



#93
JUNE 2020

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Tales of heroic adventure
lend flavour to our cultural identity –
but what if they're fake?

A smart app creation space
for virtual factories

Sniffer sensors
locate home-made bombs

SPECIAL FEATURE
**A QUANTUM LEAP
FORWARD FOR EUROPEAN
FUNDAMENTAL
RESEARCH**

Editorial

Showcasing innovative EU research in quantum technologies, how hands can help identify child abusers and the importance of nuclear safety

welcome to this month's Research*eu magazine

With most of Europe still hunkered down under the COVID-19 crisis but with some countries tentatively opening the shutters and trying to take the first concrete steps to a post-lockdown life, many of us are probably questioning just how bright and rosy the future might actually be. Many would argue that, indeed, there is a need for a little optimism in our lives. To do our part, we always try to highlight through Research*eu how human progress and scientific breakthroughs are continuing to happen regardless of the current situation and they're still expanding and bettering our understanding of both ourselves and the vibrant, complex world around us.

One excellent example is the focus of this month's **special feature**, where we showcase groundbreaking EU-funded research in quantum technologies. European researchers are leading the charge in developing applications that utilise quantum mechanics in a way that promises to massively boost our computing capacity, as well as transform many sectors that we rely on today, ranging from communications to medical science to cybersecurity. Admittedly, this is probably one of the densest and most complex subjects that we've covered as a special feature topic in a long time but we hope our seven showcased projects give our readers a good glimpse into a really promising and exciting field.

Meanwhile, our **Project of the Month** meets the H-Unique team, who are working to create an application that could identify child

abusers just by using images of their hands. Whilst this is indeed a rather squeamish and highly sensitive subject, the team's success would result in a tool that would aid police forces in linking suspects to their crimes and subsequently help bring to justice those who violate the most vulnerable and precious members of our society.

Then **Life After** catches up with a scientist who is dedicated to enhancing international cooperation in the field of nuclear safety and our nine thematic sections provide a succinct roundup of EU-funded research results across a broad spectrum of subjects, so we're sure you'll definitely find something to pique your interest!

Finally, CORDIS remains dedicated to keeping our readers informed on how European researchers are supporting scientific endeavours in the ongoing pandemic. To keep fully up to date with our COVID coverage, we invite you to go to the News section of the CORDIS website at cordis.europa.eu/news, available in six languages, as well as to click through to our various social media channels.

As always, wishing all of our readers good health and until next month – but if you have any queries, questions or suggestions (hopefully never a complaint), please feel free to drop us a line at editorial@cordis.europa.eu

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Editorial coordination
Birgit Alice BEN YEDDER

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A European front on Organ-on-Chip technology

Conventional animal models and cell cultures do not always reflect human physiology, leading to error-prone results during drug development. Organ-on-Chip technology combined with human stem cells is a promising alternative, so concerted efforts are required at a European level to promote this innovative technology.

Organ-on-Chip (OoC) technology uses microchips the size of a computer memory stick that contain hollow microfluidic channels often lined with artificial human vasculature. The addition of organ-specific human cells and the application of mechanical forces and flow recapitulate the architecture and functions of a specific organ.

Offering a promising alternative to animal testing, OoC microchips could contribute to making drug and cosmetic development less dependent on animal research. The high predictive value of OoC technology has the potential to surpass standard cell culture and experimental animals in anticipating human responses to specific drugs and make precision medicine a reality. Importantly, it raises fewer ethical concerns than animal experiments and can contribute to a 3R strategy (reduce, refine, replace) for animal experimentation in drug development.

OOO TECHNOLOGY STATUS IN EUROPE

The aim of the EU-funded ORCHID (Organ on Chip in Development) project was to build a roadmap for OoC technology and establish a European network in this promising field. "ORCHID clearly identified strengths of the field in Europe, but also the needs, challenges and barriers of the technology towards a European roadmap," states project coordinator and Professor of Developmental Biology at Leiden University Medical Center, Christine Mummery. Assessment of the status of OoC technology in Europe identified an excellent communication network between developers, companies that market OoC products, end users and regulators.

In particular, the Netherlands with its strong stem cell community has integrated stem cell derivatives into

OoC modalities faster than other countries. ORCHID also identified hurdles to the full implementation of OoC technology such as uncertainty among end users on which format is best for their applications, lack of evidence on which OoC models could replace regulatory requirements as well as variability in robustness and reproducibility. To address the latter, ORCHID suggested introducing independent testing centres to assess the technical performance and biological compatibility of new chip designs.

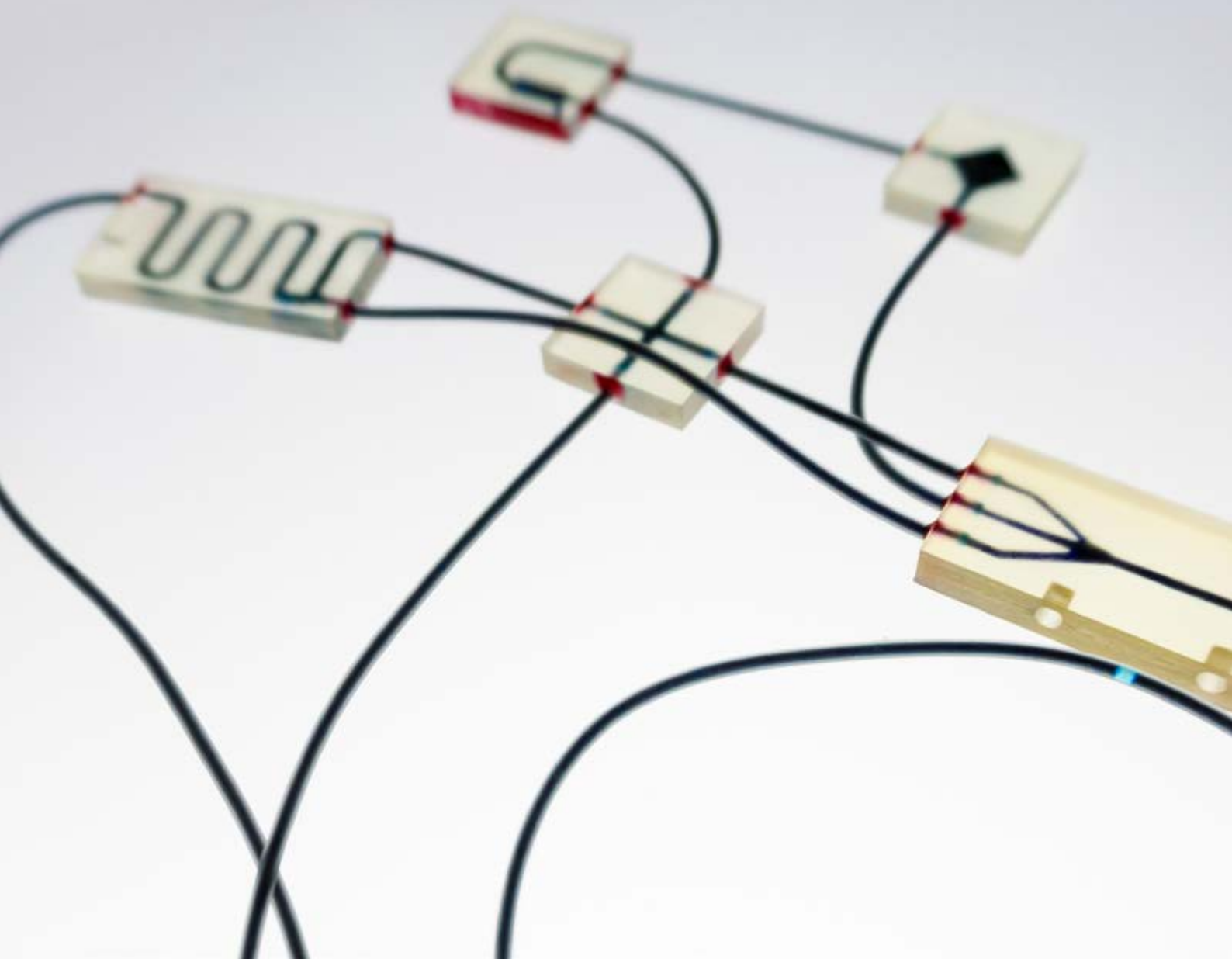
AN OOC SOCIETY PROJECT ALREADY OFFERS A HUB FOR STAKEHOLDERS

ORCHID established the European Organ-on-Chip Society (EUROOCS) to anchor the OoC network, provide a platform for dialogue and encourage research towards new healthcare solutions. EUROOCS organises an annual meeting for dissemination of results and stimulation of collaboration.

EUROOCS has become the hub for presenting technical developments such as the integration of sensors into the chips to detect changes in biological responses of cells. Importantly, it showcases biomedical, nutritional and toxic effects not previously detected in animal models or cells cultured in more standard 2D formats.

PROJECT SIGNIFICANCE AND PROSPECTS

"The ORCHID roadmap clearly set the stage for the future activities of the OoC community towards implementation of OoC models in practice," outlines Mummery. Recommendations formulated during the project are expected to encourage investment from industry and academia in research and development.



© science photo, Shutterstock

“ *The ORCHID roadmap clearly set the stage for the future activities of the OoC community towards implementation of OoC models in practice.* ”

EUROoCS will play an instrumental role in qualification and standardisation of OoC technology, contributing to the training of next-generation researchers and communicating the opportunities of the technology in health and welfare.

Plans include the establishment of independent OoC testing centres embedded in the European OoC infrastructure to further bridge the gap between developers

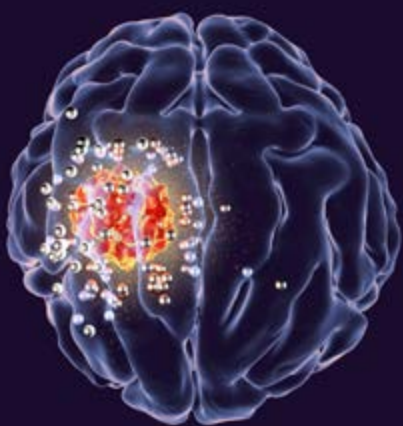
and end users. “Paramount to technology implementation in healthcare will be continuous financial support through industry and academia, alongside the exchange of expertise,” concludes Mummery.

ORCHID

- Coordinated by Leiden University Medical Center in the Netherlands.
- Funded under H2020-FET.
- cordis.europa.eu/project/id/766884
- Project website: h2020-orchid.eu

Nanoparticles deliver drugs directly to the brain

Glioblastoma multiforme is the most frequent brain tumour with an incidence of 10 in 100 000 people. The fatal prognosis necessitates new ways of delivering drugs directly into the brain.



Brain tumours are difficult to treat because of their invasive nature and aggressiveness. Another major obstacle is the natural protection of the brain that separates it from the systemic circulation, posing a challenge to treatment with systemic drugs.

A POLYMER-BASED APPROACH FOR DRUG DELIVERY

Undertaken with the support of the Marie Skłodowska-Curie programme, the HyGlio (Theranostic Injectable Hydrogel for Glioblastoma) project addressed drug delivery to the brain and imaging through the development of a multifunctional polymer-based tool that combines hydrogels and nanoparticles. “By combining hydrogels and nanoparticles, we can merge the advantage of long-term release from hydrogels and the targeting ability of nanoparticles, in the hope of extending residence time of drugs in the tumour area,” explains the Marie Skłodowska-Curie fellow Clara Mattu. HyGlio was a collaboration between the Polytechnic University of Turin and the Houston Methodist Research Institute in the United States, where the fellow spent 2 years as part of the ongoing phase of the project.

When designing particles for drug delivery, scientists must take into account the surface properties of the nanoparticle carriers as they will determine cell interaction, *in vivo* bio-distribution and tumour accumulation. In this context, the research fellow employed polyurethane-based nanoparticles 100-200 nm in diameter to load drugs. These nanoparticles contained both hydrophobic and hydrophilic domains that enhanced the affinity for both hydrophilic and hydrophobic drugs and showed an overall improvement in biodistribution and half-life within the body.

Moreover, the fellow combined nanoparticles with hydrogels that are suitable for localised drug delivery and facilitate slow release. The use of thermo-responsive hydrogels ensured that the gel is liquid and injectable at room temperature and quickly forms a 3D network when it reaches body temperature at the place of injection.

To study the tumour, Mattu loaded nanoparticles with fluorescent markers or other imaging probes that allow magnetic resonance imaging. “We, and others, have shown that concomitant loading of drugs and imaging probes can be achieved within nanoparticles,” she emphasises.

EFFICACY OF THE HYDROGEL DRUG DELIVERY APPROACH

Although the approach is in the early stages of development, preliminary *in vivo* data suggest that the combination of hydrogels and nanoparticles is safe and, most importantly, that nanoparticles can reside in the brain and in the proximity of the tumour for longer. Tumour-bearing experimental animals retained drug-loaded nanoparticles for up to 10 days post intra-tumoural injection, and the drug exhibited good biodistribution in the tumour and improved the animals' survival. Moreover, scientists observed modifications in the number and structure of tumour blood vessels after treatment. Future plans

include the testing of drug combinations in dual release strategies, where drugs are loaded partly in nanoparticles and partly in the hydrogel compartment.

Cancer therapy often requires the concerted and combined action of different chemotherapeutics to overcome drug resistance and improve patient outcome. However, synergistic treatment is hampered by incompatible pharmacokinetics and hydrophobicity of the different drugs. HyGlio proposes to overcome this through the combination of hydrogel with polyurethane nanoparticles for

efficient encapsulation of both hydrophobic and hydrophilic drugs, achieving maximal tumour accumulation and treatment efficacy.

HYGLIO

- Coordinated by Turin Polytechnic in Italy.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/658665
- Project website: bit.ly/2xewVeU

HEALTH

Time to act on passive smoking as new evidence of health risks emerges

Health risks to children and non-smokers exposed to others lighting up requires policy-makers to bring in new restrictions, say scientists in a major EU-funded study on the health effects of passive smoking across Europe.

Despite European countries' existing smoking bans within public buildings and elsewhere, scientists have found solid new evidence that exposure to second-hand smoke among non-smokers and children is still worryingly high and affects their health.

A series of coordinated studies on the effects of passive smoking across 12 European countries under the TackSHS project (Tackling secondhand tobacco smoke and e-cigarette emissions: exposure assessment, novel interventions, impact on lung diseases and economic burden in diverse European populations) found that, on average, second-hand fumes from smoking tobacco affect 31 % of the population, ranging from 68 % of the population in Greece to 24 % in Ireland.

"We know that across these countries 26 % of the adult population are smokers – 31 % men and 21 % women. But the proportion of people exposed to their smoke is as high as 31 %," says project coordinator

26 % of the adult population in 12 European countries are smokers

But the proportion of people exposed to their smoke is as high as 31 %



Esteve Fernández Muñoz, professor and director from the Tobacco Control Unit at the Catalan Institute of Oncology, Barcelona, Spain.

Passive smoking is a concern in workplaces, private homes and cars, but particularly in public venues such as bars, cafes and restaurants even on their outdoor terraces, he says. He stresses the data indicates governments must now regulate against smoking in cars and outdoor areas frequented by children.

“Using environmental biomarkers, we studied exposure to second-hand smoke in areas scarcely studied previously such as public open spaces,” Fernández says. “We interviewed representative samples of the population – 1 000 in each country – and were able to combine this information with air sample data in different locations.”

EFFECT ON CHILDREN

“Smoking at the school gates and in playgrounds as well as in the home and in cars is present in all European countries and can particularly affect children,” Fernández notes. “Smoke levels in smokers’ cars are very high, with nicotine concentrations exceeding those observed in smokers’ homes – which itself contributes the highest exposure to passive smoking in Europe.”

In 2017 alone, among children aged 0-14 years, exposure to second-hand smoke at home was associated with 344 deaths (1.5 % of total deaths in children) and in non-smoking adults it was responsible for 30 000 deaths, Fernández says.

“Smoking at the school gates and in playgrounds as well as in the home and in cars is present in all European countries and can particularly affect children.”

RISKS TO HEALTH

Tobacco smoke contains some 69 toxicants, including several carcinogens, and is the reason some non-smokers develop lung cancer or heart disease, he explains. “From previous studies we know the risk of lung cancer among non-smokers passively exposed to tobacco smoke is 20 % higher than the risk of a non-smoker who is not exposed,” Fernández adds.

The TackSHS survey information was used to compute the attributable risk of second-hand exposure for morbidity. “In adults, we estimate that 30 % of systemic heart disease, 27 % of chronic obstructive pulmonary disease, 15 % of strokes and 12 % of lung cancers are due to second-hand smoke exposure.”

E-cigarettes also affect health due to the emission of their nicotine-laden aerosols, even though they contain fewer toxic components than tobacco smoke. “They contain nicotine and some carcinogens, although at lower concentrations. We think that they are not completely safe,” says Fernández.

“We measured the effects in non-users exposed to e-cigarette aerosols and found some nasal symptoms and throat irritations that were maintained for some hours after the exposure.”

TACKSHS

- Coordinated by the Catalan Institute of Oncology in Spain.
- Funded under H2020-HEALTH.
- cordis.europa.eu/project/id/681040
- Project website: tackshs.eu



Tales of heroic adventure lend flavour to our cultural identity – but what if they're fake?

From academic hoodwinking to straightforward financial gain, the reasons for creating a forgery are diverse. But once in the public domain, a forgery can take on a life of its own. Myths can be constructed around its contents: fields of study can spring up based on manufactured sources. What impact can an unreliable source have on cultural identity?

Fascinated by the impact of forgeries on the perception of cultural authenticity and national identity in 17th and 18th century Scandinavia, principal investigator on the project Forgery (Forging Ahead: Faking Sagas and Developing Concepts of Cultural Authenticity and National Identity in 17th- and 18th-Century Scandinavia), Philip Lavender, considered how the existence of forged sagas required scholars and historians to question source materials.

He examined the role they played in refining scholarly work and considered when an artfully recopied saga shifts from creative retelling to forgery.

"I find it particularly interesting when the forgers' own interests overtake their attempt to appeal to the interests of their target audiences. It seems that the individuals involved in writing these works often had a genuine desire to write and imagine other worlds, so descriptions creep in which serve no obvious ideological purpose other than the satisfaction of the author. Writing, even forgery, can be an escape and type of therapy for the authors involved!" says Lavender, who conducted his research with the support

of the Marie Skłodowska-Curie programme based at the University of Gothenburg, Sweden.

He explains that scholars of the period used sagas as historical source material, so there was much discussion about which ones were reliable and which parts could be used. What techniques of corroboration could be applied to such works? "All of these questions became of vital importance and were neatly focused by the appearance of fake sagas," says Lavender.

The notion of the forger as: "(...) a dastardly villain or cantankerous prankster," as Lavender puts it, is too simplistic. "Forgery exposes some key concepts as not being straightforward."

As he explains: "If you forge a text of a known author, the case can be fairly open and shut, since by adding the name 'Shakespeare' to my humble play I'm quite clearly misleading people. But sagas are an anonymous genre: no authorial name is attached."

So how do you fake a work in an anonymous tradition? One technique is to replicate the style of an earlier period or even intermix fake material with real material. But even authentic sagas have been subject to copying and recopying over centuries.

Lavender explains that when people copied the texts there was no imperative to keep everything the same: sections could be added or removed, wording changes or details emended to suit the copyist's taste. None of this was considered suspect or problematic. So, what is the definition of authenticity and where does a forgery start?

If you change a few words in transmission, maybe it isn't forgery, but if you change a whole paragraph or chapter, perhaps it is. "Asking how much must be modified before a saga becomes a forgery is like asking how long a piece of string is: it depends who is looking and in what context."

CULTURAL IDENTITY BUILT ON QUESTIONABLE SOURCES

In the 17th and 18th centuries there was much debate over whether Denmark or Sweden was the true heart of ancient Scandinavia. The saga of King Krembre contributed to the discussion. This discusses a great expedition led by King Krembre, which set out from Sweden and travelled down through Europe. They conquered many lands and people and won many battles, only halting on the far side of the Alps where they were defeated by the Romans.

Lavender explains that the story is more or less that of the Cimbrian migrations, migrations which we know to have begun round about 120 BC and culminated with the defeat of the Cimbri by the Romans at the Battle of Vercellae in 101 BC.

"The curious detail here is that most historians believe that the Cimbri came from Jutland in modern-day Denmark. But it seems that the author of 'Krembre's saga' wanted to assign these great historical feats to a Swedish contingent rather than a Danish one."

Another saga, created to attract the interest of a private collector, presents an alternative narrative about the founding of Iceland.

Lavender presented his findings at the International Saga Conference in Reykjavik in August 2018 and at the international conference 'Faking It!' at the University of Gothenburg in August 2019 for which he was a co-organiser.

FORGERY

- Coordinated by the University of Gothenburg in Sweden.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/707946
- Project website: dh.gu.se/hjalmars_saga

SOCIETY

Traditional culinary habits die hard

Ancient cooking pots provide valuable clues to past cuisine and culinary variety as societies moved from hunting and gathering to farming. EU-funded archaeobotanists have found that societies continued with their old cooking traditions even while adopting the new.

The analysis of micro-botanical remains from cooking pots retrieved from archaeological sites in Greece is providing new insights into culinary practices during the Neolithic and Bronze Age, in the Aegean.

"Archaeologists often find pots with burned food crust on the inside – people have always burnt their dinner from time to time. This is an advantage for us because we can analyse that crust to shine some light on the meals they were cooking," explains project coordinator of CUISINE (An

innovative approach for the study of culinary practices in past societies), Amy Bogaard, professor of Neolithic and Bronze Age Archaeology at the University of Oxford, where she is head of the School of Archaeology.

When crust is not available, archaeologists collect and analyse the sediment trapped in the pores of the vessels.

Looking at organic residues on pots is not new in archaeology. But the usual method is to look at animal lipids, or fats, which are better preserved on ancient pottery than the residue of plants.

“Because of the lipid focus in past archaeological research into organic residues, you’d be forgiven for thinking people were eating meat constantly with very little plant material. This gives a distorted picture of diet in the past,” Bogaard emphasises.

In fact, animal products tended to be secondary in the diet. “They were harder to acquire or more expensive,” says archaeological botanist Juan José García-Granero, who received a 2-year Marie Skłodowska-Curie grant at Oxford to analyse microscopic plant remains from ancient cooking vessels.

ANALYSIS OF PLANT MINERAL DEPOSITS

García-Granero studied pots dating back to 5600-5000 BC excavated at the Greek Neolithic site of Stavroupoli, and the 1700-1100 BC Bronze Age site at Knossos-Gypsades, Crete.

“Food talks about who we are. Knowing what people ate and how people combined different foodstuffs in the

past can give us information about who they were and how they identified themselves in relation to others,” comments García-Granero.

“As an archaeobotanist, I analyse the tiny starch grains trapped in artefact utensils used in cooking. I also analyse microscopic plant remains called phytoliths,” explains García-Granero, currently a post-doctoral fellow at the Institució Milà i Fontanals d’Investigació en Humanitats, Barcelona, Spain.

Phytoliths consist of silica deposited in the cells of plants. As the rest of the plant decays, the mineral silica remains. “The shape of the silica tells you the shape of the cells it was in and therefore the kind of plant,” Bogaard explains.

“I was one of very few people doing this kind of analysis in Greece, so I had lots of interest from students wanting to be trained and I had several students coming over to Oxford,” García-Granero notes.

NEW TYPES OF INGREDIENTS APPEAR

“We were expecting to find domestic cereals – wheat, barley and domestic pulses like lentils and other types of beans consumed in the Aegean. We did find them, but we also found the wild plants being consumed, such as tubers,” García-Granero says.

“The Neolithic Age is interesting because it’s a complete change as people start farming. New ingredients appear,” he adds. But this did not mean they abandoned previous practices.

“I believe this has to do with their culture and traditions. Even though they have access to other types of foods, they still look for the plants that have always been part of their cuisine.”

CUISINE

- Coordinated by the University of Oxford in the United Kingdom.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/704867
- Project website: projects.arch.ox.ac.uk/CUISINE.html





A giant leap to commercialisation for residential fuel cell combined heat and power

Onsite generation of electricity and heat has not been particularly known for its affordability, but that may have just changed. An EU-funded project showed how production costs of fuel cell micro-cogeneration can be reduced, bringing the technology on the path to wider commercial availability.

A decade ago, the generation of electricity and heat with no pollution and considerably fewer greenhouse gas emissions sounded too good to be true for residential applications. Stationary fuel cells are now a promising alternative to combustion engines for electricity production and the cogeneration of heat as part of micro combined heat and power (micro-CHP) systems.

SHRINKING THE COST OF THE MAIN FUEL CELL COMPONENTS

Amongst the various types of micro-CHP, fuel cell cogeneration systems can reach 90 % efficiency (60 % electric

and the remainder as thermal). Their low heat-to-power ratio means that they are well suited to the evolving trend in homes towards higher electricity use and low space heating demand.

Despite their great potential for residential applications, micro-CHP systems have not yet reached the commercial stage. New advances introduced by the EU-funded HEATSTACK (Production Ready Heat Exchangers and Fuel Cell Stacks for Fuel Cell mCHP) project seem to help overcome the high capital cost challenge that has so far prevented commercial roll-out of the technology. The major focus has been on reducing production costs of the two



most expensive components of the fuel cell system: the fuel cell stack and heat exchanger, which account for the greatest part of fuel cell capital costs.

Researchers built on the success of a state-of-the-art micro-CHP system that uses a solid oxide fuel cell (SOFC) stack developed by project partner Sunfire. To date, this system has undergone extensive field trials as part of European-wide residential fuel cell micro-CHP deployment initiatives, and it is one of the most promising SOFC cogeneration technologies nearing commercial deployment.

The system uses an innovative cathode air preheater (CAPH) based on a novel gas-to-gas heat exchanger that provides air at a specified temperature to the fuel cell stack. Decreasing the costs of the SOFC stack and CAPH will render fuel cell micro-cogeneration more cost competitive and attractive to the market.

AUTOMATING MANUAL TASKS

“Sunfire’s Home micro-CHP system offers efficient cogeneration of power and heat for houses and runs on cost-efficient fuels – either liquefied petroleum gas or natural gas,” explains project engineer Frank Mittmann. To reach series production, several processes have to be automated. One of those processes is to eliminate manual work and automatically apply the glass sealant onto the SOFC stack repetition units.

“In the course of HEATSTACK, Sunfire optimised the process of printing the glass paste onto the repetition unit

with the use of a step stencil, achieving 10% savings in the total SOFC stack costs,” adds Mittmann. R&D engineers produced 10 prototype SOFC stacks with printed glass and conducted thorough tests on their mechanical compatibility, electrical properties and long-term stability.

The optimised SOFC stack was integrated into Sunfire’s Home micro-CHP units. Further performance tests on system level were conducted, showing that the technologies demonstrated by HEATSTACK are ready for use in mass production.

UTILISING ALUCHROM IN THE CAPH

Project researchers developed tooling and processes that reduced CAPH manufacturing time from 9 to 2.5 hours. They also demonstrated a considerable reduction in chromium evaporation by using a resistance heating alloy called AluChrom, rather than Inconel 625, for the heat exchange plates in the CAPH. Pre-heat treatment of the AluChrom proved to extend SOFC lifetime, thus reducing overall maintenance costs.

HEATSTACK

- Coordinated by Senior UK Ltd in the United Kingdom.
- Funded under H2020-ENERGY.
- cordis.europa.eu/project/id/700564
- Project website: heatstack.eu

LIGHT YEARS AHEAD: EU RESEARCH AND INNOVATION PROJECTS SHOW HOW PHOTONICS WILL SHAPE THE FUTURE

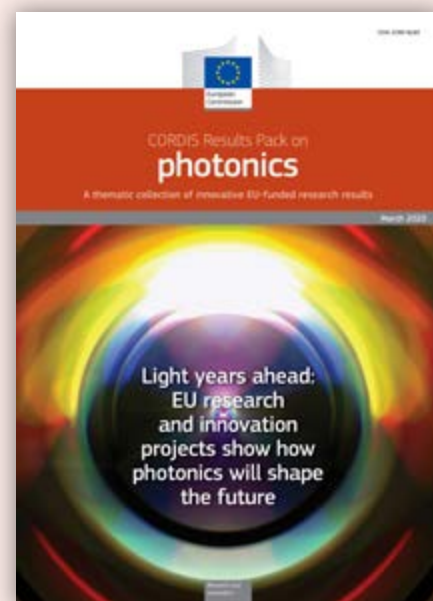
Photonics – the science of generating, controlling and detecting light – is the future. Just as the 20th century depended on the electron to witness advances in electronics and electricity, the 21st century relies on the photon to propel many scientific breakthroughs in different fields.

Where today’s conventional technologies are approaching their limits in terms of speed, capacity and accuracy, photonics offers unique solutions. It can revolutionise medicine by enabling quick, sensitive and accurate detection. Light-based technologies can also enhance energy conversion and conservation, lighting and high-quality manufacturing.

This CORDIS Results Pack features 10 of the most promising photonics projects funded by the European Research Council (ERC), the premier European funding organisation for excellent frontier research.

To find out more, browse, download or order a physical copy of the Results Pack here:

cordis.europa.eu/article/id/413590



Big Data replaces eyes for high-resolution corrosion assessment of oil rig structures

When it comes to oil rigs, structures in the splash zone are particularly vulnerable to corrosion. Automated analyses of inputs from multiple non-destructive inspection techniques in near real time will be an attractive alternative to current visual inspection.

Offshore oil wells are large, complex structures requiring significant investment. As operators work to extend the lifetime of their rigs, advanced non-destructive health monitoring of critical parts is essential. The conductor, the outermost casing providing structural support and protection to the hole that forms the well, is one of those parts.

Currently, technicians wearing a harness and suspended by a rope inspect conductors visually, but only above the waterline. The EU-funded ASPIRE (Assessment Strategy for Upstream Plant Inspection and Repair) project has automated that process with high-tech data analysis software able to assimilate different types of non-destructive

inspection (NDI) data. It promises to reduce the probability and consequences of failure, enhancing the competitiveness of the oil and gas industry.

WHERE SEA MEETS AIR

Structures in the splash zone are under attack from both the air and the sea. As Konrad Reber, Head of R&D at coordinating company Innospection Germany, explains: "Traditionally, a technician spot checks the wall thickness of a conductor at points above the waterline. Data is insufficient to yield a meaningful assessment. In addition, most defects are located at the air-water interface or below water, areas that cannot be reached by rope-access technicians and that are dangerous for divers due to waves."

ASPIRE takes advantage of advanced NDI technologies such as magnetic eddy current and ultrasonic corrosion mapping, which can be implemented via remote control at the waterline and below it. The project's decision support software assimilates data using open data formats. Payam Jamshidi, Team Manager of Asset Integrity Management at project partner TWI underlines: "The ASPIRE™ software package generates wall thickness risk data combining inputs from the various NDI techniques, making it possible to create a more complete and accurate picture of the asset's condition. This is used to calculate the probability of failure."

Sebastian Hartmann, Sales and Business Development Manager of Innospection, adds: "ASPIRE™ produces an assessment report and key indicator graphs regarding asset condition and remaining lifetime with the click of a button. The software can also rank several conductors by risk, enabling operators to prioritise repairs and optimise



service and maintenance scheduling.” The inspection data can be archived and compared to future results.

RIDING THE WAVE AND EXPANDING REACH

So far, ASPIRE has analysed the results from 86 conductor splash zone inspections to determine the typical profile of corrosion defects. In addition, as Reber explains, “the ASPIRE™ software package was tested by loading existing inspection data and comparing assessment results to manual assessments for a number of cases. Outcomes confirm that accurate asset integrity assessment and management can only be made based on automated inspection results.”

ASPIRE™ is now being used by client organisations to make informed decisions about well conductor maintenance and repair. In the future, the team envisions

application to other structures in the splash zone. Jamshidi summarises: “The new ASPIRE™ software package automates the inspection process, allowing easy upload of high-resolution data received from advanced and proven inspection techniques to provide an accurate integrity assessment of splash zone structures, thus filling a gap in the oil and gas industry.”

ASPIRE

- Coordinated by Innospection Germany GmbH in Germany.
- Funded under H2020-Societal Challenges and H2020-Industrial Leadership.
- cordis.europa.eu/project/id/760460
- Project website: aspire-analysis.com
- ▶ bit.ly/2yBphvw

ENERGY

Understanding psychological, socioeconomic and financial factors that influence energy efficiency

Even though Europe is performing better than other industrialised countries with respect to energy efficiency, it's falling slightly short of its promise to cut greenhouse gas emissions by at least 40 % by 2030. An EU initiative analysed consumer energy-related behaviour to improve the development of future energy efficiency policies.

Energy saving through energy efficiency is crucially important because it contributes to a variety of benefits, including the reduction of greenhouse gas (GHG) emissions, one of the pillars of the Paris Agreement. Drawing up energy efficiency policies will ultimately help meet the required EU energy savings targets. “However, energy efficiency doesn’t only depend on the availability of cheap technologies or policy interventions, it’s largely influenced by the behavioural choices of users,” says Cristina Cattaneo, coordinator of the EU-funded PENNY (Psychological, social and financial barriers to energy efficiency) project.

PENNY studied the psychological, social, economic and financial factors that influence energy efficiency in the residential sector. It addressed two distinct decisions in the energy efficiency space: energy usage and adoption of energy-efficient products.

THE ROLE OF INDIVIDUAL BEHAVIOUR IN ENERGY EFFICIENCY

In cooperation with energy companies and retailers from different EU Member States, the PENNY team applied an



innovative methodology in conducting field experiments. This was done to test the effectiveness of behavioural interventions aimed at influencing both energy use and investment decisions. The first is behaviour related to energy reduction that represents a routine, repetitive effort to decrease consumption on a day-to-day basis. The second is behaviour concerning investments that are one-time actions, such as purchasing new energy efficiency products like energy savings and light emitting diode lightbulbs or A+++ refrigerators.

One of the main findings was that information barriers are an important constraint of energy efficiency. “However, to fill in the knowledge gap of individuals, not all types of information interventions are effective,” explains Cattaneo. “Policy-makers should be aware that the format in which the information is presented is a strong moderator of the effectiveness of information policies.”

Project partners also compared the acceptability of different types of policies. They found that policies targeting energy efficiency investments are more accepted by consumers than policies targeting reduction in consumption.

FUTURE POLICIES TO MAXIMISE ENERGY-EFFICIENT BEHAVIOUR

Lastly, the researchers emphasised that financial motivations aren’t the sole drivers of energy efficiency behaviour. There are a variety of barriers pertaining to individual behaviour – status quo bias, bounded rationality, reference-dependent preferences and strong environmental

“Energy efficiency doesn’t only depend on the availability of cheap technologies or policy interventions, it’s largely influenced by the behavioural choices of users.”

preferences – that can’t be addressed using only economic and regulatory instruments. “The complexity and variety of barriers relating to individual behaviour call for increasing insight from behavioural economics,” adds Cattaneo. “This final result demands additional effort in studying consumer behaviour in order to design effective policy interventions in the energy efficiency domain.”

“PENNY has advanced the understanding of consumer decisions in relation to both the use of energy and adoption of energy-efficient technologies,” concludes Cattaneo. “It will contribute to supporting the development of energy efficiency strategies, policies and programmes across Europe.”

PENNY

- Coordinated by the Eni Foundation Enrico Mattei in Italy.
- Funded under H2020-ENERGY.
- cordis.europa.eu/project/id/723791
- Project website: penny-project.eu



LIFE AFTER...

Catching up with ALISA: A continued emphasis on international cooperation and innovative research for better nuclear safety

In our special feature on nuclear power in April 2019, we met Xiaoyang Gaus-Liu, technical coordinator of ALISA (Access to Large Infrastructures for Severe Accidents), a project that had at its heart the aim of better cementing European and Chinese cooperation in the field of nuclear safety and new research opportunities. We reconnect with her to see how she has been continuing her work over 1 year later.

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Without a doubt, fostering better cooperation and collaboration between Europe and China in her field seems to be an important professional drive for Gaus-Liu. “Since the end of ALISA, I’ve been continuing to extend established cooperation with Chinese organisations on a more bilateral basis with my organisation, the Karlsruhe Institute of Technology (KIT), as the know-how we’ve accumulated from both our past and current research work is of high interest to Chinese stakeholders,” she comments.

The challenges of Chinese cooperation

She has also submitted follow-up project proposals for EU funding that would also

include the cooperation with various Chinese organisations. “However, alas, I’ve yet to be successful in this regard,” she admits. “Part of the reason is because there is no real tradition of cooperation amongst Chinese organisations, and also the Chinese government will usually promote a key research lab or institute for a large project. This makes it more of a challenge to organise several Chinese partners inside one project and consequently, it’s more difficult for an EU coordinator to balance the interests between the Chinese partners.”

Admittedly from the EU side, there are also further

administrative considerations to take into account when planning to include a Chinese partner in an EU-funded consortium, due to China and the EU’s very different legal regimes.

However, Gaus-Liu and her team continue to participate in other EU-funded projects, such as IVMR and ESFR-SMART.

Continued scientific success

Meanwhile, on the scientific front, things are going well for Gaus-Liu. Following the end of the ALISA project, she and her team have successfully performed two test series of multi-layer melt pool heat transfer tests in a LIVE-2D test facility, related to the in-vessel melt retention Severe Accident Management strategy (for nuclear power plants).

“This was the first of its kind worldwide that demonstrated the heat transfer process in a melt pool with self-separated layers, and crust formation between the layers,” she says. “Thanks to the transparent front wall of the test facility, this whole process can be directly optically observed and will be of important scientific relevance for further nuclear research in the field of safety.”

ALISA

- Coordinated by the Karlsruhe Institute of Technology in Germany.
- Funded under FP7-EURATOM-FISSION.
- cordis.europa.eu/project/id/295421

“I’ve been continuing to extend established cooperation with Chinese organisations on a more bilateral basis with my organisation, the Karlsruhe Institute of Technology (KIT), as the know-how we’ve accumulated from both our past and current research work is of high interest to Chinese stakeholders.”



Antarctic pre-drilling survey prepares for the climate lessons of 'Oldest Ice'

Ice cores offer the only directly accessible archive of past atmospheric compositions. BE-OI has identified a promising drill site in Antarctica for 1.5 million year-old ice which could give up secrets about the Mid-Pleistocene Transition and so teach us about future climatic scenarios.

During the Mid-Pleistocene Transition (MPT), around 0.9 to 1.2 million years ago, glacial and interglacial cycles changed from being 40 000 to 100 000 year cycles. One theory is that the climatic shift happened as the Earth responded to changes in the orbit and inclination of its path around the sun ('orbital forcing').

So far, lack of evidence about the atmospheric composition of the period thwarts firm conclusions. Analysing climate proxies in the ice records could yield information about the impact of these changes, in particular greenhouse gases, on the climate system.



“Solving one of the most enigmatic riddles of the climate system – Why did the glacial/interglacial cyclicity change during the Mid-Pleistocene Transition? – will improve our understanding of how the climate system works.”

The EU-supported BE-OI (Beyond EPICA – Oldest Ice) project was established to identify a drilling location from which future drilling, as a continued part of the Beyond EPICA project, could obtain the first high-resolution climate records older than 800 000 years old.

The EU's coordination and support action enabled the team to locate just such a site, where ice approximately 1.5 million years old is undisturbed and of sufficient resolution, about 40 km away from the Italian-French station, Concordia. The team are now preparing for the drilling phase.

QUALIFYING SITES AND VALIDATING THEIR ICE AGE

Given the vast expanse of the East Antarctic Ice Sheet, the BE-OI consortium focused on more accessible regions with permanent stations – specifically those around Dome C, as well as in Dronning Maud Land, near Dome Fuji. Both locations are known to host ice at least 700 000 years old.

To gauge the age of ice cores, the team used radar to measure, in high resolution, ice thickness and so determine the topography (the internal stratigraphy) of the bedrock underneath the ice sheet.

Repeated radar also determined the vertical velocity of the ice (how fast it moves downwards) and estimated the geothermal heat flux from the bedrock underneath. This is critical to determining the rate of melting at the base of the ice sheet.

A rapid-access drilling technique was used to measure boreholes' temperature distribution, providing estimates for the age of the ice in the upper part of the ice sheet.

The combined data informed ice-flow models, used to estimate age for those depths hitherto unknown.

“Encouragingly, one of our best radar systems, deployed last season, observed a stagnant layer of ice at the base, not clearly visible before. Independently, our updated version of the ice-flow model also predicted this. Both predicted the same thickness – with the age of the ice reaching 1.5 million years at the top of the basal layer,” recalls Olaf Eisen, project coordinator.

CARBON CYCLE-CLIMATE FEEDBACK MECHANISMS

BE-OI was pursuing an objective developed by the International Partnerships for Ice Core Sciences (IPICS) to explain what caused the MPT and as a pointer to long-term carbon cycle-climate feedback mechanisms. The former EPICA consortium took on the challenge by providing BE-OI as the European contribution.

In the coming Antarctic field season (November 2020 to January 2021), the BE-OI drill system will be set up, preparing the hole for the casing in the firn (snow left from past seasons) column. Researchers will then be able to measure specific greenhouse gas levels in air bubbles.

“Solving one of the most enigmatic riddles of the climate system – Why did the glacial/interglacial cyclicity change during the MPT? – will improve our understanding of how the climate system works, especially the role of greenhouse gases, such as carbon dioxide and methane. This is vital to reliably predict the long-term future of our climate,” explains Eisen.

BE-OI

- Coordinated by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research in Germany.
- Funded under H2020-ENVIRONMENT.
- cordis.europa.eu/project/id/730258
- Project website: beyondepica.eu/en

What global warming and efforts to adapt mean for human health

Rising temperatures caused by a changing climate will have a big impact on Europeans' state of health in the coming years. To be prepared, health planners and policy-makers need to know how higher temperatures are already affecting our health and how much moves to adapt can help.

Most projections of the number of deaths due to a warmer Europe, known as heat-related mortality, do not take into account the fact that adaptation is already happening. For this reason they may be an overestimation, according to Joan Ballester, assistant research professor of climate and health at the Barcelona Institute for Global Health or ISGlobal.

With the support of the Marie Skłodowska-Curie programme for his project ACCLIM (Acclimatization scenarios and early warning system of temperature-related mortality in Europe), Ballester has spent the last 2 years producing a more accurate picture. He studied the recent trends in heat-related mortality and the theoretical decrease in this number due to adaptation together.

"There are big efforts to adapt to climate change in terms of both mitigation and adaptation, we need to know if it is worth it. If not, we need to rethink," he says.

The dataset includes records of daily temperatures and deaths in 150 regions of Europe from 1998 to 2012. Analysing the information per country has allowed Ballester to see in which countries adaptation is working best. This insight could help shape future strategies and might be helpful for people needing to project Europe's future health burden.

MITIGATION IS KEY

Ballester found adaptation to rising temperatures is certainly happening across Europe, but that the effects of the higher temperatures themselves cancel out the gains.

"Every year we are less vulnerable to a given temperature, but as temperatures are increasing, the number of deaths is constant," says Ballester. "We are decreasing the vulnerability

but not the mortality. Only if we can limit the magnitude of climate change will we get to see real benefits," he believes.

Introducing GDP as another variable and looking at the differences between countries since the 2008 recession, produced some surprises.

"We would normally expect economic growth to closely relate to well-being, but the countries which felt the economic shutdown less were the ones that experienced an increase in mortality," adds Ballester.

While the number of heat-related deaths decreased by 1.54 % per decade in Spain and by 1.96 % in Italy between



2008 and 2012, in Germany it actually increased by 0.37 % and in Poland by 2.25 % over the same period.

DIRTY AIR NOT GDP

This suggests that heat-related mortality is pro-cyclical – it goes up during periods of economic expansion – but does not mean that an increase in GDP will directly cause more deaths.

More economic and industrial activity is associated with higher levels of air pollution in cities, which would seem to indicate dirty air is the main culprit. Other factors contribute – in times of prosperity, people drive, drink and smoke more, whereas an economic downturn tends to limit people's unhealthy habits.

"I am not saying we should reduce economic growth because this will reduce mortality. The effects of austerity come several years later, and they might have an impact. The message is that we should reduce air pollution in cities so that economic growth is compatible with a healthy population," explains Ballester.

“ Every year we are less vulnerable to a given temperature, but as the temperatures are increasing, the number of deaths is constant – we are decreasing the vulnerability but not the mortality. ”

The climatologist will broaden the scope of his investigation in his next European Research Council funded project EARLY-ADAPT by looking at temperature and the role of 11 environmental factors in mortality.

ACCLIM

- Coordinated by the Barcelona Institute for Global Health in Spain.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/737480
- Project website: isglobal.org/en/-/clima-y-salud

CLIMATE CHANGE AND ENVIRONMENT

Closed loop toilet can turn urine into treated water

A new kind of public toilet, designed by a French start-up, combines the power of biological and electrochemical processes to reduce the waste of resources in some countries, and the lack of facilities in others.

For the user, the equipment, developed by WeCo, looks and functions like a normal flush toilet. But a separate section at the back of the installation houses a series of tubes and tanks which can treat the waste or black water and return it as clean water for the next flush within a mere 2 hours. Working as a closed loop system, it recycles the water and avoids the need for a costly connection to the sewers.

During the summer and autumn of 2019, developers WeCo received a helping hand via EU funding for the RecyclLoo (The water recycling bio toilets) project.

Black water from the toilet goes through a macerating pump into a small tank. Here bacteria eat and reduce the faecal sludge, and sedimentation sends any remaining solid matter to the bottom. The liquid passes through a filter into a second chamber where an electrochemical reaction kills the bacteria, produces chlorine and clarifies the water to produce clean treated water.

PRODUCING A SURPLUS

After passing through a second filter, what is left is clean treated water available for flushing once more. "It

is actually the quality of drinking water, but I doubt we would get the cultural acceptance and the legal authorisation to use it for that,” says WeCo CEO and founder Cécile Dekeuwer.

She explains that any surplus can be used for watering plants or cleaning the toilet since the electrolysis produces detergent which can be reused onsite.

While working as a lawyer advising start-ups in South-East Asia, Dekeuwer was impressed by the level of innovation of Japanese toilets and started on a 2-year search for new inventions.

Inspired by research from the California Institute of Technology in the United States, WeCo came up with its own technology and worked with a major train manufacturer to further develop the system.

EU funding for RecycLoo in 2019 has helped WeCo conduct a study of the potential market and prepare a business plan aiming to raise EUR 2 million for expansion. The company has also been able to file patents covering France and Europe.

INNOVATION AND EFFICIENCY

Biological treatment of human waste only functions within a set temperature range and takes time to produce uncertain results. Using solely an electrochemical reactor

“ So the major innovation is the way we have combined and made secure the benefits of biological treatment with the certainty and efficiency of electrochemical treatment and also enhanced and scaled up the technology ready for commercial production. ”

on black water produces gas which is potentially explosive if not handled with care.

“So the major innovation is the way we have combined the benefits of biological treatment with the certainty and efficiency of electrochemical treatment,” says Dekeuwer. “We have also enhanced and scaled up the technology ready for commercial production.”

The team is going to stress test the system at 300 000 cycles so they will soon have information on the durability of the equipment. “The tests will also enable us to assess how the composition of the water is impacted by chlorine and chemical reactions,” she adds.

During 2020, five WeCo toilets, housed in recycled shipping containers, will join the first two installed in France in 2019. The system will be adapted to the ISO standard for Africa, and buyers from Germany, Cameroon and Senegal are showing interest.

RECYCLOO

- Coordinated by WeCo in France.
 - Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT.
 - cordis.europa.eu/project/id/867076
 - Project website: en.weco-toilet.com
- ▶ bit.ly/38jYYO





SPECIAL FEATURE

A QUANTUM LEAP FORWARD FOR EUROPEAN FUNDAMENTAL RESEARCH

Editorial

“If you are not completely confused by quantum mechanics, you do not understand it” – John Archibald Wheeler, theoretical physicist

Up until a few years ago, quantum technologies were the reserve of science-fiction and the excitable minds of physicists who were determined to bring them from the realm of theory to the realm of reality. Now, there are very high hopes that the first quantum supercomputers will appear within the next few years, potentially before even the end of the current decade.

Quantum computers are arguably the most visible of the technologies of the emerging quantum revolution but what are they? The clue is in the name – a quantum computer utilises the laws of quantum mechanics, a theory that describes physical phenomena on the atomic scale. They allow for a specific particle, such as an atom, to exist in a different state at the same time – known as ‘superposition’. From a practical perspective, the quantum computer trumps a conventional computer because a conventional computer uses bits to code information that can take the form of only one value, either 0 or 1, whereas the quantum computer uses qubits that can *simultaneously* take the values of 0 and 1. Furthermore, when two qubits interact, they are no longer fully independent and are thus in a state of ‘entanglement’.

Why is all this so important? Because thanks to both superposition and entanglement, a quantum computer in theory has access to all of the possible results of a calculation in a single step, a feat that a conventional computer could never achieve because it is built in a way in which it must process each piece of information separately, one after the other. This makes the quantum computer phenomenally more powerful and leaves its conventional cousins behind in the dust.

But the promise of quantum is not just limited to raw computing power – researchers across Europe are also working

to utilise and apply quantum effects to realise fundamentally superior performance and capabilities in communications, the medical sector and life sciences, metrology, robotics and AI, simulation technologies and cybersecurity, to name just a few. Because of the expectation that quantum technologies will eventually permeate into many of the systems and sectors that we rely on today, the EU views quantum technologies as a field of major strategic importance, for governments, businesses and citizens.

Of course, to ensure Europe's place as a world leader in unlocking the power of quantum technologies, supporting innovative research is an absolute must. Luckily, there is already a 20-year record of excellence for European research efforts in the field. Building upon this legacy, EU funding for quantum research has continued to be a high priority through the Horizon 2020 programme. EU research funds are supporting numerous projects across Europe with many having the goal of bringing commercial applications to market. The EU has also created the Quantum Technologies Flagship, a 10-year research and innovation initiative that began in 2018 and will see up to EUR 1 billion in funding over the course of its lifetime.

Whilst we would happily feature dozens of projects based within this exciting field, as usual we only have space for seven in our special feature, but we hope they give our readers a good snapshot of how the quantum revolution is already beginning to play out and bear fruit.

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

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Silicon technology for large-scale quantum processors

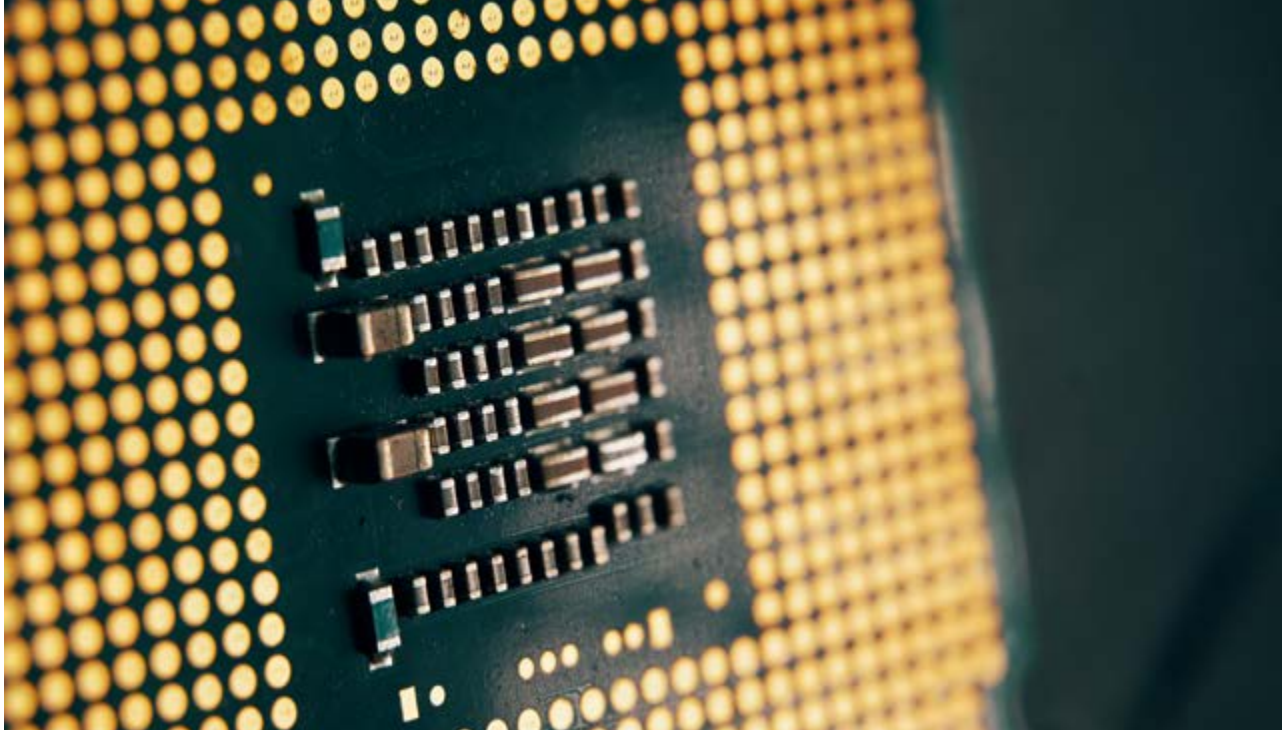
Being able to use silicon technology to create the new generation of quantum processors would be a welcome plus for the sector, as it would allow for the use of already existing CMOS production lines. The MOS-QUITO project set out to make this possible in the near future.

Quantum computing may offer a whole new world of possibilities, but it's also a Herculean challenge. Researchers and engineers had to go back to the drawing board and revolutionise the way processors are built.

In this context, any already proven technology that can be used to advance research is somewhat of a blessing. The MOS-QUITO (MOS-based Quantum Information Technology) project focused its attention on one of these to create scalable quantum processors: silicon technology. The team's ambition is to demonstrate that silicon-based qubit devices can be entirely fabricated using an industry-compatible CMOS platform. They also looked into the possibility of developing traditional CMOS electronics capable of operating at very low temperature and serving as control hardware for quantum processors.

"The project builds upon years of basic research. These have provided us with an important understanding of low-temperature (sub-Kelvin) electronic properties of silicon metal-oxide semiconductor transistors and, more specifically, transistor devices based on silicon-on-insulator technology," says Silvano De Franceschi, coordinator of the project on behalf of the French Alternative Energies and Atomic Energy Commission.

The project's rationale is that the use of silicon technology for quantum computing can actually leverage the large-scale integration capabilities of an already well-established industry. As De Franceschi points out: "The purpose of quantum computers is to solve practical problems that current ones couldn't possibly handle, and for that they require a very large number of physical qubits. Leveraging silicon technology seems like a compelling option to realise this vision."



“By sharing the same CMOS technology, qubits and at least part of the control electronics could even be co-integrated on the same chip.”

Over the course of the project, De Franceschi and his team designed and tested a variety of silicon spin qubits – qubits relying on the spin degree of freedom of a localised electronic charge to hold quantum information for a very long time. From there, they took advantage of a 300-mm CMOS fabrication line in Grenoble. They wanted to demonstrate that high-quality silicon spin qubits can be manufactured using industry-standard CMOS processes within a large-scale nanofabrication facility.

It wasn't an easy process, as De Franceschi explains: “The main difficulties were encountered at the level of device fabrication. Some new fabrication processes had to be developed, and unexpected fabrication issues resulted in some delay. We also suffered from delays due to equipment problems.”

MOS-QUITO's other important objective consisted in developing a toolkit of CMOS-based devices such as low-noise amplifiers, circulators and multiplexers. Eventually, these could be used as low-temperature peripheral electronics for improved qubit control and readout. “By sharing the same CMOS technology, qubits and at least part of the control electronics could even be co-integrated on the same chip. This unique opportunity could be particularly helpful for the development of fast and scalable readout circuitry,” De Franceschi points out.

WORK IN PROGRESS

The project has been particularly fruitful, with a total of 55 publications and seven patents introduced. Besides demonstrating and studying the first qubit-based CMOS technology, the project released proof-of-concept demonstrations of several cryo-CMOS circuits with a variety of functionalities. This work is essential for the development of large-scale quantum computers, as quantum information stored in qubits can rapidly degrade and become unusable if not cooled down to temperatures close to absolute zero.

Other achievements include the development and optimisation of spin readout techniques based on: RF gate reflectometry; improved understanding and use of electric-dipole spin resonance for both holes and electrons; and initial results on charge control in silicon CMOS-based quadruple quantum dots.

Although MOS-QUITO was completed in September 2019, work continues in two follow-up projects. These projects, an ERC Synergy project named QuCube and a Quantum Technology Flagship project called QLSI, both aim to take silicon qubits closer to scalable quantum computing.

MOS-QUITO

- Coordinated by the Alternative Energies and Atomic Energy Commission in France
- Funded under H2020-LEIT-ICT
- cordis.europa.eu/project/id/688539
- Project website: mos-quito.eu

Schrödinger's cat meets magnetomechanical platforms

We know that quantum sensors, as they become available, will surpass their traditional counterparts in almost every way. But how do we actually observe and quantify these benefits? Meet the new technology platform by MaQSens.

Quantum sensors are among the most exciting applications of quantum physics. The Pentagon wants them on future satellites, navigation service providers see in them the future of GPS, and yes, even doctors could one day rely on quantum sensors to detect early signs of disease. But while the possibilities seem limitless, researchers still need improved technology platforms to conduct experiments.

Specifically, the MaQSens (Magnetomechanical Platforms for Quantum Experiments and Quantum Enabled Sensing Technologies) project aimed to develop a platform capable of answering a crucial question: How can we use quantum features or methods from quantum physics to enhance our present sensing capabilities? It particularly focused on inertial sensors, which are used for the likes of seismological event measurements and navigation.

"Answering this question calls for a high level of control over an object that is susceptible to external forces," says Markus Aspelmeyer, co-coordinator of the project on behalf of the University of Vienna. "Quantum computing has pushed the development of superconducting elements for quantum control at a breathtaking pace, and similar developments have been seen over recent decades in the domain of nanomechanics. With MaQSens, we combine these developments. We use them in a platform that provides access to quantum control of much larger masses than previously possible, and therefore push the frontiers of inertial sensing."

The founding fathers of quantum theory (remember Schrödinger's cat?) knew it all too well. Demonstrating quantum effects for large or even massive objects is the Holy Grail of quantum science, and devising a platform to that effect would be an incredible breakthrough.

A SUPERCONDUCTING SPHERE

To get there, the project team uses small superconducting objects as extremely sensitive probes for forces and accelerations. As Aspelmeyer points out, the main innovation lies in the project's combination of different ideas



and technologies including nanomechanics, atomic physics and even quantum computing to control the quantum properties of object motion on a chip-scale platform.

"We start with a superconducting sphere that is a few hundredths of a millimetre across," explains Michael Trupke, a Senior PostDoc who was also actively involved in the project. "We attach this sphere to a small mechanical beam or levitate it using magnetic fields that are generated by superconducting coils. The sphere is kept close to another coil that is connected to a so-called superconducting circuit, which acts as an external quantum system. In that way the sphere's motion is coupled to the circuit, meaning that both can influence each other."

From there, the team can use interaction with the quantum system to control the motion of the sphere in the quantum regime. They aim, for example, to cool it to a level where its motion is only dominated by quantum fluctuations. "At the same time, we can use the quantum circuit to read out the motion of the superconducting sphere. Any additional displacement, for example due to motion of the whole apparatus or due to some external force, can therefore be sensed with extreme sensitivity. All of this is integrated in a miniature chip-scale architecture only a few square centimetres in size," Trupke continues.

“The next important milestone is to exploit the already demonstrated coupling to the superconducting quantum circuits in order to enter the regime of quantum sensing.”

NEXT STOP: THE QUANTUM SENSING REGIME

Now a few months away from completion, the project has already led to the development of several platform prototypes. The team has notably achieved the levitation of a microscopic superconductor with almost no damping, which is a necessary precondition for inertial sensing. Eventually, this will allow unrivalled control for quantum sensing combined with unique access to the large mass regime.

“The next important milestone is to exploit the already demonstrated coupling to the superconducting quantum circuits in order to enter the regime of quantum sensing.

All of the team's efforts are focused on this right now,” says Aspelmeyer.

In the long run, Aspelmeyer and Trupke anticipate a large impact in domains such as avionics and space, where the strong requirements for inertial sensors still pose unresolved challenges to existing technologies. They also hope that the MaQSens platform will enable a completely new generation of fundamental physics studies of macroscopic quantum phenomena, not the least of which are quantum effects under the influence of gravity.

MAQSENS

- Coordinated by the University of Vienna in Austria
- Funded under H2020-FET
- cordis.europa.eu/project/id/736943
- Project website: maqsens.univie.ac.at

Maintained coherence for better quantum information applications

How do we prevent decoherence in quantum information technology and, in turn, create more advanced applications? This question is at the heart of the MQC project, which investigated ways to maintain coherence in quantum systems.

With Moore's Law soon to hit a wall, all eyes are on quantum information technology. We're not too far off: quantum architectures such as trapped ions, colour defects in crystals and Rydberg atoms are already available and can be used to implement quantum information applications.

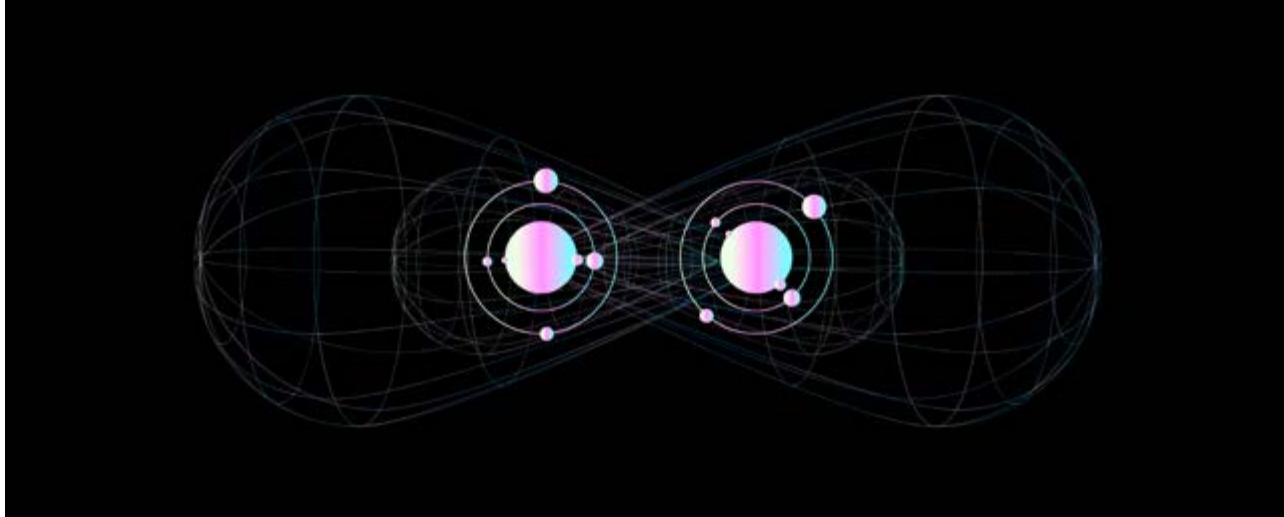
From there, the principle is simple at least on paper: the longer quantum coherence can be maintained, the richer and more interesting quantum applications get. In other words, quantum physicists are in need of new approaches preventing decoherence due to noise, leakage and decay channels.

Itzik Cohen has investigated ways to maintain this coherence and realise a variety of quantum applications under the MQC (Maintaining Quantum Coherence for Quantum Information Applications) project. The Marie Skłodowska-Curie fellow agreed to discuss his approach and findings with us.

Your work focuses on quantum coherence. Why is it important for the future of quantum computing?

Itzik Cohen: In physics, coherence is maintained as long as waves preserve their relative phase, thus enabling the interference phenomenon. The same applies to quantum coherence, which is maintained when the quantum superposition (phase and amplitude) is kept stable.

Quantum coherence is at the heart of quantum information technology. The latter can only be realised as long as quantum coherence is preserved. In fact, as quantum applications increase in complexity, coherence time needs to be extended. In a similar manner, longer coherence times reveal higher performance and higher quantum operation fidelity, which is extremely important especially for quantum computing.



How do you achieve such coherence?

To maintain coherence, one should overcome noise, leakage and decay channels that constitute the main sources of decoherence. Refocusing techniques such as dynamical decoupling and quantum error correction have been developed specifically to this end.

The field of dynamical decoupling was born with Hahn's idea to refocus inhomogeneous broadening in Nuclear Magnetic Resonance (NMR). This effect was named Spin Echo. It is currently used in many areas of physics, from atomic systems to condensed matter. Breakthroughs in this field have given us the ability to initialise, manipulate and detect the state of a qubit with extremely high precision. Even more impressively, it enabled the prolongation of the coherence time of qubits by many orders of magnitude. A complementary approach to pulse dynamical decoupling is the continuous one: A continuous resonant driving field opens an energy gap that protects against the slow power spectrum of the decoherence source.

The field of quantum error correction, on the other hand, was born with Peter Shor's syndrome measurement and feedback algorithm. In Shor's algorithm, a single computational qubit is described by 9 real qubits, and noise is detected by measurements which may preserve the qubit subspace intact. Then one can apply feedback operations and invert the noise process. Note that as the QEC protocols demand more resources, it is experimentally preferable to use DD schemes when possible.

What would you say makes the project's approach particularly innovative?

Utilising refocusing schemes to maintain quantum coherence depends on the noise sources that vary between each quantum platform, and each experimental setup. Naively using this protecting intervention might also refocus and destroy the desired quantum application.

Overcoming this difficulty makes my projects particularly innovative, since a great deal of creativity has to be taken in order to obtain the noise compensation while realising the desired applications.

How did you proceed to solve problems with quantum communications platforms?

In a previous project, we theoretically proposed a scheme for entanglement distribution in quantum networks. By sending a single photon between quantum nodes – each consisting of an atomic qubit embedded in a cavity – we manage to generate a multi control phase gate between the atoms. This is an important universal gate, needed for quantum search protocols. One of the experimental obstacles lies in maintaining the optical phase of the photon due to optical length fluctuations. We overcame that problem by sending multiple photons to the quantum network: We used a pulsed version of dynamical decoupling to refocus the random optical phase.

More recently, in a theory-experiment collaboration with the Weizmann Institute group led by Ofer Firstenberg, we demonstrated that continuous dynamical decoupling can be applied to protect a collective excitation in warm atoms against Doppler broadening. When a photon (or a weak coherent pulse) is absorbed by atomic vapour, this global atomic excitation performs as a spin wave. Each atom possesses a phase according to its position, and the momentum of the absorbed photon. Due to random atomic velocities, the global excitation is subjected to Doppler decoherence that destroys the desired atomic phase.

To tackle this, we introduce an additional ancillary sensor state, having an opposite sensitivity to the same Doppler mechanism. By smartly driving the transition between the excited and sensor states, we couple them and obtain a protected dressed state that is insensitive to Doppler noise. The coherence time is prolonged.

What are, according to you, the most important outcomes of these two projects so far and why?

Both projects are important to the field of quantum information technologies. Both have many further applications, and can lead to more enriching research. However, as a theoretician, I think that any theoretical proposal that matures to be experimentally realised is eventually more important than the ones that do not. For that reason, I think that the experiment-theory collaboration in the second project is more important. This is true at least for now, until the first project is realised experimentally.

In the long run, what do you hope will be the impact of your research on quantum computing? What applications do you foresee?

Rydberg atoms have recently become an interesting candidate as a quantum computation platform. Our scheme can be used to protect against Doppler decoherence, while still effectively populating the Rydberg states that are needed for generating interactions between different atoms. Therefore, I am sure that our scheme will be useful for upcoming experiments in quantum computing with Rydberg atoms.

Scaling quantum computation over a large number of qubits remains one of the main challenges of quantum information processing. Using our scheme for entanglement distribution in quantum networks goes hand-in-hand with the concept of a hierarchy quantum computer, where each quantum node is a quantum computer of a few qubits. I am therefore convinced that, even though our



Itsik Cohen,
© Itsik Cohen

“Our scheme can be used to protect against Doppler decoherence, while still effectively populating the Rydberg states that are needed for generating interactions between different atoms.”

scheme has yet to be verified experimentally, it eventually will be.

Can you tell us more about your follow up plans, if any?

There are many options. One of them is to pursue academic research in the field of quantum technologies. On the other hand, there are many companies outside academia where I can also contribute. I haven't quite decided yet!

MQC

- Coordinated by Aarhus University in Denmark
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/785902

Superposition of operation orders for more efficient quantum computing

Experimental demonstrations of quantum computation still have a long way to go. The InCaSQuC team is convinced that a promising avenue resides in the superposition of operations enabled by quantum mechanics. They have been devising a quantum switch to showcase the scalability of this approach.

Ever heard of quantum switches? If not, suppose that you need to perform a computation involving two operators (A and B). Instead of choosing between order AB and BA, a quantum switch can go for both orders simultaneously by superposing them – making for a more efficient computation.

This is perhaps one of the most promising pathways for quantum computing. While quantum computation usually increases speed by placing quantum bits (qubits) by superimposing different states, quantum mechanics allows for going a step further by enabling the superimposition of both states and operations. In other words,

tasks can be completed with fewer operations than with any other known quantum algorithm.

MORE COMPLEX THAN JUST A, B, C

But what if the computation involves three operators instead of two? Suddenly, things become more complex. “In the A, B, C situation, the options are much wider. Do we mix orders ABC and ACB, or maybe just CBA and ABC? There are 57 options in total,” says Nadia Belabas, coordinator of the InCaSQuC (Indefinite Causal Structures on an Integrated Silicon Platform for Applications in Quantum Computing) project on behalf of C2N – a joint laboratory of CNRS and the University of Paris Saclay.

Together with Marie Skłodowska-Curie fellow Lorenzo Procopio, Belabas has set out to achieve such scalability. They specifically investigated how integrated and fibred optics could enable the creation of a quantum switch for more than two operations.

“We are talking about a complex quantum circuit combining a source of quantum light with operators A, B and C. It should be able to implement and switch between the different possible routes by following the principles of quantum mechanics. Experimentally, this poses similar difficulties to implementing any circuit for quantum light: detrimental losses,” explains Procopio.

InCaSQuC’s first merit lies in the theoretical demonstration of these complex conditions, in which a quantum switch needs to handle more than two operations. In the context of quantum communication, for instance, the team could elaborate on a pioneering study from researcher Giulio Chiribella which had showed how putting two noisy channels in an indefinite order counterintuitively allowed for the transmission of information. “We have shown that this effect gets stronger when all six possible orders of three channels are superimposed, but also when a lower number of orders is used,” Procopio notes.

“If we can demonstrate the necessary key elements – such as frequency-encoded quantum operations on appropriately bright sources – it would be a decisive step towards a scalable, integrated and fibred version of the quantum switch.”

INSPIRED BY, BUT NOT LIMITED TO, SILICON PHOTONICS

To implement these ideas, the project team drew inspiration from recent progress in silicon photonics. “Silicon photonics is a mature technology for active and passive devices,” Belabas explains. “We are collaborating closely with teams at C2N and InPhyNi who have developed beyond-state-of-the-art filters and sources in the telecom regime. We are especially interested in the high dimension of the frequency space accessible with these sources.”

Although ultimately all functionalities can be achieved on chip and high quality samples are made available through foundries, the InCaSQuC approach stands out because it can also be achieved with off-the-shelf telecom components. As Procopio points out, “Silicon is indeed a very promising horizon, but we want to focus on the implementation of indefinite causal order regardless of the platform.”

With 3 months to go before its completion, InCaSQuC enters its most crucial phase. Whether an experimental demonstration will be achieved remains to be seen. As Belabas notes, a fully scalable implementation of the quantum switch in a multi-operation scenario is particularly challenging even in the absence of a pandemic crisis. “We need to control many experimental parameters and the cumulative losses of each element. If we can demonstrate the necessary key elements – such as frequency-encoded quantum operations on appropriately bright sources – it would be a decisive step towards a scalable, integrated and fibred version of the quantum switch,” she says.

Should such demonstrations take place, the superposition of operators will undoubtedly become a serious option in the future implementation of quantum computing.

INCASQUC

- Coordinated by CNRS in France
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/800306



Quantum processing scales up and bursts out from theory to reality

The VLS-QPP project has been working on a new generation of quantum photonics processor and the algorithms to fully exploit its capabilities. Potential applications range from medical science to data security.



neural network, which requires hybrid interfacing of our technology with commercially available advanced photonic circuits (PICs). This is a key development currently taking place.”

One of the key projects hosted by Lodahl is a Marie Skłodowska-Curie fellowship named VLS-QPP (Very-Large-Scale Quantum Photonic Processing). The project aims to develop the next generation of quantum optical technology. It does so through symbiotic development of hardware and algorithms, and by using the silicon photonics platform.

PIONEERING QUANTUM PHOTONIC PROCESSORS

The Marie Skłodowska-Curie Global Fellow leading the programme, Jacques Carolan, says that VLS-QPP aims to add the missing ‘quantum’ components to existing ‘classical’ hardware: “While commercial technologies like silicon photonics offer unprecedented scale and complexity, they lack key quantum functionality.” VLS-QPP is developing the next generation of very-large-scale quantum photonic processors by augmenting existing classical optical technology with new quantum componentry.

“The main enablers of the project are single-photon sources and coherent photon-emitter interfaces. The latter has enabled us to demonstrate giant photon nonlinear operations sensitive at the level of single photons. This is a key enabler and hitherto missing component for photonic quantum gates. It enables quantum computing and quantum communication,” Lodahl explains.

VLS-QPP’s main innovation lies in its use of planar technology to couple photons with nanophotonic circuits. Unlike most other approaches which use vertical structures where photons are coupled off-chip, the planar technology is scalable to create advanced photonic circuits where functionalities can be integrated directly on-chip. “Our technology is being commercialised in the spin-out company Sparrow Quantum founded from my group,” says Lodahl.

“These are exciting times for quantum photonics.” For 3 years now, Peter Lodahl, Head of the Quantum Photonics Group at the University of Copenhagen, has been observing the steady materialisation of quantum hardware building blocks, and he’s clearly optimistic about the future. With every new building block, the world gets closer to the first generation of quantum computing, communication and precision sensing devices.

Lodahl has actually been much more than an observer. He also supervises a group of about 30 scientists working on quantum photonics technology.

“Our group has specialised in developing deterministic and coherent single-photon sources and photon-emitter interfaces of sufficiently high quality to be scaled up,” he explains. “We now leverage this know-how and technology by applying photonic resources in advanced quantum-information processing. We are heading towards photonic quantum simulations and a quantum photonic

“We are heading towards photonic quantum simulations and a quantum photonic neural network, which requires hybrid interfacing of our technology with commercially available advanced photonic circuits (PICs).”

FROM THEORY TO REALITY

Critical to the success of VLS-QPP is the close interplay between theory and experiment. “The hardware we develop is only as good as the algorithms and protocols we have to run on it,” adds Carolan. “We have therefore developed new methods to control such large-scale quantum photonic systems, and an entirely new suite of applications in the emerging field of quantum machine learning.”

All in all, VLS-QPP’s main contribution to the quantum photonics field is the development of quantum processors at an unprecedented scale. The project, which will end in September 2020, has also been laying the foundations of scalable photonic quantum computing and has resulted in a number of publications. Its novel quantum processor is likely to considerably impact the fields of computing

and machine learning by enabling a scalable and robust hardware platform that can implement an entirely new family of near-term quantum algorithms.

Potential applications for the project’s findings can be found in three core sectors: medical science for studying biochemical processes towards drug discovery; data security through the development and implementation of new and secure quantum key distribution and quantum repeater architectures; and quantum machine learning by directly performing inference on optical signals. Overall, Lodahl is confident that these advances will create new market opportunities in the quantum industry and even beyond.

VLS-QPP

- Coordinated by Copenhagen University in Denmark
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/751016
- Project website: nbi.ku.dk/english/research/quantum-optics-and-photonics/quantum-photonics

Future proofing the connected world of quantum computing

To help mitigate the unique cybersecurity risks posed by quantum computing, a group of EU researchers are developing a Quantum-Resistant Trusted Platform Module.

Society is on the cusp of a new era – the era of quantum computing. By performing calculations based on the probability of an object’s state before it is measured, quantum computers can process exponentially more data than even the most advanced computers.

Although these super-fast, super-powerful computers will bring many benefits, they also create new risks. For example, their superior ability to crack state-of-the-art security systems could compromise our digitised world and create new challenges for communications, finance, healthcare and government.

Currently, such cybersecurity risks can be managed using Trusted Platform Modules (TPM), a dedicated microcontroller designed to secure hardware through integrated

cryptographic keys. However, to mitigate the specific risks posed by quantum computing, a new generation of TPM-based solutions is needed. That is why the EU-funded FutureTPM (Future Proofing the Connected World: A Quantum-Resistant Trusted Platform Module) project is working to develop a Quantum-Resistant Trusted Platform Module (QR TPM).

“The FutureTPM project is dedicated to developing the QR TPM solutions needed to ensure the long-term security, privacy and operational assurance of future ICT systems and services,” says Ursula Polessnig, a member of the FutureTPM Coordination Team and an employee at Technikon, an Austrian engineering and research company. “The security of hardware security modules, trusted execution environments, smart cards and the Internet of

“The FutureTPM solutions will be key to ensuring the long-term security and trust of a range of applications as they transition into the era of quantum computing.”

Things all stand to benefit greatly from the FutureTPM solution.”

A NEW GENERATION OF TPM SOLUTIONS

Current TPM environments are based on traditional cryptography. The FutureTPM project aims to transition these legacy environments to systems that can provide enhanced security using such QR cryptographic functions as secure authentication, encryption and signing functions. In doing so, the project will essentially transform the host device into a ‘hardened’ security token that could, in theory, remain secure even against the enhanced threats presented by quantum computing.

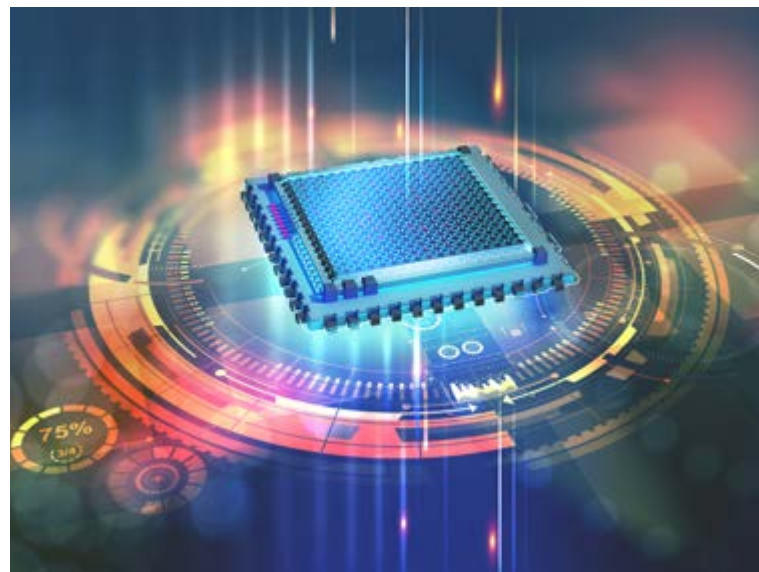
By selecting current state-of-the-art QR algorithms (and designing new ones) for primitives like key management, encryption, signatures, hash functions, message authentication codes and direct anonymous attestation, FutureTPM filled in the perceived gaps in current cybersecurity systems. Researchers then investigated a security threat model for each of these primitives to formalise security properties and provide formal proof.

This architecture was then enhanced with detailed threat modelling and risk assessment (during both design- and run-time) functionalities. The result is a holistic TPM-backed solution capable of capturing the strict security and privacy requirements of all deployed edge and infrastructure assets considered in various application domains.

“We successfully developed a new generation of TPM-based solutions that incorporate robust and physically secure QR cryptographic primitives,” explains Polessnig. “These solutions will be key to ensuring the long-term security and trust of a range of applications as they transition into the era of quantum computing.”

AN ARCHITECTURAL BLUEPRINT

FutureTPM has provided the first concrete results on how QR algorithms can be implemented in resource-constrained devices (such as TPMs) to build even more secure, decentralised chains of trust.



“In doing so, we provided an architectural blueprint on how the next generation of hardware-based security tokens should be designed to provide QR crypto functions, measure and report the behaviour of computing platforms, and securely store data,” adds Thanassis Giannetsos, a researcher at the Technical University of Denmark and technical lead of the FutureTPM project.

With the project set to end in December 2020, researchers are currently working to turn their results into standardisation proposals that will further advance the state-of-the-art of cryptography and TPM.

FUTURETPM

- Coordinated by Technikon in Austria
- Funded under H2020-SECURITY and H2020-LEIT-ICT
- cordis.europa.eu/project/id/779391
- Project website: futuretpm.eu
- bit.ly/2YbSOBU

Towards quantum communications for all

A team of ambitious young researchers are working to facilitate the widespread deployment of quantum communications.

Quantum technologies have the potential to revolutionise how we go about computing, communicating, measuring and sensing. There are, however, a number of obstacles that must be overcome before this technology becomes a part of our everyday lives.

This is where the EU-funded QCALL (Quantum Communications for ALL) project comes in.

"QCALL is dedicated to overcoming these obstacles and facilitating the widespread deployment of quantum communications," says Mohsen Razavi, a professor at the University of Leeds and QCALL project coordinator. "That's why we call the project 'quantum communications for all!'"

QCALL is part of the European Innovative Training Networks (ITN), an initiative that aims to train the next generation of creative, entrepreneurial and innovative early-stage researchers.

ADDRESSING KEY CHALLENGES

By bringing together 15 doctoral researchers, the QCALL project set out to address the key challenges facing quantum communications technologies. For example, one group of researchers developed prototypes with provable security that could serve as the first generation of metropolitan-area quantum networks.

"With the advancement of fibre-to-the-home technology, it won't be long before most households are directly connected to an optical fibre network," explains Razavi. "To take advantage of this, our researchers have demonstrated quantum key distribution on a chip and at unprecedented distance records."

One of the ultimate goals of quantum communications is to enable two network users, at any distance, to exchange secret keys. As this will initially be achieved via a network of trusted nodes, the QCALL project also focused on developing long-distance quantum networks via both satellite links and the so-called quantum repeater systems.

A third line of research was dedicated to devising novel cryptography primitives and the services needed to enable widespread exploitation of quantum communications. Building on existing developments in the field, QCALL researchers have developed new protocols and the supporting devices needed to implement such systems.

THE NEXT GENERATION OF EU RESEARCHERS

According to Razavi, the key to the project's success has been its team of young, ambitious researchers. "These researchers have undergone a remarkable transformation during this project," he says. "They are now ready to lead the next generation of research in the EU – that will be the true legacy of the QCALL project."

With the project set to conclude in November 2020, researchers are busy finalising their deliverables – a timeline that has inevitably been impacted by the COVID-19 pandemic. With this in mind, the project is pursuing various routes to support continued research in quantum communications.

QCALL

- Coordinated by the University of Leeds in the United Kingdom
- Funded under H2020-MSCA-ITN
- cordis.europa.eu/project/id/675662
- Project website: qcall-itn.eu





FOOD AND NATURAL RESOURCES

Versatile CleanPack delivers cleaner food packaging, boosts SME competitiveness

The food packaging industry constantly seeks better and safer ways to package food for consumers. Researchers have developed a modular machine that creates an ultra-clean environment while reducing the carbon footprint of food packaging.

The industry sector responsible for preparing and packaging solid, refrigerated foods, such as dairy products, meat, fish, ready-to-eat (RTE) meals, salads and cut fruits and vegetables, is demanding increased levels of hygiene to package products with minimal microbial contamination or commercial sterility conditions. The sector is also in need of new innovations that reduce food-borne diseases along with costs of production and carbon footprints.

The EU-funded CleanPack (UltraCLEAN thermoforming equipment for food PACKaging, a cost-effective alternative to clean rooms) project set out to produce new, ultra-clean packaging for food products. The researchers

worked to extend the shelf life of food without the need for additional chemical preservatives. The project integrates many different techniques into one CleanPack machine, “to allow SME packaging to maintain the same level of food safety as clean rooms and extend the shelf life and freshness of their packed foods even more than big producers,” says project leader Alejandro Vidal.

A MODULAR DESIGN

The team started off by designing CleanPack as a modular configuration of four parts: a thermoforming module, a filling module with essential oils to decontaminate



“CleanPack is helping an array of food sector SMEs achieve better products and extended shelf life, which also increases competitiveness in the industry.”

surfaces, a thermosealing module, and a cutting module. The researchers validated the microbiologically controlled enclosure in line with the ISO class 5 standard within the first year of the project, ensuring ultra-clean conditions.

Next, the researchers tested the CleanPack prototype under different real-world conditions using different food products. The team was so pleased with the results that they were then able to establish pre-commercial agreements with several potential clients and distributors interested in installing the CleanPack machine.

“The four-module design of the CleanPack machine can be adapted to different market and customers’ needs, resulting in a more efficient and economic process,” Vidal says. “In addition, the new decontamination technique using essential oils, within the filling module, helps to extend shelf life of products, estimated at a minimum of 150 %, without additional chemical preservatives.”

THE RTE MARKET

Following the success of CleanPack real-world tests, the researchers brought the project into the RTE food packaging market, using the thermoforming part of the machine to produce ultra-clean food trays. This approach ensures

that foods such as sliced meat and fresh-cut fruits and vegetables will be free of food-borne diseases, and lowers food waste, which provides a technological advantage over competitors.

A GREENER PROCESS OF FOOD PACKAGING

The implementation of this milder technology also has the potential to reduce energy consumption and the dependence on cold chain logistics, and it enables decentralised production in more sustainable and economic ways. In this way, CleanPack is helping an array of food sector SMEs achieve better products and extended shelf life, which also increases competitiveness in the industry.

“The project has become a successful landmark in our production line, and we will continue pursuing improvement and evolution developing new and better machines,” Vidal says. Going into the future, the CleanPack team aims to adapt to new market trends and to customers’ current and future needs by focusing on reaching customers who value and appreciate the new technological advances developed for improving the cost-efficiency of their packing lines.

CLEANPACK

- Coordinated by Tecselor SL in Spain.
- Funded under H2020-FOOD and H2020-SME.
- cordis.europa.eu/project/id/777900
- Project website: cleanpack.es/en/

FOOD AND NATURAL RESOURCES

Stopping olive oil fraud with the help of blockchain

Fraudulent olive oil is a major problem in the European Union and beyond. New digital seals could help in the fight against fakery.

Europe is a powerhouse in the olive oil world, home to many of the world’s best-known quality brands. Europe manufactures around EUR 3 billion worth of olive oil each year, mostly in Greece, Italy and Spain.

Olive oil may not seem a likely candidate for fraud, but counterfeiting is a major and growing problem throughout the European Union. The estimated market loss in Europe from olive oil fraud is around EUR 1.5 billion per

“ *There are different ways to perform a counterfeit: you may just invent a brand, pour something inside the bottle and label it whatever you like.* ”

year. Aside from money, there can be huge consequences for human health: in Spain in 1981, an event involving fraudulent oil affected over 20 000 people and resulted in hundreds of deaths from a toxic syndrome.

“There are different ways to perform a counterfeit: you may just invent a brand, pour something inside the bottle and label it whatever you like,” explains Enrique Lizaso, CTO of BlockTac and STOPTHEFRAUDINOLIVEO (Fighting counterfeiting in Olive Oil with blockchain – a working product has arrived) project coordinator.

Oils can be diluted with low-quality and chemically refined oils, or with oils that will have rotted by the time consumers open the bottle and start adding it to their salad. Customers – for the most part – can’t tell that their oil is fake, even after they’ve tried it.

The estimated market loss in Europe from olive oil fraud is around **EUR 1.5 billion per year**



Olive oil inspectors exist, but there simply aren’t enough to check every bottle. What’s more, the fines aren’t enough to prevent the fraud. The STOPTHEFRAUDINOLIVEO project has developed a savvy technological solution to the problem.

BlockTac is a new type of digital seal, based on blockchain technology, which lets customers verify the authenticity of the oil just through their smartphone in the supermarket.

SIGNED, SEALED, DELIVERED

“Right from the start, we decided that the system should be super easy to use: the customer should point his/her smartphone at the QR in the product, and immediately tell whether that single bottle is original or not,” says Lizaso.

Each unit has a double-layer label. The customer peels away one layer to reveal a QR code. Any regular smartphone (iOS or Android) can be used to scan the code, and an app checks whether the bottle is registered on the blockchain. If it is a legal bottle, it is then marked as opened. If it has been checked before, the customer is advised.

“If the blockchain register does not contain the QR code, the bottle is shown as ‘no info, beware, no info, consume at your own risk!’” continues Lizaso.

When a counterfeiter copies a product, it usually involves making far more than one unit extra. This means manufacturing hundreds, or thousands of bottles. In this case,



the fraudster may copy the QR code, and each of the fake bottles will share the same code. As soon as one of these is 'opened' through BlockTac, all the other ones are then marked as opened, or a possible counterfeit. The customer can then decide how to proceed.

The project currently has agreements for 3.5 million units, and the goal for 2020 is to reach 10 million products, making it the largest use of blockchain so far after cryptocurrencies.

"We are deeply grateful to the EU for giving us this opportunity," concludes Lizaso.

STOPTHEFRAUDINOLIVEO

- Coordinated by Hashed BlockTac SL in Spain.
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT.
- cordis.europa.eu/project/id/866703
- Project website: blocktac.com/sme-phase-1-summary-of-results/

FOOD AND NATURAL RESOURCES

Biopesticides can boost global food supplies, making agriculture greener, safer and more efficient

Innovative natural products developed in the European Union avoid the harmful impacts associated with synthetic pesticides.

Currently, up to 35 % of farming yield losses are due to pests, so overcoming this problem would go a long way to boosting global food supplies.

Since the 1930s, synthetic pesticides have been widely used to try to combat pests, but these come with a wide range of environmental, ecological and health problems. These range from skin irritations, to damage to the nervous system, along with problems with fertility and, in some rare cases, even death. The European Union has been taking crucial steps toward improving the regulation and use of pesticides; many have been banned from the market. New solutions are needed.

Another promising approach lies in 'biopesticides', products with lower toxicity that decompose easily into the environment. The DISPERzero (High performing micro-granulated Biopesticides for plants protection) project, led by Spanish firm Indalva, is working to bring to market a new biopesticide range with an innovative type of technology, creating insecticides and fungicides that have no negative impacts on human health or the environment.



“In the medium to long term,
the benefit to agricultural productivity is
immense.”

“The main objective of the DISPERzero project is the commercial development of a range of four biopesticides formulated with a special type of technology”, says Pablo Baeza, Technical Director of DISPER at Indalva and DISPERzero project coordinator. These include a broad-spectrum fungicide, a fungicide for oidium (powdery mildew), a broad-spectrum insecticide and an acaricide (a pesticide mainly used against mites).

According to Baeza, the products have advantages at both the environmental level and the human health level. They offer reduced transport pollution, while user-safety is also improved, with no risk of inhalation and guaranteed 100% solubility.

A NATURAL SOLUTION

Biopesticides are phytosanitary products that have been developed from natural compounds. As such, they are free from any substances that could cause harm to the farmer or to the final consumer.

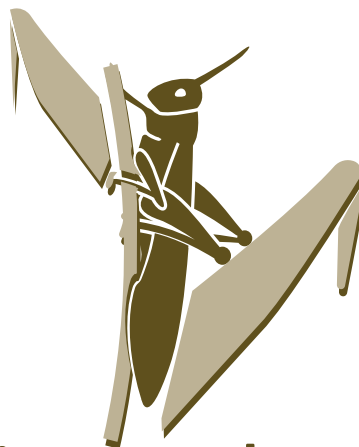
“In the short term, the effectiveness of biopesticides may be slightly lower than synthetic pesticides, since they do not generate such a severe shock effect. But in the medium to long term, the benefit to agricultural productivity is immense. They avoid soil degradation, respect auxiliary fauna and reduce pest resistance, unlike synthetic pesticides,” emphasises Baeza.

SMART GRANULES

The DISPERzero team have developed an innovative technology known only as WSG-FB, which allows them to create biopesticides as solid granules.

The granules have several advantages. Compared to liquids, the volume of product transported can be reduced, lowering the associated environmental and financial costs. The application is simple, and the dosage of each product can also be lowered. Plastic waste associated with other pesticide products can be removed, and as it doesn't contain water, there is guaranteed product conservation.

Up to 35 % of



farming yield losses
are due to pests

The biopesticide granules have no dust, which reduces the risk of inhalation by the farmer during handling.

“There is an exclusive self-dissolution mechanism that guarantees that the product does not produce lumps or precipitation during its use, which maintains irrigation equipment in perfect condition,” explains Baeza.

The biopesticides market is valued at around EUR 2.4 billion and is expected to grow an average of 14.1 % per year to 2025.

“We are currently in the chemical and agronomic development phase of other products to address specific pests and diseases by crop, with the aim of continuing to offer sustainable tools to farmers,” says Baeza.

DISPERZERO

- Coordinated by Indalva SL in Spain.
- Funded under H2020-Societal Challenges, H2020-LEIT and H2020-SME.
- cordis.europa.eu/project/id/868191
- Project website: indalva.com/en/index.html



A smart app creation space for virtual factories

An open operating system for virtual factories will allow software developers to create factory apps and boost European manufacturing.

The fourth digital revolution is underway. Traditional factories across Europe and beyond are transforming into smart digital manufacturing environments.

Production systems are increasingly digitally connected within the confines of the building and through customers and across supply chains. This network of assets and connectivity is termed a 'virtual factory'. However, to enable such systems is still time-consuming and expensive due to the diverse equipment and the hardware/software knowledge necessary.

The goal of the vf-OS (Virtual Factory Open Operating System) project has been to create a virtual factory operating system designed to aid in the creation of software applications to create virtual factories of the future. vf-OS, which ran from 2017 to 2019, aims to become a reference system software for managing factory-related computer hardware and software resources.

The vf-OS team expected to reach technology readiness level (TRL) 4 (meaning the technology is validated in a lab), yet it surpassed expectations and delivered aspects above TRL 5 (technology validated in a relevant environment).

"The working prototypes were significantly more robust than expected," says Stuart Campbell, Director and CEO at Information Catalyst and vf-OS project coordinator.

A MODERN TOOLKIT

vf-OS created an Open Applications Development Kit, which is given to software developers to create the vf-OS apps (vApps). By creating this framework, app designers can quickly tailor software to the specific needs of each factory.

There is a marketplace in which these vApps can be purchased, sold and deployed without the constraints of

physical and geographical barriers. "This vf-OS Store will be open to software developers who can quickly develop smart applications to enable, for example, sensing and sharing of information between machines and across the supply chain," says Campbell.

Apps could be created to manage a variety of smart factory processes, improving overall efficiency and productivity. One such app could deal with data analysis from sensors throughout a factory, evaluating progress of machines in comparison to past trends, and predicting potential future failures. Another could be used at construction sites, to detect defective fresh concrete deliveries as early as possible.

PUTTING IT INTO PRACTICE

Several pilots of vf-OS have been run so far, in which multiple vApps per pilot were developed and deployed for meeting individual factory needs.

In a manufacturing and assembly system pilot, vApps were tested to prevent and manage machine failures, establish stock refilling mechanisms and closely monitor production lines. In a construction site setting, vApps included site management, identification of steel bars, reporting and management of delays, and concrete quality checking.

vf-OS has produced an initial prototype of this mixed development and execution environment for smart manufacturing applications. Several assets, such as IoT devices, software packages (through APIs), analytics models and other external services (through third-party services) can be linked to or included in the core of each vApp.

vf-OS ideas and technology were also a cornerstone of another continuing project, Zero Defect Manufacturing Platform (ZDMP), which started in 2019 and where the proposers could already see the solid work.



One of the main aims of vf-OS was to set up a company at the end which could exploit the technology. Industry 4 Factory Solutions Ltd (i4FS) was incorporated by several partners of the project in October 2019. In fact, several ZDMP partners also decided to take shares in this company as well.

"If the research and innovation of vf-OS can be further developed, EU manufacturing industry will have at their disposal new mechanisms to quickly develop smart applications for their own factory environments," concludes Campbell.

VF-OS

- Coordinated by Information Catalyst for Enterprise Ltd in the United Kingdom.
- Funded under H2020-LEIT-ICT.
- cordis.europa.eu/project/id/723710
- Project website: vf-os.eu
- ▶ bit.ly/2xXV3IR

INDUSTRIAL TECHNOLOGIES

Redefining waste, re-imagining textiles

One Estonian start-up is transforming gelatine produced from discarded animal waste to create an eco-friendly textile that looks and feels just like real leather.

The livestock industry is full of waste. For example, did you know that only up to 60% of an animal is used for meat, with the rest often being discarded? That's up to

5 million tons of waste every year in Europe alone. At the other end of the equation is the leather production market. As a result of the substantial amounts of water and

chemicals used during the tanning process, and the vast amount of CO₂ emitted during production, the leather industry is one of the world's biggest polluters.

But between the slaughterhouse and the tannery there's gelatine – a versatile natural protein derived from the abundantly available waste produced by the livestock industry. But where others saw a waste product, one Estonian start-up saw a wasted opportunity.

"At Gelatex, we believe that with innovation, we can give value to this abundant, undervalued resource," says Mari-Ann Meigo Fonseca, Gelatex co-founder and CEO. "For us, that innovation is a revolutionary process for turning gelatine into gelatine-based nano-fibrous materials faster than any other existing technology."

Now, thanks to the support of the EU-funded GELATEX project (The first process to synthesize Leather – A fabric with the identical chemical composition and exact mechanical properties as leather), the company is ready to scale up its production process and bring its eco-friendly textiles to the global market.

LIKE LEATHER, BUT WITHOUT THE TOXINS

Although there are already plenty of alternative textiles on the market, including PVC and plant-based products, none offers the composition or properties of real leather. Gelatex's eco-friendly, non-toxic textile, on the other hand, not only looks and feels like real leather, it's the only leather-like material that is easily scalable, 100% non-toxic, comes in rolls, and is made from waste.

"We developed a cutting-edge method for synthesising gelatine, creating a fabric of unprecedented quality and chemically equivalent to leather," explains Fonseca. "Gelatex is the first company to deliver this new animal-like leather without the need for toxic tanning."

The GELATEX platform upcycles gelatine from discarded animal waste and mixes it into a solution. Next, using a proprietary method, the solution is spun into an insoluble nano-fibrous mesh. This mesh is then combined with other materials, creating textiles for a range of applications and industries.

"The final product is designed and configured according to industry requirements on tensile strength, resistance, insulation, permeability and comfort," adds Fonseca.

READY FOR MARKET

With interest in sustainable textiles growing, Gelatex needed to evaluate the opportunity for a small start-up to scale fast while also strategically planning for the future. "With the EU funding, we were able to assess options for tensile and tear strength optimisation and specifications of production machinery components," explains Fonseca.

"We also conducted an in-depth cost analysis and identified global commercial strategies, sales channels and future funding needs."

According to Fonseca, the company expects to achieve revenues of EUR 10 million in just 3 years. Furthermore, with plans to expand production facilities and a possible licensing model, there is a potential to generate EUR 2 billion within a decade. "The project played an important role in bringing the first easily scalable, eco-friendly leather-like textile to market," she notes.

The company is now busy constructing a pilot line, looking at options for launching a large-scale industrial line, and securing all necessary certifications and patents.

GELATEX

- Coordinated by Gelatex Technologies OÜ in Estonia.
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT.
- cordis.europa.eu/project/id/876086
- Project website: gelatex.com





Resilient, secure and adaptive cloud computing

The opportunity presented by cloud computing is huge. ATMOSPHERE is providing the confidence for European businesses to seize it.

Digital systems across the private and public spheres are increasingly dependent on cloud computing. Yet the adequate technologies and frameworks for inspiring confidence in the security and proficiency of cloud applications are still lacking. In order for European businesses to thrive with this new opportunity, confidence in the cloud is paramount.

ATMOSPHERE (Adaptive, Trustworthy, Manageable, Orchestrated, Secure, Privacy-assuring, Hybrid Ecosystem for REsilient Cloud Computing), an international project funded under the fourth EU-Brazil coordinated call, has

designed and developed a framework and a platform to implement trustworthy cloud services in a federated intercontinental resource pool.

“ATMOSPHERE focuses on a broad spectrum of trustworthiness properties and their measures such as security, privacy, coherence, isolation, stability, fairness, transparency and dependability. Based on the given definition of trust in cloud computing, trustworthiness can be defined as the worthiness of a service and its provider being trusted,” says Ignacio Blanquer, professor at the



Polytechnic University of Valencia (UPV), Spain, European coordinator of the ATMOSPHERE project.

Over a 24-month period, the ATMOSPHERE project designed and developed a suite of tools and services to build and evaluate trustworthy data analytics applications in interlinking cloud networks.

“As a result of the project, data owners, system administrators, application developers and managers, and data scientists can now develop more trustworthy and secure cloud computing applications while being compliant with data protection regulations on both sides of the Atlantic,” comments Francisco Brasileiro, professor at the Federal University of Campina Grande (UFCG), Brazil, the Brazilian coordinator.

HARNESSING THE CLOUDS

ATMOSPHERE worked on developing four services across its framework: a robust cloud computing platform for deploying complex applications automatically; a framework that evaluates trustworthiness levels through quality models; distributed data management services for secure storage and data access; and a service for data analytics.

“All these components can be deployed on standard cloud offerings,” says Blanquer.

The Trustworthy Data Management Services in ATMOSPHERE securely store sensitive information even in untrusted cloud services. The system includes mechanisms for data scientists and others to store encrypted data on a disk, process them under encryption and guarantee that only authorised processes can access such data. This prevents users even with administrative credentials from accessing data in a disk or memory, making it ultra-secure.

HEALTHY TESTS

The main pilot application of ATMOSPHERE was a screening service for the diagnosis of rheumatic heart disease based on cloud-based processing of medical images, metadata and clinical information using artificial

“As a result of the project, data owners, system administrators, application developers and managers, and data scientists can now develop more trustworthy and secure cloud computing applications, while being compliant with data protection regulations on both sides of the Atlantic.”

intelligence. The system processed a large set of medical images efficiently and securely, which led to better and quicker disease diagnosis.

Beyond medicine, ATMOSPHERE is already being used to manage a range of assets in both Europe and Brazil. These include Dell, Vodafone, Talkdesk and INDRA, as well as the EGI Foundation and the Brazilian National Education and Research Network, RNP. Others are expected to start using the services soon.

“ATMOSPHERE has been the result of the joint development of a large and distributed team of 14 partners. The high degree of collaboration and the team spirit created during the project have been an intangible result that will set up the basis for long-term collaboration,” adds Brasileiro.

ATMOSPHERE constitutes the latest step in a long trajectory of Europe-Brazil collaborative projects in cloud computing, started back in 2010.

ATMOSPHERE

- Coordinated by the Polytechnic University of Valencia (UPV) in Spain.
- Funded under H2020-LEIT-ICT.
- cordis.europa.eu/project/id/777154
- Project website: atmosphere-eubrazil.eu

Making fitness fun with the first wearables for body motion gaming

It is estimated by the OECD that more than one in two adults and one in six children are obese or overweight. The Atomic Bands project takes one of the problems in this health crisis – our increasing screen time – and turns it into a solution, by gamifying exercise.

Obesity has nearly tripled worldwide since 1975 to approximately 650 million people. The WHO estimates that, in the EU, 30-70% of adults are overweight, and obesity affects 10-30%. Over 60% of children are overweight before puberty and remain so in early adulthood. Obesity is linked to cardiovascular disease, type 2 diabetes, orthopaedic problems, mental disorders and lower self-esteem.

The situation is exacerbated by young children spending more time looking at screens than playing outside. One study found that by the age of 7, children will have been looking at screens for the equivalent of 456 days, with just 182 spent playing outdoors.

Filling a gap in the market with a solution to spark the interest of a generation used to static gaming, Atomic Bands (Next generation motion sensing bands for promotion of fitness and health tracking) are the first smart, affordable, Bluetooth gaming device for interactive fitness sessions. The wearable Funky Bots solution, currently in prototype form, comprises dual motion sensing bands designed to be used with mobile apps for full body stimulation and real-time health feedback.

Showcased at CES in 2017, Atomic Bands received four Best New Gadget mentions, notably from the BBC and CNET, and were ranked 7th for innovative VR and AR technology, right behind Huawei and Xiaomi.

GAMIFYING FITNESS

The Atomic Bands come in pairs for the left and right wrist and/or left and right ankle, generating data from two reference points. BTLE Sensors measure the heart rate, respiratory rate, steps, distance and calories burnt.

A Bluetooth chip provides communication between the bands and smartphone.

The software has a unique 'gesture pattern recognition' algorithm to maximise user interaction with the various games, providing real-time motion tracking without field-of-view restrictions.

The app offers activities designed to help players learn movement-based skills and play AR fitness-oriented games with leaderboards, competitions and social network integration.



In the EU, over 60% of children who are overweight before puberty remain so in early adulthood



© Funky Bots

The app also has a dedicated user dashboard to visualise fitness details, analyse moves and display tips. The algorithm helps users engage their entire body, burning over 600 cal/h (rivalling a 10 km/h jog of 590 cal/h). Users can also create 3D worlds with gestures corresponding to phenomena such as hills or valleys.

“Star athletes and other masters of their craft all started somewhere. By making something fun, you make it a habit and the skills follow,” says Rosa Mei, Funky Bots CEO and project coordinator.

Testing with children in Belgium taught the researchers the importance of ease-of-use, scoring (to help with engagement), and the need for a complete solution – not just a fitness band but a whole platform.

CREATIVE INNOVATION AND MAXIMISING USER EXPERIENCE

While the team are currently seeking additional funding to arrange contract manufacturing, they have been future-proofing the technology to be usable with interchangeable components, independent of particular motion

“We’ve gone from building our first robotic prototypes in a Canary Islands living room, staying in a windsurfers’ hostel, to competing with billion-dollar companies like Huawei.”

sensor chips. They anticipate securing a patent this year and releasing the product 1 year after securing funding.

“We started with nothing, growing from a ragtag group of eccentric designers and software engineers, in remote European places. Now we are working with 50 engineers from Intel, as the only start-up chosen to collaborate on their new Curie chip,” recalls Mei.

“We’ve gone from building our first robotic prototypes in a Canary Islands living room and staying in a windsurfers’ hostel, to competing with billion-dollar companies like Huawei.”

ATOMIC BANDS

- Coordinated by Funky Bots in the United Kingdom.
- Funded under H2020-LEIT, H2020-Societal Challenges and H2020-SME.
- cordis.europa.eu/project/id/867026
- Project website: funkybots.com



SECURITY

Sniffer sensors locate home-made bombs

Ideally, police want to know where a bomb is being made before it explodes. Now they can.

One of the main ways that terrorists threaten public safety is via home-made bombs. Police usually prevent bombings using indirect means such as intercepted communications. So far, direct detection of explosives in the preparation stage has not been possible.

The EU-funded UCTIL (Urban Chemical Threat Location and Identification) project solves that. Researchers developed technologies that sample urban air and detect the chemical ingredients of explosives, allowing the manufacture location to be pinpointed. The technologies were inspired by the SIGMA+ mission under the United States' government agency, DARPA. Although the two projects had similar goals, the UCTIL technologies

are different, independently developed, and more ambitious than SIGMA+. UCTIL could in principle also detect the operation of drug labs. The project examined the concept's feasibility and the possibility of developing the technologies to a higher readiness level.

SENSITIVE SENSORS

The UCTIL system effectively sniffs out the chemical signatures (odours) of ingredients in explosives. The sensors are based on mass spectrometry, a technique able to analyse minute chemical samples, in this case the target chemicals at one part per quadrillion, or a thousand million!



Project modelling indicates that a mobile network would require fewer sensors than a stationary network, and that 4-5 mobile sensors per city should suffice. In the first instance, the sensors would be mounted on vans that drive around sampling the air. At a future stage of development, the sensors could be carried by automated drones.

City air can contain thousands of different molecules. "Detecting those of interest from a security perspective, with high sensitivity and specificity, is technically demanding," says project coordinator Aleksei Shcherbinin. "We propose to chemically map the city's ambient air, then use artificial intelligence and state-of-the-art meteorological simulations to locate and track the sources of the emissions."

The sensors would normally work in a continuous monitoring mode. If something suspicious is detected, the system switches to a tracking mode that actively looks for chemical sources. That permits location-pinpointing to the building level. "The UCTIL concept is unobtrusive and avoids surveillance that might jeopardise the privacy of citizens," adds Shcherbinin.

GREEN LIGHT

The team determined that the system would be technically and economically feasible. During the project, researchers revised their understanding of likely operational use, and produced business models that can be refined once the technology is proven.

Police will be the primary users, but fire departments and industrial organisations might use the system

as well. So far, potential users have given very positive feedback.

Most importantly, work conducted during the project allowed members to develop a solid plan for how to proceed with development. The consortium has submitted an application to Horizon 2020 for substantial next-stage development funding. If successful, researchers would work with meteorologists and police forces to develop the system and perform operational trials in four major European cities (Helsinki, Madrid, Brussels and Amsterdam).

The fact that UCTIL can sample air also makes it suitable for monitoring urban air quality. This will prove invaluable for environmental management purposes and opens an additional potential market for the data.

UCTIL will make it easier for police and other authorities to detect illegal activity, including the manufacture of bombs and drugs, in progress. The system will furthermore contribute to air quality monitoring, helping to make city air less polluted.

UCTIL

- Coordinated by Karsa Oy in Finland.
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT.
- cordis.europa.eu/project/id/837253
- Project website: karsa.fi

SECURITY

New technology for drone-based emergency response missions

A Spanish geopositioning company is using drones to provide emergency first responders with the accurate, real-time information they need to quickly locate – and rescue – victims of natural disasters.

In 2017, the world saw 335 natural disasters, affecting over 95.6 million people and resulting in 9 697 deaths

and nearly EUR 300 billion in damages. 2017 also saw many emergency first responders leverage the power of

drones to quickly locate victims and get them the support they needed.

From earthquakes to forest fires, hurricanes to floods, drones are revolutionising disaster response efforts and helping to save lives. But this is just the tip of the iceberg. To truly benefit from the full potential of drones, their use needs to be backed by an efficient, structured operating system. This needs to be capable of processing data in real time and providing objective information for critical decision-making.

Enter the project DRONECOP (The first integral control and command system for managing missions which delivers 3D cartography and georeferenced data in real-time), which focused on drone-based emergency response missions. “DRONECOP gives natural disaster management bodies the critical information they need to plan their missions and make fast, effective decisions,” says Luis Izquierdo, a researcher at Geointelligence Systems, a Spanish geopositioning company and creator of the DRONECOP system.

“This will ultimately result in a drastic decrease in fatalities and injuries – among both civilians and rescue crews – and reduce a disaster’s social, environmental and economic impact.”

ACCURATE 3D MAPPING INFORMATION

Developed with the support of EU funding, DRONECOP provides accurate and updated 3D mapping information and georeferenced targets. The system includes a very accurate, real-time kinematic (RTK) positioning system,

which is installed onto the drone. It also contains a robust digital communication channel and a high-performance, ground-control system. This is capable of processing imagery in near real time.

During the project, Geointelligence also conducted an in-depth feasibility study. “We defined the specific requirements and configurations for three different use applications: forest fires, floods and earthquakes,” explains Izquierdo.

“We also analysed the technical viability of integrating firefighting systems, such as fire-extinguishing capsules, directly into the drone.”

READY TO DISRUPT

Confident that the DRONECOP solution was technically feasible, researchers next analysed whether it was economically viable. This included a comprehensive review of the manufacturing process and costs.

According to Izquierdo, what the team found was that not only does the system provide outstanding accuracy (< 2 cm at 80 km/h), it does so at a very attractive price point (up to two thirds the cost of competing solutions). In other words, DRONECOP is well positioned to tap into the estimated EUR 10.5 million aerial disaster relief services market.

“DRONECOP will disrupt mapping for the incidents and emergencies market, carving out a new niche of integrated management systems with real-time 3D mapping and georeferenced data,” adds Izquierdo. “More importantly, it will make disaster management operations safer, faster and more efficient than ever.”

Geointelligence is currently working to secure financing to bring DRONECOP to market. They are also in conversation with such international government bodies as the United Nations.

DRONECOP

- Coordinated by Geointelligence Systems in Spain.
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT.
- cordis.europa.eu/project/id/867732
- Project website: geoint.systems

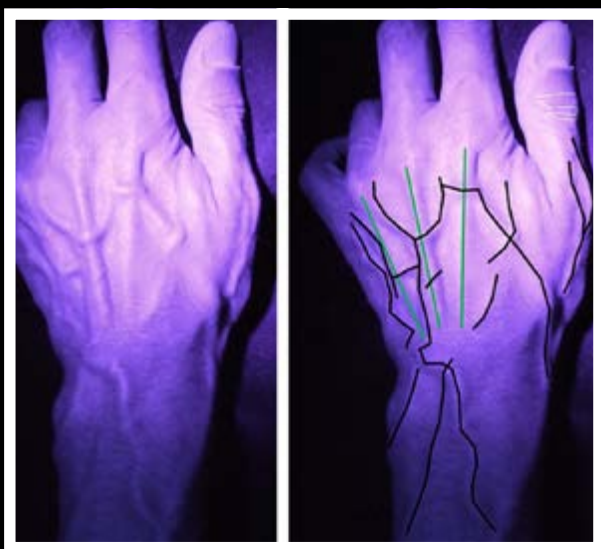




PROJECT OF THE MONTH

Protecting vulnerable children by identifying child abusers from images of their hands

British researchers funded through the European Research Council H-Unique project are developing a truly pioneering programme to help identify child abusers just from images of their hands. The research focuses on whether our hands are completely unique by looking at anatomical variation.



© Lancaster University

A key motivation for the H-Unique (In search of uniqueness – harnessing anatomical hand variation) study is to help investigators identify the perpetrators of child sexual abuse from footage and images shared online, where the backs of hands are often one of the only visible features of the abuser.

“Public participation is vital to designing computer models that understand the minutiae of hand anatomy across the whole spectrum of society. The response to our launch in February was fantastic; the contributions are already being annotated and built into our models. All images are gratefully received and many more are needed so please consider contributing.”

Bryan M. Williams, H-Unique Project Lead

“This research impacts directly on our ability to bring to justice those who violate our most vulnerable in society and exonerate those who are unjustly accused. Justice rightly demands that if science is to be admitted into the court room, then it must be reliable, repeatable and robust.”

Sue Black, H-Unique Project Coordinator

The researchers will achieve this by teaching computers to extract anatomical features from anonymous photographs of hands sent in by members of the public. This allows the development of computer algorithms that will aid police forces in linking suspects to crimes just through evidence from the uniqueness of their hands. In total, the project needs hand photos from 5 000 ‘citizen scientists’.

The team has created a web-based app that allows individuals over the age of 18 to submit photos of their hands. To take part, please go to <http://h-unique.co.uk> on your smartphone. In accordance with data protection and privacy rules, the images are not shared with any external agencies and will be destroyed at the end of the project.

H-UNIQUE

- Hosted by Lancaster University in the United Kingdom.
- Funded under H2020-ERC.
- cordis.europa.eu/project/id/787768
- Project website: lancaster.ac.uk/security-lancaster/research/h-unique/

If you are interested in having your project featured in ‘Project of the Month’ in an upcoming issue, please send us an email to editorial@cordis.europa.eu and tell us why!



FUNDAMENTAL RESEARCH

Designing molecular switches to build cell polarisation from the ground up

For many biochemical processes to take place in cells, components must organise within the space, a process known as symmetry breaking. European researchers investigated this phenomenon through a bottom-up synthetic biology approach using biological building blocks.

Cellular life is thought to have emerged when mixtures of precursor molecules became encapsulated into crude compartments to generate primitive cells called 'proto-cells'. However, to exhibit the behaviours we associate with life, such as cell division and motility, cellular components must also self-organise in space and time.

USING BIOLOGICAL BUILDING BLOCKS TO GENERATE ARTIFICIAL MOLECULAR SWITCHES

One such self-organisation process is cellular polarisation, where homogeneously distributed molecules within

cells become asymmetrically arranged. 'Top-down' methods are usually used to study this process, where the outcome of perturbations applied to a natural system is measured. With the support of the Marie Skłodowska-Curie programme, the POLAR (Synthetic Mimicry of Cellular Polarisation) project instead employed a complementary bottom-up synthetic biology approach.

"We built minimal models from biological building blocks to produce synthetic systems that recapitulate a fundamental mechanistic aspect of cell polarisation and self-organisation," explains POLAR project fellow Leon Harrington, who led the project under the guidance of



project coordinator Petra Schwille. To test mechanisms of self-organisation, the researchers built a synthetic membrane-targeting switch inspired by the *Escherichia coli* Min proteins, a well-studied pattern-forming system that facilitates bacterial cell division.

Working with collaborators Jordan Fletcher and Dek Woolfson from the University of Bristol, Harrington designed and built a reversible membrane-targeting switch using minimal peptide motifs known as coiled coils. These molecules are much smaller than protein domains and have more tractable and predictable design rules.

The team were able to switch the coiled coils between monomer and heterodimer states by reversible phosphorylation and dephosphorylation. The resulting 'module' was subsequently coupled to membrane-targeting motifs to build reversible membrane switches that can be used to study mechanisms of symmetry breaking.

Biomolecules are prone to non-specifically stick together in synthetic contexts, rendering the engineering and control of protein-protein and protein-lipid interactions particularly difficult. Harrington admits it was technically challenging, but added: "The best proof of a theory or mechanism is to actually build it from the ground up and test it."

The bottom-up approach of the POLAR project allows scientists to focus on the bare essentials required for living processes and enables the use of a broader range of measurement techniques than would be possible inside a living organism.

FUTURE APPLICATIONS OF THE POLAR SYSTEM

Future plans include introducing additional modules to generate positive and negative feedback, thereby decisively testing mechanisms of symmetry breaking. The

“*The development of reversible, coiled-coil interaction modules opens up many avenues for the design of dynamic molecular systems.*”

scientists are also incorporating DNA-based components into the POLAR system. The ease of DNA manipulation and its predictable behaviour make these particularly attractive as biological building blocks.

Applications of the molecular switches extend beyond the main aim of studying symmetry breaking. With collaborators, Harrington and co-workers are interested in expanding the scope of the POLAR molecular switches, for example by using other types of post-translational modification, or by designing switches with higher stoichiometries, such as trimers and tetramers. They also plan to integrate these switches within designed protein structures to generate dynamic behaviour inside cells.

Overall, the development of reversible, coiled-coil interaction modules opens up many avenues for the design of dynamic molecular systems. Looking ahead, Harrington concludes: "These technologies will be broadly beneficial to the synthetic biology community."

POLAR

- Coordinated by the Max Planck Society for the Advancement of Science in Germany.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/705587
- Project website: biochem.mpg.de/schwille

Yeast model gives new insights into glycan regulation in eukaryotes

An EU research initiative has used yeast to increase understanding of how essential cellular processes are controlled in higher organisms, thereby providing new avenues for drug discovery and research.

Cellular life is based on four fundamental building blocks: nucleic acids, lipids, amino acids and sugars. The sugar molecules, also referred to as glycans, encode biological information and are important structural components of proteins, cells, tissues and organisms. However, compared to DNA or proteins, glycans are more difficult to analyse and the functional roles of these building blocks are therefore often overlooked.

The Yeast-Glyco (Nucleocytoplasmic O-glycosylation in Yeast) project used *Saccharomyces cerevisiae*, commonly known as baker's yeast, as a model organism to map the elusive O-linked mannose (O-Man) glycans. "The aim was to develop methods that enable identification of O-Man sites on proteins, dynamics and regulatory mechanisms in higher organisms (eukaryotes)," says Marie Skłodowska-Curie research fellow Adnan Halim.

FRESH APPROACH LEADS TO PROGRESS

O-Man glycans are evolutionarily conserved post-translational modifications, present in organisms ranging from yeast to humans. However, despite decades of research, scientists have been unable to pinpoint their locations and how common they are in higher eukaryotes.

Biological information encoded by glycans is decoded in nature by glycan-binding proteins, also known as lectins. For decades, lectins have been used as tools to study glycans *in vitro*. "In Yeast-Glyco, we further developed a lectin chromatography technique that allows us to enrich the subset of proteins carrying O-Man from complex protein mixtures, which we identified and characterised by quantitative mass spectrometry," explains Halim.

The analytical workflow was further combined with CRISPR/Cas9 engineering of human cells, targeting candidate genes involved in O-Man biosynthesis and

determining novel regulatory pathways that control O-Man glycans. Halim notes: "When combined, these cross-disciplinary techniques enabled us to overcome major hurdles that have hampered progress in the field."

Results demonstrated that O-Man glycans are widespread in mammals and that higher eukaryotes have evolved multiple, distinct biosynthetic pathways to regulate these structural components. "We can also show that O-Man glycans fulfil unexpected, poorly understood biological roles and that their dysregulation is the direct cause of diverse and previously unexplainable developmental disorders, for example severe brain malformations in humans," Halim comments.



GREATER UNDERSTANDING OF NEURODEVELOPMENTAL DISORDERS

Furthermore, there is a great unmet need to understand how eukaryotes diversify protein functions, which in part is achieved by glycan modifications. These modifications add a layer of structural complexity, thereby shaping and influencing protein structures, interactions and functions – which, by extension, influences the fitness of cells, tissues and organisms.

Developing new technologies aimed at decoding the regulations and functions of O-Man glycans, a key objective in Yeast-Glyco, has led to fascinating discoveries and provided novel insight into how cellular functions are regulated and fine-tuned by glycans. These results may pave the way for new strategies aimed at exploiting O-Man glycans in diagnostics, treatments and drug developments.

Halim is excited about where the project may lead. “I would never have guessed that after 3 years we’d have a molecular explanation for a broad range of neurodevelopmental disorders with O-Man glycans at the centre of attention,” he observes. “There is a wealth of

“*Developing new technologies aimed at decoding the regulations and functions of O-Man glycans, a key objective in Yeast-Glyco, has led to fascinating discoveries and provided novel insight into how cellular functions are regulated and fine-tuned by glycans.*”

biological information encoded in glycans and further studies focused on this class of molecular building blocks will undoubtedly lead to remarkable discoveries at the intersection of cell biology and advanced biomedicine.”

YEAST-GLYCO

- Coordinated by the University of Copenhagen in Denmark.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/704228
- Project website: icmm.ku.dk/english/research-groups/halim-group

FUNDAMENTAL RESEARCH

New insights into highly symmetric partial linear spaces

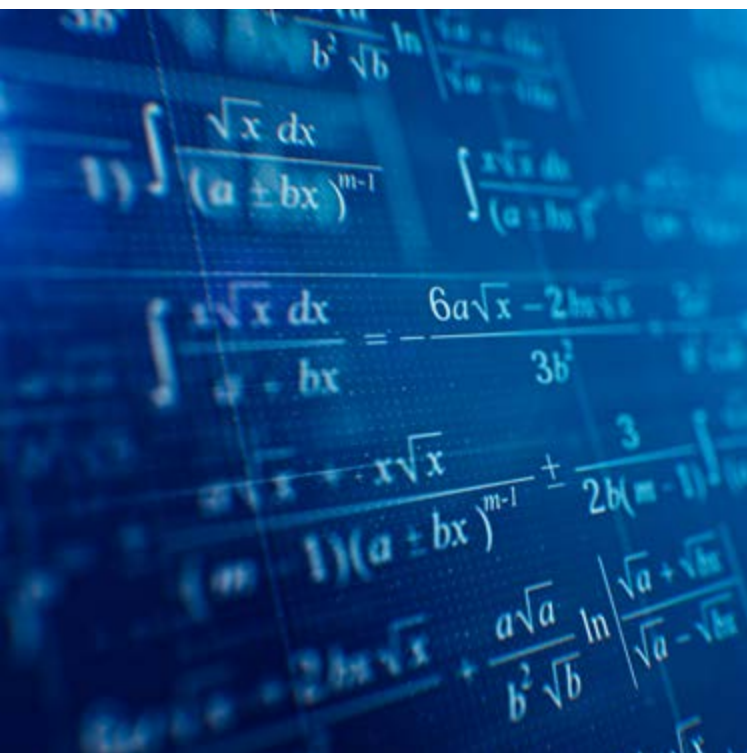
Understanding of rare mathematical forms has been furthered, thanks to research carried out by a Marie Skłodowska-Curie fellow, whose work offers group theorists a deeper understanding of symmetry.

In nature, symmetry is ubiquitous. Mathematicians use a tool called a group to capture this symmetry through motion. To illustrate, a square can be rotated by 90 degrees or reflected top to bottom without altering its appearance. By repeating this process, eight symmetry-preserving motions can be obtained. This collection of motions is a group.

“Objects with the most symmetry are those with the biggest groups – and such objects are surprisingly rare,” says

Joanna Fawcett, a Marie Skłodowska-Curie Individual Fellow in the Department of Mathematics at Imperial College London. “Because this rarity means we can list all of these objects, we are better able to understand the very essence of symmetry.”

Fawcett’s research focuses primarily on group theory, combinatorics, discrete geometry, and representation theory. Through the support of the EU-funded HSPLS (Highly symmetric partial linear spaces) project, she



“Combining the results achieved in this project with my earlier work means our understanding of the C7-homogeneous graphs is nearly complete.”

recently conducted in-depth research into objects called partial linear spaces (PLSs), or a collection of points and lines where each line can be thought of as a collection of points. The goal was to understand the PLS for which local symmetries always arise from global ones.

THREE GOALS, MANY QUESTIONS

When lines all have exactly two points, PLSs are called graphs or networks. Mathematically, a graph is homogeneous whenever two subgraphs look the same. These homogenous graphs are extremely rare and have all been identified. What Fawcett is interested in are the subgraphs with some specified structure, such as those appearing in a collection X (a symmetry property called X-homogeneity).

“As we vary the possibilities for X, can we still enumerate the X-homogeneous graphs, and can we also do this for all PLSs, not just graphs?” asks Fawcett. “Moreover, the

group of a homogeneous PLS is special because it has a small rank, and our understanding of the groups with rank 4 or 5 has remained incomplete for over 30 years – can we remedy this?”

To answer these questions, Fawcett’s research focused on achieving three main goals. First, to enumerate the C-homogeneous PLS, where C consists of all connected PLSs; then prove her conjecture that any C5-homogeneous graph containing squares but not triangles is C-homogeneous, where C5 consists of the connected graphs with at most 5 points. Lastly, complete the classification of the groups with rank 4 or 5.

A USEFUL TOOL FOR UNDERSTANDING SYMMETRY

According to Fawcett, once a few loose ends are tied up, she will have successfully completed her three goals: “Combining the results achieved in this project with my earlier work means our understanding of the C7-homogeneous graphs is nearly complete.”

Fawcett notes that her work on the third goal will provide group theorists with a useful tool for understanding symmetry.

“It feels like we are at the tip of the iceberg for understanding the effects of the choices for the collection X when studying X-homogeneous PLSs,” adds Fawcett.

“Although studying X-homogeneity in PLSs revealed that these objects have even more symmetry than we first believed, if we’re going to get to the bottom of this mystery, we still need to consider lots of other possibilities for X in a more systematic way.”

HSPLS

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- cordis.europa.eu/project/id/746889
- Project website: j.fawcett.com

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