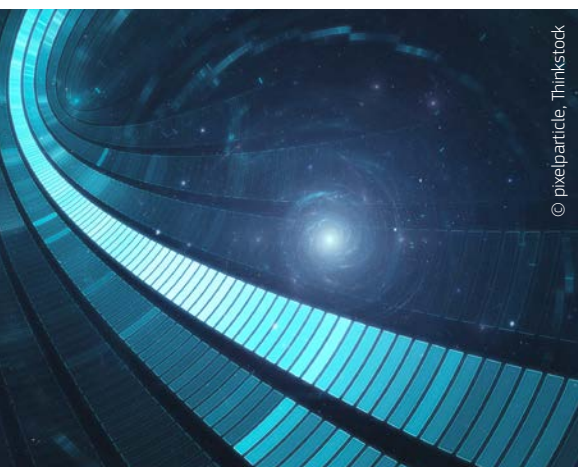
Promising systems for this purpose are mechanical oscillators. The EU-funded project OMENT (Optomechanical entanglement and teleportation) was established to demonstrate quantum control of a micrometre-sized mechanical oscillator and use it for a crucial quantum information application: teleportation.

OMENT sought to prepare low-entropy mechanical states such as the ground state of an optomechanical oscillator. Based on this, scientists would create and verify entangled optomechanical states. Such states only appear in

quantum mechanics and are the resource in numerous quantum information applications. The optomechanical entanglement created would be used to teleport information.

Novel optomechanical protocols included suggestions on how to implement optomechanical entanglement, teleportation and ultrafast cooling schemes in the pulsed optical regime.

A decisive step in OMENT was to use mechanical oscillators with high Q factors — lower rates of energy losses — as high as 10^7 at low temperatures. Scientists investigated a novel material system based on 'Indium gallium phosphide' (InGaP) for membrane mechanical resonators. This allowed easy and monolithic



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“Major effort was devoted to achieving two stable cavity-optomechanics systems at low temperatures in a dilution refrigerator and a helium flow cryostat.”

integration of stacked membranes that promise a high single-photon coupling strength.

Major effort was devoted to achieving two stable cavity-optomechanics systems at low temperatures in a dilution refrigerator and a helium flow cryostat.

Quantum-controlled mechanical oscillators extend the physical regimes of information processing where quantum effects are significant to macroscopic scales. Furthermore, they also allow for designing ultra-sensitive quantum-limited measurement devices.

Project advances significantly contributed to realising a set of experimental

parameters that should eventually allow for observing optomechanical quantum entanglement between a laser field and a micromechanical oscillator. All project findings were published in peer-reviewed journals.

OMENT

★ Coordinated by the University of Vienna in Austria.

★ Funded under FP7-PEOPLE.

★ http://cordis.europa.eu/result/rcn/158437_en.html

LIGHT AND MATTER IN NANO-SCALE DEVICES

The use of ultrafast (femtosecond) laser sources to optically excite electrons in metals provides the basis for novel applications in the field of optoelectronics, including ultrafast switches. Young scientists have advanced the field with EU support.

Interaction of light or photons with matter provides an important window onto both the classical and quantum behaviours of materials and paves the way to development of new devices. EU-funded scientists launched the project UPNEX (Ultrafast phenomena in nanoparticle exci-

tations) to investigate collective oscillations (surface plasmons) in free electrons of a metal in the sub-10-femtosecond range. The team studied spatially and spectrally resolved ultrafast

“The team elucidated certain mechanisms of band gap dependence of induced currents.”

photoemission (the emission of electrons from a surface caused by incident photons) from nano-structured metal samples.

The first step was construction of an advanced imaging spectrometer. It was used to analyse the generation of ‘terahertz’ (THz) radiation in the form of ejected photoelectrons from plasmonic nanoparticles. Researchers published important results demonstrating the correlation of the plasmonic resonance of nano-structured samples with the THz signal generated by them.

Elucidation of mechanisms opened the door to exploitation in the field of laser-driven surface-integrated THz sources. Such sources could overcome current limitations associated with damage in non-linear crystal-based THz sources and enhance utility in materials science experiments and applications.

In other experiments, scientists constructed a vacuum chamber in which the coupling of two opposing nanotips was investigated. They managed to decrease the coupling distance to approximately 100 to 150 nm. The system was used to demonstrate a nano-scale vacuum-tube diode consisting of two metal nanotips as an ultrafast electronic



device exploiting pulsed electrons emitted by few-cycle photoemission. Further reduction in coupling distance should enable optical directional control of the current between the tips, paving the way to nano-sized ultrafast switches and devices.

A final line of research investigated optically induced currents in dielectrics and development of novel light sources. In particular, building on a recently published article in the prestigious journal *Nature*, the team elucidated certain mechanisms of band gap dependence of induced currents. Results have potential application to even faster petahertz (PHz, 10¹⁵–10¹⁸ Hz) electronics.

UPNEX fostered the careers of associated researchers and strengthened collaborations between them, and improved the capabilities of the two laboratories involved. Along the way, it produced important new findings in the field of light-matter interactions at the nano scale with applications to nano-scale optoelectronics and nanoplasmonics.

UPNEX

★ Coordinated by the Max Planck Society in Germany.

★ Funded under FP7-PEOPLE.

★ http://cordis.europa.eu/result/rcn/159647_en.html

EVENTS



Constanta, ROMANIA

CONFERENCE

2015 INTERNATIONAL CONFERENCE ON ADVANCES IN ENGINEERING MATERIALS (ICAEM 2015)

The 2015 International Conference on Advances in Engineering Materials (ICAEM 2015) will take place from 26 to 29 June in Constanta, Romania.

The main objective of this conference is to provide a platform for engineers, academics, scientists, industrial professionals and researchers to present the results of their research activities in the field of Advances in Engineering Materials. Topics of interest for submission papers include subjects like: Advanced Design Technology; Polymer Materials; Modelling, Analysis and Simulation of Manufacturing Processes; Laser Processing Technology, etc.

For further information, please visit:
<http://www.icaem.org/>



Limassol, CYPRUS

SYMPOSIUM

14TH IEEE INTERNATIONAL SYMPOSIUM ON PARALLEL AND DISTRIBUTED COMPUTING (ISPD)

The 14th IEEE International Symposium on Parallel and Distributed Computing (ISPD) will take place from 29 June to 1 July in Limassol, Cyprus.

The conference will comprise a programme of papers describing original and unpublished research advancing the state-of-the-art in the field of new parallel and distributed computing paradigms and applications. Parallel and distributed computing is today a central topic in science, engineering and society in the development of new approaches for the modelling, design, analysis, evaluation and programming of future parallel and distributed computing systems and applications.

The University of Cyprus and Easy Conferences are the local organisers of the conference.

For further information, please visit:
<http://cyprusconferences.org/ispd2015/index.html>



Paris, FRANCE

CONFERENCE

EUROPEAN CONFERENCE ON NETWORKS AND COMMUNICATIONS

The European Conference on Networks and Communications (EUCNC 2015) will be held from 29 June to 2 July 2015 in Paris, France.

The conference is the 24th edition of a successful series of a technical and scientific conference open to the world research community, sponsored by the European Commission. Focusing on telecommunications networks and systems, the event aims to showcase the results of R&D programmes and projects co-financed by the EU, as well as to present the latest developments in this area.

The Conference Proceedings will be submitted for indexing to databases including Inspec, EBSCO, Scopus/Elsevier/Compendex (Engineering Village), Thomson Reuters — Web of Science and DBLP. Accepted and presented papers will be published in the EUCNC 2015 Conference Proceedings and submitted to other Abstracting and Indexing (A&I) databases. Paper submission is open to all researchers independently of being associated with European Framework projects.

For further information, please visit:
<http://www.eucnc.eu/>

Mylene, GREECE

SYMPOSIUM

NINTH INTERNATIONAL SYMPOSIUM ON HUMAN ASPECTS OF INFORMATION SECURITY & ASSURANCE (HAISA 2015)

The Ninth International Symposium on Human Aspects of Information Security & Assurance (HAISA 2015) will be held from 1 to 3 July in Mytilene, Greece.

This symposium, which is run in association with the Tenth International Workshop on Digital Forensics and Incident Management (WDFIA 2015), will bring together leading figures from academia and industry to present and discuss the latest advances in information security from research and commercial perspectives.

The event will be held over three days, with presentations delivered by researchers from across the international community.

For further information, please visit:
<http://haisa.org/?page=home>

JULY
09►10

Porto, PORTUGAL

CONFERENCE

SECOND EUROPEAN CONFERENCE ON SOCIAL MEDIA (ECSM 2015)

The Second European Conference on Social Media (ECSM 2015) will take place from 9 to 10 July in Porto, Portugal.

The conference seeks to establish a platform where academics and professionals can share and learn. This will be an opportunity to bring together interested parties, be they practitioners, scholars or doctoral students to share examples, cases, theories and analysis of social media. In addition to the two-day conference, there will also be a one-day seminar on Qualitative Research Methods which will take place on 8 July.

For further information, please visit:
<http://academic-conferences.org/ecsm/ecsm2015/ecsm15-home.htm>

JULY
13►14

Lisbon, PORTUGAL

CONFERENCE

SECOND INTERNATIONAL CONFERENCE ON ENERGY AND ENVIRONMENT RESEARCH (ICEER 2015)

The Second International Conference on Energy and Environment Research (ICEER 2015) will take place from 13 to 14 July in Lisbon, Portugal.

ICEER focuses on the state-of-the-art technologies pertaining to energy and environment research, and the applications of energy and environment research in domains such as astronomy, biology, education, geosciences, security and health care, etc. It is a technical congregation where the latest theoretical and technological advances are presented and discussed.

For further information, please visit:
<http://www.iceer.net/>

JULY
13►14

Lisbon, PORTUGAL

CONFERENCE

2015 INTERNATIONAL CONFERENCE ON MATERIAL SCIENCES (ICOMS 2015)

The 2015 International Conference on Material Sciences (ICOMS 2015) will take place from 13 to 14 July in Lisbon, Portugal.

The conference will focus on state-of-the-art technologies pertaining to material sciences. The latest theoretical and technological advances will be presented and discussed, as will the applications of material sciences to domains such as astronomy, biology, education, geosciences, security, health care, etc. The organisers expect that the conference and its publications will be a trigger for further related research and technology improvements in this area.

For further information, please visit:
<http://www.icoms.org/index.html>

EVENTS

For more forthcoming events:
<http://cordis.europa.eu/events>

JULY
20►21



Barcelona, SPAIN

CONFERENCE

FOURTH INTERNATIONAL CONFERENCE ON MECHANICS AND INDUSTRIAL ENGINEERING (ICMIE'15)

The Fourth International Conference on Mechanics and Industrial Engineering (ICMIE'15) will take place from 20 to 21 July in Barcelona, Spain.

ICMIE is a comprehensive conference covering various topics of mechanical engineering (fluid and solid mechanics), robotics, aerospace and mechatronics. The aim of ICMIE'15 is to gather scholars from all over the world to present advances in these fields and to foster an environment conducive to exchanging ideas and information. This conference will also provide an ideal environment for developing new collaborations and meeting experts on the fundamentals, applications and products of mechanics and industrial engineering.

For further information, please visit:
<http://icmie.net/index.html>

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