ISSN 2599-7920

European Commission

#101
APRIL 2021

Research*eu

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What a Stone Age climate crisis can tell us about our own future

Novel materials for high-performance, eco-friendly skin-contact products

Improved tracking by drone swarms helps keep us safe

SPECIAL FEATURE
TRANSFORMING EUROPEAN HEALTH SYSTEMS IN THE WAKE OF COVID-19

Editorial

Exploring exciting innovations to transform our healthcare systems, an initiative to spur the power of SMEs against COVID, reaching for the skies with an industry-leading European-developed satellite and plugging our podcast

Welcome to this month's Research*eu magazine

Up until the last year, it was often very easy in our fast-paced interconnected lives to overlook the importance of healthcare, at both an individual and a societal level. Of course, COVID-19 changed that and for the last year, we have been forced to think about little else but the health of our loved ones, friends and society as a whole. But even before COVID-19, European healthcare systems were having to face numerous challenges, the most prominent being that of an increasingly elderly and ageing European population, with around 20 % of EU citizens being over the age of 65.

Strategies and innovations to address these demographic challenges had already begun to be hatched before the pandemic struck, with an increasing trend towards the digitalisation of healthcare, seen as a key tool to help healthcare systems adapt to the pressures of ageing societies. The roll-out of eHealth initiatives and technologies continues to be seen as a promising boost for European healthcare systems over the coming years and if anything, the pandemic has likely sped up their uptake and, crucially, acceptance amongst patients. Your editor's mother had to have an emergency operation last year at the height of the spring crisis and all of her subsequent follow-up appointments with her consultant were planned to be done online unless her recovery took a turn for the worse. Luckily, that didn't happen, however she was initially very disgruntled about not getting in-person appointments… but then she realised she actually preferred them as it meant she didn't have to make the arduous journey to the hospital (and, though she has not admitted this, but your editor very much suspects, it meant she could also do the appointments in her pyjamas).

Alongside the growth of online appointments with health professionals, the digitalisation of healthcare, which is very much a priority for the European Commission through the Digital Single Market Strategy, offers many other transformative opportunities, from the increasing sophistication of wearable tech to the push to more efficiently make use of healthcare data (within the boundaries of the GDPR of course!). In this month's special feature, we meet seven EU-funded projects that are really laying down the foundations for technologies and processes which will likely be commonplace within European healthcare within the next 10 years or so.

Sticking with our healthcare theme, **Project of the Month** showcases **COVID-X**, an ambitious project that aims to help fund and support some of Europe's most innovative SMEs in order to help them devise solutions that will see us through the pandemic and get us out to the other side. Then we have **Life After**, which reconnects with the **iSIM** project and finds out how they have further developed and refined their pioneering micro satellite which has been making waves in the EU's space industry. And of course, our last page is dedicated to **EU Agenda** – but as always, we remind you to closely monitor the status of any event you're interested in!

Finally, your editor would like to take this moment to encourage all of our Research*eu readers (if they haven't already) to go and download the recently launched CORDIS podcast, **CORDIScovery**, which can be found through Anchor.fm, Spotify, Google Podcasts, Apple Podcasts or wherever you prefer to get your podcast fix. The podcast takes the format of an engaging panel discussion on a single subject between three Horizon 2020 project coordinators and our wonderful host and will be regularly exploring topics that are covered here as well. So do go check it out!

As always, if you have any queries, questions or suggestions (but hopefully never a complaint), please feel free to drop us a line at. editorial@cordis.europa.eu.

Published on behalf of the European Commission by the Community Research and Development Information Service (CORDIS) at the Publications Office of the European Union
2, rue Mercier
L-2985 Luxembourg
LUXEMBOURG
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ISSN 2599-7912 (Printed version)
ISSN 2599-7920 (PDF)
ISSN 2599-7939 (HTML)
Catalogue No ZZ-AG-21-003-EN-C (Printed version)
Catalogue No ZZ-AG-21-003-EN-N (PDF)
Catalogue No ZZ-AG-21-003-EN-Q (HTML)

Luxembourg: Publications Office of the European Union, 2021

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HEALTH

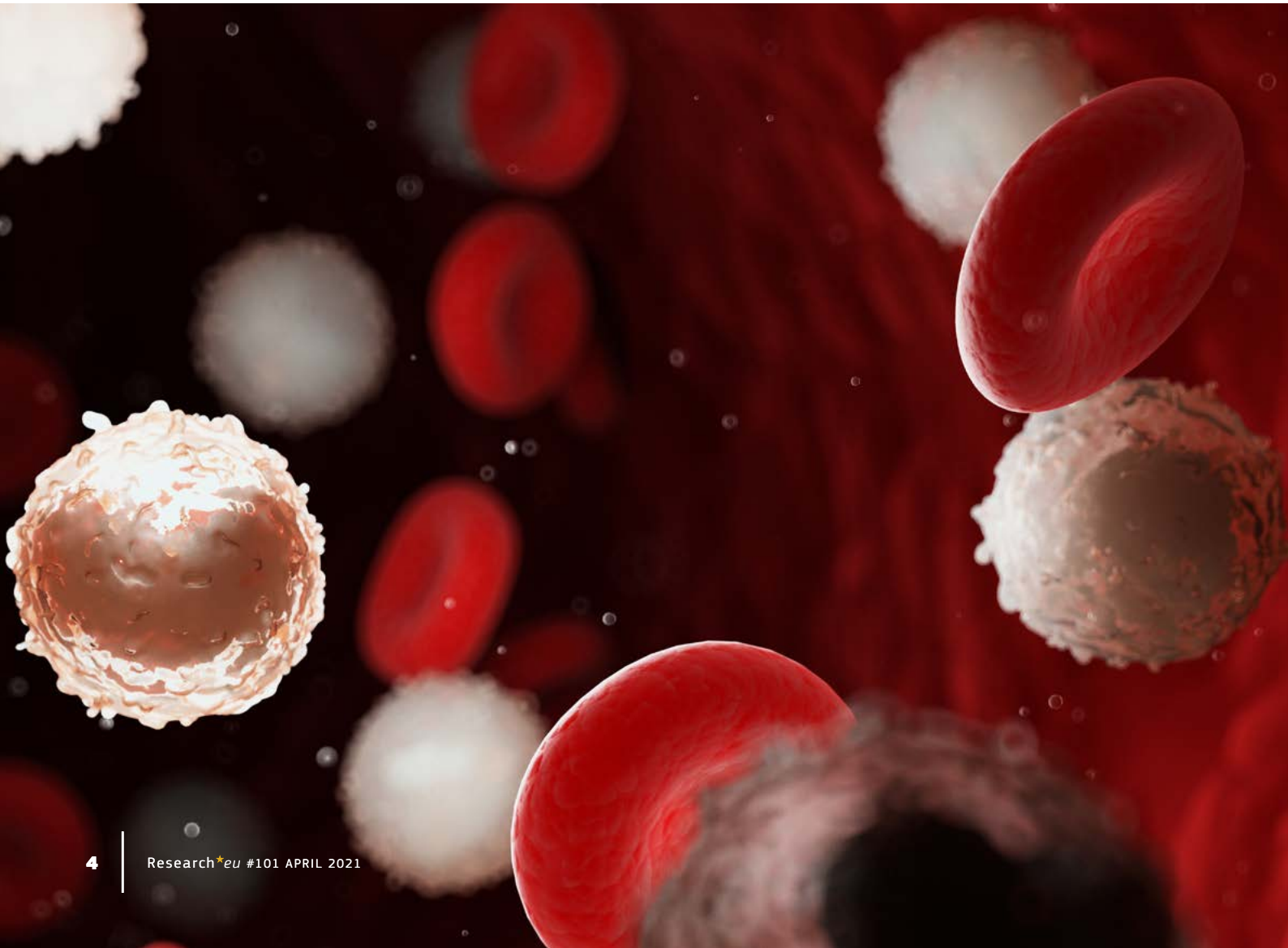
Biobank innovation could lead to targeted leukaemia treatments

EU-funded researchers have pioneered an innovative method for screening anti-leukaemia therapeutics. This has the potential to revolutionise drug discovery and ultimately save the lives of cancer patients.

Acute myeloid leukaemia (AML) is a disease where white blood cells proliferate uncontrolled and displace red blood cells and platelets. This can lead to fatigue, bleeding and a high risk of acquiring infections.

"Despite our increased understanding of the underlying mechanisms, current treatments can only cure between 40% and 50% of younger patients and 10% to 20% of older patients," says PNANOMED (Personalized Nanomedicines for Leukemia Patients) project coordinator Michael Heuser, a clinician-scientist at Hannover Medical School in Germany.

A key challenge to treating this condition is the fact that few patients are alike. Even within a single patient, leukaemic cells vary enormously, and many of these cells



> *Our ability to serially transplant these patient-derived leukaemia cells enabled us to screen therapeutics targeting leukaemia-related mutated genes.*

do not respond to treatment. The difficulty of developing clinical models that represent this complexity has been an obstacle to achieving breakthrough research.

INNOVATIONS IN SCREENING

To address this challenge, the PNANOMED project, which was undertaken within the Marie Skłodowska-Curie Actions programme, was launched with several key objectives in mind.

Heuser wanted to establish a genetically characterised biobank of AML xenografts (tissues that can be transplanted from one species to another, in this case, humans to mice). He then sought to characterise the mutations in these xenograft models, and from this, identify effective strategies capable of stopping the tumour-causing activity of these mutated genes.

"This biobank of human AML cells was transplanted into immunodeficient mice," he explains. "Our ability to serially transplant these patient-derived leukaemia cells enabled us to screen therapeutics targeting leukaemia-related mutated genes."

Through this technique, Heuser and his team discovered that combining azacitidine (a drug that switches on genes that stop cancer cells growing and dividing) and another anticancer drug called trametinib significantly prolonged the survival of mice, compared to single-agent treatments.

The project team was also able to develop a highly efficient and non-toxic nanoparticle-based delivery system for small RNA pieces (siRNA) that shut down the activity of cancer-causing genes. The delivery system is similar to the ones currently being developed for mRNA SARS-CoV-2 vaccines and Heuser expects that the broader use of this technology will also benefit cancer patients.

PNANOMED

- Hosted by Hannover Medical School in Germany
- Funded under Horizon 2020-ERC
- cordis.europa.eu/project/id/638035
- Project website: bit.ly/3tR2eF6

FRONTIER RESEARCH FOR THE GREEN DEAL: DRIVING FORWARD EUROPE'S CLIMATE AMBITIONS THROUGH INNOVATION AND TRANSFORMATION

With the European Green Deal, the EU aims to be completely carbon-neutral by 2050. This is an enormous ambition, and innovative frontier research supported by the European Research Council (ERC) will play a vital role in powering forward the cutting-edge research and technological development needed to achieve it.

Being such a large undertaking, advances in human understanding and knowledge driven by frontier research can help provide important context and comprehension of the issues at stake and can already begin laying the groundwork for real solutions to emerge.

The 15 ERC-funded projects featured in this Results Pack are already engaged in pioneering research that may now be at a more theoretical or early technological development stage but could soon form the backbone of the drive to achieve the Green Deal aims. Their research is broad, taking in many different fields but all of which have a key role to play.

To find out more, browse, download or order a physical copy of the Results Pack here: cordis.europa.eu/article/id/422669

The genetic link between immunity and schizophrenia

Understanding the genetic risk of developing a disease is central to the design of preventative strategies. European researchers unveiled key genetic loci that determine immune response to infectious stimuli and are associated with the development of schizophrenia.

For many diseases, genome-wide association studies (GWAS) have identified genetic variants in loci close to immune-related genes, underscoring the importance of the immune system in the pathophysiology of many diseases. With respect to schizophrenia, emerging evidence suggests that inflammation in the central nervous system may be an underlying factor with monocytes and microglia playing a central role.

IDENTIFYING GENETIC VARIANTS OF IMMUNE-RELATED GENES

Given the central role of inflammation in many diseases, the project IMAGENE (Characterizing Function Genetic Variants Linking Immunity and Psychiatric Disorders) elucidated the link of immune genetic variants with schizophrenia. "We looked into genetic factors that affect variation in immune response among different individuals and found that some of them help us to better understand complex diseases such as schizophrenia," explains Marie Skłodowska-Curie Actions (MSCA) research fellow Sarah Kim-Hellmuth.

The research was undertaken with the support of the MSCA programme and involved the comparison of expression quantitative trait loci (eQTLs) – genetic variants associated with gene expression – in monocytes at baseline and upon immune stimulation. This led to the identification of so-called response eQTLs (reQTLs), where the eQTL effect differs between immune stimuli. "Such genetic variants can impact the response to infection, and highlight the context-specificity of genetic regulation," says Kim-Hellmuth.

Interestingly, results demonstrated that genetic polymorphisms associated with schizophrenia risk are eQTLs of immune response genes. These results indicate that environmental interactions with microbial ligands might play a role in the underlying mechanism of genetic risk of schizophrenia.

Extensive efforts also went into the development of a method for studying the cell specificity of eQTLs in bulk tissue by mapping interactions between computational estimates of neuron abundance and genotype in 13 different brain tissues of post-mortem donors from the Genotype-Tissue Expression (GTEx) database. Applying this approach to the massive GTEx resource enabled the research fellow to identify the cellular origin of hundreds of disease susceptibility loci including those for psychiatric disorders.

THE IMPORTANCE OF STUDYING VARIABILITY IN IMMUNE RESPONSE

Emerging evidence underscores the importance of the human immune system not only in host protection and autoimmune and inflammatory diseases, but also in cancer, metabolism and ageing. Given this central role in many human pathologies, it is crucial to understand the

> *IMAGENE results illustrate the importance of studying genetic variation in the right cell type and under relevant conditions to resolve functional genetic variants and the transcriptional responses associated with schizophrenia.*

variability of immune responses at the population level and how this variability relates to disease susceptibility.

Studying the genetic influence on immune response is impeded by the complexity of the immune system. This pervasive network consists of many different cell types that respond to a plethora of signals, interact with each other and induce different effector functions under diverse kinetics.

"IMAGENE results illustrate the importance of studying genetic variation in the right cell type and under relevant conditions to resolve functional genetic variants and the transcriptional responses associated with schizophrenia," concludes Kim-Hellmuth. Furthermore, the IMAGENE project supports a model where the genetic risk of a disease can sometimes be driven by the failure to respond properly to an environmental stimulus. This realisation opens new avenues for tailored treatments in individuals suffering from schizophrenia.

IMAGENE

- Coordinated by the Max Planck Society for the Advancement of Science in Germany
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/706636

HEALTH

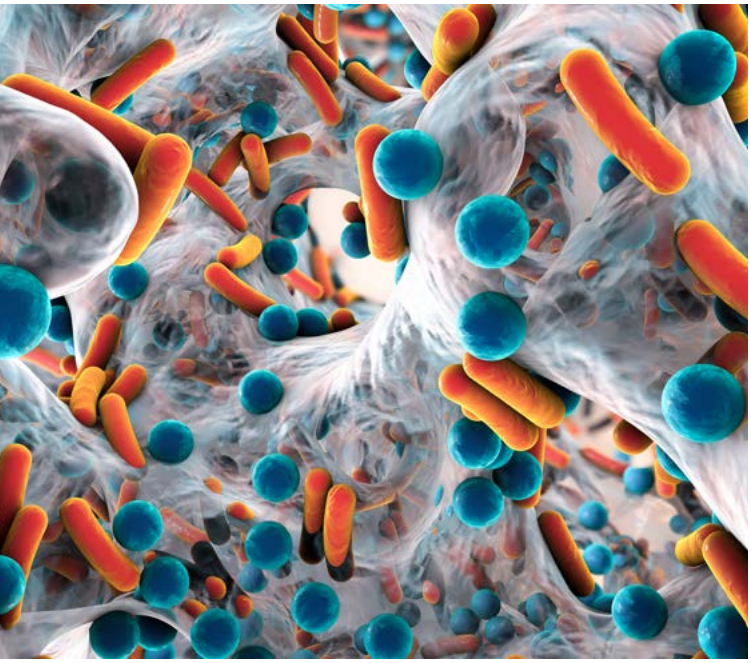
Love thy neighbour: how bacteria cooperate against an antibiotic threat

Wastewater treatment plants are considered as hotspots for antibiotic resistance dissemination from pathogens to environmental bacterial species. By studying the interactions between antibiotic-resistant and -sensitive bacteria in such treatment plants, European researchers hope to understand the mechanisms underlying antibiotic resistance spread.

The European Commission has declared antibiotic resistance a major socio-economic challenge. Emerging evidence indicates that the environmental sector contributes to the spreading of antibiotic resistance, but the mechanisms remain poorly understood. Wastewater bacteria are well known to connect the human, animal and environmental sectors, so it is central to understand how antibiotic resistance spreads and circulates back to the human population.

DELINEATING BACTERIAL INTERACTION IN BIOFILMS

The scope of the project SHARE_WW (Spatial organization and Horizontal gene transfer of Antibiotic Resistance by ESBL in WasteWater) was to study how bacteria growing together in specialised 3D communities known as biofilms contribute to the transmission of resistance genes. The research was undertaken with the support of the Marie



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Skłodowska-Curie Actions (MSCA) programme and involved the co-culture of four different bacteria to generate multispecies biofilms. "In nature, bacteria do not live alone, as individual cells, but in microbial cities, as neighbours, interacting with each other in a friendly or competitive way," explains MSCA research fellow Ana Filipa Silva.

The work focused on the resistance to beta-lactams, a widely used class of antibiotics, currently being exploited as the last resource in hospitals to treat multidrug-resistant infections. Bacteria detected in wastewater have been documented to degrade beta-lactams through the production of beta-lactamase enzymes which cleave the antibiotic chemical molecule, rendering it inefficient. To obtain a better understanding of the relationship between biofilm production and beta-lactam resistance, Silva investigated the impact of the antibiotic in bacterial organisation in the biofilm matrix.

She discovered that bacteria that have preferred neighbours and biofilms are more stable when cooperation is established. In the presence of an antibiotic threat, biofilm matrix production increases to enclose sensitive bacteria and their neighbours in a dense and protective matrix. If antibiotic-resistant bacteria are present, then resistance genes are transferred to the sensitive species to protect them against the antibiotic. Moreover, resistant species seem to secrete to the surroundings the enzyme responsible for antibiotic degradation, thereby offering an additional layer of protection to their sensitive neighbours.

> *"Importantly, our work unveiled the importance of all bacteria in biofilms – sensitive and resistant to antibiotics – in clinical diagnosis and treatment."*

TARGETING THE NEIGHBOURS: AN ALTERNATIVE APPROACH TO TACKLING ANTIBIOTIC RESISTANCE

Collectively, the work of the SHARE_WW project provided fundamental knowledge on biofilms resistant to beta-lactams in the environmental framework. "Importantly, our work unveiled the importance of all bacteria in biofilms – sensitive and resistant to antibiotics – in clinical diagnosis and treatment," adds Silva. Bacteria in biofilms generate a cooperating community against the antibiotic threat, with resistant bacteria sharing resistance genes and enzymes while sensitive species build on a protective biofilm matrix.

Understanding the conditions and the mechanisms underlying such events will fuel future research into strategies for eliminating antibiotic resistance from wastewater. Furthermore, this information has the potential to shift the focus of therapeutics from targeting only antibiotic-resistant bacteria to devising strategies against all species in a biofilm. Wastewater treatment plants have already shown interest in the SHARE_WW results and are working to incorporate the knowledge to develop tailored water treatments, especially when the treated effluent is recycled for anthropogenic activities.

SHARE_WW

- Coordinated by the University of Copenhagen in Denmark
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/794315

PROJECT OF THE MONTH

Supporting SMEs to advance their solutions in the fight against COVID-19

This month we showcase the COVID-X project that began in November 2020. Its mission: To invest around EUR 4 million to fast-track to market over 30 European data technology solutions that have the potential to confront and overcome many of the challenges that have resulted from the COVID-19 pandemic.

© COVID-X

The 2-year COVID-X (COVID eXponential Programme) project will jump-start over 30 European solutions onto the market, providing: 1) Up to EUR 150000 in equity-free funding to companies to validate their initiatives in real-world health-care sites; 2) A 10-month acceleration programme to consolidate the ideas, including technical support, ethical validation and business coaching; 3) Exclusive access to the COVID-X SandBox, the one-stop platform for exploiting COVID-19 data sources for management, integration and visualisation.

The first COVID-X Open Call closed in January 2021, receiving 112 applications from 29 countries. Following evaluations, the top 10 solutions with TRL7+ will be supported to begin advancing their solutions in the areas of diagnosis, prognosis and follow-up.

The second COVID-X Open Call is due to take place before summer 2021. For more information, please see:

→ covid-x.eu

> *"COVID-X is working to ensure that the selected projects will deliver concrete solutions to fight the pandemic by the end of the acceleration programme. We are confident that the project we'll be supporting through the acceleration programme will help save lives and contribute to a more resilient society."*
>
> Antonio Damasceno, COVID-X project coordinator

COVID-X

- Coordinated by F6S Network Ireland Limited in Ireland
- Funded under Horizon 2020-HEALTH
- cordis.europa.eu/project/id/101016065
- Project website: covid-x.eu

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!

SOCIETY

Towards a more inclusive and effective paradigm for achieving criminal justice

We all have experience with 'punishing' or 'being punished': from being scolded by our parents for bad behaviour, to handing out our own reprimands. EU-funded research explored how punishments are perceived by the wrongdoer, with important findings for criminal justice systems.

Punishment, as a topic of academic study, spans a range of scientific fields, with much research focusing on the act of punishing itself. To date, however, not much is known about how transgressors perceive and make sense of their punishment.

The project PUNISH (Punishment as Communication: Transgressors' Interpretation and Understanding of Punishment), undertaken with support of the Marie Skłodowska-Curie Actions programme, approached this question by exploring the notion of punishment as a social interaction, in which a punisher 'communicates' a message to a transgressor.

HOW TRANSGRESSORS UNDERSTAND THEIR PUNISHER'S MOTIVES

Using an interdisciplinary theoretical framework, the project created a basic taxonomy classifying five kinds

> *Specifically, our results indicate that transgressors are sensitive to the interpersonal or relational dimensions of punishment. The motive they attribute to the punisher influences their reactions, and thereby the effectiveness of sanctions at changing attitudes and, potentially, behaviour.*

of punisher motives: relationship-oriented (aimed at restoring the relationship between transgressors and society), harm-oriented (aimed at making the transgressor suffer), self-oriented (aimed at benefiting the punisher), victim-oriented (aimed at addressing victim needs) and society-oriented (aimed at generating a society-wide benefit). The research team then conducted two experimental studies to test how transgressors attribute punisher motives – in other words, why they think they are being punished.

First, the researchers ran an online study using a hypothetical vignette design, a common paradigm in social psychology. "Participants were asked to imagine themselves in a situation where they were punished by their workplace manager for stealing money, and we tested whether the way their punishment was communicated to them (respectfully vs disrespectfully) influenced motive attributions and attitudes," says project coordinator Mario Gollwitzer.

In the second study – a laboratory-based game, borrowed from behavioural economics – participants worked in small teams to maximise a shared resource. They could choose to act selfishly by keeping more game points for themselves or act cooperatively by contributing more points to the public good (a shared pool of points). Selfish players were punished by another referee player.

The results of both experiments showed that punishment communicated in an interpersonally respectful manner increased the likelihood of transgressors attributing the punishment to relationship-oriented motives – i.e. a motive with a constructive impact on the transgressor. Importantly, transgressors' motive attributions had flow-on effects: interpreting punishment as relationship-oriented increased perceived legitimacy and motivation to change. In contrast, when transgressors believed they were being punished for self- or harm-oriented reasons (e.g. self-serving or spiteful motives on behalf of the punisher), they responded defensively, expressing hostility towards their punishment and punishers and less willingness to change.

FROM EXPERIMENTAL TESTS TO REAL-WORLD APPLICATION

The project's results are a significant contribution to literature on punishment, showing that a transgressor's own interpretation of the message implied in their penalty matters more than hitherto expected. Gollwitzer explains: "Specifically, our results indicate that transgressors are sensitive to the interpersonal or relational dimensions of punishment. The motive they attribute to the punisher influences their reactions, and thereby the effectiveness of sanctions at changing attitudes and, potentially, behaviour."

Project researcher Melissa de Vel-Palumbo adds that this finding has important implications for sanctioning systems: "Authorities should convey that they are punishing transgressors, not to harm or humiliate them, but rather in an inclusive manner that communicates an opportunity to repair the relationship breached by the wrongdoing." As a next step, therefore, the researchers aim to conduct field research to test whether the findings hold in a real-world criminal justice context and can help authorities communicate punishment in ways that better achieve justice.

PUNISH

- Coordinated by Ludwig Maximilian University of Munich in Germany
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/839639
- Project website: bit.ly/2Ovr1ym

Bringing to light the unobservable term premium of Euro Area government bonds

Previously considered an obscure part of academic jargon, the term premium of government bonds has become key to discussions on monetary policy and economic stability. An EU-funded project sheds further light on this unobservable component of the yield curve to the benefit of policymakers, central bankers and the general public.

The financial crisis and, more recently, the coronavirus pandemic, have posed new challenges for the European Central Bank (ECB). To stabilise financial markets and stimulate economic growth, the ECB adopted unconventional monetary policy measures, such as negative interest rates and quantitative easing.

In this context, a clear understanding of the forces underlying the movements in interest rates is highly relevant. Focusing on one of the two main components of interest rates, the EUTERPE (Estimation of the term premium in Euro Area government bonds) project, with support from the Marie Skłodowska-Curie Actions programme, implemented an innovative system producing timely and reliable estimates of the 'term premium' for government bonds of the euro area (EA).

SEPARATING THE TWO FUNDAMENTAL COMPONENTS OF INTEREST RATES

The yield curve of government bonds is used to predict changes in economic growth and is vital for the transmission of monetary policy. However, proper interpretation of yield curve information requires separating the two fundamental components of interest rates: the expectations component and the term premium.

Project coordinator of EUTERPE, Andrea Berardi, explains: "The expectation component in yields reflects the average of current and future expected short-term rates over the maturity of the yield, while the term premium component represents the additional compensation investors demand to hold a longer-term bond relative to a series of shorter-term bonds, thus reflecting market participants' uncertainty with respect to future interest rates. The distinction between the two components is crucial for central bankers."

The EUTERPE project aimed to disentangle the term premia from expectations of future interest rates and developed a new analytical tool with various applications for European policymakers and the financial industry. Specifically, the project results showed that long-term yields can be split into several components, each with a specific economic content. The practical analytical tool developed will help to derive estimates for all these unobservable variables from market data. "We might say that 'it makes visible the unobservable' in the term structure of interest rates," says Monica Billio, supervisor of the project. In this regard, the application of the EUTERPE methodology may represent a very useful tool for central bankers making monetary policy decisions.

A UNIQUE EUROPEAN DATABASE

The project also developed a system of indicators calculating the exposure of EA government bonds to diverse risks. "Looking in particular at the European dimension, these techniques may provide a contribution, for example, to the new legislation for a Pan-European Personal Pension Product or the development of a comprehensive model for European asset allocation in the context of the European Commission's new Action Plan for a Capital Markets Union," notes Berardi.

To disseminate the findings as broadly as possible, the project's website content can be divided into three

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> *The expectation component in yields reflects the average of current and future expected short-term rates over the maturity of the yield, while the term premium component represents the additional compensation investors demand to hold a longer-term bond relative to a series of shorter-term bonds, thus reflecting market participants' uncertainty with respect to future interest rates. The distinction between the two components is crucial for central bankers.*

sections: a scientific section including technical notes, working papers and publications; a data section including downloadable estimates of the term premium and interest rate expectations for EA countries; and a popular science section. "All these sections will be updated monthly to provide a unique database, which can be useful not only to policymakers, but also to long-term investors and researchers, and with potential to become a reference point at European level," adds Berardi.

EUTERPE

- Coordinated by Ca' Foscari University of Venice in Italy
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/793763
- Project website: bit.ly/euterpe-project

SOCIETY

What Norse myths tell us about our own world

A groundbreaking study into Norse mythology sheds new light on a fascinating culture from the past and contains some vital lessons for a modern world full of its own urban myths.

Old Norse culture encompasses both the 'Viking' and the medieval cultures of Iceland and Norway, as well as parts of England, Ireland, Scotland and several other North Atlantic islands.

"As 'Viking' can sometimes be interpreted as 'pirate' or 'robber', it can be misleading when we call the Scandinavians of the 9th to the early 11th century Vikings," says SYMBODIN (The Symbolism of the Body in Northern Europe. Cognitive Metaphors and Old Norse Myth from the Viking Age to Late Medieval Times) project coordinator Jens Eike Schnall, associate professor of Old Norse Studies at the University of Bergen, Norway.

Schnall notes that these people were mostly farmers. Some were merchants or, indeed, went on military expeditions, and among them were some refined craftsmen and poets.

Christianity was gradually taken up from around 900 AD onwards. "Anyone dealing with the pre-Christian religions and beliefs in the North faces a challenge here," adds Schnall. "Apart from runic inscriptions, pretty much all the written Nordic sources originate from a far later Christian context. Trying to penetrate these texts is extremely difficult."

© SYMBODIN, Kozak2

CRACKING THE CODE

Nonetheless, this was the ambitious goal set by the SYMBODIN project, undertaken with the support of the Marie Skłodowska-Curie Actions programme. "Old Norse religion belongs to the pre-Christian traditions of Europe and offers a unique cosmology and world view," says Marie Skłodowska-Curie fellow Jan Kozák. "And this world view was expressed in myth."

Kozák's specific aim was to better understand how the image of the body was used in Norse myths to speak symbolically about topics other than the body itself. By cracking this 'code', Kozák hoped to offer a wider explanation of why myth was such a useful tool for describing their world.

To begin, Kozák collected examples of body symbolism from primary sources (Old Norse mythological texts) and sorted them into various categories. He then devised a theoretical framework based on psychological, semiotic and cognitive linguistic concepts and applied this to the sorted data.

MYTHS AS INSIGHT

Kozák's research led him to conclude that Norse myths are so surreal because they give preference to the associative links that our minds make. "They are in a way 'true stories' – not about the reality out there, but about the reality of our cognitive apparatus and its inner logic," he notes.

> *"I hope the long-term legacy of this work will be to show that myths are not 'primitive science.'"*

Kozák argues that these findings are important, not just for understanding cultures of the past, but also for understanding contemporary religions and secular mythology (urban folklore, etc.). "We still misunderstand myth as 'bad facts'," he explains.

"Myths use a different code than our everyday communication. They are reflective formations that give us a unique insight into how our cognitive apparatus and our social symbolic system works."

For example, despite all our technological advancement, we as a society still lack a fundamental understanding of contemporary political myths, urban myths, nationalistic myths, etc. "We really don't know how these phenomena function and why they attract people," says Kozák. "Studying Old Norse myths instead of contemporary secular mythology gave me the distance to stand back and analyse this phenomenon, without being entangled too much."

Kozák is currently completing a paper based partially on data from the SYMBODIN project. He plans to follow up with research focusing on the god Thor, mapping the phenomenology of the deity and its various aspects. "I hope the long-term legacy of this work will be to show that myths are not 'primitive science', but rather psychological and sociological phenomena that express something real about our mind and society," he concludes.

SYMBODIN

- Coordinated by the University of Bergen in Norway
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/750379
- Project website: bit.ly/symbodin-project

ENERGY

Automation drives cheaper fuel cell technology

The single most expensive component of a solid oxide fuel cell system is the fuel cell stack. EU researchers have developed a new mass manufacturing process for stacks that improves quality control and reduces costs.

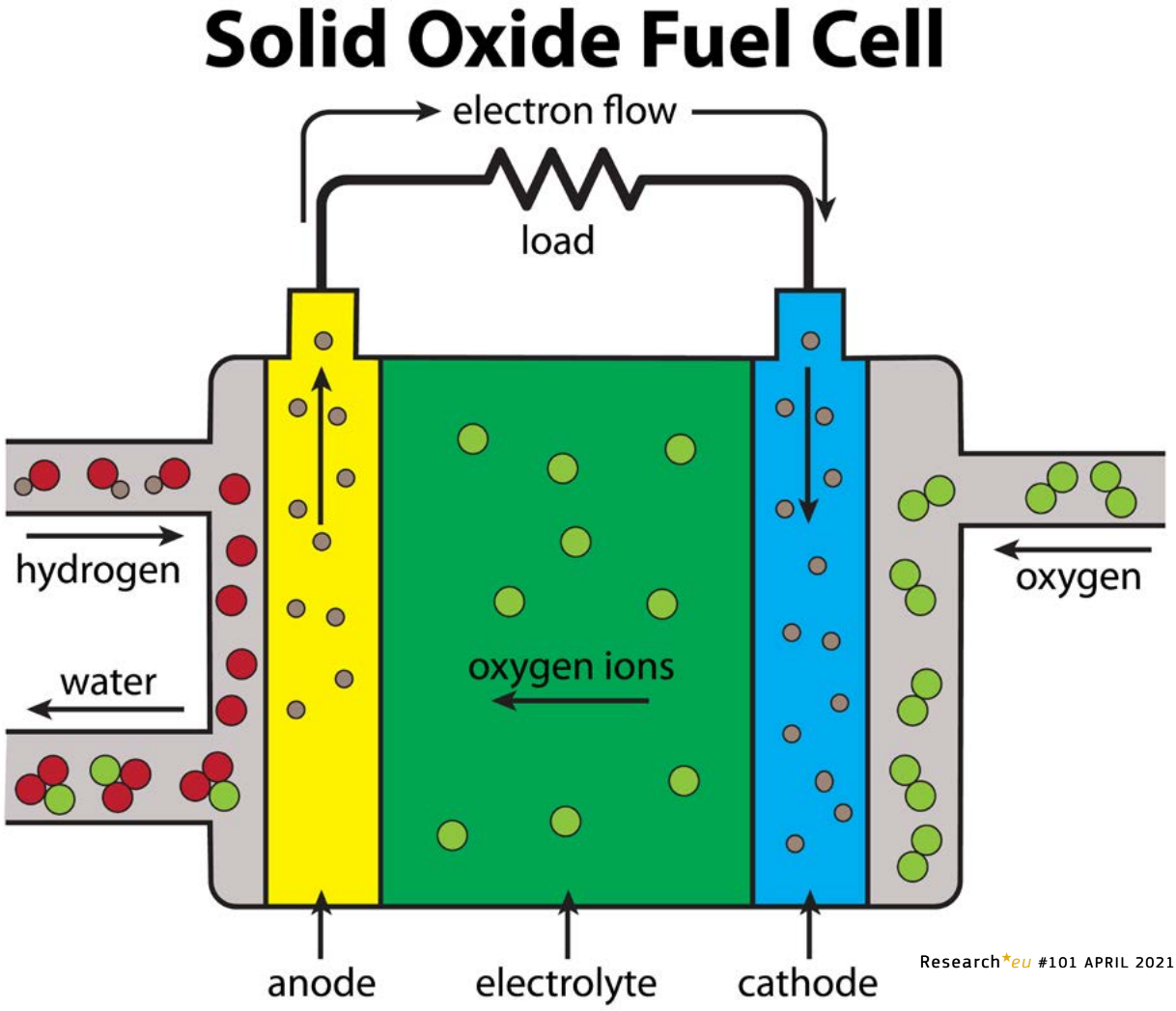
Solid oxide fuel cell (SOFCs) are among the most promising renewable energy technologies for reducing carbon, sulfur and nitrogen oxide emissions. However, a single cell only produces some tens of watts of electricity. The solution is to arrange the cells in a stack to provide greater power – like batteries in a battery pack.

In terms of mass manufacturing, fuel cell technology is at a relatively early stage. Only now have some fuel cell technologies matured to a high enough level for serious production to begin. But, despite significant progress over the last decade in SOFC technology, cost remains the greatest obstacle to wider acceptance.

Current capital expenditure on state-of-the-art SOFC systems focuses on SOFC stack cost reduction and quality improvement. This would be achieved by replacing manual labour with automated procedures in all key parts of the stack manufacturing and quality assurance processes.

QUALITY INSPECTION IS THE KEY

The EU-funded project qSOFC (Automated mass-manufacturing and quality assurance of Solid Oxide Fuel Cell stacks) addressed this challenge by developing automation and quality assurance for SOFC stack manufacturing. "This will lead to significantly cheaper



SOFC stacks with higher quality, thus boosting market penetration of the technology," says project coordinator Markus Rautanen.

Researchers optimised key steps in cell manufacturing and quality assurance by developing and testing a high-speed cell-manufacturing process. "This included an automated 3D machine vision inspection system (MVIS) to detect defects in cell manufacturing," Rautanen explains.

Project partners designed and built a novel MVIS capable of fully inspecting a fuel cell within 10 seconds, detecting defects as small as 10 µm in size. "We also developed the test matrix for the application of an advanced analysis tool known as Distribution of Relaxation Times (DRT) for assessing and quantifying the performance of cells, stacks and stack components," notes Rautanen.

A WORLD LEADER

DRT is an analytical tool for interpreting data from electrochemical impedance spectroscopy and is capable of distinguishing and qualifying each electrochemical process. According to Rautanen: "DRT can examine the quality and homogeneity of a given cell batch and identify any anomalies or need for specific improvements faster and more extensively than traditional methods."

This allows cell manufacturers to conduct quality control of cell batches to evaluate the consistency of electrochemical response and produce a statistically relevant quality control data set. The data set is used for benchmarking the impact of modifications on the manufacturing process. These include changes in raw material source and typology and improvements in cell architecture, similar to those already well established in other fields that involve mass manufacturing.

> *This will lead to significantly cheaper SOFC stacks with higher quality, thus boosting market penetration of the technology.*

By developing manufacturing and quality assurance procedures suitable for mass production of stacks and stack components, such as individual fuel cells, qSOFC strengthened Europe's position as a leader in fuel cell and hydrogen technologies. "These promise to provide a more sustainable future and new business opportunities for companies across the EU and increase the competitiveness of the European fuel cell industry, as well as benefiting society as a whole," concludes Rautanen.

QSOFC

- Coordinated by VTT Technical Research Centre in Finland
- Funded under Horizon 2020-ENERGY
- cordis.europa.eu/project/id/735160
- Project website: qsofc.eu

ENERGY

Innovations suggest bright future for printed photovoltaics

New material and processing innovations could make printed photovoltaics more reliable, long-living and cost-effective. This in turn could speed up Europe's transition to a decarbonised energy system.

Printed photovoltaics (PVs), which can be used to convert sunlight into electricity, offer numerous advantages. They are lighter than conventional wafers, and potentially cheaper to mass produce. As a result, they have been identified as a promising future source of renewable electric power.

"The potential for cost reduction in printing PV modules could be significant," explains Sol-Pro (Solution Processed Next Generation Photovoltaics) project principal investigator Stelios Choulis, founder and head of the Molecular Electronics and Photonics Research Unit at Cyprus University of Technology.

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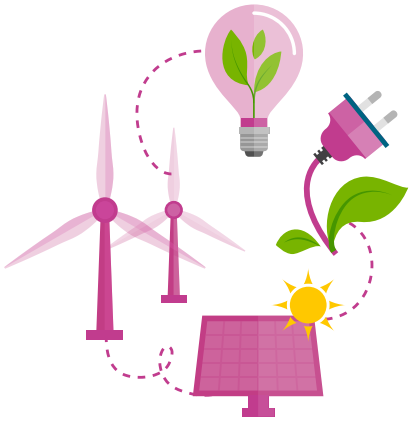
"A roll-to-roll print production line has the potential to produce the same area in tens of hours as a conventional wafer production plant can in a year."

Printed PVs are now reaching the same efficiency values as conventional silicon PVs. A key challenge however is ensuring that organic and hybrid perovskite optoelectronic materials – materials used in the production of printed PVs – are environmentally stable over the long term. This is critical to ensuring that printed PVs can be part of Europe's sustainable future.

PVs have been identified as a key enabling technology for decarbonising Europe's energy system. In fact, the EU needs to increase its PV capacity from 117 GW to over 630 GW by 2025 and 1.94 TW by 2050 in order to cover 100 % of its electricity needs from renewable energy.

The EU needs to increase its PV capacity to 1.94 TW by 2050 in order to cover 100 % of its electricity needs from renewable energy



> *These innovations can in practice now be applied to roll-to-roll PV printing manufacturing.*

OPTIMISING SOLAR CELL PERFORMANCE

The European Research Council-funded Sol-Pro project set out to address some of these challenges. Choulis and his team analysed printed PV materials and devices, with a view to optimising their cost competitiveness and lifetime reliability.

New material systems were trialled and tested. Innovative optoelectronic synthetic material and processing methods were also developed, with the aim of precisely controlling critical elements, such as nanoparticle size and crystallinity. Such improvements were shown to improve PV device performance and reliability.

"We were also able to show that many of the physical and engineering aspects that govern the behaviour of printed PVs occur at the PV device interfaces," adds Choulis.

"This enabled us to develop high-quality interfaces that optimise PV performance." Novel surface interlayer treatment and active layer additive engineering methods were also shown to deliver dramatically increased lifetime performance, under accelerated heat and humidity conditions.

FUTURE ENERGY GENERATION

Choulis is confident that the advances made in the Sol-Pro project will contribute positively towards the ongoing development of low-cost and large-area printing PVs for energy generation. The team successfully demonstrated how the heat lifetime performance of printed PVs can be improved through the incorporation of diffusion blocking layers within the PV device architecture.

"These innovations can in practice now be applied to roll-to-roll PV printing manufacturing," he notes. "They offer simple engineering routes to reducing the efficiency-stability-reliability gap of solution-processed PVs."

The Sol-Pro project also identified some persistent lifetime limitations. Choulis and his research team are

currently partners in RoLA-FLEX, a recently launched EU-funded project that seeks to address this specific challenge. Cost-effective electrodes with novel printing methods will also be further addressed under this project.

In the meantime, electronic material developers, chemical companies, printing equipment manufacturers and printed PV module producers all stand to benefit from Sol-Pro's research. Much of the work has been published in open access scientific papers and represents an excellent starting point for the future development of long-life, reliable next-generation printed PVs.

SOL-PRO

- Hosted by Cyprus University of Technology in Cyprus
- Funded under Horizon 2020-ERC
- cordis.europa.eu/project/id/647311
- Project website: web.cut.ac.cy/mep

ENERGY

Microorganisms reveal location of oil and gas reserves

Fossil fuels are expected to be needed for three more decades before the world fully transitions to 100 % renewable energy use, according to the most optimistic forecasts. This will require oil and gas exploration to be conducted with the minimum amount of damage to the environment.

Even with the best available technology, oil and gas (O&G) companies may need to drill multiple wells before they successfully find oil or gas. This is extremely expensive as it requires an enormous logistical effort and is costly to the environment.

Every shale well not drilled saves USD 6 million, as well as 10 million litres of water, 100 000 litres of chemicals and 4 000 lorry journeys. Offshore exploration is much more costly as it requires expensive offshore rigs and supply vessels, plus there is the associated damage to the ecosystem.

The EU-funded Biodentify (Oil and Gas Exploration Made Greener and Cheaper) project developed a revolutionary technology that avoids unnecessary drilling by predicting whether an O&G field will be sufficiently productive. "Biodentify uses DNA from 30 cm deep soil samples to identify an oil or gas accumulation before drilling with a 70 % or higher accuracy," states project coordinator Jonathan Zwaan.

HOW IT WORKS

Every oil or gas accumulation produces microbubbles that travel upwards through the rock via microcracks before reaching the surface. Although the seepage is too small to measure directly, it does influence the composition of microorganisms living in the ground.

By extracting the DNA from surface soil samples, Biodentify researchers were able to obtain a DNA 'fingerprint' made up of the biomarkers from the different bacterial species present. "We first extract DNA, producing tagged 16S rRNA, and use it to identify all bacterial species present in the soil sample," comments Zwaan.

The hundreds of thousands of species counted in thousands of soil samples create an enormous quantity of data, which is correlated with the presence or non-presence of hydrocarbons. "Advancements in computer processing power now make it possible to construct reliable and predictive computer models by applying machine learning," Zwaan notes.

HIGHLY ACCURATE TECHNIQUE

Researchers tested a suite of AI algorithms on current data in the Biodentify database to achieve the greatest possible accuracy in correlating microbes and the presence of O&G. They also performed four successful proof of concept pilots to prove the technology to clients from the O&G sector.

The first pilot in Argentina predicted the presence of hydrocarbons in a conventional hydrocarbon setting with 97 % accuracy and was able to distinguish shallow oil from deep gas locations. The North Sea pilot used drill cuttings to predict the presence of oil or gas with an accuracy of 82 %. In the United States, two pilots were conducted, one for shale gas in Texas and one for shale oil in North Dakota, with 85 % correct prediction as a result.

> *"Our technology will greatly assist in de-risking drilling O&G wells, both for shale and for on- and offshore conventional exploration thanks to our robust and accurate predictions."*

Biodentify will help to make both shale production and offshore/onshore conventional exploration cheaper and reduce environmental impacts as well as complement conventional seismic surveys to quantify the amount of hydrocarbons present. "Our technology will greatly assist in de-risking drilling O&G wells, both for shale and for on- and offshore conventional exploration thanks to our robust and accurate predictions," Zwaan concludes.

BIODENTIFY

- Coordinated by Biodentify in the Netherlands
- Funded under Horizon 2020-LEIT, Horizon 2020-SME and Horizon 2020-Societal Challenges
- cordis.europa.eu/project/id/829284
- Project website: biodentify.ai

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bit.ly/CORDIScovery_Aviation

What a Stone Age climate crisis can tell us about our own future

An abrupt shift in the climate 12 000 years ago holds clues for how global warming might affect different regions of Europe.

Greenhouse gases from human activity are warming the planet, but how climate change will manifest at the fine scale is still an open question. "We know things are not changing uniformly," says palaeoclimatologist and geochemist Dirk Sachse, project coordinator of STEEPclim (Spatiotemporal evolution of the hydrological cycle throughout the European continent during past abrupt climate changes). "It's more important to know that certain regions have droughts or floods, than a wholesale increase in temperature."

ICE AGE

To better understand the properties of a rapidly changing climate, Sachse and his team turned to a historical period known as the Younger Dryas, which occurred ca 12 000 years ago. At the end of the last glaciation, after a period of warmer temperatures and melting continental ice sheets, temperatures in the northern hemisphere suddenly plummeted, almost sending Europe back into an ice age.

"It was a 4-degree temperature change over 100 years; an extremely abrupt climate change for a geologist," explains Sachse, head of the Organic Surface Geochemistry Lab at GFZ Helmholtz Centre Potsdam in Germany. "These changes happened over the period of a human lifespan."

To understand how this period of sudden climate change affected different regions in Europe, Sachse and his team, supported by the EU, looked at sediment cores taken from lakes across the continent. Trapped in the layers of mud are the remnants of leaf waxes, the shiny protective layer of hydrocarbons that covers all higher plants.

HISTORICAL RECORD

These compounds are referred to as molecular fossils, and the proportions of stable isotopes of carbon and hydrogen in these waxes act as a record of the hydroclimate at the time.

"It's not like we reconstruct temperature, but we can see certain conditions such as droughts and wetter periods," he notes.

Through collaborators, sediment cores were taken from 20 lakes, from Estonia to southern Spain. Age estimates were made using laminations in the cores that result from seasonal changes in deposition, acting like rings in a tree. These measurements were calibrated with isochrons – ash deposits from volcanic eruptions that appear across all samples at the same moment in time.

The work was supported by the European Research Council. "This would never have been possible without such funding," adds Sachse. "We're working on a Europe-wide scale. It could have been done in individual legs, but would have taken 20 years."

TIPPING POINT

Sachse says the evidence shows that western Europe was more immediately affected by the Younger Dryas, with cooler and dryer conditions spreading from Greenland over a period of 170 years. "It shows global change is always about regional change," he says.

> *If this were to happen today, there would be huge consequences for society.*

The findings will be used to generate more accurate and precise climate models in the future. The Younger Dryas is believed to have been driven by changes to the Gulf Stream, which is also expected to weaken in the future as a result of human-induced climate change and which is considered an important climate system tipping point.

"If this were to happen today, there would be huge consequences for society," adds Sachse. "The whole Holocene has been amazingly stable, now we're turning the knobs on this system."

STEEPCLIM

- Hosted by GFZ Helmholtz Centre Potsdam in Germany
- Funded under Horizon 2020-ERC
- cordis.europa.eu/project/id/647035
- Project website: bit.ly/STEEPclim

CLIMATE CHANGE AND ENVIRONMENT

Combining wood anatomy assessment techniques improves modelling of carbon sequestration

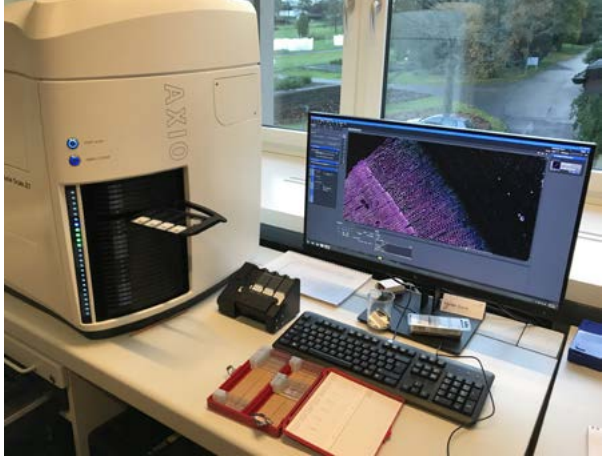
Forests pull carbon from the air, which mitigates climate change. A new study shows how much under various environmental conditions, helping to refine climate models.

Forests help regulate the gas composition that affects Earth's climate, via a process called carbon sequestration. This means that forests absorb atmospheric carbon via photosynthesis, and then lock it away in wood.

To date, models of carbon sequestration have assumed that the process is directly proportional to a forest's rate of photosynthesis. Newer information suggests that under certain environmental conditions, a tree could be photosynthesising yet producing little or no wood. Knowing how much wood is produced under various conditions is an important variable for modelling global warming.

DETAILS OF WOOD GROWTH

The EU-funded project INTREE (How and when does climate influence carbon sink activity? Multi-temporal analysis of wood formation in conifers) examined the environmental factors affecting tree carbon sequestration in temperate and boreal (high-latitude) forests. The



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traditional way to measure tree wood growth is via tree ring analysis. However, the annual scale lacks the resolution to assess the effect of weather on wood formation and how tree ring width relates to wood mass. INTREE filled this gap by innovatively relating intra-ring wood anatomy to three measurement techniques, each being applicable at different scales. The research was undertaken with the support of the Marie Skłodowska-Curie Actions programme.

The study combined tree ring analysis, quantitative wood anatomy and xylogenesis. "Tree ring analysis mainly consists of measuring the width of the annual ring increment of several trees at a site," says project coordinator Patrick Fonti. Then researchers cross-date each tree ring to correctly assign it to the correct calendar year. "Once cross-dated, the relations between the width of the annual rings can be established." Widely spaced rings mean relatively rapid growth.

Quantitative wood anatomy involves microscopic sizing of cells forming the tree ring. Dimensions of the water-transporting conduits indicate how the environmental conditions affected cells production and their anatomic characteristics. The total area of the vessel walls provides a good estimate of the amount of carbon stored in the wood. Finally, xylogenesis study means weekly monitoring of a growing tree, using micro core samples, to examine the formation of the annual ring. This also relates the formation of cells to environmental conditions.

MORE ACCURATE CLIMATE MODELS

The study concluded that quantification of the growth of water-transporting cells is a superior indicator of carbon sequestration in wood compared to tree ring growth. "So forest carbon sequestration can be better indicated by assessment of the cell characteristics of the annual rings," adds Fonti, "rather than by the widths of the rings."

Researchers also found that the recent onset of early summer drought can affect the size of a tree's water-transporting conduits. Therefore, even at high latitudes, increased summer temperatures can affect conduit formation. As climate change worsens, this could cause hydraulic deterioration, growth decline and reduced carbon sequestration.

Joining up the three measurement techniques has never previously been done. Doing so allows accurate measurement of how climatic variations affect the amount of carbon annually locked up in the tree stem. INTREE's results add important detail to the modelling of carbon sequestration, giving improved capacity for prediction of climate change. This will also improve mitigation through forest management.

INTREE

- Coordinated by the Swiss Federal Institute for Forest, Snow and Landscape Research in Switzerland
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/788951
- Project website: bit.ly/intree-project

SPECIAL FEATURE

TRANSFORMING EUROPEAN HEALTH SYSTEMS IN THE WAKE OF COVID-19

Editorial

"Healing is a matter of time, but it is also sometimes a matter of opportunity" – Hippocrates, Ancient Greek physician

Even before COVID-19, Europe's healthcare systems were facing numerous challenges. Many of them are well known, such as a need to reduce waste and for the more robust and efficient use of health data. Arguably the trend that received the most attention pre-COVID and poses the greatest overall structural challenge is Europe's ageing population. An ageing population (around 20% of the EU's population is aged over 65) means a higher prevalence of major chronic conditions, such as heart disease, stroke and cancer. It means an ever higher slice of the national budget needs to be allocated to healthcare. It means that innovative strategies to streamline and digitalise healthcare become more essential than ever. And, finally, Europe's ageing population is likely to be one of the key reasons why it has been so badly walloped by the COVID-19 pandemic in terms of overall mortality rates.

So, more than a year after Europe locked down for the first time to combat the novel coronavirus but with the imminent arrival of mass vaccination, many could argue that now is the time for a rethink on where to go from here in terms of transforming European health systems. Looking back at the last year, the pandemic has indeed accelerated some trends that had already begun but had been very much still in their infancy pre-2020.

One of these is eHealth (or 'telemedicine'), long touted as an important solution to mitigate the increased healthcare needs of the ageing population. For example, many Europeans would have experienced an online consultation with their family doctor for the very first time in 2020 due to the sheer necessity of maintaining strict social distancing protocols. Whilst probably an unnerving experience at first for many due to the novelty, this is likely to become more acceptable when, for example, only minor ailments need to be discussed that don't necessarily require a physical examination.

We're also seeing the development of increasingly sophisticated wearable technology that can monitor health indicators such as heart rate and blood sugar levels as well as those indicators associated with mental health distress. Many of these devices are also being designed in order to transmit such readings directly to healthcare professionals, adding an exciting dimension to the digitalisation of health systems. And of course, to tie all of these innovations together, is an emphasis on the safe and appropriate use of health data to not only improve healthcare outcomes but also ensure the rights of the individual patient are observed and protected.

The seven projects funded through the EU's Horizon 2020 programme and showcased in this month's special feature offer a tantalising glimpse of exciting innovations that could help define what European health systems will be offering patients and citizens over the next decade and beyond. Whilst it may take some time for these innovations to become more ingrained in our healthcare systems and for patients to experience them and their benefits first-hand, the scientists and researchers who are moving them forward have all done so with one ultimate end goal in mind: to ensure all citizens can live healthier, fuller lives as we move decisively into the Post-COVID Brave New World.

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

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SPECIAL FEATURE

TRANSFORMING EUROPEAN HEALTH SYSTEMS IN THE WAKE OF COVID-19

New evidence for better care: learning from the pandemic

An EU-funded project has delivered actionable data and analysis to help practitioners and policymakers improve healthcare in the wake of the pandemic and beyond.

What determines Europeans' attitudes towards vaccination? What's the link between COVID-19 and the decline in blood donations? How can we measure hospital quality performance? And how can such insights be translated into better care?

The IQCE (Improving Quality of Care in Europe) project has provided answers to these and other important healthcare questions, making a tangible difference for decision-makers and care professionals as they deal with the fallout from the pandemic.

The project created a European Training Network (ETN) under the Marie Skłodowska-Curie Actions framework, connecting and supporting health economics researchers at doctoral level from different European universities. While the ETN's work was not limited to the effects of COVID-19, a key part of the research effort has been focusing on the current health emergency to identify concrete pathways for emerging stronger from the crisis.

GETTING THE JAB

The European COvid Survey (ECOS), conducted every 2 months since April 2020, looked at public opinion on topics such as containment policies and vaccination in seven European countries (Denmark, France, Germany, Italy, Netherlands, Portugal and the United Kingdom).

Willingness to get the jab varies from one country to another, but one pattern is similar across the seven countries surveyed: "Trust in vaccines is of high importance – and trust is achieved by information," says Jonas Schreyögg, IQCE project coordinator and professor of Health Care Management at the University of Hamburg, which hosted the project. "78 % of those who follow the news very closely would like to get vaccinated, against 42 % of those who are less well informed."

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TARGETED OUTREACH

To increase uptake, the researchers therefore proposed targeted information campaigns for population groups whose lower educational status and media consumption make them more difficult to reach.

The ECOS has become an important tool for informing both decision-makers and the public. It has been quoted in nearly all large print media of the seven countries surveyed and saw almost 44 million online visits. Funding has been secured to continue the survey beyond the IQCE project's duration.

Vaccine acceptance is not the only area where the project has delivered new data enabling more focused communication. Research carried out by IQCE fellow Torsten Chandler for example highlighted that blood donations – negatively impacted by COVID-19 – could be boosted by campaigns targeting repeat donors rather than first-time donors.

EUROPE-WIDE ACTION

In addition to research with a strong empirical focus, the network also helped to develop new research approaches. For instance, IQCE fellow Angela Meggiolaro developed a hospital quality index using administrative data from a statutory health insurer in Germany. The index was replicated across several European countries and could potentially help to improve standards by encouraging quality-based competition.

> *Trust in vaccines is of high importance – and trust is achieved by information.*

If the health crisis has taught us one thing, it's that countries cannot go it alone: "More coordination and collaboration is needed among European countries to boost the quality of care for all European citizens – also beyond the pandemic," Schreyögg notes, citing the sharing of hospital bed capacities across borders as a case in point.

The IQCE project put this approach into practice. "Through active cooperation and communication, we have facilitated Europe-wide coordination of health economic research," he says. Work is currently underway to create a joint doctoral degree programme to further strengthen Europe's health innovation capacity.

IQCE

- Coordinated by the University of Hamburg in Germany
- Funded under Horizon 2020-MSCA-ITN
- cordis.europa.eu/project/id/721402
- Project website: iqce.uni-hamburg.de
- bit.ly/iqce-video

Preparing an innovative telemedicine system for marketisation with PPI

The COVID-19 pandemic has created an increased need for telemedicine services. Using a process called public procurement of innovative solutions, the EU-funded THALEA II project is delivering the innovative telemedicine systems that today's overwhelmed Intensive Care Units demand.

Facing an increasingly ageing population, Europe must develop new solutions for providing quality healthcare services using fewer resources. While the COVID-19 pandemic has made this challenge all the more urgent, it has also put the spotlight on a possible solution: telemedicine.

Although the need for social distancing has accelerated the uptake of telemedicine, the concept is not unique to the pandemic. In fact, the EU-funded projects THALEA and THALEA II (Telemonitoring and Telemedicine for Hospitals Assisted by ICT for Life saving co-morbid patients in Europe as part of a Patient personalised care program of the EU) have been working on developing effective telemedicine systems for years.

"The aim of both projects was to develop a manufacturer-independent, interoperable software solution for intensive care telemedicine," says Gernot Marx, THALEA II project coordinator. "Such solutions will enable ICUs to detect complications quicker, which in turn will result in a better quality of life for intensive care patients and – most importantly – more lives being saved."

The focus of the THALEA II project is to push these telemedicine systems to market using public procurement of innovative solutions (PPI). According to Marx, PPI is what happens when the public sector uses its purchasing power to act as an early adopter of the innovative solutions developed during pre-commercial procurement (PCP), the focus of the THALEA project.

"PPI shortens the route to market, allowing early adopters to implement an innovation and enabling public procurers to efficiently answer market demand with innovative products," adds Marx.

AN INNOVATIVE TELEMEDICINE SYSTEM

During the project, researchers developed a telemedicine technology aimed at supporting ICU specialists in their day-to-day routines. "The technology serves as an intermediary between specialists located in the ICU and those located at a telemedicine centre," explains Marx. "By sharing patient data and parameters via the THALEA system, this team can identify critical situations faster and adapt treatment more efficiently."

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The innovative THALEA system was prepared for marketisation during the THALEA II project. After successfully getting the THALEA system certified, THALEA II researchers turned to securing buyers. "These buyers will purchase a highly innovative, telemedical software solution – which is a huge success for both the project and the European Commission," notes Marx.

RESPONDING TO THE COVID CRISIS

Most recently, the project published a call for tenders, which was followed by an extremely important purchasing of the product by Aachen University Hospital in Germany. The system has now been deployed at 18 hospitals across Austria and Germany, where it is already being used to help ICUs treat COVID-19 patients.

> *The pandemic has given this work a sense of urgency, as our telemedicine system is well-positioned to provide specialised, effective care and treatment to a large number of ICUs.*

In light of the pandemic, medical and IT specialists are currently working at full speed and with all the necessary resources to install the THALEA systems, not only in Austria and Germany, but also across Europe.

"The pandemic has given this work a sense of urgency, as our telemedicine system is well-positioned to provide specialised, effective care and treatment to a large number of ICUs," concludes Marx. "I am happy to say that we successfully responded to this urgency and have delivered ICUs with an effective, tailored way to provide the best care to their patients."

THALEA II

- Coordinated by University Hospital Aachen in Germany
- Funded under Horizon 2020-HEALTH
- cordis.europa.eu/project/id/689041
- Project website: thalea-pcp.eu

TO-REACH sets an agenda for the cross-country transfer of innovations in healthcare

Whilst the benefits of greater translational cooperation in healthcare are widely acknowledged, its realisation is overdue. The TO-REACH project has prepared a Strategic Research Agenda to boost it and enable better health services and systems.

Europe's health services and systems are under pressure, and COVID-19 was just the latest symptom of a more profound and fundamental ailment partly caused by a lack of translational cooperation. The question is, how do we translate this widely acknowledged assessment into large-scale, sustainable and effective countermeasures?

The EU has answered this question with TO-REACH (Transfer of Organisational innovations for Resilient, Effective, equitable, Accessible, sustainable and Comprehensive Health Services and Systems), a coordination and support action (CSA) tasked with laying the groundwork for a joint European research programme. Its goal: Building on Europe's diversity to produce research evidence supporting more resilient, effective, equitable, accessible, sustainable and comprehensive healthcare. The project supports transnational learning, enhances cooperation between ministries and funding bodies, and highlights joint interests worth further investment while pointing at fragmented and duplicate efforts.

"We have been identifying means to overcome persistent barriers between different healthcare subsystems," says Walter Ricciardi, professor of Hygiene and Public Health at the Catholic University of the Sacred Heart in Rome. "We notably uncovered several gaps in the way we currently evaluate the transferability of health services and policy innovations. To ensure success of such transfers, we need to know more about the context allowing for innovation success in a specific country and the impact of organisational arrangements. We need to identify the nature of evidence needed to inform transfers of service and policy innovations, and the factors facilitating or hindering the implementation and scaling of innovations from other countries. Finally, we need evidence of the impact of service and policy innovations on performance."

TARGETING POLICYMAKERS

To enable more effective transfers, TO-REACH brings together a unique consortium of governmental and funding organisations from 20 countries within and beyond Europe. All partners share the same ambition: They want to systematically learn about the organisation of care in other settings and to build upon the challenges and priorities identified under TO-REACH.

Thanks to a mapping of policy documents and strategic roadmaps at national and international level, national expert consultations in partner countries, and an online consultation with the wider scientific and stakeholder communities, the project identified 10 such priority areas.

> *Too often innovative solutions that work in small-scale pilot studies fail to live up to expectations when rolled out in national strategies, or fail to transfer from one country to another as a result of contextual differences.*

Those include the integration of services, the redefinition of hospitals, efforts to improve mental health, person-centred health service and systems, and increased concern for the health workforce.

TO-REACH is set for completion in May 2021, but its main foreseen output – the Strategic Research Agenda (SRA) – is already wrapped up. "The document provides a European strategy to advance our knowledge and understanding of the adoption, implementation, potential scale-up and joint development of service and policy innovations. It supports their translation to other settings within and across countries. It is built around three components: identified priority challenges, review of existing literature, and proposed strategic research priorities through a conceptual model," Ricciardi explains.

Project partners are currently drafting an executive summary of the SRA for policymakers. Ricciardi hopes that the project's efforts will help build the appropriate framework for successful cross-country cooperation. "Putting the SRA into practice requires a partnership and cooperation approach, bringing together stakeholders including funders, researchers, policymakers, practitioners

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and the wider public. In fact, too often innovative solutions that work in small-scale pilot studies fail to live up to expectations when rolled out in national strategies, or fail to transfer from one country to another as a result of contextual differences," he concludes. "A common vision based on mutual learning and collaboration among countries and regions in Europe is key to allowing a transformation of health and care systems. It is key to making them stronger and more efficient and to tackling existing and future challenges."

TO-REACH

- Coordinated by ISS in Italy
- Funded under Horizon 2020-HEALTH
- cordis.europa.eu/project/id/733274
- Project website: to-reach.eu
- bit.ly/to-reach-video

Innovative personal tech can help people manage their affective disorders

It's great to wear a smartwatch or smart wristband telling us about our heart rate or level of stress. But for people with serious affective disorders, this isn't of much help. The AffecTech project has devised a set of wearable technology that not only warns them, but also allows them to take effective countermeasures in case of episodes.

Just as we get an early taste of spring and the widespread COVID-19 vaccination looms, it's also time to look back and take stock of how almost a year of lockdown affected European citizens. Beyond the many bankruptcies, lost jobs and sometimes the loss of loved ones, there is a clear trend materialising: Isolation and lack of human contact are causing enormous psychological distress, and affective disorders have become omnipresent.

Corina Sas from Lancaster University had been convinced of the need to tackle this problem long before COVID-19 emerged. As the AffecTech (Personal Technologies for Affective Health) project launched in

2017, she warned that the likes of stress, depression and bipolar conditions would become some of the highest causes of disease by 2020. But she and her partners were also convinced that personal health technology could help.

The AffecTech consortium has spent the past 4 years working on new, low-cost wearable devices to help people with such conditions. Their objective is to take the leap from monitoring technologies like smartwatches and smart wristbands to alternatives that can help patients self-manage their condition.

Why exactly did you feel the need to advance technologies related to affective disorders? What were the main problems you wanted to overcome with this project?

Corina Sas: The value of technologies for mental health is not new. In fact, it has been long acknowledged through early self-help internet sites, computerised cognitive behavioural therapy systems, or virtual reality systems for exposure anxiety in treatment of anxiety disorders. About two decades ago, we saw personal health systems shift from PC-based interventions to physiological monitoring, used mostly for the management of heart or diabetes conditions. Yet, physiological monitoring through biosensors such as those measuring galvanic skin response or heart rate can also be used to capture emotional responses.

Everyday technologies have become increasingly powerful: Our smartphones or smartwatches can capture for instance biodata associated with our emotional experiences, which holds potential for affective disorders. We just need to find how we can move beyond the monitoring of emotional responses towards actively managing them.

This is precisely the focus of the AffecTech project: to design and develop novel personal technologies that empower people to not only monitor their emotions, but understand them and more importantly, learn how to control such emotional responses in adaptive ways.

Can you tell us more about the technologies you developed? What makes them particularly innovative?

We have developed a range of technologies as research prototypes. A few examples include wearable devices to be worn on the wrist that include biosensors measuring perspiration or heart rate, and integrated with actuators to provide colour-, vibration- or temperature-based biofeedback. So, when people experience an increase in their stress level, they can immediately see, or feel on their skin this feedback, helping them to become aware.

We have also explored and developed interfaces providing such biofeedback in a way that help people lower their heart rate and calm down. These technologies have been acknowledged by the European Commission's Innovation Radar. They are innovative because we used low-cost smart materials such as thermochromic paints – which people can assemble themselves in order to make personalised affective interfaces – as actuators.

Another example is wearable devices integrating EEG sensors with subtle vibration- or temperature-based biofeedback to support mindfulness training. The novelty of this technology lies in the choice of haptic actuators and the design of the neurofeedback, informed by bodily based metaphors of meditative states. Another neurofeedback technology is our Anima prototype, which integrates two tables and EEG sensors to provide subtle visual feedback on meditation states.

Could you provide one or two examples of concrete use cases for patients?

All our prototypes are designed to be used in everyday life, for instance during emotionally charged conversations, meetings or challenging activities. The point is to provide subtle awareness of feelings and help people calm down through rhythmic vibrations. They may also be used during short breaks, for brief meditation sessions with thermal-based neurofeedback on the body to support bringing attention back to the present moment.

Corina Sas
AffecTech project coordinator
© Corina Sas

> *All our prototypes are designed to be used in everyday life, for instance during emotionally charged conversations, meetings or challenging activities.*

How did you proceed to test these technologies and with what results?

Our research prototypes have been evaluated through small-scale studies, and we are planning large studies with people living with affective disorders. Initial findings confirm their value for increasing users' emotional awareness, along with strong engagement with these technologies.

Looking back, what would you say are the project's greatest achievements?

Apart from the range of technologies that we explored, designed and developed, another great achievement is the superb quality of our academic publications. Throughout its 4 years, the AffecTech project has generated 129 academic publications including 43 journal papers with key highlights including papers in high-impact journals such as 'Nature', 'JMIR', the 'Journal of Anxiety Disorders' and 'Systematic Reviews'. The consortium also published 17 papers at flagship ACM conferences, such as the Conference on Human Factors in Computing Systems (CHI) with 11 papers and Designing Interactive Systems (DIS) with six papers. Six of these 17 papers have received Honourable Mention awards.

AffecTech technologies were acknowledged by the Commission's Innovation Radar Prize. We also have a patent application with Philips Research: Method and system to assess depression severity by means of analysis of MRI scans together with perceptual bias in experiencing facial expression.

Another positive outcome of the project is its very successful dissemination and communications strategy. We reached over 14.25 million people through broadcast media, online and print media in the United Kingdom, across Europe and internationally.

The project will soon be completed. What are your follow-up plans after that, if any?

We are looking to partner with interested companies and investors who may help us take our prototypes to the next stage needed for the market.

AFFECTECH

- Coordinated by Lancaster University the United Kingdom
- Funded under Horizon 2020-MSCA-ITN
- cordis.europa.eu/project/id/722022
- Project website: affectech.org

Putting the impact of health data under the microscope

How does the work of national health information systems impact actual policymaking? In the middle of a COVID-19 crisis that sheds unprecedented light on the relationship between science and policy, the BAHCI project brings about a reference framework that can help provide answers.

We live in a world where policymakers' decisions related to public health tend to be backed by solid data evidence. The COVID-19 crisis perfectly illustrates this, with governmental measures across Europe being constantly justified by means of data gathered by independent experts. But it also shows how any issues in the transmission of information can quickly backfire.

"We only have limited visibility of the actual impact of data on healthcare provision, management and policymaking," says Marie Delnord, Marie Skłodowka-Curie fellow at Sciensano, the Belgian Institute of Health, and lead investigator for the project BAHCI (Bringing a health claim to information: Measuring the impact of health data on the health outcomes of European citizens). "Let's say for instance that we have a

national public health report fresh off the press, or clinical guidelines that have just been developed. What happens and what should ideally happen next? The lack of such feedback limits our capacity to assess the impact of health information (HI) systems on healthcare."

With BAHCI, Delnord aimed to bridge the gap between science and decision-making. She developed a conceptual framework that can monitor and support the process of knowledge translation into concrete outcomes. This is a new research avenue, as the focus rather used to be placed on data accuracy and quality assessment of national HI systems. Instead, BAHCI aims to determine the societal impact of investment in health data. Its approach accommodates structural differences across Member States' HI systems, different types of outputs and innovations (AI, big data, etc.) and the wide range of stakeholders involved.

A KNOWLEDGE TRANSLATION FRAMEWORK FOR ALL MEMBER STATES

"We initially conducted an extensive review of existing knowledge translation frameworks and found none covering the health system overall. We ended up developing our own around four main domains of assessment. These are: the production of high-quality evidence by trusted entities at the right level of intervention (HI evidence quality); access to and availability of such evidence (HI system responsiveness); how this evidence is applied to the health system (stakeholder engagement); and the use of evidence across sectors beyond healthcare and by civil society (knowledge integration)," Delnord explains.

> *Rapidly leveraging evidence for intervention has been the key issue in 2020. Meanwhile, the strengths and limitations of routine health information systems across Europe were also exposed.*

From there, Delnord proceeded to engage 120 public health professionals who agreed on a list of 30 criteria to monitor knowledge translation capacity within 38 countries. The project's web-based tool was then piloted in 15 countries and in Belgium specifically in the field of precision oncology, to evaluate the uptake of next generation sequencing guidelines and testing routine clinical practice. Although the project is now completed, Delnord doesn't rule out further use of evidence in other priority health areas such as maternal and child health, or to test associations with health outcomes.

The project team learned several lessons from COVID-19 as well. As Delnord notes: "Rapidly leveraging evidence for intervention has been the key issue in 2020. Meanwhile, the strengths and limitations of routine HI systems across Europe were also exposed. Since the early days of the pandemic, we got to see how health data discrepancies and information gaps affect the capacity for coordinated intervention. Case definitions varied across countries, while fake news competed with scientific evidence. This all confirmed the necessity to proactively engage a broad range of players with scientific evidence."

BAHCI effectively addresses a growing problem faced by society, only made more pressing by COVID-19: the need for more transparency and accountability in the use of health data and scientific evidence by policymakers. By getting knowledge translation right, the project can encourage experts to not only provide data but also help guide intervention. Its reference framework can also be key to building the future European Health Data Space, which will support health data sharing, exchange and research across EU Member States.

BAHCI

- Coordinated by Sciensano in Belgium
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/795051
- Project website: bit.ly/bahci-project

From EU projects to twinnings: a pathway to the digital transformation of healthcare

Numerous EU research projects have focused on the development of innovative digital healthcare technology, but many of them lack the time and means to ensure large-scale adoption across Europe. The DigitalHealthEurope project fills this gap and others, to advance the Digital Transformation of Health and Care.

The long-forecasted golden age of eHealth has yet to materialise and become tangible for most clinicians and patients. The problem is not so much that health data isn't available or that innovative solutions to store, process and share it don't exist. If anything, data is actually available in too many forms and managed differently across and even within Member States. Meanwhile, stakeholders can have a hard time browsing through thousands of innovations to identify the most suitable one for their needs.

DigitalHealthEurope (Support to a Digital Health and Care Innovation initiative in the context of Digital Single Market strategy) is a unique attempt at solving both of these problems while helping the EU advance its agenda for the Digital Transformation of Health and Care (DTHC). "Our main objective is the deployment of digital solutions for person-centred care," says Veli Stroetmann, coordinator of the project and head of eHealth and Policy Research at empirica Communication and Technology Research. "The other is to create multi-stakeholder communities developing resources such as white papers, guidelines and policy recommendations."

A TALE OF 25 TWINNINGS

The first issue is being tackled with 'twinnings' and catalogues of digital innovations, among other things. Twinnings are small, highly specific projects aiming to transfer knowledge from its owner (originator) to one or more healthcare providers (adopters). As Stroetmann explains: "They build on the originator's extensive know-how and deployment experience. By doing so, they shorten adoption time compared to initiating an explorative research and development process that's not based on mature, tested and proven initiatives."

A total of 25 twining projects were funded under DigitalHealthEurope. One example is AppSaludable, which addresses the challenges arising from an ever-growing number of health applications being made available to patients. "We need governments and healthcare authorities to ensure that citizens can choose applications that are safe, secure and provide added value to users. In this context, the AppSaludable twinning has developed common requirements for mHealth app design, use and assessment in Andalusia and Portugal."

A second interesting example is REHAB-LAB-4ALL, which empowers patients with disabilities by letting them participate in the development of everyday devices conceived specifically with their condition in mind. Twinning originator the Centre Mutualiste de Rééducation et de Réadaptation Fonctionnelles de Kerpape (France) has developed a first-of-its-kind fabrication lab and an overall concept enabling healthcare providers to work collaboratively with patients to produce 3D-printed assistive devices. They are currently sharing this participative approach with adopters from Belgium, Denmark, Italy, Romania, Spain and Switzerland.

As far as catalogues are concerned, the project team published two. The first is a catalogue of digital solutions key to achieving the DTHC. Stroetmann and partners

> *Our main objective is the deployment of digital solutions for person-centred care.*

screened over 1 000 projects from different sources and compiled the 65 most promising ones in a browsable catalogue that can be filtered based on different selection criteria. The second one is a catalogue of mature telehealth solutions ready to be deployed across Europe, an issue made more urgent than ever by the COVID-19 pandemic.

A PATH FORWARD

DigitalHealthEurope also provides guidelines and recommendations. Thanks to a large-scale survey aiming to understand European citizens' knowledge, attitude and opinions regarding their data, the project team developed recommendations on citizen-controlled health data sharing governance models. They also drafted: a white paper on better citizen access and control of data; a roadmap for patient empowerment; a guide for scaling up digital solutions for citizen-healthcare provider interactions; and a white paper on the better utilisation of data infrastructures.

In a little under 2 years, DigitalHealthEurope has successfully managed to establish itself as the go-to platform for different stakeholders who wish to share information, receive support and learn about the digital transformation of health and care in Europe.

DIGITALHEALTHEUROPE

- Coordinated by empirica in Germany
- Funded under Horizon 2020-HEALTH
- cordis.europa.eu/project/id/826353
- Project website: digitalhealtheurope.eu

Better cost and outcome analysis for new medical devices

Cost and outcome analysis can help push the right medical device innovations at the right time. But should it be done based on real-world data? Maybe on surrogate endpoints? The COMED project investigated existing practices, identified challenges and laid out some recommendations.

Health systems need to constantly adapt to an ever-changing environment. These changes are reflected in the very nature of threats to public health, and also in advances in research that keep bringing existing practices into question. Policymakers need to keep adapting to these trends and – when it comes to novel medical devices – cost and outcome analysis is crucial to making the right call.

This process is at the heart of Health Technology Assessment (HTA): HTA bodies are asked to evaluate how a new technology compares to existing alternatives. They do so by assessing the device's impact on health and well-being, possible side effects, costs implications for the patient and impact on the organisation of healthcare systems.

Enter the EU-funded COMED (Pushing the boundaries of Cost and Outcome analysis of Medical Technologies) project, which aimed to refine existing methods of cost and outcome analysis for medical devices. "Whilst data on costs and health outcomes are available from an increasing range of sources, there are still numerous methodological issues that must be explored," says Aleksandra Torbica, director of the University of Bocconi's Centre for Research on Health and Social Care Management (CERGAS) and coordinator of COMED.

One such issue is the use of real-world data (RWD) in cost and outcome analysis. This data, which includes the likes of databases, surveys, patient chart reviews, clinical trials, patient registries and observational data from cohort studies, can support decision-making before and after market entry. COMED aimed to provide empirical evidence on this contribution.

"We systematically mapped existing RWD sources in Europe for three selected case studies: hip and knee arthroplasty, percutaneous transcatheter valve replacement technology, and procedures performed by the da Vinci Surgical System. From then on, we provided a comprehensive assessment of their content and evaluated their appropriateness for conducting HTAs of medical devices," Torbica explains.

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In total, the consortium identified 71 RWD sources in arthroplasties, 95 in valve replacement and 71 in robotic procedures. After an in-depth analysis, they concluded that, while RWD sources indeed bear great potential for an HTA of medical devices, remaining challenges include data accessibility, lack of standardisation of health and economic outcomes, and inadequate comparators.

SURROGATE ENDPOINTS

A second issue identified by COMED is the use of surrogate endpoints – effects of a specific treatment that may correlate with a real clinical endpoint but do not necessarily have a guaranteed relationship – to support the licensing and commercialisation decisions of medical devices. "The use of surrogate endpoints is becoming increasingly important for faster patient access to innovative health technologies. We screened available guidelines from HTA bodies and demonstrated an increase in their use over the past decade. But there are considerable differences in the depth of this guidance across agencies," Torbica notes. The project team concludes that further methodological and policy research on the harmonisation of approaches to surrogate outcome evidence in healthcare decision-making is warranted.

> *We systematically mapped existing RWD sources in Europe for three selected case studies: hip and knee arthroplasty, percutaneous transcatheter valve replacement technology, and procedures performed by the da Vinci Surgical System.*

Another aspect considered by COMED is coverage with evidence development (CED). These schemes consist in conditioning health insurance coverage on data gathering through a clinical trial or registry. COMED looked for challenges faced by taxpayers and manufacturers when applying CED schemes for medical devices, and found important ones at the initiation, design, implementation and evaluation stages. The project also provides recommendations and alternative strategies for future policy choices.

With all these contributions, COMED is likely to contribute to improving the decision-making process in European healthcare systems. The project advances scientific knowledge, and also provides immediately applicable policy advice and tools.

COMED

- Coordinated by the University of Bocconi in Italy
- Funded under Horizon 2020-HEALTH
- cordis.europa.eu/project/id/779306
- Project website: comedh2020.eu

FOOD AND NATURAL RESOURCES

A 'shotgun' approach to fish metagenome reveals gut bacteria connections to health

Proper feed selection that actively increases beneficial bacteria in the gut can boost fish health and growth. Using a unique sequencing method, EU-funded researchers have cracked the underlying biological mechanisms good bacteria trigger in rainbow trout hosts for better feed regimes.

Once a fledgling industry, aquaculture has become the fastest-growing food sector worldwide; it is now producing more fish for human consumption than what comes from wild fisheries. The key to securing continued development of sustainable aquaculture is to increase feed efficiency.

The feed conversion ratio is a major indicator of feed efficiency and describes the amount of feed used to grow a kilogram of fish. Knowing how much feed will be needed allows a farmer to determine profitability. Besides offering a measure of aquaculture production efficiency, the feed conversion ratio also indicates the fish's ability to convert animal feed into the desired output. Inefficient ratios place a burden on the environment.

FISH HEALTH AT THE HANDS OF BACTERIA

Lately, animal proteins have increasingly been replaced by plant-based ingredients in aquaculture diets. The

> *Results should facilitate developing more effective feed protocols that can 'work together' with the beneficial gut bacteria to boost growth and health of farmed fish.*

effect on the related metabolic processes that regulate fish health and growth of this strategy remains unknown. Identifying beneficial bacteria would help optimise feed efficiency and make farmed fish immunity stronger.

Promising solutions for optimising feed efficiency and fish health stem from recent studies on metagenome sequencing, focusing on how the gut microbiome interacts with metabolic and immunological pathways in humans and mice. Funded by the Marie Skłodowska-Curie Actions programme, the project HappyFish (Understanding the role of the rainbow trout metagenome on growth and health in aquaculturally farmed fish) investigated the different functions of gut bacteria and their role in the overall health of farmed fish. Furthermore, it explored how different feed formulae interact with the gut microbiome of the rainbow trout – a commercially important fish species for aquaculture worldwide – and how to optimise these formulae in the future.

A MODERN METAGENOMICS METHOD

State-of-the-art aquaculture research has largely used a simple gene marker that allows for only comparing the groups of bacteria found in the fish gut microbiomes. HappyFish significantly advanced microbiome research in the field by pioneering the use of so-called shotgun sequencing in the rainbow trout metagenome. This method enabled researchers to decipher the functional properties encoded by genes in the microorganisms that make up the gut microbiome of the rainbow trout.

"We first chopped the whole metagenome up into pieces that are small enough to sequence," explains Morten Limborg, HappyFish coordinator. "The challenge was then to sort out the partial sequences and assemble them into specific metagenomes by putting these overlapping fragments in the same way you would put together a puzzle." Researchers met this challenge using advanced bioinformatics tools.

"We characterised for the first time the functional roles of symbiotic microorganisms that contribute crucial functions to their rainbow trout host. Examples include the ability of some microorganisms to improve feed conversion into biomass (feed conversion ratio), thereby reducing waste," adds Limborg. The team, including PhD student Jacob Rasmussen, also observed interesting patterns of specific bacteria that were significantly more abundant in fast-growing fish.

LOOKING INTO THE FUTURE WITH CONFIDENCE

HappyFish is breaking new ground in the move towards more sustainable food production in the aquaculture sector. Limborg concludes: "Results should facilitate developing more effective feed protocols that can 'work together' with the beneficial gut bacteria to boost growth and health of farmed fish." Proper feed that can modify the natural components of the gut microbiome could reduce feed costs, minimise the negative impact on the environment and eliminate the use of antibiotics.

HAPPYFISH

- Coordinated by the University of Copenhagen in Denmark
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/745723

Nutrition with evidence-based immune function

Researchers have responded to the increased demand for better nutrition in food products, with a health ingredient clinically proven to support immune function and well-being.

People want to live a long and healthy life and there is a huge demand for food products that enable immune function and increase resistance to infections. Additionally, not only do food products have to be natural, wholesome and nourishing, they must also have a positive impact on health, all without compromising taste and texture or ease of consumption.

The EU-funded project NUTRI-NEED (Final development, clinical validation and launch preparation of NL01, an innovative health ingredient for supplements, food products and foods for special medical purposes) set out to develop the Xtramune™ food ingredient targeting food products used by young adults, adults and the elderly for their nutritional and immune function needs. Team members conducted a clinical study to test the efficacy of the product and to scale up the production process for the product.

Having collected preclinical data and proven the ingredient safe in humans, the work puts coordinating company NutriLeads on track to become the first to launch an ingredient with an approved health claim for supporting immune function and increasing infection resistance.

FILLING A GAP FOR EVIDENCE-BASED NUTRITION

"NUTRI-NEED has a specific focus on delivering science-proven health claims for its ingredients. This will allow it to stand out and truly differentiate in the market and towards its stakeholders," remarks Ruud Albers, CEO of NutriLeads.

Strikingly, none of the currently marketed food products are sufficiently backed by convincing evidence, leading the European Food Safety Authority (EFSA) to reject claims of immune support for functional foods, including those for market-leading prebiotic and probiotic products.

XTRAMUNE PRODUCT DEVELOPMENT

NUTRI-NEED collaborated with a toll manufacturer to upscale the production of the Xtramune™ food ingredient and produced five core batches for quality assurance purposes. The project registered the Xtramune™ brand name, completed four patent applications and published two scientific papers as well.

Researchers conducted a clinical trial to determine the effectiveness of Xtramune™ in a susceptible population of over 65-year-olds. These vulnerable older subjects consumed the health ingredient or a placebo over a 6-month period. The researchers found that Xtramune™ supports immune function and increases resistance to a respiratory infection in healthy subjects with a common cold virus.

> *NUTRI-NEED has a specific focus on delivering science-proven health claims for its ingredients. This will allow it to stand out and truly differentiate in the market and towards its stakeholders.*

The team obtained and published the safety data needed to obtain market access in the United States and to file a Novel Foods dossier for evaluation by the EFSA (EFSA-Q-2020-00186). Having initiated these regulatory processes, the project can now seek out partners for production and commercialisation across the globe.

FUTURE DEVELOPMENT PLANS

"We are seeking to obtain additional funding such as an EIC Accelerator grant to perform high-risk activities to accelerate and maximise the market uptake of our lead ingredient," Albers concludes. "This will enable us to secure Xtramune's health claim approval through completion of two human studies, and to implement a sustainable production process by using Xtramune's side-stream waste."

NUTRI-NEED

- Coordinated by NutriLeads in the Netherlands
- Funded under Horizon 2020-SME, Horizon 2020-Societal Challenges and Horizon 2020-LEIT
- cordis.europa.eu/project/id/811592
- Project website: bit.ly/nutri-need
- bit.ly/NutriLeads

FOOD AND NATURAL RESOURCES

New mechanical harvester successfully picks white asparagus

A new white asparagus harvesting machine solves the problems that previous versions couldn't. Finally, Europe has a harvester ready for market.

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White asparagus is a delicacy variety, larger and sweeter than the familiar green kind. The flavour results from a lack of chlorophyll (plants' green pigment), due to the stalks being grown underground. If stalks break the surface, they start to develop chlorophyll and bend towards the light. If so, they are rejected as second rate and sold for 50 to 70 % less.

The underground growth habit poses several harvesting problems. Firstly, white asparagus is harvested selectively, meaning that only a portion of the crop is taken, and the plant continues growing for further harvesting later. This creates difficulty for pickers, who cannot see the plant underground and may therefore damage it during harvesting. Such damage can reduce yields by 30 %.

Secondly, harvesting white asparagus is physically hard and unappealing work. This creates a problem with

> *We managed to develop and build the world's first selective harvesting machine that is actually ready for commercial selling.*

labourer availability. During 2020 alone, approximately 19 % of the German crop, the largest in Europe, could not be harvested due to lack of personnel.

A NEW HARVESTING MACHINE

The EU-funded project SPARTerS (Subsurface Precision detection of Asparagus with Robot Technology for Selective harvesting) developed a new mechanical harvester. Researchers advanced a prototype, previously not ready for production, to a market-ready system. The team also developed the necessary operating software and tested the complete system.

"Our most unique solution is subsurface detection," explains project coordinator Thérèse van Vinken. "Previous attempts have used camera techniques, which tried to copy human eyes for detection. But the human eye cannot detect subsurface." Instead, using a patented technology, the harvester introduces a weak electrical signal to the soil, which makes salt water in the plants' tissues visible to the harvester's sensors.

Sensors are mounted at several depths on stalks that are dragged through the soil as the harvester moves forward. When the sensors detect an asparagus stalk, they quickly withdraw to enable cutting. A robot arm cuts the stalks underground to better than 5 mm precision. This results in less disturbance of the plant and reduced crop loss. Other machinery collects and bundles the cut stalks.

READY FOR MARKET

Researchers optimised the detection and cutting modules of the prototype, while also integrating the whole system. This took the device from technology readiness level (TRL) 7 to TRL 8. After the 2019 season, the team converted the machine to a single-row self-propelling version. Testing

During 2020 alone, approximately 19 % of the German crop, the largest in Europe, could not be harvested due to lack of personnel

during 2020 confirmed that the machine works. The quality target started at 70 % and was 80 % at the end of season. Yield was about 80 % of expectations. This brought the device to TRL 9.

"We managed to develop and build the world's first selective harvesting machine that is actually ready for commercial selling," adds van Vinken. By November 2020, the team had sold three units to be delivered during early 2021. For the 2021 season, the team will build six more. Within 5 years, the company expects to be producing 150 machines per year.

Without the mechanical harvester, the white asparagus market would have become extinct. Now, the industry can expect to thrive, with an improved yield and lowered costs.

SPARTERS

- Coordinated by Cerescon in the Netherlands
- Funded under Horizon 2020-SME, Horizon 2020-Societal Challenges and Horizon 2020-LEIT
- cordis.europa.eu/project/id/811469
- Project website: cerescon.com
- bit.ly/SPARTerS-video

Novel materials for high-performance, eco-friendly skin-contact products

Companies haven't paid much attention to the environmental impact of skin-contact products like nappies and wound dressings. An EU initiative introduced new materials for more sustainable, environmentally friendly products.

Most skin-contact products in the cosmetics, personal care, sanitary and biomedical industries are still made from fossil-based polymers that are not recyclable or biodegradable. There's a need to replace conventional fossil-based materials with more sustainable, bio-based alternatives in high-value market segments.

The market for products in all these sectors is massive. However, due to increased competition, growing ecological awareness and changing consumer demands, the market is looking for more healthy and sustainable product options with reduced environmental footprint.

UNPRECEDENTED SKIN COMPATIBILITY PROPERTIES AND FUNCTIONALITIES

The EU-funded project POLYBIOSKIN (High performance functional bio-based polymers for skin-contact products in biomedical, cosmetic and sanitary industry) formulated and developed bio-based, biodegradable and biocompatible materials to deliver skin-contact products for the hygiene, cosmetic and biomedical industries. The products used as models were a nappy, a face beauty mask and a wound dressing. All three products are very representative of these target industries.

Project partners produced three high-performance prototypes that were validated in a relevant industrial environment. These prototypes were created by using bio-based materials, in particular polylactic acid, polyhydroxyalkanoates, as well as other biopolyesters and polysaccharides, such as chitin nanofibrils, nanolignin, pullulan and starch. The novelty in these products lies in the fact that they are mostly bio-based – the renewable content is about 90%. In addition, they comply with safety and regulatory requirements. High performance is granted by exploiting bionanotechnology.

Advanced *in vitro* experiments confirmed the products' compatibility with skin. "The importance of these compatibility tests is also linked to the value that bio-based materials could bring to a market that shouldn't just be focused on environmental impact," explains project coordinator Simona Neri. "Indeed, the beneficial properties demonstrated in terms of compatibility could also justify the materials' higher price in the market."

The researchers also tested the three products' end of life in terms of their compostability. Compostable products should lead to better management of solid waste in the future.

UNLEASHING THE POTENTIAL OF BIO-BASED POLYMERS

The new nappy contains antimicrobial and antioxidant functionalities to prevent skin reddening and inflammation. The facial beauty mask is based on electrospun textiles or films impregnated with functional bioadditives, thus releasing active molecules that are beneficial for the skin. The tissue used in the wound dressing protects the skin of people with temporary or chronic wounds. The developed materials' antimicrobial properties stimulate skin cells' viability and self-defence. These properties were exploited in all the products.

The POLYBIOSKIN team laid the groundwork for a deeper examination of materials that come into contact with skin, in sectors applying for regulation that aren't as strict as the biomedical industry, for example. The team also paved the way for the further investigation of biomaterials and their properties that continue to remain unexplored.

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> *Thanks to POLYBIOSKIN, the possibilities of new-generation bio-based materials finding applications in these important industrial sectors were demonstrated, opening up potential routes and markets for bio-based products with high performance.*

"Thanks to POLYBIOSKIN, the possibilities of new-generation, bio-based materials finding applications in these important industrial sectors were demonstrated, opening up potential routes and markets for bio-based products with high performance," concludes Neri. "It's a truly disruptive project that for the first time took into consideration the development of sensitive bio-based products and investigated the intrinsic properties of biomaterials." POLYBIOSKIN received funding from the Bio-based Industries Joint Undertaking, a public-private partnership between the EU and industry.

POLYBIOSKIN

- Coordinated by IRIS Technology Solutions in Spain
- Funded under Horizon 2020-FOOD
- cordis.europa.eu/project/id/745839
- Project website: polybioskin.eu
- bit.ly/polybioskin-video

INDUSTRIAL TECHNOLOGIES

Bringing efficiency to the smart factory

European SMEs need to incorporate advances from Industry 4.0. A new framework will help the integration of robotics work seamlessly.

The fourth industrial revolution is already under way. European businesses are moving to embrace it, and starting to integrate robotics and other smart technologies into the workforce.

Yet while this may be more straightforward for large businesses, SMEs face a number of challenges. These include a lack of expertise, highly-qualified workforce and the resources needed to transform an entire business in

one step. As the benefits of the advances are not always immediately clear, there is still some reluctance to change.

Even for those that have introduced robotics into manufacturing, the use of robots is still not efficient. Safety regulations continue to keep robots isolated from humans. Collaborative robots, designed to work alongside humans, don't always resolve safety issues if the technology behind the collaboration isn't up to scratch. Humans and robots are also given specific tasks, and it is difficult to change these quickly as is often needed in manufacturing.

"Digitisation encompasses much more than just buying and setting up an industrial robot," says Anastasia Garbi, head of Research and Development at European Dynamics.

HORSE (Smart integrated Robotics system for SMEs controlled by Internet of Things based on dynamic manufacturing processes) is an EU-funded project that aimed to take a leap forward for the manufacturing industry, by proposing new flexible and versatile production lines. The project offers a new model for the smart factory, involving efficient collaboration of humans, robots, automatic guided vehicles and machinery.

The HORSE system was trialled in 10 pilots, in diverse manufacturing factories in seven European countries. Within 9 months, seven of these pilots, the so-called second wave, had adopted their framework and components and deployed them in novel and ambitious ways, project coordinator Garbi adds.

"All of them were able to demonstrate important robotic automation solutions in challenging applications which had not been resolved prior to HORSE. They proved the value of our tools and concepts and they extended the prototype tools with additional components," explains Garbi.

> *Human, robot and machine workers are all orchestrated through a unique user interface accessed by computers or tablets.*

FRAMEWORK FOR THE FUTURE

The HORSE system is a framework designed to support human-robot collaboration tasks. Human, robot and machine workers are all orchestrated through a unique user interface accessed by computers or tablets. Managers can monitor the production processes at any time.

"The rest of the systems are not visible to the human, they are supporting and optimising robotic tasks," adds Garbi.

A HORSE prototype system was built to show the full capabilities, and can be deployed and configured to individual factory requirements. HORSE can be installed either locally or on the cloud. Selected components of the system can be downloaded and used as needed, providing more flexibility for each factory.

Some of the possible technologies that use HORSE include: augmented reality for quality control and product assembly; visual inspection using artificial intelligence; and a smart object locator.

DIGITAL INNOVATION HUBS

The project also paved the way for the creation of Digital Innovation Hubs, and established five of them: two in Germany, and one in France, the Netherlands and Slovenia. These act as regional hubs, offering a place for consultation, training, demonstration and experimentation. The idea is to engage European SMEs with Industry 4.0 and keep them competitive in the global business landscape.

"These hubs interconnect regional policymaking authorities, technological suppliers and manufacturing industries, which are looking for the paths toward adopting advanced technologies," concludes Garbi.

HORSE

- Coordinated by European Dynamics Advanced Information Technology and Telecommunication Systems in Greece
- Funded under Horizon 2020-LEIT-ICT and Horizon 2020-LEIT-ADVMANU
- cordis.europa.eu/project/id/680734
- Project website: horse-project.eu

Automatic testing set to streamline software development process

A new tool can automatically generate test cases for software applications, making the entire development process more efficient.

Before a software application can be marketed, it must first be fully validated – a process that involves extensive and costly testing. While there are plenty of tools and methods for automatically conducting unit- and integration-level testing, system testing remains a largely manual affair. As a result, system testing is an expensive bottleneck in the software development process.

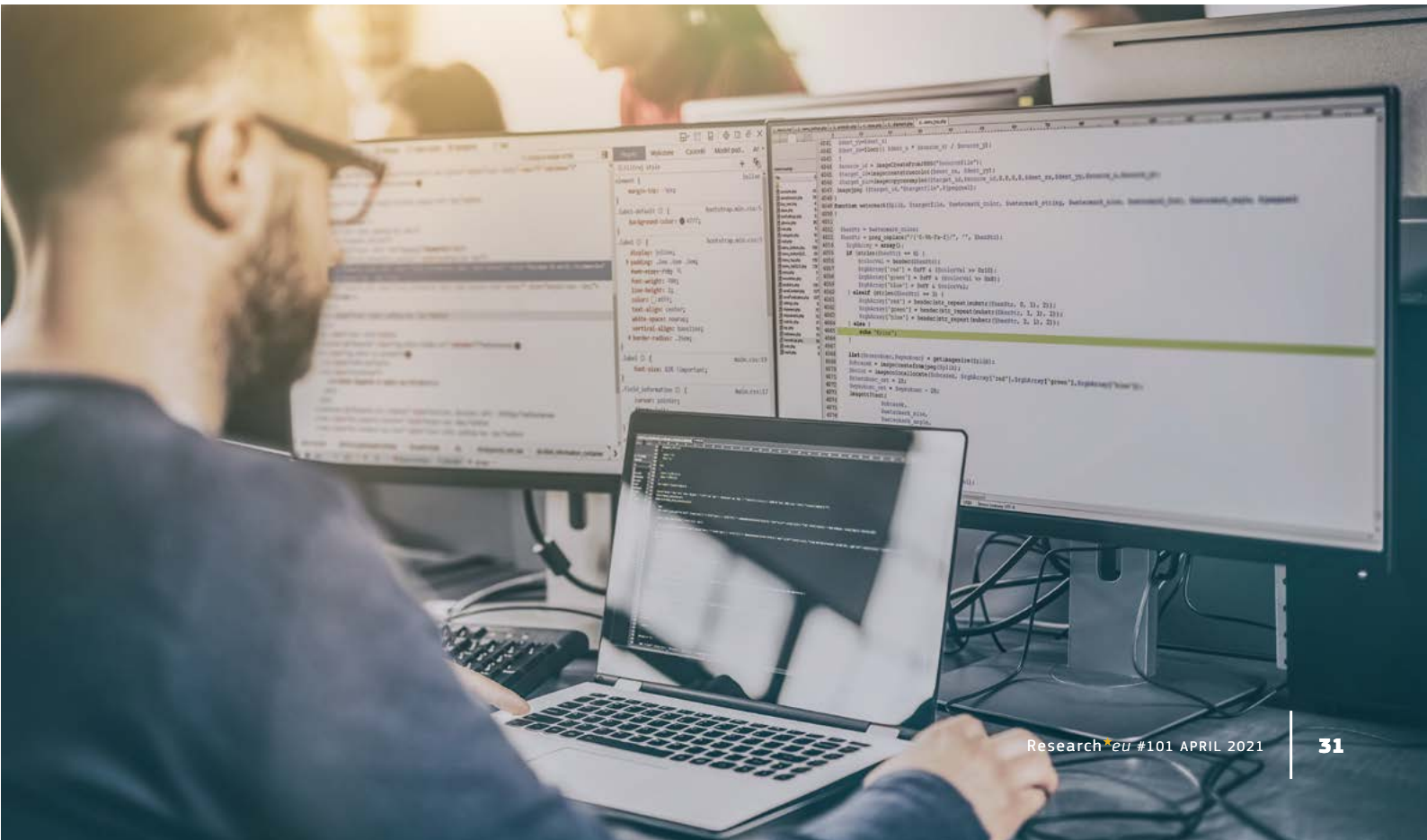
To help, the EU-funded AST (Automatic System Testing) project, whose work was supported by the European Research Council, developed a pre-commercial tool that can efficiently and automatically generate test cases for software applications.

"Currently, a software engineer must spend a significant amount of time checking the correctness of the applications they develop and maintain," says Leonardo Mariani, a professor at the University of Milano-Bicocca and AST project coordinator.

"By quickly validating several scenarios, automatic test cases will ensure that these engineers can focus their time on the more subtle cases that must be checked manually."

AN AUTOMATIC TESTING SOLUTION

By combining a number of different techniques, including artificial intelligence, the project successfully created an



automatic testing solution. "Our automatic test generation solution uses reinforcement learning to incrementally learn how the software being tested behaves," explains Mariani. "Based on what it learns, it gradually improves the effectiveness of the generated tests."

According to Mariani, when a solution is run parallel across multiple machines, the learning process becomes even faster. "We also addressed the problem of automatically obtaining meaningful input values, such as the name of a real address to be entered into an application," he adds.

"To do this, we created a solution that reuses the existing data repositories, such as testing and production databases, that are normally available within an organisation."

A GOOD START FOR TEST AUTOMATION

When the COVID-19 pandemic threw a wrench into the project's work, the team quickly pivoted and found a way to remotely access the servers and software. "Working remotely and running only virtual meetings is not the same as physically working together," notes Mariani. "But we still managed to achieve what we set out to do: create technology solutions that can efficiently generate test cases for complex web applications."

> *By quickly validating several scenarios, automatic test cases will ensure that these engineers can focus their time on the more subtle cases that must be checked manually.*

Although the AST tool represents a good start for test automation, there is still more work to be done. As such, the project team is currently scaling the tool so it can address ever more complex and larger software systems. Researchers are also working to ensure that the tool can recognise the increasing number of problems that could affect software during testing.

"We extended our knowledge base in the area of test automation and released tools that can be used both to advance research in web testing and to study the industrial application of automatic test case generation," concludes Mariani.

AST

- Hosted by the University of Milano-Bicocca in Italy
- Funded under Horizon 2020-ERC
- cordis.europa.eu/project/id/824939

DIGITAL ECONOMY

New software tool makes all web content available for users with cognitive disabilities

Web pages should be accessible to everyone. People with cognitive disabilities can now communicate on an equal footing through a new software interface.

Many web pages are difficult to access for people with learning difficulties. The needs of these users aren't fully covered in current accessibility guidelines and developers often aren't familiar with these users either. An important aspect of inclusion is that any information is accessible to all people.

NEW TECHNOLOGY ASSISTS THE COGNITIVELY DISABLED IN NAVIGATING THE WEB

The EU-funded project Easy Reading (A Framework for Personalised Cognitive Accessibility when using Original Digital Content) developed the Easy Reading software, a

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support tool users can install as a browser add-on or app on their computers or mobile devices.

"The tool adjusts web content in real time based on the individual user's needs. With the Easy Reading software, the user can see a personalised version of any existing web page," explains Klaus Miesenberger, project officer of Easy Reading. There are three main support features which adjust the layout and structure of web pages, explain web content with symbols, pictures and videos and translate content into a different language level, e.g. Plain Language, Easy-to-Read, symbol writing systems.

The software provides these (semi-)automated support features by using human-computer interaction techniques like pop-ups, Text-To-Speech captions through mouse-over or eye tracking. This allows the user to remain and work within the original digital document. As the original content of the web pages is not changed, the user can switch between the personalised and the original version of the visited page at any time.

"Everyone with limited reading and language skills can profit from the software – people with cognitive disabilities, older people or people with a different mother tongue," explains scientist Peter Heumader from Easy Reading.

"The tool adjusts web content in real time based on the individual user's needs. With the Easy Reading software, the user can see a personalised version of any existing web page."

The user interface is embedded in the web page and the tools try to analyse sentences, detect keywords and find matching symbols for the keywords. The results appear within the web page.

DEVELOPERS AND END USERS WORK SIDE BY SIDE

People with cognitive impairments know best about their limitations and needs for accessibility of digital contents. "As such, they worked as peer researchers in all phases of the project and drove the research and development process for 'their' solutions. This ensured that the target group requirements were considered in each phase of development and this is what made it a success," concludes Miesenberger.

The project also developed a scalable cloud-based framework that enables external developers and researchers to extend the framework with new technology that would help people with different support needs to better use and understand digital web-based content.

This software framework enables users to participate more fully in the workplace and independent living, education, access to knowledge, healthcare and banking. Significantly increasing the communication abilities and level of independence for people with cognitive disabilities, they are now able to communicate equally with others.

EASY READING

- Coordinated by the University of Linz in Austria
- Funded under Horizon 2020-LEIT-ICT
- cordis.europa.eu/project/id/780529
- Project website: easyreading.eu
- bit.ly/3d873nC

SECURITY

Improved tracking by drone swarms helps keep us safe

Unmanned aerial vehicles, commonly referred to as drones, are becoming smaller, smarter and cheaper to produce, enabling new applications. These include using swarms (networks) of mini unmanned aerial vehicles for locating and mapping services in GPS-deprived environments, such as indoors, or during unexpected events.

Unmanned aerial vehicles (UAVs) can sense their environment, exchange information with other UAVs within the network and locate their position to reconstruct a map of their surroundings. Moreover, UAVs carrying radiofrequency sensors are more flexible and reconfigurable than traditional (fixed) on-ground sensors as they can easily change their positions over time. Thus, they can always maintain a reliable communication link with other UAVs or targets and avoid obstacles that obscure their line of sight.

During a fire, for example, UAVs can provide a temporary positioning infrastructure for first responders and assess the status of a building. They can enter smoke-filled structures to map the indoor environment and track firefighters and others inside.

UAVs can also form a network to act as a cooperative radar system for real-time high-accuracy tracking of unauthorised 'malicious' UAVs. The network can estimate the Doppler signature, a feature of the return signal that comes from the UAV propellers, enabling it to discern between UAVs and other flying objects and birds. This can help prevent terrorist attacks by small unauthorised UAVs that are barely detectable using conventional terrestrial radar.

NEW SENSING NETWORK

The EU-funded project AirSens (High-Accuracy Indoor Tracking and Augmented Sensing using Swarms of UAVs) developed swarm intelligence algorithms and data processing techniques enabling UAVs to conduct

> *The processing is distributed across the UAV network: each UAV can be considered as a collaborative and autonomous agent.*

highly accurate tracking and environmental sensing in indoor and outdoor environments. This research was undertaken with the support of the Marie Skłodowska-Curie Actions programme.

AirSens initially verified the UAVs' ability to form a new radar network that supports the terrestrial network for monitoring the surroundings. "The processing is distributed across the UAV network: each UAV can be considered as a collaborative and autonomous agent. To limit battery consumption during the flight, UAVs communicate only with their closest neighbours," comments research fellow Anna Guerra.

Using millimetre-wave multi-antenna radars employing a frequency range between 30 GHz and 300 GHz enables a large number of antennas to be fitted into the confined space of a UAV. "The resulting fine angular resolution and the wide signal bandwidth permit a centimetre-level degree of localisation accuracy even when using a single UAV radar," Guerra explains.

A WIDE RANGE OF APPLICATIONS

Another important aspect of the project involved investigating the swarms' mapping capabilities to enable UAVs to avoid obstacles and buildings blocking their line of sight. Researchers also explored how to control the UAV swarm by developing 'information-seeking' algorithms that 'seek' UAV trajectories to maximise the accuracy of their positioning. "AirSens brings together this need for integration, autonomy and intelligence of UAVs," notes Guerra.

The swarm can be helpful for investigating unknown and/or dangerous environments such as mining operations and rescuing human beings following a fire, accident or natural disaster. Furthermore, the same algorithms that were originally developed for target tracking and navigation can be readapted to sense dangerous pollution particles and to monitor overall air quality.

AirSens also provides solutions for innovative industrial services contributing to Europe's competitiveness and growth. "They form the basis for future initiatives, such as investigating the performance of UAV 3D networks for joint communication and sensing in the next generation of 6G cellular systems," Guerra says.

AIRSENS

- Coordinated by the University of Bologna in Italy
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/793581
- Project website: bit.ly/AirSens

SECURITY

Hands-on guidance helps save lives in emergencies

When emergency situations such as fires or bomb alerts require evacuation of crowded public spaces, every minute counts.

The results of the EVACUATION (Testing communication strategies to save lives in emergency evacuation) project provide new clues for cutting down evacuation times. The research, which was undertaken with the support of the Marie Skłodowska-Curie Actions programme, identified and tested communication strategies and pinpointed the most common risky behaviours hampering the evacuation process.

"We found that staff guidance is more effective compared to alarm sounding only," explains Natalie van der Wal, Marie Skłodowska-Curie research fellow and EVACUATION project coordinator. "If people don't see the danger, they need extra information for a fast response."

DYNAMIC DIRECTIONS

Staff guidance is instrumental in reducing the amount of time it takes for people to decide to move towards the exit, which has been shown to take minutes or even hours, depending on the situation. For instance, in an unannounced evacuation drill at a train station, people took up to 10 minutes to start moving. This so-called response time reached 25 minutes in WTC tower 2 during the 9/11 attacks.

The total evacuation time is the sum of this response time and the time it takes for the group to then walk towards the exit. "For the second part, we have found that dynamic signs and running lights can help guide people to exits. We recommend these be applied in practice more regularly, in addition to signs and warnings," says van der Wal.

> *"If people don't see the danger, they need extra information for a fast response."*

The research team's findings are based on videos of actual evacuations and interviews with emergency service members as well as agent-based modelling (ABM), which enabled them to test the new communication strategies before their application in the real world.

"You create a computer model in which individuals are represented as software 'agents' that can interact with each other and their environment. The strengths of ABM are that you can find out what will happen on the aggregate level and run simulations for many different populations and environments – something you cannot easily do in real life," van der Wal adds.

TOP FIVE RISKY BEHAVIOURS

The team also looked into those behaviours most likely to slow down the evacuation process and result in bottlenecks. Five behaviours emerged as key risk factors: slow response times; picking up belongings before evacuating; taking the familiar route, rather than the nearest exit; running; and filming the incident with smartphones.

To ensure that the findings of the project are effectively translated into faster evacuations with fewer casualties, its results and recommendations were communicated to safety practitioners including police, firefighters, safety managers and crowd managers through workshops, magazines, research blogs and one-on-one sessions.

EVACUATION

- Coordinated by the University of Leeds in the United Kingdom
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/748647
- Project website: bit.ly/evacuation-project

FUNDAMENTAL RESEARCH

Massive DNA collation of wolf fossils offers fresh clues to survival of the fittest

The Swedish Museum of Natural History extracted DNA from hundreds of wolf fossils spanning the last 100 000 years, the largest ancient wolf genome data set ever collected. The work will be key to understanding why some wolves and other animal species survived and why others became extinct.

Since Charles Darwin's 'On the Origin of Species', published in 1859, biologists and other scientists have probed the 'survival of the fittest' notion. The Swedish Museum of Natural History has just provided fresh fodder for them. Its Centre for Palaeogenetics has extracted DNA from wolf fossils throughout Eurasia spanning the last 100 000 years – the largest ancient wolf genome data set ever collected.

"It will be critical for understanding how wolves, and other species, have or have not adapted to historic climate change," says Dave Stanton, who carried out the data collation during the 2.5-year SURVIVOR (Historic response

of a wide-ranging carnivore to climate change) project with the support of the Marie Skłodowska-Curie Actions.

Supervised by Love Dalén, professor in Evolutionary Genetics, Stanton prepared and sequenced hundreds of ancient samples from different museums across Europe, Asia and North America using next-generation sequencing.

The technique reads huge numbers of DNA sequences in parallel, which allows for generating billions of DNA letters in a single run. "In the last 10 years, advancements in laboratory methods and analysis techniques have allowed this technology to revolutionise the field of ancient DNA," explains Stanton.

The researchers chose 20 wolf samples where the DNA was especially well preserved and carried out whole genome sequencing on them. Those genomes were added to about 50 ancient wolf genomes previously collected and sequenced.

WOLVES THAT ONCE WALKED THE EARTH

The data collection has shed light on wolves that went extinct before the Last Glacial Maximum some 14 000 years ago.

"Wolves then appear to be very different to how they are today, in terms of their morphology, their ancestry and their adaptive genetic variation – the genes that determine how they interact with and adapt to their environment,"

> *What is surprising is the clear and sudden nature of the changes that we see between these wolf populations.*

notes Stanton. "What is surprising is the clear and sudden nature of the changes that we see between these wolf populations."

The wolf genomes collected will be crucial for a future case study on the wolf populations, which will be used to model the extinction process in other species to try to predict which of these species are more likely to be vulnerable to future climate changes.

Stanton and his team will share their findings on wolves in a paper due out shortly.

"The funding has facilitated the generation of numerous results that will lead to scientific publications and data sets that will be valuable for future research," observes Stanton.

SURVIVOR

- Coordinated by the Swedish Museum of Natural History in Sweden
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/796877
- Project website: bit.ly/3pcQ6KZ

FUNDAMENTAL RESEARCH

Untangling the secrets of DNA in virtual space

A team of physicists worked on predicting how the twists and turns of the genetic code influence its output.

Nearly every type of cell in your body contains two metres of DNA, wound up to fit inside a nucleus no wider than one tenth the breadth of a human hair. Understanding the structure of this tightly wrapped DNA was the goal of the EU-funded THREEDCELLPHYSICS (The physics of three dimensional chromosome and protein organisation within the cell) project.

A hair cell and liver cell have the same DNA, but very different functionality. This difference is linked to

epigenetic pieces of information appended to the DNA strand as biochemical tags. "Our interest is in the structure of chromosomes and genes, and how this links with function," explains Davide Marenduzzo, project lead. "We came up with a bottom-up model to explain this in a general way."

POLYMER MODELLING

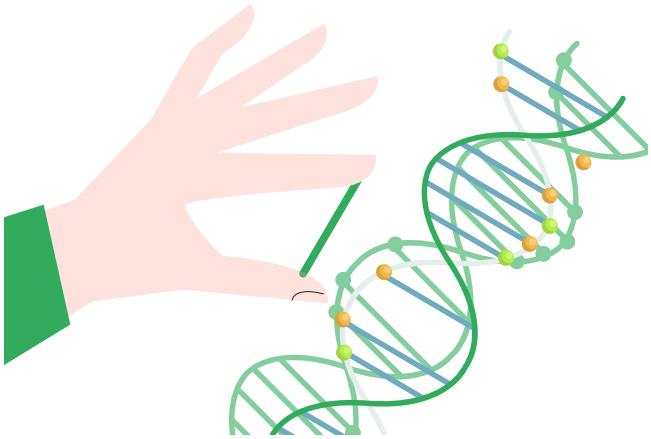
Marenduzzo's approach was to create a digital version of DNA, using polymer modelling software that is commonplace in physics. Using this, they could predict which parts of the chromatin – the name given to DNA and its accessory proteins – may lie in close contact with each other.

For example, proteins in the nucleus tend to form small and numerous droplets, which Marenduzzo and his colleagues refer to as microphase separation. These clusters are related to transcription, as genes in the DNA chain that lie in close physical proximity tend to be expressed at the same time.

Simulating such a complex structure required the use of supercomputers and a combination of physics, biology and polymer modelling. "Polymer modelling is a traditional physics technique, but the very large scale of the biophysical simulations we perform are not typical," adds Marenduzzo. "For chromosome modelling there are only a handful of groups in the world who do such large simulations."

> *There are only a handful of groups in the world who do such large simulations.*

Nearly every type of cell in your body contains two metres of DNA



MECHANISTIC APPROACH

The team's approach set them apart from most of these other groups. "A lot of people start from the data and create models to fit this data," notes Marenduzzo. "We had a mechanistic focus, we started with a hypothesis and generated predictions based on that, and tried to prove them through further experiment."

Their predictions were tested using chromosome conformation capture (3C) and Hi-C, molecular biology techniques that grab areas of close proximity and sequence them for identification. Details of the work are discussed in a preprint available online.

As well as looking at different cell types, Marenduzzo's team predicted the effects of the chromosome deletion which gives rise to DiGeorge syndrome. Most recently, the group developed the Hip-Hop model, or 'highly predictive, heteromorphic polymer', which is now being used, among other things, to study the difference between healthy and cancerous cells.

GENE CATALOGUE

The work was supported by the European Research Council. "I was able to give two talented people 5 years of placement, you can't do that with many other grants," says Marenduzzo. "It helps a lot to have that continuity. The flexibility was also really good – if I had the right person at the right time I could recruit them."

Next, the Marenduzzo group plans to develop a second version of Hip-Hop and catalogue all possible structures of genes. "We're really excited about this, it will be a great resource for experimentalists. If you have a gene of interest, you will be able to use these results to see what 3D predicted structures it has."

THREEDCELLPHYSICS

- Hosted by the University of Edinburgh in the United Kingdom
- Funded under Horizon 2020-ERC
- cordis.europa.eu/project/id/648050
- Project website: ph.ed.ac.uk

FUNDAMENTAL RESEARCH

Dating amber: fresh clues to evolution of insects

A groundbreaking method for dating fossils, including Baltic amber, could improve our understanding of the largest group of animals in the world.

Baltic amber is a key source of information on species evolution. This fossilised tree resin found in the Baltic Sea region provides insights into ancient ecosystems by preserving organisms from a distant past.

But how distant a past exactly? The EU-funded project AMBER (Dating fossils with molecules – innovative approach to determine the age of Baltic AMBER) has provided new tools for solving a riddle which has baffled researchers for years. The research, which was undertaken with the support of the Marie Skłodowska-Curie Actions programme, delivered an innovative method for estimating the age of fossil deposits.

"The new method can be used for establishing the age of fossil deposits using the phylogenetic approach, which is a significant advancement of science," highlights Dagmara Żyła, Marie Skłodowska-Curie research fellow and AMBER project coordinator.

COMBINING DATA

In phylogenetics, the evolutionary history of species is reconstructed using present-day data such as morphology. "The method uses genetic information as well as morphological data on extinct and living species and combines these using advanced Bayesian statistics for estimating when new species emerged," Żyła explains.

Baltic amber is believed to date from the Eocene epoch, with an age range of 34 to 55 million years. Applying the new methodology to further narrow down this range will require gathering a large number of well-dated fossil

> *"The new method can be used for establishing the age of fossil deposits using the phylogenetic approach, which is a significant advancement of science."*

© Dagmara Żyła

samples from non-Baltic deposits and combining these with Baltic amber to date the latter.

EVOLUTIONARY SUCCESS

While this process has been hampered by the ongoing pandemic, the research carried out has already contributed to improving our knowledge of an insect family of major importance for evolutionary research: Paederinae rove beetles.

"Rove beetles are the largest family of animals and a great example of evolutionary success, with around 64 000 known recent species that have adapted to nearly all possible terrestrial habitats and modes of living," Żyła says.

Paederinae are one of the oldest and most diverse rove beetle subfamilies. The methodology developed by the AMBER project has enabled Żyła and her team to trace this current diversity back to the Cenozoic era, which started 66 million years ago, and possibly narrow this timeframe further down to the Eocene.

As Paederinae rove beetles have potential for biomedical uses, pest management and conservation research, expanding our knowledge of their evolution could have wider societal implications.

CLIMATE CHANGE, THEN AND NOW

Dating Baltic amber could also make an important contribution to climate change research: "The Eocene was a time of drastic climatic changes," Żyła adds. "Reconstructing evolutionary events and species composition during this period could provide indications on how the past ecosystem reacted to these changes, how it functioned at the time of 'hothouse' conditions, and how it recovered from global warming. The results of the project provide a tool for further research on these aspects."

AMBER

- Coordinated by the University of Gdańsk in Poland
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/797823
- Project website: bit.ly/37bs50a

Catching up with iSIM: An innovative Spanish SME soars to success with its innovative satellite camera

*SATLANTIS is an innovative SME that has made quite a name for itself in the space sector over the past few years. The reason for this is their groundbreaking iSIM satellite camera that, when we interviewed them for the March 2020 issue of Research*eu, had a very promising future. For this month's 'Life After' feature, we reconnect with María Dasí, iSIM project coordinator to see how things have gone in the past year since we last spoke.*

The iSIM (Integrated Standard Imager for Earth Observation Microsatellites) satellite camera developed by Spain's SATLANTIS is only 15 kg in mass, four times more precise and 80% less expensive than its counterparts. This resonates with one of the biggest trends in the satellite industry right now, that of miniaturisation – satellites overall are becoming smaller, leaner, more compact and yet able to execute more functions than ever before.

Delayed launches but commercial success

What had been exciting for SATLANTIS was that two big missions were being planned to get the iSIM camera up into space in 2020, one to the International Space Station and one dedicated to the oil and gas sector. "And unfortunately, mainly due to COVID-19, both have been delayed," says Dasí. "But they are going ahead, specifically at the end of 2021 for the International Space Station and mid-2022 for the mission dedicated to the oil and gas sector."

But things have been going well for SATLANTIS regardless of the delays. Other than the delayed launches, luckily the pandemic has not significantly affected SATLANTIS in terms of development and production. "We've really managed to fulfil our commercial expectations over the last year as we move out of our start-up phase," Dasí continues. "We delivered one camera in 2020 and another one is due to be delivered by mid-2021. We're also implementing our industrial plan for the assembly and integration of 10 cameras for 2021."

Validating the technology, understanding the markets

SATLANTIS has been on quite the ride to success over the past few years and Dasí details enthusiastically how the EU-funded SME Instrument project has been extremely useful in terms of validating their core technology and learning to develop the business through a thorough understanding of the market.

"We have collected much better insights on customer demands and we know that they demand cameras oriented towards solutions and challenges, rather than hard technical specifications delivery," she adds. "For example, today we're focusing on solutions for fire monitoring, greenhouse gas detection and sea coast surveillance, amongst others. For this, we combine cameras with narrow and broad multispectral filter bands and consistent sensor integration."

Overall, the EU funding was critical for the company, according to Dasí. "It helped us to achieve our most important technical milestone, the In-Orbit Demonstration of our iSIM technology, proving its capability to provide submeter resolution, and has had a direct impact on our position in the international market to become a more solid actor within the New Space sector," she concludes.

© SATLANTIS

ISIM

- Coordinated by SATLANTIS in Spain
- Funded under Horizon 2020-SME and Horizon 2020-LEIT-ICT
- cordis.europa.eu/project/id/768278
- Project website: satlantis.com
- bit.ly/3rAI1BZ

María Dasí
iSIM project coordinator
© Maria Dasi

> *We delivered one camera in 2020 and another one is due to be delivered by mid-2021. We're also implementing our industrial plan for the assembly and integration of 10 cameras for 2021.*

AGENDA

MAY 2021

11 MAY

ONLINE
Photonics Online
→ bit.ly/photonics-meetings

11 MAY

ONLINE
Multiple Benefits Virtual Conference
→ mbenefits.eu/final-conference

12→14 MAY

ONLINE
ENABLE Workshop: 'Exploring Life Dynamics: In and out of equilibrium'
→ enablenetwork.eu

17 MAY

WORLDWIDE
World Information Society Day

20→21 MAY

ONLINE
InGRID Expert Workshop
→ bit.ly/inGRID-workshop

22 MAY

BERLIN, GERMANY
International Day for Biological Diversity

MORE EVENTS
cordis.europa.eu/news

5-6 MAY

ONLINE
EuroNanoForum 2021

The EuroNanoForum 2021 conference will address the role of nano-enabled technologies and industries in the transformation towards EU prosperity. The event will bring forward the role of R&I, as well as the opportunities offered by Horizon Europe. The event will bring together experts across different sectors to identify policy options and priorities. In addition to sharing insight on technical, industrial and social challenges, views and ideas will be discussed on the role of nanotechnology and advanced materials in the EU's recovery.

→ euronanoforum2021.eu

Whilst at the time of writing all of these events were scheduled to take place, we advise all of our readers to regularly check the status of each event due to the continued uncertainty caused by the novel coronavirus epidemic in Europe – events may be cancelled, rescheduled or reformulated (e.g. switched to being a digital event only) at any time.

RESULTS PACK ON VIRUSES

In this Results Pack, we meet a number of EU-funded projects that are not only helping in the battle against COVID-19 but also contributing to the wider virology field that will improve our overall understanding of viruses, as well as our ability to create even more effective antiviral treatments and vaccines.

Check out the Pack at:
cordis.europa.eu/article/id/418269

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