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EDITORIAL
by the editorial team

OLED – FOR MORE INNOVATION THAN MEETS THE EYE

A few weeks ago, OLED (Organic light emitting diode) technology made its most noticed entrance on the mainstream market yet, with Apple's take on what a 10th anniversary iPhone should look like. The company's influence on the market, along with its financial weight, will undoubtedly benefit the technology by pushing competitors to follow suit and providing economies of scale. Besides, there is actually much more to OLED than the eye-flattering colours and better contrast of the displays it powers – which have slowly been making their entrance in smartphone and TV markets since 2012.

'In 2020, the OLED market is expected to be worth close to USD 44 billion, against 16 billion in 2016'

After a long gestation – OLED technology was first invented by Kodak in 1987 – most observers agree that the time has come for OLED to break through. This flat light emitting technology, which consists of organic thin films placed between two conductors that light up when electrical current is applied, is turning heads among display, printed electronics and lighting application manufacturers.

In 2020, the OLED market is expected to be worth close to USD 44 billion, against USD 16 billion in 2016. Compared to LED technology, OLED is much more energy-efficient. It is bendable and even rollable, and offers great image quality, better durability, transparency and lighter weight.

Some barriers, however, are still preventing the OLED market from truly blossoming. Cost is probably the most important one, especially when combined with OLED's sensitivity to oxygen and moisture. If OLED is to take over the lighting and display markets, the industry will have to resolve the encapsulation issue by finding a cheap encapsulation process to protect OLED films whilst maintaining their flexibility.

This month's special feature tackles this issue and others, such as increased efficiency, the development of new OLED devices for smart glasses and fingerprint scanners, or the use of OLED technology for the optogenetic control of neurons. A total of eight projects recently or soon-to-be completed have been selected for their ability to shape the future of this promising market.

Besides these, other project outcomes are presented across nine themes of research: health, society, transport, environment, agriculture and forestry, industry, information and communications technologies, space and fundamental research. 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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Focus on New technologies for fighting crime

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SPECIAL FEATURE
SEEKING AN EDGE IN OLED TECHNOLOGY

FLEXIBLE OLED LIGHTING STRETCHES THE BOUNDARIES OF DESIGN

Nowadays, whoever wants to manufacture OLED lighting is restrained by its panel-based conception. FLEXOLIGHTING has successfully deconstructed these panels into individual elements that can be repackaged at will.

Shoppers at Marks & Spencer might notice it as early as next year: lighting is entering a new era where design constraints are gone, sustainability is a given and costs are down considerably. This is the result of a highly-innovative concept brought about by an EU-funded project where OLED, a technology that can increasingly be found in TVs, cell phones or even watches, no longer needs to rely on glass substrates and glass encapsulation.

'We can turn the OLED upside down, maintain conductivity with alternative anodes and cathodes, process the device in a new way and protect it with a thin film. The end-product can be formed into an infinite number of design choices and it is all made possible with European expertise and know-how,' says Poopathy Kathirgamanathan, Chair Professor in Electronics Materials Engineering at Brunel University London and coordinator of FLEXOLIGHTING.

Over two years and with the building blocks in place, the consortium, which covers the full supply chain, has pushed state-of-the-art to achieve world-firsts in processing technologies. They used novel substrates such as planarised flexible steel, developed transparent top contacts with metallic films, demonstrated other alternative top contacts using conducting polymers or graphene, proved thin film encapsulation and showed how effective light extraction with their new technology can be.

Better in every respect

Five months away from the project's completion, the team is now focusing on the fabrication of impactful demonstrators. 'We set out with targets relating to efficiency, lifetime, colour, panel size, uniformity of emission, voltage drop and cost and I have always believed those targets could be achieved,' says Prof. Kathirgamanathan. 'In fact, those related to colour, panel size and voltage drop are already behind us.'

The consortium has also demonstrated that the cost of panels can come down dramatically by using either alternative processing methodologies such as Organic vapour phase deposition (OVPD), or solution processing techniques – to better performance than devices fabricated using traditional vacuum thermal evaporation technology.

They achieved world-leading water vapour deposition rates for barrier layers and proved how devices protected with thin film moisture barrier layers are every bit as good as those encapsulated with glass. Finally, they could demonstrate: a working OLED on a steel substrate that utilises a transparent metal top contact; PEDOT deposited by polymer vapour phase deposition that has world-leading conductivity and may be a future alternative to ITO; as well as exciting levels of light extraction.

Besides its lower energy consumption compared to alternative lighting solutions, FLEXOLIGHTING technology also excels in terms of material consumption. OVPD/solution processed devices mean that less raw material is wasted during device fabrication compared to VTE processing of OLEDs, and the glass and steel substrates can be recovered and recycled at end of life. 'It is also interesting to note the growing body of evidence around the harmful effects of UV emitted by other CFLs and LEDs. OLED lighting has good colour rendering with no UV output,' Prof. Kathirgamanathan points out.

Besides project partner Marks and Spencer, which will most likely use the new technology for in-store lighting and domestic lamps, Prof. Kathirgamanathan mentions OLED-lit roofs or OLEDs integrated into the very fabric of cars and trucks as potential applications.

'It's very exciting to know that, within the next few years, I'll be able to walk into shopping centres, board rooms, banks and hospitals, etc. that will be lit entirely by OLED; and that OLED displays will be commonplace in the automotive and medical sectors,' he enthuses, before concluding: 'I'm confident that project partners AIXTRON and Beneq will sell equipment as a direct result of the results we've been able to demonstrate during the FLEXOLIGHTING project. We will all see OLED lighting in stores very soon.'

FLEXOLIGHTING
★ Coordinated by Brunel University London in the United Kingdom.
★ Funded under H2020-ICT.
★ http://cordis.europa.eu/project/rcn/194181
★ Project website:
   http://www.flexolighting.eu/

DEEP SCANNING TECHNOLOGY FOR NEXT-LEVEL FINGERPRINT SENSORS

Imagine a fingerprint sensor with guaranteed identification success, regardless of any fingertip alteration. The INGRESS project has brought us a step closer to achieving this high-value breakthrough in a market set to be worth EUR 7.6 billion by 2022.

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Ever since they started appearing on smartphones in 2007, fingerprint sensors have been proving quite popular. However, they are far from perfect: any change or damage to the finger will prevent current scanners from recognising it.

'In the case of altered fingerprints, existing sensors will not be able to capture a fingerprint image of sufficiently high quality for automatic processing in order to perform recognition,' explains Stéphane Revelin, Programme Manager at Idemia and coordinator of the INGRESS (Innovative Technology for Fingerprint Live Scanners) project. Most smartphone owners who have tried scanning their fingerprints after they have been in contact with liquid, or after an intensive day of manual work, will probably be familiar with this scenario.

The two technologies developed under INGRESS were created with these problems in mind. Using ultrasound and Optical coherence tomography (OCT), respectively, they are capable of capturing internal fingerprints – that is, fingerprints under the surface of the skin.

'Some studies have showed that the fingerprint pattern is present in the epidermis. The goal of our innovative sensor is to capture this pattern and get a fingerprint image that is usable for fingerprint recognition with legacy systems and algorithms,' Revelin says. 'Besides, a third technology has been developed under INGRESS: a slim sensor based on Printed organic electronics (POE). It has several advantages compared to current sensors: a lower cost and a very small form factor even for large surfaces.'

Developing such technologies was not easy. Over the course of the project, the team first found out that OCT technology was better at recognising internal fingerprints than ultrasound. The technology could capture sub-surface fingerprint images with a high enough quality to allow for processing. From there on, the team could demonstrate that, in the case of a damaged fingerprint, recognition was not affected.

'We have made tremendous progress,' Revelin enthuses. 'However, we cannot yet pretend to outperform current solutions. There is still some work required to improve the quality and the accuracy of our system. Our benchmarks indicate that the legacy sensors are still providing more accurate results, but OCT is quite close.'

The team goal for POE was to achieve a resolution of 500 dpi for the sensor, compared to state-of-the-art scanners which provide 64 dpi images. Whilst this objective couldn't be reached in the timeframe set for the project, the team came very close to developing a prototype. Just like for OCT, they intend to pursue their work in order to get closer to the future industrial phase.

When they finally reach this level of maturity, INGRESS technologies may find use notably in border control, as Revelin explains. 'Border police are facing a number of situations where voluntarily or involuntarily damaged fingerprints make it very difficult to access information about the traveller. Sub-surface sensors might come in very handy in these situations. When mature, POE technology could even be integrated into the screen of a smartphone or tablet.'

If successful here, POE will certainly find a prominent place in the highly competitive smartphone industry.

INGRESS
★ Coordinated by Idemia in France.
★ Funded under FP7-SECURITY.
★ http://cordis.europa.eu/project/rcn/110929
★ Project website:
   http://www.ingress-project.eu/

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SPECIAL FEATURE

OLEDS FOR BETTER CONTROL OF NEURONS

OLEDs might soon be powering state-of-the-art optogenetics, paving the way to a better understanding of neural networks as well as next-generation prosthetics.

We might not realise it, but neurons are at the heart of our capacity to make sense of and interact with our environment. Thanks to optogenetics, these cells can now be controlled with high precision using light, with potential applications in the cure of neurological diseases or visual impairment. This technique does, however, rely on LED or laser light sources which lack precision and spatial resolution, meaning that they are often unable to control individual neurons.

'Delivering light from these sources to the relevant region of the brain in a live animal typically requires holding the animal underneath a microscope or introducing bulky and rigid components that do not conform to the soft tissue and, thus, may influence the animal's behaviour,' explains Caroline Murawski, Marie Skłodowska Curie fellow at the University of St Andrews.

With funding under the NEUROLED (Organic Light-Emitting Diodes for Optogenetic Control of Neurons) project, Murawski is aiming to overcome these limitations by structuring OLEDs 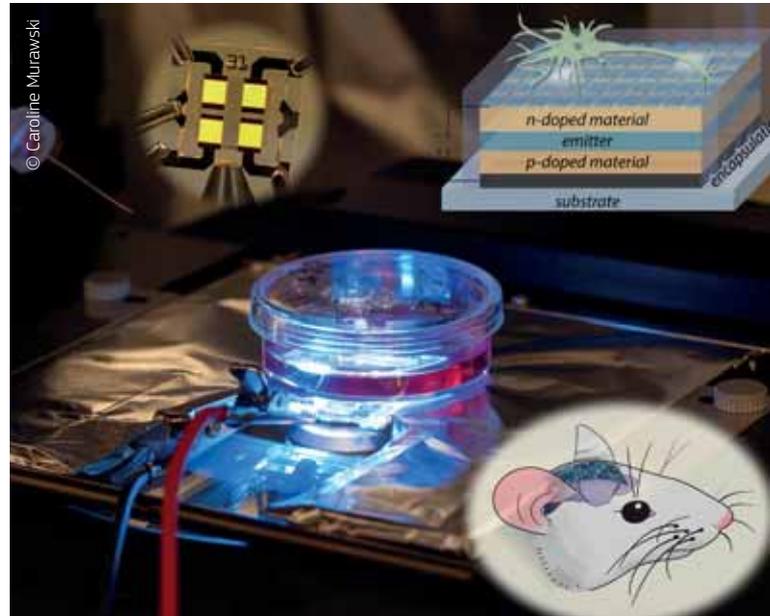to sub-cellular length scales with an extremely high resolution, so as to allow quick switching between targeted cells over large areas. The possibility of producing these OLEDs on flexible substrates also means that they could eventually be adapted to the shape of the targeted organ *in vivo*. 'I envision that OLEDs will be able to individually address thousands of cells at once and that their mechanical flexibility will be highly beneficial for bio-implantation,' Murawski enthuses.

> "Neuroscientists will benefit from a tool allowing completely new experiments."

The project uses photolithography to obtain OLED pixels with sizes of 10-100 μm, depending on the required spatial resolution. The OLEDs emit colours matching the activation spectrum of genetically-introduced light-sensitive proteins, and include electrically-doped charge transport layers with high conductivity to achieve high brightness at low driving voltages – therefore generating minimum resistive heating that would otherwise spread to the adjacent cells. As the efficiency of OLEDs typically strongly decreases at higher brightness, Dr Murawski had to balance the two aspects by using fluorescent emitters instead of the phosphorescent compounds that are widely found in commercial OLEDs.

'Another difficulty is the quick degradation of OLEDs when they come in contact with water,' Murawski adds. 'In order to target cells with high spatial resolution in the aqueous environment that is naturally required for cell growth, the organic materials need to be protected with a very thin encapsulation film. Here, we follow two routes: using oxides and polymers that are grown by chemical vapour deposition, and employing ultra-thin flexible glass encapsulation sheets.'

The next step for Murawski and her colleagues in the group of Prof. Malte Gather was to use their high brightness OLEDs for proof of concept optogenetics experiments. Their plan consists in growing cells directly on top of the OLEDs or to implant miniature versions of the devices into live animals. As Murawski explains, the OLEDs are then driven with ms-long current pulses, generating high-power light pulses that evoke action potential firing in adjacent neurons.

'We have used the larvae of *Drosophila melanogaster* (fruit flies), which is a model organism in genetics, for our proof of concept. We have demonstrated that OLEDs achieve the required brightness levels to stimulate the larvae's neurons and were able to control the larval behaviour with our devices. We are now working to demonstrate that OLEDs can evoke waves of action potentials in cultures of primary neurons, and to combine this with optical readout of neuronal activity.'

Thanks to this research, neuroscientists will benefit from a tool allowing completely new experiments, for instance studies of the pattern of network activity as systematically inhibitory neurons are added or removed. This would provide a powerful yet simple model for studying medical conditions such as Alzheimer's disease.

'Flexible OLEDs may also be used as bio-implantable light sources to empower well-defined stimulation of certain regions of the brain in animal studies, or further down the line potentially even in patients. We are already working with a large US-led consortium to develop prosthetics and we are hoping to win funding from a UK charity to develop and use OLEDs for a basic research-oriented neuroscience study,' Murawski concludes.

© Caroline Murawski

MORE EFFICIENT OLED LIGHTING COMES AT A LOWER COST

OLED lighting enables the production of larger, lighter and thinner lighting devices. But these also have a higher cost and lower performance compared to LED alternatives. Thanks to work under the LEO project, they will soon benefit from better mechanical properties, greater potential flexibility, higher light extraction, reduced environmental footprint and cheaper production processes.

In a nutshell, what the LEO (Low-cost / energy Efficient Oleds for lighting) consortium aimed to develop when they kicked off their work three years ago was a high-performance, bendable and low-cost OLED technology for general and mood lighting. By replacing conventional glass and polymer substrates in state-of-the-art OLED lights with conformable metal substrates, and by introducing new emitter materials and processes, they are indeed paving the way to a long sought-after cost-effective OLED lighting technology.

To get there, the team proceeded with four key innovations. First, they created low-cost metal foils integrating OLED anodes and possibly backside monitoring printed circuits. Compared to PET plastic sheets, these metal foils are mechanically much more robust and constitute a natural barrier against moisture. Then, they developed smart OLED top-electrode architectures and light out-coupling solutions in association with novel thin film top-encapsulation strategies – thereby increasing by 50 % the amount of emitted light and providing better surface scratch resistance.

The team also reduced the environmental footprint of OLED technology thanks to noble metal-free emitters based on Thermally activated delayed fluorescence (TADF) materials. Finally, they developed a cheap hybrid OLED deposition technology that combines vacuum and wet deposition processes.

A bit more than a month away from the scheduled end of the project, the project team is essentially left with the task of proceeding to a full cost evaluation. 'It has not been completed yet,' says Dr Etienne Quesnel, senior expert in Material Sciences at CEA-Grenoble and coordinator of LEO. 'We can, however, anticipate a lowering of the final OLED costs through the use of low carbon steel substrates. The strategy of our industrial partner consists in developing metal substrates that could address both the photovoltaic and OLED market and could help decrease the final substrate cost by 50 %.'

A similar reduction is also foreseen for the encapsulation of the OLED device – which is key to ensuring a long lifetime. Replacement of conventional emitter materials by TADF, on the other hand, should have a more limited impact on cost – just like the LEO's new, hybrid manufacturing process. 'The actual interest in such a hybrid approach has still to be confirmed industrially and in terms of final device performances,' Dr Quesnel explains.

Wide industrial plans

Industrial partners are already busy exploiting the project's results: OSRAM, for instance, is focusing on process integration for both hybrid systems and metal-based OLEDs in automotive applications and special applications in general illumination. ArcelorMittal is developing new materials and coatings based on R2R process technologies, as implemented in LEO, to produce advanced steel foils for printed electronics applications. Cynora is providing state-of-the-art TADF dopants to worldwide leading panel makers, and CEA notably aims to transfer its knowledge to both OLED and photovoltaic device manufacturers.

'Unexpected applications are also emerging beyond lighting. These include conformable OLED panels for aeronautics, as well as display and micro-display applications requiring higher image contrast than the conventional glass cover approach,' Dr Quesnel points out.

LEO partner CYNORA has already signed a partnership with some of the most prestigious display manufacturers in Asia. And whilst this success goes beyond the sole LEO project's impact, it validates a posteriori the technological route followed four years ago by the seven members of the project consortium.

"Unexpected applications are also emerging beyond lighting."

© LEO

SPECIAL FEATURE

INTERVIEW

SOLUTION-PROCESSED OLEDS PAVE THE WAY TO FUTURE LIGHTING APPLICATIONS

Before it can take over our streets and homes, OLED lighting needs to be made more accessible. The SOLEDLIGHT project has developed novel multilayer OLEDs thanks to a new process that promises to increase production efficiency by 20 %, thereby reducing its cost.

© SOLEDLIGHT

"Using a combination of cross-linkable components and orthogonal solvents, we have been able to prepare fully solution-processable OLEDs."

Benefitting directly from the PI-SCALE project – which involves the creation of pilot lines for the production of flexible OLEDs using roll-to-roll deposition methods – SOLEDLIGHT (Solution Processed OLEDs for Lighting) successfully developed multilayer OLEDs with power efficiencies achieving 20 lm/W. Whilst not yet on par with vacuum-processed equivalents, the new devices are hoped to achieve 100 lm/W and lifetimes superior to 15 000 hours by the end of the project.

Dr Henk Bolink, researcher at the University of Valencia and coordinator of SOLEDLIGHT, discusses the project's achievements so far and its potential, notably in general lighting and automotive applications.

★ How does your project provide a potential solution to the OLED lighting cost issue?

Dr Henk Bolink: Printed or coated multi-layer OLEDs combine the benefit of high performance with high through-put deposition methods that are efficient in materials usage. Additionally, the initial investment cost is lower compared with industry-standard vacuum deposition processes.

★ How about efficiency and lifetime of your OLEDs? How do they compare to alternatives?

The SOLEDLIGHT solution processed OLEDs are not yet on par with the vacuum-processed equivalents. Initial fully solution-processed OLEDs consisting of five active layers have been successfully prepared and achieved 20 lm/W.

★ Can you tell us more about the specifics of your technology and production processes?

Our approach towards fully solution-processable OLEDs is based on a dual approach of cross-linkable layers and orthogonal solvents. The roll-to-roll (R2R) coating line that we used, available at the Holst Centre for R&D, consists of two coating stations inside a compact cleanroom. It includes two closed drying ovens, one of 20 m and one of 10 m, for air or inert atmospheres, located outside the cleanroom. The two coaters and dryers are coupled together in one line, using a unique web transport system which allows substrate handling without ever touching the sensitive surface where the coating is applied.

★ Why did you choose this production line specifically?

One objective of the SOLEDLIGHT project was to demonstrate high-throughput, large-area production of OLEDs by solution-based technologies. The R2R coating line developed within the PI-SCALE project at the Holst Centre is unique in Europe for its ability to deposit functional OLED inks over large areas at high speeds.

Economic analyses have shown that mass production of OLED lighting elements at commercially-competitive cost requires solution processing, as vacuum deposition is predicted to be way too expensive (note however that the situation is different for display applications). The R2R line is therefore excellently suited to the needs of our project.

★ **Where were the main lessons learned?**

The success of R2R OLED production by solution-based techniques very much depends on the exact properties of the materials involved, especially their chemical stability / sensitivity regarding environmental agents like water and oxygen, which potentially can degrade them and affect the devices' performance.

This is a much more serious issue in R2R manufacturing than in sheet-to-sheet processing, where the complete exclusion of influences from the ambient atmosphere can be much more easily achieved. When sufficiently stable materials systems are available, however, the R2R process can be carried out without compromising the quality of the final OLED devices compared to sheet-to-sheet production.

★ **What difficulties did you face and how did you overcome them?**

Light emitting layers consisting of small molecular weight materials are difficult to protect against subsequent layer deposition from wet processes. Using a combination of cross-linkable components and orthogonal solvents, we have been able to prepare fully solution-processable OLEDs.

★ **What are your commercialisation plans after the end of the project?**

SOLEDLIGHT has two industrial partners – OSRAM OLED GmbH and Solvay – as well as the Open Innovation Centre Holst. OSRAM is currently focusing on OLED for automotive, but continues its activities for general lighting.

Solution processed OLED and R2R techniques are regarded, for both fields of application, as future alternatives to the established evaporation-based process. Some of the materials and/or technologies developed within SOLEDLIGHT might be incorporated into the OLED pilot line services of the PI-SCALE project, located at the Holst

© Henk Bolink

DR HENK BOLINK

Centre, which intends to grow into a self-sustainable commercial entity after an initial period of EU funding.

SOLEDLIGHT
★ Coordinated by the University of Valencia in Spain.
★ Funded under H2020-ICT.
★ http://cordis.europa.eu/project/rcn/194103

NOVEL GRAPHENE INK STRETCHES THE LIMITS OF PRODUCT DEVELOPMENT

A European project will sometimes succeed at not only meeting its defined objectives, but also exceeding them. HIGRAPHINK is one of these. Its groundbreaking, highly conductive graphene ink is likely to trend in applications ranging from optoelectronics through to composites, batteries and flexible OLED devices.

Originally, the roadmap of HIGRAPHINK (Highly Conductive Graphene Ink) consisted in demonstrating the viability of graphene as an additive for organic semiconducting materials, to drive proof-of-concept Organic light emitting diode (OLED) displays. But the project was so successful at creating graphene with previously unthinkable properties that its host, the University of Cambridge, decided to stick to readying it for commercialisation.

"The new ink has a mobility 10 times higher than that of inks currently being used in OLEDs."

'It was probably the key challenge that we faced in this project,' Prof. Andrea Ferrari, director of the Cambridge Graphene Centre and coordinator of the project, recalls. 'At some point, we had to decide, based on the breakthrough we had, to focus on the production aspects of our graphene ink and stop exploring other options we had initially discussed.'

Who could blame them. Just two and a half years after the project was launched, six months after its end, HIGRAPHINK has resulted in the production of a material with a 100% exfoliation yield, as opposed to the mere 1% that could be achieved before the project team started their work. The new ink has a mobility 10 times higher than that of inks currently being used in OLEDs. Industry can now produce

tens of thousands of litres per year where it could only hope for quantities in the range of milligrams daily before HIGRAPHINK results kicked in.

'To get there, we started with graphite and used a technique called microfluidisation: We put the graphite through very small channels with a very high shear pressure, this very high shear takes the graphite flakes apart, and we get a yield orders of magnitude better than what people achieved before this project. Now we have inks that are highly conductive, with a low sheet resistance, that can be printed on a variety of substrates with properties unattainable before the start of the project.'

The team tested the new material in various devices. They notably created

© Cambridge Graphene Ltd

Whilst Cambridge University's own professor of nanotechnology admits that it's difficult to foresee what the most successful application of his graphene ink will be, he says that the final application may be in flexible and bendable devices, coatings, composites, sensors or energy storage devices.

'We managed to develop a new technique to create large quantities of high-quality ink. This means that there is potential for demanding sectors in applications ranging from batteries to supercapacitors, displays, flexible electronics, optoelectronics, composites, coating or even medical devices. We are not restricted to one particular area,' says Prof. Ferrari.

One of the applications he particularly believes in is the ink's integration into batteries. Thanks to this, enhanced batteries with higher storage density and recyclability may be produced. This integration process is in fact already on track: Although Prof. Ferrari says it's too soon to give out more information, he has already obtained further funding to bring HIGRAPHINK's production technique to batteries.

ultrafast lasers by incorporating the ink into polymers, on top of an optical fibre. They also used this material to modulate light in the terahertz range, which is the first step in creating ultrafast terahertz lasers. They created devices that can be photo-switched, and even novel memory devices. 'We have also been able to extend this technique to other layered materials such as phosphorene or boron nitride,' Prof. Ferrari enthuses.

As a result, when it comes to applications, it would now seem that only the sky is the limit. HIGRAPHINK resulted in the creation of a spinoff called Cambridge Graphene Ltd, which was recently acquired by Versarien – a UK company exploiting novel materials to create innovative engineering solutions. Furthermore, the material is available for purchase from the Sigma-Aldrich catalogue, which now belongs to Merck.

'Our intention was to create graphene with properties good enough to be used in transistors with a certain flexibility. This was also achieved, and we are now working with a company called FlexEnable to integrate our material into the design of future OLED displays,' Prof. Ferrari adds.

HIGRAPHINK
- ★ Coordinated by the University of Cambridge in the United Kingdom.
- ★ Funded under H2020-ERC.
- ★ http://cordis.europa.eu/project/rcn/198081
- ★ Project website:
  http://www.cambridgegraphene.com/

INTERVIEW

HIGH-PERFORMANCE OLED MICRODISPLAYS FOR NEXT-GENERATION SMART GLASSES

A consistent trend across the tech sector is the one-upmanship of increasingly high screen resolution and larger display size. Yet, the fact that the former increases faster than the latter means that manufacturers must achieve ever-higher pixel density. Large OLED microdisplays developed under the LOMID project could help solve that problem, thereby providing Europe with a competitive edge.

They are increasingly considered as a must-have for near-eye applications such as virtual reality glasses: within the next few years, OLED microdisplays are likely to play a major part in a market set to be worth USD 1.7 billion in 2027.

To be able to demonstrate their benefits in commercial applications, however, industry will need such microdisplays to be highly flexible, achieve high resolution over large areas and provide acceptably high yields.

The LOMID (Large cost-effective OLED microdisplays and their applications) project, which is coordinated by Dr Uwe Vogel from Fraunhofer FEP, is on track to successfully meeting these expectations. The project's 13 x 21 mm curved microdisplays, boasting a 1 920 x 1 200 (WUXGA)

pixel count and exceeding 2 000 ppi have already been manufactured at satisfactory yields, and the consortium is still improving these yields in order to compete in markets where price is as important as performance. The technology is already being demonstrated in smart glasses for both virtual reality and visually-impaired people.

★ **What makes LOMID microdisplays so innovative?**

The LOMID displays are larger (1") and of much higher resolution (WUXGA) than anything that has been available on the market until very recently. We have gone to great pains to ensure high contrast and high bandwidth/frame-rates – the latter is very important for removing motion artefacts and making VR use both immersive and comfortable.

The OLED display of course has high brightness and excellent colour rendition. A novelty of the project is the ability to make curved CMOS/OLED displays – we believe that the use of curved displays will in future enable simpler and ultra-compact optical designs for near-eye viewing such as in smart glasses.

★ Can you tell us more about the manufacturing process?

We would rather not! We can say that a key challenge for the project was the CMOS-OLED interface – this has to be extremely flat for good yields and device performance. Because larger displays are inherently more expensive to produce, we have also placed great emphasis on attempting to improve yields at every step of the manufacturing process in order to keep the final display cost reasonable.

★ What were the main difficulties you faced in creating the LOMID chip?

Apart from the CMOS-OLED interface, our biggest challenge was achieving the required bandwidth for the large chip, whilst keeping the circuitry compact and with low power consumption.

★ Does the device live up to your initial expectations?

Yes! We got the first fully specified project chips (with and without colour filters) towards the end of September and we are very happy with the performance of displays from the first few wafers.

★ What has been industry's feedback so far?

Very positive. In particular, we showed some interim project results at the Society for Information Display's meeting on 'Wearable and Projection Displays' in Dresden earlier this year, and the feedback we received confirmed that both the new microdisplays and our innovative optical design are meeting market demands. We expect further feedback during the upcoming EFECS event in Brussels from 5 to 7 December 2017, where we plan to demonstrate the LOMID microdisplay chip to the audience.

★ The project included the creation of smart glasses. Can you tell us more about these?

One of the partners in the project, the Spanish start-up Limbak, has a patented optical approach that allows us to make much more compact head-mounted displays with a very wide field of view. This makes the smart glasses more comfortable and less obtrusive, and enhances the sense of immersion for virtual reality applications. For people that will be wearing smart glasses all day for work, or because they have to for visual prosthetics, it is important that the glasses are comfortable and aesthetically acceptable. Another partner in the project, Oxford University, will test the new microdisplays in smart glasses that will improve the quality of life for blind people, by making the best use of their remaining vision.

> *"The technology is already being demonstrated in smart glasses for both virtual reality and visually-impaired people."*

★ What are your plans for commercialisation?

The microdisplays developed by the project will be available from the company Microoled – we expect demonstrator kits to be available from 2018, and we already know of some seriously interested customers. The optical designs can be licensed from Limbak – they are happy to talk to partners about custom designs.

© Uwe Vogel

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DR UWE VOGEL

SPECIAL FEATURE

CHIRAL-INDUCED SPINNING FOR MORE EFFICIENT OLED DEVICES

One of the main barriers to a wider adoption of OLED technology resides in its lack of efficiency compared to fluorescent lamps or Light-emitting diodes (LED). The SOLED project hoped to solve this problem using chiral organic semiconductor structures.

The difference is undisputable: when put side by side with an LED display, its OLED counterpart will stand out thanks to its sharper images, better contrast and crisp colours. Energy efficiency, however, is a key concern for consumers, and OLED is still lagging behind other technologies in this regard. In fact, the only type of display it can top is LCD, but only marginally.

To solve this problem, the Weizmann Institute kicked off the SOLED (Chiral organic semiconductor structures) project in January 2016. They aimed to tackle the OLED efficiency problem at its source: 'The low efficiency of OLED technology is a result of low light emission yield due to the formation of triplet electronic states, in which the two electrons have the same orientation,' explains Prof. Ron Naaman, coordinator of SOLED.

The project's plan was to use electrons' spin control with a view to reducing the probability of producing triplet states. This is known as the spin-LED/OLED concept: electrons injected into and from the light-emitting species have a predetermined spin, which helps avoid the formation of 'dark', non-emitting triplet states.

The team had already benefitted from past experience in this field. They could capitalise on their earlier research on the Chiral-induced spin selectivity (CISS) effect, and proposed to develop chiral organic semiconductor structures to control the spin state of injected electrons and holes in OLEDs. As they initiated the SOLED project, they expected this effect to be able to increase the energy efficiency of OLED devices by a factor of four.

'The chiral-induced spin selectivity effect is supposed to allow full control of the electrons' spin orientation by ensuring that the electron that leaves the emitting molecule has the same spin orientation as the electron entering into the molecule,' says Prof. Naaman.

Whilst the concept was successfully demonstrated in principle, the team quickly realised that further research would be required to reach their objective. 'In collaboration with the group of Richard Friend from Cambridge and E. W. (Bert) Meijer from Eindhoven, we could demonstrate our ability to affect the spin orientation in the OLED, but the efficiency of the process was not very high,' Prof. Naaman explains. 'The reason for it is the organisation of the molecules in the OLED. Now, we pursue this work with our collaborators towards better control of material organisation.'

Until this problem is solved, the team has had to postpone the pre-commercialisation measures they had originally planned for. However, Prof. Naaman is still hopeful that the technology will help OLED technology spread throughout European homes in the form of flexible light emitters. He also underlines the realisation that material organisation is the key factor in achieving spin control as a major outcome for the project.

"We pursue this work with our collaborators towards better control of material organisation."

'We intend to study molecules that self-assemble into three dimensional organised structures, like micro-crystals. We hope to do that under either the FET-OPEN programme or other specific programmes,' Prof. Naaman concludes.

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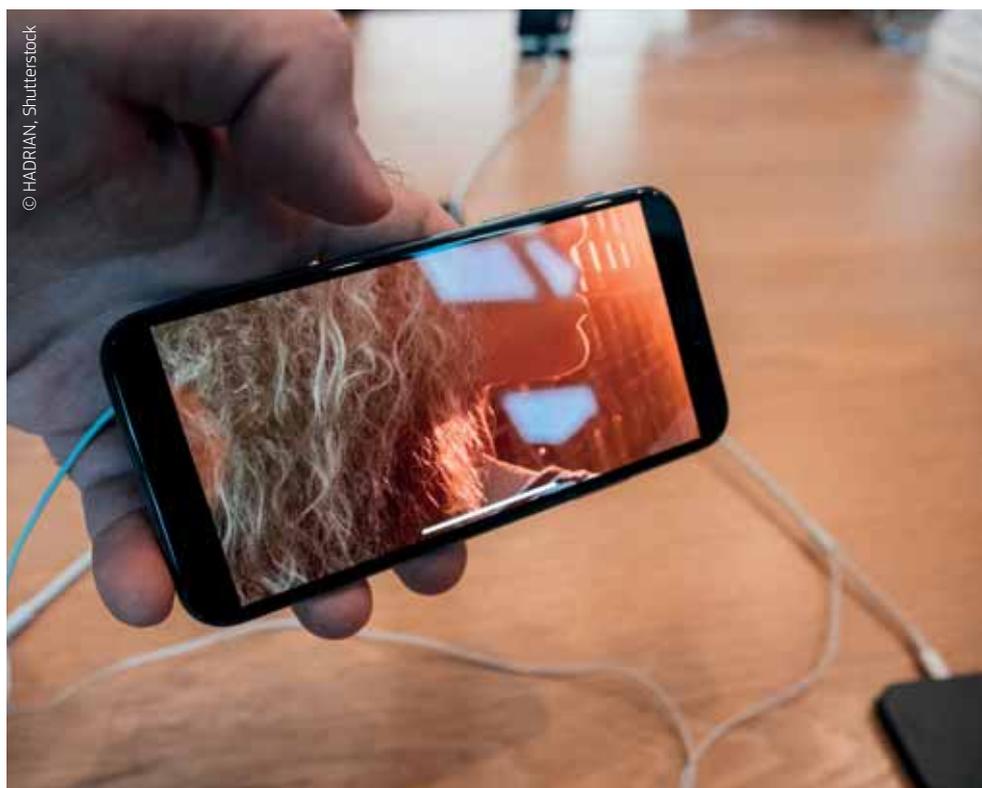
HEALTH

RESTORING SENSORY FEEDBACK TO AMPUTEES

EU-funded scientists have succeeded in restoring sensory feedback in amputees, enabling them to control artificial limbs in real time. The ground-breaking technology, which could transform the lives of thousands of patients, is testament to the benefits of coordinated European research.

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The four-year NEBIAS (NEurocontrolled BIdirectional Artificial upper limb and hand prosthesiS) project, due for completion at the end of January 2018, represents a significant leap forward in cybernetics and builds on 10 years of dedicated research. The NEBIAS bionic prosthesis consists of a dexterous hand prosthesis, electrodes and embedded electronics for recording and stimulation.

A major leap forward

A new neural interface provides sensory information from the artificial hand to the brain. This interface links the patient's nervous system with the artificial sensors embedded in the prosthesis, enabling the user to control complex hand and finger movements. The electrodes are selective in that they interface with some areas of the nerves and not with others close by. The sensors detect information about touch, which is sent in real time to the patient, allowing for the natural control of the hand.

'A prototype of this bionic prosthesis was successfully tested in June 2016 during a clinical trial in Rome,' says project coordinator Dr Silvestro Micera from the Sant'Anna School of Advanced Studies in Italy. 'A second patient received an implant in July 2017.'

NEBIAS consortium members have since created a start-up in order to move the technology towards commercialisation, and further research to bring these results forward is also planned. 'The next steps mainly involve the development of long-term biocompatible electrodes and the miniaturisation of sensory feedback electronics in order to obtain a fully implantable and portable prosthetic system,' says Micera. 'These steps will be pursued with the final aim of making this clinical trial available to more patients.'

To this end the forthcoming EU-funded SENSARS project will build further on the ground-breaking work of NEBIAS. 'The main aim of this project is to commercially exploit the results obtained during this project and to verify whether the innovations generated during NEBIAS could be used to provide valuable devices for lower-limb amputation,' says Micera.

Dedicated research

NEBIAS brought together researchers from materials, computer and neurosciences, biomedical microtechnology and electronic engineering with a common goal in mind – to make a prosthetic hand that can enable natural sensation and motion. The project's success in achieving this is the result of this successful collaboration, and also because of the innovative work carried out through previous EU-funded projects.

These include CYBERHAND, which sought to demonstrate the feasibility of direct interfacing to the nervous system to enable natural control of a mechanical hand.

Efforts to connect robotic artefacts to the nervous system were then pursued notably under FP6 and FP7 projects such as NEUROBOTICS and TIME, with successful testing of a prototype electrode without sensory feedback and investigations on how electrodes could be implanted into a patient's nerve.

'Thanks to these projects, important steps were taken towards developing dexterous hand prostheses as well as electrodes for interfacing with the peripheral nervous system,' explains Micera. 'A key drawback to date however has been the lack of sensory feedback. The main goal of this project was therefore to restore sensory-motor function in amputees in order to enable them to feel artificial limbs as a part of their own body.'

Having achieved this, NEBIAS's ground-breaking technology will continue to be built upon, miniaturised and improved. If all goes to plan, the final stage some years from now will be large-scale clinical trials to establish if the prosthesis has real medical and commercial potential.

H E A L T H

IMPROVED STATISTICAL METHODOLOGY FOR SMALL POPULATION GROUP TRIALS

Over 30 million European citizens suffer from rare diseases with an incidence of less than five in 10 000 people. The IDEAL project addresses the limitations of conventional statistical methodology in evaluating new therapies in clinical trials.

From 2000 to 2010 in Europe alone, over 60 orphan drugs were approved with the majority based on studies with sample size below 50. Ethical limitations and age variability in paediatric clinical trials also limit sample size, as do studies on personalised medicine where efforts to tailor therapies to individual patients' needs significantly lower the participant number.

Statistical methodology is well-accepted for validating the results of clinical trials and proving the efficacy and safety of new therapies. However, most statistical methods are suited for large population studies where assumptions on the validity of the methods are usually handled by increasing the sample size. This cannot be implemented in small group trials where the rarity of the disease or the sparse geographic distribution of patients hampers clinical trial recruitment numbers. On the other hand, prolonged recruitment time may lead to reduced motivation of patients as well as physicians. As a result, application of classical statistical methodology often overlooks treatment effects since only large effects can be observed.

Lately, the applicability of standard clinical trial approaches to small populations has come under increasing scrutiny and criticism. There is an imminent need for adapting innovative methodologies in the setting of small sample population group trials. To address this, scientists of the EU-funded IDEAL (Integrated DEsign and AnaLysis of small population group trials) project proposed to refine statistical methodology for application in small population group trials such as those testing novel therapies for rare diseases.

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Addressing the shortcomings of existing methods

According to the guidelines of the European Medicines Agency, clinical trials should be designed based on benefit risk assessment and avoided if knowledge can be transferred from similar large population studies. 'If information about the dose response relation is known in larger populations, such as adults, extrapolation would allow smaller clinical trials in the paediatric population,' project coordinator Prof. Hilgers explains.

When applied to small population size trials, conventional statistical methodology leads to reduced confidence. Furthermore, it cannot adequately address heterogeneity in patient outcome or the limited repeatability of clinical trials. To circumvent these issues, IDEAL researchers developed statistical methods to adapt the significance level and allow confirmatory decision-making in clinical trials with small populations.

In addition, they developed methodology for the selection of the best practice randomisation procedure, a key technique used in clinical trials to avoid bias. Further achievements included modelling approaches for trial outcome analysis, methods accounting for individual responses as well as identifying biomarkers and prognostic scores in small sample studies.

Clinical benefits

The small numbers of patients that could be involved in trials of rare diseases means that alternative approaches are required that extract more information from patients or repeatedly measure them. 'Clinical trials in small population groups could be made more efficient, so that therapies for rare diseases could be approved,' Prof. Hilgers continues.

Undoubtedly, methodological progress will aid the design and analysis of clinical trials, leading to more cost-effective and reliable studies. 'Importantly, the tools, software packages and the 33 recommendations generated during the IDEAL project will support clinical research of rare diseases and pave the way for medical and pharmaceutical advances,' Prof. Hilgers predicts.

No surprise the project attracted worldwide interest from patient advocacies and rare disease consortia as well as regulatory agencies that have over 1 000 new therapies in the pipeline for approval.

UNDERSTANDING THE ROLE MICROENVIRONMENTS PLAY IN METASTASIS COULD LEAD TO BETTER CANCER TREATMENT

Increasing evidence suggests that certain proteins of the extracellular matrix (ECM) support the viability of disseminated cancer cells at distant sites, facilitating metastatic outgrowth. Targeting these components may provide a means to impair the competence of these cancer cells and inhibit metastatic relapse.

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Every year there are over 1.5 million new cases of breast cancer globally, making it the most common form of cancer diagnosis amongst women. Most of the 500 000 deaths associated with breast cancer are caused by metastasis, where malignant cells spread to a range of distant organs, common sites being the bone and the lungs, generating a secondary tumour. As metastasis is currently incurable, there is a pressing need for innovations for effective treatment.

The EU-funded BONEMETTNC (Analysis of Tenascin C function in breast cancer metastasis to bone) project concentrated its research on the ECM protein tenascin C (TNC) and its role in breast cancer metastasis. BONEMETTNC has identified surface receptors that mediate TNC function in metastatic progression and demonstrated that TNC also promotes resistance to chemotherapy in mouse models.

The importance of the metastatic niche

There is increased evidence indicating that metastasis depends on the dynamic interactions between cancer cells and the microenvironment in secondary organs, rather than being the result of cancer cell properties alone. For disseminated cancer cells to metastasise they must adapt to, and manipulate the often inhospitable microenvironments of secondary organs. This interaction creates a 'metastatic niche', maintaining cancer cell health and metastatic growth.

Explaining the importance of understanding this dynamic, the project coordinator Dr Thordur Oskarsson says, 'Most properties of cancer cells are dependent on a particular molecular context that can be generated by the microenvironment such as the niche. Therefore, it is important to target both the cancer cells and the niche when battling metastasis.'

It is widely recognised that stem cell properties influence cancer progression and metastasis. BONEMETTNC team members had previously identified the ECM protein TNC as an essential component of the breast cancer metastatic niche showing that, in mouse models, TNC is essential for metastatic colonisation of the lung and bone. BONEMETTNC gave the team an opportunity to explore further how TNC may have a role in regulating stem cells' characteristics that are likely to be important for tumour initiation, particularly at distant sites.

The team used modelling techniques to investigate the signalling and transcription output mediated by TNC within the metastatic niche. The modelling also enabled them to analyse potential surface receptors to which TNC may bind to promote signalling. The modelling rendered 3D culture systems of primary cancer cells, RNA interference, transcriptomic screens, genetic and xenograft mouse models of cancer progression and metastasis.

As Dr Oskarsson explains, 'The 3D structure of these cultured tumour spheres is particularly important when studying ECM proteins. The proteins are secreted into the intracellular space within the spheres providing a more relevant physiological context compared to monolayer cultures. Moreover, these cultures enrich for stem cell properties in cancer cells, making the assay of interest to study molecular interactions regulating these attributes. Finally, tumour spheres may be especially appropriate for studying TNC and other matricellular proteins, since many proteins within this group have been linked to stem cell regulation and are highly induced in spheres.'

ECM as a source of targets in the fight against breast cancer

One of the project's most important findings was the identification of TNC's role in chemotherapy resistance. Currently, little is known about the role of ECM proteins in therapy resistance. However, this group of proteins may be an important source of drug targets against cancer and so merits increased attention.

Looking to the future, as Dr Oskarsson offers, 'The project's continued work will characterise further the role of TNC receptors in therapy resistance. We are also interested in looking in more detail at the overlap between TNC-induced mechanisms in breast cancer and molecular mechanisms promoting activation of normal mammary stem cells.'

NEW BRAIN VISUALISATION OF ALZHEIMER'S, AT DIFFERENT AGES, HOLDS OUT HOPE FOR FASTER DIAGNOSIS AND TREATMENT

As Alzheimer's disease is associated with a wide variety of symptoms, usually observed through patients' behaviour and actions, effective and timely treatment has proven elusive. An EU-funded project has contributed towards the capture of images which show the changes a brain with Alzheimer's undergoes, at different ages, with promise for future diagnostics and treatment.

The prevalence of Alzheimer's disease (AD) is increasing and is most common in the elderly. AD has various symptoms, often reflective of the life-stage of the sufferer when the disease initially presents itself. This variation presents a treatment challenge, especially for younger patients, in whom it is often difficult to reach a correct diagnosis.

Researchers supported by the work of the EU-funded BIOFINDER (Biomarkers For Identifying Neurodegenerative Disorders Early and Reliably) project, have succeeded in developing a methodology to visualise AD in the brain at different ages, publishing their findings in the journal of neurology Brain.

Imaging disease onset and progression

Prior to the age of 65 sufferers tend to experience reduced spatial perception and diminished orientation. Older patients are more inclined to have symptoms traditionally associated with the disease, especially memory impairment. This research means that, as one of the research team Michael Schöll, based at Lund University and the University of Gothenburg, summarises, 'Now we have a tool which helps us to identify and detect various sub-groups of Alzheimer's disease. This facilitates the development of drugs and treatments adapted to various forms of Alzheimer's.'

A known indicator for the establishment of Alzheimer's is when the brain's tau protein creates neurofibrillary tangles or lumps, inhibiting the functioning of the synapses and neurones, the brain's signalling devices. These are identifiable using new imaging techniques, including the usage of a Positron-emission tomography (PET) camera along with

the deployment of a molecule acting as the trace substance. The molecule binds to tau which the PET camera can capture.

'The changes in the various parts of the brain that we can see in the images correspond logically to the symptoms in early onset and late onset Alzheimer's patients respectively,' elucidates Professor of Neurology, Oskar Hansson, at Lund University and the BIOFINDER project coordinator.

The findings are based on the study of around 60 Alzheimer's patients at Skåne University Hospital, Sweden, along with 30 people who displayed no cognitive impairment acting as a control group.

Working towards clinical application

As well as placing a tremendous strain on patients and their families, neurodegenerative disorders such as dementia and Parkinson's disease are also a burden for healthcare systems. Yet despite investment in treatments – typically drug therapies – none has proved to be successful in arresting or retarding the progress of the diseases. Disappointment also extends to a lack of effective early detection for underlying disease pathologies and scant knowledge about the precise disease mechanism in humans.

Yet, many neurodegenerative disorders have distinct and known development pathways which emerge as many as 10-15 years before clinical symptoms are overtly manifested. This means there is opportunity for early diagnosis and so also effective treatment. New therapies hope to exploit this intervention window using biomarkers for early diagnosis. Early treatment would help avoid unnecessary tests, reducing patient anxiety and uncertainty.

At the moment, the imaging technique has only been applied in research settings, where it can be used to help identify patients more likely to respond to new therapies as well as to quantify relevant drug targets, such as oligomers of β-amyloid and α-synuclein. However, Professor Hansson believes that after clinical trials, actual clinical applications are likely within a few years.
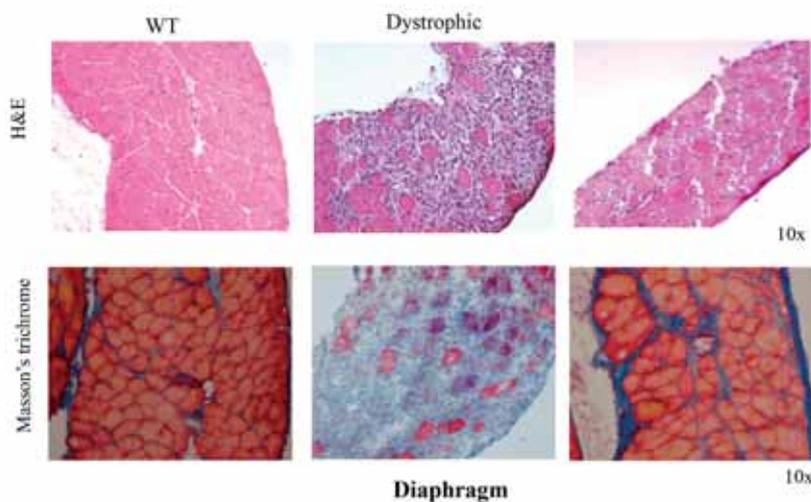

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BIOFINDER
- ★ Hosted by Lund University in Sweden.
- ★ Funded under FP7-IDEAS-ERC.
- ★ http://cordis.europa.eu/project/rcn/107847
- ★ Project website:
  http://biofinder.se/

RESEARCHERS IMPROVED MUSCULAR DYSTROPHIES BY MAKING THE MUSCLE SLOWER

Skeletal muscle keeps our posture, causes movement and drives breathing. EU research has investigated muscle development to find the best possible approach to combat loss of muscle mass occurring in muscular dystrophies (MDs).

© REGENERATIONFIX

Patients with MD, such as Duchenne muscular dystrophy, suffer from dystrophy or wasting of skeletal muscle, which compromises movement. At worst, breathing and heart function is affected leading to wheelchair dependency, respiratory failure and premature death.

There is still no therapeutic solution for these severe genetic disorders, and trials based on induction of muscle building to counteract the progressive wasting led to poor or transient success.

A complete new look at therapy for MD

The REGENERATIONFIX (Role of the transcription factor Nfix in muscle regeneration and muscular dystrophies) project has taken a radical, groundbreaking approach to slow down MD. In previous research, the team showed that the transcription factor Nuclear Factor IX (Nfix) drives the switch from embryonic to foetal muscle formation – from slow to fast twitching and more mature muscle fibres.

Prof. Graziella Messina, head researcher of the project, outlines the overall thrust and rationale of the project. 'This project aimed to introduce a conceptually different proof of concept to preserve and maintain the musculature in dystrophic patients.'

Although this concept had already been demonstrated through Nfix silencing, all the evidence suggested that any other possible pharmacological approaches to reduce muscle regeneration and promote a slower twitching musculature may be equally effective.

Assessing these research results, as Prof. Messina describes, 'We proposed that a slower twitching and regenerating muscle might escape dystrophic muscle degeneration. Paradoxically, if muscles are forced to regenerate, this can exacerbate the phenotype.'

Testing the effects of Nfix

The researchers crossed different MD animal models with mice lacking Nfix. Results showed an impressive improvement of the observable physical (phenotypic) and functional symptoms associated with dystrophic muscles in animals up to six months of age.

'Importantly, this amelioration was also observed in the mdx Duchenne mouse model, thus demonstrating the broad validity of this approach,' Prof. Messina points out. Lack of Nfix led to delayed and slow muscle regeneration upon acute injury and provoked a conversion of the musculature towards an oxidative metabolism, as published in Cell Reports.

As for protection of the dystrophic muscle against further degeneration, absence of Nfix leads to a general switch towards a slow-twitching contraction and

"Absence of Nfix leads to a general switch towards a slow-twitching contraction and a reduced muscle regeneration."

a reduced muscle regeneration, which better protect muscle wasting in time. These results are now in press in Nature Communications.

Nfix modulation for future MD therapeutics

Now, just after the project's end, the REGENERATIONFIX team are continuing to work on Nfix and its therapeutic use for MDs. The main focus is on the role of Nfix in macrophages, the most important players in tissue inflammation.

During the project term, the researchers identified and characterised members of the pathway upstream from Nfix. Prof. Messina believes this will be the course of research that will result in possible pharmaceutical interventions to inhibit Nfix production. 'In line with this, a "druggable" way to inhibit Nfix or its function will represent the future research topic of my laboratory.'

In parallel, they are developing more specific ways to inhibit Nfix using molecular design based on the crystalline structure of the transcription factor.

Summing up the achievements of the project, 'Both approaches will represent a translational outcome of the REGENERATIONFIX project, which started as a fundamental research study and whose results might become a real opportunity to develop a potential therapy in human MD patients,' Prof. Messina concludes.

SOCIETY

RESILIENCE IN TIMES OF CRISIS

The financial crisis has taken its toll on vulnerable citizens in Europe, leading to more poverty on the continent. Identifying the factors that create more resilient societies can help mitigate the phenomenon.

Over the last decade, the economic crisis has been steadily affecting the livelihood and poverty levels of European citizens, compromising social cohesion and inclusion. Measures to deal with poverty put in place before the crisis have not been adequate, requiring more research into improving the resilience of European communities.

The EU-funded RESCUE (Patterns of resilience during socioeconomic crises among households in Europe) project studied resilience in 250 households across Europe. Over a period of three years, it looked at how people were coping in several European countries, namely Finland, Germany, Greece, Ireland, Poland, Portugal, Spain, Turkey and the United Kingdom. This was achieved by gathering data through interviews with ordinary citizens and interviews with stakeholders from charities, NGOs and welfare institutions.

RESCUE studied the impacts of the crisis on vulnerable households and identified factors that advance or compromise resilience. It then analysed socioeconomic and cultural practices from different perspectives. The study also involved investigating the role of local welfare state institutions, as well as the social economy and communities, and looked at inequalities based on gender, ethnicity and migration.

This enabled the team to document numerous resilience practices, bearing in mind that most vulnerable houses had rarely developed any resilience. In those that did, it found that socioeconomic resilience is linked to how a household mobilises cultural resources, social values and traditional day-to-day survival mechanisms. RESCUE also found that family, friends, neighbours and community are important supporters in dealing with poverty, while personal assets and properties have proven to be pivotal in alleviating hardship.

Needless to say, government support in the form of social protection, subsidised housing and civil rights also contributed significantly. Strong resilience was further attributed to smarter use of utilities, reliance on public transport, access to natural resources, and community or society drives such as foodbanks, church initiatives and free education.

The project's findings and results were disseminated through conferences, journals, books and the project website. The outcomes are useful in helping advance the resilience of vulnerable citizens and communities in times of crisis.

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IRON AGE TEXTILES GIVE UP THEIR SECRETS TO REVEAL PATTERNS IN HUMAN INTERACTION

Textiles dating from between 1 000 and 400 BC survive in mineralised forms often found in burial sites. The material was frequently placed in contact with metals conducive to their reservation, buried alongside the bodies in the form of ornaments or tools. New research is unravelling what these fragments can tell us about the cultures that produced them.

Fabric doesn't hold up well over millennia, with a few notable exceptions garments are rarely discovered. But tiny fragments found alongside micro-organism killing metals can offer insight into population movements, trade and culture. The metal salts create casts of the fibres, preserving the microstructure for analysis and comparison.

By the meticulous use of digital and scanning electron microscopy, high performance liquid chromatography and other advanced methods, the EU-funded PROCON (PROduction and CONsumption: Textile Economy and Urbanisation in Mediterranean Europe 1000-500 BCE) project uncovered information on the nature of the structural features of the raw material, such as weave, thread thickness and thread count along with other parameters.

The findings, and the conclusions drawn from them, are presented in a recently published paper, 'Tracing textile cultures of Italy and Greece in the early first millennium BC'. Dr Margarita Gleba, the study's author and researcher at the McDonald Institute for Archaeological Research, University of Cambridge, states that there is overwhelming evidence of frequent contact between Italy and Greece during the first half of the first millennium BC, but that the textile traditions of each culture were very different.

Her research indicates that the populations of the two regions made an active decision to clothe themselves in a certain way, perhaps in connection with traditions already established in the Bronze Age. This runs counter to our previously held assumption that Italy and Greece had similar technological and aesthetic traditions of textile production during the first millennium BC.

What can ancient cloth tell us about the people who spun and wore it?

Economic activities related to metal, ceramic and agricultural production and their relationship to urbanisation in Iron Age Italy and Greece has long been of interest to researchers. But the more ephemeral commodity of fabric and the light it shines on wealth generation and subsistence has not been investigated. The project considered the significance of the production and consumption of textiles in the development of city-states (as clothing, elite regalia, trade and exchange items).

PROCON looked at warp, weft, thread diameter, thread twist direction, the type of weave or binding, thread count indicating cloth quality, the edges and the material of the fibres. The textiles reviewed, 192 for Italy, and 107 for Greece, came primarily from funerary contexts, with only a few fragments excavated in settlements, and a special group that was found frozen in the Italian Alps. This means their purpose was to clothe or wrap rather than, for example, use as sails or furnishing.

The colour of the mineralised textiles is unknown, but dye analysis of some of the organically preserved finds indicates the use of sophisticated dyeing methods and a variety of plant dye sources, including muricid shellfish for purple, madder for red, woad for blue and a variety of yellow dyes. The paper explains textiles were probably decorated with various beads, buttons and appliqués in precious materials, such as bronze, gold, amber, glass and faience, found in their hundreds and even thousands in rich Iron Age tombs across Italy. Small domed bronze buttons are particularly common over a very wide geographic area.

Analysis shows similarities in the Grecian samples with techniques of weaving used in the Near East rather than Central Europe, mirroring the close connections that existed between the areas. One textile form was found to have spread westwards early in the first millennium. In central Adriatic Italy, on the other hand, the predominance of another type of weave appears to agree with the generally accepted Adriatic- or Balkan-looking trends in the local material culture.

PROCON aims to investigate the role of textiles in the urbanisation and state formation of Mediterranean Europe (Greece, Italy, Spain) from 1 000 to 500 BC and to demonstrate that textile production and consumption were a significant driving force of the economy and in the creation and perception of wealth.

"The textiles reviewed, 192 for Italy, and 107 for Greece, came primarily from funerary contexts."

HONOUR, CULTURE AND BEHAVIOUR

An EU team has studied honour as a cultural mindset. Results showed that people perceive honour as spatially located and including gender stereotypes, and also that honour can increase anger in adults and reduce cheating in children.

People think, feel and behave through the lens of culture. Individualism and collectivism as cultural dimensions have been well studied. However, much less is known about honour cultures, as seen in Arab and Latin societies.

The EU-funded HONOR AS MINDSET (Honor as a cultural mindset: Effects on cognition, emotions, and behavior in children and adults) project examined theoretical assumptions about honour. Studies involved activating honour mindsets, examining how honour involves self-esteem and is associated with individualism and collectivism, testing spatial mental representation of honour, and looking at how an activated honour mindset influences how adults and children think, feel and behave.

Results indicate that even in people who do not necessarily highly endorse honour values, an honour mindset can be activated. Furthermore, results reveal that, in both Japan and the US, facets of honour are related to both individualism and collectivism. Findings however show that honour is not similarly associated with self-esteem across cultural groups (i.e. no associations in so-called 'low-honour' cultures).

Further findings indicate that honour is mentally represented in space. Using a lexical decision task, the team determined that honour is mentally located upwards and to the right, rather than downwards to the left. Researchers further found that once honour is activated in memory, an individual will be more likely to interpret potent characteristics as male.

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Additional sets of studies illustrated the consequences of an accessible honour mindset on cognition, emotion and behaviour. Activating an honour mindset in adults and children improved performance in tasks requiring hierarchical thinking (e.g. lightest-darker-darkest), but not in tasks requiring nominal thinking (e.g. red-green). Priming honour also increased moral clarity.

Among adults, an accessible honour mindset meant individuals were more certain about what is morally right and what is morally wrong. They were also more angered, and more readily communicated their anger in public, but not in private settings. Among children, priming honour reduced cheating.

Study results show that honour can be considered as a cultural universal and that an honour mindset can improve or undermine performance if the task does not fit the characteristics of the mindset.

"Even in people who do not necessarily highly endorse honour values, an honour mindset can be activated."

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T R A N S P O R T

MORE EFFICIENT AIRCRAFT ENGINES LOWER RUNNING COSTS AND ENVIRONMENTAL IMPACT

Burning fuel makes the aviation industry one of the fastest growing emitters of greenhouse gasses (principally CO_2 and NO_X). The EU has committed to work with the industry to reduce these emissions and the EU-funded E-BREAK project has contributed by improving engine efficiency.

E-BREAK (Engine Breakthrough Components and Subsystems) has developed more advanced, lighter aircraft engine components capable of withstanding higher temperatures and pressures. Further maximising the engine's ability to operate across a range of flying conditions (including take-off, cruising and landing) and in various weather conditions, E-BREAK also improved internal sub-systems performance such as sealing systems as well as the accuracy, weight and load capability of engine devices.

Better sub-systems for more robust engines with predictive maintenance

The drive towards more efficient and reliable engines has resulted in smaller engine cores which run hotter and faster at higher pressure ratios and require less scheduled maintenance. As previous projects had focused on core engine technologies, E-BREAK was set up to address the evolution of engine sub-systems, which have to adapt to the new constraints of core technologies.

As the E-BREAK project coordinator Dr Manuel Silva explains, 'An engine is like a puzzle. If you improve one part, you have to be aware of how that change then affects the other parts. Generically designed supportive systems we call technology enablers, allow you to keep the parts working together, effectively and seamlessly and across a broad range of aero-engines.'

Examples of technology enablers are oil and air cooling systems for temperature control. While an aircraft has to use most of its air intake mass flow to achieve thrust, it also relies on air to keep the oil from overheating, which could damage the engine. The E-BREAK team developed better performing sealing technologies for the oil and air systems, to further enhance overall engine performance under extremely high pressures.

E-BREAK has also accomplished other key innovations. For example, the improvement of abradable coatings between engine components that rub together and so are prone to degradation, such as the material between the blade tips and their casing. The project also achieved a major breakthrough in reducing engine weight by considering lighter turbine blades, constructed using the new titanium aluminoide intermetallic alloy. While considered a very promising alloy, it has been difficult to process. The project was able to optimise the blade's design and manufacture after testing the alloy's properties and performance during flight.

Another important E-BREAK contribution is its health monitoring system, which anticipates engine component deterioration. The system uses sensors and advanced algorithms to pin-point the location of a problem. Previously, as the location of a fault was often unknown, engineers replaced multiple parts as a precaution. E-BREAK's system reduces the amount of time aircraft are grounded for repairs, lowering overall maintenance costs and loss of revenue through reduced flying time. Crucially, it also increases overall safety through its accurate identification of problems.

Working towards targets

The Advisory Council for Aeronautics Research in Europe (ACARE) has set the goal of a 50% reduction per passenger kilometre of CO_2 emissions, with NO_X emissions to be reduced by 80% and a decrease by 15 to 20% of SFC, an indicator of jet engine fuel efficiency.

The E-BREAK project is part of a wider EU-funded initiative to lower emissions by concentrating on improving aircraft engines and which includes the LEMCOTEC, NEWAC, DREAM, VITAL and ENOVAL projects. Together, these projects will reduce aviation CO_2 emissions by between 21 and 32% and lower NO_X emissions by as much as 65 to 70%, depending on engine size.

As Dr Silva concludes, 'E-BREAK's results offer crucial steps towards ensuring the compatibility of a new generation of engine sub-systems with the increased constraints in temperature, pressure and mass of future engines, necessary to meet ACARE targets. Through these efforts, the aviation industry and the people it serves can look forward to even more efficient, reliable and safer air travel that is also kinder to planet Earth.'

E-BREAK
★ Coordinated by Safran Helicopter Engines in France.
★ Funded under FP7-TRANSPORT.
★ http://cordis.europa.eu/project/rcn/103887
★ Project website:
   http://www.e-break.eu/

NEW STUDY OFFERS ANSWERS TO IMPROVE ELDERLY TRANSPORT MOBILITY

A new study led by the University of Plymouth and funded through the EU-funded TRACY project has advised governments to do more to develop transport policies that allow those over the age of 65 to remain mobile and active.

As Europe possesses an increasingly ageing population, finding methods to promote healthy ageing has become a major policy concern, focusing on health, social care, economic development and even urban design. Policymakers at both EU and national level have indeed been attempting to ensure that research and policy are closely intertwined to ensure the best results for guaranteeing older citizens' mobility but the Plymouth researchers wanted to understand better to what extent national governments promote the age-friendly qualities of transport systems.

The research team achieved this by assessing documents from across the European Union, Norway and Switzerland, and spoke to government employees from 20 countries. By getting a more holistic view of the picture across Europe, they were able to determine to what extent individual countries encouraged mobility, independence and social and economic inclusion.

Overall the international assessment identified 146 documents from 29 countries which could be classed as falling under EU-wide guidelines on 'people with reduced mobility', with 63% solely concerned with older people. The research team then scored them against 11 qualities, seeking to establish if they were focused on being: affordable; available, barrier-free; comfortable; comprehensible; efficient; friendly; reliable; safe; secure; and transparent.

They found that policymakers at EU and national level place disproportionate emphasis on safety, affordability and disabled (or barrier-free) access, whereas a more rounded approach could actually lead to substantial mobility increases amongst older people. The results have been published in the journal 'Transport Policy'.

'It's very clear from this work that there will be difficult challenges for policymakers as they seek to cater for older people's transport requirements in the future,' commented Professor Jon Shaw, a lead author of the study. 'This may well be the last thing they want to hear in an environment of restricted public expenditure, but a key message here is that improving the quality of the transport system for older people generally means improving it for everyone.'

He added: 'One small but important example is better information provision: clearly legible and audible announcements on the bus regarding what stop is coming next helps not only people whose hearing or sight is deteriorating, but also anyone who isn't familiar with the route. And if some of those people who aren't familiar are car drivers, then a better experience on public transport might help us address our traffic congestion problems.'

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"Improving the quality of the transport system for older people generally means improving it for everyone."

The researchers also add that as attention shifts to considering and providing for older people's mobility in years to come, they would suggest that increasingly flexible thought will need to be devoted to their transport system needs. 'The basic desire of people to be together is unlikely to go away, and the challenge for policymakers will be to provide systems capable of meeting the travel patterns of senior citizens in such a way that proper account is taken of their needs,' they write.

The research was funded through the FP7 TRACY (Transport Needs for an Ageing Society) project that officially ran for two years from 2011 to 2013 and provided detailed recommendations to EU policymakers on improving transport and mobility options for older citizens. Whilst the current research only looked at Europe, TRACY also collected substantial data from countries across the globe, including the United States, Australia, Japan and New Zealand.

TRACY
★ Coordinated by Erfurt University of Applied Sciences in Germany.
★ Funded under FP7-TRANSPORT.
★ http://cordis.europa.eu/project/rcn/100606
★ Project website: http://www.tracy-project.eu/

FLIGHT TESTS PAVE THE WAY TO GREENING OF AIRCRAFT OPERATIONS

Clean Sky's Systems for Green Operations (SGO) programme seeks to develop systems that enable environmentally sustainable flight operations. An EU initiative has conducted real-life trials on two of these new green concepts.

SGO has evaluated new operational concepts for integration in future flight management systems in order to minimise environmental effects and provide more sustainable and green operations to airliners. Among these, the Multi-criteria departure procedure (MCDP) and ECO STEP were modelled and tested in a laboratory. They exhibited significant savings in terms of fuel consumption and environmental pollutants.

MCDPs are based on noise abatement departure procedures designed to provide noise reduction for surrounding airport areas and reduce fuel burn. This serves to minimise cash operation costs as well as carbon dioxide and nitrogen oxide emissions during departure. ECO STEP is an optimised multistep procedure used mainly for long-range cruising. It computes an optimised cruise profile in order to minimise fuel consumption and/or flight time.

The EU-funded ATAEGINA (Airline trials of environmental green flight management functions) project took MCDP and ECO STEP out of the lab and into real flight conditions. The two operational concepts were evaluated by analysing their compatibility with aircraft operations and conducting a safety assessment.

MCDP flight simulations were successfully carried out, demonstrating the compatibility of the new functions introduced for the MCDP operation in non-automatic execution with current flight management functions. ECO STEP simulation tests were not carried out due to long delays.

A real MCDP flight trial campaign was also carried out. Different assessments were conducted using data recorded during the MCDP flight trial campaign. Results show that it is feasible to carry out MCDP as a new operational concept in daily operations. In addition, the procedure could be fully accepted by flight crews, with some minor procedure modifications. However, due to the low number of MCDP flights, there is no conclusive evidence regarding the benefits it could provide in terms of noise, fuel and emission reductions.

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Lastly, researchers analysed MCDP integration/certification aspects. They presented different integration approaches and identified on-board equipment modifications and regulations for certification.

Through real-life testing and validation, ATAEGINA fully supports Clean Sky's SGO in its future steps towards reducing the environmental impact of aircraft operations.

ATAEGINA
★ Coordinated by Pildo Consulting in Spain.
★ Funded under FP7-JTI.
★ http://cordis.europa.eu/project/rcn/191513

ENVIRONMENT

THE CONCEPT OF ECOSYSTEM SERVICES APPLIED TO THE REAL WORLD

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New and more accurate ways of defining and measuring ecosystem services have enabled scientists and the wider public to gain a clearer understanding of how nature contributes to human wellbeing.

Earth's stock of natural resources such as its geology, soils, air, water and all living organisms forms its natural capital (NC). Some NC assets directly contribute to human wellbeing through the provision of clean water, fertile soil, waste decomposition, the pollination of crops, and climate regulation. These so-called ecosystem services (ES) underpin our economy and society to make human life possible.

Despite an improved understanding of the link between healthy ecosystems, the delivery of ES and humanity's welfare, further work is still needed to ensure the ideas of NC and ES become part of the mainstream. The EU-funded OPENNESS (Operationalisation of natural capital and ecosystem services: from concepts to real-world applications) project was established to translate these concepts into effective operational frameworks that integrate ES into land, water and urban management. The aim is to inform decision-making to support EU social and environmental policy initiatives.

'The OPENNESS approach was based on applying the concept of ES in 27 real-life case studies covering different sociological-ecological systems in 13 European and four non-European countries using real-world observations and analysis,' says Project Coordinator Professor Eeva Furman. 'The case studies served as test-beds for biophysical, socio-cultural and monetary methods as well as conceptual frameworks to assess and value ES.'

These case studies targeted key policy problems, such as improving water quality, preserving biodiversity, using natural resources more responsibly, and combating climate change through increased use of renewable energy. An important message to emerge was that ES knowledge is most effective when decision-makers, practitioners and key stakeholders have been closely involved in the assessment process. This ensures that all actors find the information relevant and reliable, and are ready to act upon it.

Professor Furman comments: 'Land and water managers and other stakeholders adopted new ideas and practices from the real-life case studies to make a significant difference in urban planning and water and forest management by employing the concept of ES. Furthermore, all case studies succeeded in building intellectual capital and advancing understanding of ES and their role in human wellbeing.'

Researchers also produced an analysis of opportunities and challenges for mainstreaming ES in EU regulatory frameworks. These were subsequently used in the Intergovernmental Platform for Biodiversity and Ecosystem Services' regional assessment for Europe and Central Asia and its policy support tools and methodologies for scenario analysis and modelling of biodiversity and ES.

Project results were integrated into Oppla, a new knowledge hub developed in collaboration with the OPERAs project. 'The platform collates information and makes it available to researchers and practitioners, thereby providing a one-stop-shop for accessing up-to-date knowledge on ES and nature based solutions,' explains Professor Furman.

OPENNESS successfully provided ways of helping people to visualise the idea of ES, allowing them to apply it more easily to their work by providing a raft of multi-scale solutions. These can be used in real life by stakeholders, practitioners and decision-makers in public and business organisations by providing new frameworks, data-sets, methods and tools that are fit-for-purpose and sensitive to different decision-making contexts. This will empower communities and organisations within the EU, enabling them to improve the management of natural resources for the wellbeing of its citizens.

EVEN OPTIMISTIC CLIMATE CHANGE PREDICTIONS HAVE PERIGLACIAL ZONES AT TIPPING POINT

Researchers find that the decline of cold regions called periglacial zones is now inevitable. Even based on optimistic future carbon emissions estimates, they predict a 72 % reduction in the periglacial zone in their study's northern Europe region.

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About a quarter of the Earth's land surface is made up of areas known as periglacial zones, which are found at the edges of glacial regions mainly in far northern and southern regions, as well as at high altitudes. These environments with frost-induced and permafrost-controlled Land surfaces processes (LSPs) are vital for the cryosphere. However, researchers have recently concluded that, even based on the more optimistic estimates for future carbon emissions, periglacial zones will reduce substantially by 2050 and will be almost non-existent by 2100.

The study published in the journal Nature Communications points out that periglacial environments have already seen much change due to climate change such as glacier recession, shrub expansion to alpine tundra and alteration to permafrost thermal-hydrological regimes. Crucially, as well as impacting on landscapes and biodiversity, these ground condition changes can induce what is referred to as 'climate feedback'. Here, dependent systems, such as ground surface reflectance (light reflected by snow and ice), can trigger processes that further amplify or diminish the effects of climate change.

Investigating the current and future periglacial climate

The scientists in this study, part funded by the EU's HELIX (High-End cLimate Impacts and eXtremes) initiative, looked specifically at four periglacial zone processes. They worked with data which had been remotely sensed and field-quantified to an unprecedented scale, to investigate active surface features pertaining to cryoturbation, gelifluction, nivation and permafrost peat mounding across a high-latitude Fennoscandia region of ca. 78 000 km².

The researchers contend that the absence of deep permafrost, unlike comparable regions such as the High Arctic Canada, will mean that changes to the LSPs are likely to be rapid. They point out that changes to this region are also reflective of likely changes to similar sensitive landscapes at high latitude with areas of discontinuous and isolated permafrost, including large parts of Canada and Russia between 55 and 70° N latitudes. The team analysed the LSPs based on a modelling technique which used statistical algorithms to track the occurrence of climatic variables such as freezing and thawing degree days, water and snow precipitation, local topography and soil characteristics.

Once the climate baseline distributions had been established for the years 1981-2010, they developed climate projections of greenhouse gas concentrations based on three Representative concentration pathway scenarios, over two time periods (2040-2069 and 2070-2099).

They concluded that there is likely to be a reduction in the current periglacial climate realm in the study area and that by the end of this century, active periglacial LSPs will exist only at high elevations. Most worryingly, team member Dr Juha Aalto, of the University of Helsinki and the Finnish Meteorological Institute says, 'The results suggest that profound changes can be expected in current periglacial zones regardless of climate change mitigation policies.'

Speaking of the implications of the findings, Dr Aalto says, 'Our results indicate significant changes in Northern European plant life. Many rare species can only be sustained in areas of intense frost activity or late-lying snow packs, so the disappearance of such unique environments will reduce biodiversity.' This raises an important aspect regarding mitigation efforts, that of establishing realistic, evidence-based expectations.

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research*eu Results Pack

Marine research

Environmental processes, biodiversity, human activities, climate change, socio-economic impact of marine protection,... This Results Pack introduces 12 projects that have pushed the boat out on gaining a deeper understanding of the opportunities that the oceans will bring forth over the coming years.

For more information, go to: http://cordis.europa.eu/article/id/400695

ENVIRONMENT

HOW ARTIFICIAL NIGHTTIME LIGHTING NEGATIVELY AFFECTS ECOLOGICAL COMMUNITIES

The explosive growth of electric lighting is eroding the natural nighttime environment across more and more of the Earth's surface. While there is growing awareness of the adverse effects of light pollution on the behaviour of some nocturnal animals, a thorough understanding of potential impacts has been lacking.

Artificial lighting from streetlights and other sources disrupts natural cycles of daily and seasonal lighting. In turn, this has been found to alter the structure and functioning of plant and animal populations and communities.

The negative consequences of light pollution on ecosystems

'Artificial nighttime lights have long been known to alter the physiology and behaviour of organisms such as moths, turtles and seabirds,' says Professor Kevin J. Gaston, project coordinator for the EU-funded ECOLIGHT (Ecological effects of light pollution) project. This is predicted to impact their population dynamics, and the structure and composition of ecological communities. 'ECOLIGHT conducted the first key experiments to test for such population and community effects,' he says.

ECOLIGHT centred on two experiments. The mesocosm experiment sought for the first time to determine the impacts of streetlighting on the multi-generation composition and dynamics of simple multi-trophic communities of organisms. It had a multi-factorial design, with three nighttime lighting treatments for each of plants, plants and herbivores, and plants and herbivores and predators.

'The mesocosm experiment provided valuable insights into the impacts of streetlighting under circumstances in which organisms could not move to avoid the lighting treatments they were exposed to,' explains Prof. Gaston. To complement this, a field experiment was constructed in which 'open' plots of grassland were subjected to one of five lighting treatments. Here, organisms could move into or away from plots in response to the treatments.

A major benefit of ECOLIGHT is that it took a long-term experimental perspective on assessing the influences of artificial nighttime lighting. The two core experiments each ran for five years.

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Gaining important insight into ecological outcomes of nighttime light pollution

Findings show that streetlighting changes the abundances of plants, and of invertebrate herbivores and predators. It also changes the trends in those species numbers, and alters community structure and function. These outcomes result from both bottom-up (resource-controlled) and top-down (predation-controlled) impacts of artificial lighting on species abundances.

A variety of approaches to mitigate such impacts of artificial lighting were tested, including dimming lighting, changing the spectrum of lighting and limiting the timing of lighting. While some of these lessened such impacts, none alone was sufficient to remove them altogether. According to Prof. Gaston, streetlighting has quite pervasive ecological impacts, and nuanced approaches to such lighting will be required to limit such effects.

'ECOLIGHT contributed key findings to the discussion concerning the trade-offs between societal demands and expectations around streetlighting, and the negative environmental impacts of that lighting,' concludes Prof. Gaston. 'It will bring about a step change in the understanding of ecological consequences of nighttime light pollution.'

Even though the project officially ended in April 2017, its researchers are currently using imagery taken by astronauts aboard the International Space Station. This will help to determine how the colour spectrum of artificial nighttime lighting varies across Europe and how it is changing over time, and to map the environmental risk profiles.

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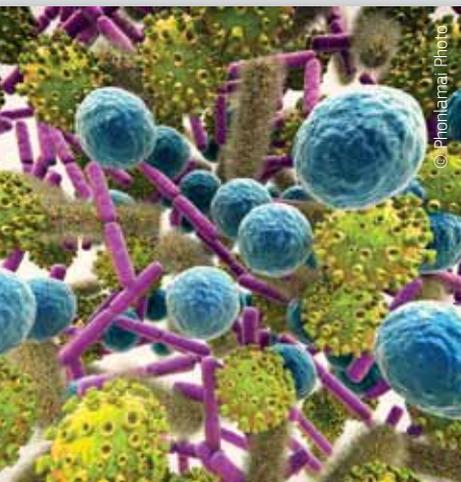
research*eu Results Pack

Microbiome research

Currently there is a lack of understanding about the importance of the human gut microbiome, which represents a vast new area of research that offers the potential for nothing less than a food and nutrition revolution. Our new Results Pack offers a detailed insight into the work of 13 EU-funded projects that are at the forefront of this exciting field.

For more information, go to: http://cordis.europa.eu/article/id/400693

THE COLOUR OF LIGHT – WHAT IT TELLS US ABOUT WATER CONTAMINATION

EU-funded scientists have found innovative ways to detect chemical and biological contaminants in water using light to take measurements and to control microfluidic flow.

The challenge in measuring water contamination is to make low-cost devices that can function autonomously, providing accurate information on chemical and biological contaminants over months or even years.

The EU-funded NAPES (Next Generation Analytical Platforms for Environmental Sensing) project has developed a prototype colorimetric chemical sensing device that takes water samples and, using microfluidics, adds reagents to generate a specific colour.

'We use a low-cost LED (light emitting diode) photo-detector to measure the colour, which is related to the concentration of nutrients and other contaminants in water,' says project coordinator Dermot Diamond of the National Centre for Sensor Research at Dublin City University, Ireland.

While there was a particular focus on phosphate, a major contaminant in water bodies across Europe, 'the chemistry can be adapted to detect other important contaminants,' he says. Prototype devices were deployed in the Mediterranean Sea and Arctic region and at wastewater treatment plants in Italy and Ireland.

Project partner Tellabs of Ireland estimates the commercial price of the NAPES device will be around EUR 2 000 or 10 times less than the current commercial price of autonomous environmental analysers. 'If we can drive down the cost of these instruments, we can dramatically increase the number of devices we deploy and measure more often in more locations to give a more accurate picture of environmental status,' Professor Diamond explains.

Bio-detectors

For detecting biological contaminants such as E. coli bacteria, the project team built on a sensitive optical sensor first developed by the University of Milan, Italy. 'The polymer used in this detector is invisible in water as it has the same refractive index as water,' Professor Diamond elaborates.

The surface of the material is treated to target a particular molecule. 'Because it is refractive-index matched, if you change the surface you change the refractive index and what is invisible suddenly become visible, which provides a very sensitive detection method,' he says.

Bio-receptors from Aquila Biosciences were immobilised on microbeads by another project partner, the Curie Institute in Paris, France. In the presence of bio-contaminated water, bacteria are concentrated on the beads and subsequently released for measurement via the Milan optical detector. These complex building blocks were all individually advanced under the NAPES project and then integrated into functioning demonstrator platforms for validation in lab-based trials.

Disruptive devices using light

The project team also developed innovative photo-switchable materials – molecules were synthesised and used to produce a gel whose properties change dramatically when exposed to light, making the gel expand and contract.

Fluidic control requires valves that consume a lot of power and are currently too large to be integrated into a microfluidic chip. 'We incorporated this photo-switchable gel into microfluidic channels and used light to make the gel expand and contract, closing or opening the channel on demand,' Professor Diamond explains. 'We demonstrated that not only can we turn the flow on and off, but we can hold the polymer gel at an intermediate stage, partially open, to precisely control the flow rate in the microchannel.'

The light-controlled 'valve', which has been patented, can be incorporated onto a microfluidic chip, and has the potential to become a disruptive technology by significantly driving down the cost of microfluidic systems used in analysers.
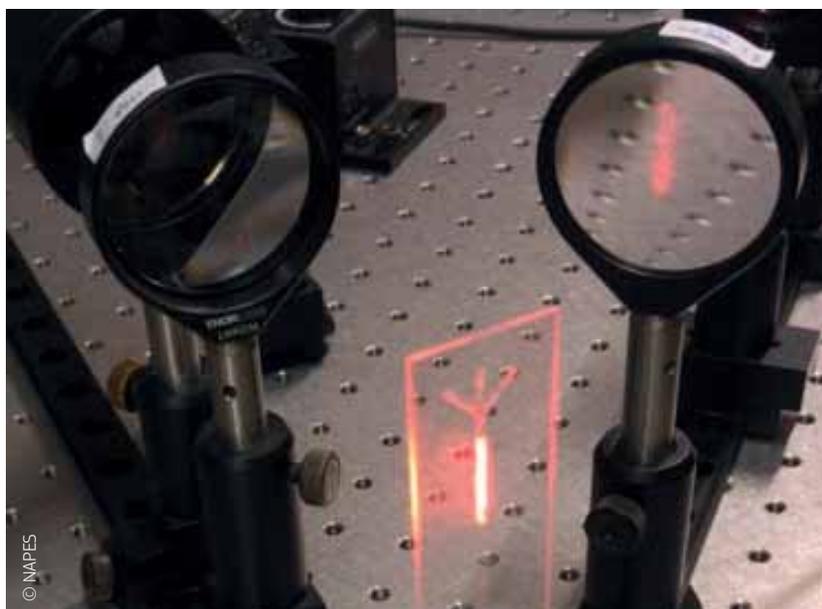
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NAPES
- ★ Coordinated by Dublin City University in Ireland.
- ★ Funded under FP7-NMP.
- ★ http://cordis.europa.eu/project/rcn/111018
- ★ Project website: http://www.napes.eu/

"Project partner Tellabs of Ireland estimates the commercial price of the NAPES device will be around EUR 2 000 or 10 times less than the current commercial price of autonomous environmental analysers."

AGRICULTURE AND FORESTRY

A NEW VISION FOR AGRO FOOD WASTE

The successful transformation of solid waste and wastewater into useful bio-based products bodes well for the food production industry.

Europe's agro food industry is flourishing, from winemaking and cheesemaking to fruit juice production. While a robust agro food sector is good for the economy and its population, it produces large amounts of biowaste and emissions that can both be exploited in better ways.

With this in mind, the EU-funded VALOWASTE (Valorisation of waste streams from the agro food sector) project developed a low-cost eco-efficient method to exploit waste and waste streams from the winery sector. 'We worked on reducing environmental impacts by recovering bio based products,' says project researcher Dr Arunima Nayak. 'These products include biofuels, bioactive food ingredients like the polyphenols and other by-products like activated carbon which can eventually be used to reduce wastewater effluents.'

Eco-friendly waste treatment for wineries

To achieve its aims, the project team worked on recovering bioactive polyphenols from winery solids and wastewater. It also researched the potential for recovering biofuels from the wine wastewater while simultaneously treating the wastewater effluents in line with discharge standards.

Based on its research outcomes, the project team effectively recovered significant amounts of polyphenols from the solid winery waste (grape pomace) using green solvents and processes. 'We then applied an innovative technology of anaerobic digestion and achieved high biodegradability of wine wastewater to biomethane with significant yields,' adds Dr Nayak.

Another key project achievement includes low-environmental-impact separation technologies like adsorption in recovering phenolic compounds from the winery wastewater. The novelty of this method lies in using the exhausted grape pomace to prepare highly effective low-cost activated carbons. 'We developed bio-based activated carbon and biochar from winery waste solids to use as low-cost adsorbents for wastewater treatment,' clarifies Dr Nayak.

Eco-innovations to treat agro food waste

In addition to developing eco-friendly smart separation technologies (e.g. adsorption, ultrasound), the use of microbial bioremediation – especially anaerobic digestion – represents an innovative technology in several ways. 'Not only is it cost effective, but it also serves the dual role of wastewater treatment along with being an environmentally safe method to manage food waste,' says Dr Nayak. 'Anaerobic digestion of organic winery wastes to create biofuel will also help reduce emissions and decrease our dependence on fossil fuel.'

Moreover, the new low-cost, environmentally friendly adsorption technology can remove 100% of trace organic contaminants that might be found in the treated water after bioremediation. 'The novelty of the method used in the project lies in using waste materials from agricultural by-products and dead biomass to prepare highly effective low-cost activated carbons via appropriate heating and chemical treatment,' explains Dr Nayak.

Other sectors can benefit too

By publishing its results and highlighting new environmental processes in treating agro food waste and wastewater, the project has ensured knowledge transfer on the topic to other interested researchers and sectors.

VALOWASTE results can be directly implemented in other agro food sectors such as olive oil and palm oil production, cheesemaking and fruit juice. 'Such sectors have a similar wastewater composition containing high organic constituents which can be easily exploited to recover antioxidants, bioenergy and other bio-based components like activated carbon,' adds Dr Nayak.

The project's achievements are very much in line with today's zero waste sustainability concept. Armed with these and similar research innovations, the agro food industry in Europe can become a green model for the rest of the world.

DNA SEQUENCING GETS TO THE ROOT CAUSE OF VARIETY AMONGST BIRCH TREES

Trees fulfil valuable functions including carbon sequestration, the provision of wood and the maintenance of ecosystems. The EU-funded BETWOOD project set out to find out more about their adaptability, by exploring the genetic make-up of the silver birch.

BETWOOD (Identification of novel regulators of growth and wood formation by studying natural variation in Arabidopsis and Betula pendula, a novel model tree) took advantage of breakthroughs in next generation sequencing technology to map the genome of birch accessions representing several geographically distinct populations (in Central and Northern Europe as well as in Siberia and Asia). Genomic sequencing also enabled the team to identify candidate genes, such as LAZY, that underlie the creation of special tree forms, offering clues to adaptation processes. Earlier this year the journal Nature Genetics presented BETWOOD as integral to a wider effort to sequence the silver birch genome.

'Now we can identify the molecular basis of tree traits!'

Researchers have long been aware of the variation between birch trees within a single forest, as well as across different geographical locations around the world.

BETWOOD was able to take advantage of new DNA sequencing methods to look for the molecular basis of such variation. Recalling the methodology, the BETWOOD researcher Dr Kaisa Nieminen states, 'DNA sequencing in a high-throughput manner is now really cost effective, with prices lowering substantially even during the project period. The real challenge was how to interpret the resulting bioinformatics.' The project response was to train a whole team of bioinformaticians to interpret the novel genomic data.

For the geographical analysis of silver birch (*Betula pendula*), using so-called selective sweeps, the team were able to conclude that local adaptation had influenced the timing of fundamental plant processes. The team observed that genetic variation around the tightly-linked light response genes PHYC and FRS10 correlated with latitude and longitude and temperature. The same correlation was found for variation in the growth-promoting cytokinin response regulator ARR1, and the wood development genes KAK and MED5A.

In the analysis of special growth forms BETWOOD also identified a stop-in-frame mutation in the LAZY1 orthologue (genes that evolved from a common ancestral gene) of the *Arabidopsis* genus. The team are currently working to confirm whether this mutation explains the 'weeping birch' phenotype popular in various gardens throughout Europe.

These polymorphisms and mutations will form a strong basis for further genetic analysis of tree characteristics. As leader of the Birch genome project Professor Ykä Helariutta reflects, 'It was somewhat unexpected to be able to identify candidate genes for certain traits simply by re-sequencing the variant and comparing that to the reference genome. An analysis of this kind was not possible five years ago in any plant species besides *Arabidopsis*. Now we can actually identify the molecular basis of tree traits!'

© BETWOOD

"An analysis of this kind was not possible five years ago in any plant species besides Arabidopsis. *Now we can actually identify the molecular basis of tree traits!"*

The work continues to branch out

Forests function as important carbon sinks, crucial for tackling climate change. Carbon dioxide is absorbed by trees through photosynthesis, but carbon released into the atmosphere through the greenhouse effect is also deposited directly onto tree trunks. According to project coordinator Professor Katri Kärkkäinen it is important to understand the physiology of this process, because as she contends, 'Global warming through its changes to the composition of the atmosphere also affects the growth condition of trees. Furthermore, as wood is an important industrial resource, a better genetic understanding of it can facilitate its use in a more sustainable way and potentially contribute to entirely novel future uses.'

Now that BETWOOD has helped establish birch as a new genetic model, the team intends to continue exploiting its short-generation time (at around one year, very short for a tree species) to further explore the genetic variations that result in its geographic and phenotypic diversity.

AGRICULTURE AND FORESTRY

NEW-GENERATION SPRAYERS FOR HEALTHIER FARMING

Farmers might not have heard of smartomisers yet, but they certainly will find them indispensable in the near future if they are to produce more whilst rationalising their pesticide use. Spanish SME Pulverizadores Fede is bringing about this new generation of sprayers, generating substantial environmental and financial benefits.

We've all been brought up with the notion that, in order to be healthy, we need to eat five fruits and vegetables every day. What is less known, however, is the fact that humanity will probably run short of these in 2050, when there won't be enough to feed a world population of 9 billion people. Sure, pesticides are a solution, but their misuse and imprecise application are having increasingly notorious side effects on health and the environment.

Enter Pulverizadores Fede, a company active in the production of agricultural machinery which, with the help of EU funding under the H30 (Healthy crop, Healthy environment, Healthy finances … through Optimization) project, recently developed a completely new generation of sprayers. Unlike existing alternatives, these sprayers can adjust airflow and recommend spray volume in accordance with the characteristics of the canopy and the pest or crop treatment needed. The icing on the cake: H30 sprayers can connect to a private cloud through which farm management teams can send treatment orders to the sprayer and supervise the treatment. This has spearheaded a new generation of sprayers known as 'smartomisers'.

'One of our most important values is application efficiency, leading to direct Return on investment (ROI) for growers,' explains Dr Lars T. Berger, Director of Innovation at Pulverizadores Fede and coordinator of H30. 'At the same time, application efficiency means less crop protection products in the environment, which explains the triple win at the heart of our project: healthy crop, healthy environment and healthy finances through optimisation.'

So far, around 65 H30 sprayers have been delivered to pilot customers in different countries. Dr Berger says that they were all very happy with H30's capacity to provide precise information about the crop protection process, as well as the possibility of supervising the spraying wherever they are. These sprayers also confirmed a significant

reduction in pesticides and fuel use, along with noticeable noise reduction and time savings.

'The estimation of annual savings in pesticides for a 900-hectare fruit trees plantation is EUR 340 000, and one of our main Spanish clients who owns a fruit plantation of 2 000 hectares has estimated that he will save around 756 000 per year,' Dr Berger enthuses, continuing: 'Fuel savings are also remarkable, with one of the first users of the system stating that he managed to save over 25 % in fuel.'

Laboratory and field trials were also run by well-known research institutions over the course of the project. They revealed that H30 is capable of reducing fuel consumption by 55 %, noise contamination by 15 dBA, and potential sediment drift by 48 %. Last but not least, the extra investment to acquire a high-end sprayer has a payback period of less than two years.

As a result, Pulverizadores Fede has been piling up awards: Technical Novelty Awards at the International Agricultural Machinery Fair (FIMA) in 2014 and 2016; and the Outstanding Technical Innovation Award and Blue Award at the International Agricultural Machinery Fair (EIMA) in 2016 in Bologna. 'The H30 range of sprayers is very likely the most awarded spraying

technology for specialty crops in the world,' says Dr Berger.

Now that the project has been completed, Pulverizadores Fede will focus on its objective of leading market-oriented research and development in 3D/speciality crop services. And whilst competition is starting to catch up, Dr Berger is confident that the company will continue to stand out through continuous innovation and customer co-creation, while protecting its results with a series of registered and unregistered rights such as patents, industrial designs, copyrights, trademarks and trade secrets.

Follow-up projects are also on the table: 'We are very open to cooperating with academic and industrial players, as well as other public and private stakeholders to successfully execute follow-up projects with clear customer focus and obvious environmental and socio-economic benefits. This is in line with our H30 motto,' Dr Berger says.

H30
★ Coordinated by Pulverizadores Fede in Spain.
★ Funded under H2020-SME.
★ http://cordis.europa.eu/project/rcn/197149
★ Project website: http://www.fedepulverizadores.com/?lang=en
★ 📹◄ http://bit.ly/2yzwHKH

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SENSORS HELPING FARMERS TO AVOID WATER AND NITROGEN OVER-USE

With food security issues becoming ever more pressing, much research is being done to strike the right balance between high yields and low environmental impact. A major EU-funded project has run a successful pilot bringing together data from sensors and satellites to boost yields while accurately identifying levels of fertilisers needed.

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Arable farming can be challenging and getting the balance right between the chemicals the crops need to thrive while minimising the impact on the environment is one key difficulty. On the other hand, the global food challenge is clear: by 2050 the world will need to feed 9 billion people, according to the World Economic Forum. This represents an increase of between 50-100 %. A host of issues need to be addressed to achieve the target, from gender inequality, ageing demographics, skills development and global warming. But at farm level, agriculture needs to become more productive.

The EU-funded IOF2020 (Internet of Food and Farm 2020) project has the ambitious goal of making precision farming a reality and one successful pilot project is bringing that ideal closer. Wheat harvested from a field in Boigneville, 100 km south of Paris, France, in August this year will have been grown with the benefit of data from sensors. Nitrogen is a particular problem in agriculture: surplus nitrogen leaches from the soil into rivers and lakes and runoff ends up in water bodies. This can lead to eutrophication – algal blooms which consume oxygen, impacting fish stocks and biodiversity. While satellite pictures can indicate nitrogen levels in crops, soil levels are not revealed, which is where sensors come into play.

IOF2020's wheat field pilot project combines on-the-ground sensor information with satellite data to tell farmers how much nitrogen or water their fields need. Florence Leprince, a plant scientist at Arvalis - Institut du végétal, the French arable farming institute which is running the wheat experiment, explains, 'Sensors are costing less and less, so at the end of the project we hope to have something farmers or farm cooperatives can deploy in their fields.'

IOF2020, with a total budget of EUR 35 million, is fostering a large-scale uptake of smart machines and networks in the European farming and food sector. The heart of the project is formed by 19 use-cases in different European regions, organised in five trials covering several subsectors such as fruits, dairy, vegetables, meat and arable farming. Over 70 partners are involved, bringing together around 200 researchers.

The pilot's success shows how important harnessing data from different types of sensors (soil moisture, soil organic matter, climate, etc.) is. The information can be used to predict yields, define management zones and prepare task maps for farm equipment (e.g. variable application of herbicides, water and fertilisers). The project's work in the area of arable farming covers four domains: management zoning in fields; soya protein management; precision crop management; and farm machine interoperability.

INDUSTRY

MODELLING NANO-ENABLED SYSTEMS VIA INTRICATE, MULTI-SCALE SIMULATIONS

The EU-funded SIMPHONY project designed and developed several specialised, multi-scale modelling design tools capable of reducing the time it takes to discover novel nano- and micro-fluidic devices for biomedical, chemical and energy related applications.

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Accurately modelling nano-enabled systems demands the use of intricate, multi-scale simulations and multi-model approaches capable of linking relevant phenomena on the nano, micro, meso and macro scales. Although currently available simulation tools and models can accurately describe a material on each of these scales separately, research lacks an integrated, multi-scale simulation framework that provides seamless linking and coupling of various models operating on different scales.

The EU-funded SIMPHONY (Simulation framework for multi-scale phenomena in micro- and nanosystems) project helped fill this gap by developing an easy-to-use, integrated multi-scale modelling environment for nano-enabled materials and systems by design. 'One of the project's main objectives was to develop an extendable and open platform for integrating various existing open source and commercial simulation and pre- and post-processing software packages,' explains project coordinator Dr Adham Hashibon.

According to Hashibon, this integration was achieved by wrapping the simulation packages with an efficient, interoperable interface designed and implemented in a high-level language (i.e. Python) with a common Application programming interface (API) to the outside world. 'As this system allows both linking and coupling of codes, the SIMPHONY framework provides a platform for the development of new, multi-scale science,' he says. The modelling tools integrated in the project cover all models at all scales, including electronic, atomistic, mesoscopic and continuum.

A number of important results

The SIMPHONY project resulted in several important results. For example, by conducting a taxonomy of inter- and intra-process communications and data requirements as required by each set of tools and models, researchers developed an initial set of high-level software design requirements for the interface wrappers and Common unified data structures (CUDS). 'CUDS provide an interoperability layer between all models and simulation software,' explains Hashibon.

'An important result of this work was the development of a basic ontology of computational applications and models.'

Another significant result was the development of the Common universal-unified basic attributes (CUBA) as a common nomenclature and metadata for multi-scale modelling and applications. 'Whereas the CUBA essentially define metadata for multi-scale modelling, the CUDS define the relevant metadata schema,' says Hashibon. 'Together, they facilitate the seamless passage of information and the representation of models and data in all sub-domains, thus allowing models to seamlessly couple and link.'

The efficiency of the modelling framework

Based on the general requirements and CUDS specifications, project researchers developed two flavours of interface wrappers for modelling engines. This resulted in a set of simulation applications that cover all models and scales, including the three main computational domains for lattice, particles and mesh-based systems.

'The SIMPHONY project successfully demonstrated the efficiency of the modelling framework in relevant nanotechnology fields by designing and developing several specialised, multi-scale modelling design tools that can reduce the time to discover novel nano- and micro-fluidic devices for biomedical, chemical and energy related applications,' concludes Hashibon. 'In particular, it addresses systems for nano-printing, Nano electro mechanical systems (NEMS), foam forming processes and micro-fluidic applications.'

ADAPTING METAL ADDITIVE MANUFACTURING PROCESSES FOR HIGH-PERFORMANCE PARTS

With the scope of data collected, the AMAZE project is the most comprehensive metals additive manufacturing (AM) project ever undertaken. Alongside the experimental data, the results of micro-, macro- and meso-scale multiphysics modelling all contribute to making AM processing a mainstream industrial process.

Using traditional manufacturing processes to machine complex parts, for example from forging, can result in as little as 10 % of the original material being used in the final part. AM processing, whereby parts are 'grown' to the final shape required, is much more efficient.

The EU-funded AMAZE (Additive Manufacturing Aiming Towards Zero Waste & Efficient Production of High-Tech Metal Products) project was set up precisely to exploit this approach. The project was able to save manufacturing costs by as much as 50 %, reduce material waste to negligible amounts and half the floor space required, by combining two processes into one machine (combined additive and machining for a gas turbine part repair). Additionally, improved AM materials have been developed which, through their higher performance, cater for more demanding applications, for instance high temperature refractory materials which had never been processed by AM before and are very difficult to process using conventional manufacturing methods.

Ensuring efficiency and quality

A key aspect to the success of the AMAZE project was a better understanding of the role that feed-stock (powder and wire) quality has on the integrity of parts produced and the AM process in general. The project was able to develop new specifications for AM material as well as generate test protocols. It also improved ways of storing, handling and recycling AM material. As project coordinator Professor David Wimpenny adds, 'Trials were also performed to understand the impact of processing parameters on the microstructure, defects generated and residual stress – this information will help to develop the next generation of AM machines, materials and process models.'

The AMAZE project was able to dramatically increase the productivity of the AM processes, in some cases by as much as ten-fold in build rate. It did so by employing a range of techniques, such as using higher power/multiple processing lasers and novel build strategies whereby only the surface of a part is formed in the AM machine, with the remaining material fused in a (Hot Isostatic Pressing) HIP furnace.

In terms of the parts themselves, quality was enhanced by optimising the process parameters and also by closely monitoring the key process variables. Dimensional accuracy was also improved, for instance the team achieved a threefold improvement in the accuracy of high deposition rate powder bed fusion processes.

However, as Prof. Wimpenny recalls, 'One of the key challenges in the AMAZE project was the development of an effective way of assessing the integrity of complex AM parts. A solution developed in the project was to employ X-ray computer tomography methods, which were pioneered for scanning the human body for medical diagnosis.'

Increasing industry confidence for a wide range of high-performance parts

Significant improvement of both the productivity and consistency of metal AM processing, along with the clearly demonstrated industry benefits, will accelerate Europe-wide adoption of this new manufacturing approach. As Prof. Wimpenny summarises, 'This will lead to all kinds of benefits for people. For example, better healthcare provision through the availability of more durable, customised medical implants, more robust global communication through lightweight satellites which cost less to launch or the generation of limitless electrical energy, by enabling nuclear fusion technology to be adopted.'

Since project completion, the end-users of the AMAZE project, including Thales Alenia, Bombardier Aerospace Belfast, the Culham Centre for Fusion Energy and the European Space Agency, are continuing to assess the long-term performance of the project's demonstration parts for future applications. Another legacy has been the contribution to the establishment of new standards, including a benchmarking process based on a 'suite' of test artefacts to assess: geometrical accuracy, surface finish, resolution, density, microstructure and productivity.

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ASSESSING THE RISK OF NANOMATERIALS

The EU-funded GUIDENANO project has created an easy-to-use web-based tool to guide users through the risk assessment process for nanomaterials.

Despite the massive potential of nanotechnology and nanomaterials, one major roadblock to their widespread use is a lack of information on the potential human and environmental health risk of nano-enabled products. For example, once nanomaterials are released to the environment, understanding their mobility and transformations is critical to identifying possible effects on the environment and our health.

To better understand these potential risks, the GUIDENANO (Assessment and mitigation of nano-enabled product risks on human and environmental health: Development of new strategies and creation of a digital guidance tool for nanotech industries) project developed an innovative methodology for evaluating and managing the human and environmental health risks of nano-enabled products across the product's entire life-cycle.

'The GUIDENANO project built a web-based tool that guides users through the risk assessment process for nanomaterials and on the selection of risk management measures for mitigating the potential risks,' explains project coordinator Dr Socorro Vázquez-Campos. 'To reach these goals, the project built upon the state-of-the-art on risk assessment, followed by validation of critical assumptions in the risk assessment process, generating new and revised predictive models and risk management solutions.'

The GUIDEnano tool

The key outcome of the project is the GUIDEnano Tool. 'If a potential risk is identified during the risk assessment process, then this web-based tool will help developers of nano-enabled products design and apply the most appropriate mitigation and reduction strategies for a specific product,' says Vázquez-Campos.

One of the challenges in developing the tool was finding a way to integrate the different exposure, fate and hazard assessment parts for both human and environmental health into a single framework. However, by doing so, the GUIDEnano tool goes beyond the current state-of-the-art in risk assessment for nano-enabled products.

According to Vázquez-Campos, the tool integrates materials characterisation, exposure, environmental fate and hazard and risk assessment strategies. 'The tool can be used by industrial partners under different scenarios,' she says. 'For instance, it can be used to assess worker exposure during such manufacturing activities as spraying nanomaterials onto a surface or to assess the environmental impact of a commercial product, like polymer nanocomposites or fabrics, once it has been placed on the market.'

> *"The GUIDEnano tool goes beyond the current state-of-the-art in risk assessment for nano-enabled products."*

Easy to use

To use the GUIDEnano tool, the user simply logs onto the website. For each nano-enabled product, he or she creates a case and provides such product information as: included nanomaterials, life-cycle activities, human and environmental exposure estimates and hazard data.

Based on this information, the tool generates a risk assessment table and provides the user with a risk mitigation strategy. 'From this information, the user will be able to clearly see whether the risk is acceptable, possible or (quantitatively) unacceptable in each of the product's life-cycle stages and to plan accordingly,' says Vázquez-Campos.
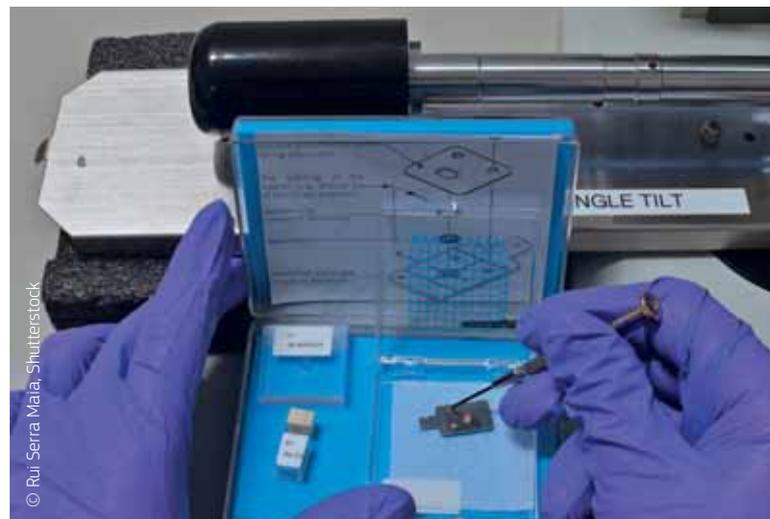
Dealing with the challenge of nanomaterials

Protecting human and environmental health from the adverse effects of chemical substances is a priority of several EU policies, such as REACH. 'The results of the GUIDENANO project, in terms of providing a systematic tool for new approaches to assessing the risks associated with nanomaterials, can support some of these policies in implementing their goals while dealing with the challenges of nanomaterials,' concludes Vázquez-Campos.

Project researchers are currently finalising a business plan aimed at extending the current version of the tool and bringing it one step closer to commercialisation.

GUIDENANO
★ Coordinated by LEITAT in Spain.
★ Funded under FP7-NMP.
★ http://cordis.europa.eu/project/rcn/110541
★ Project website:
  http://www.guidenano.eu/
★ 📹 http://bit.ly/2jn5Gay

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ENZYME FIRM DEMONSTRATES SCALE OF AMBITION

An EU-funded project has made a range of innovative industrial enzymes commercially viable by ramping up production and supply chain capabilities. Using enzymes across a range of processes could help energy intensive sectors such as pulp and paper, chemicals and biogas achieve sustainable production and reduce harmful waste.

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"We've developed enzymes that enable converting lignocellulosic biomass sugars into bioplastics, which previously could not be done."

Enzymes are crucial to life, triggering natural reactions that take place in our bodies and in nature. These natural catalysts however are not always suited to extreme industrial conditions, which often involve high temperatures. As result, many industrial sectors have relied on chemicals that contribute towards pollution and waste.

Finnish firm MetGen has sought to address this by developing genetically modified enzymes that can operate in industrial conditions. MetZymes are patented enzyme solutions capable of addressing lignocellulosic biomass – inedible plant matter – even breaking it down to its constituent molecules.

From lab to industry

'It's one thing to invent new enzymes but it's another to be able to use them in solving specific industrial challenges at the largest scale,' explains APEX (Advanced Process Economics through Oxidoreductases) project coordinator Matti Heikkilä, chief technology officer of MetGen. 'This requires demonstrations at the hundreds of tonnes scale, which is a serious issue for a small company like ours.'

The key objective of the EU-funded APEX project, which was completed in March 2017, was therefore to take MetGen's production and supply chain capabilities up to the next level. 'Scaling up allows for market demonstrations to be carried out in industrial-scale trials, which in our business is mandatory,' says Heikkilä. This was achieved through improving existing processes and refining a technology platform that provides a focused path for developing tailored solutions to customers.

This means that the pulp and paper industry for example can discuss their needs and then see how the enzymes might work in practice, finishing up with a final product of paper or card. 'This provides focus and enables us to work on customer specific challenges,' explains Heikkilä. 'The process has become so standardised that we can bring new enzymes from idea to industrial scale in less than six months.'

Tapping market potential

As well as paper, high-performance enzymes capable of breaking down lignocellulosic biomass have a range of other industrial applications. The chemical sector for example is increasingly interested in renewable chemicals and materials to complement – or replace – their current portfolio in a bid to reduce their environmental footprint.

Large-scale industrial processes also often require waste water treatment, and natural enzyme solutions could help achieve efficiencies here and reduce pollution. The ability of certain enzymes to break down lignocellulosic biomass in water soluble conditions could also enable biorefineries to extract even more value.

'We've developed enzymes that enable converting lignocellulosic biomass sugars into bioplastics, which previously could not be done,' says Heikkilä. 'Converting lignocellulosic sugars into platform chemicals could also open up a range of new possibilities. But again, all of this requires demonstrations at a serious scale, and we would not have been able to do this without the APEX project funding through the 2020 SME Instrument.'

Heikkilä believes that this type of project is an example of what needs to be done to ensure European global competitiveness. 'Europe has a lot of work to do here,' he says. 'Both the US and China are aggressively investing in almost-ready businesses. Europe will fall behind in investments in science, technology and knowledge unless it is willing to finance innovations all the way.' For MetGen this kind of support provided a vital funding bridge that enabled the firm to take enzymes from the lab into industry-scale demonstrations.

INFORMATION AND COMMUNICATION TECHNOLOGY

A NEW ERA
IN BRAIN-INSPIRED COMPUTING

Brain plasticity is unmatched by current computing devices. This is about to change with an innovative hybrid system that combines natural and artificial neurons.

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Computing technologies have reached unprecedented speed and computational power that allows them to simulate parts of animals' brains and behaviours. However, in order to truly emulate animal intelligence, the energy required by these systems grows exponentially.

The brain contains an extremely high number of synapses while neurons are plastic and adaptive. Strikingly, the brain is structured as an evolving system where synapses emerge and die as well as strengthen and weaken. These essentially reconfigure neuronal connectivity and allow the neural network to adapt motor and behavioural responses to the ever-changing environmental inputs.

For years, the implementation of artificial neural networks has been in the form of software run on conventional computers. Recently, neuromorphic computation schemes have emerged that utilise nanoscale electronic devices capable of simulating neuronal and synaptic properties.

A bio-hybrid system between artificial and real neurons

The EU-funded RAMP (Real neurons-nanoelectronics Architecture with Memristive Plasticity) project proposed to develop a bio-hybrid system that interfaces artificial neural networks to biological ones. 'Our rationale was to exploit the intrinsic properties of real neurons and synapses as well as their organisation into neural circuits,' explains project coordinator Prof. Stefano Vassanelli.

Artificial neurons were formulated as silicon microchips and physically interfaced to natural neurons through electrical transducers, forming a bio-hybrid neurochip. Since neurons are electrically active excitable cells, transducers can record their electrical activity or facilitate their stimulation. For this purpose, researchers exploited one of the most promising technologies, the Memristive integrator sensor (MIS), which can operate as a smart neuronal sensor by simultaneously detecting and encoding electrical signals in a communication set-up with real neurons.

To emulate natural synapse behaviour, MISs were generated that could encode and compress neuronal spiking activity. Signals recorded from neurons through conventional extracellular electrodes are fed to the MIS, which senses neuronal spikes encoding them as changes in internal resistance in a similar way to what happens in real synapses. 'Both in the case of the MIS and the synapse such individual changes of resistance are integrated over time upon arrival of a series of spikes,' continues Prof. Vassanelli.

In a parallel effort to reproduce in the artificial part of the bio-hybrid what happens in real synapses – where connectivity depends on neuronal activity – scientists generated neurobiology-inspired algorithms. In essence, the number of connections between artificial neurons was a function of activity emulating brain plasticity.

Future applications

MISs comprise invaluable tools for exploring brain computation and for reading out brain activity. Monitoring neuronal cell activity is fundamental to neuroscience, but processing of neural data in real-time poses restrictive requirements in bandwidth, energy and computation capacity. The memristive devices consume little energy in the encoding process and thus not only address this bottleneck but will also lead to a better understanding of the biophysical basis of information processing in real neuronal circuits.

Long term, these elements could be employed to create innovative neuroprostheses such as in brain implants, where artificial neuromorphic circuits replace or assist native brain networks. Such prosthetics could be used in patients with neurological disorders for treatment and rehabilitation purposes.

Intriguingly, to speed up development RAMP partners engineered a way to let neurons and MISs communicate through the internet. This opens a revolutionary way to build neuro-electronics networks across Europe.

Overall, the RAMP system provides a first proof-of-concept that neurons can mutually interact with nanoelectronic memristive devices sharing similar memory and plasticity rules. The patent applications and start-up companies that emerged during the project further attest to the RAMP innovation.

INNOVATIVE WEARABLE DEVICE TO TRACK INDOOR AND OUTDOOR AIR QUALITY

EU-funded researchers have developed a worldwide unique multi-sensor wearable device encompassing a large number of sensors. New sophisticated sensor technology can find and measure invisible pollutants that harm our health and change the climate as well as sense light or measure temperature and humidity.

Air pollution is a major environmental risk to health, affecting everyone in developed and developing countries alike. Ambient air pollution, made of high concentrations of small and fine particulate matter, is the greatest environmental risk to health, causing more than 3 million premature deaths worldwide every year. Indoor air pollution can have the same toll on human health, with an estimated 2 million premature deaths having been reported mostly in developing countries. However, exposure to air pollutants is definitely beyond the control of individuals. Up until now, there has been no system on the market for personal monitoring of the air and screening potential environmental health hazards.

"The project developed highly competitive production technologies, enabling flexible integration of nanotechnology-based sensors with conventional electronic chips."

Researchers with the EU-funded MSP (Multi-sensor-platform for smart building management) project successfully designed novel 3D-integrated multi-sensor systems to help combat this enormous problem. The MSP multi-sensor system features can detect harmful and toxic gases, sense particulate matter and ultrafine particles, detect infrared, visible and ultraviolet light, and also measure temperature and humidity.

Becoming a mobile environmental monitoring station

'The MSP demonstrator integrates a variety of highly sophisticated gas sensors based on nanowires, nanoparticles and graphene, as well as optical sensors for ultraviolet, visible and infrared light,' says project coordinator Anton Köck. The system is implemented in a wearable wristband and comprises 57 sensors in total, of which 52 are gas sensors. Armed with this information, wristband wearers might seek cleaner air by taking a certain street or opening the window to a smoky room. Equipped with such a tool, wearers are empowered to assess their own environment and take actions to improve it when needed.

Nanotechnology sensors meet conventional electronics

The project developed highly competitive production technologies, enabling flexible integration of nanotechnology-based sensors with conventional electronic chips. To meet desired device requirements such as high performance, low power consumption and a small footprint, researchers used Through-silicon via (TSV) technology, which is the building block that enables 3D-integrated circuits. TSVs are holes created in a silicon wafer using an etch process. Interconnects were formed by filling these holes with tungsten.

'However, not all devices were based on CMOS technology. This urged researchers to adopt a mixed approach combining wire-bonding and the TSV approach, which was a big issue for the overmoulding process,' Mr Köck explains. Researchers employed TSV technology for the gas, temperature and visible light sensors. For other types of gas sensors, including the infrared and the ultraviolet sensors, wire-bonding technology was used.

Air quality sensors in smartphones and smart houses

MSP developed a variety of highly sophisticated sensors as elements of a toolbox that enables a highly flexible plug-and-play 3D integration of these sensors to miniaturised smart systems with significantly advanced functionalities. This approach should provide the customer with a high flexibility when designing multi-sensor systems.

From the very beginning, MSP was focused on developing innovative smart multi-sensor systems for both indoor and outdoor air quality monitoring. Other possible applications include smart building management, smart homes and consumer electronics. Smart air quality monitoring with sensors for particulate matter, carbon dioxide, temperature and humidity available on smartphones, tablets or in smart homes can be of special benefit for people suffering from asthma attacks or cardiovascular diseases.

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INFORMATION AND COMMUNICATION TECHNOLOGY

INTRODUCING A NEW ROBOTIC CLASS WITH ABILITIES OUT-PERFORMING EXISTING MACHINES OR EVEN BIOLOGICAL ORGANISMS

Swarm intelligence refers to natural and artificial systems comprising many individuals that coordinate using decentralised control and self-organisation. An EU-funded project has designed the first self-assembling multirobot system able to display sensorimotor coordination equivalent to that observed in monolithic robots.

Robots tend to be controlled by sensors and actuators connected to a central processing unit – a sort of robotic nervous system. Traditionally, flexibility in the system is limited as these nervous systems are mapped strictly to the shape of the robot. The development of a more modular system formed instead by multiple units would allow more adaptability. Indeed, in principle robots could display more lifetime morphological adaptation than natural organisms, with robots of different capabilities, shapes and sizes configuring themselves as required.

However, limits to the predefined shapes that units can form into as well as the reliance on distributed control have curtailed the coordination and control of modular robots, which have only been able to display a limited range of hardwired behaviours. The team behind the E-SWARM (Engineering Swarm Intelligence Systems) project have recently reported that they have successfully designed a modular system that can adapt their arrangement, autonomously forming shapes and sizes depending on the task or environment.

Introducing mergeable nervous system (MNS) robots

The study recently published in Nature Communications points out that the behaviour of most current modular robots functions under control paradigms akin to the biochemical signalling used by simple natural organisms, such as unicellular slime mould, which can alter their body composition. However, as is the case with these biological counterparts, they lack a nervous system that can holistically unite disparate parts into a functioning and adaptive whole. This means that while they can be individually autonomous, they rely on distributed approaches for coordination.

The E-SWARM team outlines how they created robots whose bodies and control systems formed new robotic systems as necessary, while retaining full

sensorimotor control, regardless of shape and size. Within this MNS robotic system, where the units connected via the robot nervous system, the centralised decision-making unit is known as the 'brain unit'. These MNS robots were able to merge by absorbing units of different capabilities into its body forming larger clusters with a single centralised controller, split into separate bodies with independent brain units, and self-heal by removing or replacing malfunctioning body parts including a malfunctioning brain unit.

The team set up an experiment for 10 robotic units. The units formed a series of MNS robots of different shapes and sizes, as they adhered to pre-determined behavioural rules. For example, the MNS robots all displayed the same coordinated sensorimotor reaction to a provided stimulus which involved 'pointing' at the stimulus, using Light emitting diodes (LEDs), as well as retreating from it, when it was sufficiently close. When a cluster of units points to the stimulus, only the LEDs closest to the stimulus illuminate, regardless of the robotic unit to which they belong.

Building the agile robots of the future

Despite only engaging 10 units for the experiment, the paper's authors point out that their system is designed to be scalable, in terms of both computational resources for robotic control and reaction time to stimulus, within the system. Looking to the future, the team suggest that robots will likely be designed for adaptability to changing task requirements and no longer only for specific tasks.

The project team are now looking to extend the concept to self-reconfigurable modular robots, beyond the realm of two dimensions into three, for example with the design of flexible joints. The team suggest that advances in computational power and techniques should be able to compensate for the millions of years that evolution has been afforded to resolve the same sort of design questions in nature.
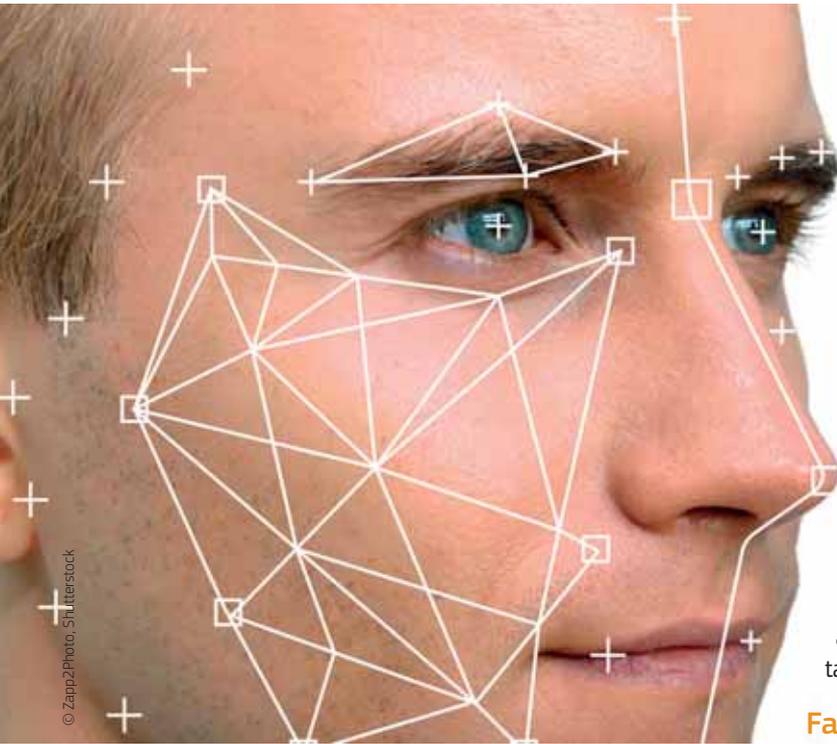
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CUTTING-EDGE FACIAL RECOGNITION GOES MAINSTREAM

Advances in facial recognition have led to exciting new ways in which human-computer interaction is finding its way into everyday applications. The technology is already proving very promising in the fields of health, security, education and entertainment.

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For millions of years, humans have communicated using facial gestures to express emotion and to send messages to others, even before the advent of speech. As faces still play a pivotal role in human communication, it is only natural for facial image processing to play a pivotal role in today's high-tech environments.

The EU-funded MMFP (Multimodal face processing) project coordinated by Istanbul Technical University in Turkey has made great strides in this area. 'We've focused on applications such as gamification, technology-enhanced learning, assistive systems, multimedia indexing and animation,' says project researcher Dr Hazim Kemal Ekenel, Associate Professor at the University's Department of Computer Engineering.

In this vein, the project team developed a common framework to derive information from face images and maximised information extraction performance. It also made important progress benchmarking face processing under ambient conditions. One important step forward has been in exploiting Convolutional neural networks (CNNs), artificial neural networks inspired by biological processes, which has successfully been used for analysing visual imagery.

Award-winning technology for games and more

'We've developed a face recognition system that exploits deep CNN representation and score normalisation for face recognition under mismatched conditions,' notes Dr Ekenel. 'The developed system ranked first in the International challenge on biometric recognition in the wild,' he adds, referring to the first event of its kind under the International Conference on Biometrics.

In effect, the project developed generic, fast and robust facial image processing algorithms that can handle several types of variations simultaneously and operate in real time under uncontrolled conditions. 'The versatility, speed and robustness of the developed facial image processing approaches have enabled applications in a wide variety of real-world applications,' says Dr Ekenel.

Two such applications were achieved by the project team in the field of gamification, which represents an excellent opportunity to demonstrate the technology's accuracy and robustness. 'We built two proofs of concept: one is a paintball-like game that lets you target the opponent through facial recognition, and the other is an imitation game where you score by imitating facial expressions.'

Faces don't lie about age and even taste

In more technical terms, the team successfully furthered deep learning-based representation for face recognition under various conditions, including pose, illumination, misalignment and image degradations. It improved the technology in areas such as face de-identification, age estimation and gender classification. 'We've also developed a facial expression recognition system that works on both static and dynamic representations,' explains Dr Ekenel, 'in addition to exploring innovative applications of facial image analysis such as visual estimation of taste appreciation and intelligent tutoring.'

A spin-off has already emerged out of the research lab that worked on the project. 'We have also completed several industrial projects,' reveals Dr Ekenel. All the project's efforts were enhanced by international partners from 11 countries in America, Asia and Europe, highlighting the importance of the topic in today's high-tech research circles.

The new unified framework for deriving information from face images and the enhanced information extraction have already begun making applications that rely on face recognition smarter and more accurate. Thanks to these efforts, the future of these applications now looks brighter than ever.

SPACE

CREATING A 3D MAP OF THE MILKY WAY

An EU-funded project has created an archive that contains some of the most precise and accurate measurements ever taken of the Milky Way. This will help to guide astronomers through our galaxy and lead to some truly out-of-this-world discoveries.

The European Space Agency (ESA)'s Gaia mission is developing the largest, most precise three-dimensional map of our galaxy ever. This valuable data opens the door to a new world of potential discoveries and breakthroughs, by enabling astronomers to measure different properties – brightness, density, size, etc. – of distant objects with unprecedented accuracy.

New discoveries might include planets orbiting other stars, far-distant supernovae and quasars. In order to be fully exploitable however this data must be accessible and understandable.

Making the Milky Way accessible

This is where the EU-funded GENIUS (Gaia European Network for Improved data User Services) project comes in. By creating an ordered archive, together with special search tools, scientists will be able to carry out thorough investigations of available Gaia data and find exactly what they are looking for.

'The Data Processing and Analysis Consortium (DPAC) – made up of software developers and scientists – was assigned to design, implement and operate the Gaia archive,' explains project coordinator Xavier Luri from the University of Barcelona in Spain. 'We found that while the basic tools for archiving were in place, there was a

need for more advanced tools to allow for easier and more extensive exploitation of the data. Thus, we formed the GENIUS consortium and applied for European funding.'

Launched in 2013 the GENIUS project set about developing an archive system that would enable full scientific exploitation of the Gaia data. The archive portal currently provides an interactive visual exploration of over 1 billion galactic objects.

'We know of no other service currently providing this in a scientific context,' says Luri. 'Since we are integrated into the DPAC consortium and several of the GENIUS members are part of the DPAC executive committee, our contributions form an integral part of the Gaia archive system. These developments will now be developed and built upon.'

The sky is the limit

The archive will be used to facilitate outreach and academic activities in order to engage the public in science in general and astronomy in particular. The service is also expandable, and will form the platform for future data releases and even to other mission archives.

'During GENIUS we also started to explore new ways of working with huge data volumes based on state-of-the-art technologies for Big Data,' says Luri. 'This has applications not only for

astronomy but also for many scientific data processing developments such as particle physics, where the data size and computing needs will require new methodologies to work with large datasets.'

Initial data from Gaia on over a billion stars was released in September 2016, the biggest archive of celestial objects in the Milky Way that has ever been collected. This archive will be fine-tuned before its final publication, in order to increase precision and reduce uncertainties. It is expected that the finalised archive will contain around 2 billion objects.

Luri also believes that the project is a good example of how ESA and the European Commission can successfully collaborate on strengthening the foundations of European space science and technology. 'While Gaia spacecraft construction and operations is funded and managed by ESA, data processing and exploitation is the responsibility of the European scientific community and national funding agencies,' he says.

NEW INSTRUMENTS FOR THE EUROPEAN SOLAR TELESCOPE

An EU-funded initiative brought together prestigious European research institutions, infrastructures (telescopes) and data repositories with the aim of helping the solar physics community prepare for operation of the European Solar Telescope (EST).

Founded in 2006 by a group of solar physicists from 14 European countries, the European Association for Solar Telescopes (EAST) aims to provide solar physicists with access to world-class high-resolution ground-based observing facilities. To this end, EAST intends to develop and operate a next-generation large-aperture EST in the Canary Islands.

EST will be a four-metre class solar telescope that will be used to further understand the magnetic coupling between the deep photosphere and upper chromosphere. This will require improving diagnostics capability of the thermal, dynamic and magnetic properties of the plasma over many scale heights by using multiple wavelength imaging, spectroscopy and spectropolarimetry. European solar physicists unanimously share the view that a large-aperture new-generation solar telescope is needed to further understand the fundamental processes of plasma physics in the Sun's upper layers.

Supported by EAST and funded by the EU, the SOLARNET (High-resolution solar physics network) project was initiated to ensure that all European solar physicists have access to state-of-the-art facilities and data repositories. Joint research activities were aimed at developing tools and prototypes for innovative data instruments and data processing and access.

© SOLARNET

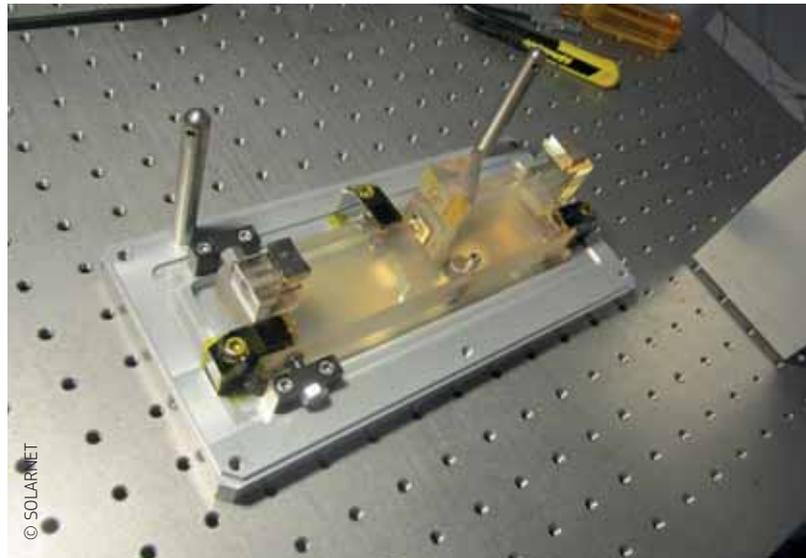## Keeping Europe at the forefront of solar physics

In practically all areas and disciplines and so too in solar physics, Europe has public or private research centres allowing highly skilled researchers to conduct cutting-edge world-class research. Several European research institutes have achieved a high level of competence in developing sophisticated scientific instruments and this has given them a high profile in the area of ground-based observation technology. Robust partnerships with industry also help confront engineering challenges of existing and next-generation telescopes.

'Together, researchers successfully developed a number of innovative instrument prototypes to define the future instruments of EST. These prototypes were designed and constructed using present telescopes as test beds to demonstrate their performance,' says project coordinator Manuel Collados.

An innovative heat rejector prototype for the GREGOR solar telescope was fabricated. This heat rejector follows the concept of the design proposed for the EST and thus represents a proof of concept for the technical solution proposed for this new large facility.

Another project achievement has been the development of a large tuneable Fabry-Perot interferometer prototype 150 mm in diameter. This activity represents an important step towards the optimisation of such devices for use in instrumentation tailored for large solar telescopes like the EST.

Two prototypes of integral field units to obtain spatially resolved spectra of all points in a 2D region were constructed for the GREGOR and the Swedish Solar Telescope (SST). The first one is based on an image slicer optimised for GRIS – the GREGOR infrared spectrograph. The other one uses micro-lenses to feed the TRIPPEL spectrograph of the SST. Both prototypes were successfully tested at the corresponding telescopes and validated these concepts for EST instrumentation.

A fast solar polarimeter was also designed and tested along with a new polarising beam splitter using novel detector concepts.

Solar physics in the big data era

SOLARNET brought together all data science fellows working with SOLARNET telescope data, as well as United States data scientists working with data regarding the upcoming four-metre solar telescope DKIST in Hawaii. The project worked to establish consistency in data and issued guidelines with general recommendations so that external observers can easily get their data reduced to facilitate posterior analysis. 'Thanks to SOLARNET, there are now modern data pipelines for all major European solar instruments,' says Mr Collados.

All project activities brought together European and United States solar physicists to ensure participation of the widest possible community for this revolutionary ground-based telescope. When it becomes a reality, this four-metre ground-based EST will allow observation of solar phenomena with unprecedented accuracy and resolution of only a few tens of kilometres at the solar surface.

SMART STRUCTURES FOR ACTUATED NANOSATELLITES

Small satellites are more than just a trend. In 10 years from now, this market will be worth USD 30 billion, and stakeholders are already stretching their imagination to create ever lighter, cheaper and smarter components. A consortium led by TNO is hoping to take part of the pot with its 'smart structures'.

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At the core of the PEASSS (Piezoelectric Assisted Smart Satellite Structure) project is the rapidly growing market of piezoelectric devices, a technology found in common applications such as smartphones, fuel injectors, ultrasonic welding, ultrasound scanners or sonars for underwater communications. However, its advantages – which include low weight, volume savings and high accuracy – are yet to be commercially exploited in space.

The consortium's 'smart structures' include a piezo-actuated structure and pointing mechanism, power generation, fibre-optic sensing and innovative electronics. According to Matthew Maniscalco, coordinator of the project, and his team, these smart structures can improve the accuracy and stability of nearly all Earth observation platforms – thereby keeping Europe on the cutting edge of space research.

The core market for such technology is none other than CubeSats, satellites about as small as a carton of milk generally used for gathering data about the Earth's surface and atmosphere. 'The improved pointing accuracy and potential for reduction of mechanical noise stands to improve all types of observations. Furthermore, it will advance alternative power generation in space, which stands to enable distributed sensor networks and other next generation space technologies,' says Mr Maniscalco.

On 15 February 2017, after four years of research, the consortium successfully launched its own CubeSat consisting of a pyro power generator and a smart structure. The main objective was to demonstrate the latter's ability to change the tilting angle of a sensor.

Indeed, as satellites are exposed to extreme temperatures in space, they are likely to deform, thereby affecting the measurements made by their equipment. The PEASSS CubeSat can take deformation measurements using fibre-optic sensors and send them to Earth. Sensors' angles can then be corrected accordingly thanks to piezoelectric actuators. 'Industrial members within the consortium are very pleased with the functionality of the satellite in space,' says Mr Maniscalco.

They have reason to be pleased: Seven months after its launch, the satellite is still up and running – proving that the built-in technology works and opening doors to no less than 13 market applications within the next four years. These include pyroelectric generators for space usage, an advanced locking device, innovative powers systems for nanosatellites, cryogenic temperature measurements of fuel tanks, miniaturised optical instruments, a new payload-platform interface, etc.

'European industry will benefit from our research in three ways. First, with technologies for a more accurate pointing direction of instruments. Then, with shorter development time applications and satellite development at a lower cost. Finally, there are potential applications for smart structures in other industries, such as automotive and aviation,' Mr Maniscalco explains. One of these includes the reduction of noise and related fatigue in future aircraft composites.

Whilst the test campaign for the PEASSS CubeSat is still ongoing, TNO is already moving forward and will continue to develop instruments for small and large satellites. These include a small space spectrometer, a spectral imager for small satellites, a Fibre-Braggs grating instrument for spacecraft fuel tank monitoring, and additive manufacturing in space for small satellites.

PEASSS

★ Coordinated by TNO in the Netherlands.
★ Funded under FP7-SPACE.
★ http://cordis.europa.eu/project/rcn/106620
★ Project website: http://www.peasss.eu/

"The PEASSS CubeSat can take deformation measurements using fibre-optic sensors and send them to Earth. Sensors' angles can then be corrected accordingly."

ASHES-TO-ASHES BUT NOT QUITE DUST-TO-DUST, AS SUPERNOVAE DEATH REVEALS LINK TO STARS' BIRTH

It was previously thought that molecules and dust would be completely obliterated by the tremendous explosions of supernovae. Yet, for the first time, scientists have discovered that this is not actually the case.

A group of scientists, including those funded under the European Research Council (ERC) financed SNDUST (Supernova dust: production and survival rates) and COSMICDUST (Lighting up the dark – the evolution of dust throughout cosmic time) projects, have identified two previously undetected molecules; formylium (HCO+) and sulphur monoxide (SO), found in the cooling aftermath of Supernova 1987A. Having originally exploded in February 1987, Supernova 1987A is located 163 000 light years away in the Large Magellanic Cloud, a satellite galaxy of our own Milky Way galaxy.

The dust factory of a very young supernova remnant

The lead author of the study published in the journal Monthly Notices of the Royal Astronomical Society, Dr Mikako Matsuura, from Cardiff University's School of Physics and Astronomy, said, 'This is the first time that we've found these species of molecules within supernovae, which questions our long held assumptions that these explosions destroy all molecules and dust that are present within a star.' Accompanying these newly identified molecules were compounds such as carbon monoxide (CO) and silicon oxide (SiO) which had already previously been detected.

Finding these unexpected molecules opens up the possibility that the explosive death of stars creates clouds of leftover gas which cool down to below 200 °C, resulting in the various synthesised heavy elements starting to harbour molecules, creating what has been dubbed a 'dust factory'.

As Dr Matsuura goes on to explain, 'What is most surprising is that this factory of rich molecules is usually found in conditions where stars are born. The deaths of massive stars may therefore lead to the birth of a new generation.'

As new stars are created from the heavier elements scattered during explosions, this work opens up the prospect of better understanding the composition of these nascent stars by analysing their source.

A spectacular celestial farewell

The mechanics of supernovae are relatively well understood. When massive stars come to the end of their stellar evolution, they essentially run out of fuel, with not enough heat and energy remaining to counteract the force of their own gravity. Consequently, the outer regions of the star crash down on the core with formidable force, triggering the spectacular explosion and leaving what looks to be a new bright star behind, before it fades away.

Ever since its discovery over 30 years ago, astronomers have faced hurdles in the quest to study Supernova 1987A, especially when it comes to investigating its innermost core. This research was conducted using the Atacama Large Millimetre/submillimetre Array (ALMA) which enabled the team to explore in remarkable detail. As the facility with its 66 antennae is able to observe wavelengths in the millimetres – situated between infrared and radio light in the electromagnetic spectrum – it can penetrate the dust and gas clouds of the supernova. This ability enabled it to expose the newly formed molecules.

"Finding these unexpected molecules opens up the possibility that the explosive death of stars creates clouds of leftover gas which cool down to below 200 °C."

To expand on their current findings, the team are planning to continue using ALMA to ascertain the prevalence of HCO+ and SO molecules, as well as further explore for hitherto undetected molecules.

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F U N D A M E N T A L   R E S E A R C H

MORE ACCURATE COMPUTER SIMULATIONS FOR BIGGER MOLECULAR SYSTEMS

The developments achieved by the EU-funded LCC project will open a new era of accurate quantum calculations on large molecular systems such as nanoparticles and proteins.

Over the course of the last three decades, it has become increasingly common to interpret various macroscopic chemical phenomena and reaction mechanisms in terms of specific inter- and intramolecular interactions. Today, this is the case not only within the classical fields of physics and chemistry, but also within such modern areas of natural science as molecular biology and nanotechnology. Thus, quantum chemistry, or the application of quantum mechanics to molecular systems and phenomena, has become an integral tool for all chemical, biological and material sciences.

Besides contributing qualitative information on molecules and their different interactions, modern quantum chemistry may also provide a deeper understanding of molecular processes, which cannot be solely derived from such experimental work as elusive chemical reaction intermediates. 'The majority of experimental results are supported by modern computational work, and theory is now used more than ever as an apparatus to lead and guide future experimental work within the medicinal industry and material sciences,' says Poul Jørgensen, a researcher with the EU-funded LCC (Coupled Cluster Calculations on Large Molecular Systems) project. 'As a result, accurate computer simulations on increasingly larger molecular systems are desired, not only by academia, but also by various industrial research labs.'

However, according to Jørgensen, the problem is that computation efforts grow dramatically with the size of the molecular system whenever an increasingly higher accuracy is requested. 'In order to circumvent this computational problem, so-called local correlation methods have been devised, which describe the fundamental repulsive interactions between individual electrons in a spatially local manner instead of the typical delocalised, canonical manner,' he says.

Improving the LSDalton code

Jørgensen was part of the research team that developed the quantum chemistry code called LSDalton – a massively parallel and linear-scaling programme used for the accurate determination of energies and other molecular properties for large molecular systems. Now, through the LCC project, Jørgensen and his team have further developed the LSDalton code. 'The ultimate goal of this project was to obtain cluster methods that scale linearly with system size and where the calculations are massively parallel, such that calculations for small and large molecular systems require the same computational wall time,' says Jørgensen.

The key to accomplishing this goal was to express the coupled cluster wave function in a basis of local Hartree-Fock (HF) orbitals. 'We successfully demonstrated how such a local HF basis may be obtained and described how linear-scaling, massively parallel coupled cluster energies can be obtained,' explains Jørgensen. 'At different levels of coupled

cluster theory we performed efficient massively parallel calculations for the energy and the molecular gradient, and in the future the same technology will be applied for even higher-level coupled cluster methods to yield not only the energy and gradient of a large molecule, but also other molecular properties such as excitation energies and transition moments, nuclear shielding, polarisabilities and electronic and vibrational circular dichroism.'

A new era for quantum calculations

The developments achieved in the LCC project will open a new era of accurate quantum calculations on large molecular systems such as nanoparticles and proteins. 'The improved performance has the potential to benefit all areas of molecular science and engineering by enabling increases in both the maximum molecular system size that can be simulated and the overall accuracy achievable,' explains Jørgensen.

The developments are particularly interesting in the context of supercomputers, where the wall time to solution is the most important measure and the LSDalton program may be efficiently utilised. This has been recognised at Oak Ridge National Laboratory (ORNL) in the US, where one of the largest supercomputers, TITAN, is located and where the world's largest supercomputer SUMMIT will be operational in about a year. Here, LSDalton was successfully utilised to perform extremely large correlational calculations on TITAN. 'The LSDalton programme is now being further developed at ORNL and will soon be ready to explore new challenging applications on SUMMIT on for example carbon nanotubes, graphene and the preferred crystal form of organic molecules,' says Jørgensen.

RHOMBOID PROTEASE MECHANISM OF ACTION UNVEILED

Deciphering mechanisms of protein function often requires structural information on their interaction with ligands. European scientists worked on novel substrates and inhibitors of rhomboid protease to show the catalytic mechanism of these enzymes.

Proteins of the rhomboid family of intramembrane proteases are known for their important biological functions including intercellular signalling, mitochondrial dynamics and invasion of eukaryotic parasites. However, little is known regarding the mechanism of function in mammals and bacteria despite recent data on the crystal structures of prokaryotic intramembrane proteases. This is mainly due to lack of information on rhomboid protease-substrate complexes.

To shed light onto the function of these enzymes, scientists from the RHOMBOID SUBSTRATES (Substrate specificity, mechanism and biological roles of rhomboid intramembrane proteases) project investigated their natural substrates using a combination of advanced substrate specificity analysis, quantitative proteomics and genetics. The identified substrates helped the consortium uncover the mechanisms underlying the biological function of certain rhomboid proteases in human epithelial cells as well as in model bacteria.

Novel substrates help delineate rhomboid substrate mechanism of action

Work on *E. coli* and *B. subtilis rhomboid* proteases revealed that they ensure quality control of membrane proteins, akin to the ER-associated degradation known from eukaryotic cells. With respect to mammalian rhomboid proteases, efforts

focused on RHBDL2, one of the four known enzyme homologues that localise in the secretory pathway. RHBDL2 localises to the plasma membrane where it functions as a secretase by catalysing the proteolysis of cell surface transmembrane proteins.

Researchers used quantitative proteomics to identify the repertoire of RHBDL2 substrates. They studied various novel molecules that are specifically cleaved by RHBDL2, including the interleukin-6 receptor, the cell surface protease inhibitor Spint-1, the collagen receptor tyrosine kinase DDR1, N-Cadherin and others. Interestingly, these substrates exhibited high specificity as they could only be cleaved by RHBDL2 and no other rhomboid paralogues.

The team uncovered the basic principles of substrate recognition by rhomboid proteases and solved the first ever structure of a complex of an intramembrane protease with substrate-derived peptides. 'This enabled us to devise novel, highly sensitive and versatile activity assays, and, more importantly, led us to discover a new class of rhomboid protease inhibitors that are unprecedentedly potent and selective and have a clear rationale of how to modify their selectivity,' project coordinator Prof. Kvido Strisovsky explains. The identified compounds constitute the first tools for studying the biological function of rhomboid proteases but may also serve as pharmaceutical inhibitors of these enzymes.

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FUNDAMENTAL RESEARCH

Clinical significance of rhomboid proteases

The clinical significance of rhomboid proteases is only beginning to emerge. 'Analysis of the gene expression of RHBDL2 and our most rigorously characterised substrates highlights that they are highly expressed in epithelia of the skin, airways and digestive tract and exhibit changes in their expression under similar pathological conditions,' Prof. Strisovsky continues.

Some of the identified substrates seem to contribute to the maintenance of epithelial homeostasis, a complex process that requires regulation of cell adhesion, migration and sensing of the extracellular environment. Given that impaired epithelial homeostasis is a characteristic of a number of diseases such as cancer, inflammation and fibrosis, rhomboid proteases may have a new therapeutic role.

Additional examples of rhomboid proteases with clinical potential include the *Plasmodium falciparum* homologue PfROM4. Required for the infectivity of the parasite, its inhibition may have antimalarial effects. Furthermore, the human mitochondrial rhomboid protease PARL functions as a negative regulator of mitochondrial degradation. Since the pathogenesis of Parkinson's is associated with the accumulation of damaged mitochondria, boosting mitochondrial autophagy by inhibiting PARL may have neuroprotective effects.

Overall, the findings and deliverables of the RHOMBOID SUBSTRATES project advance existing knowledge and improve our ability to understand the physiological roles of these important enzymes.

RHOMBOID SUBSTRATES
- ★ Coordinated by IOCB in the Czech Republic.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/project/rcn/103065

SPINTRONICS ADVANCING NEXT-GENERATION ELECTRONICS

EU researchers have demonstrated that you can use the spin of an electron without its charge to carry information.

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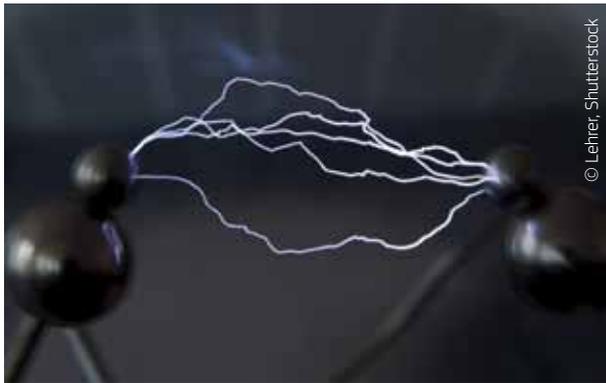
A team of physicists from five European universities have devised a means of using spin currents to process information without the motion of electrical charges. The research, carried out under the EU-funded INSPIN (Insulator Spintronics) project, represents a significant advance in the emerging field of spintronics – the study of the properties of the electron spin – which could pave the way for new alternatives to conventional electronics in the future.

Magnons, the quasiparticles which are associated with the excitations of magnetic materials known as spin waves, are seen as an interesting candidate for carrying information as they have a low rate of energy dissipation.

New way of carrying information

The INSPIN team has spent the past three years devising ways of detecting, manipulating and transporting spin currents inside magnetic insulators. 'A magnon … behaves like a particle although it is actually a wave and that is what carries the information,' says Arne Brataas, project coordinator and professor of physics at the Norwegian University of Science and Technology. 'By manipulating this wave, we can change the way that we can manipulate and transport information.'

In order to work, this new kind of insulator spintronics must be able to be seamlessly integrated with conventional electronics. Finding the right interface between the insulator and metal was therefore vital.

'The biggest challenge was to convert the electrical signal into this spin signal inside the insulator and the related process to extract it – how to get the signal in and out,' says Prof. Brataas. 'This was difficult because at the start of the project we didn't know which mechanism responsible for transferring the information from the electrical charge to the spin was dominant.'

The team also explored whether different combinations of materials would make the conversion more or less efficient. 'Many different kinds of materials were explored, but what we found was that the conversion is quite robust so it doesn't depend so much on the type of material,' says Prof. Brataas.

Less heat

The fact that this new way of transporting information is accompanied by very little dissipation of energy is significant. With devices based on conventional charge-based electronics, the smaller they become the harder it is to avoid them overheating. 'One of our motivations in doing this is to find ways to process information that generate less heat,' says Prof. Brataas, 'so if we can make it low power, that means we can generate signals without generating a lot of heat.'

Three years from the start of the project the INSPIN team has achieved its main aim of using a completely different entity for carrying information by making a transistor that works entirely based on spin. Although INSPIN has finished, the researchers involved will continue exploring this area of fundamental science and continue developing what they believe has the potential to become a revolutionary, disruptive technology in the future.

INSPIN
- ★ Coordinated by NTNU in Norway.
- ★ Funded under FP7-ICT.
- ★ http://cordis.europa.eu/project/rcn/110729
- ★ Project website: https://www.inspin.eu/

EVENTS

**FEBRUARY
01▶04**

Djerba, TUNISIA

CONGRESS

FIRST INTERNATIONAL CONGRESS ON ENERGY SECURITY & ENVIRONMENT ESE'2018 TUNISIA

The EU-funded FETRIC project will be supporting the First International Congress on Energy Security and the Environment, in Djerba, Tunisia.

ESE'2018 Tunisia is being organised by the General Direction of Technological Studies of the Tunisian Ministry of Higher Education, in partnership with the IEEE organisation. The Congress will consist of invited talks, special sessions, oral and poster presentations of peer-reviewed papers, security training and a workshop, as well as a dedicated space for exhibiting innovative research products.

The FETRIC (Future European Tunisian Research Innovation Cooperation) project works to improve cooperation in the domains of science and technology between the EU and Tunisia by strengthening bilateral cooperation.

For more information, please see:
http://www.fetric.eu/en/2013-12-02-09-38-22/news/222-first-international-congress-energy-security-environment-ese-2018-tunisia.html

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EVENTS

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

**FEBRUARY
02▶07**

New Orleans, USA

CONFERENCE

THE 32ND AAAI CONFERENCE ON ARTIFICIAL INTELLIGENCE

The EU-funded REACH project is supporting the 32nd AAAI Conference on Artificial Intelligence, to be held in New Orleans, USA.

The EU's REACH project is working on intelligent prediction to help people by providing new, personalised help in the form of interventions targeting mobility, rehabilitation, food and nutrition and patient motivation, among other goals. It is interested in the increase in physical activity levels of the elderly through the combination of wearable and ambient sensors along with data analytics and prediction.

The project is supporting the 32nd AAAI Conference on Artificial Intelligence, AAAI-18. The conference series aims to promote research in artificial intelligence (AI) and foster scientific exchange between researchers, practitioners, scientists, students and engineers in AI and its affiliated disciplines.

AAAI-18 will continue the tradition of previous AAAI conferences with technical paper presentations, invited speakers, workshops, tutorials, poster sessions, senior member presentations, competitions and exhibit programmes, all selected according to the highest standards. AAAI-18 will also include additional programmes for students and young researchers.

For further information, please visit:
https://aaai.org/Conferences/AAAI-18/aaai18call/

**FEBRUARY
05▶10**

Obergurgl, AUSTRIA

STUDY WEEK

THE GRAPHENE FLAGSHIP'S 'GRAPHENE STUDY – WINTER 2018'

The EU-funded Graphene Flagship will be holding a study week titled 'Structural characterisation of graphene-based materials' in Obergurgl, Austria.

Graphene production is now becoming a mature technology, with several graphene-based products already on the market, and with different production techniques routinely used, yielding materials with different properties and cost/performance. All the new developments, and the fact that a wide range of other 2D materials are being intensively researched at fundamental levels, make it necessary for researchers in aca-demia and industry alike to know the potentiali-ties and limitations.

The Graphene Study week will go some way to providing a strategic overview of the most common techniques and methodologies available to determine the nature, composition and behaviour of 2D nanomaterials, thin films and nanostructured composites.

The programme will include an introduction to what is meant by materials characterisation, an introduction to (S)TEM imaging and analysis, and EELS and EDS spectroscopy among many other areas of interest.

For further information, please visit:
http://graphene-flagship.eu/graphenestudy/GS_Feb_2018/Pages/Topic.aspx

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**FEB.
09▶10**

Lausanne, SWITZERLAND

WORKSHOP

THIRD ENIGMA WORKSHOP

The EU-funded ENIGMA project will be organising a workshop in Lausanne, Switzerland.

The ENIGMA network is setting out to train a new generation of young researchers in the development of innovative sensors, field survey techniques and inverse modelling approaches. To further this aim the project is hosting its third workshop called 'Predictive modelling and upscaling of flow and reactive transport in heterogeneous aquifers'.

The programme will cover stochastic approaches of uncertainty analysis and model legitimacy including field methods and involves industrial case studies on simulating flow and transport for waste storage problems (there will be a presentation by the industrial partner SKB), among other subjects.

ENIGMA (European training Network for In situ imaGing of dynaMic processes in heterogeneous subsurfAce environments) will place special emphasis on mixing and mixing-controlled reactions in heterogeneous media and will use field methods for the identification and characterisation of non-ideal behaviour. Hands-on practice, using simple problems, will illustrate predictive modelling honouring extensive data sets and acknowledges uncertainty.

For more information, please see:
http://enigma-itn.eu/training/workshop-3/

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research*eu Results Pack

Bioplastics

To transition to a circular bioeconomy, Europe needs its plastics industry to be on board with ever-more efficient bioplastics. A new Results Pack highlights eight projects showing how Europe is determined to continue cementing itself as a leading global player in the sector.

For more information, go to: http://cordis.europa.eu/article/id/400694

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