ISSN 1977-4028

European Commission

research*eu

RESULTS MAGAZINE

N°58
DECEMBER 2016 – JANUARY 2017

SPECIAL FEATURE

DRILLING IN THICK ICE: LESSONS FROM THE PAST

BIOLOGY & MEDICINE

NOVEL REGENERATION THERAPY PROMISES TO SIGNIFICANTLY IMPROVE BONE REPAIR

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FOOD & AGRICULTURE

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RESULTS MAGAZINE

Published by
The Community Research and Development Information Service (CORDIS) managed by the Publications Office of the European Union
2, rue Mercier
2985 Luxembourg
LUXEMBOURG
cordis@publications.europa.eu

Editorial coordination
Melinda KURZNE OPOCZKY

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ISSN 1831-9947 (printed version)
ISSN 1977-4028 (PDF, EPUB)

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EDITORIAL

by the editorial team

CLOSING IN ON THE WORLD'S FROZEN TIME CAPSULES

In the early 1950s, a handful of pioneering scientists initiated the first ice core drilling in the likes of Alaska, Antarctica and Greenland. The practice, which is now commonplace, has allowed for the analysis of ice samples dating back 130 000 years in Greenland and 800 000 years in Antarctica. Just like tree age rings, these ice cores feature annual layers which can easily be dated, and provide invaluable information about past climate and atmospheric conditions.

Even though they have been studied for almost seven decades, ice cores still have much to tell us. Not only about our planet's past, but also indirectly about its future. In the face of rising concerns over the consequences of unbridled CO_2 emissions and the resulting climate change, scientists indeed hope that ice core-related revelations will allow for the design of better climate models.

The EU is no stranger to ice core science. The European Project for Ice Coring in Antarctica (EPICA), which was partly supported by the European Commission, notably helped to obtain full documentation of the climatic and atmospheric record archived in Antarctic ice and compared it with that of Greenland — thereby revealing precious information about natural climate variability and mechanisms of rapid climatic changes during the last ice age.

'Even though they have been studied for almost seven decades, ice cores still have much to tell us.'

These efforts have been pursued under FP7 and now under Horizon 2020, with a total of 21 projects funded under the two framework programmes. As winter comes and some of these projects get very close to their end, the CORDIS editorial team decided it was time to put the spotlight on seven of them. From traces of cosmic dust to forest fires, abrupt climate changes and oceanic carbon storage, these projects provide a great insight into ice core science's added value for the scientific community.

As usual, this special feature is followed by eight other sections focusing respectively on biology and medicine, social sciences and humanities, energy and transport, the environment, IT and telecommunications, industrial technologies, food and agriculture, and physics and mathematics. The magazine closes with a list of upcoming events hosted by or involving EU-funded research projects.

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

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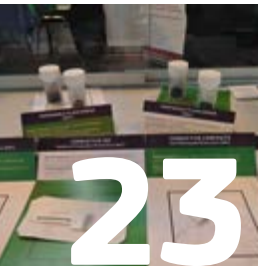

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SPECIAL FEATURE

DRILLING IN THICK ICE: LESSONS FROM THE PAST

INTERVIEW

HOW ANTHROPOGENIC FOREST FIRES MAY HAVE IMPACTED EARTH'S CLIMATE OVER 10 000 YEARS AGO

© EARLYHUMANIMPACT

Recently paleoclimatologist William Ruddiman suggested that humans may have had a significant impact on the Earth's climate already thousands of years ago — through carbon and methane emissions originating from biomass burning and deforestation associated with early agriculture. The EARLYHUMANIMPACT project set out to verify this hypothesis.

Whilst global warming means more forest fires, the opposite is also true. Forests store about 30% of the carbon found on the planet's surface, and each forest fire not only releases this carbon into the atmosphere but also other climate-impacting substances such as aerosols. The impact of these aerosols on climate change, however, is not yet well understood.

The EARLYHUMANIMPACT project builds upon the idea that the answer might lie in Earth's history books. Over 10 000 years ago, human agriculture started to thrive at the expense of forests, and the project team believes that anthropogenic aerosols resulting from this process may have altered the global climate system for thousands of years.

To verify this, Prof Carlo Barbante and other researchers from the University of Venice examined data from ice and lake core climate records of seven continents and compared it with parallel histories of fire regimes. They used a new technique for determining a specific molecular marker of biomass burning — known as levoglucosan — which can record past fire in ice cores and lake sediments. With the project soon coming to an end, Prof Barbante discusses the process and the main outcomes of his work.

★ **Why did you choose to focus your research on fire reconstruction?**

Prof Barbante: The role of aerosols in the climate system is still poorly understood and even less is known about the relative role of biomass burning.

Fire affects the climate system by releasing carbon, which would otherwise be stored in woody vegetation. It contributes to the levels of several aerosols and atmospheric gases in the air and is an important cause of their variability over the years. It also influences regional and global climate through the emission of greenhouse gases, mainly carbon dioxide and methane.

The decrease in the spatial extent of forests which started around 7 000 to 5 000 years BP may be related to early agricultural activity, including forest clearance through burning which should leave a quantifiable signal in climate proxies. Under this ERC Advanced Grant, we are aiming to provide essential insight into the interplay between climate and human activity, especially with the advent of agriculture, as well as the role of aerosols through time.

★ **How do you explain that we know so little about aerosols' past influence on climate change?**

Anthropogenic and natural aerosols may have altered the global climate system for thousands of years as suggested by

PROF CARLO BARBANTE

comparing late-Holocene greenhouse-gas (GHG) concentrations to those from previous interglacial periods. Now, human activities including fossil fuel burning are currently altering the composition of the atmosphere and the global climate system at rates faster than ever recorded in geologic time.

The problem is that, for most of the climatic and environmental archives that paleoclimatologists study (e.g. three rings, marine and terrestrial records), it is difficult to find the right transfer functions that link the concentration of a specific marker in the record with its atmospheric occurrence in the past. It is therefore of paramount importance to look at past atmospheric composition through the use of paleoclimatic records and appropriate proxies for which the cause/effect relationship is known.

★ How did you proceed to verify Ruddiman's hypothesis?

His hypothesis is centred on the observation that atmospheric carbon dioxide and methane levels were at their minima around 7000 to 5000 years before the present day, respectively, and then slowly increased until the rapid rise in GHGs caused by the Industrial Revolution. The increase in methane is attributed to biomass burning and rice cultivation in the tropics. The carbon dioxide increase is more difficult to ascribe to human activity, but Ruddiman argues that deforestation and biomass burning may be a primary factor.

Ice and lake core proxy records provide quantifiable data on past fire regimes across all possible spatial and temporal scales. We aim to quantify the temporal and spatial changes in Holocene biomass burning in ice and lake core records from seven continents which correspond with centres of the origin of agriculture. We have developed for this a novel technique for measuring a globally-present molecular marker of biomass burning (levoglucosan, 1,6-anhydro-β-D-glucopyranose) in ice cores and lake sediments. We supplemented these pyrochemical analyses with palynological evidence of the impact of past fire regimes.

★ What are the main takeaways from the project so far?

For example, recent studies of the Greenland ice sheet have shown that climate changes including summer North Hemisphere insolation and temperature affect boreal fire activity over millennial timescales.

Our results on fire reconstruction in the Holocene show an important peak in fire activity 3–2 ka year ago. However Northern Hemisphere temperatures and especially summer fire season temperatures remain stable or decrease between 3 and 2ka. Therefore, major climate parameters and environmental changes alone cannot explain the levoglucosan flux reaching Greenland during the middle to late Holocene.

Given the lack of a plausible climate control for this pattern, coupled with the absence of paleoclimate evidence for any synchronous global climate change at this time, we argue that human activity associated with agriculture and land clearance provides the best explanation for observed trends in fire activity during the late Holocene. Extensive deforestation in Europe between 2.5 and 2 ka is synchronous with the Greenland levoglucosan fire peak, demonstrating a quantifiable early human impact on the environment beginning about 4000 years ago.

★ Did you manage to differentiate between natural and anthropogenic fires?

This is certainly one of the most challenging tasks of the whole research project and we are working on this. The links between biomass burning and increased agriculture (and therefore increased GHGs including carbon dioxide and methane) and the prolongation of interglacial climate are only valid if measured increases in burning demonstrate a quantifiable relationship with increased temperature, as can be measured in ice cores. In addition, lake cores contain necessary palynological evidence for human-induced fires such as the anthropological pollen index, pollen indicators of slash-and-burn cultivation, the presence of fire-tolerant species suggesting frequent fire activity, and changes in the arboreal pollen influx.

The multi-proxy nature of ice and lake cores makes them the perfect material to investigate the linkages between early agricultural activity and climate change, as temperature, palynologic evidence, and levoglucosan are measured from the same depth and time within the surrounding matrix.

★ What are you planning to do until and after the end of the project?

We are actually concentrating on a part of the project that was not originally foreseen in the implementation of the proposal. Novel organic molecular proxies are proposed for the reconstruction of fire events in association with anthropic activities. Namely, faecal sterols and a suite of polycyclic aromatic hydrocarbons were individuated and tested as suitable molecular markers of human presence and fire activity, in addition to the levoglucosan that we already use. These are very promising proxies in paleoclimatic reconstructions and we aim to pursue on this research direction in the near future. This ERC grant has been a great opportunity to study a poorly understood and often neglected part of the climate system.

EARLYHUMANIMPACT

★ Hosted by Ca'Foscari University of Venice in Italy.
★ Funded under FP7-IDEAS-ERC.
★ http://cordis.europa.eu/project/rcn/99498

SEEING UNDER ANTARCTICA'S ICE

EU-funded researchers have used a new process called comminution dating to better understand Antarctica's geological and climatic history.

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"With this information, researchers can reconstruct the history of continental weathering, sediment transport mechanisms and timescales."

Although scientists have been studying Antarctica for many years, most research has focused on the conditions of Antarctica as they currently are. Based on this information, scientists have been able to make predictions on both what caused these conditions and how they are likely evolve in the future. But because our understanding of the icy continent is essentially limited to what happened over the last 100 years, our overall knowledge is surprisingly limited. To truly understand Antarctica, scientists must 'see' the continent's geological and climatic history dating back to the late Quaternary period — a history that is literally frozen from sight.

Due to the Antarctic Ice Sheet (AIS) that covers the continent, land-based observations into its geological past remain largely unknown. However, scientists from the COMANT (Comminution dating of glacio-marine sediments in Antarctica and the Southern Ocean) project discovered that this geological information can be retrieved by studying the origins and transport times of eroded materials found in the marine sediment cores surrounding Antarctica. With this information, researchers can reconstruct the history of continental weathering, sediment transport mechanisms and timescales.

'This project uses an innovative approach called comminution dating to determine spatial and temporal changes in the transport time of fine clastic sediments produced by Antarctic subglacial erosion during the late Quaternary period, which can be seen in the flux of ice and sediment discharged into the Southern Ocean,' explains Project Lead Adi Torfstein.

Determining the comminution age

The COMANT project builds on recent results coming from the Weddell Sea showing that, depending on glacial-interglacial timescales, sediment transport times range between tens to hundreds of thousands of years. 'Building on these preliminary results, I studied the comminution ages of a large number of glacial-marine deposits at sites across the Southern Ocean,' says Torfstein. 'This in turn allowed me to conduct a comprehensive study of natural and analytical biases on the comminution dating approach.'

The project focused their efforts on U-series disequilibrium in detrital material, which is a measurement of weathering and transport time. Once a rock fragment is ground to a small particle of only a few microns in diameter, which is something that happens very quickly in glacial settings, one of the isotopes of uranium (234U) is continuously lost from the rim of the particle due to radioactive decaying. 'This loss of 234U is measurable and depends, amongst other things, on the known decay rate of uranium isotopes,' says Torfstein.

According to Torfstein, this change, or loss of 234U, is a geological clock that can be used to estimate the age of formation of a particle (rather than the age of formation of a rock or mineral). The time elapsed between the formation of the particle and the present is known as the 'comminution age'.

Better understanding Earth's history

Although the project is ongoing, researchers expect results to provide the first systematic and wide-scale study of comminution ages in the Southern Ocean. As such, the study will expand the possibilities of dating continental deposits, leading to a better understanding of the fundamental aspects of sedimentology, glaciology and landscape evolution.

'This is important because the comminution age of a particle is controlled by the interplay between climate change, the tectonic evolution of the continents and the efficiency of transport mechanisms on the continents and in the oceans,' adds Torfstein. 'Thus, comminution ages reflect the cumulative impact of processes that govern the shaping of the Earth's surface over time, and by reconstructing these ages, we can better understand its history.'

COMANT

- Coordinated by the Hebrew University of Jerusalem in Israel.
- Funded under FP7-PEOPLE.
- http://cordis.europa.eu/project/rcn/109554

INTERVIEW

ABRUPT CLIMATE CHANGE EVENTS FROM THE PAST COULD HELP PREDICT THE ONES AHEAD

Coping with climate change will already be difficult enough without worrying about Dansgaard-Oescheger (DO) events that could come on top of it. However, their possible occurrence cannot be dismissed: We need to know more about these events, how they impacted our planet in the past, and how they could continue to do so in the future. The world's most well-preserved ice cores could provide all this information while allowing for improved climate models.

There is a risk that increasing atmospheric greenhouse gas levels could trigger abrupt changes in the climate system — that is, changes so abrupt that they could seriously challenge the ability of humans, plants and animals to adapt. Ice core records can help us better understand this risk: they notably show that, during the last glacial period (around 100 000 to 20 000 years ago), temperature over the Greenland ice sheet could change by up to 16°C within a few decades.

With his INTERCLIMA (Inter-hemispheric Coupling of Abrupt Climate Change) project, Dr Joel Pedro of the University of Copenhagen has been trying to advance understanding of the governing mechanisms and inter-hemispheric coupling involved in abrupt climate change. By doing so, he hopes to help scientists trying to understand the extent and nature of the anthropogenic climate change we are witnessing to improve their climate predictions.

DR JOEL PEDRO

★ How can past climate change events inform us on future risks?

Dr Joel Pedro: The Ice Age temperature jumps, termed Dansgaard-Oeschger events, are thought to be associated with natural instabilities or 'tipping points' in ocean and atmospheric circulation. A crucial distinction between anthropogenic climate change and these natural events is that today land and ocean temperatures are increasing almost everywhere, whereas during the Dansgaard-Oeschger events temperature quickly warmed in Greenland and the North Atlantic while at the same time cooling in large parts of the Southern Hemisphere. There was basically a redistribution of heat in the climate system. Trying to understand whether anthropogenic climate change could push the climate system over similar tipping points is an important motivation for studying the Dansgaard-Oeschger events.

By studying ice cores and other climate records from around the world, we gain information on the potential triggers of such abrupt changes, the processes which are involved, and their global impact.

Accurately documenting past abrupt climate change events also helps with testing climate models. We can gain more confidence in models used to make predictions about future climate if our models are able to simulate the full range of what climate has done in the past.

★ Why did you specifically base your research on Law Dome and Greenland ice cores?

For my research I selected ice cores which preserve the most detailed records in time (the highest temporal resolution). Abrupt climate change occurs by definition extremely quickly so to really get to the details of the where, how and why of past abrupt climate change, high time resolution records are essential. On the polar ice sheets the time resolution of an ice core is set by how much snow falls every year and then how much those annual layers are later compressed and smeared out by ice flow. The North Greenland Ice Core Project ice core (drilled by Danish researchers) and the Antarctic Law Dome and West Antarctic Ice Sheet Divide cores (drilled by Australian and US researchers, respectively) are amongst the highest resolution climate records available for the past tens of thousands of years.

However, my research was not restricted to ice cores. I also reached out to communities working with lake, marine and cave sediment records. Bringing in data from these sources was important to gain information about climate variability at lower latitudes during Dansgaard-Oeschger events.

★ How did you proceed to get the information you wanted?

The project greatly benefited from networking and data-input from many research groups in Europe, Australia, New Zealand, South America, Africa and the US. I used ice core data from my previous research group in Australia and I collaborated with colleagues in the US to obtain data from the excellent West Antarctic ice core record. At my host institute, the University of Copenhagen, I had access to data and expertise on the Greenland Ice cores.

© INTERCLIMA

Once the project built momentum, via presentations at international conferences and research trips, I was able to obtain input from researchers working with lake, marine and cave records. For the modelling component of the research I collaborated with researchers at the University of Wisconsin Maddison and Kiel University.

★ What can you tell us about the results from the project?

Making well-informed decisions on how to best adapt to future climate change and how to mitigate the worst effects of climate change requires information on what the climate system is capable of.

The INTERCLIMA project has improved our understanding of how abrupt climate change signals are communicated to different parts of the climate system. It showed that changes in meridional atmospheric heat transport drive abrupt climate variability in the southern hemisphere tropics and that slower ocean heat transport changes and sea ice feedbacks are more important in communicating abrupt climate change signals to the southern high latitudes.

★ How are you/do you plan to build upon the project's results for future research?

I'm working on the influence of abrupt climate variability on the Southern Ocean. The Southern Ocean is currently responsible for the uptake of around 75 % of the ocean storage of anthropogenic heat and around 40 % of the storage of anthropogenic carbon.

Whether the Southern Ocean will continue to take up so much heat and carbon in the future is not well known. I think that one way to try and close this knowledge gap is to use examples of how past abrupt climate change influenced heat and CO_2 uptake and storage. To do this I am working with paleoclimate observations, mainly ice cores and marine cores, along with model results and results from experiments and theory on Southern Ocean physical oceanography. I hope this work will improve our understanding of past and future sea ice, ice sheet–ocean interactions and CO_2 storage in the Southern Ocean.

I'm also working on an 'adjoint modelling' project in which we aim to directly input paleoclimate data to model simulations.

INTERCLIMA
★ Coordinated by the University of Copenhagen in Denmark.
★ Funded under FP7-PEOPLE.
★ http://cordis.europa.eu/project/rcn/108394

RECONSTRUCTING GREENLAND'S CLIMATE

Using ice-cores and a new isotopic method that can provide more precise temperature information, Marie Curie Fellow, Takuro Kobashi, has gained an insight into Greenland's climate history. His data suggests Greenland's temperatures and global-sea-levels may increase faster than current climate projections.

It is not easy to reconstruct past temperature changes beyond the 150 year time frame of recorded observations, but EU Marie Curie Fellow, Takuro Kobashi at the University of Bern has developed a tool that can do just this. In the two-year GREENTEMP (Investigation of Greenland temperature variability over the 6000 years using trapped air in ice cores)project which ended in April 2016, Kobashi reconstructed the precise temperature of Greenland over the past millennia using ice cores. In a contrast to conventional methods, he collected data from argon and nitrogen isotopes trapped in air bubbles within ice cores.

'It has been known that Greenland temperature co-varies with North Atlantic temperature so understanding Greenland's temperature variability provides information on North Atlantic temperature and changes in ocean current change in the past.' explains Kobashi. The last period of glacial retreat occurred 6000 years ago and so being able to probe temperature changes at that time could provide useful for understanding the impact of current climate changes.

The ice core samples used in his work were collected more than 10 years ago during from the North Greenland Ice Core Project (NGRIP) which extracted 11 cm diameter ice cores stretching back to the last ice age. Kobashi's new technique measures nitrogen and argon isotope ratios within trapped air bubbles, rather than measuring oxygen isotopes ratio's which is the standard method.

The method takes advantage of the changes in air occurring in the snow layer that fell on top of Greenland's ice-sheets, which are eventually trapped in the bubbles at the bottom of the snow layer before themselves freezing into ice. Gravity and the temperature gradient that exists within the snow layer causes a variable distribution of air. The isotope ratio of two types of gasses (nitrogen and argon) in the bubbles can therefore be used to estimate the past temperature gradient of the snow layer, and the thickness of the layer, allowing Kobashi to reconstruct the past surface temperature changes.

'We have reconstructed temperature over the past 4000 years and our preliminary analyses show the variations of Greenland temperatures significantly correlate with solar activity' says Kobashi

but adds the interpretation is not what might be expected. 'When solar activity increases, Greenland's temperatures actually get colder, and vice versa'. The phenomenon seems to be related to atmospheric and oceanic changes, and is also reproduced in some climate models. Temperature changes can also be explained by changes in volcanic activity, orbital changes and greenhouse gas levels in the atmosphere.

'Whilst natural variability may mask anthropogenic influence on Greenland temperature, eventually Greenland temperature will start rising by anthropogenic influence,' Kobashi says. Greenland generally follows global temperature rises, but Kobashi's work shows the link between solar activity and temperature could help predict future temperature changes. Solar activity will be decreasing over the next decades and that means Greenland's temperature may increase faster than projected by climate models that use only greenhouse gas increases in their projections. In turn, that could result in faster melting of the polar ice-sheet, and increasing global sea-levels.

Kobashi's new method is an improvement on previous methods because it provides seasonally unbiased and more precise temperatures in a multidecadal time scale, as long as the ice core are from high snow fall areas such as Greenland, Antarctica, and possibly alpine glaciers. 'As the method is now established, we will likely be able to have highly precise temperature records from these areas in coming decades, which could revolutionise our understanding of climate changes over the past millennia,' concludes Kobashi.

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GREENTEMP

- Coordinated by the University of Bern in Switzerland.
- Funded under FP7-PEOPLE.
- http://cordis.europa.eu/project/rcn/186017
- Project website: https://sites.google.com/site/greenlandtemperature

INTERVIEW

SALT CONCENTRATIONS IN ICE CORES COULD UNVEIL DO EVENTS' RECIPE

It is one thing to know that Earth has already faced abrupt climate changes — also known as Dansgaard–Oeschger (DO) events — in the past. But finding out the reasons for these dramatic and rather short term changes is another story, one that Dr Rachael Rhodes from the University of Cambridge is reconstructing using chemistry records from ice cores taken from Greenland.

© Rachael Rhodes

DR RACHAEL RHODES

A common assumption with past DO events is that their occurrence was closely linked to major changes in Arctic sea ice extent: such changes feedback positively on Arctic temperature, and finding out exactly how this relationship works could be key to predicting how Arctic ice will react to ongoing climate change.

Within the framework of her SEADOG (Sea ice across Dansgaard-Oeschger events in Greenland) research, Dr Rhodes is analysing records of sea salt and methane sulphonic acid in Greenland ice cores with a view to defining whether they can be used as proxies for Arctic sea ice extent. She is investigating four ice core records for spatial and temporal variability across DO events, and exploring the controls on marine aerosol deposition over the Greenland Ice Sheet thanks to the p-TOMCAT chemical transport model.

Thanks to her findings, Dr Rhodes has optimised the p-TOMCAT model to represent modern-day sea salt aerosol deposition across Greenland. Ongoing work will identify scenarios of sea ice change consistent with ice core chemistry data across DO events.

★ What are DO events and why is it important to better understand them?

Dr Rhodes: DO events are rapid and abrupt changes in the climate of the Northern high latitudes that occurred during the Last Glacial Period. They are named after two famous ice core scientists: Willi Dansgaard (Denmark) and Hans Oeschger (Switzerland) who first recognised these events in the stable isotopic ratios of water (a proxy temperature) of Greenland ice cores.

★ How come we don't know more about these events yet?

We know quite a lot about them. For example, from Greenland ice cores, we can decipher that temperatures changes of 5-16.5°C occurred within centuries over Greenland. However, we still don't understand what ultimately caused these events. Several theories involve major changes to Arctic sea ice extent but there is little evidence from the paleoclimate archives to constrain this.

★ How did you proceed to gather the desired information from ice cores?

I am using sea salt (NaCl) concentrations measured on Greenland ice cores. Sea salt concentrations are relatively easy to measure but difficult to interpret in terms of climatic or environmental changes because many other factors can influence the signal that is eventually preserved in ice cores. In particular, variations in meteorology, such as the weather systems that transport the sea salt aerosol through the atmosphere to the ice core site, are known to impact the signal.

I am using an atmospheric chemical transport model called p-TOMCAT to investigate to what extent ice core sea salt signals are influenced by sea ice area and by meteorology. This will help answer the question of whether or not the abrupt sea salt concentration changes across DO events can be linked to Arctic sea ice conditions.

★ What can you tell us about your main findings so far?

My initial work has focused on understanding the processes controlling Greenland ice core sea salt signal in the present-day. I have modified p-TOMCAT to calculate sea salt concentrations in the deposited snow and the model is doing a great job of replicating both the concentrations and seasonality of sea salt records preserved in ice cores. Results indicate that meteorology is the dominant factor affecting ice core sea salt signals at the inter-annual scale, but that sea ice conditions do exert some influence. I am testing how great a change in sea ice area is needed to override meteorology and become the dominant influence.

★ How can these results help predict the future evolution of Arctic sea ice?

This work will help us understand if/how sea salt concentration records in Greenland ice cores can be used as a proxy for Arctic sea ice extent. A positive result would disentangle the effects of sea ice-related and meteorology-related sea salt change, allowing sea salt concentrations to be employed as a sea ice proxy with confidence. Reconstruction of Arctic sea ice changes across the abrupt DO events is important because we ultimately need to understand how Arctic sea ice reacts to rapid climate change, like the one we are witnessing occurring right now.

★ What do you still need to achieve before the end of the project next year?

Now that the processes leading to ice core sea salt signals are well-understood for present-day Arctic conditions, I am adapting the model to run tests using meteorology and sea ice typical of the Last Glacial Period when DO events occurred. It will be interesting to test how the simulated sea salt signals respond to the huge changes in climate and sea ice thought to happen during DO events.

SEADOG

★ Coordinated by the University of Cambridge in the United Kingdom.
★ Funded under H2020-MSCA-IF.
★ http://cordis.europa.eu/project/rcn/195554

CLEARING THE POLAR AIR ON COSMIC DUST

By developing several innovative experimental systems, EU-funded researchers now have a better indication of how much cosmic dust enters the Earth's atmosphere and what impact it has.

Our solar system is a dust-filled place. As comets travel around their orbits and near the sun they begin to evaporate, leaving a trail of cosmic dust in their wake. These dust particles then enter the Earth's atmosphere at a very high speed — anywhere in the range of 40 000 to 260 000 kph — where they collide with air molecules. This collision then causes flash heating and a subsequent melting and evaporation of the particles.

'Sometimes this dust is visible as meteors, which is the case of dust particles greater than 2 mm,' says CODITA (Cosmic Dust in the Terrestrial Atmosphere) project coordinator John Plane. 'But most of the dust mass entering the atmosphere is so small that it can only be observed using specialised meteor radars.' More so, Plane says that even though we know the dust is there, there is little indication of how much cosmic dust enters the Earth's atmosphere — the range of estimates being between 3 and 300 tons a day — and what impact it has.

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Clearing the air

The CODITA project is working to clear the air on this question. To accomplish this, the project launched two successful experimental systems to study the chemistry of the metallic molecules and ions produced from evaporating meteors. According to Plane, the first system detected the metallic molecules using a flow tube reactor, coupled to a time-of-flight mass spectrometer. The system uses pulsed laser radiation to softly ionise the metallic molecules. 'For the first time we were able to successfully study the reactions of such metallic species as metal oxides and hydroxides, which have proved undetectable by other methods,' says Plane.

The second experiment also used a flow tube, this time with a plasma source and coupled to a quadrupole mass spectrometer. 'With this system we can study the dissociative recombination of metal-containing ions with electrons, which is the main route for neutralising ions found in the upper atmosphere,' adds Plane.

A dust bin

These experiments — combined with an astronomical model of dust evolution in the solar system and high performance radar measurements — show that around 40 tons of cosmic dust enters Earth's atmosphere on a daily basis.

But so what? Sure, our atmosphere may look like it needs a good dusting, but what's the effect? According to the CODITA project, quite a lot: 'The metals being injected into the atmosphere from evaporating dust particles are the direct or indirect cause of an array of phenomena,' says Plane.

For example, the metals condense into very fine dust known as meteoric smoke, which plays a role in the formation of noctilucent clouds. These ice clouds occur in the polar regions at a height of 82 km during the summer months. 'The clouds first appeared in 1886, and their increasing occurrence appears to be signal of climate change in the middle atmosphere, where water vapour is increasing and temperatures are falling because of increased levels of greenhouse gas — the reverse of the lower atmosphere,' says Plane. 'Meteoric smoke also affects polar stratospheric clouds that cause depletion of the ozone layer, and the deposition of cosmic iron in the Southern Ocean provides a critical nutrient for plankton, which draw down carbon dioxide from the atmosphere.'

Now, thanks to the work done by the CODITA project, it is possible to model the effects of cosmic dust on a consistent basis and from the outer solar system all the way to the Earth's surface. But the project's scope isn't limited to Earth. To further understand the effects of cosmic dust on a planet's atmosphere, the project also explores the impacts of meteoric smoke in other solar system bodies, including high temperature chemistry on Venus, the formation of noctilucent clouds on Mars, and production of benzene on Titan.

CODITA

- ★ Hosted by the University of Leeds in the United Kingdom.
- ★ Funded under FP7-IDEAS-ERC.
- ★ http://cordis.europa.eu/project/rcn/102627

UNIQUE BARIUM DATASETS IMPROVE OUR UNDERSTANDING OF OCEANIC CARBON STORAGE

The West Antarctic Peninsula (WAP)'s high sensitivity to climate change makes it a perfect location for furthering scientific understanding of ocean chemistry. An EU-funded project is pursuing this objective with a focus on barium (Ba), which can provide a unique insight into both organic and inorganic carbon storage.

Ice core records indicate that atmospheric carbon dioxide varies naturally over time — a process to which the Southern Ocean strongly contributes by influencing natural carbon storage capacity. First, its deep waters take up and lock away carbon and heat from the atmosphere. Then, it exerts an important control on the distribution of nutrients to a large portion of the Earth's oceans, which in turn regulate algal population structure and thereby carbon uptake.

With the BARIUM (Barium cycling in Antarctic waters: Understanding present and past ocean processes) project, Dr Kate Hendry of the University of Bristol hopes to use Ba cycling to examine how oceanic carbon storage has varied over time.

'I worked together with my graduate students Stephanie Bates and Kimberley Pyle on making some of the most precise and accurate high-resolution measurements of seawater and marine carbonate Ba, using cutting-edge methods and instruments,' Dr Hendry explains. 'Our unique dataset allows us to test theories about how Southern Ocean circulation is linked to global climate over a range of timescales, and how nutrient cycling will respond to future climatic change.' These findings could prove to be of great interest to both policy-makers and industry.

The most climate-sensitive areas

The team's work was mostly focused on the WAP, which not only responds to more global temperature changes than other parts of the region, but is also strongly influenced by complex, interconnected, local and regional processes — from sea-ice and glacier dynamics to ocean and atmospheric circulation. 'This, along with the low levels of background man-made contamination, makes the WAP a key location for understanding ocean chemistry,' Dr Hendry points out. This didn't prevent the team, however, from expanding their work to the Drake Passage and samples from even further afield.

'We have produced a fantastic dataset of dissolved Ba from the WAP and Drake Passage regions of the Southern Ocean,' she explains. 'From the WAP shelf, our results reveal insight into the processes that control sources and sinks of Ba in seawater (sediment dissolution, sea-ice processes, ocean circulation and biology, etc.), as well as showing that there is significant variability between years as a result of changes in these processes. Our open ocean results show how the physical structure of the fronts within the Southern Ocean influences the behaviour of Ba in seawater. These results help us understand the link between Ba, nutrients and carbon drawdown in the Southern Ocean.'

In addition to this, the team produced climate records extending back through time by using sedimentary records of Ba content trapped within carbonate shells of single-celled organisms — called foraminifera — from the Southern Ocean. 'These archives

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provide us with information on changes in inputs of Ba and other aspects of ocean chemistry in the past. We have found significant differences between the Ba concentration of the Southern Ocean today and 125 000 years ago, during the last warm period (interglacial) before the last ice age,' Dr Hendry says.

Ice core records show that this period was warmer than the pre-industrial era and had a higher atmospheric carbon dioxide concentration, which makes it a potential point of comparison with the global warming expected over the next few decades. 'Our results have implications for how the circulation of the Southern Ocean may respond to a warmer world, and for our predictions of future change,' she adds.

Another key result from the project lies in the first barium isotope measurements for foraminifera and for seawater in the Equatorial Atlantic, which have tremendous value for furthering scientific understanding of the processes controlling Ba distributions in seawater and helping interpret Ba archives in marine sediments.

Lessons learned and plans ahead

Overall, BARIUM results provide valuable information about how Ba is cycled in the ocean and how it relates to biology — who is growing in the ocean and where — as well as nutrient and carbon uptake. 'This means that we can better understand how to use Ba archives locked away in marine sediments to interpret past changes in the ocean during periods of climatic change. In understanding how the ocean responds — or indeed drives — climate change in the past, we are in a better position to predict what will happen in the future,' Dr Hendry says.

For Dr Hendry and her team, the future promises more research and discoveries. 'As with most scientific research, our results have opened up more questions,' she explains. 'One such question is the role of sea-ice in Ba cycling, and how this links to carbon uptake. We have already been able to extend our project to the Arctic, via a new collaboration with colleagues at the Norwegian Polar Institute that has included a field campaign in 2015 to investigate winter sea-ice north of Svalbard. We already have some fascinating results from this new project, so watch this space!'

BARIUM

- Coordinated by the University of Bristol in the United Kingdom.
- Funded under FP7-PEOPLE.
- http://cordis.europa.eu/project/rcn/105350
- Project website: https://oceanbarium.wordpress.com/

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BIOLOGY AND MEDICINE

NOVEL REGENERATION THERAPY PROMISES TO SIGNIFICANTLY IMPROVE BONE REPAIR

EU-funded researchers have pioneered a new bone regeneration therapy that promises to significantly improve bone repair and provide a realistic solution for patients who require partial bone replacement.

Currently there is no adequate therapy available that can accelerate long bone fractures and promote healing. Present solutions in this therapeutic area rely on expensive and side-effects associated bone devices. The EU-funded OSTEOGROW (Novel Bone Morphogenetic Protein-6 Biocompatible Carrier Device for Bone Regeneration) project has developed an entirely new therapy that promises to be safe and cost-effective and will decrease the need for secondary interventions.

The new therapy works by using the patient's own blood in order to create a clot when in the operating theatre. The blood is then injected with 'Bone morphogenetic protein-6' (BMP6) and placed in the spot where new bone is needed to be created. The therapy also has the advantage of reducing inflammatory reactions which are common as a result of employing currently-used bone devices.

Within several months, the new bone piece is created, taking only a decilitre of blood to create the needed clots. The bone diseases which will be treated locally with the OSTEOGROW device are acute radius fractures and recalcitrant non-unions of the tibia. These conditions are particularly widespread and highly debilitating for which this new treatment method promises to significantly alleviate associated pain. The treatment would also be employed to treat another common cause of serious pain, degenerative changes in the spinal cord.

Phase 2 clinical trials are taking place in Zagreb, Croatia (where the project is coordinated), Sarajevo and Vienna. This follows tests on rabbits and sheep, which were highly successful in generating new bone. Ten patients underwent the pioneering new therapy at the Sisters of Charity Hospital in Zagreb, which resulted in no complications or toxic effects. In Vienna, surgeons are using the new therapy to treat patients with debilitating spinal fusion. By the end of the trials, 75 patients will have undergone treatment with the new OSTEOGROW device.

The research team is also particularly proud of the fact that OSTEOGROW is the first major international collaborative project to develop an entirely new medical treatment led and coordinated by clinicians in Croatia. 'For the first time the European Commission confided the project coordination to a Croatian medical institution, with 11 European partners from six states. They all helped, but the innovation and originality come from Zagreb, while partners enabled us to do preclinical trials and move the project to clinical trials,' stated project coordinator Slobodan Vukičević.

As the project enters its final months and clinical trials have thus far proved extremely promising, the research team are now concentrating on the commercial prospects of the new treatment. Acute bone fractures are prevalent in the EU and it is estimated that by 2050, due in part to an ageing population, 12 million bone fractures will occur on an annual basis. As such, new therapies to enhance bone formation, shorten healing times and prevent non-unions will become an increasing medical requirement.

It is expected that the new therapy pioneered by OSTEOGROW will be market-ready within the next two to three years.

OSTEOGROW

- ★ Coordinated by the School of Medicine, University of Zagreb in Croatia.
- ★ Funded under FP7-HEALTH.
- ★ http://cordis.europa.eu/project/rcn/101812
- ★ Project website: http://osteogrow.eu/

GENE INJECTION PROMISES A NEW WEAPON IN THE FIGHT AGAINST ALZHEIMER'S

Research funded jointly by the European Research Council (ERC) and Alzheimer's Research UK has demonstrated that the crippling neurodegenerative disease could be stopped by an injection into the memory centres of the brain.

Published in the journal 'Proceedings of the National Academy of Sciences', the research team based at Imperial College London have shown that it's possible to deliver a gene which produces a plaque-busting protein directly into the brain. The degeneration of brain cells in Alzheimer's disease is largely due to amyloid plaques. The sticky protein build-up happens when amyloid proteins fold and divide improperly. The main component of these protein clumps are amyloid-beta peptides. Preventing these proteins from forming may help prevent the death of brain cells which causes the disease and its symptoms to escalate. Nearly 9 million people in Europe suffer from Alzheimer's.

The research team studied a gene called PGC-1a as previous research had suggested that the gene could prevent the formation of amyloid plaques. They injected the gene into mice that were in the early stages of Alzheimer's disease. The mice did not develop any plaques and performed as well in memory tasks as healthy mice after four months.

Dr Magdalena Sastre, senior author of the research, commented that these findings could eventually provide a method of preventing the disease or halting it in the early stages. 'Although these findings are very early, they suggest this gene therapy may have potential therapeutic use for patients. There are many hurdles to overcome, and at the moment the only way to deliver the gene is via an injection directly into the brain,' she expanded. 'However, this proof of concept study shows this approach warrants further investigation.'

To administer the gene, the team used a harmless lentivirus that was modified to include the gene. The virus then infects brain cells and rewrites their genetic code to produce more of the plaque-fighting PGC-1a. Injections were administered in the hippocampus and cortex of the brain, as these are responsible for memory formation and orientation, and are the first to be affected by Alzheimer's disease.

"To administer the gene, the team used a harmless lentivirus that was modified to include the gene."

Professor Nicholas Mazarakis, co-author of the study and recipient of the ERC's IRLVGTMND (Improved retrograde lentiviral vectors for gene therapy in motor neuron diseases) project grant, added: 'Scientists harness the way the lentivirus infects cells to produce a modified version of the virus that delivers genes into specific cells. It is being used in experiments to treat a range of conditions from arthritis to cancer. We have previously successfully used the lentivirus vector in clinical trials to deliver genes into the brains of Parkinson's disease patients.'

Dr Doug Brown, Director of Research and Development of the UK's Alzheimer's Society also commented: 'So far potential treatments that directly target amyloid build-ups in the brain have mostly had disappointing results in clinical trials, whereas this study could pave the way for a new plan of attack.'

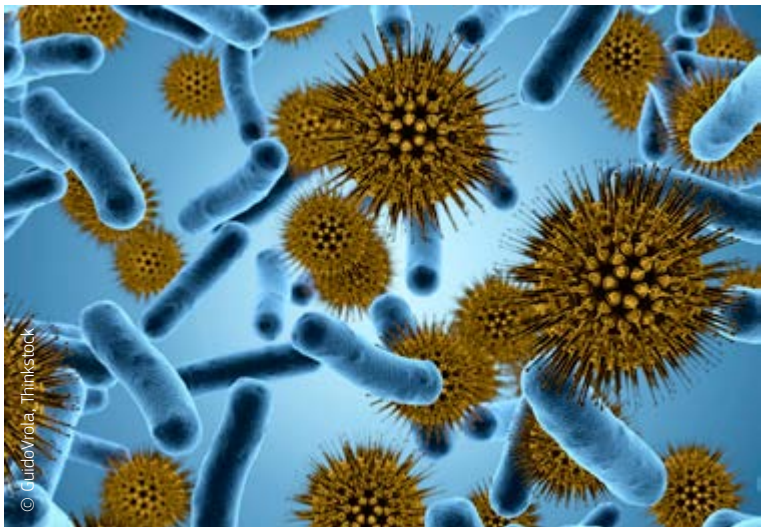
The team's results suggest that therapies utilising PGC-1a may be able to prevent Alzheimer's disease if the patient is treated early. Human trials are still a long way off but this provides new hope for the development of a treatment for a currently incurable disease.

IRLVGTMND

- Hosted by the Imperial College of Science, Technology and Medicine in the United Kingdom.
- Funded under FP7-IDEAS-ERC.
- http://cordis.europa.eu/project/rcn/89779

MICROBIAL DYNAMICS OF ANTIBIOTIC RESISTANCE

Microbial antibiotic resistance develops in the gut through the selection of pre-existing resistant bacteria and gene transfer events. Scientists investigated the dynamics of the entire collection of 'Antimicrobial resistance determinants' (ARDs), also known as the resistome, in the human gut.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The emergence of antibiotic resistance in bacteria has dramatically decreased the therapeutic options available for treating bacterial infections. To address this issue, the EU-funded EVOTAR (Evolution and transfer of antibiotic resistance) project worked to uncover mechanisms involved in the evolution and spread of antibiotic resistance in human pathogens.

The consortium employed different technologies, such as full metagenomic sequencing, functional metagenomic selections, and resistance gene capture platforms. Their objective was to

characterise the human reservoir of antibiotic resistance genes, the resistome.

Metagenomic sequencing revealed that long-term (chronic) exposure to antibiotics decreased the richness of the microbiome and increased the abundance of ARDs. It clearly demonstrated that such exposure selects species than can survive in the constant presence of antibiotics due to the ARDs they encode. The functional selections found that hospitalisation and antibiotic treatment have profound effects in some patients through expansion of their ARDs. Importantly, some of the data indicated that after six months the abundance of antibiotic resistance genes returned to the original level.

Optimised cultivation methods for the human gut microbiota were developed to capture a representative majority of the cells in a sample. These novel culture technologies in combination with whole genome sequencing revealed reservoirs of antibiotic resistant organisms and antibiotic resistance genes in soil and marine environments.

EVOTAR also developed the PLACNET tool for the reconstruction of plasmids carrying resistance genes from whole genome sequence data to track the transmission and study the natural history of these plasmids. Another new method was developed to identify ARDs in large complex datasets. This helped them to significantly expand the list of known resistance genes.

Project members introduced new mathematical models for studying the host transmission of antibiotic resistance. These models enabled the study of the spread of different diseases and antibiotic resistance through the network of hosts (i.e. patients, hospitals, farms), and identification of hosts that are at risk of becoming infected.

The consortium successfully developed an antibiotic resistance gene-capture platform, which currently consists of 80 000 targets of resistance genes and genes associated with the mobile genetic elements. This could contribute to dissecting the spread of resistance at an unprecedented level of quality and speed.

A novel intervention approach was taken in EVOTAR and was aimed at administering a compound that absorbs and inhibits residual antibiotics in the human colon. It was anticipated and proven correct that this approach minimizes selective pressures leading to the emergence of antibiotic resistance in and perturbation of the commensal flora, without changing the antibiotic's absorption rate and its potential to treat the infection for which it has been administered.

Taken together, EVOTAR provided new information on the evolution, transfer and emergence of resistance genes. Novel in vitro and in vivo models provide a platform for future studies into the efficacy of novel intervention approaches.

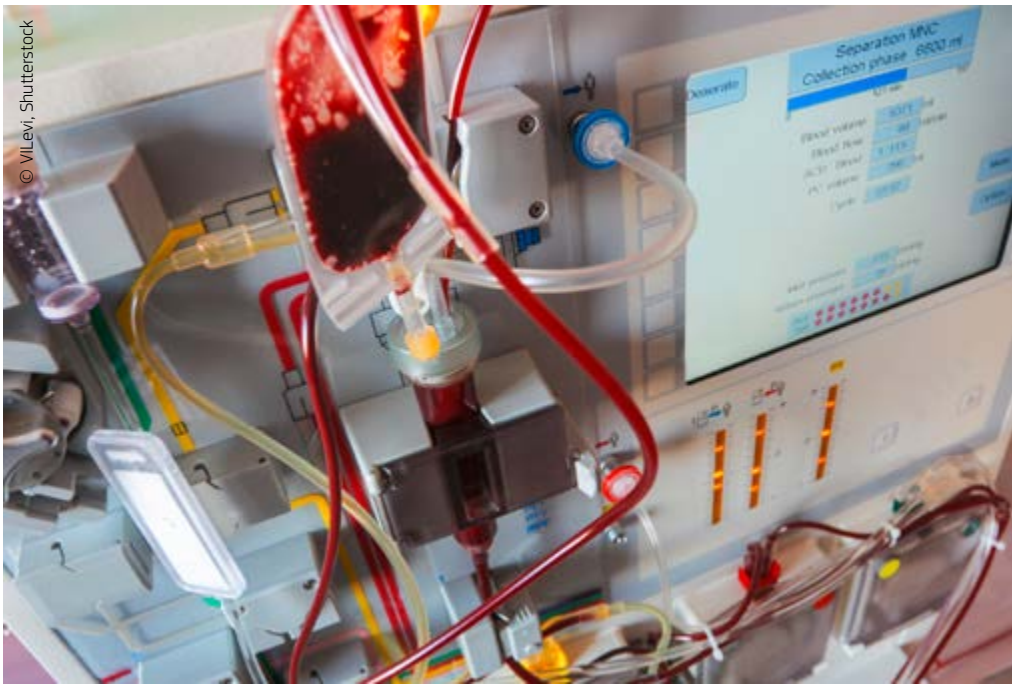
EVOTAR

- Coordinated by UMC Utrecht in the Netherlands.
- Funded under FP7-HEALTH.
- http://cordis.europa.eu/project/rcn/100088
- Project website: http://evotar.eu/

CLINICAL BREAKTHROUGHS OFFER YOUNG CANCER PATIENTS HOPE

An EU-funded project has made significant advances in treating a common form of childhood leukaemia, potentially saving thousands of young lives.

Researchers have developed new tests that could improve the diagnosis and treatment of a common form of childhood leukaemia. By tracking special structures in the blood released by cancerous acute lymphoblastic leukaemia cells, scientists believe they will be able to more accurately monitor and treat the disease, saving lives and making more efficient use of medical resources.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What makes this discovery so interesting is that, until recently, these special structures — extracellular vesicles — were thought to be inconsequential debris. However, the INTREALL (International study for treatment of childhood relapsed ALL 2010 with standard therapy, systematic integration of new agents, and establishment of standardized diagnostic and research) project discovered that cancerous leukaemia cells not only produce but also send these structures to anywhere in the body through blood.

This discovery opens up two new research avenues in the treatment of 'Acute lymphoblastic leukaemia' (ALL): the possibility of monitoring the progress of the disease by tracking these structures; and the possibility of improving the delivery of drugs by actually combining them with the vesicles. The team also hopes that the vesicles might provide

individualised information about tumours, helping doctors to deliver personalised care in the future.

ALL is a malignant cancer characterised by an over-production of white blood cells. It predominantly affects children, with fatal relapse in some patients. It is the most common malignant disease in childhood, affecting four in every 100 000 children per year in Europe. Over the past four decades, survival has improved from less than 20 % to over 80 %.

Nonetheless, relapse remains a leading cause of mortality in childhood cancer. About 15 % to 20 % of patients suffer a relapse of the disease. Relapses are currently treated with intensive chemotherapy and 'Haematopoietic stem cell transplantation' (HSCT). Many of these drugs have toxic side-effects, and invasive surgical procedures can be painful and stressful for young patients.

The INTREALL project therefore sought to bring together European experts with expertise in childhood cancers in order to investigate novel new therapies and to facilitate the world's largest ALL-focused clinical trial. The project has successfully integrated up to 300 European hospitals as well as innovative 'Small and medium-sized enterprises' (SMEs) involved in biotechnology and IT, and has also fostered links with relevant networks for paediatric oncology, drug development and parent organisations.

INTREALL

- Coordinated by Charité in Germany.
- Funded under FP7-HEALTH.
- http://cordis.europa.eu/project/rcn/102104
- Project website: http://www.intreall-fp7.eu

BACTERIA SHAPE NEONATAL IMMUNE SYSTEM

The first months of life are critical for immune system development and maturation. A European study looking into this process has illustrated the central role of maternal gut microbiota.

Commensal microbiota inhabit the inner and outer body surfaces of healthy mammals, such as the skin, airways and intestine. The role of these bacteria in the intestine is well-established for the digestion of food, production of vitamins and immune protection. Changes in gut microbiota composition are associated with an increased risk of developing inflammatory bowel disease.

Colonisation with beneficial bacteria starts after birth and is intricately associated with the immediate environment. This underscores the importance of exposure to the maternal microflora during early childhood in shaping the health of the infant. Scientists in the EU-funded MICROBIOTA-NEONATE (Characterization of maternal microbiota-dependent imprinting of the neonatal immune system) project set out to investigate the phenotypic and functional effects of maternal microbiota on neonatal immunity and the mechanism behind this phenomenon.

The researchers exposed pregnant germ-free mice to the commensal strain of E. coli, HA107, and compared their offspring to those that had remained germ-free throughout pregnancy. They observed that offspring exposed to commensal E.coli while in the uterus had more immune cells responsible for maintaining homeostasis at the host-microbial interface as well as immunity against invading pathogens.

"MICROBIOTA-NEONATE scientists also demonstrated the significance of microbiota exposure during gestation."

MICROBIOTA-NEONATE scientists also demonstrated the significance of microbiota exposure during gestation. Offspring fed by germ-free mothers exhibited bacterial translocation to the lymph nodes while those exposed to maternal microbiota were protected. Furthermore, the latter expressed higher levels of genes involved in antimicrobial defence and intestinal homeostasis.

Mechanistic insight indicated that the majority of the alterations observed in the offspring immune system introduced by gestational colonisation were dependent on the presence of maternal antibodies. This takes place in the uterus via the placenta and, postnatally, via the maternal milk. Interestingly, the maternal antibodies carried bacterial-derived factors in the maternal milk that could reach the offspring by gestation.

Overall, the increased incidence of allergic diseases in children in developed countries, as well as neonate and child mortality from infectious diseases in developing countries, emphasise the need for improving neonatal immunity. The findings of the MICROBIOTA-NEONATE study will contribute to the prenatal prevention of allergic diseases and new therapeutic tools that reduce child mortality.

MICROBIOTA-NEONATE

- Coordinated by the University of Bern in Switzerland.
- Funded under FP7-PEOPLE.
- http://cordis.europa.eu/project/rcn/188094

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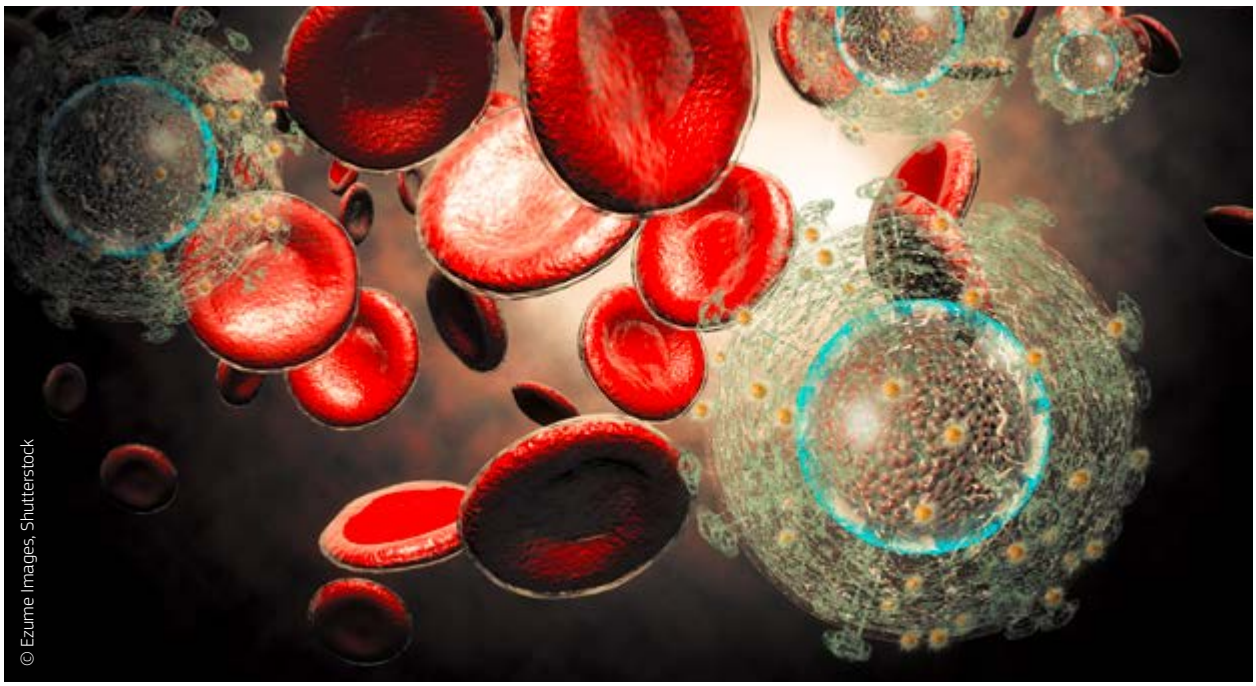
EXPLOITING HIV'S WEAKNESSES TO DEVELOP EFFECTIVE VACCINES

EU-funded researchers have made significant progress in identifying promising pathways that could lead them towards developing an HIV vaccine.



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Around 6 300 people a day are infected by HIV, the virus that ultimately causes AIDS, whilst over 25 million people have so far died overall. Finding a vaccine has been the focal point of HIV research since the 1980s. Although this remains elusive, the success of a recent study suggests that scientists are on the right path.

Part-funded through the ERC-funded SHEV (Stabilizing the exposure of neutralization epitopes on HIV-1 envelope glycoprotein trimer vaccines) project, the study, recently published in the journal 'Cell Reports', has identified a key vulnerability in the HIV molecule that could one day be targeted by an effective vaccine. Researchers are also confident that targeting a virus's precise molecular structure — in order to prompt the immune system to produce specific antibodies — could also be applied to efforts to fight other viruses, such as influenza and Ebola viruses.

The key is that every virus has a signature structure. Understanding the structure of HIV has enabled scientists to gain a better idea of exactly where HIV is vulnerable to infection-blocking antibodies. This is highly significant, because a major problem facing scientists has been the fact that HIV generally conceals vulnerable sites under a dense layer of sugars and fast-mutating parts. This is one reason why the virus has proven so difficult to neutralise; much of the body's antibody response to infection is directed against fast-mutating parts that render the body's response useless.

A major step forward was the discovery of random holes in HIV's protective outer shell of glycan molecules in the 1990s. Although scientists were initially unsure if antibodies could target these holes, this study has now confirmed that these holes could indeed be viable targets for antibodies, and thus play a crucial role in the design of an HIV vaccine.

The findings build on work pioneered at Cornell, The Scripps Research Institute (TSRI) and the Academisch Medisch Centrum in Amsterdam, which coordinated the SHEV project. A stabilised version of an important HIV protein — called the envelope glycoprotein (Env) trimer — was designed in order to encourage rabbits to produce antibodies against the virus.

The scientists then examined where the antibodies bound to the virus, revealing HIV's vulnerabilities. They found that the antibodies did indeed target holes in the glycan shield of this protein, opening the door to possible future vaccines that encourage the immune system to create hole-targeting antibodies.

While the SHEV project is due for completion at the end of 2016 EU-funded research in this field will continue. A key focus will be on evaluating possible vaccine candidates, and understanding the immune response induced by these vaccines. Much of this research will be financed by the EU's European AIDS Vaccine Initiative (EAVI2020), which brings together leading HIV researchers from public organisations and biotech companies from across the world.

The ultimate goal is to develop novel candidate vaccines that can be taken through to human trials within five years and provide a platform for discovering new vaccine candidates. The development of a protective vaccine remains the most attractive option for halting the global spread of HIV; around 34 million people are currently living with the virus.

SHEV

- Hosted by the Academic Medical Center in the Netherlands.
- Funded under FP7-IDEAS-ERC.
- http://cordis.europa.eu/project/rcn/102000

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SOCIAL SCIENCES AND HUMANITIES

UNDERSTANDING HOW FINANCE CAN BETTER SERVE THE ECONOMY, SOCIETY AND THE ENVIRONMENT

During its final conference in Brussels from 27 to 28 September, the FESSUD project brought together leading academics, economists and financial experts to disseminate its key results and discuss how Europe's financial system can be better structured to serve economic, societal and environmental needs.

Following the major financial crisis and subsequent Great Recession of 2008-2009, from which it can be argued that Europe has still not fully recovered, the EU-funded FESSUD (Financialisation, economy, society and sustainable development) project was formed to devise solutions to minimise the risks of such a catastrophic financial meltdown occurring again. The five-year project, due to end in November 2016, has examined the increased 'financialisation' of economies over the past 30 years, and has explored how this process has impacted the sustainability of the financial system, and how this has affected the achievement of specific social, economic and environmental goals.

Financialisation and regulation

As financialisation (the process by which financial institutions, markets, etc. increase in size and influence) has become a defining feature of the world economy since the 1980s, the regulation of the financial system has been a key focus for the project. Speaking during the conference, Jan Kreugel from Tallinn University of Technology argued that politicians and regulators tend to have an 'illusion of control' with regards to financial regulation. He argued that rather than being effective at stopping a future crisis, regulations tend to set the conditions that will inevitably lead to the next financial crisis.

He detailed how a one-size-fits-all approach to regulation will not prevent a future financial crisis. The project examined seven European countries (comprising a mix of initial members of the European Community, later members, and countries that formerly had a planned economy). They discovered that when transposed into national legislation, European and internationally agreed financial regulations became much more specific to the conditions of each national economy.

He concluded that new financial regulations should ensure only pure monetary institutions have access to international payment systems, as well as guarantee adequate liquidity in the system. This will help to prevent regulations becoming too specific to certain countries and maintain a more general, yet still robust, regulatory framework.

The social consequences of financialisation

FESSUD also examined the social consequences of financialisation, particularly amongst disadvantaged and economically poorer sections of society. The project partners found, by taking an extensive pan-European survey, that due to banks being the main interface between the financial system and society, participants reported experiencing the 'disproportionate' power of finance over their lives.

Financial institutions demonstrate very little responsiveness to the needs of marginalised groups, encouraging them to take on ever more credit to increase consumption, even if this is not in their best interests. Respondents felt that they had become 'merely an account number'. Consequently, without any viable mechanisms for marginalised groups to express how financial services can work for them, they have grown to distrust banks and fear engaging with them.

The FESSUD research also highlighted how individuals have undertaken collective action to resist finance's influence on their lives. For example, many individuals in the UK and Germany refuse a credit card, whilst many Belgians reported that they store some of their savings as cash rather than depositing into a bank. Overall, it is clear that new ways must be developed by financial institutions so they can better engage with individuals and respond to their real and actual needs.

Financing green investment

Another important topic discussed at length was how the financial system and the process of financialisation could best power the development of a greener economy and fund green investment.

Alessandro Vercelli, from the University of Siena, outlined how 'core' banks should be organised into a specific network to coordinate their actions, allow for the exchange of best practices and favour transnational or particularly ambitious environmental projects. He argued that the scope of a core bank should not be restricted to financing green investment in its own country.

Core banks would be held accountable through apt metrics, both financial and also metrics based on sustainability targets (such as emissions of GHGs and energy saved, and the number of 'green' jobs created).

The future of finance in Europe

Another survey carried out by the project, this time focussing on 50 economists from across Europe, painted a gloomy picture for the next decade. In particular it predicted a revival in household lending, mainly through mortgages that will pose a moderate to significant threat. They also predict greater inequality in income and wealth distribution that will do little to restore trust in the financial system following the crash and Great Recession.

The FESSUD project, which has clearly highlighted the need for even greater and deeper structural reform of world finance through its groundbreaking and comprehensive research, received nearly EUR 8 million of EU funding.

FESSUD

- Coordinated by the University of Leeds in the United Kingdom.
- Funded under FP7-SSH.
- http://cordis.europa.eu/project/rcn/101356
- Project website: http://fessud.eu/

STUDY SHOWS BETTER COOPERATION AMONGST ISRAELI TEENAGERS AFTER LEARNING PEOPLE CAN CHANGE

A recently published study supported by the EU-funded EMOTIONS IN CONFLICT project has highlighted how Jewish and Palestinian-Israeli teens cooperate better after being taught that people can change.

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As the Israeli-Palestinian conflict has now been running for decades, mutual distrust between Jewish-Israelis and Palestinian-Israelis has built to a point where the two groups often struggle to work cooperatively on resolving common challenges together. However, a team of psychologists led by Stanford University and Israel's Interdisciplinary Center, Herzliya, have found that teaching Jewish-Israeli and Palestinian-Israeli teenagers that groups are generally capable of change — without mentioning a specific adversary — can significantly improve their ability to cooperate.

The study builds upon earlier research by two members of the team — Professor Carol Dweck, as well as Professor Eran Halperin who was senior author on this study which was recently published in the journal 'Social Psychological and Personality Science'. Previously, they had found that Israelis and Palestinians expressed more favourable attitudes towards each other and were willing to compromise after they were presented with a news article arguing that groups could change.

'When you think people have fixed traits your job is just to figure them out and go from there,' commented Professor Dweck. 'If you think people can develop and change, you don't tend to make blanket judgements.'

This latest study is the team's first attempt to bring Jewish-Israelis and Palestinian-Israelis physically together in order to test their ideas. The team conducted four sessions with 74 Jewish and 67 Palestinian-Israeli students, aged 13 and 14, from a Palestinian-Israeli school and a Jewish-Israeli school over a period of three months.

Each school's students were divided into two groups and, over the course of three sessions, one group was taught about people's ability to change, whilst the other group learned about ways of coping with stress. In the fourth session, the Jewish and Palestinian-Israeli students met and were separated into mixed teams of four to six participants. They then completed several tasks which were used to measure their levels of cooperating with each other.

One of the tasks saw the students using spaghetti, marshmallows and tape to build the tallest tower they could in 10 minutes. The results showed that students who were taught the ideas about people's ability to change built towers that were 59% higher and had more positive emotions towards each other in comparison to the groups in the control condition.

'We expected to see some change, but not such big changes,' said Amit Goldenberg, a graduate student and lead author of the paper. 'It's much easier to see changes in people's attitudes, but to actually see that these people are cooperating better is remarkable.' Goldenberg and his colleagues said the workshops' content could potentially produce positive outcomes if implemented more widely in Israeli and Palestinian schools.

The research team is currently conducting similar studies in adults, which they argue is important in order to show how long the change in attitudes might last.

In the meantime, they are excited about the implications of the latest study and their work with the teenagers. 'The Israeli-Palestinian conflict affects millions of lives every day,' Goldenberg said. 'Any contribution you can make to this problem is progress.'

The study was funded by the European Research Council (ERC) project EMOTIONS IN CONFLICT (Direct and Indirect Emotion Regulation as a New Path of Conflict Resolution) that is being led by the Interdisciplinary Center Herzliya, and has received nearly EUR 1.5 million in funding. The project, which will run until January 2019, is studying how human emotion regulation can provide positive outcomes in conflict resolution.

"This latest study is the team's first attempt to bring Jewish-Israelis and Palestinian-Israelis physically together in order to test their ideas."

EMOTIONS IN CONFLICT

- Hosted by the Interdisciplinary Center Herzliya in Israel.
- Funded under FP7-IDEAS-ERC.
- http://cordis.europa.eu/project/rcn/192360

ONE SMALL STEP FOR ROBOTS, ONE GIANT LEAP FOR ROBOT-KIND?

The EU-funded ROVINA project has developed an autonomous robot which can navigate, explore and digitally map hard-to-access areas.

Digital technology is frequently used to record and map our cultural heritage, enabling research, preservation efforts and increased public access for sites of archaeological interest for example. Most contemporary techniques involve people entering such areas to capture them using a static 3D laser scanner. While this works for many sites, it does not work for all.

The ROVINA (Robots for Exploration, Digital Preservation and Visualization of Archeological Sites) project sought to address this limitation by using advances in autonomous robotic technology, which can get to hard or dangerous places to reach, such as tunnels or mines. The robots can navigate and explore, build textured 3D models (including a semantic interpretation) and return home on their own. ROVINA set out to build on advances in robotic digital mapping by improving accuracy, reliability and autonomy.

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Building a whole new robotic system

To achieve the desired robust mapping, autonomous behaviour, realistic rendering, etc. the ROVINA team had to create a whole new robotic system. As Professor Cyrill Stachniss the project coordinator puts it, 'Our techniques are at the forefront of robotics, computer vision and photogrammetry research.' ROVINA faced a number of challenges. For example, as well as often arduous terrain, the scanning technology was faced with scene interpretation barriers, such as low lighting. Additionally, the situation was further complicated by constraints in communication with the robot which compromised the human tele-operation and supervision.

To tackle these hurdles ROVINA drew upon the specialties of a diverse team with competency in the fields of digital preservation, autonomous and networked robots, 3D reconstruction and mapping, object detection and online learning, vision and perception, semantic analysis and user interface design. To integrate the various specialisms, the project proceeded using a modular software design, whereby each module which performed a specific task interacted through a middleware interface. Periodically, the modules were integrated and tested at different cultural heritage sites.

The project developed a prototype that was able to explore the catacombs of Rome and Naples. The work fine-tuned intuitive and flexible user interfaces for remote robot interaction, despite the complex and unpredictable locations under exploration. Ease-of-use was an important project result as the likely end-users will vary — historians, archaeologists, construction engineers and even potentially virtual tourists.

The prototype also demonstrated increased autonomy and reliability, with an ability to perform more accurate traversability analysis, resulting in improved navigation. The processing of the sensory data for navigation also facilitated semantic information, such as the identification of interesting artefacts.

Expanded capabilities

ROVINA offers a powerful tool for cultural preservationists such as the International Council of Monuments and Sites. As Professor Stachniss explains, 'With the ability of quickly acquiring digital models over time using the ROVINA system, combined with the tools for the analysis of temporal change in sites, it is possible to monitor levels of decay.' Importantly, as ROVINA reduces the cost and time to make digital models, so the scope of area under investigation can be enlarged within a similar budget and time constraints. With the software able to adjust to sensors for scanning larger areas, autonomous (or semi-autonomous) digitisation becomes possible for GPS-denied environments, such as complex factory floors or indoor environments.

In addition to the cultural heritage goals of the project, the work is also of interest to those working on autonomous robotics and who are seeking to make their innovations more robust. To support this, key ROVINA development components have been released under a dual licensing model, as open source software available over the internet through the project website, as well as under a commercial license.

"The work is also of interest to those working on autonomous robotics and who are seeking to make their innovations more robust.."

Looking ahead to the future, Professor Stachniss summarises, 'ROVINA's main target was geometric modelling firstly, with semantics only to some degree. We believe that the semantic aspect offers future potential and must be exploited. Secondly we need to simplify the robotic use and to target the automation of geodetic high-precision scanning, currently labour-intensive and so an expensive task.'

ROVINA

- Coordinated by the University of Bonn in Germany.
- Funded under FP7-ICT.
- http://cordis.europa.eu/project/rcn/106847
- Project website: http://www.rovina-project.eu/
- http://bit.ly/2fXZray

RECOMMENDATIONS FOR SECURE AND SUSTAINABLE EUROPEAN CULTURAL LANDSCAPES

Following its final conference that took place in Brussels on 4 October 2016, the EU-funded HERCULES consortium has provided stakeholders with a detailed set of policy recommendations that will preserve Europe's diverse heritage in cultural landscapes.

Over millennia, we have created and maintained cultural landscapes. They provide us with a variety of values and services that are essential for human societies to function and grow. These include cultural and recreational facilities, tourism opportunities, ecological and environmental knowledge, and the ability to grow food, use medicinal resources and extract raw materials. Cultural landscapes adapt over time, though with the dawn of the modern age, many have changed rapidly through factors such as deforestation and urbanisation. This has impacted their sustainability and raised concerns over the need to effectively preserve cultural heritage.

The three-year HERCULES (Sustainable futures for Europe's HERitage in CULtural landscapES: Tools for understanding, managing, and protecting landscape functions and values) project was formed to empower public and private actors to protect, manage and plan for sustainable landscapes of significant cultural, historical and archaeological value at local, national and pan-European scales. But what exactly is a cultural landscape? The HERCULES project utilised the definition of landscape within the Council of Europe's European Landscape Convention (ELC): 'An area as perceived by people, whose character is the result of the action and interaction of natural and/or human factors.' At the heart of the ELC therefore is the premise that all places — be they natural, rural, urban or marine — are

'cultural landscapes', and are inherently dynamic.

A landscape approach to governance

Through their research, the HERCULES project team found that Europeans tend to feel that their landscapes are threatened, culturally, economically and environmentally. In Europe there tends to be a natural sense of conservatism with regards to the landscape and how it changes. Even in cases where landscapes were/are more or less stable, the team found that people still tended to believe that their landscape was threatened.

This is one of the key reasons as to why the project recommends a 'landscape approach' to environmental governance, an approach which is participative and transdisciplinary. This avoids the pitfalls of single-sector or single-discipline approaches and encourages the active participation of local citizens in finding the best means to not only protect and preserve their environment but also help them embrace positive change to their landscapes.

Specifically, from a policy perspective, the project recommends that EU policies impacting all land (urban, rural and marine) should be harmonised to avoid the ineffectiveness of policies that concentrate too narrowly on single sectors of economic land use, or that impact on sections of society that are too narrowly defined. HERCULES also advocates that the landscape approach should be considered at every stage of the policy and decision-making process. This includes the development of policy areas and tools that have a direct or indirect bearing on the natural and/or human factors of the landscape.

A HERCULES Knowledge Hub to inform policymaking

The project team arrived at these recommendations by setting up nine 'study landscapes' that were located across Europe. They were selected to ensure a balanced representation of environmental and land use gradients within Europe and to encompass diverse European cultural landscapes. The data collected was also fed into the HERCULES 'Knowledge Hub', an online, two-component system that allows users to view, explore, extrapolate and interact with the data collected from the nine sites.

The Hub also contains a wealth of further information that will be of great benefit to policymakers and other stakeholders, including examples of best practices for cultural landscape management, the lessons learnt from the 'Cultural Landscape Days' organised in five of the study landscapes, and evaluations of the potential threats to European cultural landscapes on a European scale.

"The Hub also contains a wealth of further information that will be of great benefit to policymakers and other stakeholders."

With the project due to end in November 2016, HERCULES has been successful in bringing back landscapes to the forefront of the political agenda, arguing that an interdisciplinary and inclusive landscape approach is the best means to preserve Europe's vast cultural heritage and diverse environments.

Indeed the project has acted as a trailblazer, with further calls within the Horizon 2020 programme due in the near future for large demonstration projects linking heritage and landscape preservation.

HERCULES

- Coordinated by Humboldt University of Berlin in Germany.
- Funded under FP7-ENVIRONMENT.
- http://cordis.europa.eu/project/rcn/110482
- Project website: http://www.hercules-landscapes.eu/
- http://bit.ly/2fAaHcw

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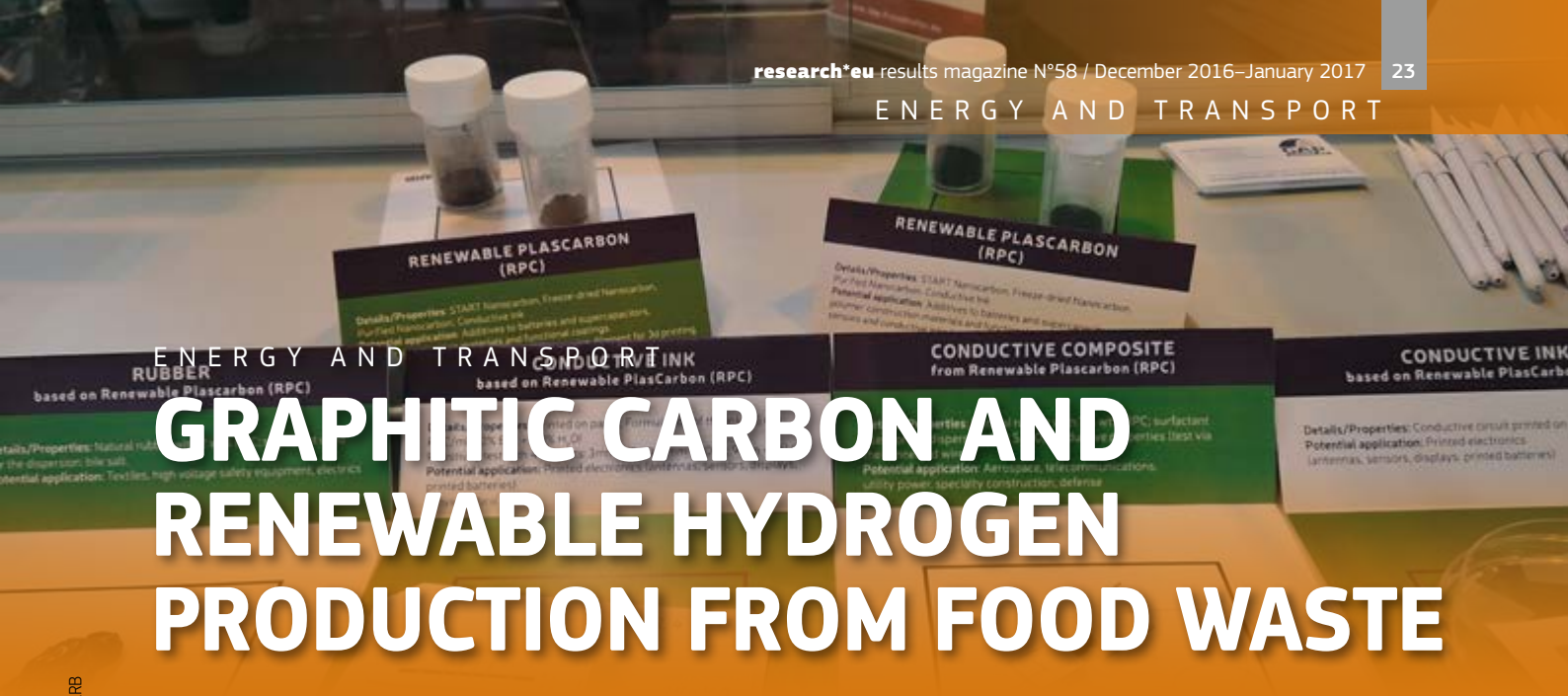

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ENERGY AND TRANSPORT

GRAPHITIC CARBON AND RENEWABLE HYDROGEN PRODUCTION FROM FOOD WASTE

Graphitic carbon and renewable hydrogen will be two cornerstone resources of the green economy. Thanks to EU funding under the PLASCARB project and an innovative, low energy microwave plasma process, researchers aim to produce both from food waste.

Let's contemplate for a second the future as the EU is trying to shape it: people drive electric or hydrogen fuel cell-powered cars, waste gets reused and recycled to reduce our environmental footprint, and new materials allow for groundbreaking technologies we could never have hoped for otherwise. While this surely sounds like an ambitious plan, an EU project with funding of just a little over EUR 4 million is trying to make it a reality with the help of a novel processing technology.

The plasma process that the PLASCARB (Innovative plasma based transformation of food waste into high value graphitic carbon and renewable hydrogen) project came up with consists of transforming the biogas output from 'anaerobic digestion' (AD) of food waste into graphitic carbon — a compound made of different layers of graphene — and renewable hydrogen (RH_2).

'We take the food waste through an anaerobic digester, which is a well-established technology to produce biogas (CH_4 & CO_2). Then, following purification, it passes through a low temperature microwave plasma reactor to produce the graphitic carbon (named as renewable PlasCarbon) and renewable hydrogen,' says Neville Slack, coordinator of the project for the UK's Centre for Process Innovation (CPI).

Graphite/graphitic carbon is notably a key component of lithium-ion batteries, whilst H_2 is used in many chemical and process industries and a potential fuel to power H_2 fuel cells. The first is worth some EUR 10 billion per year, and the second is set to take over a market that was worth 286 million tonnes in 2016 — 95 % of which is currently produced from fossil fuels.

Pilot scale demonstration

In its original form, the project aimed to validate at pilot scale the continuous operation of its integrated process for a period of one month. The team planned to build its own plant with a view to having 150 tonnes of mixed food waste digested and generating over 25 000 m^3 of biogas, before transforming 2 400 m^3 of this biogas into highly graphitic carbon with a market value of over EUR 2 500/tonne and RH_2.

But that was before they had to face unforeseen difficulties: 'We initially had a delay in obtaining a major piece of equipment from a supplier, which eventually resulted in the AD plant not being available within the timescale of the project,' Slack explains. The consortium had to take AD biogas via food waste from another source before it was able to create the required plant and products. Other pitfalls included a partner which filed for insolvency, and a review of the renewable hydrogen that was deemed not to be commercially viable at this scale of operation and therefore could only go through a desk top validation.

'Despite the problems we faced, our trial produced good quality Renewable PlasCarbon from biomethane derived from food waste,' Slack notes.

Looking into market opportunities

The team's work didn't end there. 'We looked at the market opportunities from two sides. Firstly we carried out a market appraisal which looked at the potential applications in which the Renewable PlasCarbon could be used: these included batteries, supercapacitors, rubbers, sensors, printed electronics etc. Secondly — and probably more importantly — we carried out extensive product characterisation of the renewable PlasCarbon to find out just exactly what it was made of in terms of structure, and also just how good it was. From there we have used the material in a range of test products that include conductive inks, rubbers, 3D printed lattice structures, supercapacitors, photoluminescence, catalysts, and also investigated opportunities in the fuel cell market,' Slack says.

One of the most recent outcomes of PlASCARB was a scientific study on the value and usefulness of Renewable PlasCarbon, and the team is now producing a post-project engagement portal named PLASCARB Viability Assessment that will include business information, case studies of PLASCARB's applicability in other countries for example Germany, Hungary, Norway. 'Now we are actively looking for opportunities to take the technology to the next commercial stage,' Slack concludes.

PLASCARB

- ★ Coordinated by the Centre for Process Innovation Ltd in the United Kingdom.
- ★ Funded under FP7-ENVIRONMENT.
- ★ http://cordis.europa.eu/project/rcn/185458
- ★ Project website: http://www.plascarb.eu/

A SWEET SOLUTION TO THE THERMAL ENERGY STORAGE PROBLEM

Researchers have combined sugar alcohols with carbon nanotubes to create a material capable of storing renewable energy as heat.

As scientists and researchers continue to seek new ways to reduce dependency on fossil fuels and decrease the amount of CO_2 put into the air, one area that is sometimes overlooked is how heat is stored. For example, although much research has gone into collecting and using solar and wind energy, little has gone towards answering the question of how to store excess energy for the times when the sun is down or the wind isn't blowing.

Traditionally, the answer to this storage question has been batteries or, in some cases, pumped hydroelectric storage — two solutions that are far from perfect. In fact, some of their inefficiencies can actually cancel out any environmental benefit created by using solar and wind energy in the first place.

One possible solution to the storage question is to convert the energy into thermal energy and store it in thermal energy storage facilities, which have been shown to be generally more efficient, better at capturing wasted heat and able to provide more low-cost energy. However, before we can make widespread use of thermal energy, research into the development of cost-effective, high-density storage technology is needed.

And this is exactly what the researchers from the EU-funded SAM.SSA (Sugar Alcohol based Materials for Seasonal Storage Applications) project delivered.

Thinking outside the box

The project's objective was to develop new 'Phase change materials' (PCM) for 'Seasonal thermal energy storage' (STES) applications in the range of medium temperatures. Researchers wanted these materials to be low-cost, environmentally sound, safe and easy to use. Furthermore, the materials would have to be able to serve as a long-term storage solution that provided significantly lower levels of thermal loss than currently available options.

This was an innovative approach to the problem as PCM are not typically viewed as a STES option. This is due to their insufficient energy densities and their high risk of solidification during storage — a phenomena caused by inadequate insulation for maintaining temperatures beyond the melting point.

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The magical material

For SAM.SSA, the magical material for overcoming the PCM problem was sugar alcohol, a common and abundantly available waste product of the food industry. Also known as 'Molecular alloys based on sugar alcohols' (MASA), this material allows for the adjustment of the melting point and, as a result, significantly increases energy density. According to a recent article on the project published in 'The Journal of Physical Chemistry', sugar alcohols, when mixed with carbon nanotubes, create a material capable of storing renewable energy as heat.

The project focused on sugar alcohols as they permit high levels of undercooling, which minimises the risk of spontaneous PCM solidification. They also reduce the requirements for insulation, as well as thermal loss during long-term storage. With the application of a local thermal shock or ultrasound, nucleation and subsequent crystallisation is induced, allowing for an easy and efficient discharge of the energy from the storage system.

Laying the foundation

When carbon nanotubes of varying sizes are mixed with two types of sugar alcohols — erythritol and xylitol — researchers found that, with one exception, heat transfer within a mixture would decrease as the nanotube diameter decreased. They also found that, as a general rule, higher density combinations meant better heat transfer. These findings are significant as they lay the foundation for the future design of sugar alcohol-based energy storage systems.

"The project focused on sugar alcohols as they permit high levels of undercooling, which minimises the risk of spontaneous PCM solidification."

At the time of the project's conclusion, researchers had created an early-stage prototype for treating pure sugar alcohol or sugar alcohol blends to achieve crystallisation. With basic concepts for further prototypes already in the works, along with exploitation strategies, SAM.SSA researchers are optimistic about the use of MASA as an answer to the problems of thermal energy storage.

SAM.SSA

- Coordinated by CNRS in France.
- Funded under FP7-ENERGY.
- http://cordis.europa.eu/project/rcn/103643
- Project website: http://samssa.eu/

ADVANCED TECHNOLOGIES AND NOVEL SOLUTIONS FOR A COMPETITIVE AND SUSTAINABLE EUROPEAN BIOGAS SECTOR

The EU-funded ATBEST project recently hosted its final international conference from 7 to 8 September 2016 in Linköping, Sweden, where it outlined its toolbox of innovative solutions to support and promote the future growth and sustainability of the European biogas sector.

Biogas, a mixture of methane and carbon dioxide, is a source of carbon neutral energy for electricity generation, heating and transport, which can make a significant contribution to achieving Europe's far-reaching and ambitious climate change commitments. However, the production and utilisation of biogas is not yet equally established around Europe, currently relying on government subsidies to ensure the development of biogas infrastructure that would be not only environmentally sustainable but also an economically viable investment.

In order to address these structural and financial challenges, the ATBEST (Advanced Technologies for Biogas Efficiency Sustainability and Transport) project's outputs have focused on delivering improvements to the effectiveness and efficiency of each stage of the biogas supply chain. These include investigating alternative feedstocks and better digester configurations, novel monitoring techniques, new biogas upgrading solutions and improved biogas utilisation techniques.

'The ATBEST researchers have produced some excellent work which will influence the biogas industry across Europe as it faces challenges posed by reduced government subsidies and competition from other renewable energy technologies,' commented project manager Dr Simon Murray from Queen's University, Belfast, UK. 'For example, we have developed new knowledge surrounding control of viscosity in digesters which will lead to lower mixing power requirements, novel absorbents which will reduce the size of, and energy used by, the equipment employed to upgrade biogas to biomethane, and explored alternate biogas utilisation technologies which will capture the energy which is currently lost when biogas is used in a CHP engine.' He continued by explaining that all of this work has been underpinned by life cycle analysis and economic modelling that will allow the correct decisions to be made to ensure increased economic and environmental sustainability of the biogas industry.

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Key conference results

The project's final international conference, with more than 90 participants from Europe as well as representation from Brazil and South Africa, aimed to combine both the outcomes from the project in terms of new contributions to the scientific community, as well as active engagement with a range of stakeholders from the biogas sector to support active discussion for the future of the sector. The conference — a cooperation between Linköping University, Scandinavian Biogas Fuels AB, the Swedish Biogas Research Centre (BRC) and the QUESTOR Centre at Queen's University Belfast — included sessions on the potential of 'anaerobic digestion' (AD) technologies and their applications, the importance of new feedstocks, innovative digestion conditions, process monitoring and sustainable investments.

During the first day, the conference focused on applied solutions for biogas optimisation, including presentations on novel techniques for biogas upgrading, synergistic possibilities for the recovery of CO_2 into valuable commercial by-products, as well as addressing the technical challenges for full-scale implementations. The importance of AD as a driver for societal progress in times of change was highlighted by Prof. Willy Verstraete (Ghent University, Belgium). Topics such as development of macroalgae as a substrate for biogas production, microbial community structure and their correlations with process operation and productivity, sustainability and life-cycle assessments of feedstock digestion systems, and arable land as carbon sink including carbon sequestration in biogas systems were also addressed.

'Biogas is a growing sector not yet fully exploited,' stated Dr Francesco Ometto, one of the ATBEST project researchers. 'Although the technology and knowledge is there, in comparison with other renewable energy sectors, biogas is still too small "to make a difference". The conventional concept of an AD system where waste material is converted to methane and fertiliser has now passed.' He further outlined the belief of the ATBEST community that future biogas production will be integrated with other sectors providing substrates (e.g. the aquaculture, pulp and paper industries) or the capability to develop high valuable products from the post digestion material, such as pure protein from nitrogen as suggested by Prof. Verstraete.

Education and training focus

The project also had an educational focus, with a key aim being the delivery of industry-relevant training to 14 researchers specialising in the biogas sector, which included secondments and participation in three dedicated summer schools. ATBEST has also fostered the growth of

collaborative partnerships between eight organisations from four EU Member States (Germany, Ireland, Sweden and the UK). Each collaborator has brought their own complementary expertise in a wide range of environmental technologies to the project that will go a long way towards building the future prosperity, competitiveness and sustainability of the European biogas sector.

ATBEST

- Coordinated by Queen's University Belfast in the United Kingdom.
- Funded under FP7-PEOPLE.
- http://cordis.europa.eu/project/rcn/109084
- Project website: http://www.atbest.eu/

BANKING ON INNOVATIVE IT TOOLS TO HELP DATA CENTRES SAVE ENERGY

Businesses looking to cut costs and reduce their carbon footprint now have access to a new tool that evaluates the energy performance of data centres.

The ever-increasing popularity of the internet, cloud computing and high-powered computing have created new and exciting ways of working, communicating and storing information. However, new data centres are urgently needed just to keep pace with this exponential growth of online traffic.

This in turn has created a challenge — how can we continue to keep building these energy-hungry facilities if we wish to meet our climate objectives? To date, stakeholders have often felt that they lack the necessary tools that might enable them to make the most carbon footprint-conscious decisions.

This is where the EU-funded RENEWIT (Advanced concepts and tools for renewable energy supply of IT Data Centres) project comes in. The project's newly launched tool — now online and free to use — is targeted at data centre operators, designers and other stakeholders interested in building new facilities and refurbishing existing ones with energy efficiency measures and renewable energy sources built in.

Through accessing details of over 60 locations across Europe, the tool analyses the costs and benefits of various efficiency measures and energy sources for users via an easy to use interface. This makes it easy to compare facilities in terms of electricity costs, access to renewables and other factors that influence decisions when planning the site of a new facility.

'After three years of research and development, it's great to be able to launch the finalised RENEWIT Tool and more importantly that we can make it available for free,' said Andrew Donoghue, RENEWIT project spokesperson. 'The tool is truly unique. It not only allows data centre operators to model the benefits and costs of on-site and grid renewable, but also enables the efficiency gains from technologies such as free cooling, and even workload management, to be assessed in detail.'

Although focused on Europe at present, future development of the tool may extend this to North America and Asia.

In order to develop this innovation, the RENEWIT project consortium worked with large data-focused businesses such as Netherlands-based financial services company and bank ING. Using models developed through the project, RENEWIT was able to demonstrate how the bank could improve the efficiency of one of its carbon-neutral facilities by using a biogas fuel cell and by raising the operating temperature in its data centre.

The project team also found that the data centre for a major bank in the south of Europe could achieve significant energy reductions through putting in place hot/cold aisle containment, using high-efficiency chillers and implementing a biogas fuel cell system. The project estimated that this sustainability scenario would reduce non-renewable primary energy by 30% and CO_2 emissions by 1650 tonnes a year. Given the projected expansion of data centres in the near future, achieving such savings could be significant.

RENEWIT, due for completion at the end of September 2016, has left behind other tools to help ensure that the valuable research carried out over the past three years is effectively implemented. A renewable energy optimised data centre monitoring tool to manage facilities that generate energy on-site using renewables sources — such as solar and wind — is now available in demo version on the website. The project has also published a free catalogue of advanced renewable and energy efficiency-technologies to help data centre operators integrate renewable and energy-efficiency methods.

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RENEWIT

- Coordinated by IREC in Spain.
- Funded under FP7-ICT.
- http://cordis.europa.eu/project/rcn/110428
- Project website: http://www.renewit-project.eu/

FUTURISTIC FREIGHT

Urban freight services are in the process of being modernised. A recent EU project set out to produce efficient new designs to automate them and also make them greener and safer.

© Elvezia M. Cepolina

Freight services are fundamentally based on 19th century design, still sporting numerous features that could be modernised. Looking ahead, freight trains of the future would be fully robotic and more efficient in many other ways.

The EU-funded FURBOT (Freight urban robotic vehicle) project was put in place to make this a reality. Incorporating eight European partners, the project designed a radically new kind of electric urban freight vehicle and introduced new ideas about how it would be serviced.

"While the FURBOT vehicle can be used by itself, it is more efficient within a fleet."

Its design priorities included modularity, energy efficiency, mobility dexterity, safety, and automated driving and freight robotised fork handling. Specific components of the system included a frame–platform structure, plus efficient power supply and drive-train layout incorporating an X-by-wire transmission. Other components included a new internal-state sensor system and automatic controls.

While the FURBOT vehicle can be used by itself, it is more efficient within a fleet. This is why system-wide concepts were also developed, offering highly efficient intra-urban freight operation and optimal fleet management which adapts to changing freight demands and availability.

In more detail, the system is based on the pick-up point concept — which includes Pick&Pay, Pack Stations and Bento Boxes — offering an innovative solution for e-commerce deliveries. It is also a cooperative freight system that integrates the resources of the cooperating companies for more cost efficiency.

The project's dissemination activities focused on furthering the introduction of the FURBOT vehicle and boxes into the mass market while promoting the FURBOT transport system to numerous municipalities. This was supported by the project website, publications, several conferences, robotic fairs and a final demo workshop (see FURBOT videos on YouTube).

FURBOT's work will result in a radical new urban freight system. It will be greener, more efficient and safer, while strengthening the competitiveness of the freight transport industry in the EU. Lastly, the system also represents an opportunity to expand urban freight systems into parts of cities previously considered unsuitable. It may well herald the beginning of a new paradigm shift in urban freight transport if fully exploited.

FURBOT

- Coordinated by the University of Pisa in Italy.
- Funded under FP7-TRANSPORT.
- http://cordis.europa.eu/project/rcn/100348
- Project website: http://www.furbot.eu/
- http://bit.ly/2eLrc48

NOW ON CORDIS

PCP AND PPI
A PUBLIC BOOST TO SOCIETAL CHALLENGE-DRIVEN INNOVATION

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Rising public needs and interests require not only innovation per se, but also innovative ways to trigger, fund and support the R&D process up to the commercialisation of new products and services that will be answering these needs.

In the EU, two mechanisms are increasingly used to this end, putting governments' purchasing power to good use by pulling demand for innovation, creating a signalling effect and facilitating the diffusion of innovations. Public Procurement for Innovation (PPI) is used in challenges that can be addressed by innovative solutions close to commercialisation or already commercialised in small quantity, while Pre-Commercial Procurement (PCP) is favoured when there are no existing near-to-the-market solutions and new R&D is needed.

Although these co-financing mechanisms were already used extensively under FP7, Horizon 2020 reinforces them by introducing two dedicated instruments. In total, the EU is putting EUR 130 million on the table for PCP and PPI funding over 2016 and 2017.

This CORDIS ResultsPack aims to shed light on the main innovations brought by EU-funded PPI and PCP projects. It demonstrates how these tools concretely help innovative products to reach commercial success, increase the quality of public services, support SMEs and help address major societal challenges.

Discussed projects cover a wide range of topics, from smart firefighter equipment to intelligent transport systems, ehealth and telemedicine, technologies to support independent living, brownfield decontamination and ICT solutions to support road construction and repair processes.

About CORDIS ResultsPacks

CORDIS ResultsPacks are a new set of products grouping EU-funded project results per topic and target audience. The aim is to disseminate information about new studies, scientific findings and technologies to the relevant target audience, in order to facilitate their exploitation across Europe.

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ENVIRONMENT AND SOCIETY

MAGNETIC ATTRACTION HELPS EXPLAIN THE MOTION UNDER THE OCEAN

The EU-funded GEOPLATE project uses magnetic sensing techniques to expand our understanding of the Earth's tectonic past, while also offering tools to help locate future natural resources.

When dating and tracking the evolution of oceanic crust, plate tectonics research usually relies on a combination of knowledge about periods when the polarity of the planet's geomagnetic field was reversed, alongside magnetic anomalies. After volcanic activity, the ensuing magma cools at the mid-ocean ridge and the minerals contained in the newly forming rock magnetise and align with the direction of the planet's magnetic field. These magnetic traces can therefore serve as a date stamp for the crust.

However, the planet's geomagnetic field polarity has actually stayed stable in the past for periods lasting for as long as tens of millions of years (Myr), a timeframe known as a superchron. The ocean floor for these periods, lacking prominent magnetic anomalies, thus presents a challenge when it comes to the creation of accurate plate kinematic models.

Interpreting magnetic wiggles to understand the past

The EU-supported GEOPLATE (Global Plate Reconstructions During the Cretaceous Normal Superchron) project set out to examine the progression of plate motion during the period known as the 'Cretaceous normal superchron' (CNS, between ~ 121 and 83 Myr ago). By analysing oceanic records, the project investigated the geomagnetic field's behaviour to present the first plate kinematic models for the CNS.

The project was able to do so by applying an innovative approach which reconstructed plate movement from evidence left by past fluctuations in the strength of the geomagnetic field. These fluctuations left magnetic traces, described as tiny 'wiggles', which were located using magnetic sensing equipment.

The project results have expanded understanding of a number of continental and oceanic phenomena related to the interaction between surface tectonic plates, mantle convection and geomagnetic field processes, during the long CNS period. For example, it helps explain some of the contributing factors for phenomena such as sea levels which are considered to have been abnormally high during the mid-Cretaceous.

Techniques which could help locate future natural resources

These new kinematic models which GEOPLATE accomplished, contribute to a deeper appreciation of how rates of crustal production and sea floor spreading (resulting from new oceanic crust created by volcanic activity) influence continental drift and so could help explain the plate motion process which resulted in the breakup of the ancient supercontinent Gondwana. Analysing the marine magnetic records has also resulted in age models that have produced some noteworthy results. For example, GEOPLATE techniques indicated that the oldest oceanic crust in the world is located in the eastern Mediterranean Sea and that it is possibly almost 340 million years-old.

However, as well as deepening our understanding of the past the project also offers tools applicable to the present. We know that past tectonic motion has helped shape the development of the lithosphere, biosphere, hydrosphere, cryosphere and global climate with important consequences. For instance, by providing insights into the formation of continental marginal basins, GEOPLATE could help researchers locate prospective regions for new mineral and hydrocarbon reservoirs.

GEOPLATE

- ★ Coordinated by Ben-Gurion University of the Negev in Israel.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/project/rcn/104252

FIRST EVIDENCE THAT DEEP-SEA ANIMALS ARE INGESTING MICROPLASTICS

Collaborative research funded by the ERC's CACH project has announced the first real evidence that deep-sea animals are ingesting microplastics that are finding their way into the world's oceans. This comes at a poignant moment as several governments are considering a ban on plastic microbeads, most often found in toiletries and cleaning products.

The environmental fallout from plastic microbeads has over recent months become a pressing political priority. The British government is planning to ban plastic microbeads in cosmetics and cleaning products by the end of 2017. This follows reports by the UK's House of Commons Environmental Audit Committee that a single shower can result in 100 000 plastic particles entering the ocean. France and the United States have also taken steps to impose their own restrictions.

Alarming discovery

Now researchers from the universities of Bristol and Oxford, working on the Royal Research Ship (RRS) 'James Cook' in the mid-Atlantic and south-west Indian Ocean under the CACH (Reconstructing abrupt Changes in Chemistry and Circulation of the Equatorial Atlantic Ocean: Implications for global Climate and deep-water Habitats) project have found evidence of microbeads inside hermit crabs, squat lobsters and sea cucumbers, at depths of between 300 m and 1 800 m. In total, nine organisms were studied and microplastics were found in six of them. This is the first time that microplastics have been shown to have been ingested by animals at such depth.

Microplastics are generally defined as particles less than 5 mm in length and include the microfibres analysed in the study and the microbeads used in cosmetics (such as toothpaste and shower gel). Among the plastics discovered in the deep-sea animals in this study were polyester, polypropylene, viscose, nylon and acrylic. Microplastics are roughly the same size as 'marine snow', the shower of organic material that falls from upper waters to the deep ocean and which many creatures residing at those depths feed on.

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Professor Laura Robinson from Bristol's School of Earth Sciences commented: 'The result astonished me and is a real reminder that plastic pollution has truly reached the ends of the Earth.'

'The main purpose of the research expedition was to collect microplastics from sediments in the deep ocean — and we found lots of them,' said lead author of the study, Dr Michelle Taylor from Oxford University. 'Given that animals interact with this sediment, such as living on it or eating it, we decided to look inside them to see if there was any evidence of ingestion. What's particularly alarming is that these microplastics weren't found in coastal areas but the deep ocean, thousands of miles away from land-based sources of pollution.'

Reducing contamination risks

The animals were collected using a 'Remotely operated underwater vehicle' (ROV). This method was chosen to reduce the risk of contamination by surrounding sediments, as well as reduce trauma to the organisms. Using an ROV also ensured that the research team knew the exact location and habitats of the organisms. Stomach, mouth, all internal cavities and breathing organs (gills and ventilation cavities) were dissected from the nine deep-sea organisms and examined under a binocular microscope to identify whether or not they had ingested or internalised microplastics. Microfibres were classified using a Nikon polarised light microscope, a method commonly used in forensic science and with proven benefits for the fast and effective identification of fibres.

The research team also included the Natural History Museum in London and Staffordshire University's Department of Forensic and Crime Science, which made sure that the results were robust and free from potential contamination.

'Existing forensic approaches for the examination of fibres are tried and tested for their robustness and must stand up to the scrutiny of the courts of law,' said Dr Claire Gwinnett of Staffordshire University. 'These techniques were employed in this research in order to effectively reduce and monitor contamination and therefore provide confidence in the fact that the microplastics found were ingested, and not from the laboratory or other external contaminant.'

The study has been published in the journal 'Scientific Reports'.

CACH

★ Hosted by the University of Bristol in the United Kingdom.
★ Funded under FP7-IDEAS-ERC.
★ http://cordis.europa.eu/project/rcn/100593

EU RESEARCHERS SHOW THAT MOLE RAT SOCIETY IS BASED ON AGE, NOT ON CASTE

A new study has shown that individual mole rats perform different roles at different ages, and that age rather than caste behaviour accounts for the changes in their behaviour.

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Mole rats, including the naked mole rat, live in underground colonies and the majority of the rats in the colonies are 'workers', with only one female ('the queen') and one male responsible for breeding, thus having a rigid social structure which is more associated with insects such as bees and ants in the public consciousness. All individual mole rats cooperate by digging large underground tunnel systems to forage for food, and if a large food source is found, this is then shared with the entire colony.

'Queens' and the reproductive male remain in their roles for their entire life after they have achieved this position. When a 'queen' dies, the strongest and largest worker is most likely the prime candidate for inheriting the breeding position.

Earlier studies suggested that non-reproducing mole rats could be divided into non-workers, infrequent workers and frequent workers and that most individual rats stay a member of a particular caste for the entirety of their lives. It was commonly believed that each individual would focus solely on a particular task — digging, nest building or colony defence.

However, in a new study published in 'Proceedings of the National Academy of Sciences', researchers from the Department of Zoology at the University of Cambridge, and funded through the European Research Council's (ERC) THCB2011 (The evolution and development of cooperation in mammalian societies) project, have shown that in Damaraland mole rats, the contributions of individuals to cooperation activities change with age. Individual differences in behaviour that appeared to be caste-based are in fact age-related changes in behaviour. It is still to be confirmed that variation in behaviour between naked mole rats is also a consequence of age, but the researchers are confident that this is indeed likely.

'In some ants, aphids and termites, individuals are born into castes that fulfil certain roles, such as soldiers or workers,' explains Dr Markus Zöttl, first author of the study explained. 'Initially, everyone thought that this was only found in social invertebrates, like ants and bees, but in the eighties, the discovery of the social behaviour of mole rats changed this view. Social mole rats were thought to be unique among vertebrates, in that they also had castes. To understand this fully, what we needed was long-term data on many mole rats over extended periods of their lives.'

In order to gather such data and study mole rat behaviour in more detail, the research team, led by Professor Timothy Clutton-Brock, THCB2011's principal investigator, built a laboratory in the Kalahari Desert, where Damaraland mole rats are native. They then established multiple colonies of mole rats in artificial tunnel systems.

Over a period of three years, they followed the lives of several hundred individual mole rats to document how their behaviour changed as they aged. All individuals were weighed and observed regularly. It was through this detailed documentation that the team realised that mole rats are generalists, not specialists as previously thought — they play different roles as they get older, rather than remain in one set and caste-defined role for their entire lives. Thus, unlike insects such as ants and termites, all mole rats are involved in a range of different activities, and their contributions to cooperation activities increases with age.

"They followed the lives of several hundred individual mole rats to document how their behaviour changed as they aged."

'As Damaraland mole rats do not have castes, this may mean that castes are only found in social invertebrates and have not evolved in any vertebrates,' adds Dr Zöttl. 'Mole rat social organisation probably has more in common with the societies of other cooperative animals, such as meerkats and wild dogs, than with those of social insects.'

THCB2011

- Hosted by the University of Cambridge in the United Kingdom.
- Funded under FP7-IDEAS-ERC.
- http://cordis.europa.eu/project/rcn/104484

EFFICIENT PAPER RECYCLING, FROM FIRST PAGE TO LAST

New methods for achieving efficient paper recycling have been developed, creating new business opportunities in sustainably managing waste.

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In many ways paper is the perfect example of the circular economy; it is both an end product and the main raw material when recycled into the next generation of products. In order for the paper sector to remain profitable — especially important given the recent surge in raw material prices — recycling must be made as operationally efficient as possible and able to create innovative new products of higher value than before.

One key challenge to this has been determining the overall efficiency of the recycling process from start to finish. Current tools can determine, say how efficient a recycling plant is processing raw material at any one given time, but achieving a global picture of the entire process has been difficult to capture. The EU-funded REFFIBRE (Tools for Resource-EFficient use of recycled FIBRE materials) project, which hosted its final conference in September 2016, has developed new tools to achieve exactly this.

Achieving recycling efficiencies will have significant — and positive — business implications for the paper sector. The policy and consumer-driven shift towards a bio-based economy (and away from a fossil fuel-based one) has had the knock-on effect of increasing demand for tree-based raw materials from sectors like energy, which has in turn driven up prices.

The project's concept is that by gathering information on the potential impact of new processes, raw material input and product innovations — and combining this information with key processing data — paper makers will be equipped to make the most informed decisions on how to run their operations as efficiently as possible.

REFFIBRE began by identifying and then testing various production and process modelling tools. As raw material selection and stock preparation can influence pulp properties, tools for predicting this have been developed. This means that key parameters, such as the Mean Fibre Age (number of times a fibre has been used before entering a paper mill) and the Mean Number of Uses (number of times a fibre will be used after leaving the paper mill), can now be calculated.

REFFIBRE partners have also worked on tools to help paper makers take into full consideration issues such as the impact on energy use outside the paper mill, and what happens if reduced quality recycling material is fed into the process. These tools were then tested under real processing conditions, and the results of each case study combined into a practical guide targeted at industry decision makers. In addition, it is expected that the results will be used to further develop industry standards.

Achieving recycling efficiencies is one way that the pulp and paper industry can mitigate raw material price increases, and at the same time reduce its environmental impact. There is a significant business opportunity here; Europe paper fibre is recycled an astounding 3.5 times a year; worldwide the average is 2.4 times. The recycling rate in Europe reached 71.7 % in 2012. All this strongly suggests that the infrastructure for paper recycling is already in place. And now, thanks in part to the REFFIBRE project, so is the technology.

REFFIBRE

- Coordinated by VTT Technical Research Centre in Finland.
- Funded under FP7-NMP.
- http://cordis.europa.eu/project/rcn/110765
- Project website: http://reffibre.eu/
- http://bit.ly/2eU8Uvn

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IT AND TELECOMMUNICATIONS

WHY HUMAN BRAINS HOLD THE KEY TO SMARTER ARTIFICIAL INTELLIGENCE

Understanding how our brains sustain 'internal evolution' — and help us to adapt and learn complex skills such as language — could one day lead to smarter robots.

Why is it that humans are capable of learning complex languages from such an early age? And why does the solution to an 'insight problem' (such as connecting nine dots on a rectangular grid with four contiguous straight lines without lifting the pencil) suddenly pop into your head first thing the morning after?

INSIGHT (Darwinian Neurodynamics), a ground-breaking EU-funded project led by one of the current pioneers of theoretical evolutionary biology, has achieved a better understanding of exactly how we solve problems, by examining how ideas in our brains could evolve throughout our lives. The findings could have implications for programming problem-solving robotics that think for themselves and advance our knowledge of how human language developed.

'Open-ended human problem solving and open-ended learning remain far superior to what can currently be achieved by machines,' explains Professor Eörs Szathmáry, Director of the Parmenides Centre for the Conceptual Foundations of Science at the Parmenides Foundation in Munich, Germany and Professor of Biology at Eötvös University in Budapest, Hungary. 'In particular, robots lack adequate algorithms for insight problem solving in various contexts, which is vital in human understanding.'

By insight, we mean the ability of humans to create new and more useful representations of a problem, in order to allow for solutions other than by 'brute force', and guide future actions. This enables us to tackle problems that are not routine in a highly creative manner, something that artificial intelligence has difficulty in doing.

For example, over several years we learn through experience and play how to walk, talk and socialise, while the development of complex, knowledge-expanding ideas such as Einstein's theory of relativity can take one decade or more. Often a 'eureka' solution can pop into your head without prior warning, suggesting that unconscious processing plays a crucial role in insight.

The evolution of thought

'The deep similarities between thought and evolution led us to hypothesise that cognitive adaptations — achieved by "neuronal" natural selection — run in real-time in the neuronal networks of the human brain during its lifetime,' explains Szathmáry. 'This process we call Darwinian neurodynamics.'

The INSIGHT project provided evidence to support this theory by using computer simulations, robots, examinations of cell cultures and human psychology experiments and neuroimaging. For example, rat neurons were stimulated to learn temporal patterns of activity, which were recorded and then played back to a naive network to see if the learnt information could be copied.

Robots were fed natural selection algorithms designed to create open-ended creative autonomous exploration, and tested to see if they could, in effect, create their own objective.

'Unlike artificial selection, which says "here is your function, this is what you've got to evolve", we found that a robot could develop its own game,' explains Szathmáry. 'Ultimately, robots could be able to generate their own values and desires, and in a sense have minds of their own.' In order to test this hypothesis, the project developed a new evolutionary robotics toolkit, called Robogen, which allows anybody with a computer to evolve robot bodies and brains in physics-based simulations, 3D print evolved body parts, assemble the entire robot and observe its behaviour in the real world. The project has also made progress in mapping how Darwinian dynamics in the brain are crucial to language processing.

The implications of this research are far-reaching. One interesting twist might be that the evolutionary processes going on in the brain could ven be more powerful than in the wild, as they are modified and guided by learning. While much of this remains speculative — and further refinement of models is required — the INSIGHT project has begun to put flesh on the bones of a theory that could one day lead to self-learning machines and smarter language translation and transform teaching and problem solving.

"Ultimately, robots could be able to generate their own values and desires, and in a sense have minds of their own."

INSIGHT

- Coordinated by the Parmenides Foundation in Germany.
- Funded under FP7-ICT.
- http://cordis.europa.eu/project/rcn/108232
- Project website: http://www.insightproject.eu/

CONNECTING THE JUNGLE AND OTHER REMOTE PARTS OF THE WORLD

With the use of affordable, low-tech femtocells, the EU-funded TUCAN3G project is bringing 3G connection to the otherwise unconnected regions of the world.

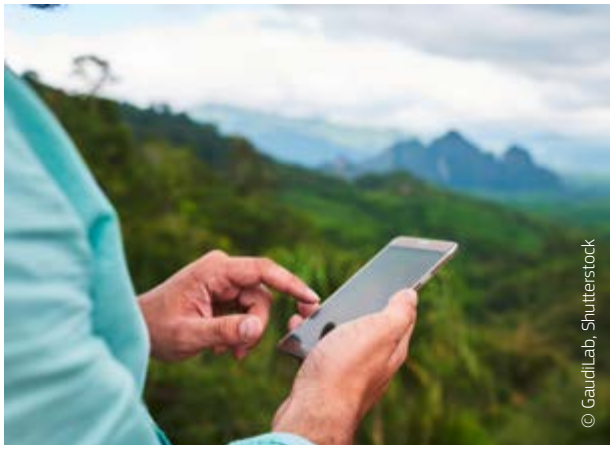
The world is clearly mobile and well connected. Thanks to the massive penetration of cellular telephony, wherever you go you're always just a call or a text away.

But there is one exception to this well-connected world: the truly isolated and rural areas, such as the Amazon jungle, which are often inhabited by small, low-income populations. Here, because of the costs to build classical access and backhaul infrastructures, the return on investment in such projects is nearly 1 000 times lower than what can be achieved in urban areas. As a result, cellular companies tend to overlook these rural areas.

The problem, however, is these are the same places that are also in the most need of developmental aid and support — for which communication is crucial. To fill this void and to connect these otherwise unconnected regions, the EU-funded TUCAN3G (Wireless technologies for isolated rural communities in developing countries based on cellular 3G femtocell deployments) project aims to introduce mobile telephony and data services into the world's most isolated and rural regions.

Simple, cheap yet powerful

The TUCAN3G solution utilises new wireless technologies to create access networks based on 3G femtocells. These femtocells, which resemble a wireless router, are essentially small, low-power cellular base stations that act as repeaters capable of boosting signals. According to project researchers, the advantage of using femtocells is that they work via solar energy, thus eliminating the need for costly energy infrastructures that are simply not feasible in remote areas. For instance, installing a classical access station could cost upwards of EUR 40 000, whereas a femtocell can be bought for just EUR 500. On top of this, femtocells are easy to install and can be maintained with a simple reconfiguration performed remotely.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Hello, the Amazon calling

To demonstrate the economic viability of this system, the TUCAN3G project set up a demonstration platform in a very remote part of the Amazon rainforest. The demonstration consisted of two platforms supplying 3G telephony to six villages along the banks of the Napo River, located in the Balsapuerto region of the north-eastern Peruvian Amazon.

Using only small 3G femtocells installed in each village, locals were able to communicate with relatives, coordinate health care services and even negotiate the price of the crops they were selling. The cost for the voice over IP was a flat rate of around EUR 9, plus the costs of the downloaded kB. Since the system has been in place, users are making an average 40 calls per day.

Towards universal connectivity

In addition to connecting remote villages, the project also convinced local governments to support the development of small, mobile rural operators connected to the Telefonica

backbone, thus ensuring ongoing connectivity for the villagers. Furthermore, a South American development bank has committed over EUR 700 000 towards expanding the programme to another 15 villages.

But perhaps the project's biggest achievement is proving that the development of sustainable, long-term cellular solutions for remote villages with fewer than 250 residents is economically viable. When one considers the number of remote villages, not only in developing countries, but also across the developed world, the potential impact of the TUCAN3G project is huge. Soon, thanks to research such as this, universal connectivity could become a reality.

TUCAN3G

- Coordinated by the Polytechnic University of Catalonia in Spain.
- Funded under FP7-ICT.
- http://cordis.europa.eu/project/rcn/108002
- Project website: http://www.ict-tucan3g.eu/
- http://bit.ly/2ffz260

WEARABLE ROBOTS USHER IN NEXT GENERATION OF MOBILITY THERAPIES

Wearable robots that can anticipate and react to users' movement in real time could dramatically improve mobility assistance and rehabilitation tools.

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Wearable robots are programmable body-worn devices, or exoskeletons, that are designed to mechanically interact with the user. Their purpose is to assist or even substitute human motor function for people who have severe difficulty moving or walking.

The BIOMOT (Smart Wearable Robots with Bioinspired Sensory-Motor Skills) project, completed in September 2016, has helped to advance this emerging field by demonstrating that personalised computational models of the human body can effectively be used to control wearable exoskeletons. The project has identified ways of achieving improved flexibility and autonomous performance, which could assist in the use of wearable robots as mobility assistance and rehabilitation tools.

'An increasing number of researchers in the field of neurorehabilitation are interested in the potential of these robotic technologies for clinical rehabilitation following neurological diseases,' explains BIOMOT project coordinator Dr Juan Moreno from the Spanish Council for Scientific Research (CSIC). 'One reason is that these systems can be optimised to deliver diverse therapeutic interventions at specific points of recuperation or care.'

However, a number of factors have limited the widespread market adoption of wearable robots. Moreno and his team identified a need for wearable equipment to be more compact and lightweight, and better able to anticipate and detect the intended movements of the wearer. In addition, robots needed to become more versatile and adaptable in order to aid people in a variety of different situations; walking on uneven ground, for example, or approaching an obstacle.

In order to address these challenges, the project developed robots with real-time adaptability and flexibility by increasing the symbiosis between the robot and the user through dynamic sensorimotor interactions. A hierarchical approach to these interactions was taken, allowing the project team to apply different layers for different purposes. This means in effect that an exoskeleton can be personalised to an individual user.

'Thanks to this framework, the BIOMOT exoskeleton can rely on mechanical and bioelectric measurements to adapt to a changing user or task condition,' says Moreno. 'This leads to improved robotic interventions.'

Following theoretical and practical work, the project team then tested these prototype exoskeletons with volunteers. A key technical challenge was how to combine a robust and open architecture with a novel wearable robotic system that can gather signals from human activity. 'Nonetheless, we succeeded in investigating for the first time the potential of automatically controlling human-robot interactions in order to enhance user compliance with a motor task,' says Moreno. 'Our research with healthy humans showed such positive and promising results that we are keen to continue validation with both stroke and spinal cord injury patients.'

Indeed, Moreno is confident that the success of the project will open up potential new research avenues. For example, the results will help scientists to develop computational models for rehabilitation therapies, and better understand human movement in more detail.

'In the project we also defined novel techniques to evaluate and benchmark performances of wearable exoskeletons,' says Moreno. 'Further innovation projects are planned by consortium members to follow up on this research, and to exploit developments in the field of human motion capture, human-machine interaction and adaptive control.'

BIOMOT

- Coordinated by CSIC in Spain.
- Funded under FP7-ICT.
- http://cordis.europa.eu/project/rcn/109702
- Project website: http://www.biomotproject.eu/
- http://bit.ly/2fDU63X

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INDUSTRIAL TECHNOLOGIES

APPLYING SHOP FLOOR KNOWLEDGE TO ACHIEVE BETTER RUN FACTORIES

Innovative 3D simulation software enables plant managers to streamline factory operations and take into account the experience of workers themselves.

A highly skilled workforce — supported by advanced automation and IT tools — has enabled European industries to become leaders in fields ranging from car making to chemicals. In order to ensure that factories and assembly lines remain at the cutting edge in a highly competitive world, the EU-funded INTERACT (Interactive Manual Assembly Operations for the Human-Centered Workplaces of the Future) project has sought to better utilise workers' knowledge in the development of next generation digital tools.

'Manufacturing companies often use 3D software tools to simulate human tasks on the factory floor prior to their implementation,' explains INTERACT project coordinator Professor Martin Manns from the University of Siegen in Germany. 'Initially, tasks are described in a textual manner, before being translated into 3D simulations. This enables managers to make time and cost estimations and achieve production efficiencies. However the skills and knowledge of workers is often not utilised, and there is no standard mechanism for taking into account this valuable input.'

The INTERACT project has sought to facilitate the automatic generation of 3D assembly plant plans and enable workers and engineers themselves to contribute to optimising processes. 'In traditional process planning, an initial plan is created by a planning engineer who documents critical issues and proposes solutions' adds Manns. 'Our aim has been to replace this with a completely virtual model.'

This has been achieved by using software involving controlled natural language commands — where grammar and vocabulary are restricted in order to eliminate ambiguity and complexity — along with a statistical motions database to generate realistic human motions. In addition, low-cost sensors were used to track actual tasks on the shop floor, in order to make the project's 3D simulations more intuitive and interactive. The idea of motion optimisation through real life actions led to the design of new innovations such as a data glove with inertial sensors and bending and force sensors.

"The key outcome has been a proof of concept demonstrator for automated, context dependent motion synthesised from controlled natural language."

'In this project, we specifically focused on manual production assembly lines and warehouse operations, and ran two case studies on an automotive manufacturer and a white goods manufacturer,' explains Manns. 'We looked at three key questions: whether a task is feasible by any worker;

whether a worker can do the tasks in a given cycle time; and whether ergonomics issues are likely to arise if the worker does the same process over a period of years. Obviously, all three questions leave room for process optimisation.'

The key outcome has been a proof of concept demonstrator for automated, context dependent motion synthesised from controlled natural language. 'This algorithmic solution has been developed from scratch and produces realistic-looking body motions, though we haven't succeeded in visualising fingers yet,' says Manns. 'Interestingly, we found a rich variety of motions from the shop floor, which enabled us to increase the number of input motions to over 10 000.'

However, even this number only allowed 11 of the original 22 planned motion types — walk, pick up, carry, etc. — to be modelled. Extending the number of motion types will require further input data. Nonetheless a browser based live demo is available on the INTERACT website. And while the technology is not yet ready for commercialisation, the project has sparked interest from companies in other fields such as motion capture, virtual reality, entertainment and academia. Further research projects are currently being prepared in order to bring the technology to market.

INTERACT

- Coordinated by Daimler in Germany.
- Funded under FP7-ICT.
- http://cordis.europa.eu/project/rcn/110466
- Project website: http://www.interact-fp7.eu/
- http://bit.ly/2fSSQPd

EU RESEARCHERS OFFER SUSTAINABLE SOLUTIONS FOR EUROPEAN MANUFACTURING

During its final conference held in Brussels on 18 October 2016, the EU-funded USE-IT-WISELY project outlined its innovative frameworks and tools that will equip European manufacturers to effectively compete in an increasingly globalised world economy.

With industrial processes and supply chains becoming more digitalised with the rise of new technologies such as the Internet of Things (IoT), the Industrial Internet and the Cloud, the vast majority of companies are still struggling to understand the implications that an increasingly globalised and connected world economy brings to their businesses.

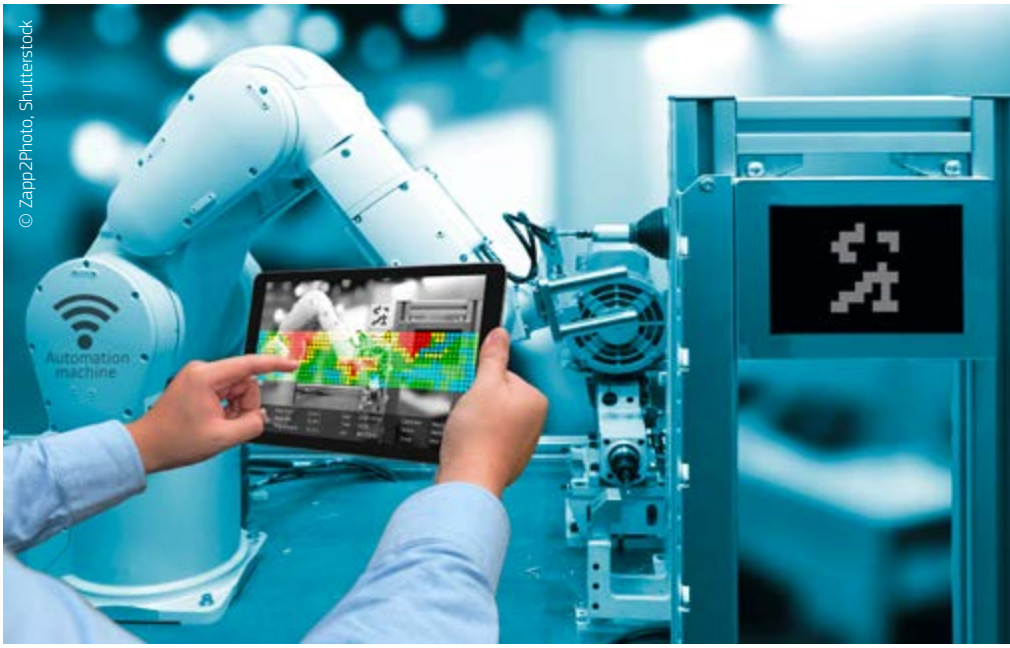
This is where USE-IT-WISELY (Innovative continuous upgrades of high investment product-services) comes in, offering a comprehensive solution for improving products and services through effective upgrade innovation, allowing for sustainable solutions for demanding customers and consumers. The project took a holistic approach based on a collaborative style of working and undertook comprehensive system modelling, focused on business, technology and people, to identify business opportunities and develop the technical solutions required within industrial value networks.

However, it was not just an emphasis on equipping European businesses to face the dynamic markets of the twenty-first century that was a key focus of the project. The 20 consortium partners were also highly mindful of the need to develop solutions and business practices that would be environmentally-friendly and help contribute to the EU's ambitious plans for the creation of a truly viable Circular Economy.

A clustered approach

USE-IT-WISELY organised its research into six clusters, with each cluster based on a particular industrial sector or theme. These were respectively power plant turbines, machinery, space, trucks, shipping and office furniture. Each of the clusters and their successes were presented at the final conference. Clustering was viewed by the project partners as an advantage as it allowed for the exploitation of the existing strong links between research organisations and industry, thus allowing for a more productive project and in turn, greater benefits for the end user.

Consortium member Karin Verploegen, representing Dutch organisations Gispen and TNO, presented how their cluster focus was to extend the lifespan of office furniture by implementing Circular Economy principles. In particular, they developed two tools to enhance sustainable business practices, a Circular Life Cycle Assessment tool and a Design Framework for flexible, modular, adaptable products. These innovations will not only increase customer



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awareness of Circular Economy concepts but could also reduce material, transport and energy costs.

Moreover, the project also harnessed the latest technological breakthroughs in 'virtual reality' (VR) and 'augmented reality' (AR), which the project team believes will play a vital role in upgrading industrial processes in the coming decades. Consortium member Tommi Mannerjoki, from Finnish engineering firm RD Velho, spoke about his involvement in research carried out on the upgrading of mobile rock crushers. Using 3D scanning, AR and Additive Manufacturing, he and his colleagues researched how best to gather 3D information from mobile crushing machines and how to manufacture single parts. They tested two different 3D scanning techniques, and research results will allow for better and easier communication between manufacturers, their stakeholders and customers, and for networking success for SMEs.

3D modelling was also utilised in other clusters, as a tool that will reduce the time and costs involved in maintaining power plant turbines and for the adaption of truck manufacturing systems.

A lasting legacy

Project coordinator Dr Göran Granholm commented during the project: 'USE-IT-WISELY will offer a comprehensive solution for improving existing products and services. Through effective upgrade innovation, we can achieve sustainable solutions for demanding customers. This will help industry struggling with keeping abreast of global competition, new technologies and changing requirements.'

With the end of the project in November 2016, USE-IT-WISELY's innovations and breakthroughs will continue through the project's dedicated online platform. This provides online peer support, dedicated work spaces and a repository of information on all of the project's key tools and advice, all of which will be vital in informing and inspiring European companies to adapt, compete and thrive both within and beyond Europe's borders.

USE-IT-WISELY

- Coordinated by VTT in Finland.
- Funded under FP7-NMP.
- http://cordis.europa.eu/project/rcn/109516
- Project website: https://use-it-wisely.eu/

GROUNDBREAKING 3D PRINTING TECHNOLOGY FOR METAL

Tapping the market for small, customised metal parts could boost the competitive position of 'Small and medium-sized enterprises' (SMEs). A new manufacturing platform enables mass production of 3D metal printed parts, and can also simultaneously clean and polish up to 100 parts in a single session.

"Pilot implementation was demonstrated with serial production of customised high-quality parts on the order of 10 mm."

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Additive manufacturing is a maturing technology well suited to such jobs. A part of complex 3D geometry is built up from details provided in a computer-aided design file. However, improvements in accuracy and post-processing are required to reduce product costs.

Within the EU-funded project HYPROLINE (High-performance production line for small series metal parts), researchers demonstrated a high-performance 3D printing production line for serial fabrication of customised high-quality small metal parts. Coupled with this line is a high-speed finishing line using laser polishing.

Project partners further developed the manufacturing process itself and carried out research and application work on materials, pre- and post-treatment of the parts produced and

supporting software. In this way, HYPROLINE has added capabilities to commercially available manufacturing systems in terms of speed, product quality and versatility.

HYPROLINE's sophisticated machine consists of a carousel unit that has room for 100 pallets and a robot that picks and places non-finished components, extracts finished products and adds specific modules. The pallets pass underneath a patented 3D metal inkjet printer (Digital Metal) on a fixed Z axis. A key part of this machine is a laser scanner that compares the finished 3D prints with the 3D models used for them, while a laser ablation module polishes parts and removes any excess material.

With the addition of process monitoring and metrology, predicted benefits include reduced time to market, fewer rejects and scrap, and better products with higher market value.

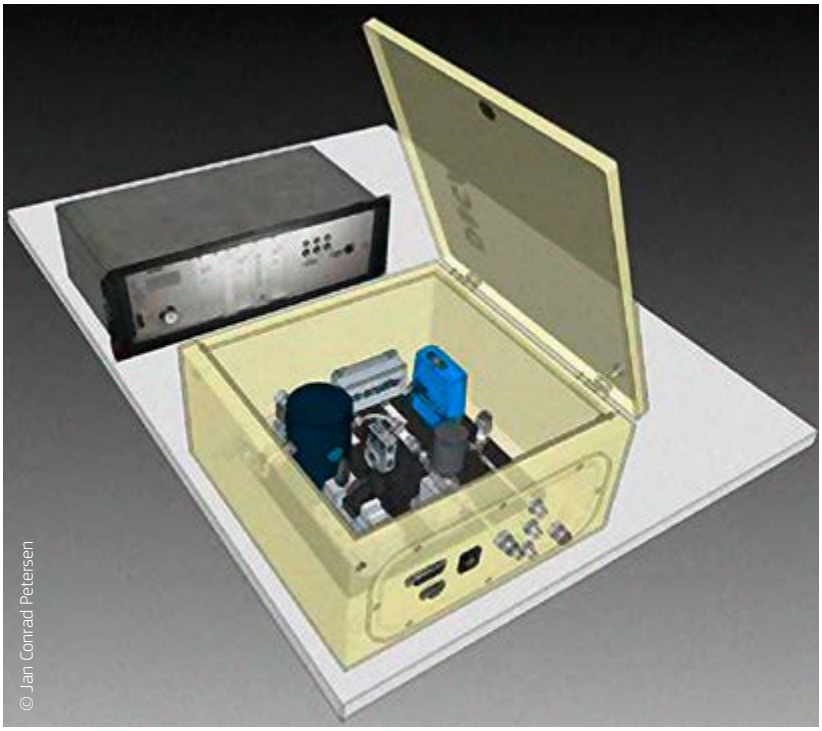
The HYPROLINE machine can produce parts from three different metals: stainless steel 316L, titanium and copper. Pilot implementation was demonstrated with serial production of customised high-quality parts on the order of 10 mm for jewellery companies, dental parts and microwave electronics.

The automated and high-speed HYPROLINE system for production of small metallic parts with high precision promises to significantly enhance the competitive position of Europe's SMEs. It will also foster the production of innovative components that were previously cost prohibitive for consumers.

HYPROLINE
- Coordinated by TNO in the Netherlands.
- Funded under FP7-NMP.
- http://cordis.europa.eu/project/rcn/104393
- Project website: http://www.hyproline.eu/
- http://bit.ly/2fE4vfI

NEW TECHNOLOGY FOR OIL-FREE COMPRESSED AIR

Oil contamination in compressed air can greatly affect production as it can cause product waste, recall or quality control issues, and a single test can cost up to EUR 3000. An EU-funded project came up with a new cost-effective solution for monitoring contaminants in compressed air that eliminates labour-intensive sampling and laboratory analysis.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When compressed to a smaller volume, air attains higher-than-atmospheric pressure that makes it useful in many industrial and domestic applications. Compressed air generates force per unit area that can be used to impart motion in pneumatic tools. It can also atomise or spray substances such as automotive coatings, provide aeration for oxidation in pharmaceutical processes or clean electronics during production. Compressed air is extensively used in the health sector.

These and other high-end applications require very-high-purity compressed air. Oil contamination is a pressing problem and there is currently a lack of any reliable, highly sensitive online sensor system to deal with it. EU-funded scientists provided the much-needed solution with a new real-time sensor system through the project DOCA (Detection of oil in compressed air (DOCA)).

Investigators chose optical spectroscopy as the sensor technology. This is the most promising technology to guarantee extremely high sensitivity (meeting ISO-8573 Class I standards of air quality), repeatability, robustness to interference and stable calibration. The sensor platform consists of three units: the sampling system, the optical spectroscopy unit, and the electronics and software.

In particular, the newly developed sensor system is capable of detecting contaminant concentrations of less than 1 ppb in all lubricants or mixed oils. The connection of the sensor to the compressed air system is achieved by a patented quick lock system.

The DOCA technology for online and real-time identification of oil contamination in compressed air will have a major impact on the costs, effectiveness of monitoring and quality assurance. A recently started follow-up Eurostars project titled Pasoca will take the developed prototype sensor to a certified commercial product.

DOCA
- Coordinated by DFM in Denmark.
- Funded under FP7-SME.
- http://cordis.europa.eu/project/rcn/104716
- Project website: http://www.docaspec.com/

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FOOD AND AGRICULTURE

NEW SENSORY TOOL GIVES INDUSTRY FOOD FOR THOUGHT

EU researchers have developed a new system to monitor industrial food processing in real time, an innovation that could have real commercial potential.

The EU-funded MUSE-TECH (MUlti SEnsor Technology for management of food processes) project has developed an innovative new system to monitor industrial food processing in real time by combining three different sensors into one easy-to-use tool. Positive test results suggest that the device could help food makers across a number of sectors to achieve greater processing efficiencies and ensure high standards of safety.

The starting point of this three year project, which began in October 2013, was to find ways of helping the food industry to move on from conventional process control strategies — where food is only tested at the end of the process, and batch failures and reworks are frequent — to more predictive process control. This is where in-process raw materials can be checked in real time and any compositional variations or problems dealt with during manufacturing.

The project team found that one effective way of achieving in-process control was to integrate three novel sensors into what is called a 'Multi sensor device' (MSD). The MSD is based on a flexible plug-in architecture, allowing additional inputs from other sensors already installed in the process lines.

These MSD devices were built and then tested at both pilot plant and industrial level in three case studies: bread production, fried potato chips and beer production. The first technology — 'Distributed temperature sensing' (DTS) — proved robust for all three case studies, allowing accurate monitoring of complex temperature profiles under harsh environments such as during dough fermentation.

The second sensor, 'Quasi imaging visible-near infrared' (QIVN), successfully gathered data simultaneously from different points of the process. Finally, a 'photoacoustic spectroscopy' (PAS) sensor was shown to be capable of simultaneously monitoring CO_2, ethanol and humidity during baking.

Raw data gathered by the MSD was then processed in real time using new statistical tools, and made available to end users via an easy to use interface.

"These MSD devices were built and then tested at both pilot plant and industrial level in three case studies: bread production, fried potato chips and beer production."

The project team investigated suitable communication systems and software, which were then implemented to support the integration of the MSD.

The team behind the MUSE-TECH project, which has just been completed, are confident that their MSD tool will help to meet growing demand from businesses, policy makers and consumers for increased transparency along the global food supply chain. Consumers want to know where their food comes from and how it has been processed. For food makers, a problem somewhere along this chain — a batch of poor quality ingredients or contamination by unauthorised compounds for example — can shut down production and lead to significant losses unless it is dealt with efficiently and effectively.

The success of the project also highlights the market potential that exists in the food sector for sensory technology developers. There is also an opportunity for food process equipment manufacturers to design and commercialise innovative equipment with tailored MSDs installed to monitor and control the specific food processes.

Further research and development is now needed to develop a commercially viable MSD, with a particular focus on the design of robust and efficient probes to monitor dough during mixing and improving the PAS sensor for frying and beer production.

MUSE-TECH

- Coordinated by IRTA in Spain.
- Funded under FP7-KBBE.
- http://cordis.europa.eu/project/rcn/110427
- Project website: http://www.musetech.eu/

CHICKEN KORMA CURRY HELPS RESEARCHERS EXPLORE GENETIC VARIANTS IN FOOD CHOICES

New research supported by the EU-funded STILTS and NEUROFAST projects has discovered that individuals who carry variants in a particular gene have an increased preference for high fat food, but a decreased preference for sugary foods.

The study, led by the University of Cambridge, is one of the first studies to show a direct link between food preference and specific genetic variants in humans. The research builds upon previous studies on mice, which highlighted that disruption of a particular pathway in the brain involving the 'melanocortin-4 reception' (MC4R) can lead to mice eating a lot more fat. What was unusual was that these mice consumed a lot less sugar.

Chicken korma and an Eton mess

Recently published in the journal 'Nature Communications', Cambridge researchers have shown a similar correlation with humans who possess the MC4R gene. They gave participants in the study an all-you-can-eat buffet of chicken korma curry, one of the most popular dishes in the United Kingdom. They prepared three different options of korma, all manipulated to look and taste the same, but each with differing levels of fat content — one with 20% (low), one with 40% (medium) and finally one with 60% (high) of the calories. The study tested lean people, obese people, and people who were obese because they have a defect in the MC4R gene (which affects approximately one in 100 obese people).

After taking a small taster of each meal, the participants were then allowed to eat freely from the three kormas. Importantly, they could not tell the difference between the foods and were unaware that the fat content varied in each dish. The research team discovered that although there was no overall difference in the amount of food eaten between the groups, individuals with the defective MC4R gene ate almost double the amount of high fat korma that lean individuals ate and 65% more than obese individuals without the defect.

In a second experiment, the participants were served Eton mess, a traditional English dessert that includes strawberries, whipped cream and broken meringue. Again, there were three options to choose from, but this time it was the overall sugar content that differed between low, medium and high concentrations. The fat content though was fixed. Again, participants could choose which of the three desserts to eat.

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Lean and obese individuals preferred the high sugar dessert more than the other two options. However, individuals with the MC4R defect were less enamoured with the high sugar option and actually ate significantly less of all three desserts compared to the other two groups. For obese individuals who do possess the defective MC4R gene, this makes them much more likely to put on weight. The research team believes that for these individuals, the fact that the MC4R pathway is not working may lead them to subconsciously prefer high fat food which then contributes to their weight problem.

A survival mechanism against starvation

'Our work shows that even if you tightly control the appearance and taste of food, our brains can detect the nutrient content,' commented Professor Sadaf Farooqi, who led the research at Cambridge. 'Most of the time we eat foods that are both high in fat and high in sugar. By carefully testing these nutrients separately in this study, and by testing a relatively rare group of people with the defective MC4R gene, we were able to show that specific brain pathways can modulate food preference.'

Prof. Farooqi and her colleagues believe that humans and animals may have evolved pathways in the brain that modulate the preference for high fat food in order to cope with times of famine. 'When there is not much food around, we need energy that can be stored and accessed when needed: fat delivers twice as many calories per gram as carbohydrates or protein and can be easily stored in our bodies,' she explained. 'As such, having a pathway that tells you to eat more fat at the expense of sugar, which we can only store to a limited extent in the body, would be a very useful way of defending against starvation.'

The NEUROFAST (The Integrated Neurobiology of Food Intake, Addiction and Stress) project ended in March 2015, whilst the ERC-funded STILTS (Genetic and physiological basis of thinness) project will continue until December 2016.

STILTS

- Hosted by the University of Cambridge in the United Kingdom.
- Funded under FP7-IDEAS-ERC.
- http://cordis.europa.eu/project/rcn/101508

MAKING RICE SAFE FROM ARSENIC

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"A method of cooking the rice was developed; it removed around 90% of the inorganic arsenic burden from individual rice and rice bran samples."

Rice accumulates significantly higher levels of 'arsenic' (As) than other crops. This threat to human health was addressed by EU-funded scientists who conducted risk assessments of 'inorganic arsenic' (i-As) in rice-based products and developed new ways of limiting exposure.

The main exposure route of i-As to EU citizens is through their diet, the main source being rice. Children are particularly susceptible to arsenic exposure, which can adversely affect long-term health, with infant consumers of rice products one of the groups with the highest exposure levels in the EU.

The aim of the RICENIC (Risk assessment of inorganic arsenic in EU rice-based infant products and strategies to reduce exposure) was to provide risk assessments of inorganic arsenic compound exposure to infants and young children and devise effective strategies to reduce inorganic arsenic burden in rice-based infant products.

A database of 'total arsenic' (t-As), i-As and As bioavailability was created for rice-based products marketed in the EU and consumed by babies and young children. In addition, the effects of agricultural practices on the As concentration and speciation in rice grains and the effect of the manufacturing process on As were determined in rice-based infant products. Researchers also improved the framework for understanding i-As in the human diet. This framework was used to help set i-As standards for food.

Scientists found that it was best to use polished rice in rice-based products for infants and young children, as this type of rice has significantly less i-As than whole grain rice. In addition, variations in i-As from paddy field samples and commercial samples from the Iberian Peninsula were studied. Paddy field areas with low inorganic arsenic rice were also identified. Therefore, rice with low concentrations of i-As should be selected for the manufacture of food for infants and young children.

A method of cooking the rice was developed; it removed around 90% of the inorganic arsenic burden from individual rice and rice bran samples. Its use in the manufacture of rice-based infant products will therefore significantly reduce the concentration of i-As. Rice and rice-based products with low inorganic arsenic could potentially be sold as premium products, in doing so highlighting the potential socio-economic impact of the RICENIC project.

Food Standard Agencies have already taken advantage of the project's results, which have been applied to assess early-life inorganic arsenic exposure in several EU countries and to minimise health risks for the most vulnerable sub-populations.

RICENIC

- Coordinated by Queen's University of Belfast in the United Kingdom.
- Funded under FP7-PEOPLE.
- http://cordis.europa.eu/project/rcn/187670
- Project website: http://ricenic-project.blogspot.co.uk/

FRESH AIR FOR CHEESE

An EU team has helped to improve cheese ripening through sequential ventilation technology. The new systems lower energy consumption while improving yields and quality; the developments can be applied to small or traditional businesses.

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Cheesemaking is an ancient art, but the level of ripening efficiency can be improved with modern, controllable ventilation. Although suitable systems are available for modern premises, such methods do not adapt well to the traditional facilities used by the bulk of cheesemaking businesses.

The EU-funded SMART-RIPE (New ripening room monitoring technology for improving the efficiency and sustainability of cheese ripening processes) project built on the work of a previous EU project, TRUEFOOD (2006-2010), which introduced new sequential ventilation technologies to control cheese ripening and reduce energy consumption. SMART-RIPE exploited the previous results to construct a prototype system demonstrating the TRUEFOOD concept.

The development is intended to help smaller or traditional businesses optimise their ripening processes in an energy-efficient way that also minimises cheese mass loss. The system developed utilises innovative sensors and control software.

SMART-RIPE's system consumes 40-60% less energy during ripening. Such an outcome helps cheesemakers compete in a market demanding sustainability and low carbon dioxide emissions. The system has shown a 40% reduction in environmental impact compared to conventional systems.

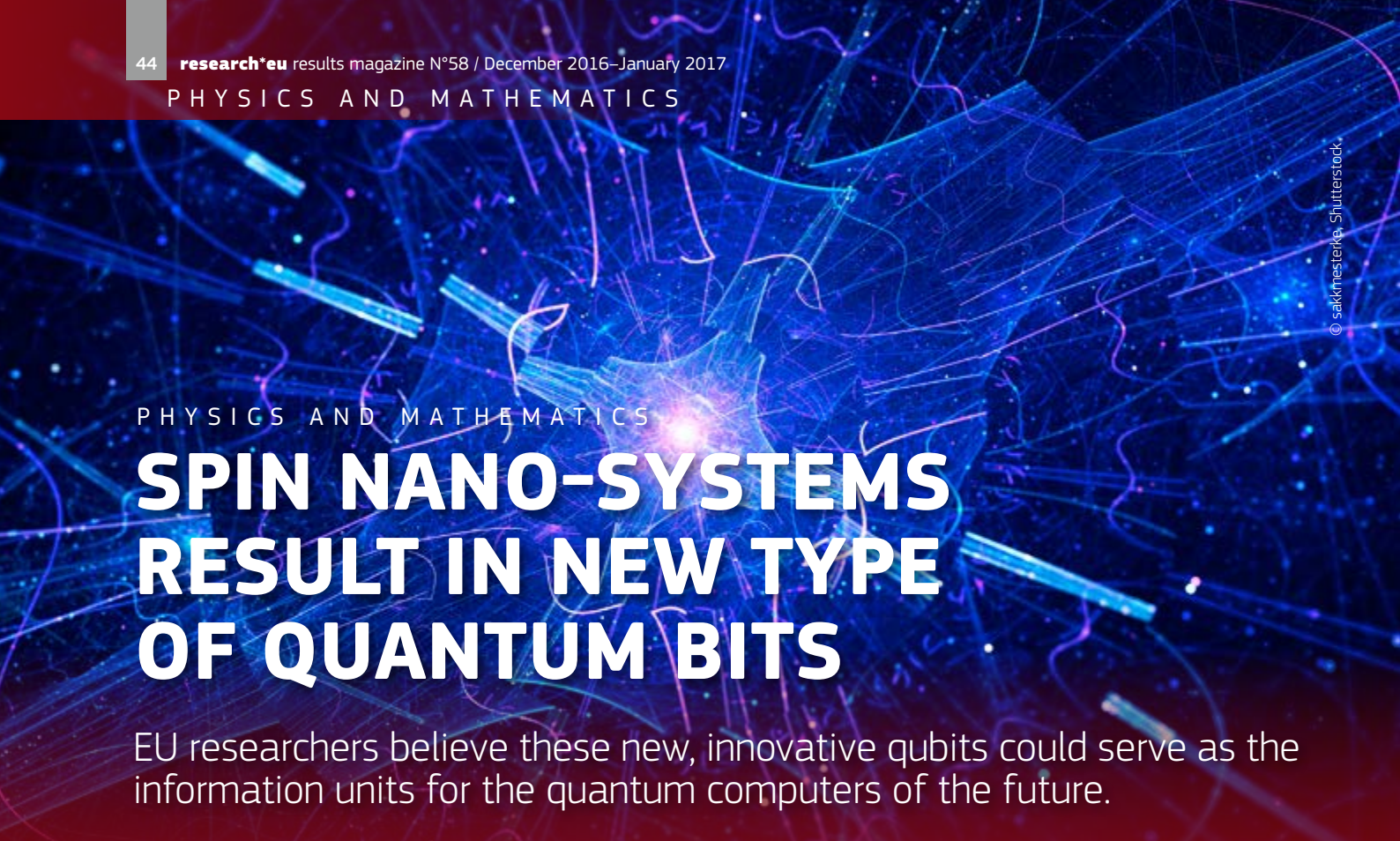
Additionally, the development lowers cheese mass loss (water evaporation) rates to between 0.6 and 0.9%. The outcome means improved yield without lowering quality, therefore resulting in minimal wastage.

Other results for producers include the ability to remotely monitor ripening rooms, and the ability to expand the system to other ripening rooms at minimal cost.

The SMART-RIPE technology allows producers to differentiate their products on the basis of quality and environmental impact. Additionally, the improved yields and lowered costs provide a boost to profitability.

SMART-RIPE

- Coordinated by IRIS in Spain.
- Funded under FP7-KBBE.
- http://cordis.europa.eu/project/rcn/111141
- Project website: http://smart-ripe.eu/



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PHYSICS AND MATHEMATICS

SPIN NANO-SYSTEMS RESULT IN NEW TYPE OF QUANTUM BITS

EU researchers believe these new, innovative qubits could serve as the information units for the quantum computers of the future.

The rapid progress that has been sweeping the field of crystal growth and related device technology is opening doors. Perhaps nowhere is the effect of this evolution being felt more than in the development of ultra-small structures whose material properties can be controlled on the nanoscale. The reason for this development: because solid-state nano-structures possess unique optical and electronic properties, they have the potential to be the launching pad of a new generation of devices.

Within the field, researchers are particularly focused on the properties of spins confined within the nano-structures — with the ultimate goal being to use spin nano-systems to develop, for example, robust 'quantum bits' (qubits) capable of storing vast amounts of information. Here, the EU-funded S^3NANO (Few Spin Solid-State Nano-systems) project has successfully developed qubits in a new, innovative form. According to project researchers, these qubits could serve as the information units of the quantum computers of the future.

S^3NANO, which has recently published its full key findings, was a collaborative effort of studies and researchers. It brought together existing studies on the development of new device concepts in the field of few spin solid-state nano-systems with a team of leading international researchers and institutions. Over the course of four years, this 'few spin solid state nano-system network' achieved numerous breakthroughs in the understanding and successful utilisation of nanoscale systems in future devices via research, exchange programmes and training sessions.

The answer is in the hole

Before S^3NANO, qubits have only been available in the form of individual electrons. To create these electron-based qubits, an electron must be locked in what is called a quantum dot — a tiny semiconductor volume that spins the electron until it forms a small permanent magnet. Researchers can manipulate the spin by using an external magnetic field, with the direction of the spin being used to code information.

Even though this development was a significant breakthrough in itself, it was far from perfect. The problem with electron-based qubits is that the electrons themselves cause interferences that render the information carriers difficult to programme and read. Thus, a better method was needed.

Taking the next step, the S^3NANO project helped find a solution. Researchers discovered that the key was to utilise electron holes, not electrons, as qubits. Instead of locking individual electrons in the quantum dot, the team decided to remove specific electrons. The result was the generation of positively charged vacancies within the electron structure itself, the so-called electron holes. As electron holes also have a spin, they can be manipulated via a magnetic field in order to code information.

However, unlike electrons, electron holes are positively charged, meaning they are decoupled from the positively charged nuclei that surround atoms — making them virtually immune against interference caused by nuclear spin.

The research continues

Researchers are enthusiastic about the high-quality quantum dots they have been able to develop, noting that they represent an important step towards being able to manufacture reproducible components based on quantum bits. However, since electron holes are more susceptible to being disturbed by warm temperatures than electrons are, their use is only applicable at low temperatures.

To address this shortcoming, as well as to carry the S^3NANO project's efforts forward, in 2016 a successor network was launched. The Marie Sklodowska-Curie ITN Spin-NANO Network currently employs 15 PhD students.

S^3NANO

- ★ Coordinated by the University of Sheffield in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/project/rcn/101612
- ★ Project website: http://spin-nano.sites.sheffield.ac.uk/

NEW MATERIALS FROM ATOMIC PHYSICS SIMULATIONS

Most advanced materials have been developed using expensive and cumbersome trial and error methods. However, recent work shows that computer simulation of atomic properties can reduce the waste and cost of development.

Computational simulations based on atomic-level theories are going to play an increasing role in the search for advanced and high-performance materials. In most cases, these methods deliver accurate data related to the atomic, electronic, chemical and magnetic structures of materials. First-principle methods also provide an opportunity to study atomic-level structures and phenomena that are beyond present-day experimental abilities.

The main methodological achievements of the ALPAM (Atomic-level physics of advanced materials) project include a newly developed quasi-non-uniform density functional scheme and an atomic-level approach to thermodynamic and kinetic properties of alloys with non-trivial magnetic degrees of freedom. Most recently, the project put forward a transparent atomic-level theory of plasticity for face-centred cubic metals and alloys.

Project tools have been applied to the investigation of order-disorder phase transition in important classes of magnetic alloys, including interstitial alloys. They have addressed the thermodynamics of different point and planar defects (vacancies, interfaces and stacking faults) in iron (Fe) alloys, and revealed a series of anomalously magnetic effects. In iron-chromium-nickel (Fe-Cr-Ni; austenite) alloys, the stacking fault energies — controlling the plastic deformation mechanisms — follow a strongly non-linear composition dependence, which can be ascribed to the magnetic contribution to the defect energy.

Accurate knowledge of elastic properties is indispensable in many practical applications, including the phenomenological modelling of strengthening mechanisms. Most of the scientific problems addressed by this project are closely related to important industrial problems. For instance, the effect of non-equilibrium segregation is believed to be largely responsible for the Cr depletion at grain boundaries in austenitic stainless steel under irradiation, leading to radiation-induced stress corrosion cracking, which is often involved in accidents at nuclear power stations.

The team's insights into the electronic properties of Fe have also made it possible to carry out significant interdisciplinary work in geology. They have shown that at high pressure and high temperature the 'Body-centred cubic' (BCC) phase of Fe is dynamically stable. Furthermore, they have demonstrated that the properties of Fe-rich BCC alloys including a small amount of light metals are consistent with those indicated by seismology. This suggests that BCC-structured Fe alloys are possible models for the Earth's inner core.

ALPAM has shed light on the atomic-scale properties and processes behind the observed macroscopic properties of materials and delivered comprehensive first-principles data for multi-scale modelling. As a result, detailed information on the composition–structure–property relations, defect interaction parameters and atomistic mechanisms of processes in the sampled alloy phases has been obtained.

ALPAM

- Hosted by the Royal Institute of Technology in Sweden.
- Funded under FP7-IDEAS-ERC.
- http://cordis.europa.eu/project/rcn/90064

"The team's insights into the electronic properties of Fe have also made it possible to carry out significant interdisciplinary work in geology."

SHEDDING LIGHT ON THE SECRETS OF NANO-SIZED PROCESSORS

EU-funded researchers have successfully filmed light and electrons coupled together as they travel undercover through nano-sized processors.

When light couples to electrons on a surface, their concerted motion can travel as a wave guided by the surface geometry itself. Known as 'surface plasmons', these waves could impact the development of telecommunications and computing, as in the future data will likely be processed using light instead of electricity. Not only is the use of light more energy-efficient than electricity, it also allows developers to reduce the processors' size to the nanoscale — a necessary step in the quest to build high-resolution sensors and nano-sized signal processing systems.

The challenge, however, is that to build these nano-sized processors we must first be able to stack different layers of advanced materials and track the guided light as it travels across the layers. Unfortunately, scientists have not been able to accomplish this — until now.

According to a recent study published by the journal 'Nature Communications', researchers have reached a breakthrough for future optical-electronic hybrid computers. Scientists from

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the Ecole Polytechnique Fédérale de Lausanne (EPFL), working via the EU-funded TRUEVIEW (Time-Resolved Ultrafast Electron Visualization of Evanescent Waves) and USED (Ultrafast Spectroscopic Electron Diffraction (USED) of quantum solids and thin films) projects, developed an ultrafast technique capable of tracking light and electrons as they travel through a stacked, nanostructured surface.

Ground-breaking work

The USED project focused on the understanding and control of material properties at the atomic level. The project was the first to successfully implement an ultrafast 'Transmission electron microscope' (TEM) based on a new design that enables an unprecedented time resolution and sensitivity to magnetic contacts. A TEM is an advanced telescope that allows the user to take femtosecond snapshots of materials with the atomic resolution guaranteed by high-energy electrons. By confining an electromagnetic field on the surface of one single nanowire and imaging its properties in space and energy, the USED-designed TEM takes a snapshot of light itself, simultaneously revealing its quantum and classical nature.

TRUEVIEW, on the other hand, successfully unravelled the working principles of nanoscale-confined optical waves and the manipulation of light in optoelectronic nanostructures. By implementing innovative electron imaging techniques to directly visualise and characterise photonic and plasmonic nanostructures in both space and time with nanometre and femtosecond resolution, the project successfully established the field of ultrafast electron microscopy within the European research community.

Lights, camera, nano-action

Combined with the USED-designed TEM, the two projects laid the groundwork for an array of optoelectronic applications, including the ultrafast technique for tracking light and electrons across stacked nanostructured surfaces. The process includes a tiny antenna array consisting of an extremely thin membrane of silicon nitride, which is then covered with an even thinner film of silver. The array's surface is full of nano-holes, which serve as antennas and allow plasmons to travel across its interface.

These antennas are then lit up by firing ultrafast laser pulses onto the array, followed by ultrashort electron pulses fired across the multilayer stack. This process allows scientists to map the plasmons radiated by the antennas at the interface between the silver film and the silicon nitride membrane. By using the ultrafast PINEM technique, scientists are actually able to film the propagation of the guided light and read its spatial profile across the film. In a sense, the USED and TRUEVIEW breakthrough gives scientists the ability to see through walls — and from here they can design the confined plasmonic fields in multilayered structures that are needed for the development of optoelectronic devices.

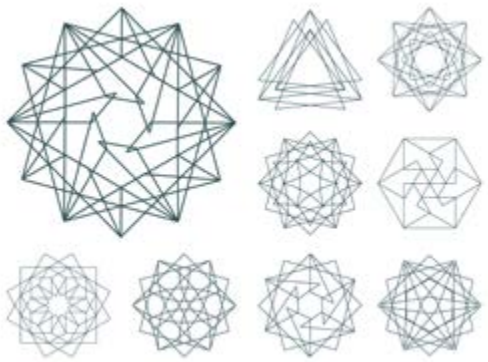
"In a sense, the USED and TRUEVIEW breakthrough gives scientists the ability to see through walls."

TRUEVIEW / USED

- ★ Coordinated by EPFL in Switzerland.
- ★ Funded under FP7-IDEAS-ERC / FP7-PEOPLE.
- ★ http://cordis.europa.eu/project/rcn/187815
- ★ http://cordis.europa.eu/project/rcn/95129

NEW TOOLS TO SOLVE PARTIAL DIFFERENTIAL EQUATIONS

EU-funded scientists have pioneered in the implementation and testing of new methods for solving partial differential equations with a suite of software tools made freely available.



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'Isogeometric analysis' (IGA) was introduced just a decade ago for the discretisation of partial differential equations, but it has already proven to be a powerful method. The basic idea is to combine computer-aided geometric design and finite element analysis. As a generalisation of standard 'Finite element methods' (FEMs), the new method has the ability to maintain the same description of the computational domain geometry throughout the analysis process.

IGA has been shown to outperform FEMs in every numerical test that scientists have tried so far. However, for those working on complex engineering applications, the amount of work required to adapt existing codes needs to be carefully considered before undertaking such a task. Against this backdrop, the GEOPDES (Innovative compatible discretization techniques for partial differential equations) project was devoted to developing software tools for research into IGA.

The GEOPDES software suite is designed to serve as a starting point for scientists who wish to become familiar with the practical issues involved in implementing IGA. By decoupling the various aspects of IGA-related algorithms as much as possible, it also allows users to test their ideas without having to deal with issues that fall outside their field of expertise. Importantly, it is designed to be used as a testing tool for new IGA algorithms.

To help share new ideas regarding IGA among scientists from different fields, GEOPDES has been implemented in an interpreted language: Matrix Laboratory (MATLAB). To make it as accessible as possible, it has also been optimised to work in the free Octave interpreter. The software has been made available here. Since the first release, GEOPDES has been updated from time to time, either to add new features to the original code or to fix bugs.

GEOPDES

- ★ Hosted by the National Research Council in Italy.
- ★ Funded under FP7-IDEAS-ERC.
- ★ http://cordis.europa.eu/project/rcn/87408
- ★ Project website: http://rafavzqz.github.io/geopdes/

EVENTS

FEBRUARY 01

Paris, FRANCE

CONFERENCE

OPTIFEL FINAL CONFERENCE

The EU-funded OPTIFEL project will host its final conference in Paris, France, on 1 February 2017.

The event will showcase and disseminate the major results of the project's outputs that would be of great use for health professionals, meals-on-wheels services, caterers and the food industry.

Additionally to the open final conference on 1 February, the project will also host its final project meeting bringing together all consortium partners on 30 and 31 January 2017. This meeting will discuss internally the final project results before the main conference.

With an ageing population in Europe, the OPTIFEL project has been concerned with ensuring healthy eating and good nutrition for elderly citizens that will help to improve health outcomes, including disability and chronic diseases.

For further information, please visit:
http://www.optifel.eu/category/events/

FEBRUARY 07▸09

Malaga, SPAIN

CONFERENCE

JOINT CONFERENCE ON NANOMATERIAL SAFETY ASSESSMENT

Five EU-funded projects – NANOSOLUTIONS, GUIDENANO, SUN, NANOMILE and ENANOMAPPER – will be holding a joint conference in Malaga, Spain, from 7 to 9 February 2017.

The conference aims at presenting the main results achieved in the course of the projects, fostering a discussion about their impact in the nano safety field and the possibilities for future research programmes.

The conference welcomes consortium partners from the organizing projects, as well as representatives from other EU projects, industry and government, civil society and media.

The conference will be wrapped up with a stakeholder workshop which will provide a platform for an open discussion with interested stakeholders that could ultimately guide the research needs that should be addressed in future projects.

For further information, please visit:
http://www.nmsaconference.eu/index

FEBRUARY 08▸10

Vienna, AUSTRIA

CONFERENCE

HUMAN BRAIN PROJECT STUDENT CONFERENCE

The EU-funded flagship Human Brain Project will be hosting its first conference targeted at young researchers in Vienna, Austria, from 8 to 10 February 2017.

The first HBP Student Conference provides an open forum for exchange of new ideas among young researchers working across various aspects of neuroscience, brain medicine and computer science relevant to the Human Brain Project.

The scope of the conference offers a plethora of opportunities for extensive scientific discussions, both intra- and inter-disciplinary, among peers and faculty through a variety of discussion sessions, lectures and social events.

Participation in the first HBP Student Conference is open to advanced master students, PhD students and young researchers, regardless of whether they are affiliated with the HBP or not and regardless of whether they make a submission to the scientific programme or not.

For further information, please visit:
https://education.humanbrainproject.eu/web/studentconference/home

EVENTS

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

FEB. 08▸10

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Rotterdam, THE NETHERLANDS

CONFERENCE

DIVERCITIES FINAL CONFERENCE

The EU-funded DIVERCITIES project will be hosting its final conference from 8 to 10 February 2017 in Rotterdam, the Netherlands.

The final conference, titled 'Governing Urban Diversity', will present detailed findings from the study and how they relate to existing knowledge and practice. The programme will comprise a range of formal scientific presentations through to interactive workshops led by our researchers. It is designed to create a dialogue between academic researchers, policymakers and practitioners and to act as a platform for the dissemination of new findings and concepts on the theme of diversity in contemporary European cities.

It will consider how urban diversity can positively affect social cohesion, social mobility and economic performance in cities and how the right balance of governance arrangements can be used to tap the full potential of diversity's substantial assets for specific urban groups, for areas within cities, and for cities and metropolitan areas as a whole.

For further information, please visit:
https://www.urbandivercities.eu/governingurbandiversity/

ZZ-AC-16-010-EN-N

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Should your project meet the criteria to be featured in one of the magazine's sections, our editors will contact you to get some background information and conduct an interview. The article will then be planned for release in the next magazine, enabling your project results to reach our large audience of over 25 000 subscribers in science and industry across Europe.

This service is offered to all completed or close-to completed EU-funded projects. Priority will be given to those projects which have resulted in the development of a new technology with potential for commercialisation over the next few years, or in potentially game-changing research for a specific field of science. If you feel like your project is a match, please feel free to book your space now!

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