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#97
NOVEMBER 2020

Research*eu

BRINGING YOU THE RESULTS OF EU RESEARCH AND INNOVATION

Study of mixed families
tests sociological assumptions

Preserving the intangible:
New technology for the visual arts

No need for walkie-talkies
with smart emergency communication

SPECIAL FEATURE
INNOVATIVE EU RESEARCH HONES IN ON HIV

Editorial

Recognising innovative research on HIV/AIDS, protecting mass gatherings in the age of COVID-19 and a new model that can predict drought in the Amazon months in advance

Welcome to this month's Research*eu magazine

When your editor sat down to outline the 2020 special feature editorial calendar for Research*eu at the end of 2019 and plumped for a special feature on HIV/AIDS for the November issue (so published before World AIDS Day on 1 December), he had absolutely no idea that he would spend most of 2020 writing about a completely different novel virus that has wreaked havoc across the world. But, regardless of the chaos caused by COVID-19, we felt it was still important to go ahead with our feature on the other major global pandemic of the past 50 years and the excellent EU-funded research that has been carried out (and is still being carried out) into developing new treatments and, ultimately it's hoped, the holy grail of a working vaccine and/or cure.

Around 32-33 million people have died of AIDS-related complications since the beginning of the crisis in the early 1980s. According to the UN, 38 million people are today living with HIV across the world and in 2019 alone, approximately 690 000 people died of AIDS-related illnesses. People living with HIV today still have to deal with significant social stigma and in developing countries, where most people with HIV live, access to treatment can be both logistically difficult to obtain and expensive.

In the past 40 years being diagnosed with HIV has evolved from being considered a certain death sentence to a much more manageable disease that when treated well does not adversely impact quality of life. This shift can be attributed to the passionate work of AIDS patients, their supporters and dedicated researchers, who have never given up hope that better treatments and one day a cure and/or vaccine can be found. Indeed, whilst the struggle against HIV/AIDS has been both long and painful, we can also draw lessons from that struggle that can help us cope with the current predicament the world finds itself in due to COVID-19. Namely that we can, and will, advance forward – even in the darkest of days – with sheer determination to come out of the other side, into the light and a better future.

Meanwhile, in **Life After** we reconnect with the **LETS-CROWD** project team, which has continued to develop its solutions to keep mass gatherings safe. Originally having terrorist threats in mind, in a world currently without mass gatherings (unless you're an enviable reader in New Zealand), they have innovatively modified their technology to help provide solutions to the challenges posed by COVID-19. And finally, in **Project of the Month**, we were very impressed with the **TIPES** project that has recently published a fascinating new paper that describes a new model that can help predict severe droughts in the Amazonian basin months before they happen.

As our December 2020/January 2021 double issue will only be published after the festive period, we at CORDIS want to wish all of our readers good health, as always, and also hope you all have, as much as possible, a relaxing Christmas and New Year break. We look forward to engaging with you in 2021.

In the meantime, 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.

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Contents

#97
NOVEMBER 2020

HEALTH

SOCIETY

ENERGY

CLIMATE CHANGE AND ENVIRONMENT

PROJECT OF THE MONTH

SPECIAL FEATURE

FOOD AND NATURAL RESOURCES

INDUSTRIAL TECHNOLOGIES

DIGITAL ECONOMY

SECURITY

FUNDAMENTAL RESEARCH

LIFE AFTER...

HEALTH

Targeting Plasmodium egress as a novel treatment for malaria

Malaria continues to be a major health challenge for developing countries, causing nearly half a million deaths every year. To address the lack of vaccines and the emergence of resistance against existing drugs, European researchers investigated a key step in the parasite life cycle.

When malaria parasites invade host red blood cells (RBCs), they enclose themselves within a membrane-bound compartment known as a parasitophorous vacuole. Approximately 48 hours later, at the end of its asexual blood stage growth cycle, the parasite ruptures the membrane in a coordinated manner before breaking out of the RBC, a process known as egress. Currently, the mechanism by which malaria parasites disrupt this membrane is completely unknown but it is central to parasite replication. At the same time, considering the notorious ability of Plasmodium parasites to rapidly develop resistance against antimalarial drugs, there is an urgent need to identify new drug targets and overcome the limited efficacy of existing solutions.

INVESTIGATING THE ROLE OF MEMBRANE-LYSING ENZYMES IN PARASITE EGRESS

Undertaken with the support of the Marie Skłodowska-Curie Actions programme, the MalariaEgress (Role of perforin-like proteins and phospholipases in malaria parasite egress) project based in the host lab of Mike Blackman at The Francis Crick Institute in the United Kingdom worked under the hypothesis that the malaria parasite must use a type of membrane-lysing enzyme called a phospholipase to egress from RBCs. "Malaria is an ongoing epidemic and so there is a pressing need to identify new drug targets involved in crucial processes in the parasite life cycle," notes research fellow, Abhinay Ramaprasad.

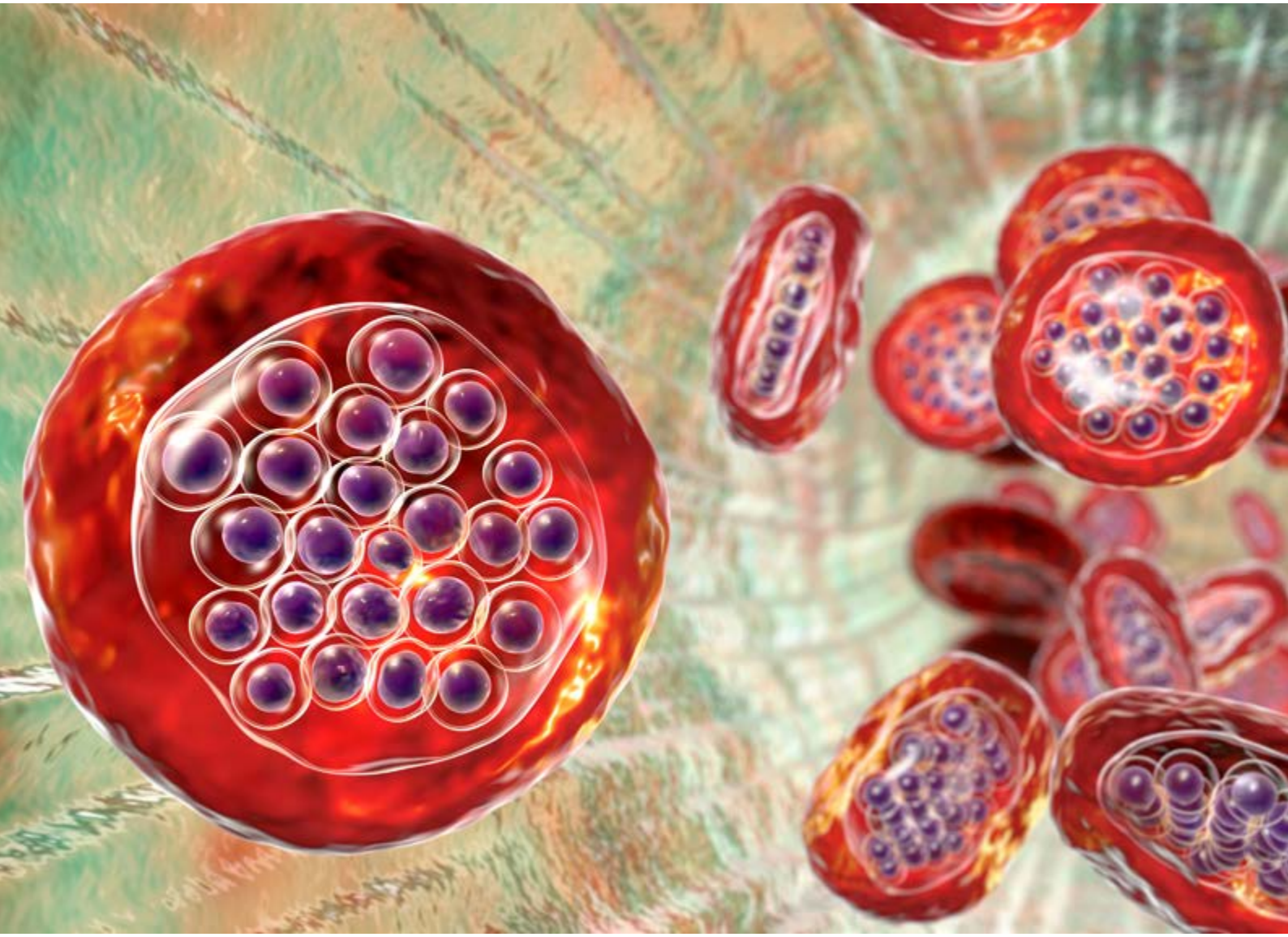
There are 23 different phospholipases in the malaria parasite that are potentially involved in the synthesis and breakdown of phospholipids of the parasitophorous vacuole. The scientists used gene knockout and gene editing technologies such as CRISPR-Cas9 to disrupt these genes, then performed extensive investigation of the impact of knockout on the parasite's ability to grow, multiply and break out of the RBCs. Analysis of the lipids produced by the parasite enabled them to infer the function of the phospholipases under investigation.

Over the period of the project, Ramaprasad characterised the functions of four phospholipases and found that they play a role at different points in the parasite's life cycle in the blood. Two of the enzymes were found to be essential for parasite growth while another was required for efficient egress, suggesting they could serve as therapeutic targets for the development of novel antimalarial drugs. Of particular interest, the phospholipase that aids the parasite in undergoing egress efficiently functions by modifying the vesicle membrane around it, making it more amenable to rupture.

PROJECT SIGNIFICANCE AND PROSPECTS

Research towards novel treatments for malaria is fundamental. "Enzymes including phospholipases constitute excellent targets for drugs against pathogens causing important infectious diseases," explains Ramaprasad. Prime examples include the HIV protease and influenza virus neuraminidase, which are targets of

> *"Malaria is an ongoing epidemic and so there is a pressing need to identify new drug targets involved in crucial processes in the parasite life cycle."*



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clinically successful drugs. Based on this, MalariaEgress researched the fundamental biology underlying malaria parasite proliferation and pathogenesis with a view to developing novel drugs.

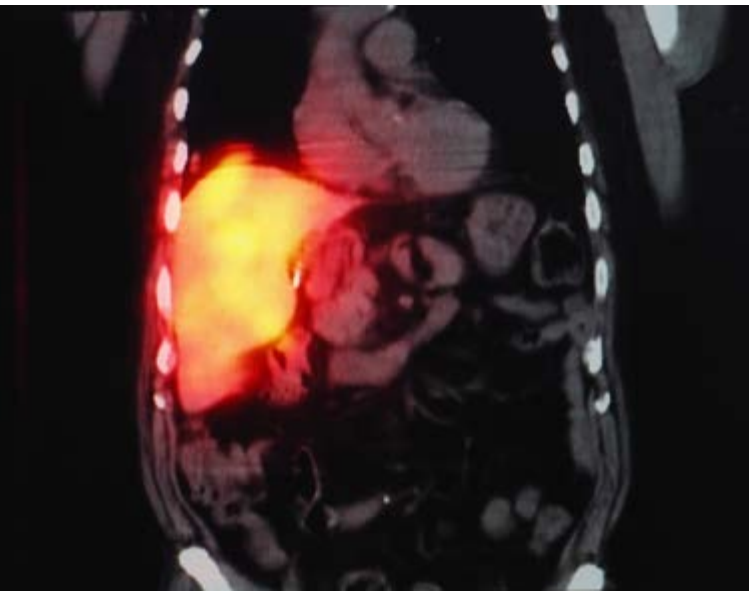
The project results unveil a key role of phospholipases in the membrane dynamics required for the parasite's asexual blood life cycle, including egress from the RBCs. With a view to the future, Ramaprasad adds: "Activities will focus on targeting these essential phospholipases with drug-like small molecules that are safe to use in humans."

MALARIAEGRESS

- Coordinated by The Francis Crick Institute Limited in the United Kingdom
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/751865
- Project website: crick.ac.uk/research/labs/mike-blackman

Innovative gold-based drugs for guided anticancer therapy

Metal-based drugs are gaining ground in the therapy against cancer, offering reduced side effects and resistance. European scientists have implemented a strategy for the synthesis and biodistribution monitoring of gold-based prodrugs to improve existing chemotherapy options.



The therapeutic potential of metal-based compounds is not new and dates back to ancient Greece and China. Platinum-based drugs, such as cisplatin and its derivatives, are used as anticancer drugs; however, there is a growing demand for alternative metal-based compounds with enhanced cytotoxicity and pharmacokinetics and reduced side effects.

NOVEL GOLD-BASED COMPOUNDS

Undertaken with the support of the Marie Skłodowska-Curie Actions programme, the PhoRAu (Photochemistry and radiolabelling of gold(III) anticancer prodrugs) project developed compounds based on gold(III) decorated with radioisotopes. Researchers wanted to understand when and how gold(III) prodrugs are converted to gold(I) drugs. "Indeed, this promising class of molecules can result in novel cytotoxicity mechanisms, as they can potentially undergo controlled reduction into gold(I) compounds in cell compartments," explains the Marie Skłodowska-Curie research fellow Alessio Terenzi.

Researchers wanted to combine therapy with imaging capabilities, so they labelled the gold prodrugs with radioactive iodide. This allowed monitoring of the biodistribution of the prodrug *in vivo* via positron emission tomography (PET), similarly to the radioactive fluoridelabelled glucose used for imaging tumours in oncology.

Unlike traditional strategies where radionuclides are covalently attached to organic molecules, PhoRAu scientists used inorganic reactivity to perform the labelling. Importantly, this straightforward inorganic reaction between the radioactive iodide and gold(I) led to the formation of the desired gold(III) prodrug that they wished to produce. They also investigated the thermodynamic, kinetic and redox properties of these gold(III) complexes in aqueous solution and in the presence of biological molecules.

Biodistribution studies of the gold(III) prodrugs allowed scientists to monitor the gold reduction process *in vivo* and understand how gold(III) complexes are metabolised and activated. Following PET imaging, the gold(III) prodrug accumulated in the major organs, such as lungs, kidneys and liver, through the blood circulation. Intriguingly, the gold(III) prodrug was not immediately reduced to its gold(I) analogue, but reached some organs in its oxidised form, providing important insight into gold-based therapeutics.

PROJECT DYNAMICS

Through their radioactive gold derivatives, PhoRAu researchers have managed to add an imaging functionality to their candidate gold-based prodrugs and guide therapy

> *Our strategy overcomes an intrinsic limitation of metal-based drugs which can rarely be monitored in real time* in vivo.

through PET imaging. "Our strategy overcomes an intrinsic limitation of metal-based drugs which can rarely be monitored in real time *in vivo*," says Terenzi. Importantly, our strategy is based on an original labelling concept that can find additional applications for the labelling of other anticancer metal-based drugs.

Furthermore, the data on the interplay between gold(III) and gold(I) species *in vitro* and *in vivo*, shed light on the mechanism of action of this family of anticancer drug candidates. *In vivo* biodistribution studies of gold complexes are still quite rare and therefore the PhoRAu work is seminal in the field. Although the clinical application of these candidate compounds is still years away, Terenzi notes: "Our approach will inspire others and lead to the development of drugs that can ultimately reach clinical trials."

PHORAU

- Coordinated by the Donostia International Physics Center in Spain
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/746976
- Project website: lucasalassa.wixsite.com/salassa/alessio-terenzi

HEALTH

Artificial intelligence overcomes laboratory testing for pathogen detection

Almost all respiratory infectious diseases, including COVID-19, present with very similar symptoms, making correct diagnosis difficult. EDAS HEALTHCARE developed an artificial intelligence-based system that can instantly predict the cause of infection remotely, based on patient demographic parameters only.

Current point-of-care capacity for detection of respiratory infectious diseases is limited, often failing to discriminate between bacteria and viruses. As a result, physicians prescribe antibiotics which are often inappropriate, or even unnecessary, incurring a high economic burden and increasing the risk of antimicrobial resistance. In the COVID 19 era, the ability to eliminate COVID-19 infection for mass populations remotely and in seconds is a game changer for containing the pandemic and optimising medical resources.

AI AT FRONT-LINE DIAGNOSIS

From a clinical perspective, providing the right treatment within the first 24-48 hours of symptoms is essential. With this in mind, scientists from the EDAS HEALTHCARE (AI-based infectious diseases diagnosis in seconds) project devised a decision support system for physicians that relies on Big Data and machine learning algorithms to diagnose infectious diseases instantly and remotely. "Our patented technology uses artificial intelligence (AI) and anonymous historical lab data to accurately predict infection cause based only on simple demographic parameters," explains Gil Mildworth, chief business officer at EDAS Healthcare Ltd.

The system relies on epidemiology and location-based diagnosis and feeds the information into a combined virology, epidemiology and demographic engine. On a

daily basis, the system accumulates information, which is presented as geographical heat maps, showing the current state of infection per pathogen down to the street level.

The system considers very few inputs, such as the patient's age, gender and address, to provide instant and remote diagnosis without a visit to the clinic or hospital. Importantly, the AI technology relies on fact-based data from laboratory tests and can thus be implemented in several clinical workflows.

This technology was clinically validated at the Hadassah Medical Centre in Jerusalem, Israel in tens of thousands of patients, enabling the detection of practically all common respiratory pathogens, such as *Bordetella pertussis*, *Haemophilus influenzae*, *Mycoplasma* and *Streptococcus pneumoniae*. It can also detect viruses that can cause respiratory diseases, including SARS-CoV-2, adenovirus, human metapneumovirus, influenza and respiratory syncytial virus.

In terms of performance, EDAS HEALTHCARE results demonstrated over 97 % accuracy in excluding infecting pathogens and over 70 % accuracy in predicting the actual cause of respiratory infection. For COVID-19, accuracy reached 80 %, all without the need for any equipment. Mildworth notes: "The accuracy of excluding a pathogen as the cause of a given respiratory infection is usually 99 %, which is key for providing optimal treatment and coping with COVID-19."

> *Our patented technology uses artificial intelligence (AI) and anonymous historical lab data to accurately predict infection cause based only on simple demographic parameters.*

IMPLEMENTING THE TECHNOLOGY IN THE CLINIC

Based on market research and interviews with leaders and stakeholders from the United Kingdom's healthcare market, EDAS HEALTHCARE partners will focus on primary care and soaring telemedicine services. The technology enables remote accurate diagnosis, which can minimise pathogen spread, as infected patients do not interact with medical staff and other patients in the clinic.

Implementation of the EDAS HEALTHCARE technology will lower healthcare costs by increasing primary care capacity, eliminating the need for patient return visits and additional treatments, and reducing unnecessary drug costs and workload in clinical laboratories. Importantly, it can help fight the growing medical challenge of antimicrobial resistance by avoiding unnecessary prescription of antibiotics.

In light of the COVID-19 epidemic, the EDAS HEALTHCARE tool enables remote diagnosis without compromising possible isolation. Additionally, it can be used by health organisations to screen mass populations and thus prevent further spread of the virus in the community, thereby increasing the efficiency of existing medical resources.

According to Mildworth: "Instantly eliminating COVID-19 with 99 % accuracy is crucial for helping economies return to normality, offering employers the opportunity to scan their employees on a daily basis while enabling molecular labs to double their capacity and optimise test priority. This also means that disease control agencies can react ahead of time and take appropriate containment measures."

EDAS HEALTHCARE

- Coordinated by EDAS Healthcare Ltd in Israel
- Funded under H2020-SME, H2020-LEIT and H2020-Societal Challenges
- cordis.europa.eu/project/id/887845
- Project website: edashealthcare.com

SOCIETY

Study of mixed families tests sociological assumptions

Mixed families in contemporary European society offered ReMix the opportunity to analyse how the overlap of family, migration and religion is changing that society.

Religious pluralism and growing migration patterns are producing broad social change. As spaces where individuals explore multiple identities, but also ethnic and religious difference, so-called 'mixed' families are both representatives and drivers of these social changes.

The project ReMix (Christian-Muslim families dealing with religious pluralism in everyday family life: Religious reconstruction in religiously mixed marriages), supported by the Marie Skłodowska-Curie Actions programme, set out to investigate this phenomenon by focusing on Christian-Muslim couples, where religion apparently represented the main difference, but included many others.

By studying what makes a couple 'mixed', ReMix also challenged the language used in social sciences to discuss this growing social phenomenon.

"I was struck by the sociological use of the word 'mixed'. What makes a couple 'mixed'? Aren't all couples with different backgrounds and life experiences, mixed? What is the distinction between a 'mixed' and a 'non-mixed' couple and when do these differences matter?" asks Francesco Cerchiaro, Marie Skłodowska-Curie research fellow from KU Leuven, the project host.

Cerchiaro became the first researcher to be allowed access to some mixed couple associations.

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TESTING ASSUMPTIONS

ReMix investigated the well-established statistic that indicates interfaith marriages have higher divorce rates, asking: 'What are the apparent tensions in mixed marriages about, and how are they resolved?'; 'What role does gender play in the processes and outcomes?'; and 'How do offspring identifications develop and manifest themselves?'

"There are many sociological assumptions about why this might be, such as communication difficulties, cultural differences and hostility from families of origin, religious institutions and society. But they remain largely assumptions," notes Cerchiaro.

ReMix completed ethnographic observations and in-depth interviews with parents and their offspring: 11 families in Antwerp (Belgium, Flemish region); 15 families in the metropolitan area of Brussels (Belgium); and 20 families in the metropolitan area of Paris (France).

When it came to partners' religious identities, ReMix demonstrated that reconstructing religious identities to minimise differences was the rule not the exception. Couples do it in various ways, such as removing religion from the family context, conversion to their partner's religion or focusing on a common faith in God.

Regarding gender, ReMix found that female Christian French or Belgian women experience the most familial opposition, seemingly because of the perceived lower socio-economic status of male Muslim partners. This suggests the lingering importance in European culture placed on the male breadwinner.

In terms of offspring identifications, unlike past research on interreligious and interethnic marriages, ReMix found a reshaping, rather than a loosening or dilution of religiosity, at work.

However, the project did confirm other recent studies which have suggested that the majority of offspring try to escape fixed categories based on racial grounds.

> *"I was struck by the sociological use of the word 'mixed'. What makes a couple 'mixed'? Aren't all couples with different backgrounds and life experiences, mixed?"*

TOWARDS AN INCLUSIVE AND MULTICULTURAL EUROPE

Cerchiaro organised the first International Symposium on Muslim Non-Muslim families at KU Leuven with the participation of nine leading international scholars. He is currently co-editing a special issue publication following the conference which will compare the experiences of Christian-Muslim families worldwide, offering new perspectives on the study of mixed families.

"Ultimately ReMix tries to counter Islamophobia and stereotypes about Muslim integration in Europe. It shows how our identities are much more intertwined and mobile than what we think they are, saying a lot about being European," explains Cerchiaro.

Cerchiaro now wants to take his future research beyond the confines of family, to look more closely at the agency and constraints in the relationship between mixed families and social change.

REMIX

- Coordinated by KU Leuven in Belgium
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/747592
- Project website: bit.ly/2ZAa9t0

Critical analysis of unedited texts shines light on key medieval patriarch

A literary analysis of largely untouched holy texts reveals much about the life, times and practice of a patriarch in 14th century Constantinople.

Sacred texts can reveal much about times past. The EU-funded SLLB (Sacred Landscapes in Late Byzantium) project investigated the creation of sacred space in 14th-century Byzantium, on the basis of a little-studied body of late-Byzantine saints' lives composed by Philotheos Kokkinos, the patriarch of Constantinople in the second half of the 14th century.

SLLB produced critical editions of two previously unedited hagiographic texts composed by Kokkinos: his discourse (logos) on All the Saints and that on the Twelve Apostles. The third aim of the project was to investigate the representation of women in Kokkinos' hagiographic works.

"A late-Byzantine man of letters, theologian and ecclesiastical figure, Kokkinos' importance for the political and ecclesiastical scene of 14th-century Byzantium is difficult to overstate," says Mihail Mitrea, Marie Skłodowska-Curie fellow at Newcastle University and SLLB lead researcher.

"Kokkinos graced the patriarchal throne twice and played a leading role in orchestrating the societal breakthrough of hesychast theology which is a monastic practice of silent prayer that has remained at the core of Christian Orthodoxy up to this day," Mitrea notes.

SPIRITUALITY AND SPACE

One of the most surprising and promising results of the project was the relationship uncovered between hesychast spiritual experiences and spatial setting.

"The exercise of obedience was best achieved in monasteries or in their vicinity, under the supervision of a spiritual father, while the devotion to God through prayer and mortification of the body often required withdrawal from the world in remote and inaccessible places," Mitrea explains.

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Through the practice of inner spiritual tranquillity it promotes, hesychasm poses an interesting challenge to established modes of monastic life, since, at least theoretically, monastics could attain inner quietude regardless of their location.

This project uncovered that holy men indeed pursued a hesychast way of life not only in solitude, but also as part of a monastic community, both in an urban environment and outside of it, apparently free of the constraints of a specific type of natural or social setting. This finding has important implications for the spread and continuity of hesychasm up to the present day.

"The next step in this line of research would be to expand the number of saints' lives analysed and to inquire further into holy men's patterns of movement in search of hesychia," Mitrea adds.

DIGGING DEEPER

The two edited texts reveal much about Kokkinos' views on holiness. He underlines in the introduction to the 'Logos on All the Saints' that the goal of 'the present account' is not to simply eulogise the saints. It is to show what the cause of the sanctification and deification of human nature is.

Mitrea explains: "Kokkinos essentially means that the road to sainthood is accessible and can be attained by everyone."

THE PORTRAYAL OF WOMEN WAS OFTEN DEROGATORY

"The analysis uncovered that women, to a greater extent than men, are presented as distrustful of the holy men, gossiping, and 'vainglorious, unstable, and flighty'. These depictions of women as unstable and distrustful undermine their credibility. This advances the hagiographer's purpose of promoting the holy figures and denigrating the scepticism they faced," says Mitrea.

> *A late-Byzantine man of letters, theologian and ecclesiastical figure, Kokkinos' importance for the political and ecclesiastical scene of 14th-century Byzantium is difficult to overstate.*

SLLB

- Coordinated by the University of Newcastle Upon Tyne in the United Kingdom
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/752292
- Project website: research.ncl.ac.uk/sllb
- bit.ly/32n7UuI

SOCIETY

Understanding global Catholicism in a contemporary context

The religious and spiritual factor has always been an elementary link in the construction of a European identity. EU research on the Catholic charismatic movement helps us understand its origin, evolution and success, firstly in the United States and then in Europe.

In an attempt to trace the global transformation of Catholicism over the last few decades, the EU-funded project CAT-CAM (The Catholic Charismatic Renewal (CCR): an Historical Analysis Between US and Europe) investigated the evolvement of the charismatic movement in Europe and North America. More specifically, it studied the growth of the CCR. This research was undertaken with the support of the Marie Skłodowska-Curie International Fellowships – Global Fellowships programme.

FOLLOWING THE TRACKS

The research emphasis was on the North American part of the story. It began with the identification of the origins of the CCR back in 1967, when two Catholics were baptised in the Holy Spirit in Pittsburgh, PA. CAT-CAM then presented the development of the movement in Indiana, Michigan and, further, its spread to Europe.

Initial patterns of the movement's leadership and organisation in its early institutional forms prove to be the key element that influenced the renewal in the rest of the world. The dense network of relationships between North American and European charismatic leaders and other international leaders is indicative of the movement's role in the transformations that led to the current state of Catholicism.

The findings shed light on the reaction of the Catholic ecclesiastical world, from the initial detachment from the movement to its gradual legitimisation. Moreover, project research showcases the issue of gender within the CCR, a result of the predominance of men among charismatic lay leaders and certain charismatic literature, and its impact on the whole identity of the movement.

USING FRESH TOOLS, OVERCOMING CHALLENGES

What makes CAT-CAM unique is the originality of its methodology. To investigate the origins of the Catholic charismatic movement from a historical perspective, primary sources were used "not only the historiography 'from the very beginning', but also the timely theological responses and the first sociological investigations carried out on the field," notes Valentina Ciciliot, Marie Skłodowska-Curie research fellow at project host Ca' Foscari University of Venice.

Because of the necessary utilisation of oral sources, the human factor has been an essential element of the research process. As such, the most serious challenge proved to be the need to adapt the legal framework so as to facilitate the collection of oral testimonies – interviews with actors involved in the history of the Catholic charismatic movement, for example. "It was a long and quite complicated process because of the sensitive data that were involved, but it was really fruitful at the end," Ciciliot explains.

> *"It was a long and quite complicated process because of the sensitive data that were involved, but it was really fruitful at the end."*

PROVIDING A NEW PERSPECTIVE AND GREATER AWARENESS

Now complete, CAT-CAM resulted in the opening of a new interpretive perspective for the understanding of the Catholic charismatic movement, as well as of the developments within the Catholic Church on a broader scale. The 3-year project included archival research and publications. The fellow delivered a series of specialised conferences and seminars, and project results became the core subject of a two-class course on North American Christianity. The main outcome of the project is a monograph titled 'A new Pentecost: How the Catholic Charismatic Movement Made the Church Global', which is currently in progress.

CAT-CAM

- Coordinated by Ca' Foscari University of Venice in Italy
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/654994

ENERGY

Bridging the gap between citizens and smart grid solution providers

New validated technology and solutions are paving the way towards fully integrated and highly efficient smart grid systems.

As Europe works to reduce its carbon footprint, promote the use of renewable resources and increase energy efficiency, more and more EU countries are turning to smart grid systems. These innovative, advanced and intelligent electrical grids include a range of operation and energy components, including smart metres, smart appliances and advanced grid management tools – to name only a few.

Smart grids also involve several stakeholders, from distribution system operators (DSOs) to retailers, aggregators, generators and consumers. The challenge is connecting all these stakeholders to the system in a stable and harmonised way – which is where the EU-funded project InteGrid (Demonstration of INTElligent grid technologies for renewables INTEgration and INTEractive consumer participation enabling INTEroperable market solutions and INTErconnected stakeholders) comes in.

Coordinated by EDP Distribuição, a Portuguese DSO, the project is paving the way towards developing and implementing smart grids. "We aim to turn DSOs into enablers of new business where smart grid technology is the core infrastructure," says Ricardo Bessa, the project's technical director.

BRIDGING THE GAP

In traditional grid systems, electricity is produced at large power plants and then transported to homes and buildings via cables operated by DSOs. In smart grid systems, however, energy tends to be generated locally and connected directly to distribution networks – such as from a solar panel on a roof to a small power plant. These innovative smart grid components are called distributed energy resources (DERs), and their integration, optimisation and management are the main challenges in the smart grid paradigm.

> *We aim to turn DSOs into enablers of new business where smart grid technology is the core infrastructure.*

InteGrid's vision is to bridge this gap by providing innovative ways for efficiently managing flexible assets across consumers. "In doing so, investment in grid infrastructure can be deferred and postponed, generating savings for the distribution system and, consequently, lower prices for the consumer," explains Ricardo Mendes André, a member of European Projects and Policies at EDP Distribuição and InteGrid project coordinator.

To accomplish this, the project set out to demonstrate how DSOs can enable different stakeholders to actively participate in the energy market, developing new business models and leveraging new approaches to data management. It also demonstrated scalable and replicable solutions that allow DSOs to plan and operate a network with a high level of DER and a higher degree of societal electrification.

"In the InteGrid concept, which is aligned with EU policy trends, the DSO acts as a market facilitator, ensuring the reliability and efficiency of energy distribution through a clean, reliable and cost-effective energy system," adds Sergio Potenciano Menci, an engineer at the Austrian Institute of Technology, one of the project's partners. "At the same time, the InteGrid system also empowers the consumer, who serves as a strategic actor in the system and one of its main beneficiaries."

DEMONSTRATED AND VALIDATED

InteGrid has been validated at three demonstration sites in Portugal, Slovenia and Sweden. Each site focused on a specific area of the project. For example, in Sweden, researchers worked on home energy management solutions, whereas the Slovenia site developed a virtual power plant.

In Portugal, the consumer engagement strategies demonstrated in Sweden and Slovenia came together as the Grid and Market Hub. According to Bessa, this is the project's key outcome. "It is a multiservice, multi-user service-based platform that bridges the gap between the distribution grid and grid stakeholders – including the consumers," he concludes.

INTEGRID

- Coordinated by EDP Distribuição in Portugal
- Funded under H2020-ENERGY
- cordis.europa.eu/project/id/731218
- Project website: integrid-h2020.eu
- bit.ly/330q49x

OCEAN ENERGY: PROMISING NEW TECHNOLOGIES TO HELP EUROPE ACHIEVE ITS AMBITIOUS CLIMATE GOALS

As Europe aims to be carbon-neutral by 2050 and invest significantly in renewable forms of energy over the coming decades, there's one source of green energy that shows great promise – and it's not even green, more of a blue. The oceans offer enormous potential as a source of clean, green energy, and the technologies to realise this, whilst still to fully mature, should definitely be on the radar.

Ocean energy technology is an emerging technology and there is still some way to go on the road to full commercialisation. But anchored in innovative demonstrations across Europe, often led by inspired and idealistic SMEs, they truly offer an exciting opportunity for green investors. In short, they deserve to be much more widely considered as a viable long-term form of renewable energy, alongside their more widely known solar and wind cousins.

Horizon 2020 has been active in providing support to projects that have been working to demonstrate the reliability and robustness of ocean energy technologies, as well as to make ocean energy cost-competitive with other technologies and clearly demonstrate its market potential.

To find out more, browse, download or order a physical copy of the Results Pack here:
cordis.europa.eu/article/id/422014

Heating and cooling technologies bring financial and environmental benefits to European residences

The 20 % primary energy consumption reduction targets set by the European Energy Efficiency Directive call for upgrading strategies for effective and wide-scale building heating and cooling systems. These will only be successful if they are based on the right combination of technology innovation, industrial commitment and awareness.

To meet this challenge, the EU-funded THERMOSS (Building and district thermal retrofit and management solutions) project developed an industry-focused, innovation-intensive approach that supports introduction of the latest heating and cooling technologies for energy retrofitting of buildings at the European level. The initiative targeted residential buildings and buildings connected to district heating and cooling (DHC) networks.

The consortium developed, tested and deployed a set of retrofitting heating and cooling packages based on cutting-edge, high-potential, market-ready technologies. These were linked together via an open ICT platform for smart energy management at building and district levels. "We aimed to optimise fossil fuel use and study the application of a two-way heat exchanger for thermal energy, which will favour decentralised production and storage in DHC-connected buildings, allowing stand-alone buildings to become DHC-ready," says project coordinator Fernando Centeno.

INCREASED EFFICIENCY

Project partners ensured an efficient match between supply and demand of energy through real-time management of thermal energy at building level, then scaled up to district level for DHC-connected buildings. They also increased the efficiency of residential building thermal retrofitting, with a target of 30 % energy consumption reduction, by providing a set of optimised technology packages for building heating and cooling. The packages covered both district-connected and non-district-connected buildings.

The main technologies developed by THERMOSS include a solar 2-WAY SUBSTATION (micro combined heat and power) prototype that can deliver extra heat to the district network, thus reducing gas consumption at district heat plants based on gas boilers and gas turbine-based electricity plants. Centeno notes: "This technology can open up new possibilities to connect new buildings to the grid and allow exchange of excess energy between the buildings and the thermal grid." The prototype supplies both heat and electricity from a single energy source, fostering security of supply and enhancing the grid's ability to meet peak electricity demand.

In addition, the consortium created smart thermostatic valves, which work as a sensor to indicate individual thermal needs. This provides continuous sensing, wireless transmission and centralised optimisation, granting a reduction in supply temperature using need-based decision logic.

> *We aimed to optimise fossil fuel use and study the application of a two-way heat exchanger for thermal energy, which will favour decentralised production and storage in DHC-connected buildings, allowing stand-alone buildings to become DHC-ready.*

ENVIRONMENT-FRIENDLY

The Cloud Monitoring Platform and the machine-to-machine (M2M) gateway allowed an efficient match between supply and demand of energy and are designed for the supervision of multisite buildings. "The Cloud Monitoring Platform has the special capability of communicating with high-level services, through secure communication protocols," Centeno explains.

The M2M gateway is a connectivity gateway for remote access and control of residential heating, ventilation and air conditioning devices and for error identification, preventive maintenance, system optimisation and stable data transfer. The Building Control Platform enables the transfer of data in a secure and reliable way, by using the integration of an innovative application programming interface with software solutions already on the market.

THERMOSS will help the environment through a reduction in greenhouse gas emissions and a smaller carbon footprint compared to common EU heating systems. "The main stakeholders benefiting from the project will be designers, district energy planners, industry manufacturers, heating/cooling system installers (SMEs), and public and private building owners," Centeno concludes.

THERMOSS

- Coordinated by the French Alternative Energies and Atomic Energy Commission (CEA) in France
- Funded under H2020-LEIT-ADVMANU
- cordis.europa.eu/project/id/723562
- bit.ly/3itsShk

ENERGY

A more efficient way of maintaining wind turbines

One Danish company is showing how wind turbines can leverage artificial intelligence to efficiently prevent expensive maintenance issues.

Wind power is a crucial ingredient in society's transition to renewable energy. The problem, however, is that wind turbines are still terribly expensive to operate and maintain – representing up to one third of the cost of renewable energy.

In fact, an unexpected fault on a critical component often results in the entire turbine being shut down. This could leave thousands of homes having to be powered by fossil fuels for up to several months. For the wind farm owner, it means lost revenue and very expensive repairs.

The key to preventing these potentially debilitating breakdowns is early fault detection. Traditionally, this has been done via condition monitoring, a process that uses advanced sensor data to monitor the health of mechanical equipment.

"The engineering experts involved in this process are like doctors for wind turbines, trying to identify the disease as early as possible and recommend the most effective cure," says Allan Larsen, project coordinator of the EU-funded PAVIMON (AI for Predictive Maintenance on Wind Turbines) project.

Unfortunately, condition monitoring is a manual process that doesn't scale very well, which is why project host Vertikal AI has developed an artificial intelligence (AI)

> *The PAVIMON project really validated our growth potential, and the insights we gathered now form the basis of our long-term growth strategy.*

alternative. "Our AI technology is a game changer," adds Larsen, CEO of Vertikal AI, a Danish company specialising in AI-based predictive maintenance solutions.

"It leverages historical fault data, engineering expertise and mechanical data to produce earlier and more robust fault warnings than what can be done using traditional condition monitoring."

Now, thanks to the PAVIMON project, this AI technology is well on its way to being market-ready.

NEED FOR AI TECHNOLOGY IS BIGGER THAN EXPECTED

During the project, Vertikal AI studied the feasibility of creating a profitable and scalable solution based on the company's deep learning technology. Working with several large wind turbine owners, researchers asked such questions as: How clean and complete is the customer data landscape? What are the user pains? What barriers are there to transforming existing processes? How can the market and competitive landscape support a high-growth strategy?

"Gathering data and insights required us to ask potential customers a lot of questions and dig deep into user pains and into processes," explains Larsen. "This curiosity

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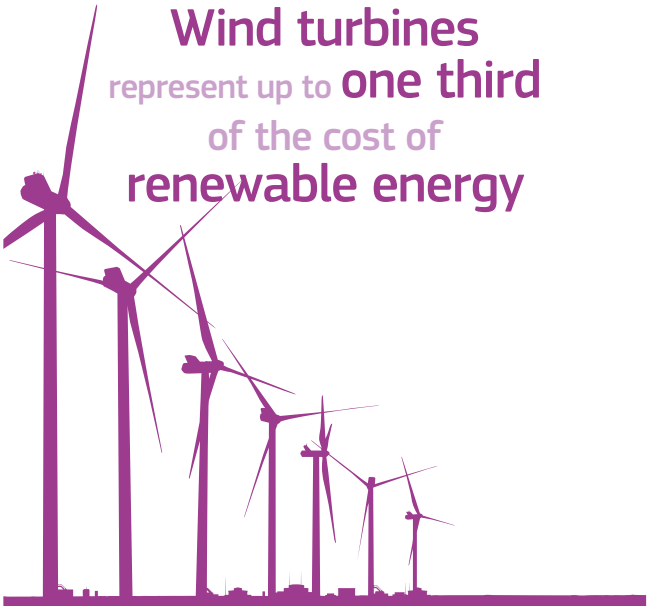


was very positively received, and the relationships we cultivated because of this are still helping us today."

According to Larsen, through these conversations the team discovered that the long-term need for its AI technology far exceeded their initial assumptions. "We realised that there is some very low-hanging fruit that we can immediately start resolving with a much simpler version of our product but that still plays into our long-term vision," he adds.

ACCELERATING TIME TO MARKET

Although the project is now finished, Vertikal AI continues to advance its solution towards market readiness. "The PAVIMON project really validated our growth potential, and the insights we gathered now form the basis of our long-term growth strategy," concludes Larsen.

The company is currently making substantial investments in R&D and working to accelerate its time to market. In the next couple of years, Vertikal AI plans to work closely with its clients to finalise the product for market readiness. For this, they are seeking both private venture capital and, possibly, EIC Accelerator Pilot funding.

PAVIMON

- Coordinated by Vertikal AI in Denmark
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT
- cordis.europa.eu/project/id/885916
- Project website: vertikal-ai.com/home

CLIMATE CHANGE AND ENVIRONMENT

How events 3 000 km beneath our feet leave a mark on Earth's surface

The evolution of tectonic plate boundaries has been successfully modelled for the first time using supercomputers, revealing how deep-Earth events affect life on the surface.

The surface of Earth is divided into plates, and these plates move against each other a few centimetres every year. "Imagine it as the same rate as your fingernails are growing," says Martina Ulvrova, project coordinator of GEOTRIBE (Generation and Evolution Of Transform-Ridge Interaction and Behavior on Earth).

The mechanics of plate tectonics are well understood, but less is known about how the plate boundaries themselves form. The GEOTRIBE project sought to understand how local and global forces combine to shape the development of new plate limits.

One type of these boundaries is transform-ridge orthogonal patterns, seen when two plates slide against each other. A disjointed mountainous ridge appears with segments perpendicular to the fault, like the teeth on a zip. "These are the most enigmatic features of plate boundaries, because they are hard to reproduce in models," adds Ulvrova.

In the past, Earth scientists used trays of cooling paraffin wax – its solid crust lying on top of a liquid interior – to replicate the evolution of plate tectonics. By contrast, Ulvrova's high-resolution models relied on months of calculations performed by supercomputers at the Swiss Federal Institute of Technology Zurich (ETH Zurich) and the Swiss National Supercomputing Centre to demonstrate how convection currents in Earth's hot mantle, twinned with local forces, dictate the process of plate boundary formation.

> *For something on the local scale, you need to study what is happening tens of thousands of kilometres away.*

Through the research, Ulvrova has published several papers detailing how convection currents in the mantle relate to the formation of these plate boundaries and their movement. "You need to look at this from a global perspective," explains Ulvrova. "For something on the local scale, you need to study what is happening tens of thousands of kilometres away."

For the first time using global models, Ulvrova's results were also able to explain the fragmentation of Pangaea, the supercontinent which existed from 335 to 175 million years ago.

"We can reconstruct the position of the plates for the past 230 million years," adds Ulvrova. "Comparing my simulations with these geological records, they match really well."

"A better understanding of the link between Earth's surface and deep mantle will help shed light on events above ground on the surface," says Ulvrova, noting that processes such as the carbon cycle and sea level change are tied closely to tectonic activity.

The work was supported by the EU's Marie Skłodowska-Curie Actions programme. "This gave me the freedom to pursue the scientific direction I wanted to," notes Ulvrova. "ETH Zurich is the dream science environment, the infrastructure, the colleagues, the rich discussions on the topic." She adds that the funding also allowed her to travel to conferences and build her professional network.

PANGAEA – the supercontinent which existed from 335 to 175 million years ago

Ulvrova says her work into Earth's dynamics will continue. "I love numerical simulations, computational geodynamics, the need to use supercomputers and advanced numerical techniques that we did not have 5 or 10 years ago. This is a very exciting research direction."

GEOTRIBE

- Coordinated by the Swiss Federal Institute of Technology Zurich in Switzerland
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/753755

CLIMATE CHANGE AND ENVIRONMENT

A sustainable way of controlling invasive species

One EU researcher is investigating the use of sterile insect techniques to control pest populations in an environmentally friendly manner.

Invasive species can wreak havoc on an environment and significantly disrupt human society. Take for example the *Drosophila suzukii* (*D. suzukii*) fruit fly. Originally from South-East Asia, this insect has become a major pest species in Europe, where it infests – and destroys – fruit during the ripening stage.

© Invasion, Ian Debelle and Joris Froissard

> *My aim is to provide both a fundamental understanding of the dynamics of sexual selection and essential information for the development of sustainable, environmentally friendly methods for fighting pest species.*

Pest species have traditionally been eliminated with pesticides. However, pesticides can have long-term, detrimental effects on an entire ecosystem – often causing more damage than the original invasive species ever did.

As researchers search for more effective methods for controlling invasive species, more and more are looking at the role of sexual selection during adaption. For example, the EU-funded SexSelec_Invasion (Understanding sexual selection to help controlling an invasive pest species) project investigated the potential of exploiting mating strategies to control pest populations in an evolutionary, sustainable way.

"My aim is to provide both a fundamental understanding of the dynamics of sexual selection and essential information for the development of sustainable, environmentally friendly methods for fighting pest species," says Julie Collet, an evolutionary biologist and Marie Skłodowska-Curie fellow at the Centre for Functional and Evolutionary Ecology in Montpellier, France.

THE SUSTAINABLE POTENTIAL OF SITS

The SexSelec_Invasion project, which was undertaken with the support of the Marie Skłodowska-Curie Actions, investigated using sterile insect techniques (SITs) to control *D. suzukii* fruit fly populations in an environmentally friendly way. SIT is a method that induces sterile mating by frequently releasing large numbers of mass-reared, sterile males.

To start, Collet identified the traits that predict male mating success. "Knowing that the shape, size and darkness of a male fly's wing spots impact their mating success, we can mass-produce sterile males that have these characteristics," explains Collet.

"This in turn ensures the sterile males can successfully compete against local, non-sterile males."

Although the SIT method has limited environmental side effects, there is a risk that females will eventually evolve to resist and discriminate against mating with sterile males. Collet's research also focused on determining whether and how fast females can counter-adapt to SITs by discriminating against sterile males.

"After using divergent artificial selection towards high and low values of male wing spot attractiveness, no evolution of female choice was observed," adds Collet. "This suggests that a population cannot rapidly counter-adapt to SITs, meaning SITs could be a sustainable method for fighting *D. suzukii*."

A PROOF OF CONCEPT

By providing a comprehensive understanding of the evolution of *D. suzukii* sexual traits, Collet's research opens the door to new ways of controlling invasive species. "This project is a proof of concept that SITs can be used to control *D. suzukii* populations in a sustainable and environmentally friendly manner," notes Collet.

"Furthermore, our work documents an exciting example of the evolution of male sexual traits and their importance in male mating success."

Collet is currently applying for a permanent position to start her own lab, from which she will continue the work started in this project.

SEXSELEC_INVASION

- Coordinated by the National Centre for Scientific Research (CNRS) in France
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/752452
- Project website: juliemcollet.wordpress.com/projects

A new model to accurately predict severe drought in the Amazon – 18 months in advance!

The TiPES project was launched in September 2019 and its primary objective is to better quantify the tipping elements that are present in the climate system and to ensure that climate projections also include these in their calculations. The project has been highly active recently, pumping out several fascinating studies, including a very recent one that argues that droughts in the Amazon rainforest can be predicted up to 18 months in advance.

> *For the first time, we can accurately predict drought in the tropical regions of South America as far as 18 months in advance. The two crucial factors in this research are the selection of the precise, relevant locations in the Atlantic Ocean, and the observation that the correlation between the southern and the northern ocean regions can be used for prediction.*
>
> Niklas Boers, lead study researcher, Potsdam Institute for Climate Impact Research, TiPES member

Droughts affect millions of people worldwide, including those in the Amazon basin, the site of one of the most threatened ecosystems on Earth due to human-driven climate change. The new open access TiPES (Tipping Points in the Earth System) study, published in the journal 'Environmental Research Letters') has revealed how surface temperatures in two coupled areas of the tropical Atlantic Ocean can be used to accurately predict severe droughts in the Amazon region.

The analysis showed that when two specific areas of the Atlantic, situated north and south of each other, start to go out of phase (aka when temperatures rise in one and decrease in the other), the Amazon is likely to experience a severe drought within 1-1.5 years. Studying this phenomenon and being able to make such an accurate prediction would help to mitigate the severe impact such a drought would have on the millions of people who live within and rely daily on the Amazon ecosystem.

For more information please see:
iopscience.iop.org/article/10.1088/1748-9326/ab9cff

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!

TIPES

- Coordinated by the University of Copenhagen in Denmark
- Funded under H2020-ENVIRONMENT
- cordis.europa.eu/project/id/820970

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!

SPECIAL FEATURE

INNOVATIVE EU RESEARCH HONES IN ON HIV

Editorial

"Go without hate but not without rage. Heal the world" – Paul Monette, American writer, died of AIDS-related complications, 1995

The two viruses that are the cause of the world's two currently ongoing pandemics are very different from each other. One can fiendishly jump from host to host with incredible ease and causes a mild respiratory illness in most patients (though the jury is still out on the longer-term implications of the disease), with many infected people being completely asymptomatic. The second virus is mostly transmitted through unprotected sex, can lay unnoticed in its host for many years before it causes symptoms and can be fatal if left untreated.

Obviously, the first virus being referred to is SARS-CoV-2 and the second is Human Immunodeficiency Virus (HIV). Many of the world's leading immunologists and epidemiologists who are currently working against COVID-19 cut their teeth in the HIV/AIDS epidemics of the 1980s and 1990s and are thus applying the lessons learnt during those difficult times to the current global health crisis.

Whilst this experience is invaluable, one such lesson that can be learnt from the HIV/AIDS pandemic, and admittedly this is one that may not be totally well-received in our current situation, is that pandemics do not necessarily end quickly. Nearly 40 years after the virus that became known as HIV began manifesting itself rapidly amongst clusters of gay men in New York and San Francisco, around 37 million people today are HIV-positive, most in Sub-Saharan Africa, but around 2.3 million are living in the World Health Organization's (WHO) European Region, which includes the EU/EEA.

At the same time, the HIV/AIDS experience offers hope in the fight against COVID-19. In the 1980s, an AIDS diagnosis equated to a death sentence. Then slowly, but surely, and off the back of immense activist campaigns driven by AIDS patients and their supporters, as well as huge levels of devotion amongst HIV researchers, new treatments began to filter through, with major breakthroughs in antiretroviral drugs in the 1990s. Today, at least in the rich world, an HIV diagnosis is no longer a death sentence but is now essentially considered a manageable chronic disease.

The important takeaway here is that if they have to, human societies can adapt and learn to live with COVID-19 on a long-term basis if it cannot be eliminated entirely, just as they have had to do with HIV/AIDS. People had to learn the importance of safe sex as a means to protect themselves from a potentially deadly virus and this is now considered an accepted societal norm. In the same vein, we're likely to see modified social behaviours in the post-COVID world – perhaps, for example, mask-wearing when suffering from a simple cold to protect others will become more commonplace in Europe as it has been for many years already in Asian societies.

This is of course not to diminish the immense sacrifices and personal tragedies that millions of people afflicted by HIV/AIDS have had to live (and die) through over the last 40 years. With the holy grail of an effective HIV vaccine and/or cure still out of reach, researchers continue to be dedicated to developing new treatments and have definitely not given up hope of one day clasping that holy grail in their hands.

In the EU, under Horizon 2020, EUR 220 million has been assigned to innovative HIV/AIDS research since the programme's start. The EU has been dedicated to advancing HIV/AIDS research since the early years of the epidemic and will continue to do so in the years ahead. In this special feature, due to be published just before the annual World AIDS Day on 1 December, we meet seven EU-funded projects that have been at the forefront of HIV/AIDS research in Europe.

So, whilst we reflect upon a very, very difficult year filled with much loss and sacrifice, what we can draw from the HIV/AIDS experience is that there is always hope and there is always a fierce determination to steer the course and reach the light at the other end of the tunnel.

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

Contents

SPECIAL FEATURE

INNOVATIVE EU RESEARCH HONES IN ON HIV

HIV vaccines finally within reach?

Three novel HIV vaccine candidates are set to progress to clinical testing by the end of the year. This is all thanks to the EHVA project, which also devised an immune profiling platform and a central data analysis platform. With these, the project can help future research efforts in their selection of promising vaccine candidates.

Thirty-five years of active research, one breakthrough. With the RV144 trial result published in 2009, researchers looking for a promising HIV vaccine got an early glimpse of what the long-sought victory against the disease could look like. The trial – which took place in Thailand – saw 31 % of volunteers ending up with a modestly reduced risk of acquiring HIV.

Eleven years later, groups of researchers are still building on the knowledge gathered and priorities identified after the RV144 trial. The EHVA (European HIV Vaccine Alliance: an EU platform for the discovery and evaluation of novel prophylactic and therapeutic vaccine candidates) is one of them. Since 2016, the 41-strong consortium has been aiming to develop HIV vaccine candidates that would generate more durable and potent immune responses.

“One of the most important challenges in developing HIV vaccines is the ability to rapidly evaluate novel vaccine approaches early in the product development phase. This is a prerequisite to ensure that only the most promising candidates advance to large-scale testing,” says Yves Levy, coordinator of EHVA on behalf of Inserm.

To this end, EHVA is currently working on an immune profiling platform. With this tool, the consortium hopes to be able to rank novel and existing vaccine candidates. The platform will be coupled with a central data analysis platform using statistical tools and algorithms to effectively select the most promising ones.

As Levy underlines, the EHVA teams can use these tools to select best-in-class antigens and delivery systems including RNA and viral vectors. “We can then evaluate these novel candidates head-to-head with vaccine regimens already developed by partners in the Alliance, to ensure that we can down-select the most promising ones and bring

© Novikov Aleksey, Shutterstock

them to clinical testing. Meanwhile, EHVA also focuses on developing therapeutic vaccine candidates as well as helping elucidate mechanisms for a functional cure."

CLINICAL TRIALS

Now in its fifth year of research, EHVA has already developed several novel vaccine concepts. These include vector-based vaccines, a new delivery modality and HIV envelope trimer-based vaccines.

"Regarding the vector-based vaccine, the two lead candidates are a DNA-launched RNA Replicon Vaccine (DREP) and a novel VSV-GP vaccine," Levy notes. The DREP vaccine will be tested in a first-in-human clinical trial in late 2020 / early 2021. "The VSV-GP-based vaccine on the other hand has shown promising results in non-human primate studies, even though we won't be able to bring it to clinical development within the lifespan of EHVA."

The new delivery modality is a vaccine based on dendritic cell-targeting developed by the Vaccine Research Institute – Inserm. Phase I testing in healthy volunteers in France and Switzerland is due to begin later this year.

Finally, the trimer vaccines include two Clade C trimer antigens (known as ConCv5-KIKO and a complementary germline-targeting trimer ConCv5_GTv1). The plan is to combine them in order to stimulate the generation of broadly neutralising antibody responses targeting anti-CD4-BS, and also to enable the maturation of B-cells through sequential immunisation with different HIV envelope proteins. A phase I study is scheduled to start in 2021.

> *"We can then evaluate these novel candidates head-to-head with vaccine regimens already developed by partners in the Alliance, to ensure that we can downselect the most promising ones and bring them to clinical testing."*

"That's not all," Levy adds. "We also have a novel therapeutic regimen combining a vaccine candidate with an immunomodulatory therapy. It is set to enter clinical evaluation within the next few months in patients with HIV. A number of additional candidate vaccines are also advancing in preclinical development."

The consortium hopes to complete four clinical trials by the end of the project period. Meanwhile, there is little doubt that EHVA will contribute to accelerating vaccine development while saving money in the process. Levy even argues that the vaccine technologies and expertise developed through the work of EHVA could also help advance the development of vaccines for other diseases – such as COVID-19.

EHVA

- Coordinated by Inserm in France
- Funded under H2020-HEALTH
- cordis.europa.eu/project/id/681032
- Project website: bit.ly/3jAb0B8

One step closer to curing HIV

Working together, academic researchers and infectious disease clinicians are making significant advances towards curing HIV.

Finding a cure for the 37 million individuals living with HIV/AIDS is one of the great global health challenges of the 21st century. Although antiretroviral therapy (ART) is without a doubt one of the greatest achievements in HIV biomedical research – one that saves lives and reduces transmission – it is not a cure.

"The major obstacle to completely eradicating HIV using ART is the persistence of a small pool of latent HIV cellular reservoirs," explains Virginie Gautier, a researcher at University College Dublin's Centre for Experimental Pathogen Host Research.

"Once the viral genome is integrated into the host chromosome, the virus is able to persist, remaining hidden in these reservoirs and escaping both ART and immune response."

To overcome this obstacle, Gautier is leading the EU4HIVCURE (Accelerating HIV Cure in Europe) project, undertaken with the support of the Marie Skłodowska-Curie Actions. By leveraging dynamic collaborations between academic researchers and infectious disease clinicians, the project aims to accelerate the drive to find a cure for HIV.

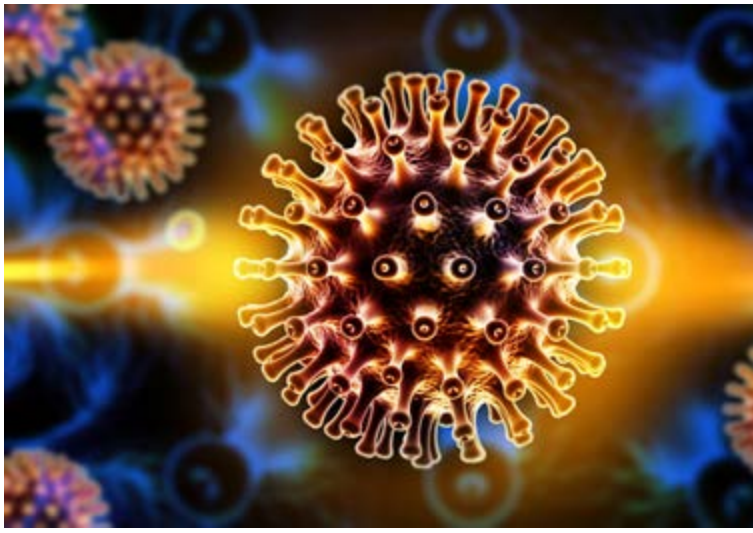
NEW SHOCK AND KILL STRATEGIES

Most efforts for curing HIV focus on purging persistent latent reservoirs by forcing viral gene expression using Latency Reversing Agents (LRAs) – all while maintaining patients on suppressive ART. "Once viral gene expression and viral particle production is reignited, the viral reservoirs become visible again," adds Gautier.

"They can then be targeted and eliminated by the immune system with the help of immune-boosting strategies."

The challenge, however, is that using multiple layers of control for HIV gene silencing limits the impact of current LRA-based strategies. "These blocks need to be collectively unlocked if we want effective HIV cure strategies," notes Gautier.

This is where the EU4HIVCURE project comes into play. "Our aim is to understand and delineate the nature of these blocks, expand the repertoire of novel therapeutic targets, and develop new classes of LRAs that could be included as part of new 'shock and kill' strategies," she remarks.



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ACCELERATING RESEARCH ON FINDING A CURE

Within just 48 months, the project successfully characterised new layers of control of HIV gene silencing. Researchers also identified potential new pharmacological targets for HIV-1 latency reversing therapeutic strategies. Furthermore, the team screened and examined new classes of LRAs and identified drugs targeting key metabolic junctions.

Perhaps most importantly, the project identified a synergistic combination of epigenetic drugs capable of targeting distinct mechanisms of HIV silencing where sequential treatments could achieve high levels of latency reversal in *ex vivo* preclinical models.

"Our work played a key role in consolidating a European ecosystem dedicated to accelerating research on finding a cure for HIV," concludes Gautier. "We also trained the next generation of infectious disease specialists and expert virologists, both of which are critical to sustaining the global effort to end AIDS, as well as current and future pandemic outbreaks."

> *Our work played a key role in consolidating a European ecosystem dedicated to accelerating research on finding a cure for HIV.*

Project researchers are working to further advance HIV preclinical and clinical programmes. To do this, they have expanded their European consortium to include new strategic alliances with patient advocate groups, voluntary non-governmental organisations, SMEs and various academic and clinical research groups.

They also launched a public-private consortium that merges the fields of infectious diseases, immune profiling, big data, artificial intelligence, clinical management trials, clinical practice and patient advocacy.

EU4HIVCURE

- Coordinated by University College Dublin in Ireland
- Funded under H2020-MSCA-RISE
- cordis.europa.eu/project/id/691119

Understanding the migration decisions of HIV-positive gay men

Using a qualitative approach, two researchers uncover the many factors that contribute to an HIV-positive gay man's decision to migrate to and remain in a certain city or country.

HIV rates continue to rise across Europe, particularly within the gay community. Despite new medical evidence that the virus cannot be transmitted when undergoing antiretroviral therapies, HIV-positive gay men still experience the combined effects of homophobia and HIV-related stigma.

"For many, an HIV diagnosis represents a turning point in their lives – a chance to 'seek a new life' in cities that offer new opportunities in terms of jobs, friendship, love and self-esteem," says Cesare Di Feliciantonio, a lecturer in Human Geography at Manchester Metropolitan University.

The HIVGAYM (Analysing the migration choices of HIV-positive gay men in England and France) project, undertaken with the support of the Marie Skłodowska-Curie Actions, aims to better understand this correlation between becoming HIV-positive and deciding to migrate. Led by Di Feliciantonio and Gavin Brown, a professor at the University of Leicester, the project is shedding new light on how the stigmatisation of being HIV-positive and gay impacts one's life choices. They analysed what policymakers can do to improve the well-being of these individuals.

A QUALITATIVE APPROACH

The goal of the project was to uncover the many factors that contribute to an HIV-positive gay man's decision to migrate to and remain in a specific place. The study stands out in that it compares participants from different 'HIV generations'.

This includes: those who got HIV in the 1980s, when such a diagnosis was a 'death sentence'; those who were diagnosed between the mid-1990s and mid-2000s, when the first effective therapies began to emerge; and those who became HIV-positive after 2008, following the launch of nearly side-effect-free treatments.

The study also compared evidence between England and Italy, two countries with different welfare systems, and between cities with different profiles in terms of economic attractiveness, gay visibility and HIV diffusion (Bologna, Milan, Leicester, London and Manchester).

To collect evidence, researchers used such qualitative methods as an online survey, interviews and discourse analysis. "Due to the stigma attached to the subject matter, recruiting participants proved challenging – especially in Bologna and Leicester," explains Brown. "To overcome this challenge, we relied on the support of local groups and organisations."

THE FIRST IN A SERIES OF RESEARCH PROJECTS

This research showed that age does not seem to play a significant role in one's decision to move. "London seems

© Cesare Di Feliciantonio

to be a sort of 'city of passage' for almost all of our English participants, although the majority do not stay due to unaffordability," remarks Di Feliciantonio.

The study also showed that issues like healthcare, welfare benefits, pensions and work opportunities all impact migration decisions, especially for those over the age of 50. "Austerity and welfare reforms, especially in England, seem to dramatically impact the most vulnerable participants," adds Brown.

> *For many, an HIV diagnosis represents a turning point in their lives – a chance to 'seek a new life' in cities that offer new opportunities in terms of jobs, friendship, love and self-esteem.*

Researchers are currently working to fully analyse their collected data and prepare it for publication. Furthermore, they are seeking funding for a research project on discretion as a paradigm to frame same-sex sexual desire among men using online 'hook-up' apps. Di Feliciantonio has also prepared a large funding application for a study on ageing with HIV across different social groups.

"Hopefully, the HIVGAYM project will be only the first of a series of collaborative research initiatives aimed at rethinking some of the key paradigms that have dominated the analysis of gay men's lives in recent social science scholarship, as well as bringing HIV and sex itself back into the focus of human geographers," concludes Di Feliciantonio.

HIVGAYM

- Coordinated by the University of Leicester in the United Kingdom
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/747110

A major boost for HIV vaccine identification and development

Failure to develop an HIV vaccine so far calls for a change of tune. EAVI2020 aims to accelerate development thanks to a platform dedicated to the discovery of new vaccine candidates. In its efforts, it even brought nine promising candidates to clinical evaluation.

The worldwide push for a COVID-19 vaccine can't make us forget about 30 years of efforts to identify one for HIV. Since 2015, some of the most competitive research groups in Europe have been working together to speed up the process and increase the chances of success.

Robin Shattock, chair in Mucosal Infection and Immunity at Imperial College London, leads one of these research groups under the EAVI2020 (European AIDS Vaccine Initiative 2020) project. The project's prototype RNA vaccines not only show promise for HIV treatment: they also have had a positive impact on vaccine development for COVID-19.

We spoke with Shattock to discuss the project's continued importance and achievements so far.

A vaccine for HIV-1 has yet to be discovered, despite decades of research. How would you explain this?

Robin Shattock: There is no shortcut to an effective HIV vaccine, and it would be easy to underestimate what needs

to be achieved to get there. We are talking about one of the biggest biological challenges of a generation. It is predicated on international cooperation and real commitment.

The biggest hurdle is the development of a single vaccine that can prevent infection from the wide range of circulating HIV strains. To make things worse, HIV can persist in infected individuals and nobody has ever been cured through a natural immune response. This contrasts greatly with COVID-19, which is currently driven by a single viral isolate showing minimal diversity and where the majority of individuals naturally recover from infection and eliminate the virus. In short, an HIV vaccine would be unlike any vaccine previously developed against infectious threats.

How can the EAVI2020 approach facilitate a breakthrough?

We have been actively developing a portfolio of vaccine candidates. These can be used both to understand human response to a diversity of HIV immunogens, and to maximise immune response to the widest range of viral isolates. Besides, we are developing a combination-vaccine approach. It can generate neutralising antibodies able to inactivate a virus before it invades target cells, along with cellular responses able to eliminate infected cells where the virus may have evaded destruction by antibodies.

This double line of defence not only offers the best potential to prevent infection, but it may also be effective in treating patients already infected. Our goal is to test both concepts through human clinical evaluation.

What are the most important outcomes of the project so far?

At the outset of the project, we were highly ambitious. We planned to bring up to 10 new stabilised envelope trimers through preclinical development, and up to eight to good manufacturing practices (GMPs). This had never been attempted in other programmes of this size and scope.

We are now happy to report that we have exceeded expectations. We have nine envelope products destined for the clinic. In parallel, we have brought two complex T-cell vaccines to the point where they are ready for clinical evaluation in HIV-positive and -negative subjects. This provides us with a unique and unprecedented portfolio of vaccine candidates. This is simply unrivalled in an international setting.

What would you consider as the most promising candidate you identified and why?

One of the major challenges in developing an effective HIV vaccine is to provide protection against the enormous diversity of circulating strains. In this context, we are not anticipating a single vaccine candidate as being appropriate to move forward. Our approach is rather to develop a combination vaccine. The latter would contain a minimal set of HIV envelope proteins to provide a diverse antibody response, as well as T-cell immunogens to engage both antibody and cellular arms of the immune response. We are still at an early stage of clinical assessment, but we are encouraged by data generated in our preclinical models.

What were the main difficulties you faced and how did you overcome them?

The major difficulty has been the COVID-19 pandemic. A number of our clinical trials were put on hold as countries and clinical centres prioritised their response to COVID-19. In addition, all research centres were closed to all non-essential work and most research staff were reassigned to support COVID-related efforts in laboratory diagnosis and vaccine development.

Many of the technologies developed within the EAVI2020 project have actually been applied to vaccine development and isolation of therapeutic antibodies. The EAVI2020 HIV vaccine clinical trials are now being reinitiated, and all

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supporting research laboratories are back to working at full capacity. Project delays have been factored into the project and timelines adjusted, and approvals for no-cost extensions to complete the work have been favourably received by the Commission. We will continue to monitor the impact of COVID-19 on the programme along with the impact of a potential second wave.

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

As we move into the final phase of the project, we are well-positioned to provide a unique set of clinical trials that will generate critical information. We need to ensure that investment in the development of our novel vaccine candidates is maximised by completing the wide range of clinical trials and associated immunological assessments. With these, we can select clinical candidates for efficacy studies. We can also feed back into the evaluation of preclinical assessment, to understand how to better use these models in the future.

Based on project outcomes, how close would you say we are to seeing a working vaccine?

The EAVI2020 project continues to provide a unique and key contribution to international HIV vaccine efforts. We are trailblazing the rapid testing of novel vaccines in humans.

During the course of the project, it has become increasingly clear that the study of human responses to vaccination

Robin Shattock,
Leader of one of these research groups under the EAVI2020 (European AIDS Vaccine Initiative 2020) project.
© Thomas Angus

> *We have nine envelope products destined for the clinic. In parallel, we have brought two complex T-cell vaccines to the point where they are ready for clinical evaluation in HIV-positive and -negative subjects.*

may prove critical, whereas animal studies have not proved predictive. The EAVI2020 project is setting a new international benchmark for what can be achieved. Our hope and vision is that clinical evaluation of the vaccine candidates in our portfolio will drive and inform large-scale efficacy testing through international agencies including the European and Developing Countries Clinical Trials Partnership.

EAVI2020

- Coordinated by Imperial College of Science, Technology and Medicine in the United Kingdom
- Funded under H2020-HEALTH
- cordis.europa.eu/project/id/681137
- Project website: eavi2020.org

A digital follow-up for people living with HIV

COVID-19 has led to an unprecedented rise in the need for digital health services across all disciplines. HIV clinicians can already count on a dedicated mHealth platform developed under the EmERGE project.

Around 2.3 million people in Europe currently live with HIV. For the 80% aware of their condition, daily life is not so different to that of other European citizens. Antiretroviral medication considerably reduces adverse health effects and, for most, hospital appointments every 6 months suffice for routine blood monitoring.

Not all is perfect though. Structural changes in service delivery have been caused by restrictions in budgets, the numbers of people being treated have increased, and people under treatment growing older has been posing new challenges.

As Jenny Whetham, a consultant in Sexual Health and HIV Medicine at the NHS Trust, points out: "The risk of co-morbidities and polypharmacy, which sees HIV drugs interacting with other medications, grows with age." When this is added to concerns over hospital capacity amidst the COVID-19 pandemic, suddenly current HIV care and prevention provision starts looking ill-adapted.

Around **2.3 million** people in Europe currently **live with HIV**

> *This strategy helps clinics manage capacity and provide more person-centred care. It frees up appointments for those patients with more complex medical needs or those who would prefer to be seen face-to-face.*

Enter EmERGE (Evaluating mHealth technology in HIV to improve Empowerment and healthcare utilisation: Research and innovation to Generate Evidence for personalised care) – an app and web portal for the management of HIV developed thanks to funding under the project of the same name. Its goal: enabling a virtual connection between patient and clinician via a secure and GDPR-compliant digital health platform.

The mHealth platform sits on a server within the hospital or clinic firewall. It receives data from the clinic database via an API and pushes it securely to an app on the patient's Android or iOS mobile device along with messages. The data covers a variety of test results, medication information and appointments, which both clinician and patient can review when needed.

One of EmERGE's greatest contributions is its process for digital health design and implementation. "We co-designed the EmERGE pathway with community members and clinicians before inviting patients to take part in a study across our five clinical sites. Some 2 251 patients living with HIV accepted the invitation and we followed them up for 12 to 30 months. Clinicians saw their patients once a year and checked interim results before they were encrypted and pushed through the application," Whetham explains.

The results of the study are quite promising. Virological outcomes remained excellent in the group – 99 % of individuals maintained an undetectable viral load – with no adverse effects and high patient satisfaction and engagement. Meanwhile, attendance at clinics was reduced by up to 30 %.

"This strategy helps clinics manage capacity and provide more person-centred care. It frees up appointments for those patients with more complex medical needs or those who would prefer to be seen face-to-face," Whetham notes.

PRESERVING CLINIC AND HOSPITAL CAPACITY

The capacity argument is certainly sound. It is sure to resonate like never before in a COVID-19 context where hospitals across Europe need to manage outpatient services very differently in order to maintain quality of care. Many services are re-evaluating digital health provision, and the EmERGE mHealth platform provides a secure and well-evaluated option.

"People have been really impressed with the project and the approach we have taken," Whetham adds. "Of course, some clinicians were a bit sceptical initially. They were

concerned about changes to clinical practice, not seeing patients face-to-face and losing income when virtual tariff payments were not in place. Many of these barriers disappeared with COVID-19. Reimbursement structures are changing rapidly, and clinicians are adjusting to new ways of working."

Though it's now drawing to a close, Whetham says the project will live on through the EmERGE mHealth not-for-profit spinout company. The platform was recently extended to include two-way messaging and video, whilst a prototype of a digital pathway for Pre-exposure prophylaxis for HIV prevention (PrEP) is also available.

With these efforts, EmERGE is set to make an important contribution to the digitalisation of health services in Europe.

EMERGE

- Coordinated by the NHS Trust in the United Kingdom
- Funded under H2020-HEALTH
- cordis.europa.eu/project/id/643736
- Project website: emergeproject.eu

Understanding how HIV-1 escapes the immune system and causes infection

By learning how the HIV-1 virus is able to escape the body's immune system, researchers hope to develop new strategies to limit infection.

Despite developments in antiretroviral therapy, HIV continues to be a major global health problem. In fact, every year, over 2 million people are infected by HIV-1, the most common type of Human Immunodeficiency Virus.

By destroying CD4 cells, the cells that help your body fight infections, the virus severely damages the immune system. Although antiretroviral therapy can limit virus replication, chronic infection leads to comorbidities, meaning novel methods are needed to strengthen the immune system.

The key to curing HIV is to better understand how the virus attacks the immune system – which is where the EU-funded SENTINEL (HIV-1 sensing and signaling in dendritic cells) project comes in.

"We set out to identify the mechanisms used by HIV-1 to escape the immune system and thereby promote infection," says Teunis Geijtenbeek, a researcher at the Amsterdam University Medical Centre and SENTINEL project coordinator.

"By identifying new strategies for enhancing innate antiviral immunity to HIV-1, we aim to limit infection and the establishment and progression of chronic disease."

GROUNDBREAKING DISCOVERIES

It has long been believed that HIV-1 is able to cause immune dysfunction by evading innate sensing in specific immune cells called dendritic cells. SENTINEL project researchers, however, discovered that the virus does not evade the innate sensing mechanism but instead actively suppresses it. "We were able to show that HIV-1 blocks a specific signalling pathway, thereby escaping the immune system," explains Geijtenbeek.

Following this discovery, researchers demonstrated that using drugs already approved for cancer successfully prevented HIV-1 from escaping. This restricted virus replication and strongly enhanced antiviral immunity.

"Moreover, we identified a novel restriction mechanism in specific immune cells that blocked HIV-1 infection by capturing the virus and degrading it via autophagy," adds Geijtenbeek.

According to Geijtenbeek, the SENTINEL research strongly suggests that inducing antiviral innate immune responses in dendritic cell subsets delays disease progression and improves survival in chronic HIV-1 infected patients.

"Our showing that the human TRIM5alpha protein is a restriction factor for HIV-1 is groundbreaking in that it was previously thought that this protein only protected against rhesus (SIV-1), not HIV-1," remarks Geijtenbeek.

"Moreover, our results led to the discovery of a degradative pathway that destroys HIV-1 and that can be switched on in other cells."

PREPARING FOR A CLINICAL TRIAL

Researchers are currently designing a clinical trial for using drugs to prevent HIV-1 from suppressing immune responses, thereby enhancing antiviral immunity and limiting HIV-1 infection. "This trial will investigate using the drugs we identified to prevent HIV-1 from escaping immunity and help the immune system to sense the virus' presence," concludes Geijtenbeek.

> *"We set out to identify the mechanisms used by HIV-1 to escape the immune system and thereby promote infection."*

The SENTINEL project also discovered that the vaginal microbiome plays an important role in HIV-1 susceptibility by affecting the degradative pathway. This is something researchers are now investigating in detail to uncover the mechanisms and identify which microbiota are involved. Geijtenbeek also notes that researchers are investigating whether some of these pathways could also be used by other viruses, such as SARS-CoV-2.

SENTINEL

- Hosted by the Amsterdam University Medical Centre in the Netherlands
- Funded under H2020-ERC
- cordis.europa.eu/project/id/670424

Progress on a needle-free vaccine to fight HIV

In the battle against HIV infection, scientists have developed a mouth patch to deliver antigens. Biocompatible and biodegradable, the patch produces a promising antibody response, though further research is necessary.

French scientists working on the EU project PolyVac (Polysaccharide-based membrane for sublingual vaccination) have made important progress on developing a patch to administer antigens orally to fight the entry of HIV through the vagina or rectum. The patch, designed to be placed under the tongue, was shown to progressively release antigens as the patch was broken down by saliva.

"As all the components of the patch are biocompatible and biodegradable, it doesn't need to be removed but will be degraded slowly by the salivary enzymes," says Claire Monge, the research fellow who developed it, supervised by Bernard Verrier, at the Tissue Biology and Therapeutic Engineering Laboratory in Lyon, France.

"Our *in vivo* data indicated that the antigen loaded in the patch is detectable (by the body's immune system) for at least 30 minutes – the time required for the antigen to cross the mucosal tissue and be taken up by the specialised immune cells: the antigen-presenting cells."

Developed with support from the Marie Skłodowska-Curie Actions programme, the patch has many advantages over traditional vaccination methods. Since it is needle-free, it would be much more comfortable for patients, and as the patch starts as a dry membrane before transforming into a gel-like texture, it can be stored at room temperature, rather than in cold storage. "That is really interesting for

© C.Monge and B.Verrier

distribution in developing countries where the cold chain is difficult, if not impossible, to maintain," explains Monge.

PIONEERING PATCH

The patch's development however isn't completed yet. Monge and Verrier were aiming to produce an antibody response to the HIV antigen in the vaginal area, where the HIV virus often enters the body. However, the response tested on mice was only produced in the mouth. With support from French NGO Sidaction and French research agency ANRS, the biologists are continuing their research and intend to test other HIV-1 vaccine candidates and other mucosal adjuvants, the substances that enhance and modulate immune responses to antigens.

The ultimate aim is for the vaccine and adjuvant loaded on the patch to be recognised by the human immune system in such a way that it produces antigens in the rectal and vaginal areas. In the case of an HIV contamination, antibodies would coat the HIV virus to prevent an infection.

Completing the development of such a vaccine and taking it to market could take about 10 years. However, the PolyVac project has made essential headway. Previously, researchers had managed to produce a mucosal immune response in the vaginal area using liquid formulations, but their assays were inconclusive since liquid formulations led to inconsistent dispersion in saliva and poor control over the dose of the vaccine delivered.

The PolyVac researchers used a fluorescent imaging technique to see the persistence of the antigen in the mouth of the mouse during testing. They found the antigen was detectable for 30 minutes compared to just 2 minutes for the liquid formulation.

"Our patch is a pioneer in the sense that it would standardise the administration of sublingual vaccines by increasing the contact time between the antigen and the mucosa, consequently allowing a better control of the administered dose," adds Monge.

POLYVAC

- Coordinated by the National Centre for Scientific Research in France
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/751061
- Project website: bit.ly/379WhKw

FOOD AND NATURAL RESOURCES

Protecting crops by unravelling the mysteries of plant immunity

Using pesticides to reduce crop losses caused by pests and disease damages the environment and contributes to climate change. An EU initiative explored alternative strategies to protect crops.

After a first infection, plants respond more effectively to a second pathogen encounter by becoming resistant. This plant immunisation, or priming, involves a certain memory following the first exposure, lasting anywhere from a few days to entire generations.

"Experts consider priming the safest and most effective approach to boost the endogenous plant immune system," says Marie Skłodowska-Curie fellow Ana López, who was responsible for the overall coordination of the EU-funded project EPILIPIN (Deciphering the role of oxylipins in the epigenetic mechanisms controlling plant immunization). "They also agree that priming represents the perfect target for new crop protection strategies because it provides natural long-lasting resistance against pathogens." However, deeper knowledge of the mechanisms involved is needed to apply priming to crop protection. This research was undertaken with the support of the Marie Skłodowska-Curie Actions programme.

SPECIFIC OXYLIPINS AND RELATED PROTEINS REQUIRED FOR PLANT IMMUNE PRIMING

Plant endogenous oxylipin compounds and epigenetic mechanisms are involved in priming processes. "Their specific contribution and the link between these two pathways haven't been addressed to date," notes López. "In line with EU concerns and priorities, EPILIPIN fills this gap in knowledge by exploring the use of natural compounds – oxylipins – in triggering long-term priming for improving crop yields while minimising agriculture's impact on the environment."

> *EPILIPIN opens new avenues for the development of alternative, more natural and sustainable agricultural strategies – an EU priority.*

Researchers began by identifying the role of oxylipins in priming. They then positioned the oxylipin signalling upstream of the epigenetic machinery between the pathogen perception and the epigenetic changes mediating priming (memory). According to the findings, mitochondria play a key role in the oxylipin signalling pathway. Mitochondria's main function is to produce the cell's energy by respiration and to modulate cellular metabolism. Results also link the mitochondrial changes as an element in priming processes.

SUCCESSFULLY APPLYING PRIMING TO CROP PROTECTION

The EPILIPIN team developed a working model in which the signalling triggered by the pathogen recognition and mediated by oxylipins induces mitochondrial changes that affect the deposition of the epigenetic marks underlying the memory of the stress (priming). Team members induced long-lasting resistance against different plant pathogens, including fungus, bacteria and oomycetes, protecting not just the treated tissues but the entire plant, and in some cases even the following generation. "The model doesn't just reinforce the role of oxylipins in priming procedures, it also positions the mitochondria as an interface integrating external signals and coordinating plant responses to environmental changes," explains López. "This could impact different fields, from epigenetics, plant defence and cell biology to ecology and evolution."

López believes the benefits of EPILIPIN are already tangible. "We have unravelled and positioned some of the elements in the signalling cascade between the pathogen recognition and the establishment of stress memory mediated by epigenetic mechanisms and conferring long-lasting plant protection."

"EPILIPIN opens new avenues for the development of alternative, more natural and sustainable agricultural strategies – an EU priority," concludes López. "Outcomes could facilitate the application of epigenetics in plant priming, which could mean a real breakthrough in future integrated pest management programmes that positively impact crop yields."

EPILIPIN

- Coordinated by the Spanish National Research Council (CSIC) in Spain
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/746136
- Project website: epilipin.wordpress.com

FOOD AND NATURAL RESOURCES

No more crop damage thanks to intelligent laser technology that keeps pest birds away

Birds can destroy up to 25 % of harvested areas, but pesticides used to deter them pose human and animal health risks. An EU initiative introduced a cutting-edge alternative to the extremely costly, inefficient and harmful methods currently available.

Farmland in northern Europe teems with life each year during winter when the numbers of overwintering geese from the Arctic Circle reach their annual peak in the millions. "It's quite a sight for nature lovers, but a nightmare for farmers whose grasslands, meadows and wheat crops get trampled and grazed by the birds," explains Steinar Henskes, coordinator of the EU-funded BIRD RELEASE (REpelLEnt Auto-SystEm) project. Meanwhile, other

bird species in southern Europe seasonally attack very valuable orchards and vineyards.

Agricultural pesticides have been a strain on birds foraging between crops. Plant protection products used in agriculture to control pests and commonly labelled for normal use can poison animals. There's evidence that bird-related mortality occurs frequently after such regular use in fields. In Europe, farmland birds have declined at a greater rate than those in other habitats. Poisoning may occur either by direct consumption of the chemical as in a treated crop or by secondary exposure like transfer within the food chain.

EFFECTIVE, COST-EFFICIENT, SUSTAINABLE SOLUTION TO BIRD PROBLEMS

Until now, scaring birds has either been ineffective or inhumane. "The holy grail is an automated, 24/7 method or product that repels birds effectively without causing any harm – all at competitive pricing," notes Henskes.

The BIRD RELEASE team developed an autonomous bird deterrent system called AVIX Autonomic Mark II that harmlessly scares away over 80 % of birds in a designated area. "It's a long-term, animal- and environment-friendly approach to repelling birds," adds Henskes.

© AVIX Autonomic Mark II

> *"It's a long-term, animal- and environment-friendly approach to repelling birds."*

AVIX Autonomic Mark II consists of an autonomic robotic laser that provides round-the-clock coverage of the location that needs protection from birds. When a bird enters a field, it's immediately detected by a software-powered camera that continuously scans the area. Based on the birds' movement characteristics, a pattern is then chosen to aim the diode laser. Birds perceive the approaching laser as a physical danger and avoid the region. Equally important, birds don't become accustomed to the laser. The technology is equipped with wireless connectivity. Its app can be used for easy installation, to remotely change configurations and check whether it's operating properly.

The system's modular design can integrate other bird detection systems. It can be incorporated into integrated pest management farming, and also add or omit parts based on customer needs. All components can be effortlessly replaced within minutes. Production can be scaled up because the system is relatively simple to build. There's room for continuous improvement thanks to all these unique features.

ROADMAP TO COMMERCIALISATION

After validating and certifying the system, project partners put a business plan in place for a successful market launch. Agreements with key partners have been established to achieve the best value for money with respect to equipment and materials.

AVIX Autonomic Mark II went into production and is now being sold all around the world. It's primarily sold to farmers with grasslands, wheat, orchards and vineyards because they suffer the most damage. "By becoming the scarecrow of the future, we have solved the age-old problem of birds eating farmers' harvests," concludes Henskes.

BIRD RELEASE

- Coordinated by Bird Control Group in the Netherlands
- Funded under H2020-FOOD and H2020-SME
- cordis.europa.eu/project/id/766610
- Project website: birdcontrolgroup.com
- bit.ly/2UaFDDl

INDUSTRIAL TECHNOLOGIES

Going underground – higher-quality diaphragm walls

Diaphragm walls are widely used to build deep embedded retaining walls – open boxes in the ground or deep basements. EU-funded researchers have developed a new joint system allowing them to be built more safely and at greater depth.

Diaphragm walls (DWs) are commonly used for the largest and most difficult below-ground projects, where they form the station 'boxes' and tunnel portals for metro and underground rail projects. They are constructed by completing individual rectangular reinforced elements (panels) one at a time, to form a continuous wall.

The vertical boundary between two adjacent panels is called a joint. DW structures can have hundreds of joints, but relatively small defects can cause a marked adverse effect on DW performance. The consequences of poor-quality joints can therefore be disastrous, with risk to people's welfare and adjacent infrastructures.

Each year, accidents resulting from settlements and/or collapse of DWs injure people and cause damage worldwide totalling hundreds of millions of euro. When the depth goes below 40 metres, traditional methods for constructing DW joints become less safe: the question is how the integrity of the joints can be guaranteed at these greater depths.

REDUCED RISKS

The EU-funded project TTMJ (New diaphragm wall joint system allowing greater depths and high quality joints) designed and built a prototype of a new machine. The team then tested the TTMJ system's capability to deliver high-quality, tighter and safer DW joints at lower costs. "The TTMJ system utilises tracks cast into the ends of a DW panel to guide a machine (the TTMJ trimmer) to trim the concrete at the end(s) of the panel, to form a construction joint to any depth," explains project coordinator Maurizio Siepi.

The tracks are manufactured from pultruded glass-fibre-reinforced polymer (GFRP) and are approximately 150 mm in diameter. A shear key and water stop can be applied to the retaining structure, and the system allows for some tension connection between adjacent panels, if required.

By profiling the primary panel with the TTMJ trimmer guided by tracks, the concrete-to-concrete contact between

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> *The TTMJ project will bring benefits to the specialised foundations industry by reducing the quantity of concrete to be trimmed; the system will significantly reduce the amount of concrete waste and the disposal of spent slurry, thereby reducing the carbon footprint for this particular sector.*

elements of the DW is ensured. "In this way, the quality of the joints in the completed DW can be substantially increased, reducing risks of defects," Siepi notes.

GREATER DEPTH

The depth of DWs is steadily increasing – and none of the current joint technologies are totally reliable. As the projects for underground structures dig deeper and deeper, especially for urban development, the requirements for high accuracy increase. In such instances, problems can arise from leakage through joints due to use of the hydromill in unfavourable soils, which generates large quantities of liquid slurry requiring disposal.

Inferior-quality DW joints can pose a potential risk of disaster. Therefore, in order to limit risk, projects are sometimes overdesigned to take into account possible deviations, defects and errors. "The TTMJ project will bring benefits to the specialised foundations industry by reducing the quantity of concrete to be trimmed; the system will significantly reduce the amount of concrete waste and the disposal of spent slurry, thereby reducing the carbon footprint for this particular sector," concludes Siepi.

TTMJ can ensure cost savings for the construction industry whilst delivering a superior-quality product. Furthermore, clients will experience overall project cost savings, and a better profile in terms of risk reduction, quality, and durability of walls. It will also reduce the impact on the built environment by minimising the risk of DWs adversely affecting the integrity of surrounding buildings in highly urbanised areas.

TTMJ

- Coordinated by Trevi in Italy
- Funded under H2020-Societal Challenges and H2020-Industrial Leadership
- cordis.europa.eu/project/id/720579
- Project website: ttmj-h2020.eu
- bit.ly/33kTOti

INDUSTRIAL TECHNOLOGIES

Bringing next-generation smart connected products closer with low-cost, flexible electronics

Printed electronics tags could convert everyday objects into smart devices, exchanging data with each other wirelessly. An EU-funded project addressed the crucial material advances needed for Internet of Things applications – initially in the packaging, healthcare and home appliance sectors.

The number of devices connected to the internet, including the machines and sensors that make up the Internet of Things (IoT), is growing at a steady pace. Estimates show that by 2025, as many as 75 billion IoT devices could be around the world, spanning everything, from vehicles to smartphones to kitchen appliances. The IoT industry could have an economic impact of more than USD 11 trillion in the same period, meaning that access to the commercial opportunities offered by the IoT could be crucial for companies to maintain innovation.

The EU-funded NECOMADA (Nano-Enabled Conducting Materials Accelerating Device Applicability) project offers businesses a way to make the integration of electronics into a wide range of everyday items a reality.

LOOKING BEYOND SILICON AND CONVENTIONAL MATERIALS

"One of the key drivers of NECOMADA was to produce near-field communication (NFC) and radio frequency identification (RFID) tags as low cost as possible," notes Neville Slack, business development manager at the Centre for Process Innovation's (CPI) National Formulation Centre and NECOMADA coordinator.

To achieve project goals, partners looked beyond traditional chip manufacturing methods and materials. "We explored alternative materials to those normally used in printed electronics. For instance, we used lightweight and flexible substrate materials such as plastics and paper in place of silicon. To further cut costs, we reduced the amount of silver used in the inks and the adhesive that bonds the flexible chips to the antenna," explains Slack. Compared to state-of-the-art materials, silver showed acceptable levels of conductivity at very low loadings (less than 10 % by mass).

DEMONSTRATION ACTIVITIES

NECOMADA trialled materials and processes on a roll-to-roll pilot line located at the CPI. The open access pilot facility that is available for use by industrial partners to trial their innovative product and material solutions has the capability to assemble complex systems at the throughputs and costs required for high-volume applications.

Initial target applications for demonstrative products included NFC and RFID tags. As a proof of concept, project partners produced 9 000 passive NFC tags for fast-moving consumer goods and 1 000 passive NFC tags on metal surfaces. The latter were equipped with a layer of ferrite that protects the magnetic field. Furthermore, partners produced 200 ultra-compact tags combining NFC and

By 2025, as many as **75 billion IoT devices** could be around the world

RFID technology for home appliance devices and 1 000 active NFC tags attached to pharmaceuticals, logging temperature over time. "Our pilot line is the first to produce ultra-thin and flexible solutions that are compatible with high-volume manufacturing platforms," adds Slack.

FUTURE POTENTIAL

Overall, the project focused on lowering the cost of future IoT devices through the development of new conductive inks and flexible adhesives that improve the effectiveness, productivity and speed of printed electronics manufacturing.

"The IoT has arrived and, thanks to NECOMADA, we are well positioned to help companies access its potential." Slack concludes: "Printed and flexible electronics will be a key component of new markets. The thin and flexible solutions developed within NECOMADA pave the way for the production of low-cost, ubiquitous data sources for sensing and monitoring in a wide range of applications."

NECOMADA

- Coordinated by the Centre for Process Innovation Limited in the United Kingdom
- Funded under H2020-LEIT-NANO
- cordis.europa.eu/project/id/720897
- Project website: necomada.eu
- bit.ly/3iqU5Ba

DIGITAL ECONOMY

Preserving the intangible: New technology for the visual arts

In today's multicultural societies, safeguarding and maintaining generations of cultural heritage and the knowledge and skills they transmit are invaluable for promoting mutual respect for different cultures and ways of life. The EU-funded AniAge project has developed technologies to preserve even the intangible cultural heritage items that might otherwise be lost.

Cultural heritage is more than monuments and collections of physical, tangible objects. It includes traditions and rituals passed down through generations, such as performing arts, folklore, festivals and social practices. UNESCO's Lists of Intangible Cultural Heritage cover a broad spectrum of fields and cultures: from Jamaica's reggae music and whistled language from Turkey, to Tahteeb (an Egyptian stick game), the manufacture of cowbells (Portugal), earthenware pottery-making skills in Botswana's Kgatleng District, and many more.

NEW TECHNOLOGIES FOR DIGITAL PRESERVATION

Technological innovation has provided many tools for digital preservation, making it possible to safeguard performance arts that would otherwise gradually disappear as their practice, rooted in traditional rural communities, decreases. However, due to the diversity and nature of intangible cultural heritage, their digital preservation is no easy feat. This is where the EU-funded project AniAge

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(High Dimensional Heterogeneous Data based Animation Techniques for Southeast Asian Intangible Cultural Heritage Digital Content) comes into the picture, undertaken with the support of the Marie Skłodowska-Curie Actions programme. Its two-fold aim was to reduce production costs and improve the level of automation with regard to archiving and reproducing style-preserved intangible cultural heritage items.

Focusing on traditional dance and folk puppetry of South-East Asia, the project has developed new techniques and tools for reconstructing 3D motion data from archived video footage. This involved compactly representing and structuring data from huge databases with video files of traditional dance and drama, then annotating it for efficient information retrieval. "This was a very expensive and time-consuming process," explains project coordinator Jian Jun Zhang. "To overcome this hurdle, we ensured that colleagues from both computer science and animation fields worked together, developing a hybrid human-computer collaborative workflow."

REDUCING COSTS

Even today, computer animation remains a very expensive and labour-intensive field. For example, blockbuster movies like Avatar and Interstellar cost over USD 1 million per minute of footage, far beyond the resources available for cultural heritage preservation and other low-cost applications. As such, there is a strong case for developing more efficient computer animation and visualisation technology to be used for digital preservation, as well as in other fields. In response to this challenge, one of the AniAge project's main achievements is the development of a 3D human skeletal motion database for South-East Asian folk dances, containing around 150 human skeletal motion sequences associated with moving image sequences. "We

> *"We are very pleased to have developed this database, which will have a wide range of applications in the performing arts field, such as choreographic modelling, dancing and theatrical kinesiology modelling."*

are very pleased to have developed this database, which will have a wide range of applications in the performing arts field, such as choreographic modelling, dancing and theatrical kinesiology modelling," adds the chief scientist of the project Hongchuan Yu.

In addition to being an important asset for the dancing community, Zhang emphasises that the techniques developed by the project to reconstruct 3D skeletal motion from archived video footage have the potential for many wider applications. They can also be applied to other traditional folk dances for intangible cultural heritage preservation and exploitation.

While the project ended in December 2019, Zhang and Yu are in the process of securing external funding for a follow-up project. This will allow the team to continue their work to develop fully automatic technology for 3D motion reconstruction.

ANIAGE

- Coordinated by Bournemouth University in the United Kingdom
- Funded under H2020-MSCA-RISE
- cordis.europa.eu/project/id/691215
- Project website: bit.ly/3104CAb

DIGITAL ECONOMY

Socially distanced, digitally connected: a mobile platform to bring workers together

The global coronavirus pandemic has accelerated a shift in working conditions, leaving employees fragmented in space and time. Mobile platforms can help.

Swiss technology firm isolutions has developed software they hope can address this shortcoming. The spin-off, ahead AG, offers a digital platform that can easily be rolled out to workers as a mobile app. It provides a two-way channel of communication to staff, particularly those who are not desk-bound as part of their daily duties.

"Digital transformation has a lot to do with company culture, especially in manufacturing, facilities management, industries where companies find it difficult to communicate with their non-desk-based workers," says Pascal Grossniklaus, product manager at isolutions, and project coordinator of ahead (The Intelligent Digital Workspace as a Service).

These employees, he says, tend to receive news about the company via blackboards in the break room or supervisors, with little ability to feed information and opinions back to upper management. Company intranets tend to be slow to install, short-lived, and fail to engage with employees.

Then came COVID-19. "We have customers who had to shut down production areas during the pandemic, all over the world, in China, Mexico and Poland," explains Grossniklaus. Keeping in touch with blue-collar workers proved difficult for many of these companies who had previously felt it wasn't necessary to onboard them into digital services.

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"One had 6 500 employees and wasn't able to reach them. It was really problematic, not being able to communicate about when they should return to work, what they should do in the meantime, whether they would be paid. All this adds to the overall feeling of insecurity," he adds. "The employees started to create WhatsApp groups with team leaders to get information. But with 6 500 employees this is a mess."

On top of solving communication issues, Grossniklaus estimates that an effective digital platform can enable up to 25 % greater productivity across the value chain and add more than EUR 100 billion in value across industries with a majority of non-desk workers.

> *"Companies with better alignment of their workforce with the company vision have more overall success in terms of customer satisfaction, revenue and profit."*

EMPLOYEES DRIVING DIGITAL TRANSITION

While the ahead app allows staff to share information with each other, it also provides a way to challenge employees with occasional questions about company values, identifying the level of agreement across the business.

"Companies with better alignment of their workforce with the company vision have more overall success in terms of customer satisfaction, revenue and profit," notes Grossniklaus. "For digital transition you need people in your company to drive this change, and it's important to know which people are influencers in the company."

The project was supported by the EU's Horizon 2020 programme. Grossniklaus says the funding helped isolutions develop models to quantify workplace cultural alignment with help from the Zurich University of Applied Sciences. "Without this study, we would just be another employee app," he says. "With this study we can have a great economic impact for industries struggling with digital transformation."

Grossniklaus now plans to grow the product, first in Switzerland and then in western Europe and the United States, and secure investment to further develop its cultural alignment capabilities.

AHEAD

- Coordinated by isolutions in Switzerland
- Funded under H2020-SME, H2020-Societal Challenges and H2020-LEIT
- cordis.europa.eu/project/id/889991
- Project website: aheadintranet.com

DIGITAL ECONOMY

Innovative AI algorithms promise to revitalise the retail industry

Shopping has changed enormously over the last 15 years as e-commerce has rapidly challenged traditional bricks-and-mortar shops. By focusing on the underlying factors of e-commerce success, the RDS project aims to use new insights to deploy its innovative AI system and improve offline retail experiences.

The way we shop is constantly evolving, powered by the inexorable rise of the internet. Advances in e-commerce have made the process easier for consumers and many traditional retailers are feeling the pinch.

Every day, 16 bricks-and-mortar shops close in the United Kingdom, and 7 000 per year in the United States. With the onset of COVID-19, this trend is likely to increase. One analysis predicts 55 % of traditional shops are at risk of bankruptcy due to the crisis.

ENTER THE RADIUS AI SOLUTION

The EU-supported project RDS (Artificial Intelligence Powered Fashion Insights and Personal Styling Solutions) has contributed to a solution that will hopefully allow e-commerce and traditional forms of shopping to successfully coexist and thrive together. A series of AI algorithms to automate strategic planning and the execution of commercial real estate operations can help.

"These AI algorithms harvest multilayered, complex data sources that are out of retailers' reach. They then process the data to deliver insights that can boost profits, right down to postcode level," explains Burak Capli, project coordinator at Radius Tech Fashion Services, based in the United Kingdom.

Through Radius technology, each month vast amounts of e-commerce transactional data are harvested from

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2.9 billion transactions over 68.7 million products. Additionally, every 2 days, 10 million consumption-related datapoints are added to complete the transactional data.

"Simply put, Radius harvests and processes the shopping journey of every 15 out of 100 consumers. This advancement is regarded as a great breakthrough for the retail industry, as businesses collectively lose over EUR 1.2 billion a year due to the inability to capture and manage data," Capli continues.

To capitalise on this rich data source, AI algorithms based on ethnographic principles have been developed: no 'off-the-shelf' tools have been used. This innovative technology offers the potential to map holistic and yet very granular shopping patterns. The analysis takes into account over 500 datapoints, including age, marital status, income, likes and interests and topic/trend/product/brand affinities.

"This enables us to identify consumers' digital personas, based on lifestyle and consumption preferences, and reflect this in both the real-life and retail context," says Capli.

A lot of research into the feasibility and value of the technology to the retail sector has been undertaken by Radius, which the EU-funded RDS project helped to support. Throughout the project's lifespan, Capli and his team had meetings with 89 retailers and 12 commercial property investors that together own over 500 shopping centres across Europe. The success rate of the technology was so impressive that several of them have since signed further agreements with Radius.

"Simply put, Radius harvests and processes the shopping journey of every 15 out of 100 consumers. This advancement is regarded as a great breakthrough for the retail industry, as businesses collectively lose over EUR 1.2 billion a year due to the inability to capture and manage data."

CONTINUED DEVELOPMENT IN A POST-COVID WORLD

As the pandemic hopefully subsides over the coming months, Capli is optimistic that solutions such as those developed by Radius will contribute to rebuilding the most impacted industries, one of which is without a doubt the retail sector.

For Radius specifically, the aim is to continue to develop its solutions and contribute to a more democratic, fairer post-COVID world.

"Radius will support industries to infuse technological innovation into their DNA, matching the technology with the consumer to the benefit of everyone. Our democratisation of data will lead to transformed, optimised and effective business models for direct-to-consumer industries," Capli concludes.

RDS

- Coordinated by Radius Tech Fashion Services Ltd in the United Kingdom
- Funded under H2020-SME, H2020-Societal Challenges and H2020-LEIT
- cordis.europa.eu/project/id/877939
- Project website: 314radius.com

SECURITY

No need for walkie-talkies with smart emergency communication

A powerful smartphone app provides secure communications between emergency service and security personnel. It enables on-the-spot teams to download pictures, video footage and important data they need to assess a fast-changing situation.

When first-response personnel arrive at an emergency, they usually communicate with other team members and with their command centre via walkie-talkie radio. But this has limited range and functionality.

The EU-funded CoP1stRespond (Secured Collaboration Platform for Law Enforcement and First Responders) project has created a smart and highly functional communications system based on existing mobile phones and networks. This could replace walkie-talkies and expand the way front-line personnel securely receive and transmit information to include images, which voice-only walkie-talkies cannot do.

The CoP1stRespond platform uses advanced encryption and exchange protocols to integrate cameras, GPS and Internet of Things (IoT) devices that can be accessed in real time on any smartphone – Android or iPhone. "It's a bring-your-own-device system. But it's secure," says Dan Peleg, CEO and co-founder of GlobeKeeper Tech, the Tel Aviv-based company that developed the system.

"Even while they are on the way to the scene, first responders can receive video from the field on their mobile phones, so they know what to expect," Peleg adds.

The system mimics the walkie-talkie's ease of voice communication. "It supports push-to-talk and also an open line. You click on the smartphone screen and speak. When you stop speaking, the communication stops," Peleg explains.

"If no one clicks the talk button, no one can hear the person with the phone app. That reduces noise and clutter in the network."

But anyone can eavesdrop on walkie-talkie radio communication unlike the encrypted smart system. "The challenge is to have the most secure platform while also keeping it real-time. There is a trade-off because encryption requires more bandwidth," Peleg notes.

EXPANDING THE FUNCTIONS

The company had a minimum viable product version of the app at the beginning of the project. "But with research and expansion we were able to integrate more capabilities, such as cameras, Bluetooth radios and earpieces and other capabilities that exist today," Peleg explains.

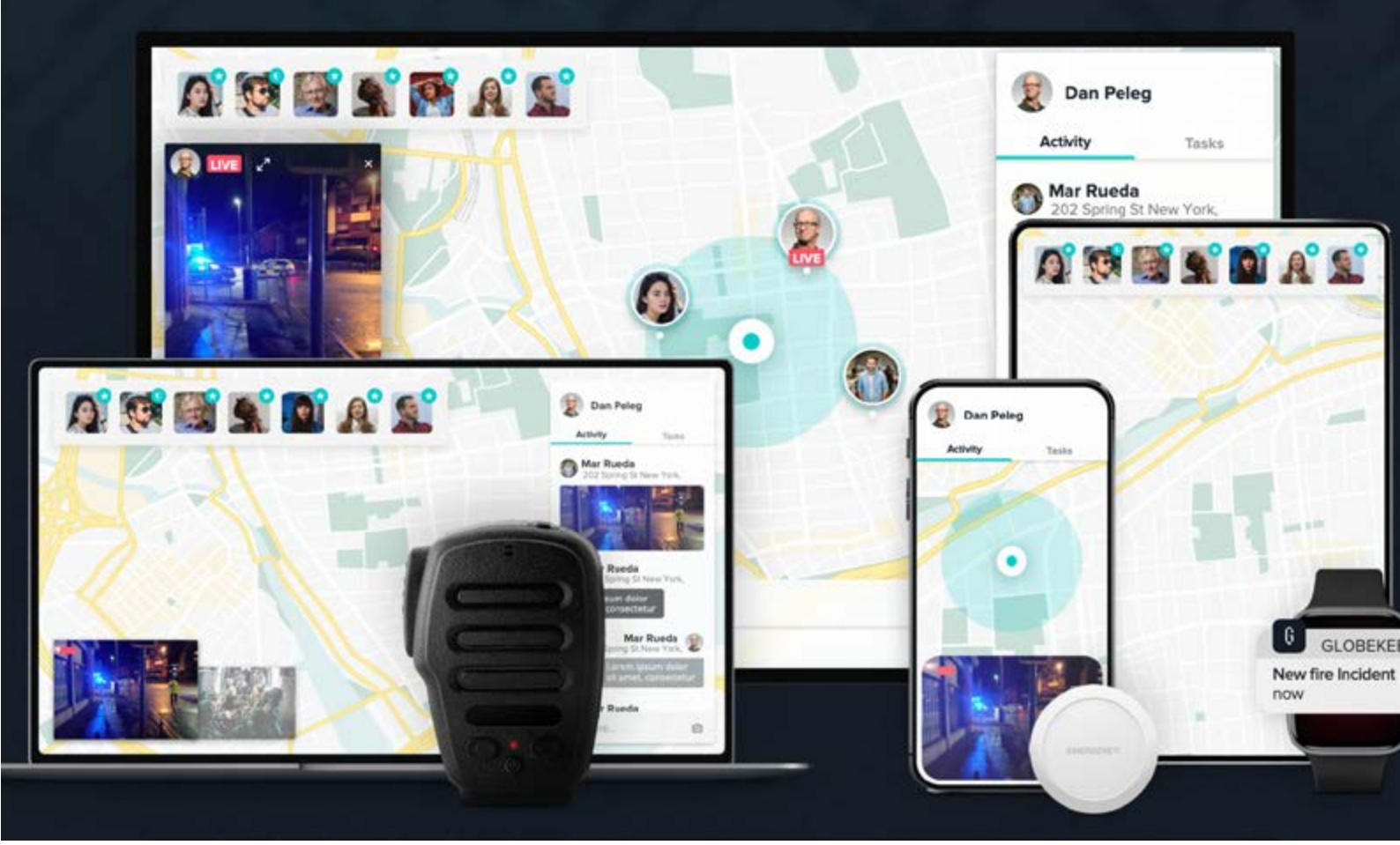
"There are hundreds of thousands of camera models and we need to find the ones in most common use and the most common protocols to integrate into them. To enable drones and bodycams to stream video into mobile phones there are a lot of technical barriers that we needed to break down," he adds.

"Mobile phone 5G networks will further expand smartphone capabilities and enable more data to move more swiftly and more responsively and will allow you to connect more devices such as sensors and other smart devices all at once," Peleg observes.

TESTING AND MARKETING

The system, which is already used by Israel's Ministry of Defence, was tested in Europe with an intergovernmental policing agency client as a design partner.

"Sometimes six different agencies were involved in the same operation and everything needed to be onboarded within 1-2 hours," Peleg says, referring to different national and agency protocols and procedures which had to be integrated onto a single platform. "You couldn't do it with any software that was out there. It was a key thing for us to solve."



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The project funding also enabled the company to study market prospects, resulting in almost a dozen new partners in Europe and Asia.

It now wants to expand its market by adding indoor location tracking. "Now the platform is location-based using GPS and mostly used outside but inside a building you want to know exactly which room or which floor you're on," Peleg concludes.

COP1STRESPOND

- Coordinated by GlobeKeeper Tech Ltd in Israel
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT
- cordis.europa.eu/project/id/876360
- Project website: globekeeper.com

SECURITY

Fully automated web-based solution tackles printed document fraud and counterfeiting

Fraudulent identity and security documents are essential for many types of criminal activity including people trafficking and illegal social insurance benefits. An EU initiative introduced a document examination system that authenticates printing techniques as well as printer and paper sources.

In contrast to security features like ultraviolet light sources and watermarks, the biometrics of documents like passports with a chip can't be counterfeited. Given this data, it's possible to detect if a document has been

created with the original printer and paper. This is because original documents are printed using specific technology on a particular printer and paper.

Document biometrics are currently checked by forensic experts only after a document has been identified as counterfeit. Each case requires many hours and even days because there are no technical systems that can streamline or automate this process.

GAME CHANGER IN DOCUMENT FRAUD DETECTION

The EU-funded ANDRUPOS (Automatic non-destructive recognition of used printing techniques on substrates) project provides a highly automated solution for real-time document analysis. "Thanks to our disruptive technology, document biometrics can be checked by anyone who scans a document, potentially leading to millions of checks daily in Europe and around the world," says coordinator Jan Schloen. "We focused on the two most pertinent threats affecting citizens and businesses: document fraud and counterfeiting."

Project partners delivered a software-based solution for printed document examination and classification using fast, optical, non-destructive methods. It extracts a printed document's biometric properties such as printing method, paper, printer and ink – that can all be traced to the source used to create the document. "Identifying the source printer, and obtaining knowledge of the individual printer and a document's printing details are important steps in fighting crime like forgery," notes Schloen.

Possible fraud of a document like an ID, passport, contract or banknote can now be determined quickly and reliably, before submitting the document for forensic examination. This means that the outcome can be compared with and potentially connected to other customers' analysis results. "An innovative feature is the ability to link counterfeits to printers, so that different counterfeits and cases can be traced back to organised criminal groups," explains Schloen. "This is a huge step in linking organised crime."

TAKING FORENSIC INTELLIGENCE TO ANOTHER LEVEL

The ANDRUPOS team developed an analysis software platform that's integrated into a web-based server. Client applications on desktop computers or mobile devices can then post scanned (magnified) images of documents to the server via the internet. The server application receives the data, analyses the image and matches the extracted features with the database entries (printing technology, brand and print mode). A software development kit is currently being tested for integration into existing forensic equipment and devices.

In addition to extracting this information from a single printed document, the ANDRUPOS system can also examine a set of documents to determine whether all the pages originate from the same printer. This makes it possible to link suspect documents to a single printer item anywhere in the world.

"The ANDRUPOS innovation will reduce the time and effort needed for the entire document examination procedure by up to 80 %," concludes Schloen. The solution will also provide useful forensic information to European law enforcement, security and intelligence agencies. "This novel examination system is essential in responding to current EU and global challenges concerning terrorism, refugees and migration. Verifying the authenticity of travel documents is a key element of border checks and a precondition for efficient border control."

ANDRUPOS

- Coordinated by EINS in Germany
- Funded under H2020-Societal Challenges and H2020-Industrial Leadership
- cordis.europa.eu/project/id/760218
- Project website: andrupos-forensics.com/fti-project

FUNDAMENTAL RESEARCH

Research reveals clues to the hidden geometry of prominent mathematical categories

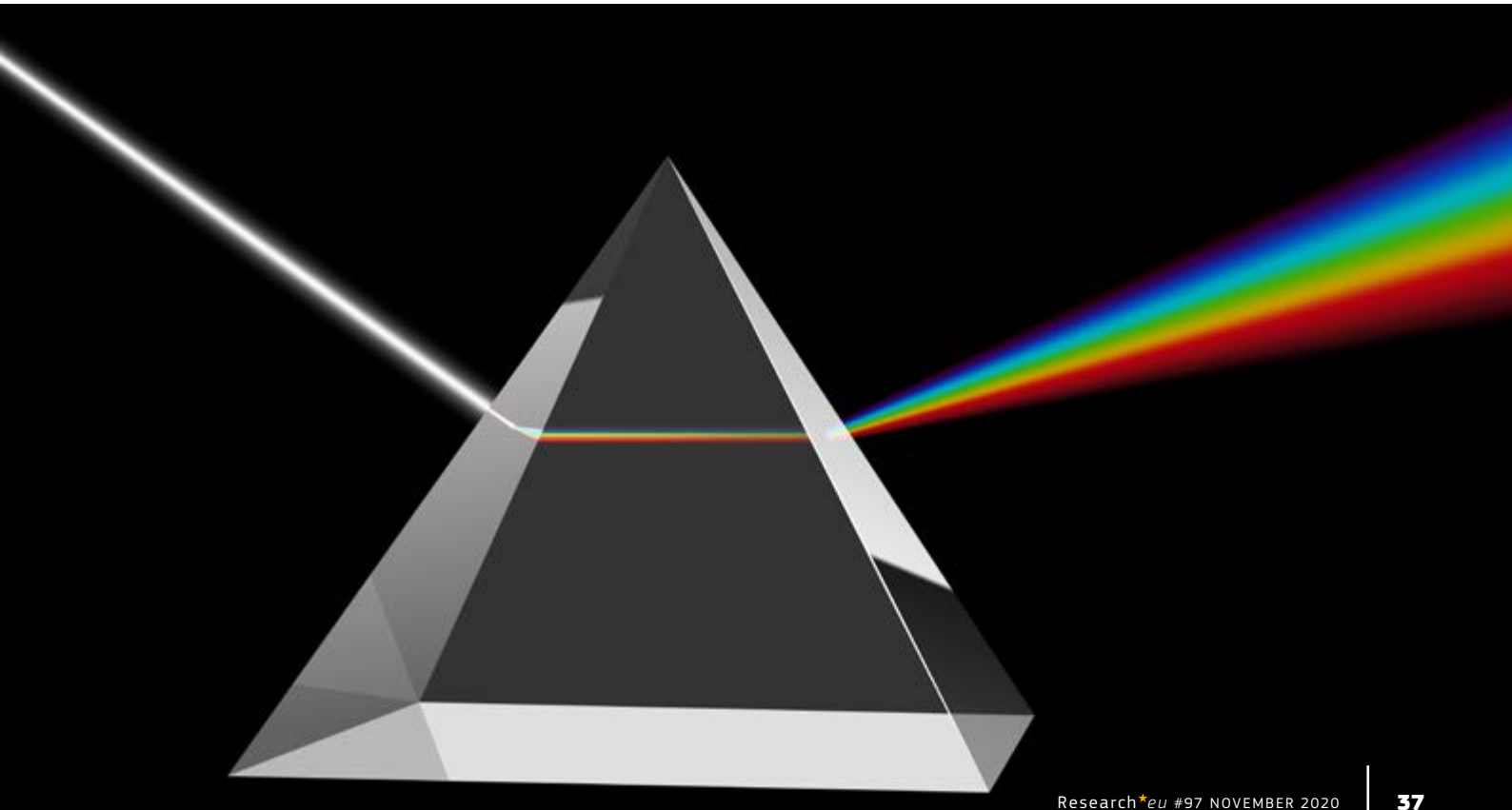
A prism dispersing white light into its constituent colours serves as a powerful guide for studying the elusive form of fundamental categories in algebra and topology. Viewing categories as geometric structures provides a unifying perspective on long-standing problems in mathematics.

Virtually every branch of modern mathematics can be described in terms of mathematics (categories). Their study takes a bird's-eye view of mathematics. It may not reveal information regarding specific properties; however, it enables identification of relations (morphisms) between their objects that would otherwise be difficult to detect from the ground. Representing abstractions of other mathematical concepts, categories often reveal deep insights and similarities between seemingly different areas, such as algebra, algebraic geometry, homotopy theory and representation theory.

VIEWING CATEGORIES THROUGH A DIFFERENT PRISM

Categories are often 'equipped' with additional operations that allow the construction of new objects from given ones. These could be referred to as chromatic categories. Extending this further, it is possible to construct new chromatic categories from old ones.

"The starting point of the EU-funded ChromoCats (The geometry of chromatic categories) project is the



observation that chromatic categories are geometric objects themselves; yet their geometric structure remains to be unfolded," explains Tobias Barthel, ChromoCats coordinator.

Chromatic categories, by analogy to a prism that disperses white light into its constituent spectral colours, decompose over a space – called Balmer spectrum – into local or monochromatic categories. This analogy helps reveal more about their geometric structure.

The geometry of a chromatic category serves as a powerful tool for studying objects themselves and their relations, and also lends theoretical insight from one mathematical field to another. "It enables us to use geometric intuition to spot new patterns in prominent chromatic categories, for example local-to-global principles – how such categories can be built from their local pieces. Taking the prism analogy, it enables us to study how white light is assembled from its spectral colours or what happens to the ultraviolet or infrared part of the spectrum," adds Barthel.

A POWERFUL NEW MATHEMATICAL FRAMEWORK

Researchers developed an innovative framework that decomposes any chromatic category – more precisely, a symmetric monoidal infinity category – into a sheaf of local categories over its Balmer spectrum. The theoretical method sheds light on three key aspects of the geometry of a chromatic category: its local structure, local-to-global principles and compactifications.

"Our theory takes as input only a few fundamental concepts and then proceeds along the same lines of modern algebraic geometry; in other words, it is truly geometric in nature. It allows us to use geometric reasoning in problems with no evident geometric structure, leading amongst other things to powerful new computational tools," notes Barthel.

> *"The starting point of the EU-funded ChromoCats project is the observation that chromatic categories are geometric objects themselves; yet their geometric structure remains to be unfolded."*

There is a universal example of a chromatic category known as finite spectra. Building on the remarkable work conducted by Devinatz, Hopkins and Smith in the 1980s, Barthel and his collaborators enhanced understanding of a more complicated variant of this category with additional symmetries. Specifically, they determined the Balmer spectrum of the G-equivariant stable homotopy category for any finite abelian group G, and more generally, for all compact Lie groups.

Finally, researchers constructed compactifications of chromatic categories via a categorification of ultraproducts from mathematical logic. This solves the algebraisation problem in chromatic homotopy.

Overall, the ChromoCats framework, made possible with the support of the Marie Skłodowska-Curie Actions programme, provides a systematic description of the geometry of chromatic categories, leading to substantial progress on outstanding conjectures in algebra and topology.

CHROMOCATS

- Coordinated by the University of Copenhagen in Denmark
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/751794
- Project website: bit.ly/2Zt6YmI

Prey behaviour study lifts curtain on depth perception

A pioneering virtual reality experiment has helped researchers to better understand exactly how the brain deals with depth perception.

Our ability to intuitively tell whether an object is near or far away is not something we typically think about. "When we look out the window, it is immediately clear that the street in front of us is closer than the clouds in the sky," notes MouseDepthPrey (The role of depth perception during prey capture in the mouse) project coordinator Mark Hübener, research group leader in the Synapses – Circuits – Plasticity Department at the Max Planck Institute of Neurobiology, Germany.

"Our brain's visual system does this automatically. It seems effortless, but there are many underlying neural processes that make this possible."

Light is transformed to neural signals by our eyes' retinas. These signals are then processed to extract information, which helps us, among other things, to tell how far away an object is.

"We have a good handle on understanding how these sources of depth information make it from the eye to the brain," says Hübener. "What we are less sure of is how these signals are combined and processed to provide us with instantaneous depth perception, by just looking."

INVESTIGATING DEPTH PERCEPTION

The MouseDepthPrey project, undertaken with the support of the Marie Skłodowska-Curie Actions programme, sought to understand how various depth cues are processed in the brain. "To tackle this question, we decided to rely on the mouse," explains Drago Guggiana Nilo, the postdoctoral fellow who worked on the project. "We needed a way to ask the mouse how far it thinks objects are."

To achieve this, a strong natural behaviour in the mouse was harnessed: prey capture. Mice readily hunt crickets and other insects for food. They rely heavily on vision to do so, most likely using depth perception.

A high-speed, 12-camera video system to track the mouse's position within an arena was set up. This information was used to create a virtual visual environment from the perspective of the mouse.

Software developed for gaming was used to refine the environment to make it as realistic as possible. A professional animator was commissioned to render a highly detailed cricket, serving as virtual prey. Brain activity of the mouse during prey capture was recorded using a miniature, head-mounted microscope.

BRAIN BEHAVIOUR REVEALED

This innovative virtual reality experiment enabled the team to obtain incredibly detailed characterisations of prey capture behaviour. "We learned that although prey

> *We needed a way to ask the mouse how far it thinks objects are.*

capture is an innate behaviour, mice still improve their performance over days," says Guggiana Nilo.

"Detailed analysis of hundreds of hunting sequences demonstrated that mice follow a surprisingly stereotypical pattern. This suggests that mice succeed by tiring the cricket."

While preliminary, the data indicate that distance-to-cricket information is present at the level of the primary visual cortex, the first brain region to combine information from both eyes. Moreover, distance information seems to be a network property rather than something that is represented in particular neurons.

"We are now continuing the project into its main goal – the understanding of depth cue integration in the mouse," notes Hübener. "This includes developing 3D mouse goggles that will stimulate both eyes independently. This is basically the same technique that enables us to see depth in 3D movie theatres."

Beyond providing insight into a biological phenomenon, Hübener believes that understanding depth perception will benefit a range of emerging fields. This includes remote collaborative work, for which virtual and augmented reality technologies have been shown to be essential. "We are confident that biology-based improvements can help alleviate current imperfections in this technology," he adds.

MOUSEDEPTHPREY

- Coordinated by the Max Planck Institute of Neurobiology in Germany
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/798067
- Project website: neuro.mpg.de/Bonhoeffer

FUNDAMENTAL RESEARCH

Achieving a clearer picture of the nuclear world

A precise and sensitive method for measuring the behaviour of nuclei, located at the centre of atoms, could help to revolutionise our understanding of the very fabric of the Universe.

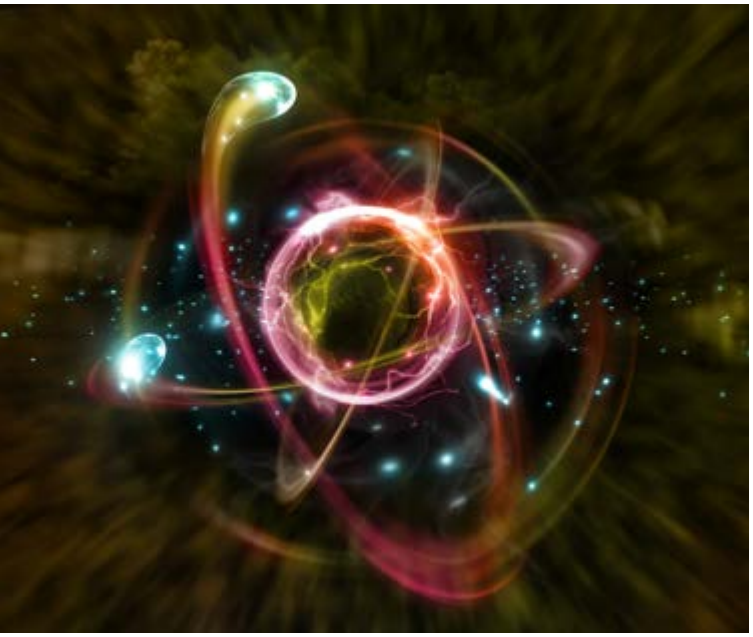
The nucleus – made up of a bundle of protons and neutrons – is at the heart of all matter. Every atom consists of a positively charged nucleus, surrounded by a cloud of negatively charged electrons. Although its existence was discovered more than 100 years ago, scientists still do not have a complete understanding of its properties.

"A key challenge to understanding nuclei is the fact that the force between nucleons, the protons and neutrons, is currently ill-defined," explains Kieran Flanagan, professor of nuclear physics at the University of Manchester, United Kingdom.

"However, there are certain nuclei that have a relatively simple structure. These nuclear systems represent an ideal laboratory for better understanding the forces between nucleons. Many of these nuclei are short-lived though, and can only be examined in specialised nuclear facilities."

STUDYING SHORT-LIVED NUCLEI

The EU-supported FNPMLS (Fundamental nuclear properties measured with laser spectroscopy) project was launched with the aim of more precisely measuring these short-lived nuclei, and bringing a useable technique to a wider scientific audience. This was achieved with the development of a method called collinear resonance ionisation spectroscopy (CRIS).



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The technique applies laser spectroscopy to deliver high-resolution measurements of nuclei. The project was carried out at the ISOLDE facility at CERN, the world's premier radioactive beam facility.

"CRIS was first proposed in the early 1980s as a means of achieving high-precision and high-sensitivity measurements simultaneously," adds Flanagan. "This makes it potentially ideal for studying these short-lived nuclei."

While Flanagan and his team had previously been able to demonstrate the high sensitivity of the CRIS method, combining high precision and high sensitivity had not been experimentally realised.

"A key objective of this project was to demonstrate that the CRIS method could achieve this," says Flanagan. "This was achieved by developing a novel chopped light method, where resonant and ionisation steps are delayed from each other. This improved our resolution by more than a factor 50."

ADVANCING NUCLEAR THEORY

The FNPMLS project builds on what Flanagan calls a 'quiet revolution' in nuclear theory – the rapid expansion of computational power. This has presented nuclear scientists with the opportunity to more accurately predict the properties of nuclei.

> *"A key challenge to understanding nuclei is the fact that the force between nucleons (the protons and neutrons) is currently ill-defined."*

Flanagan sees this project as a continuation of these advances, providing scientists with a potentially valuable tool to better understand the fundamental interactions going on within the nucleus.

Experiments carried out during the project have already helped to advance our understanding of nuclei, and contributed to nuclear theory. "The sensitivity of the CRIS method has opened up new opportunities to study short-lived radioactive molecules, such as radium monofluoride (RaF)," says Flanagan.

"No experimental studies had been conducted due to difficulties associated with preparing radioactive samples of RaF. However, we were able to measure the molecular structure of RaF for the first time, and demonstrate the CRIS method as an ideal tool for studying these short-lived systems."

The high sensitivity of the CRIS method also lends itself to enhancing other techniques. These include improving the performance of inductively coupled plasma mass spectrometry (ICP-MS). This technique has a range of critical applications, for example in the characterisation of low-level nuclear waste and the restoration of land.

"We have since established a collaboration with the United Kingdom's National Nuclear Laboratory and Nuclear Decommissioning Authority," he notes. "We have also been awarded a bursary to fund a PhD to start working on developing this concept."

FNPMLS

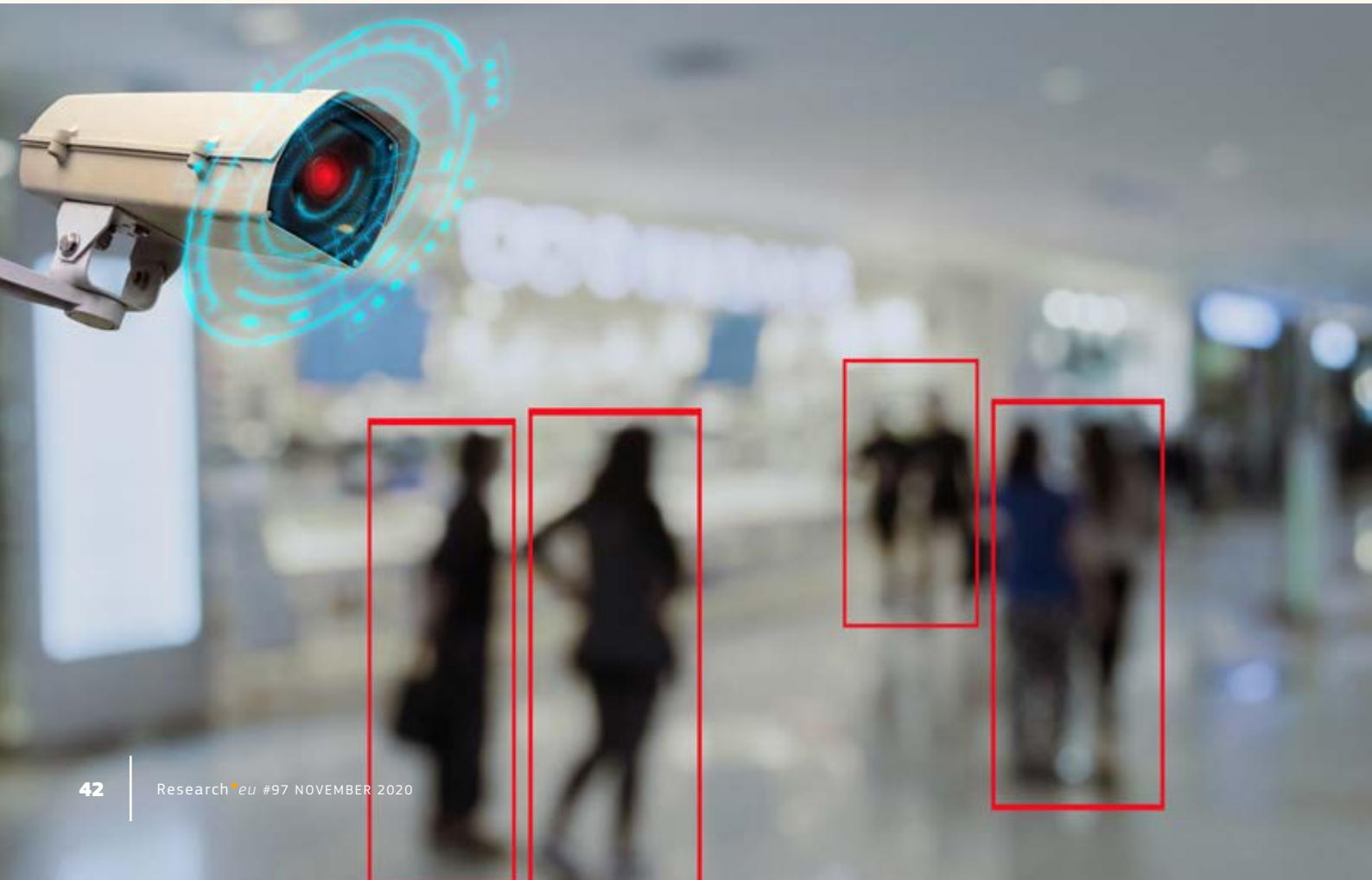
- Hosted by the University of Manchester in the United Kingdom
- Funded under H2020-ERC
- cordis.europa.eu/project/id/648381
- Project website: isolde-cris.web.cern.ch/erc.htm

LIFE AFTER...

Catching up with LETS-CROWD: Expanding a technological toolbox to keep mass gatherings safe – even in the age of COVID-19

In November 2019's special feature on innovative technology taking on terrorism, we met the LETS-CROWD project that has developed sophisticated monitoring and planning tools for law enforcement agencies to help increase security during mass gatherings, such as music concerts. We reconnect with them to see how the roll-out of their technology has progressed.

In a world currently dominated by the fight against COVID-19, mass gatherings are currently off the table, but one day in the near future they will return once the pandemic has ended. However, in the meantime, authorities need tools to help them ensure that the requirements imposed by the pandemic, such as social distancing and reduced levels of occupation in public venues, are met. This is how the project LETS-CROWD (Law Enforcement agencies human factor methods and Toolkit for the Security and protection of CROWDs in mass gatherings) has



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Antonio Marqués, ETRA I+D
© Antonio Marqués Moreno

> *Additionally, we have been approached by two other police forces in order to discuss their adoption of the toolkit. So, we are definitely very happy about this!*

found an additional – and unplanned – use for its results, which are being successfully tested to tackle the challenges brought on by COVID-19.

On top of the above, project coordinator ETRA I+D has continued to advance further the technological toolbox that it spearheaded under LETS-CROWD. Some of these tools include the Semantic Intelligence Engine (SIE) that can gather, monitor and analyse information published online in relation to a mass gathering, before and during the event, and the Dynamic Risk Assessment (DRA) that dynamically assesses risk by processing weak signals – suspicious signs of activity that alone do not constitute a threat but can become a risk when taken together. In total, there are seven LETS-CROWD tools.

Two extensions for wider adoption

Wider adoption of the LETS-CROWD tools remains a key priority. "Further to the successful validation of LETS-CROWD results as a supporting tool for the authorities to ensure the implementation of COVID-prevention measures, we reached the conclusion that to have an even larger impact in the market and better ensure civil security, LETS-CROWD results needed to be subject to two main extensions," outlines Antonio Marqués from ETRA I+D. "The first is to expand their focus from the protection of crowds to the protection of open spaces and soft targets in general, particularly in urban environments. Second, our tools' capability to handle generic threats should be complemented with specific tools and technologies specialised in the detection and handling of terrorist threats. We plan to achieve this in the framework of a new H2020 initiative."

In parallel to the above, Marqués and his team are continuing to work on the integration of the LETS-CROWD results within the information systems of two law enforcement agencies (LEAs). "Additionally, we have been approached by two other police forces in order to discuss their adoption of the toolkit," he says. "So, we are definitely very happy about this!"

Since the end of the project, which Marqués considers a total success, a number of EU police forces have shared their experiences, have new tools, and as a result of their participation are improving their operations. So, rest assured, even whilst mass gatherings are currently off limits, when they do resume, they are likely to be just that little bit safer thanks to the innovative solutions developed by the LETS-CROWD team.

LETS-CROWD

- Coordinated by ETRA I+D in Spain
- Funded under H2020-SECURITY
- cordis.europa.eu/project/id/740466
- Project website: letscrowd.eu

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 are 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.

For subscribers to the print version of Research*eu, you will also have received a copy of this Results Pack brochure alongside your regular magazine.

You can now subscribe to also get all CORDIS Results Packs posted to you anywhere in the world.
Log into your user profile at cordis.europa.eu

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