



#104
JULY 2021

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How a tiny wood-loving worm changed the course of world history

Tracking environmental change with the help of Cold War spy imagery

Robotics to accurately monitor grape production in European vineyards

SPECIAL FEATURE
ANOTHER SMALL STEP: A NEW
AGE OF SOLAR SYSTEM
EXPLORATION

Editorial

Innovative research to help us better understand our solar system, insights on the impact of global glacier retreat and emphasising 'Housing First' as a viable solution to homelessness

Welcome to this month's Research*eu magazine

One of the only redeeming aspects of the very mediocre (in your editor's humble opinion) 2001 film 'Jurassic Park 3' is when the character of Dr Alan Grant made a comparison between astronauts and astronomers. To paraphrase, he said that astronomers can explore the universe from a place of complete safety... but it's the astronauts who get to go into outer space. The context to this quote was in relation to 'normal' palaeontologists who want to study bones and adventurers who prefer to go and possibly get eaten on an island full of carnivorous dinosaurs. But this quote has stuck with your editor since 2001 and being mostly risk-averse, he would definitely plump himself in with the astronomers over the astronauts.

But why on earth is he opening this month's introductory editorial with a quote from a dinosaur film? Well, he's both a dinosaur and a space geek (regular readers will notice the latter, as sci-fi films and TV shows are frequently referenced in editorials no matter the subject). But also because, even though there are a limited number of Horizon 2020 projects covering dinosaurs (trust him, he checks every year when devising the new editorial calendar), there are many projects funded under Horizon 2020 that are concerned with space exploration and uncovering the secrets of our universe.

A new space race is currently on to better understand our immediate solar system, with eager new plans to put astronauts back on the Moon and with more probes/rovers heading to Mars than you can shake a stick at, space is definitely cool again. Europe of course wants its fair share of the space pie and the European Space Agency (ESA) in its Agenda 2025 has outlined its ambitions for Europe as a trusted partner and leader in humanity's renewed passion for exploration.

And this is where your editor returns to Dr Grant's quote. Space exploration is indeed a double-sided coin – often it's the astronaut side that makes the big flashy headlines (some of which are chronicled in the special feature editorial) but the astronomer side, which can sometimes seem a little more under-the-radar, is just as vital. Both astronauts zipping up to space and astronomers safe in their labs down on Earth are needed in equal measure to help us explore the solar system and unearth its mysteries. This month's special feature of seven EU-funded projects celebrates both sides of the same coin.

Meanwhile, in **Life After**, we meet again the **HOME_EU** project which undertook detailed and hard-hitting research that shows 'Housing First' is indeed a very viable policy solution to help move people out of homelessness. We catch up with them to see how they've advanced their work since the project's official end. And then in **Project of the Month**, we highlight a major study which the ERC-supported **ICEMASS** project contributed to that gives some stark warnings on the impact of global glacier retreat in the face of climate change.

Finally, in **EU Agenda**, we exceptionally cover two months instead of one, specifically September and October 2021. This is because we received feedback that it would be more useful to highlight events two months in advance to allow readers more time to find out more and register.

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

Published on behalf of the European Commission by the Community Research and Development Information Service (CORDIS) at the Publications Office of the European Union
2, rue Mercier
L-2985 Luxembourg
LUXEMBOURG
cordis@publications.europa.eu

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ISSN 2599-7912 (Printed version)
ISSN 2599-7920 (PDF)
ISSN 2599-7939 (HTML)
Catalogue No ZZ-AG-21-006-EN-C (Printed version)
Catalogue No ZZ-AG-21-006-EN-N (PDF)
Catalogue No ZZ-AG-21-006-EN-Q (HTML)

Luxembourg: Publications Office of the European Union, 2021

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Contents

#104

JULY 2021



HEALTH

- 4** Augmented reality advances surgical procedures
- 6** A game-changing treatment for chronic inflammatory disorders
- 7** Gut microbiota as a predictor of systemic infection



SOCIETY

- 9** How a tiny wood-loving worm changed the course of world history
- 11** 17th century 'tweets' chart the Middle Eastern Christian diaspora
- 12** How dung played a supporting role in ancient homes



LIFE AFTER...

- 14** Catching up with HOME_EU: Championing 'Housing First' as a solution to homelessness and other social intervention challenges



TRANSPORT AND MOBILITY

- 15** Paving the way to trustworthy and reliable automated vehicles
- 17** EU research cuts the ice to increase Arctic sea safety
- 18** Safest-ever child restraint seat created with breakthrough technology used for armoured vehicles



CLIMATE CHANGE AND ENVIRONMENT

- 20** Tracking environmental change with the help of Cold War spy imagery
- 21** New metric for identifying extreme events in lakes



SPECIAL FEATURE

- 01** Another small step: A new age of solar system exploration



PROJECT OF THE MONTH

- 23** Insights from the most comprehensive study ever on the world's glacier retreat



FOOD AND NATURAL RESOURCES

- 24** Robotics to accurately monitor grape production in European vineyards
- 25** Reducing mycotoxin contamination in food and feed



INDUSTRIAL TECHNOLOGIES

- 27** Grass paper – a new contender in paper packaging
- 29** Mass transfer via elastomeric stamps achieves industrial-scale fabrication of 3D integrated microelectronics
- 30** Natural extracts improve properties of industrial bioplastics



DIGITAL ECONOMY

- 32** Affordable and reliable internet access available to remote areas
- 33** New methods secure and verify IoT for European industry
- 35** Placing ethics at the heart of emerging technologies



SPACE

- 37** The Milky Way is draped in the hearts of extinct galaxies
- 38** New analytical model could shed more light on star and dark matter distribution in galaxies



FUNDAMENTAL RESEARCH

- 40** Synthetic cell models help researchers study the origins of life
- 41** Research uncovers mechanisms that steer fascinating phase transitions from the insulator to the metal



AGENDA

- 43** SEPTEMBER/OCTOBER 2021



Augmented reality advances surgical procedures

Medical imaging, such as computerised tomography or magnetic resonance imaging, apart from diagnosis, assists in preoperative planning and surgical guidance. European scientists introduce augmented reality into a novel head-mounted display that offers surgeons submillimetric surgical guidance in real time.

The idea of using augmented reality (AR) visualisation modalities to improve a surgeon's perceptive efficiency during surgery is not new. With AR, it is possible to observe the real world with further information that is virtually projected on a display worn by the user. Head-mounted displays (HMDs) offer the most ergonomic and easily translatable solution, but the quality of the virtual content dictates the efficiency of image-guided surgery through AR.

HMDs employ optical see-through (OST) or video see-through (VST) modalities. OST displays operate using optical elements to combine real-world and virtual elements. Virtual information is projected into the user's line of sight, augmenting their direct view of the real world. In VST systems, a camera captures a digital video image of the real world and combines it with computer-generated images (virtual content).

COMBINING OST AND VST TECHNOLOGIES IN A SINGLE HMD

The key objective of the EU-funded VOSTARS (Video-Optical See Through Augmented Reality surgical System) project was to enhance the surgeon's reality by adding all the information available to improve surgery. The scientific team, including experts in computer-assisted surgery, computer graphics, optics and electronics, developed a disruptive OST/VST hybrid HMD.

VOSTARS is the only AR HMD able to offer submillimetric accuracy for the planning in relation to the patient. Researchers embedded two very small cameras into the HMD to provide a highly accurate and aligned VST view. The VST modality further improves the accuracy of surgical procedures by combining numerous video frames. The hybrid HMD offers 3D orientation within the

patient anatomy and comes with highly flexible software capable of combining OST and VST applications. "With VOSTARS the preoperative plan takes place in real time, and the AR view is superior thanks to the combination of different modalities," explains Vincenzo Ferrari, VOSTARS project coordinator and associate professor of Biomedical Engineering at the University of Pisa.

Researchers have tested the VOSTARS HMD in the clinic with very promising results. According to Ferrari: "The most significant achievement of the project was undoubtedly the demonstration that AR can accurately guide the surgeon's hand offering the possibility to improve surgery."

IS THE VOSTARS HMD THE FUTURE OF AR-BASED SURGERY?

Image-guided surgery using information on patient anatomy and pathology offers surgeons the opportunity for preoperative planning, deciding, for example, optimal cutting trajectories to minimise invasiveness and improve clinical outcome. The VOSTARS HMD constitutes a disruptive tool in the context of image-guided surgery as it permits planning in real time in front of the surgeon's eyes.

“With VOSTARS the preoperative plan takes place in real time, and the AR view is superior thanks to the combination of different modalities.”



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Currently, there is no similar technology on the market for surgical navigation. It offers surgeons the opportunity to visualise the internal anatomy of the patient and parts of the body that are usually hidden from the naked eye. This is extremely useful for surgical interventions including the positioning of an implant.

Moreover, the HMD is an alternative to commercially available AR products used in various domains, including the avionics and automotive industries. Ongoing engineering activities to optimise the prototype developed during VOSTARS for surgical interventions have been supported by the ARTS4.0 project funded by the ERDF ROP.

VOSTARS

- Coordinated by the University of Pisa in Italy
- Funded under Horizon 2020-LEIT-ICT
- cordis.europa.eu/project/id/731974
- Project website: vostars.eu
- ▶ bit.ly/3eqyPvV

A game-changing treatment for chronic inflammatory disorders

Juvenile idiopathic arthritis is a chronic inflammatory disorder of the joints in children. European researchers intend to bring to the market a novel biological drug against the disease that targets a pancreatic enzyme.



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Juvenile idiopathic arthritis (JIA) is diagnosed before the age of 16 and usually presents with stiffness, swelling and pain in one of the joints as a result of inflammation. JIA can inhibit the child's growth and lead to disabilities. Existing treatments relieve symptoms and aim to reduce inflammation, preserving joint function and mobility.

A THERAPEUTIC ANTIBODY AGAINST CHRONIC INFLAMMATORY DISEASES

The EU-funded Notid (Novel Target for Treatment of Chronic Inflammatory Diseases) project supported the development of a novel biological treatment for JIA. Researchers had previously shown that patients suffering from rheumatoid arthritis exhibited increased levels of bile salt stimulated lipase (BSSL), an enzyme secreted from the pancreas into the intestine for the digestion of fat and the absorption of cholesterol. Accumulating evidence indicates that BSSL is implicated in inflammation, while mice lacking BSSL are protected from developing arthritis.

"As soon as we discovered BSSL as a target molecule for the treatment of chronic inflammatory diseases, we investigated ways to inhibit BSSL activity," explains

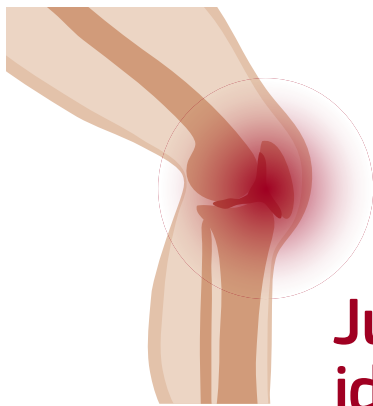
Einar Pontén, project coordinator and CEO of LIPUM AB. Experimental studies led to the conclusion that a therapeutic antibody has the potential to provide the required specificity and efficacy without unreasonable side effects. Treatment of animals with an antibody directed towards BSSL showed effective protection from disease development and progression without, however, affecting the entire immune system. Researchers tested a series of experimental antibodies and identified the nominated candidate drug SOL-116.

Notid reached several major milestones towards the evaluation of the drug in clinical studies. The project team developed a number of tools, such as cell lines, that enabled the testing of candidate anti-BSSL antibodies. Following extensive optimisation of the formulation and production of SOL-116 in bioreactors, the process was scaled up, and a clinical grade drug will be manufactured under good manufacturing practices conditions. A patent application has been submitted and a clinical trial application for regulatory approval will be ready in spring 2022 to commence the clinical testing of SOL-116.

TOWARDS IN-MAN EVALUATION OF SOL-116

JIA is a rare disease that can lead to joint destruction, and afflicted individuals often suffer from a deteriorating quality of life. As a result, JIA treatment presents with a high medical need and offers a significant market that urged Notid partners to focus on this paediatric disease. SOL-116 has the potential to become a game changer in the treatment of JIA and other chronic inflammatory diseases.

"Drug development requires significant investment, and we plan to raise capital by an initial public offering and listing on the Nasdaq First North Growth Market in



Juvenile idiopathic arthritis (JIA) is diagnosed before the age of 16

Stockholm,” says Pontén. This will support the non-clinical toxicology and safety testing of SOL-116 as well as help initiate a Phase Ia clinical study on healthy volunteers in 2022. A Phase Ib trial on patients with rheumatoid arthritis will follow to evaluate bedside safety and clinical

“As soon as we discovered BSSL as a target molecule for the treatment of chronic inflammatory diseases, we investigated ways to inhibit BSSL activity.”

efficacy. In parallel, Notid partners are testing SOL-116 in other chronic inflammatory diseases and plan to establish additional collaborations for continued clinical evaluation and product development.

NOTID

- Coordinated by Lipum in Sweden
- Funded under Horizon 2020-Societal Challenges, Horizon 2020-SME and Horizon 2020-LEIT
- cordis.europa.eu/project/id/829741
- Project website: lipum.se/eng

HEALTH

Gut microbiota as a predictor of systemic infection

Gut microbiota play an important role in health and disease. European researchers have developed an approach for determining the antibiotic resistance genes carried by gut microbiota as a predictive estimate for pathogenic infections in paediatric patients.

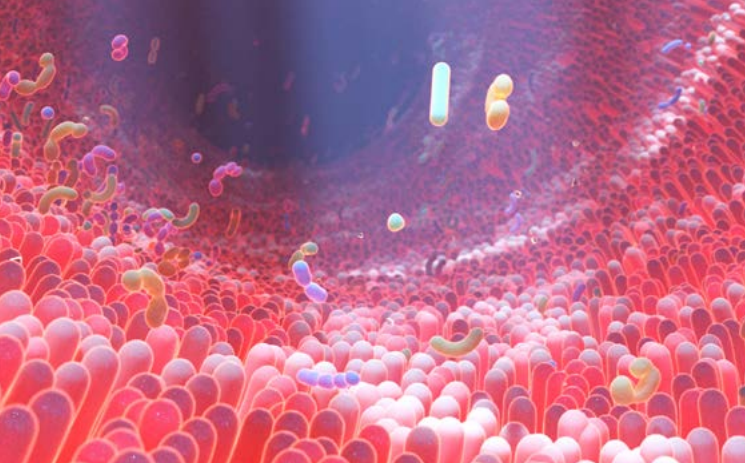
Gut microbiota have a protective role against the colonisation and infection by pathogenic organisms. However, extensive administration of broad-spectrum antibiotics may lead to commensal bacteria disequilibrium with an accompanying increase in multidrug-resistant microorganisms, particularly during hospitalisation. This is of great concern for paediatric transplant patients who rely heavily on antibiotics after surgery.

CALCULATING THE LOAD OF ANTIBIOTIC RESISTANCE IN GUT MICROBIOTA

Undertaken with the support of the Marie Skłodowska-Curie Actions programme, the project qMAR (Quantification of the intestinal load of a targeted set of resistance genes

to Monitor Antibiotic Resistance in paediatric transplant patients) aimed to develop a tool for monitoring the intestinal load of antibiotic resistance genes. “Our goal was to estimate the fraction of the microbial cells in the gut microbiota that carry antibiotic resistance genes as an indicator of things going wrong,” explains the research fellow Elias Dahdouh.

Given the size and diversity of gut microbiota, the fraction of bacteria carrying antibiotic resistance genes cannot be measured by conventional microbiology-based methods. Therefore, researchers developed a quantitative polymerase chain reaction (qPCR)-based approach for detecting specific antibiotic resistance genes and used the universal 16S rRNA gene that is present in all bacteria as an estimate of the total bacterial population. The



qMAR method offered a relative quantification of the resistance genes in the gut microbiome with respect to the total bacterial population.

Using the same technology, researchers had previously associated a high intestinal load of the *Klebsiella pneumoniae* bacterial strain in rectal swabs of adult hospitalised patients with the emergence of infection by the same pathogen. During qMAR, they employed this qPCR tool to measure antibiotic resistance genes in samples obtained from both transplant and non-transplant paediatric patients.

They discovered an association between intestinal antibiotic resistance load and antibiotic consumption. Moreover, they determined cut-off values in the order of 1-5 % for the different genes above which there is a high risk of extra-intestinal dissemination and infection.

CLINICAL AND FUTURE APPLICATIONS OF THE QMAR MONITORING TOOL

Transplant patients have often been hospitalised for long periods and received several rounds of antibiotic treatments, so it is not surprising they are colonised by antibiotic-resistant bacteria. However, when resistant species dominate host microbiota, it is very difficult

“Our goal was to estimate the fraction of the microbial cells in the gut microbiota that carry antibiotic resistance genes as an indicator of things going wrong.”

to eradicate them even if they are outcompeted by other species.

The qMAR tool offers a simple, easy-to-implement and fast approach to monitor the degree of intestinal colonisation by any bacterial strain or species. This real-time screening can help clinicians minimise adverse effects and improve the clinical outcome of patients.

“Importantly, it can be easily modified to include any resistance gene endemic in any hospital around the globe,” notes Dahdouh. The scientific team is confident the qMAR tool will be employed to help control infections and transmission of antibiotic-resistant organisms as part of the routine control surveillance methods.

Future work on elderly patients and immunosuppressed paediatric and adult patients who present with a higher risk of infection by antibiotic-resistant bacteria will further validate the clinical applicability of the qMAR method. Furthermore, partners envisage its implementation to investigate the role of the antibiotic resistance load of the intestine in the transmission between patients or to the environment.

QMAR

- Coordinated by the Hospital La Paz Institute for Health Research (IdiPAZ) in Spain
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/796084



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How a tiny wood-loving worm changed the course of world history

A plague of shipworms in 18th century Europe led to environmental disaster and religious fanaticism, but also innovation and the supremacy of Britain's navy.

Environmental catastrophe, economic collapse and a pandemic – prominent in today's public discourse, but also crises that were wreaking havoc in 18th century Europe.

On that occasion, the shipworm, a sea-living mollusc that scavenges floating and submerged wood, was to blame. Although relatively harmless today, at that time the creature was responsible for one of the world's largest environmental, political and economic disasters.

"It is still unclear why the shipworm population exploded in the 1730s, but these molluscs destroyed nearly all wooden structures along the North Sea coast in a few years," says Michael-W. Serruys, principal investigator on the EU project SHIPWORM (A transregional and interdisciplinary study of the societal impact of the shipworm epidemic in the North Sea region in the eighteenth century), and a Marie Skłodowska-Curie Actions individual fellow and historian studying the shipworms' impact on western Europe.



“As the shipworms destroyed the wooden dikes that prevented the Low Countries from flooding, the region faced an ecological disaster.”

And the crisis kept snowballing, with many of the solutions meant to minimise the shipworms’ effects having far-reaching consequences. “Political reforms, new innovations and a shift in the international balance of power – all caused by the shipworm,” adds Serruys.

With the support of EU funding, Serruys is researching the important role that innovation played in ending the shipworm crisis – research that could hold valuable lessons for how we deal with modern-day crises.

FROM WORM TO WORLD-CHANGING TECHNOLOGY

While carrying out his research, Serruys noticed that once the challenge was understood, many of the impacted societies were keen to innovate solutions. For example, it was during this era that ships were given copper-plated hulls. “Although this was initially done to protect ships from shipworms, the innovation actually made ships much faster,” explains Serruys.

Working with marine biologists and hydrodynamic engineers, Serruys estimated that copper hulls reduced a ship’s resistance in water by some 10-15%. “Countries that could afford copper plates not only emerged from the crisis quicker, they also gained an upper hand in terms of international trade.”

These new copper hulls also had a geopolitical impact. “It’s probably no coincidence that Britain, which had the largest copper deposits at the time, also had the 19th century’s most dominant navy,” remarks Serruys. “It’s rather funny to think that world-changing technology came about all because of a mollusc!”

“*It’s rather funny to think that world-changing technology came about all because of a mollusc!*”

MODERN-DAY ECHOES

Beyond financial means, being unwilling to adapt also played a role in a society’s inability to overcome the shipworm crisis. According to Serruys, many people were simply too rigid to adapt to the changing reality of the crisis – a trend with echoes today.

“Back then, some people refused to invest or to take measures that would mitigate the crisis for no other reason than they had never done so before,” he says. “This is very similar to how during the COVID-19 pandemic we see people refusing to wear masks or keep social distances even though we know that doing so slows down the pandemic.”

At the end of the day, whether it be a creature from the sea or an invisible virus, even the smallest things can have a big impact on society. “The important lesson is that it never pays to ignore a problem,” concludes Serruys. “As true as it was back in the 1700s, it’s always best to act and innovate.”

SHIPWORM

- Coordinated by the University of Western Brittany in France
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/797405
- Project website: bit.ly/3fe5K5J

17th century ‘tweets’ chart the Middle Eastern Christian diaspora

A unique project collected thousands of manuscripts to reveal how Christians from the Ottoman Empire spread around the globe.

The 16th and 17th centuries are an important time for Middle Eastern Christianity, as worshippers left their home nations and spread around the world. The EU-funded project SoSGlobal (Stories of Survival: Recovering the Connected Histories of Eastern Christianity in the Early Modern World) sought to investigate this little-studied period of history.

“The big problem is that most sources have long been hidden away in monasteries, churches and private collections,” says project coordinator John-Paul Ghobrial. “Even for basic questions, like ‘what did people write?’, we haven’t been able to get a total view.”

Fortunately, the SoSGlobal project could draw on the successes of a wave of recent digitisation initiatives that have transformed what is possible for researchers. The SoSGlobal project set out to collect as many primary sources as possible from the period 1500-1750.

WORLDWIDE SEARCH

“The challenge is almost impossible,” adds Ghobrial, an associate professor in Early Modern History at Balliol College, University of Oxford. “But you can’t get a full picture of the literary production of these communities unless you try to document every single manuscript.”

Ghobrial recruited a team of scholars from around the world, including Egypt, France, Germany, Italy, Russia, Spain and the United Kingdom, and requested details of available manuscripts in every collection they could find.

The hard work paid off: Ghobrial’s team were able to catalogue more than 5 000 manuscripts, double the number they expected, comprising liturgical works, accounts of the saints’ lives, and more.

“In general, looking at the manuscripts alone doesn’t necessarily bring too many surprises,” explains Ghobrial. “So instead we focused on colophons, the signatures of scribes at the end of a manuscript.” These colophons are like tweets, he says, containing details about who wrote the manuscript, who commissioned it, and contemporary events that were unfolding locally.

Through these colophons, Ghobrial and his team identified over 1 200 individuals involved in the production of manuscripts, commissioned by both prestigious families and even ordinary people.

“Most sources have long been hidden away in monasteries, churches and private collections.”



VOYAGE TO AMERICA

There were some surprises along the way. “Occasionally we found little gems, outliers, for example diaries kept by Middle Eastern Christian priests who’d gone to Europe or America,” notes Ghobrial.

One of these contained the earliest recorded mention of America in Arabic, from a Baghdadi account of a trip to Peru. There are only two known copies of this manuscript in existence.

One of the big discoveries made by Ghobrial and his team was the way in which Catholicism spread in the Middle East at the time, in the midst of the ongoing Reformation. “We thought it was because there were so many missionaries, but found that many conversions took place after people had travelled to Rome and back,” explains Ghobrial.

The other major takeaway, he says, is the approach to examining history exemplified by the SoSGlobal project, something Ghobrial calls global microhistory. This combines a macro-level view of societies and trends

with a personal view of everyday life as experienced by those living in the period, one which is fast becoming the favoured approach.

The project was supported by the European Research Council. “This was an incredible opportunity, there is no way we could have worked with such an array of clever, talented researchers without it,” says Ghobrial.

“One of the things I’m most proud of is that we created a whole community of scholars working on early modern Middle Eastern Christianity at Oxford, which didn’t exist before at all.”

SOSGLOBAL

- Hosted by the University of Oxford in the United Kingdom
- Funded under Horizon-2020 ERC
- cordis.europa.eu/project/id/638578
- Project website: storiesofsurvival.history.ox.ac.uk

SOCIETY

How dung played a supporting role in ancient homes

New archaeological research highlights the important role that dung-based construction materials played in allowing early humans to adapt to a changing environment.

About 12000 years ago, humans began the transition to farming. They did this by domesticating both plants and animals and, perhaps more importantly, by learning to use such by-products as milk, wool, and even manure.

“Dung is a valuable material used as fertiliser, fuel, and for construction,” says Shira Gur-Arieh, a Marie Skłodowska-Curie postdoctoral fellow working in the Culture and Socio-Ecological Dynamics group at Pompeu Fabra University (UPF). “But unlike other by-products, the use of dung, especially in construction, has been largely ignored by the archaeological community.”



“By adding to the corpus of archaeological sites where dung use has been studied and considered, these findings bring invaluable data to what was, until recently, an almost unexplored topic.”

According to Gur-Arieh, knowing how humans used dung is key to understanding humans’ relationship with animals, subsistence practices, use of technology and impact on the environment. “It provides insight on sociocultural practices, resource management and adaptation strategies,” she explains.

“All this is especially important when it comes to exploring the use of dung at the dawn of domestication and the subsequent emergence of more complex societies.”

With the support of the EU-funded project MapDung (Dung as Construction Material During the Emergence of Animal Domestication: A Multi-Proxy Approach), Gur-Arieh is exploring the early use of dung in construction as a proxy for understanding human-animal-environmental relations.

UNEARTHING INVALUABLE DATA

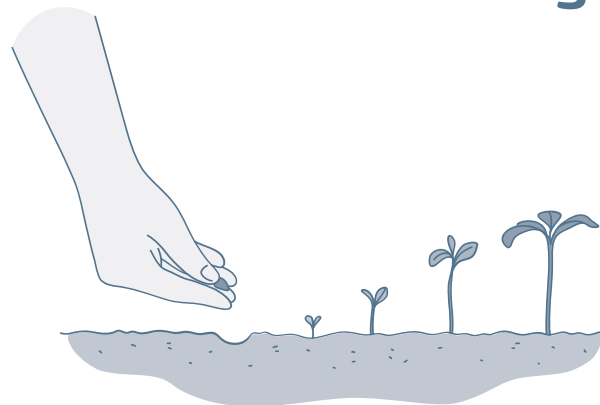
Gur-Arieh’s research had both an experimental and an archaeological aspect. As to the former, she used controlled conditions to study the pre- and post-depositional formation process of dung when used as plaster for floors and as a temper in pottery.

“By putting the material under the microscope, we were able to identify and differentiate some of the various preparation processes,” notes Gur-Arieh. “The benefit of this type of experimental work is that it can be used to help researchers identify the technological aspects of construction in the archaeological record.”

In terms of the archaeological aspect, researchers used a multi-proxy method for improving the identification of dung, especially when used as a construction material in floors and walls. This work required researchers to head into the field, where they sampled and analysed dung from four sites: Sharara in Jordan, Motza and Tel Tsaf in Israel, and Çatalhöyük in Turkey.

What they found was an absence of dung use in Sharara, possible evidence of its use at the Motza site, and clear evidence of its use in Çatalhöyük and Tel Tsaf.

About 12 000 years ago, humans began the transition to farming



“We believe that the dung used for construction in Çatalhöyük and Tel Tsaf is well preserved because of the areas’ arid environment,” says Marco Madella, a researcher at UPF who was also involved in the study.

“By adding to the corpus of archaeological sites where dung use has been studied and considered, these findings bring invaluable data to what was, until recently, an almost unexplored topic,” adds Gur-Arieh.

THE KEY TO BUILDING FARMING-BASED SOCIETIES

The project succeeded in highlighting the essential role that dung played – and often still plays – in the ability of humans to adapt to their environment.

“When humans permanently settle, they will eventually exhaust the supply of wood for fuel and their land will become unproductive without the right fertiliser,” concludes Gur-Arieh. “Without dung, which can be used as fuel, fertiliser and building material, humans would never have been able to establish a farming-based civilisation.”

MAPDUNG

- Coordinated by Pompeu Fabra University in Spain
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/794823
- Project website: mapdungproject.com



LIFE AFTER...

Catching up with HOME_EU: Championing ‘Housing First’ as a solution to homelessness and other social intervention challenges

*In the July 2020 issue of Research*eu, we featured in the Society section an article on HOME_EU, a project that had set itself the mission of tackling homelessness with an innovative ‘housing first’ model that emphasises integrated social intervention and support. We catch up with HOME_EU’s coordinator, José Ornelas, to find out more about the project’s legacy since its formal end in September 2019.*



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There are approximately 700 000 homeless individuals across Europe and since the onset of the pandemic, there’s a good chance that this number has drastically increased. The HOME_EU (Homelessness as unfairness) project, that conducted research on attitudes, knowledge and practices towards homelessness across the EU has become a major academic champion of the concept of ‘Housing First’ (HF), the provision of affordable, permanent housing as quickly as possible for people who find themselves homeless.

The rise and rise of APPSyCI

A major result of the project was the creation of the Applied Psychology Research Centre Capabilities and Inclusion (APPSyCI) in Portugal, where the project was coordinated and where Ornelas is still based.

“The centre brings together 21 full-time staff, 16 doctoral students and 17 collaborators organised to contribute solutions to concrete societal and complex problems through partnerships and collaborations amongst the public, private

and non-profit sectors,” Ornelas explains. “We’re organised into specific research clusters, which includes fields as diverse as migration, mental health and community integration, psychological well-being, empowerment studies on civic engagement and identity-based violence prevention.”

One current project of note that Ornelas cites is called DOMUS-ADEPTA, an in-depth case study on the effectiveness of social service programmes and systems to foster the social and community integration of people in Portugal who have experienced homelessness.

Housing First for other social interventions

Ornelas previously told us that the HF model could also be used for other social interventions. Since we last spoke, he and his colleagues have instigated a new project that applies HF to the equally serious social problem of domestic violence. “Our preliminary results already emphasise that housing is definitely a priority for women survivors (of domestic abuse) and their families,” Ornelas says.

Since the end of the HOME_EU project, priority has also been given to homeless women and transgender people with regards to the upscaling of Portuguese HF programmes, with both groups being particularly hit hard by the pandemic.

HOME_EU’s proud legacy

Overall, Ornelas is extremely positive about his experiences as coordinator of the HOME_EU project.

“The multi-method nature of the project provided a perspective on several approaches being implemented in different countries, providing us with valuable common perspectives despite local variations,” Ornelas outlines. “We really saw that regardless of wherever a homeless person was located, housing is without a doubt the obvious response. We consider this to be a major takeaway for future research and providing concrete solutions for vulnerable people facing life’s major challenges.”

HOME_EU

- Coordinated by ISPA in Portugal
- Funded under Horizon 2020-SOCIETY
- cordis.europa.eu/project/id/726997
- Project website: home-eu.org



José Ornelas,
HOME_EU’s coordinator
© José Ornelas

“We really saw that regardless of wherever a homeless person was located, housing is without a doubt the obvious response.”



Paving the way to trustworthy and reliable automated vehicles

Automated vehicle technology has the potential to radically change the driving experience, from reduced congestion to lower stress levels. Standing in the way of this transformation and its benefits are a lack of trust in and acceptance of automated vehicles.

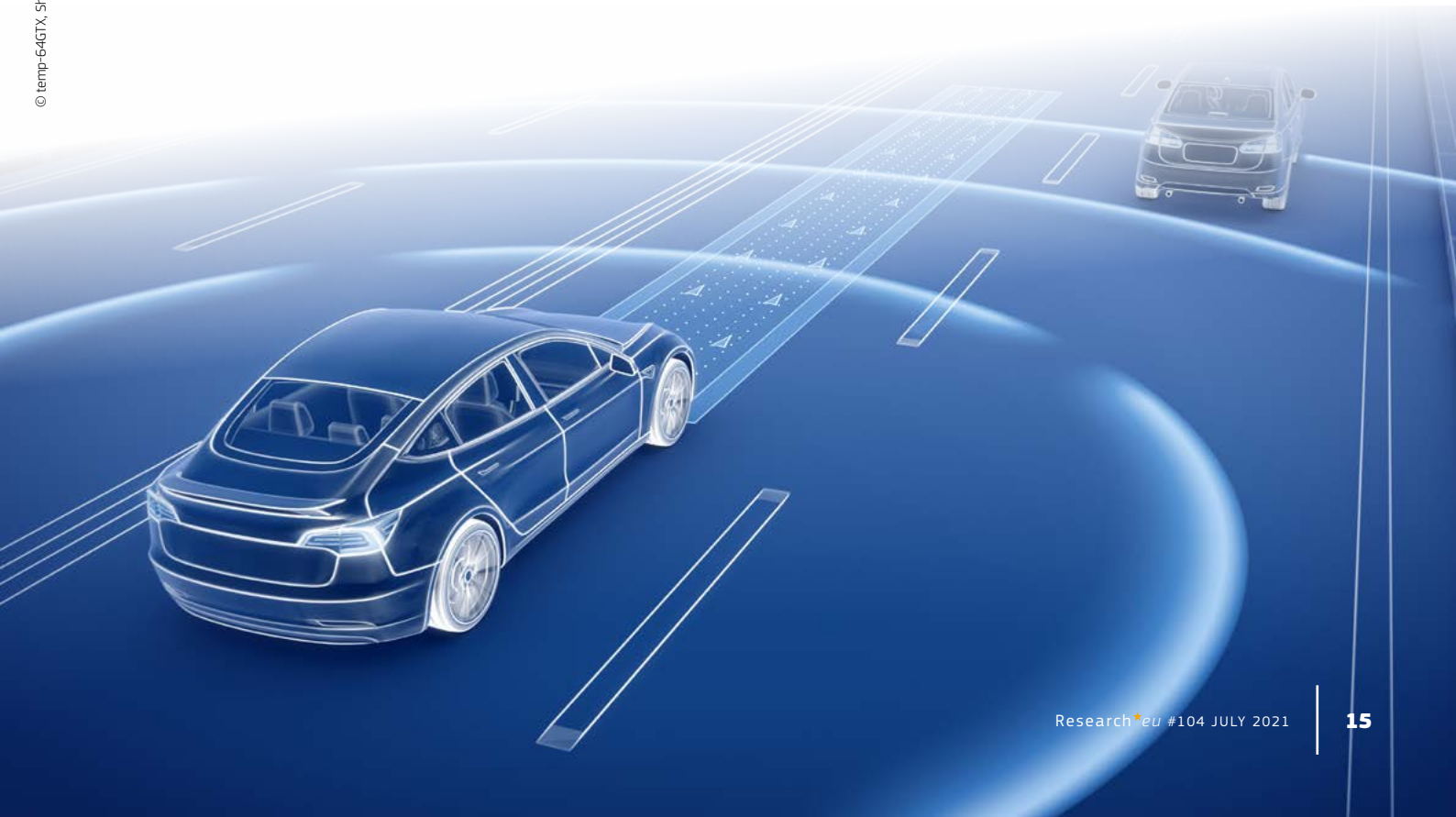
Consumers and society overall will adopt automated vehicles only if they are user-friendly, completely reliable, predictable, and safe when it comes to planned manoeuvres and their execution. A key challenge is to ensure safe vehicle handling when the driver isn't paying full attention and concentrating on other tasks.

Effective interaction between the driver and the automated vehicle plays an important role, especially for level 3 automated driving (L3AD) systems. These systems perform all dynamic driving tasks like emergency braking on behalf of the driver during specific traffic situations. Drivers can safely turn their attention to other activities such as texting. However, they must always remain prepared to intervene and take control of the vehicle. L3AD offers conditional automation, representing the first step towards fully driverless cars.

THE ROLE OF USERS IN THE DEVELOPMENT OF AUTOMATED VEHICLES

"L3AD systems should be engineered with a user-centric approach in mind," explains Daniel Watzenig, coordinator of the EU-funded project TrustVehicle (Improved trustworthiness and weather-independence of conditional automated vehicles in mixed traffic scenarios). "User acceptance is particularly important for the design of driver interfaces that will facilitate a safe transition to purely automated driving." In addition, automated driving systems should be resilient to both system and driver failures and guarantee sufficient reliability and robustness in each and every situation during actual traffic.

Project partners developed and demonstrated different concepts to increase reliability of and trust in automated vehicles for four different classes: passenger cars,



“By considering the interaction of humans with all aspects of automated road transport systems, TrustVehicle was able to offer solutions that significantly increase reliability in automated vehicles and contribute to acceptance.”

heavy trucks (including trailers), electric buses and light commercial vehicles. They took end users into account throughout by performing user acceptance studies and driving simulator studies that assessed driver behaviour and trust.

OPTIMISING AUTOMATED DRIVING FUNCTIONS

The TrustVehicle team advanced technical solutions for automated driving to better assess critical situations in mixed traffic scenarios and even in harsh environmental conditions such as heavy rain and fog. “These innovations will enhance safety and end user acceptance far beyond current levels,” notes Watzenig.

For driver monitoring and support, time-of-flight, camera-based sensor functionalities such as face detection, face identification and human pulse measurement are now available. A feature for completely autonomous, smooth reverse parking manoeuvres boosts safety and reduces stress. Self-cleaning sensors recover or maintain

availability of sensors during bad weather conditions. New methods will determine the availability of sensors during cleaning and in critical road scenarios. For example, these techniques can help to understand the effect of rain, snow and aerosol on a sensor’s field of view.

A specially designed human-machine interface monitors when an electric bus is driven in automated mode safely and accurately to a charging station. Controllers and sensor fusion systems tackle complex, uncertain and variable road circumstances. Sensor fusion algorithms have been developed for narrow street manoeuvring and reverse parking.

“By considering the interaction of humans with all aspects of automated road transport systems, TrustVehicle was able to offer solutions that significantly increase reliability in automated vehicles and contribute to acceptance,” concludes Watzenig. “In the near future, drivers will put their trust in autonomous vehicles and their accompanying technologies.”

TRUSTVEHICLE

- Coordinated by Virtual Vehicle Research in Austria
- Funded under Horizon 2020-TRANSPORT
- cordis.europa.eu/project/id/723324
- Project website: trustvehicle.eu
- ▶ bit.ly/37FnXQG

SOIL HEALTH: REAPING THE BENEFITS OF HEALTHY SOILS, FOR FOOD, PEOPLE, NATURE AND THE CLIMATE

Soil is the foundation of our lives. Soil services are essential for the provision of food through agriculture, energy and raw materials, carbon sequestration, water purification, nutrient regulation, biodiversity preservation and pest control, to name but a few.

95% of global food production relies on soil. Soil is home to a quarter of all terrestrial species, and it plays a crucial role in nutrient cycling as well as in storing carbon and filtering water, which helps mitigate climate change and prevent flooding and droughts. Yet regardless of soils’ fundamental role in the functioning of our planet’s ecosystems, soils in Europe (and globally) are being degraded which is now starting to have far-reaching consequences, for food security and safety, the integrity of ecosystems and the services they provide to humanity.

This Results Pack features 12 projects (exceptionally translated into 11 languages) working in the field of soil research and also introduces two newer projects that promise to make valued contributions over the coming years.

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

cordis.europa.eu/article/id/429351



EU research cuts the ice to increase Arctic sea safety

A rapid rise in maritime traffic in the Arctic region together with an extremely harsh environment poses severe challenges for ship navigation. EU-funded project SEDNA has developed an integrated risk-based approach to steer vessels to safety.

Ship collision, with an iceberg or an accompanying icebreaker, foundering or sinking of ships and running aground in severe ice conditions continue to be all too perilous for Arctic seafaring vessels. “The SEDNA initiative was a multidisciplinary project aimed at advancing safety in the Arctic, especially around aspects related to navigation,” says Gary Randall, project coordinator and principal consultant at the BMT Group, the coordinating company.

SAFETY MEASURES FOR ARCTIC VOYAGES

Paramount in the quest for safety in Arctic navigation is voyage planning and an understanding of ice conditions. The SEDNA (Safe maritime operations under extreme conditions: the Arctic case) project has developed several themes in parallel to achieve this while maintaining the integrity of the Arctic’s fragile ecosystem.

The researchers have developed the ‘Safe Arctic Bridge’ – an evidence-based, user-tested design framework to reliably support safer traffic movements in the Arctic. “Our ideas were embedded in virtual and augmented reality and include new map overlays, colour palettes, iconography and new collaborative tools,” notes Randall.

A customised Arctic voyage planning tool has been combined with an existing vessel management and monitoring system sold by consortium member GreenSteam. While still at the prototype stage, for the first time, customers can see weather, ice, route and ship-specific operational parameters all in one interface and can easily plan new or alternative routes.

NATURE PROVIDES SOME ANTI-ICING ENGINEERING SOLUTIONS

The research group at University College London have also addressed cutting icing from ships by taking three approaches. Ice loads on a ship’s hull affect the hull structure’s safety and the ship’s manoeuvring performance in ice-covered regions. To deal with this, the team has developed smart and multifunctional coatings with integrated anti-icing/de-icing capabilities.

Passive anti-icing occurs by virtue of their micro/nanoscale surface roughness causing superhydrophobic behaviour. As Randall explains: “Basically, ice finds it hard to ‘stick’ or even form on the surface.”

Nature-inspired principles lie behind biosurfaces that mimic duck/penguin feathers or rose and lotus leaves that all use air pockets to help prevent water adhesion due to the shape of the underlying surface.

The last prong of ice formation defence is electrothermal. As the name suggests, electricity is used to thermally remove ice build-up on a surface. Researchers did more lab testing in



the large ice testing tanks at Aalto University in Finland when a problem arose with field testing due to COVID-19.

HELPING TO PRESERVE AN ALREADY BATTERED ENVIRONMENT

A new CEN workshop agreement on the bunkering of methanol in the Arctic has also been drawn up. SEDNA has put forward technical provisions, operating protocols and an assessment of relative safety risks for three methanol bunkering concepts: Truck to Ship, Shore to Ship and Ship to Ship.

A large group of stakeholders from along the methanol production, distribution, regulation and usage chain agreed on wording to support methanol's safe use on ships. "Methanol is an important low-carbon, non-polluting, possible fuel of the future," remarks Randall.

For Randall, the most promising channels for future work are the combined ship and route management software sold by GreenSteam, along with the next developments of

“*SEDNA was a multidisciplinary project aimed at advancing safety in the Arctic, especially around aspects related to navigation.*”

the Safe Arctic Bridge. "This human-centred operational environment for the ice-going ship bridge has attracted much interest, and SEDNA partners will work in 2021 and 2022 with Microsoft and major bridge developers, such as Kongsberg, to pursue new prototypes," he concludes.

SEDNA

- Coordinated by the BMT Group in the United Kingdom
- Funded under Horizon 2020-TRANSPORT
- cordis.europa.eu/project/id/723526
- Project website: sedna-project.eu

TRANSPORT AND MOBILITY

Safest-ever child restraint seat created with breakthrough technology used for armoured vehicles

With child casualties from road traffic accidents still far too high, a new life-saving technology could greatly improve chances of survival.

Ambitious targets for greatly reducing the global number of deaths and injuries from motor vehicle crashes have been set. But with annual fatalities still around 1.3 million, as reported by the World Health Organization, drastic action is needed to meet future global targets and save lives.

In Europe alone, 700 children under the age of 15 are killed annually in traffic accidents and 100 000 are injured. Tragically, motor vehicle crashes are the leading cause of death and injury amongst children under 1 year of age.





In Europe alone, 700 children under the age of 15 are killed in traffic accidents annually

SAFER CHILD RESTRAINT SYSTEMS NEEDED

Progress in making safer child restraint systems in the last 10 years is small compared to the advancements made in adult occupant protection in that same period. The EU-funded SAFESEAT (The next generation, Smart Child Restraint Seat) project offers a new generation of smart child restraint systems based on multiple-patent breakthrough technology improving safety levels to reduce child casualties and injuries in traffic accidents.

The company behind SAFESEAT, Mobius Protection Systems, has engineered a seat based on its successful experience in designing blast-protected military seating systems. With this solid technological backing, it was able to design a seat that increases safety by a factor of 4 compared to statutory requirements and by a factor of 2 compared to the safest products on the market.

BABYARK IS BORN

Mobius Protection Systems joined forces with legendary car designer Frank Stephenson, known for his designs of the BMW, Mini, Ferrari, Maserati, McLaren and Fiat 500. Stephenson's expertise enabled the synergy between engineering and design, leading to an uncompromising product with meticulous detail. Hence, the team combined design with military-grade energy absorption technology and introduced babyark as the safest car seat in the world.

"Our mission is to introduce the most advanced technologies and design to set a new level of safety that will significantly reduce car accident-related child mortality and injuries," explains Shy Mindel, co-founder

"Our mission is to introduce the most advanced technologies and design to set a new level of safety that will significantly reduce car accident-related child mortality and injuries."

and CEO of babyark. He continues: "Our technology is based on 11 patents; it was crash-tested in the TASS labs in Holland and proven to reduce head injury risk by 2.5 times compared to leading seats in the market."

Beyond the new standard of safety, babyark was designed to be easy to use and simple to install. This prevents incorrect installation, which is the case in 70% of installed seats today.

BRINGING BABYARK TO THE MARKET

Once babyark receives regulatory certification, the company plans to begin sales in the EU and United States markets and then expand further together with a global distributor.

The company has invested a lot of time in research and production technologies to make these technologies and materials affordable in mass production. babyark is committed to making the seats accessible to as many children as possible. It is considering new business models, such as product as a service, so-called PaaS, where payment will be based on usage versus purchase.

It's all about the potential to save children from accident-related injuries and deaths. This is the company's biggest achievement. "If we can also change parents' perception about car seats from a barely tolerable (but must-have) product, to an easy-to-use and simple-to-install product, one that parents love, that would be our next greatest achievement, as it will make an even deeper change in the category and bring our safety standard to more children around the world," concludes Mindel.

SAFESEAT

- Coordinated by Mobius Protection Systems Ltd in Israel
- Funded under Horizon 2020-TRANSPORT, Horizon 2020-LEIT-ICT and Horizon 2020-SME
- cordis.europa.eu/project/id/784190
- Project website: babyark.com



CLIMATE CHANGE AND ENVIRONMENT

Tracking environmental change with the help of Cold War spy imagery

Photographs captured by American spy satellites over half a century ago reveal the long-term impact of human activity on the environment – and could help steer future conservation efforts.

Conservationists are receiving a helping hand from an unexpected source: Cold War spy photography. The EcoSpy (Leveraging the potential of historical spy satellite photography for ecology and conservation) project pioneered the use of satellite photography from the Cold War era to trace long-term changes in ecosystems and species' populations.

The research, undertaken with the support of the Marie Skłodowska-Curie Actions programme, used photographs captured by American CORONA spy satellites between 1960 and 1972 and combined these with modern-day data.

INTELLIGENCE FOR THE PLANET

Initially focusing on Soviet nuclear missiles, the CORONA satellites mapped virtually the entire globe, capturing more than 800 000 images in high resolution. "They would parachute the photo capsule into the atmosphere, where a plane would catch it in mid-flight before it could be intercepted by Soviet intelligence," says Catalina Munteanu, Marie Skłodowska-Curie fellow from Humboldt University of Berlin and EcoSpy's lead researcher.

Declassified in 1995, these historic images could now fill an important gap. While modern satellite images play a key role for ecology and conservation, they cover a limited timeframe: "The earliest high-resolution data is from the 2000s, but a lot of processes that lead to changes in ecosystems have much deeper roots."

Using software initially developed for processing drone photography, Munteanu and her colleagues were able to align the Cold War era images with more recent imagery, turning them into a powerful data source.

LONG-TERM IMPACT

"We found evidence that human activities, such as agriculture and forestry, in the 1950s and 1960s are still very much affecting our environment. Moreover, we

noticed that species responded to changes in ways we had previously overlooked," Munteanu observes.

Her team's conclusions are underpinned by pilot studies which highlight the long-term environmental impact of human activities. Their study of steppe marmots in Kazakhstan for instance enabled a new understanding of how farming is affecting this species.

"Steppe marmots are ecosystem engineers: they play a vital role for the functioning of the ecosystem and the habitat of other species," Munteanu notes. "Digging complex systems of burrows in the ground, they create small mounds of soil that can be seen from space."

Prior research found that the marmots were more abundant in agricultural fields than in the steppe, their natural habitat. Using the CORONA images to compare historic with recent data, EcoSpy's team however detected an overall drop in the marmot population since the 1960s, when Kazakhstan was converting large steppe areas into fields.

"Marmots tend to stay in the same place. The fact that agriculture was persistently disturbing their burrows might have affected their populations," adds Munteanu.

Another pilot study identified forests of high conservation value in Romania which had remained undisturbed for a long period of time while also highlighting vulnerability to human pressure. EcoSpy's data now enables decision

“A lot of processes that lead to changes in ecosystems have much deeper roots.”



makers to focus conservation efforts on those areas where they could make the biggest difference.

EcoSpy's team has been cooperating with fellow researchers at the international level to identify areas in which the imagery from earlier decades could deliver new insights.

Current collaborations include a study on the effects of the Vietnam War on the landscape and an assessment

of grazing pressure from livestock and its interaction with wild ungulate in Kazakhstan.

ECOSPY

- Coordinated by Humboldt University of Berlin in Germany
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/793554
- Project website: bit.ly/EcoSpy_project

CLIMATE CHANGE AND ENVIRONMENT

New metric for identifying extreme events in lakes

Lakes respond rapidly to increasing temperature and other climate extremes occurring due to global warming. These changes have implications for the future of lake ecosystems and the benefits they provide.

Most will recall the 2018 heatwave in Europe with the warmest May-October average air temperatures since recordings began in the early 19th century. Extreme heat, as in this case, can influence the lake surface water temperature and negatively affect lake ecosystem services.

The EU-funded IntEL (Investigating Climatic Extreme Events in Lakes) project examined how lakes are responding to the increased occurrence of extreme events, offering the first systematic detailed study of lake responses to extreme weather. This research was undertaken with the support of the Marie Skłodowska-Curie Actions programme.

Climatic changes have substantial implications for lake species as they have adapted to the local conditions and generally cannot migrate away from their lake habitat. Climate extremes can also affect the use of lakes by humans as they may lead to declines in fish species used for food or tourism or increases in toxic algal blooms that can affect the quality of drinking water. "Quantifying and understanding these changes is crucial if we are to try to mitigate these impacts. In addition, the ability to describe and quantify these effects can contribute to the weight of evidence indicating that the global population must reduce their output of greenhouse gases," notes Eleanor Jennings, IntEL project coordinator.

LAKE HEATWAVE – MONITORING ATYPICAL LAKE SURFACE TEMPERATURES

IntEL research fellow Iestyn Woolway explains: “Lake heatwaves are defined as periods of anomalous lake surface temperatures (i.e. when temperatures exceed historical average conditions for that time of year). The metric developed can be applied to any lake on Earth but, in this study, we focused solely on lakes with satellite observations.” The satellite data used played a vital role in ensuring the models successfully captured observed historic changes and were fit for this purpose.

This new metric that quantifies lake heatwaves, presented in the recent ‘Nature’ article published by Woolway and colleagues, modelled lake heatwaves for multiple sites across the globe. The most dramatic finding was that some lakes may reach a permanent heatwave state.

LOOKING AT THE FUTURE OF LAKE ECOSYSTEMS

There are important implications for the future of lake ecosystems and the services they provide. Project work provides a new metric for describing lake heatwaves and also future projections for how these will develop as global warming proceeds and impacts all lake organisms and people using them.

IntEL findings show that lake temperatures are set to rise faster than the ability of some species to disperse to cooler areas. The consequences will be more serious for species that disperse less readily (e.g. freshwater molluscs), but even the more motile species that could migrate more rapidly (e.g. some fish species) are likely to be restricted



by physical barriers. These developments could cause catastrophic damage to certain lake ecosystems, having irreversible impacts on ecological communities and a dramatic influence on local communities depending on lakes for survival.

“Future work will investigate the influence of climate change on a host of other essential lake properties, including the phenology of lake stratification (the vertical layering that exists in many lakes in summer), and the influence of warming on greenhouse gas production in lakes,” concludes Jennings.

INTEL

- Coordinated by Dundalk Institute of Technology in Ireland
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/791812
- Project website: bit.ly/IntEL_project

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SPECIAL FEATURE

ANOTHER SMALL STEP: A NEW AGE OF SOLAR SYSTEM EXPLORATION

Editorial

“The purpose of life is the exploration of the Sun, the Moon and the heavens” –

Anaxagoras, Ancient Greek philosopher

Whilst the dominant scientific concern at the beginning of the new decade has been the very much rooted-on-Earth pandemic, excitement and renewed commitment to space exploration may see the 2020s eventually remembered for a surge of reignited interest in the Final Frontier. A new global space race is under way between the world's major powers to be the first to unearth new secrets about our immediate celestial neighbourhood, the solar system.

Already in February 2021 we've seen NASA successfully land its Perseverance rover on the surface of Mars and then in April, NASA's Ingenuity rotorcraft was the first ever human-made contraption to fly above the surface of Mars. Not wanting to miss out on the action, China also landed its Zhurong rover on Mars in May. Even the United Arab Emirates (UAE) sent a satellite to orbit around the red planet. Suffice to say, Mars is arguably humanity's biggest tourist destination for 2021.

Closer to home, SpaceX recently made history by ferrying a team of astronauts to the International Space Station, the first time a private company has been entrusted with undertaking the trip. This also highlights how space exploration is now not merely the preserve of powerful governments but also a thriving space commercial sector. Later this year, the BepiColombo mission, a joint mission between the European and Japanese space agencies will reach its intended target of Mercury, a planet we still know relatively little about. Finally, plans are being fervently developed to return humans to the Moon this decade under NASA's Artemis programme.

The above milestones and planned projects are just the tip of the iceberg. And of course, Europe is not sitting idly by as

the rest of the world rediscovers its space legs. Recently, the European Space Agency (ESA) launched its Agenda 2025 that outlines how Europe can play its full role in space exploration and claim its fair share of a burgeoning global space economy. Specifically relating to further solar system exploration, Agenda 2025 ambitiously states that ESA will strive towards putting the first European on the Moon by the end of the 2020s and will have defined Europe's role in the human exploration of Mars.

Supporting and underpinning these ambitions will be the dedicated research undertaken by hugely enthusiastic and talented European astronomers, many of whom are funded through the EU's Horizon 2020 programme. Indeed, it's not necessary to be an astronaut or a robotic rover or probe to contribute to the exploration of our solar system, much of the leg work is done down here on Earth. In this year's dedicated space issue, we meet seven EU-funded projects that are positively contributing to Europe's space ambitions, such as the development of a truly high-tech moon rover, efforts to produce more detailed and comprehensive maps of Mars, Mercury and the Moon and finding out whether the conditions for life are possible elsewhere in our solar system, such as Titan, one of the many moons of Jupiter.

Maybe by 2030 we'll be able to look back and count the above work, not just beating a relentless pandemic, as our major scientific achievement of the decade. We may also be able to celebrate a new crop of astronauts on the Moon and maybe, just maybe, a gallant crew on their way to say hello in person to the red planet.

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

Contents



SPECIAL FEATURE

ANOTHER SMALL STEP: A NEW AGE OF SOLAR SYSTEM EXPLORATION

02

Better maps for more expansive
space exploration

04

Earth minerals tell us more about
their Martian counterparts

05

The deep source of magnetic
fields in planets and moons

06

Could life emerge on Titan?

08

One rover, one mission:
supporting future life on the Moon

10

A new spin on Jupiter's
stormy weather

11

New rover system can make its
own decisions and... improvise

Better maps for more expansive space exploration

The European Space Agency has set its eyes on Mars and the Moon, but successful missions call for geological maps that are currently produced almost exclusively in the United States. The PLANMAP project has brought experts together to make up for Europe's lag and has managed to devise even more advanced maps in the process.

Word is out that there is a new space race upon us, and both the European Space Agency's (ESA) and NASA's plans for the future of space exploration tend to confirm it. But what's an explorer without a good map? While geographical maps of planetary bodies have been drawn since the days of the Apollo missions, only the United States Geological Survey (USGS) has been able to consistently produce them so far. A situation the EU cannot settle for if it wants to realise its ambitions in the space sector.

Matteo Massironi, planetary scientist at the University of Padua, draws a comparison with the geological maps of the Earth. To him, a country without a geological map – and therefore no knowledge of its resources, hazards, risks and environmental features – is a lost land. The same goes for planetary science. "Any planetary mission which does not foresee the production of geological maps is at serious risk of failure. Like a country unaware of its own territory, Europe might become unaware of its own achievements in planetary exploration. It would leave to others the fruits of its technological efforts and, in the long run, this might seriously hamper the competitiveness of European solar system exploration programmes focusing on icy and rocky bodies."

This problem won't be solved tomorrow, but Massironi and partners under the PLANMAP (Planetary Mapping) project have been planting the seeds to get there. The project, which brought together various European institutions producing planetary geological maps and derived products, has devised innovative ways to do so.

"Ever since the Apollo era, planetary geological mapping has been carried out using a photointerpretative approach of black and white images. This inherently limits the definition of geological units to morphological considerations. By comparison, geological units on the Earth are defined by other parameters as well, the most important being lithology and composition. In other words, there is an important conceptual and effective gap between traditional maps of planets and geological maps of the Earth," Massironi explains.



NEW TECHNIQUES AND NEW MAPS

PLANMAP partly bridges this gap by integrating spectral and colour information into morpho-stratigraphic maps. But it even goes further. The project team borrowed methodologies used by resource exploitation companies on the Earth to reconstruct 3D models of the subsurface, and developed tools to retrieve geological measurements in Martian virtual environments thanks to Curiosity rover data sets. “This will be the future for geological analysis of planetary surfaces as well as the effective training of planetary geological mappers and astronauts,” Massironi notes.

Besides these breakthroughs, PLANMAP also contributed to worldwide planetary research creating maps of specific areas of the solar system. They produced, among other things, a traditional geological map of the South Pole Aitken basin – a primary objective for future robotic and human exploration on the Moon. They applied their novel integration of morphological criteria and spectral information to the Rachmaninoff basin map on Mercury; and they produced 3D geological models of the Crommelin crater in Arabia Terra (Mars), the Rembrandt basin (Mercury) and the interior of Comet 67P.

In reaction to the project’s findings, ESA has already started collecting geological maps of planetary bodies and setting up repositories. The Italian Space Agency is currently upgrading its scientific web tool MATISSE with the capability of exploiting semantic information

“This will be the future for geological analysis of planetary surfaces as well as the effective training of planetary geological mappers and astronauts.”

coming from planetary geological maps. Meanwhile, Italian and German geological surveys are now looking at geological planetary maps as a potential source of future development.

With PLANMAP completed, a new project called GMAP will now foster planetary geological mapping in Europe and provide virtual access to services and tools for planetary cartography. A twin project has also begun in China. Further down the line, Massironi hopes that PLANMAP will help set up a real European Planetary Geological Service.

PLANMAP

- Coordinated by the University of Padua in Italy
- Funded under Horizon 2020-LEIT-SPACE
- cordis.europa.eu/project/id/776276
- Project website: planmap.eu

Earth minerals tell us more about their Martian counterparts

The PTAL project has considerably advanced our understanding of Mars's surface thanks to analysis of Earth analogues and in-lab experiments. Their spectral database contains data on most minerals already detected on Mars and other planetary bodies.

Earth is definitely full of wonderful and valuable resources of all kinds, but there is just something about the surface of other planets and small solar system bodies that sparks the curiosity of scientists all across the world. How do these other worlds differ from ours? What are the basic physical processes underlying their evolution? Can these help us to better understand phenomena occurring on our own planet? These are among the many questions researchers are eager to see answered.

In this already very busy research field, PTAL (Planetary Terrestrial Analogues Library) stands out with a contribution that's as essential as it is unique. Since 2016, the project consortium has been building a multispectral database containing data on the many minerals detected on Mars and other planetary bodies so far.

"We collect terrestrial analogue materials and characterise these with two types of instruments: precise laboratory instruments – which are best for deriving mineralogy and petrology but cannot be flown to space – and instruments that will be installed on future Mars rovers," says Stephanie Werner, professor of Geosciences at the University of Oslo and coordinator of PTAL.

The project, which focuses specifically on Mars, doesn't stop at the study of minerals at a certain point in time. It considers their evolution by investigating weathering processes on the red planet. "These processes occur in different chemical and physical conditions than they



would do on Earth because of factors such as the CO₂-dominated atmosphere, the lack of oxygen and the different temperature range. So, we have been mimicking the mineral alteration process under Mars conditions within reaction containers, and we found that previous interpretations of how the original rock turned into weathering products are impossible on Mars. We now know that other interpretations are needed," Werner explains.

NEW INSIGHTS INTO MARS'S SOIL COMPOSITION

The project's efforts could prove crucial for future rover missions to Mars. Let's consider the European Space Agency's ExoMars 2022 mission and its Rosalind Franklin rover – the first capable of studying Mars both at the surface and below it. The exact composition of primary rocks (Si-rich volcanoclastic sediments or mafic basaltic flows) and clay (smectites or mica group vermiculite) at the mission's landing site is still to be determined, and it could have major implications on the nature of past aqueous environments. This is where PTAL's research can come in particularly handy, as Werner notes. "By combining measures of natural occurrences and in the laboratory, PTAL provides crucial data to evaluate the

“PTAL provides crucial data to evaluate the potential of biosignature preservation, interpret the geochemical evolutionary history based on original material composition and, most importantly, define which measurements will be necessary to disentangle the different composition possibilities.”

potential of biosignature preservation, interpret the geochemical evolutionary history based on original material composition and, most importantly, define which measurements will be necessary to disentangle the different composition possibilities.”

This combination of natural planetary analogue studies with in-lab experiments is the greatest strength of the project’s database. Mars’s oldest crust, for instance, is made of different layers including carbonates which cannot be found on Earth. While these have so far been thought to result from weathering of different layers of parent rocks, the project team has demonstrated that they are in fact the natural outcome of a single rock’s interaction with acidic solutions contained in the atmosphere.

All in all, the PTAL library is an excellent launch pad for future research. Finding out more information on Mars’s environmental conditions will inform scientists on weather, climate, geological evolution and their consequences for the evolution of life on another planet. But its findings are also relevant for studying the evolution of Earth itself.

PTAL

- Coordinated by the University of Oslo in Norway
- Funded under Horizon 2020-LEIT-SPACE
- cordis.europa.eu/project/id/687302
- Project website: ptal.eu

The deep source of magnetic fields in planets and moons

A journey to the centre of the Earth still belongs to the realm of science fiction but understanding what generates the magnetic field at its heart could provide new clues to what turned it into a habitable planet – and that’s exactly what one EU-funded project has been doing.

The InDyMag (Internal Dynamics and Magnetic field generation in rocky bodies: planets and large moons in the solar system) project is aiming to unravel the mysteries of magnetic fields in rocky planets and moons. Undertaken with the support of the Marie Skłodowska-Curie Actions programme, it is helping to shine a new light on how these fields are generated, and how they may have evolved over time.

To improve our understanding of these processes, the project team is confronting mathematical models with evidence of magnetic fields in the planets of the inner solar system.

POWERING THE EARTH’S DYNAMO

All rocky planets in our solar system except Venus and some moons have been shown to have generated magnetism at some point in their existence. As a major driving force of magnetic fields, the researchers focused on studying the crystallisation of planetary cores, which occurs when metallic elements such as iron cool below their freezing point. Due to pressure effects, this is expected to occur in most cores at the centre: in the case

of the Earth, for instance, the result is an inner core of solid iron, covered by a fluid outer core of liquid iron.

“Crystallisation of iron and other elements leaves the liquid core devoid of heavy elements, making it lighter than its surroundings and generating flows, similar to those of water in a heated pot. Because the outer core is mainly an electrically conducting fluid, the movements generate an electric field, and then a magnetic field. This mechanism is known as the geodynamo,” explains



“The existence of a magnetic field has been proposed as a way to assess habitability.”

Benoit Langlais, director of Research at the Laboratory of Planetology and Geodynamics, a joint research unit of the CNRS, the University of Nantes and the University of Angers, which hosts the project.

The team found that the effects of crystallisation on dynamo generation may have been overestimated. “For small cores like the Moon’s, or cores freezing really fast, we may obtain fluffy cores – imagine a sponge filled by water,” says Marine Lasbleis, Marie Skłodowska-Curie fellow and InDyMag’s principal investigator. “This porous inner core may trap liquid, preventing it from being efficiently mixed with the liquid outer core.”

While crystallisation is known to play an important role in generating the Earth’s current magnetic field, a key question that remains is what happened before its inner core started to crystallise. “Evidence of a magnetic field on Earth goes back to Archean times – billions of years before the estimated time of formation of the inner core,” Langlais notes. The InDyMag team is collaborating with

researchers in France, Germany, the United Kingdom and the United States to gain deeper insights into these ancient dynamics.

ASSESSING HABITABILITY

The results of InDyMag could also inform future research exploring the link between the presence of a magnetic field and the emergence of habitable environments. “The existence of a magnetic field has been proposed as a way to assess habitability on a given planet,” Lasbleis says.

The habitability of a celestial body depends on many different aspects, including for instance the temperature on the surface, the composition of the atmosphere and the presence of water, she adds. These are impacted both by external conditions, such as solar irradiance, and by internal dynamics, such as volcanism – which is in turn directly related to magnetism.

INDYMAG

- Coordinated by the National Centre for Scientific Research in France
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/795289

Could life emerge on Titan?

The organic chemistry going on in the atmosphere of Saturn’s largest moon could hold all the ingredients needed for life to emerge, a European project finds.

With a surface temperature of around -200 °C, Titan does not sound like a particularly hospitable place. However, this icy moon orbiting Saturn may host the building blocks of life – and offer a suitable environment for putting them together.

Titan, which is twice the size of our Moon, has some striking similarities with Earth: its climate involves a cycle of liquids with clouds and rain, as well as rivers, lakes and seas. It is also the only known moon with a thick atmosphere. The PRIMCHEM (Primitive chemistry in planetary atmospheres: From the upper atmosphere down to the surface) project, supported by the European Research Council (ERC), has now found that the chemical interactions taking place in this atmosphere could potentially foster the emergence of life on Titan.



“ *Our discovery of nitrogen-rich atmospheric molecules interacting with liquid water at Titan’s surface therefore hints at the possibility of the emergence of life on Titan.* ”

Organic compounds, which are found in all living organisms, are molecules generally containing carbon atoms bonded to hydrogen. They can contain a number of other elements called heteroatoms, including nitrogen. Nitrogen forms an important part of the structure of proteins and DNA bases.

“Titan’s atmosphere is mainly made up of molecular nitrogen and methane. We have shown that, at high altitudes, nitrogen drives organic growth and produces large molecules,” explains Nathalie Carrasco, PRIMCHEM principal investigator and professor of Geosciences at the University of Versailles Saint Quentin which hosts the project. Titan has an ideal atmosphere for exploring the scenario of an atmospheric origin for nitrogen incorporation into prebiotic molecules, she says: “Upper atmospheric layers are directly exposed to harsh solar UV radiations, triggering extremely efficient chemical reactions.”

ORGANIC POTENTIAL

The team also found that the large nitrogen-rich molecules produced at high altitudes continue to evolve during their descent in the atmosphere, generating huge organic potential at Titan’s surface. Liquid water, Carrasco explains, is another prerequisite for life. “Titan possesses a deep-water ocean in its interior, and liquid water can be brought up to the surface through cryovolcanism. Our discovery of nitrogen-rich atmospheric molecules interacting with liquid water at Titan’s surface therefore hints at the possibility of the emergence of life on Titan.”

The team’s findings were made possible through the Cassini-Huygens space mission, which first revealed the existence of large organic molecules on Titan. To unravel their chemical composition, the PRIMCHEM team developed an experimental platform to recreate the conditions on Titan in the lab – harsh UV irradiation, low pressure and temperatures of down to -200 °C. The chemical processes triggered were then observed *in situ* using analytical devices connected to the reactors.

A GLIMPSE OF THE EARLY EARTH

The project’s work could also help to improve our understanding of how life may have arisen on our own planet: the pressure at its surface, and the chemical composition of its atmosphere, make Titan the best-known observable analogue of the early Earth. “Our results suggest that the chemistry in the upper atmosphere of the early Earth fostered the incorporation of nitrogen in prebiotic molecules, before they interacted with the primitive oceans,” Carrasco notes.

PRIMCHEM’s groundbreaking discoveries will directly inform the work of DragonFly, NASA’s mission to Titan which will launch in 2027 to explore how far pre-life chemistry may have progressed there and advance our knowledge of the emergence of life on Earth and beyond.

PRIMCHEM

- Hosted by the University of Versailles Saint-Quentin-en-Yvelines in France
- Funded under Horizon 2020-ERC
- cordis.europa.eu/project/id/636829
- Project website: bit.ly/PRIMCHEM-project

One rover, one mission: supporting future life on the Moon

There is still much we don't know about the Moon and the conditions astronauts settling down on its surface will need to live in. The LUVMI-X project has been preparing the best possible rover for these future missions, with a launch expected in 2025 if everything goes as planned.

Back in 2018, CORDIS reported how the LUVMI project had devised a new kind of lightweight Moon exploration rover. Fresh from the discovery of frozen water in shadowed lunar craters, a team of researchers led by Space Application Services had built the first rover prototype capable of exploring the Moon's craters in search of ice. Eventually, the project would be tasked with locating what future explorers will need to establish a long-term settlement on the Moon.

Three years later, the development of the new rover is still going strong thanks to EU support under the LUVMI-X (LUVMI-Extended) follow-up project. The rover from 2018 has changed considerably. It now comes equipped with new instruments to detect volatiles in remote locations, study the lunar environment and its impact on human health, and measure *in-situ* resource utilisation.

Jeremi Gancet, coordinator of the project, agreed to answer a few questions about the rover's new features and what remains to be done before it can finally shoot off for the Moon.

Humanity went to the Moon over 40 years ago. How come there are still so many gaps in our understanding of its resources, environment and the possibility of living there?

Jeremi Gancet: Apollo achievements half a century ago were extraordinary. But huge gaps indeed remain in our knowledge and understanding of the lunar geology and environmental conditions. Apollo astronauts spent a total of 3.5 days on the surface of the Moon (over six missions) and performed as much science as possible within this limited timeframe and with the technologies available at the time. We learned a lot, but this was only a starting point. There are still many more things we don't know about the Moon than things we do!

Several probes recently helped analyse the geological characteristics of the Moon from lunar orbit and provided evidence of the presence of volatiles (water ice) in polar regions and some craters of the Moon. The utilisation

of such resources may be a game changer for space exploration, and over the past 10 years we saw some sort of 'lunar exploration renaissance' momentum, with spacefaring nations expressing a growing interest in going back to the Moon. This was also fostered by the rise of private actors offering competitive solutions to fly and land spacecrafts: the return of humans to the lunar surface will be possible in a few years at a fraction of the cost of the Apollo programme.

This leads us to the LUVMI-X concept. Robotic solutions such as lunar rovers bring and deploy sensors in promising areas, kilometres away from landing sites. This is what we want to achieve, with an affordable 'mobility solution' that can carry and deploy a variety of scientific instruments to remote locations where the scientific return is expected to be the highest.

Rovers are being developed all across the world now. What makes LUVMI-X stand out?

LUVMI-X includes both innovative instruments for lunar science and the rover itself which can bring and operate those instruments in suitable locations. Our rover can



© LUVMI-X



Jeremi Gancet,
Coordinator, LUVMI-X project
© Jeremi Gancet

“*Robotic solutions such as lunar rovers bring and deploy sensors in promising areas, kilometres away from landing sites. This is what we want to achieve, with an affordable ‘mobility solution’ that can carry and deploy a variety of scientific instruments to remote locations where the scientific return is expected to be the highest.*”

accommodate a selection of sensors to address scientific questions of the highest priority to the community. Volatiles, in particular, are of paramount interest: we still have key questions related to their geographical distribution, their composition, the depth where they may be found, etc.

The LUVMI-X rover is a rather small platform that weighs less than 90 kg with all payloads on board. It is very mobile – it can drive over rocks of up to 30 cm in height – and provides a standardised solution to host scientific payloads. The LUVMI-X rover may accommodate instruments in three different manners: as fixed payloads, as droppable payloads and as throwable payloads (up to 50 m distance from the rover). With this concept, we expect LUVMI-X to meet the demand and expectations of many scientists and make the Moon more accessible for science.

You’ve also come up with creative ideas targeting the broader public like a simulation and a tutorial on how to build a rover. What do you hope to achieve with these concepts?

These tools can help people better understand the challenges posed by lunar missions, the technologies involved and how LUVMI-X can help. Space and lunar exploration are great topics to foster imagination and engage with the broader public, especially youth. Some LUVMI-X partners are particularly eager to make LUVMI-X an educational instrument. For instance, the Open University produced comprehensive educational material for primary and secondary school students, which should soon be made widely available through our website and other channels.

What would you say are the most important outcomes of the project so far?

We are at a key moment of the project, with partners working on the manufacturing and testing of the different LUVMI-X components. It is already a success for us to have all LUVMI-X instruments and the rover platform

design completed at this point in time, especially when considering all the hurdles COVID-19 generated. We suffered from restricted access to laboratories, the impossibility of travelling and collocating, delays in parts manufacturing, etc.

The integration of partners’ contributions to the LUVMI-X rover is the next major step, which should allow us to proceed with the final test campaign in ‘analogue’ locations, that is, in outdoor (natural) or indoor (artificial) areas having certain similarities with the lunar environment.

What happens after that? When do you send your rover to the Moon?

By the end of the project in October 2021, we will have a preliminary design of the flight version and a ground model tested in relevant locations. But a maturation gap remains to make LUVMI-X truly ready for flight: the overall flight design should be further refined, and flight grade parts – which are very expensive – procured. Once this is all behind us, the overall platform will need to undergo a comprehensive battery of qualification tests, including vacuum, thermal and vibration. The overall maturation process is demanding and costly, and would probably span 3 to 4 years after the completion of the LUVMI-X project. We hope that the first LUVMI-X rover will fly to the Moon by 2025!

What do you hope will be the long-term impact of the project?

The LUVMI-X concept includes instruments that will help characterise lunar soil properties and exposure to radiations, identify volatiles’ composition and abundance... the science return will be very high if LUVMI-X indeed moves to the next stage. These scientific outcomes should help us better understand the Moon’s geology and history, as well as prepare for a human return to its surface. They should also further the development of technologies enabling the use of local resources – in support of human presence on the Moon of course, but also in preparation for farther space exploration.

LUVMI-X

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- Coordinated by Space Applications Services in Belgium
- Funded under Horizon 2020-LEIT-SPACE
- cordis.europa.eu/project/id/822018
- Project website: h2020-luvmi-x.eu
- ▶ bit.ly/LUVMI-X-video

A new spin on Jupiter's stormy weather

New EU-funded research is finally offering an explanation as to why winds on Jupiter are a lot more intense than on other planets. These findings could also help us better understand the dynamics of climate change closer to home, both past and present.

Jupiter is a stormy place: the strong winds sweeping the largest planet in our solar system commonly reach 360 km/h. While the gas giant's zonal jets have been observed for centuries, we have so far been unable to explain what makes these flows so powerful.

The EU-funded JUMP (JUperiter Modeling Platform) project has started to finally unravel this mystery. Undertaken with the support of the Marie Skłodowska-Curie Actions programme, the project has been able to demonstrate that the strength of the jets on Jupiter is determined by the rotational energy of the planet.

HIDDEN DYNAMICS

"So far, it has been accepted that the energetic strength of the zonal jets is directly related to the transformation of solar energy into sources of flow motion," says Stefania Espa, associate professor of Hydraulics at the Department of Civil, Construction and Environmental Engineering of the Sapienza University of Rome and JUMP project coordinator. However, she points out, this assertion cannot explain why zonal jets on Jupiter are four times stronger than those on Earth, while Jupiter receives 30 times less solar energy.

To understand the dynamics behind the formation of zonal jets, the team of researchers created the first laboratory model of a gas giant. They reproduced the flows occurring on Jupiter in the lab, simulating the mechanisms inducing the jet's formation and investigating the energy transfer that occurs.

COMBINING EXPERTISE AND DATA

To simulate air movements on Jupiter as well as Saturn, another gas giant, the team implemented a platform combining laboratory and numerical modelling. This enabled them to collect large data sets which were made available in open access to fellow researchers. The data collected in the lab and through the numerical simulations was then combined with planetary observations from space missions.

The researchers also developed a new diagnostic tool based on potential vorticity to quantify planetary turbulence. It enabled them to show for the first time that energy transfer in Saturn's atmosphere is four times less intense than in Jupiter's.

Bringing together the expertise of fluid dynamicists, planetologists and climatologists, Espa and her colleagues aimed at developing a new framework linking jet flows to the rotational energy of a planet. "We showed that zonal jets develop through the coupled action of turbulent cascades and of the spherical curvature in planets, the so-called beta effect," Espa notes. "We also demonstrated that the energetic magnitude of the jets depends on the rotation rate and the planetary radius only." These findings offer an explanation as to why the zonal jets on Jupiter are stronger than those on Earth, as Jupiter spins 2.4 times faster.

CONTRIBUTION TO CLIMATE RESEARCH

In addition to improving our knowledge of Jupiter's internal dynamics, the JUMP team's work could provide important clues for climate research. "Zonal jets are known to play a crucial role in the organisation of the climatic system by transporting heat, humidity, gases and nutrients around



Jupiter is a stormy place: the strong winds commonly reach 360 km/h

“We showed that zonal jets develop through the coupled action of turbulent cascades and of the spherical curvature in planets, the so-called beta effect.”

the planet,” Espa explains. “A deep understanding of the physics ruling the formation of these jets is a prerequisite for analysing both past and future climate changes.”

JUMP

- Coordinated by Sapienza University of Rome in Italy
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/797012
- Project website: bit.ly/JUMP-project
- ▶ bit.ly/JUMP-video

New rover system can make its own decisions and... improvise

The ADE project has conceived a new kind of rover system that can make autonomous research and itinerary decisions as it travels over long distances. It will further the path to robotic and manned exploration missions to the Moon and Mars, and can even be used in earthlier nuclear and mining environments.



Rovers are great pieces of engineering meant to function in even the harshest environmental conditions. But whilst the most recent versions of these scientific labs on wheels can perform some operations autonomously, there are still many situations they can't handle on their own.

Say a rover needs to travel a very long distance on the surface of the Moon or Mars. On its way, it might encounter unforeseen environmental hazards or even discover interesting features that arouse its scientific curiosity. There are currently two possible ways to deal with such situations: teleoperation or on-board sequencer plans improvised by an army of mission operators and scientists back on Earth. But the ADE (Autonomous decision making in very long traverses) consortium proposes an alternative: a demonstrator relying solely on autonomous decision-making by the rover itself.

“We proposed and successfully proved a system with an on-board planner that can decompose high-level goals – such as moving a sample from position A to B or taking an image at a given position – into actions fully

independent of human control,” says Mariella Graziano, executive director of Flight Systems and Robotics at GMV. “We achieved this thanks to an autonomous navigation capability, a scientific agent to search for patterns of interest and analyse them, a novel fault detection, isolation and recovery (FDIR) system, a soil traversability analysis, and many other challenging features.”

The new rover is an impressive and complex system of systems, but what truly stands out – and is even revolutionary in project coordinator Jorge Ocon’s own words – is its mission planning system. “The approach that consists in adding a dynamic planner on board and combining it with the other rover subsystems is a clear breakthrough. It’s a whole new way of commanding and managing space missions that will increase mission performance, reliability and optimisation of on-board resources in unknown and critical environments,” he notes.

To put it simply, ADE is pushing a paradigm shift in which ground station operators tell the robot what to do, but let it decide how to do it. This is all expected to reduce the time required to perform rover operations on Mars or the Moon, increase scientific return and improve rover resilience.

DESTINATION THE FINAL FRONTIER... BUT NOT ONLY THERE

With its autonomous decision-making, the ADE system could prove key to the success of future human exploration of Mars and the Moon. The astronauts who will eventually set foot there will need all the intelligence they can get to guarantee their survival, and that implies precise knowledge of the planetary environment, location

“It’s a whole new way of commanding and managing space missions that will increase mission performance, reliability and optimisation of on-board resources in unknown and critical environments.”

of resources and even places where settlements can be established.

But it can have its uses on Earth, too. “The capabilities of ADE can be used in nuclear or mining environments, during search and rescue missions or in underwater operations, and proving this potential was a secondary objective for the project,” Graziano adds. GMV successfully developed a demonstrator which can characterise an area autonomously, detect and delimit areas of high radioactivity within a nuclear power plant, and spot leaks that could require human intervention.

With the project now completed, GMV will continue to mature its new technology. They hope to see it used both in future space exploration missions and during sensitive missions here on Earth.

ADE

- Coordinated by GMV in Spain
- Funded under Horizon 2020-LEIT-SPACE
- cordis.europa.eu/project/id/821988
- Project website: h2020-ade.eu



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→ anchor.fm/cordiscovery





PROJECT OF THE MONTH

Insights from the most comprehensive study ever on the world's glacier retreat

A new study published in 'Nature' has shown that almost all of the world's glaciers have become thinner and have lost substantial mass over the past two decades – and that this trend is only accelerating. In the most comprehensive and accurate analysis yet, an international research team, which also included the EU-funded ICEMASS project, has raised the alarm about the potential dire consequences if the trend continues.

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“ICEMASS contributed a number of methods that were crucial to the study and I'm very pleased with how our findings and developments were taken up in such a collaborative and interactive way as was done with the 'Nature' study.”

Andreas Kääb, ICEMASS principal investigator

The study highlighted that the fastest melting glaciers are in Alaska, Iceland and the Alps but glaciers in the Pamir Mountains, the Hindu Kush and the Himalayas are also being profoundly affected. This is particularly concerning for countries in South Asia, such as India and Pakistan, where glacial meltwater in the dry season is a crucial source of water. However, the study also surprisingly found some glaciers experienced slower rates of retreat from 2010-2019, such as those on Greenland's east coast and in Scandinavia – but the researchers attribute this to a weather anomaly in the North Atlantic that caused higher precipitation and lower temperatures.

The European Research Council-supported ICEMASS (Global Glacier Mass Continuity) project contributed to the wider global study by developing an innovative 'sensor model' that enabled the exploration of 20 years of satellite stereo imagery (imagery taken of the same point on the

Earth's surface but from different space camera angles). This allowed the researchers to unlock valuable repeat Earth surface measurements hidden deep within the data. ICEMASS also conducted several pilot studies that tested and demonstrated for smaller regions, which was then done globally for the entire study.

For more information on the study, which was led by the Swiss Federal Institute of Technology in Zurich (ETH Zürich), please go to: bit.ly/worlds-glaciers-melting-faster

For the study itself, please go to: go.nature.com/35Axmxy

ICEMASS

- Hosted by the University of Oslo in Norway
- Funded under FP7-IDEAS-ERC
- cordis.europa.eu/project/id/320816

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!



FOOD AND NATURAL RESOURCES

Robotics to accurately monitor grape production in European vineyards

Monitoring growth and production of grapes is now greatly improved with the help of a robot. Thanks to EU-funded research, gathering critical data on plant water status and canopy vigour of vines has just become much easier.

Methods currently used to monitor grapes' growth and ripening for harvesting do not provide the most reliable and useful information on the crop to winegrowers. Manual methods are time-consuming and physically demanding, so they are not used on a regular basis.

Accuracy is critical to maintain the high quality of European wines and ensure the EU remains the world's leading producer of wine. Currently, the EU has 45 % of the world's winegrowing areas and 70 % of exports.

Water is equally important to grape quality. According to UNESCO, agriculture is the largest freshwater consumer by far and accounts for 70 % of freshwater withdrawals from rivers, lakes and aquifers. Given this high percentage, "a sustainable and circular approach is needed to optimise the water use, but it is difficult at present because there

is no efficient way to estimate the water status (and thus real needs) of the plants," explains Francisco Rovira-Más, project coordinator of VineScout (Intelligent decision from vineyard robots).

ROBOTS IN THE VINEYARDS

The EU-funded VineScout project successfully developed the concept of a monitoring robot for vineyards, creating an efficient solution for monitoring water status and canopy vigour of vines. The VineScout robot has automated this task by combining crop and ambient sensors that can make estimates in real time and without touching the plants.

The robot collects the data in the field taken less than 1 m from the plants. This allows for more accurate



and reliable data collection. Several crop sensors take canopy temperature and geo-referenced multispectral information regarding the vines, while maps on canopy temperature and vegetative growth are obtained by computing vegetative indices. The data is then transferred to the winegrower, who monitors the status and needs of the vineyard and takes decisions on the best time to irrigate, apply treatments or select different zones to harvest the grapes more efficiently.

Essentially, the robot maps the field. “We have moved from 30 measurements to over 20 000 for the same vineyard. Massive data paves the path for big data applications and the effective implementation of AI algorithms that will eventually let us understand such complex phenomena as water stress resistance and plant growth under a climate change scenario,” notes Rovira-Más.

LOOKING TO THE FUTURE OF VINEYARD AGRICULTURE

Developing this robotic concept with a navigation system that does not require any pre-recorded mapping and a propelling system relying only on renewable energy was truly an ingenious achievement. The team has also submitted a European patent on the navigation algorithm. “We believe that this solution may be the forerunner of

“ *We believe that this solution may be the forerunner of many future agricultural robots, as it has been validated in actual vineyards for many hours during the project.* ”

many future agricultural robots, as it has been validated in actual vineyards for many hours during the project,” concludes Rovira-Más.

Having reduced the drudgery of physical work with the introduction of computers and automation in European vineyards, viticulturalists expect to have not only more young professional farmers (under 35) on the scene, but also more women as managers and entrepreneurs of farm-based businesses.

VINESCOUT

- Coordinated by the Polytechnic University of Valencia in Spain
- Funded under Horizon 2020-Societal Challenges and Horizon 2020-Industrial Leadership
- cordis.europa.eu/project/id/737669
- Project website: vinescout.eu/web
- bit.ly/2R14FX4

FOOD AND NATURAL RESOURCES

Reducing mycotoxin contamination in food and feed

Climate change is increasing the adaptability, and so prevalence, of mycotoxins in food and feed, risking human and animal health. MycoKey has developed biological and ICT solutions to mitigate risk along the food and feed supply chain.

Mycotoxins, compounds produced by microscopic fungi, are harmful to humans and animals, causing illnesses ranging from acute poisoning to immune deficiency and some cancers. They can infect plants throughout the growth cycle, and contaminate crops during storage. Through infected feed, mycotoxins can also contaminate animal products such as milk, eggs and meat.

A recent study confirmed the Food and Agriculture Organization's (FAO) 1985 estimate that mycotoxin contamination was present in 25 % of food crops globally. Improved analytical methods suggest that occurrence below detectable levels has likely been underestimated.

The EU-supported MycoKey (Integrated and innovative key actions for mycotoxin management in the food and feed chain) project, building on the previous MYCORED project,



developed new procedures and tools to reduce mycotoxin contamination in fields, feed and post-harvest supply chains.

“As introducing safer crops at the start of the food chain reduces health risks, we prioritised more environmentally friendly prevention, and faster detection, of mycotoxin contamination in the field,” explains Antonio F. Logrieco, project coordinator of MycoKey and director of the Institute of Sciences of Food Production at the National Research Council in Italy. “We also developed solutions for further along the food and feed process.”

NEW SUPPLY CHAIN SOLUTIONS

MycoKey primarily selected cereals for study such as barley, maize and wheat, along with some dried fruits and grapes. The project concentrated on the mycotoxins of particular concern to regulatory authorities – aflatoxins, deoxynivalenol, fumonisins, T-2 and HT-2 toxins, zearalenone and ochratoxin A.

The team successfully tested biocontrol strategies using non-toxicogenic microorganisms introduced in wheat and maize chains in the EU and China. These biocontrol agents successfully reduced deoxynivalenol accumulation in wheat by 69 % to 85 % and in the case of maize reduced aflatoxin by 98 % to 100 %.

The team also created a prototype decision support system, available through an open-source app, to predict mycotoxin occurrence in some crops. This was supported by monitoring tools, including rapid multi-mycotoxin detection in cereal dust. Samples from this device can be analysed on-site by strip testing, or sent to a lab for mass spectrometry assessment.

For contaminated harvests, improved cleaning technologies were developed for use in sorting machinery. Industrial-scale cleaning used in the Grain Plus mechanical separator reduced aflatoxin in maize by up to 100 %. Additionally, the team developed a yeast-based fermentation process, to produce biogas and bioethanol from contaminated batches.

For contaminated feed, bentonites were tested as detoxifying agents with industry partners Laviosa and Lesaffre. The bentonites mixed with feed absorb the mycotoxins, reducing their bioavailability.

“Using these biocontrol agents, treatments and tools, farmers have sustainable solutions in line with the Farm to Fork Strategy,” says Logrieco.

SAFE FOOD REGULATION

While good agronomic practices – such as tillage, resistant plant varieties and fungicides – can mitigate mycotoxin contamination, climate change has resulted in more toxigenic fungi that can overcome plant resistance and fungicides.

MycoKey supports the European Green Deal by adapting agronomic practices to reduce the use of agricultural chemicals. The project has also set up links with scientific groups working on mycotoxins in China, which have been of increasing concern to European authorities given the importation of Chinese crops.

“MycoKey has provided new information – for example about toxicokinetics and modified forms of deoxynivalenol, zearalenone and aflatoxin – that can help EU food safety regulators and support industry in adapting their food processes,” adds Logrieco.

MycoKey’s results will now also be used in other food safety projects, for example as input for mapping exercises in the EU-supported FoodSafety4EU project, and input for training in MycoTWIN.

MYCOKEY

→ Coordinated by the National Research Council in Italy

→ Funded under Horizon 2020-FOOD

→ cordis.europa.eu/project/id/678781

→ Project website: mycokey.eu

→ bit.ly/3b98twQ



Grass paper – a new contender in paper packaging

Paper manufacturing is amongst the most intense CO₂-emitting industries. Grass Paper has mined nature for an alternative plant-fibre material derived from grass, preserving natural forest resources. The first grass paper on the market has a premium look and feel, with folding capability for packaging.

The plastic pollution crisis that overwhelms our environment and the associated greenhouse gases emitted during their manufacture are a growing threat to the Earth's climate. The intuitive idea of replacing plastics by paper is not reassuring since the basic raw material the paper industry leverages stems from forests. Biologically diverse forests are significantly being altered by pulp plantations that change their ecological value. The fast-growing sprawl of eucalyptus, which serves as a main raw material for the paper industry, exacerbates forest fires.

A SUSTAINABLE RAW MATERIAL ALTERNATIVE FOR PAPER

With EU funding of the project Grass Paper (Grass Fibre as raw material for innovative Grass Paper products: the new economic and ecological resource for the European paper industry), Germany-based company Creapaper introduced a new highly innovative, sustainable and cost-efficient raw material for the paper and packaging industries. After a few attempts with diverse raw materials beyond wood and recycled paper, the company ended up with grass,



and more specifically, hay. “Dry hay is cut to fibre length and then grinded, and finally pressed into pellets before it goes to the paper mill and becomes paper,” explains Michael Schatzschneider, Creapaper’s CFO.

Creapaper’s pure mechanical process eliminates the need for chemical additives and water for manufacturing paper pulp. With grass, no chemical treatment or large water amounts are required to dissolve lignin – a natural glue that holds cellulose fibres together and makes them sturdy – as grass hardly contains any.

The company claims that their patented mechanical process saves around 300 kg of CO₂ emissions for each tonne of grass paper produced compared to traditional paper production. On top of that, Creapaper uses only 2 l of water for manufacturing 1 t of grass pulp. Producing 1 t of pulp from wood, which is necessary for paper production, takes about 6000 l of water. Comparing the energy and CO₂ footprints yields equally positive results: “Producing 1 t of mechanical grass pulp requires only 0.2 MW of electrical energy,” adds Schatzschneider.

GRASS FIBRE’S PROMISING POTENTIAL

Grass fibre could become the paper industry’s third raw material resource besides wood pulp and recycled paper. It cannot fully replace virgin fibres or recycled pulp (wood) but can constitute currently up to 50 % of the fibre content in the final product. Grass fibre is also up to 70 % cheaper than wood pulp. Grass fibre is offering the industry a more responsive and mild way to treat forest resources. “I believe grass and wood is the perfect symbiosis when it comes to paper products and packaging in the near

“ *I believe grass and wood is the perfect symbiosis when it comes to paper products and packaging in the near future.* ”

future,” says Schatzschneider. Furthermore, grass fibres are an additional revenue stream for farmers when it comes to abandoned grassland hay, which is currently being burnt or destined for filling biogas plants.

Creapaper recently installed the first industrial grass fibre production line and is adding a smaller mobile facility this year which will save logistical costs and allow even more cost-efficient production. With grass paper, Creapaper targets the production of food bags, plates, trays, cups, straws, cards, mailers and packaging folding boxes mainly as a B2B offering for brand owners and large retailers. Large mail order companies are already testing the product as packaging material.

GRASS PAPER

- Coordinated by Creapaper in Germany
- Funded under Horizon 2020-Societal Challenges, Horizon 2020-SME and Horizon 2020-LEIT
- cordis.europa.eu/project/id/829282
- Project website: creapaper.de/en

Mass transfer via elastomeric stamps achieves industrial-scale fabrication of 3D integrated microelectronics

The production of integrated circuits on semiconductor wafers revolutionised the electronics industry. The next revolution might come with high-throughput transfer and integration of multiple microdevices on other substrates with technology resembling a rubber stamp.

Integrated circuits or ‘chips’ replaced the discrete components and soldered joints of conventional electronics with many circuit elements on a semiconductor wafer. This facilitated ever greater functionality and higher performance, significantly smaller sizes and weights and lower energy consumption. It also slashed production and testing costs and waste. Photonics integrated circuits are doing the same for optical devices and optoelectronics.

As performance demands continue to increase, achieving device scaling and cost reduction requires a new modus operandi. Heterogeneous integration unites dissimilar and separately manufactured components on a common platform in a so-called system-in-package. The EU-funded MICROPRINCE (Pilot line for micro-transfer-printing of functional components on wafer

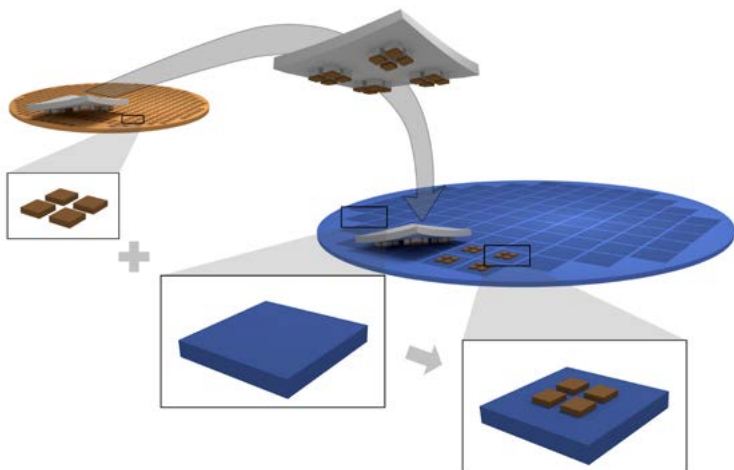
level) project has established a foundry pilot line for heterogeneous integration based on one of the most promising techniques under development over the last 15 years. A diverse portfolio of demonstrators paves the way for innovators to expedite the production readiness of their groundbreaking devices in multidisciplinary fields.

A RUBBER STAMP FOR ALMOST ANY KIND OF ‘PAPER’

With increasing component and product complexity, the likelihood of failures increases, increasing scrap and costs and decreasing yield. Integrating multiple ‘chipselets’ or subsystems is more practical and economical than producing monolithic systems. One of the most promising approaches is micro transfer printing (μ TP), also called mass transfer. μ TP uses an elastomeric stamp to move up to thousands of chiplets or wafer fabricated microscale devices at a time from one substrate to another, like ink in an inkpad is transferred to paper. Until now, the technique was used mostly in labs for scientific research.

DEMONSTRATED FLEXIBILITY FOR TOMORROW’S HIGH-TECH APPLICATIONS

MICROPRINCE established a μ TP pilot line in the X-FAB MEMS Foundry clean room and rolled out four high-tech products. These were gallium arsenide Hall plates for next-generation current sensors, human-eye-response filters for ambient light sensors, gallium nitride LEDs for car ambient lighting modules and indium phosphide photodiodes in silicon photonic circuits. These products were used in functional demonstrators of ambient light sensors, car ambient lighting drivers/packages and integrated silicon photonic infrared spectrometers.



According to Sebastian Wicht, MICROPRINCE coordinator and programme manager of transfer-printing at X-FAB MEMS Foundry, “in addition to μ TP pilot line creation, generic process developments supported the excellent potential of μ TP for 3D integration with high yield, throughput and alignment accuracy. We demonstrated printing or transfer yields of up to 99%, with misalignments below 1.0 μ m. Devices with sizes as small as 100 μ m x 100 μ m x 5 μ m were effectively transferred and stacked on complementary metal oxide semiconductor target dies.”

MASSIVELY PARALLEL PACKAGING AND SUPERIOR PERFORMANCE WITH MINIMAL WASTE

μ TP enables the transfer of thousands of microdevices in a single step with excellent accuracy for very high throughput at comparably low cost. It surpasses state-of-the-art technologies in minimising package size and nearly eliminates the waste of expensive materials and elements. Wicht concludes: “MICROPRINCE has paved the way to industrial implementation of μ TP for 3D and heterogeneous integration. It will support the development

“MICROPRINCE has paved the way to industrial implementation of μ TP for 3D and heterogeneous integration. It will support the development of innovative products with superior performance.”

of innovative products with superior performance, smaller package sizes or even new functionalities in fields from industrial and consumer products to biomedicine.” Interested customers are encouraged to contact X-FAB MEMS Foundry to bring their ideas for new applications to the production realm.

MICROPRINCE

- Coordinated by X-FAB MEMS Foundry in Germany
- Funded under Horizon 2020-LEIT-ICT
- cordis.europa.eu/project/id/737465
- Project website: microprince.eu
- bit.ly/3nMcnyo

INDUSTRIAL TECHNOLOGIES

Natural extracts improve properties of industrial bioplastics

EU-funded scientists have developed sustainable, bio-based materials for use in the automotive and construction sectors. These new materials formed from food waste and agricultural by-products exhibit improved resilience to high temperatures and mechanical stress.

In the developed world, enormous amounts of agricultural waste produced are being thrown away. This organic material can instead be reused to create bio-based plastics.

These bio-based plastics may be used for a range of industrial applications. Once treated and reinforced through the incorporation of environmentally friendly additives, they can meet the needs of manufacturers who currently use plastics from fossil fuels, such as petroleum.

The EU-funded BARBARA (Biopolymers with advanced functionalities for building and automotive parts processed through additive manufacturing) project addressed this

challenge, creating eight new materials through the valorisation of side-stream fractions and residues from agro-food production into novel polysaccharides and functional additives. “BARBARA technology enables the improvement of mechanical, thermal, aesthetical and well-being properties of novel bio-based engineering polymers,” says project coordinator Berta Gonzalvo Bas.

Consortium members received funding from the Bio-based Industries Joint Undertaking, a public-private partnership between the EU and industry. This partnership under Horizon Europe aims to accelerate the development of the circular bioeconomy in Europe, whereby the building blocks

“BARBARA technology enables the improvement of mechanical, thermal, aesthetical and well-being properties of novel bio-based engineering polymers.”

for chemicals, biofuels and materials are derived from biological resources while contributing to climate targets.

THE SWEET SMELL OF SUCCESS

Researchers developed and tested new processes for the extraction and functionalisation of high added-value compounds from agricultural waste such as fruit peels and nutshells. Natural dyes, biomordants, antimicrobials and essential oils were obtained through microwave-assisted extraction and other advanced processes such as the use of supercritical water.

Once all the organic-based components were extracted, the filament spools were prepared for building the prototypes using additive manufacturing (3D printing). The developed materials contained polysaccharides (from maize), pomegranate and lemon pigments, pomegranate biomordants, lemon fragrance and almond peels which gave the materials different colours, scents and textures with antimicrobial properties, while they exhibited resilience to thermal and mechanical stress.

“Additive manufacturing processes involve the use of a continuous filament for 3D printing, which becomes soft on heating and hardens on cooling, creating novel bioplastic pieces with advanced properties for the building and automotive sectors,” Gonzalvo Bas explains.

MULTIPLE INDUSTRIAL APPLICATIONS

Project partners used the new materials to 3D print door trims and a dashboard fascia for cars, with the participation of Italian car manufacturer Fiat. They also created moulds for fabricating truss joints for buildings for the Spanish company ACCIONA Infrastructures. According to Gonzalvo Bas: “BARBARA also contributes with direct impacts to four essential facilitating technologies: biotechnology, nanotechnology, advanced materials and advanced manufacturing technologies, which are the foundations of a wide range of industries.”

BARBARA technology will significantly improve the competitiveness of European companies in different sectors, providing clear improvement to the quality of their products. Agricultural, chemical and biopolymer producers, processing companies, automotive, building and many others fields will benefit from this technology. “Other key industrial sectors in the European economy, such as aerospace, electronics and household appliances, can use biopolymers to produce new bioplastics with excellent structural and functional properties while increasing their sustainability,” she concludes.

BARBARA

- Coordinated by the Aitiip Technology Centre in Spain
- Funded under Horizon 2020-FOOD
- cordis.europa.eu/project/id/745578
- Project website: barbaraproject.eu
- bit.ly/3xWgdeX





DIGITAL ECONOMY

Affordable and reliable internet access available to remote areas

While connectivity is improving in more parts of the world, about 1.4 billion people are still without reliable mobile broadband coverage and aren't enjoying the benefits of high-quality internet access. This is where 5G comes in.

Until now, mobile networks have been designed to address the demands of modern urban areas, where small cells increase the overall capacity and allow for better frequency reuse. This isn't economically feasible in remote areas as low population density would result in few subscribers per cell along with a prohibitive per capita operation cost.

In line with the spectrum allocation procedure, operators must acquire the licence to exploit the spectrum from an auction. But the high cost of spectrum licences makes the return on investment in remote areas unattractive to mobile operators. Quality of service is another challenge as mobile networks are designed to operate in cells within less than 10 km of reach, making performance over larger distances very poor.

LATEST TECHNOLOGY OFFERS SOLUTIONS TO LOCAL INTERNET PROVIDERS

The EU-funded 5GRANGE (Remote area Access Network for 5th GGeneration) project conceived a 5G operation mode to provide reliable coverage for applications in remote areas with a cell radius above 50 km and at least 100 Mbps using high-power customer-provided equipment such as rooftop antennas. The 5GRANGE solution has a redesigned network architecture to provide reliable and cost-effective internet access by applying advanced channel coding and multiple antenna techniques.

"The quality of service has greatly improved when compared with other wireless technologies, since

© Luciano Mendes



“ *This solution has the potential of including a large number of people in the information era, allowing those living away from urban areas to enjoy the benefits of being connected.* ”

5GRANGE is able to provide up to 100 Mbps at the cell border,” notes Luciano Mendes, 5GRANGE technical manager. To tackle the spectrum access issue, cognitive radio technology is used to exploit the vacant UHF channels commonly available in remote areas. The mobile units and the base station access the geolocation database provided by regulators to verify which TV channels are vacant in a given area. These devices carry out the spectrum sensing to assure that the channels are free of unauthorised TV transmissions. This means the vacant spectrum can be exploited without going through the cumbersome and expensive auction process, allowing small and local internet providers to become new players in this market.

BACKUP, REMOTE MAINTENANCE AND SPILLOVER BENEFITS

5GRANGE uses software radio technology, which means that all communications algorithms for the physical, media access control and network layers run on general-purpose processors. The overall cost of the equipment is reduced and allows for higher reliability. Backup base stations can even run on different virtual machines. Updates and troubleshooting can also be performed remotely, and the multiple transmit and receive antennas that provide diversity also work as redundancy in case

of a hardware failure in one of the radio frequency communication chains.

Remote and rural area mobile networks can modernise agribusiness by introducing technology to farms. This concept, known as smart farms, can improve farm productivity without increasing the exploited area. It also minimises pesticide and fertiliser use, lowers production costs and reduces contamination. This means fewer environmental impacts and improved quality of life. New digital services also become available to rural areas such as remote health services. 5GRANGE has produced an informative animated video offering an overview of all the above workings and benefits.

Connecting remote and rural areas to mobile networks is feasible and 5G can overcome all barriers to providing true universal internet access. “This solution has the potential of including a large number of people in the information era, allowing those living away from urban areas to enjoy the benefits of being connected,” concludes Marcelo Bagnulo, project coordinator.

5GRANGE

- Coordinated by University Carlos III Madrid in Spain
- Funded under Horizon 2020-LEIT-ICT
- cordis.europa.eu/project/id/777137
- Project website: 5g-range.eu
- ▶ bit.ly/3ut4rXc

DIGITAL ECONOMY

New methods secure and verify IoT for European industry

The Internet of Things has a bad reputation. New security measures bolster user confidence for various new applications.

The Internet of Things (IoT) sounds like it should refer to a separate, dedicated network. Actually, there is only one internet, and IoT refers to a fairly simple form of machine-to-machine communication using it.

One of the most important applications of IoT is allowing sensors (information collectors) to communicate with actuators (moving or changing parts). This combination permits countless technologies of the modern world.

Examples include automotive keyless entry and start systems, automated lighting systems in smart buildings, plus various kinds of smart transportation systems.

The problem is that most IoT applications are insecure and untrustworthy. This becomes very important where wireless technologies combine with security or privacy considerations. Such applications are virtually defenceless against hacking. Once one device is hacked, it can be used to hack all others on a network. In some cases, this can have catastrophic consequences. Users are thus often very sceptical about the security of IoT systems. This deters user adoption and restricts industrial efficiency.

NEW TYPES OF SECURITY EVALUATION

Since user trust in IoT systems is low, the EU-funded SCOTT (Secure COnnected Trustable Things) project developed sound methods for evaluating the security and privacy of IoT services. The new methods prioritise IoT applications in industrial settings and safety-critical domains.

Team members also developed other wireless technologies. SCOTT's technologies improve the state of the art, focusing on closing the remaining security gaps. "SCOTT does not just deal with 'things that are connected', rather 'trustable things that are connected'," explains project coordinator, Michael Karner. "This means things interconnected by dependable, wireless technologies that respect the end users' privacy rules." The new developments provide the fundamental security upon which trust can be built, while also introducing reliable interoperability. The innovations are intended mainly for European industry but also for private citizens in everyday usage.

“SCOTT does not just deal with 'things that are connected', rather 'trustable things that are connected'. This means things interconnected by dependable, wireless technologies that respect the end users' privacy rules.”

DIVERSE APPLICATIONS AND RECOGNITION

The project's system has been demonstrated in sectors including aeronautics, smart infrastructure, health and railways. Applications include air quality monitoring for indoor environments, vehicle sensors connected to smart road infrastructure, and assisted living and community care. "The latter case allows elderly people to stay in their private homes much longer," adds Karner, "as it supports them in getting immediate help in case of an accident, fall or sudden illness." Another example of the project's technology involves a secure cloud management system. It authenticates all communication from a cloud-based service to IoT devices.

SCOTT has been recognised for the security improvements it delivered, and for having helped prepare European industry for widespread adoption of IoT. The resulting IoT applications will be secure and compliant with European values.

Following the successful results, some of the project's industrial partners will release new products during 2021 and 2022. Two of SCOTT's research partners are in the process of launching start-up companies based on the project's developments. Work started in SCOTT will continue in the newly formed Electronic Components and Systems ECSEL InSecTT project. This project will further develop IoT trustworthiness, using AI, for the benefit of Europe's industry and citizens.

SCOTT

- Coordinated by Virtual Vehicle Research in Austria
- Funded under Horizon 2020-LEIT-ICT
- cordis.europa.eu/project/id/737422
- Project website: scottproject.eu
- bit.ly/3etyJmU



Placing ethics at the heart of emerging technologies

New methods and tools have been developed to ensure that ethics and human rights are fully considered in the roll-out of key cutting-edge technologies.



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Artificial intelligence (AI), human genomics and human enhancement are likely to have major economic and social impacts in the near future. At the same time, these emerging technologies raise serious ethical, legal and human rights issues.

“The objective of the SIENNA project was to study these issues, and to propose ways of addressing them,” explains project coordinator Philip Brey, professor of Philosophy of Technology at the University of Twente in the Netherlands.

ETHICAL TECH CHALLENGES

AI includes systems that support human decision-making, are able to analyse large data sets and can recognise faces and behaviours. It also includes machines like intelligent robots and self-driving cars.

“AI can autonomously make decisions and perform actions in ways that were previously reserved for human beings,” says Brey. “But this means that it can also do all

the bad things that humans can do. It can control people, discriminate and violate privacy, for example. Who is accountable if intelligent machines do bad things?”

Human genomics is a powerful technology that could improve human health. “Yet there are important ethical implications here too,” he notes. “Genome sequencing can raise significant privacy issues, as third parties become aware of one’s detailed genetic make-up. This information could be used to discriminate against employees or insurance policyholders.”

Finally, human enhancement is about the improvement of human performance beyond the typical range. Such enhancements might include superior eyes and ears, or legs and arms with improved strength and endurance.

“Many people think the very idea is wrong,” says Brey. “In any case, there are health and safety risks, and concerns about loss of human identity and inequality.”

RAISING ETHICAL AWARENESS

The EU-supported SIENNA (Stakeholder-Informed Ethics for New technologies with high socio-economic and human rights impact) project set out to identify and analyse the ethical and human rights issues connected with these three technologies. It then sought to develop tools and methods to help stakeholders better address and mitigate these concerns.

“We wanted to map out current issues as well as challenges that could be expected over the next 20 years,” explains Brey. “We also wanted to know about the concerns and viewpoints of stakeholders.”

To achieve this, hundreds of stakeholders were consulted, and some 11 000 citizens surveyed across 11 countries. Extensive legal analysis was carried out to understand the current regulatory landscape.

“Based on our understanding of these issues, we developed proposals and solutions,” adds Brey. “We also drew up ethics guidelines. This was particularly needed for human enhancement, as no guidelines existed.” Regulatory and policy recommendations concerning these three technology fields were also put forward.

For human genomics, an international code of conduct for data sharing was developed. Recommendations for including ethical and human rights requirements in legislation and regulation were drawn up. An Ethics by Design approach for AI was also put forward.

“There has already been take-up of our analyses and recommendations,” he remarks. “The European Commission will use our research ethics guidelines for AI and human

“Potentially hundreds of new research projects will make use of our tools and insights.”

enhancement, and our Ethics by Design approach in its ethics review procedure in the new Horizon Europe research programme. This means that potentially hundreds of new research projects will make use of our tools and insights.”

Ultimately, SIENNA has highlighted the fact that ethics and human rights must be central considerations in the development and use of emerging technologies, and not afterthoughts.

“General ethical guidelines can be an important first step for creating awareness of ethical issues,” says Brey. “But they need to be supplemented with specific tools and methods, like research ethics frameworks, professional ethics codes and Ethics by Design approaches.”

This has been the project's critical contribution, as Europe stands on the threshold of a new era in technological innovation.

SIENNA

- Coordinated by the University of Twente in the Netherlands
- Funded under Horizon 2020-Science with and for Society
- cordis.europa.eu/project/id/741716
- Project website: sienna-project.eu
- bit.ly/3etDLz0



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The Milky Way is draped in the hearts of extinct galaxies

An investigation into mysterious clusters of stars seen in the galactic halo suggests that some of them are the fossil remains of other star systems.

The halo of the Milky Way is studded with clumps of stars known as globular clusters. Typically containing hundreds of thousands of stars packed into a tight sphere, over 150 have been detected around the Milky Way, and many more seen around neighbouring galaxies.

The EU-funded Global-assembly (Building up the Milky Way Halo in the era of multiple stellar populations) project sought to elucidate more about these astronomical bodies. Although one of the simplest structures in the universe, little is known about their origin.

"All the stars inside these stellar systems were thought to have been born at the same time in the early universe," explains Global-assembly project researcher Anna Fabiola Marino. "We've now discovered that's not entirely true."

METALLIC STARS

Marino's research focused on one phenomenon of globular clusters, the existence of multiple populations of distinct stars within the constellation.

While some of these stellar populations are made up of primordial material – thought to have emerged in the early

universe – others are rich in elements like helium, nitrogen and sodium, suggesting that these stars appeared and developed later.

“This metallic variation is considered a feature of galaxies, which have much more mass than globular clusters,” notes Marino, who carried out the work at the University of Padua in Italy.

To investigate the globular clusters, Marino created ‘chromosome maps’, 2D charts of stellar luminescence, based on data from the Hubble telescope. These graphs combine a star’s intensity in the UV and optical blue range on one axis with intensity in the UV to infrared range on the other.

Arranging spectra for a sample of stars from a globular cluster in this way reveals the metallic characteristics of the different populations of stars. “Our spectroscopic analysis provided a key to read the map, with each population identified by its chemical profile,” adds Marino. “We can then apply that to all populations in the globular cluster, linking photometric and spectroscopic data.”

GALACTIC HEARTS

As a result, Marino found that many clusters have a similar metallic profile to galaxies, hinting that they could be the remains of much larger stellar aggregations. “A few of them could be galaxies themselves – remnants of former galaxies that have been captured by the Milky Way,” she says.

“*It’s crucial for our understanding of stellar formation, and has wider implications for many things in astrophysics.*”

Her work was supported by the Marie Skłodowska-Curie Actions programme. “The grant provided funds for research, but also the opportunity to collaborate with complementary research,” she adds. “Because of this I was able to obtain significant results.”

Marino has since secured a permanent position at Italy’s National Institute for Astrophysics in Florence. “I think the fellowship helped me a lot to get the right results to be competitive and have a chance to get this position,” she notes.

She plans to continue her research into the origin of globular clusters in the Milky Way, in particular with the aid of the forthcoming James Webb telescope, set to be launched in late 2021: “It’s crucial for our understanding of stellar formation, and has wider implications for many things in astrophysics.”

GLOBAL-ASSEMBLY

- Coordinated by the University of Padua in Italy
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/797100

SPACE

New analytical model could shed more light on star and dark matter distribution in galaxies

EU-funded researchers developed improved theoretical tools to yield a clearer picture of galaxy formation and matter distribution for different underlying cosmological models.

Near-future cosmological surveys are expected to detect billions of galaxies, pinpointing their locations and shapes with incredible accuracy. These measurements can be

used to infer how the universe has evolved and has been brought to its current state. In turn, this information can be used to infer the fundamental constituents of

the cosmos and potentially allow new insights into the mysterious dark energy and dark matter that make up the vast majority of the mass in the universe.

“To elicit meaningful information from galaxy properties for dark matter requires sound theoretical understanding of the reverse process: how do different theoretical models of dark matter and dark energy affect cosmological structure formation, and therefore, galaxy properties?” says Alexander Mead, coordinator of Halo modelling (Using the halo model to maximise the information gain from forthcoming weak-lensing surveys), a project funded under the Marie Skłodowska-Curie Actions programme.

IMPROVED COSMOLOGICAL HALO MODEL

A straightforward way to probe structure formation is to run cosmological simulations that involve exhaustive brute force attacks for every cosmological scenario imagined. The Halo modelling project developed new theoretical tools that save millions of hours of computing time.

“Our newly developed semi-analytical model brings several improvements to the long-established halo model by merging insight from state-of-the-art simulation results. For the first time, it treats the halo constituent parts – stellar, hot gas and dark matter halos – as separate, thereby drawing a more consistent picture of galaxy evolution. It also allows us to use the same underlying theoretical framework to calculate cross-correlations

“ *A semi-analytical model that bridges the gap between pure theoretical insight and simulation results will always be an invaluable tool in the arsenal of cosmologists.* ”

between different tracers of large-scale structures in the universe,” explains Mead.

Another part of research was geared towards providing a more accurate description of how gravitationally bound clumps of matter are distributed on the tenuous gas halo and invisible dark matter halo. With their new model, researchers succeeded in modelling matter distribution with accuracy greater than 3% for a wide range of cosmological models. The new model fed into new open-source software called HMcode-2020.

Ultimately, researchers realised that a serious shortcoming in the standard cosmological structure-formation theory is that it treats the halo bias – a quantity that reflects how dark matter haloes are clustered compared to the underlying matter distribution – in a simplistic way. “Linear relationships err in describing the dynamics around collapsed structures. Further developing the perturbation theory to deal with non-linearities is at the cutting edge of theoretical cosmology,” adds Mead.

“Improved simulations could render a clearer picture of how galaxy formation responds to the background cosmological model, including the amount and types of dark energy and dark matter, but simulating all weird and wonderful cosmological scenarios under consideration would be impossible. A semi-analytical model that bridges the gap between pure theoretical insight and simulation results will always be an invaluable tool in the arsenal of cosmologists,” concludes Mead.

HALO MODELLING

- Coordinated by the University of Barcelona in Spain
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/702971
- Project website: alexander-mead.github.io





FUNDAMENTAL RESEARCH

Synthetic cell models help researchers study the origins of life

Pioneering research into a key biological process has shed new light on the origins of life, and opened up new ways for scientists to study living things.

The phenomenon of self-reproduction has been extensively studied, not only because it might explain how life began, but because it plays a critical role in everyday biological processes. It helps to ensure that biological systems are self-sustaining.

“How chemical systems made from very simple materials can become autocatalytic, and how complex the chemistry from those ‘simple’ systems can become, is still not well understood,” says Stephen Fletcher, professor of Chemistry at Oxford University in the United Kingdom and project coordinator of Autocat (Autocatalysis: A bottom-up approach to understanding the origins of life).

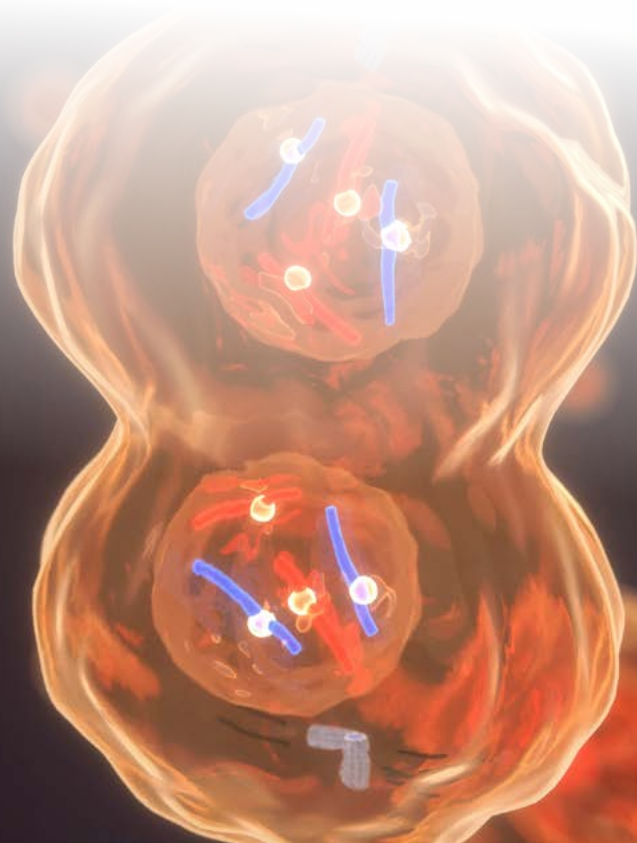
SELF-REPLICATING SYSTEMS

To address this, Fletcher set out to develop simple models of cells that self-reproduce, to explore what happens at

the level where chemical molecules become involved in systems. By using two simple chemical building blocks to produce more complex products, which then produced primitive cell-like structures, he was able to shed light on how these processes operate.

These models allowed Fletcher and his team to study processes related to how life may have started in new ways, enabling chemistry to become biology billions of years ago.

“What we have been doing essentially is sleuthing,” he explains. “We mixed different molecules together, to see if we could develop these complex self-replicating systems.”



A key breakthrough came with the ability to create self-replicating systems that broadly resemble how biological systems work. The team then kept these systems in an energy-consuming state, which scientists call out of equilibrium.

"We were able to create much more advanced self-reproducing protocell models than had been seen before," adds Fletcher.

REALISTIC BIOLOGICAL MODELS

Fletcher notes that Autocat has evolved over time. While the project has made advances in better understanding autocatalysis, the development of synthetic out-of-equilibrium systems has created new research opportunities.

"We can now examine what happens when we put these systems in competition with each other, and they compete for resources or building blocks," says Fletcher. "Does one product predominate, and is there a selection mechanism? If so, why does this happen?"

Furthermore, the research led Fletcher to understand the benefit of developing biological models that more closely replicate life. "Autocatalytic reactions are a really fast way of making something," he notes. "They just create, create, create."

"But life isn't really like that," he adds. "People are born, they live, and then they die. Our cells are the same, they don't go on replicating forever."

The Autocat project has put Fletcher and his team at the forefront of developing functional reproductive models that more closely reflect what happens in biology.

"Before, we were just trying to mimic replication," he explains. "Now we are trying to harness energy consumption and mimic other more complex biological phenomena."

Fletcher notes that there is now a whole research community dedicated to investigating out-of-equilibrium systems. "The beauty of the European Research Council grant was that very little of what we are doing now was in our original application," he says.

"But we were able to take our project forward and stay at the cutting edge of an innovative field. We would never have been able to achieve this without the ERC grant."

AUTOCAT

- Hosted by the University of Oxford in the United Kingdom
- Funded under Horizon 2020-ERC
- cordis.europa.eu/project/id/681491

FUNDAMENTAL RESEARCH

Research uncovers mechanisms that steer fascinating phase transitions from the insulator to the metal

Tuning the properties of a material by flashing extremely fast light pulses on it is a potential pay-off down the road from light-matter interactions. An EU-funded project revealed new insight into the mechanisms that underpin a quantum material's phase transitions when excited by light.

Since the discovery of the quantum nature of light and matter, researchers have devoted great effort to investigating complex dynamics phenomena arising from their interactions. Rational understanding of light-matter interactions has enabled the development of a wide range of technologies including LEDs and light-harvesting devices.

It has also offered the opportunity to synthesise materials imbued with new properties, such as conducting electricity.

Funded under the Marie Skłodowska-Curie Actions programme, the StrongLights (Controlling Photoinduced Transitions with Strong Light Pulses in Condensed Matter)



project focused on furthering understanding of the effects of shooting a quantum material with ultrashort laser pulses at the near-infrared and ultraviolet. Electrons in quantum materials strongly interact with vibrations in the crystal lattice and cause photoinduced phase transitions. “Our main goal was to investigate the key microscopic factors that govern photoinduced phase transitions and controlling them by ultrastrong light pulses,” notes Angel Rubio, StrongLights coordinator.

MODELLING THE ELECTRONIC STRUCTURE OF A PHOTSENSITIVE MATERIAL

Researchers carried out first-principle calculations for periodic molecular systems. The analysis of electronic and structural changes in certain materials at the nanoscale almost reached the processing speeds of supercomputers.

Special focus was placed on the (MeBr-DCNQI)₂Cu molecular crystal that changes its phase when excited by light. This low-dimensional system exhibits a Peierls-type distortion at low temperatures, switching from an insulating phase to a metallic one. This observation served as a benchmark for comparing the crystal's electronic band structure at high and low temperatures. The crystal also presented a unit cell three times larger than that at high temperatures.

KEY FACTORS THAT TRIGGER PHOTOINDUCED PHASE TRANSITIONS

The team demonstrated that Coulomb repulsion forces play a significant role in properly characterising the crystal's structural and magnetic properties in the low-temperature phase transition. “We have shown the need for a surprisingly high Hubbard (U) value for the conjugated molecular systems (or π systems) to reproduce the experimentally observed charge separation phase at low temperatures,” notes Rubio.

The value of the on-site Coulomb interaction U was determined from standard trial-and-error methods as well as from recently proposed first-principle calculations. Results also showed that a non-standard U value for the conjugated systems of the crystal's organic molecules is necessary for localising lone pairs.

“Although we did not calculate the specific electron-phonon couplings, we identified the geometrical changes involved in the crystal's photoinduced phase transitions. This step is crucial for interpreting the vibrational modes that initiate phase transition when the system is heated or cooled,” adds Rubio.

DETERMINING THE ELECTRONIC PROPERTIES IN EXCITED STATES

Researchers extended their local density approximation methods to determine the crystal's electronic excitation properties, such as the transition dipole moments and transition densities. The team proved their new scheme is crucial for determining exciton couplings, and therefore, excitation energy transfer dynamics that govern phase transitions from the insulator to the metal. The newly developed method has been implemented using the Octopus code.

Researchers are working on machine learning techniques such as kernel ridge regression and deep neural networks to determine the molecular excitation spectra in an efficient and predictable manner.

“Ultrastrong light pulses are powerful tools for modifying strongly correlated materials. We have taken a step forward by controlling not only the ground-state electronic properties but also the excited-state electronic dynamics of photosensitive crystals. By mixing different light pulses, we create new meta-stable states that demonstrate intriguing properties that have far-reaching implications for materials science,” concludes Rubio.

STRONGLIGHTS

- Coordinated by the Max Planck Society for the Advancement of Science in Germany
- Funded under Horizon 2020-MSCA-IF
- cordis.europa.eu/project/id/795246



AGENDA

SEPTEMBER/OCTOBER 2021

BRUSSELS, BELGIUM
InGRID-2 Final Conference
→ inclusivegrowth.eu
→ bit.ly/InGRID-2finalconference

**9 → 10
SEPT**

**9 → 11
SEPT**

ROME, ITALY & ONLINE
World Congress on Infectious Diseases (WCID 2021)
→ bit.ly/WCID2021

LYON, FRANCE
Hydropower-Europe (HydroES 2021)
→ bit.ly/HydroES2021

**21 → 23
SEPT**

**15 → 17
OCT**

BUDAPEST, HUNGARY
2nd World Conference on Social Sciences Studies
→ 3sconf.com

AACHEN, GERMANY & ONLINE
CIVITAS Forum 2021
→ civitas.eu/forum2021

**20 → 21
OCT**

**20 → 22
OCT**

MILAN, ITALY
European Research Workshop in International Trade (ERWIT) 2021
→ bit.ly/ERWIT2021

**25-29
OCT**

ONLINE

EU Sustainable Energy Week (ESEW)

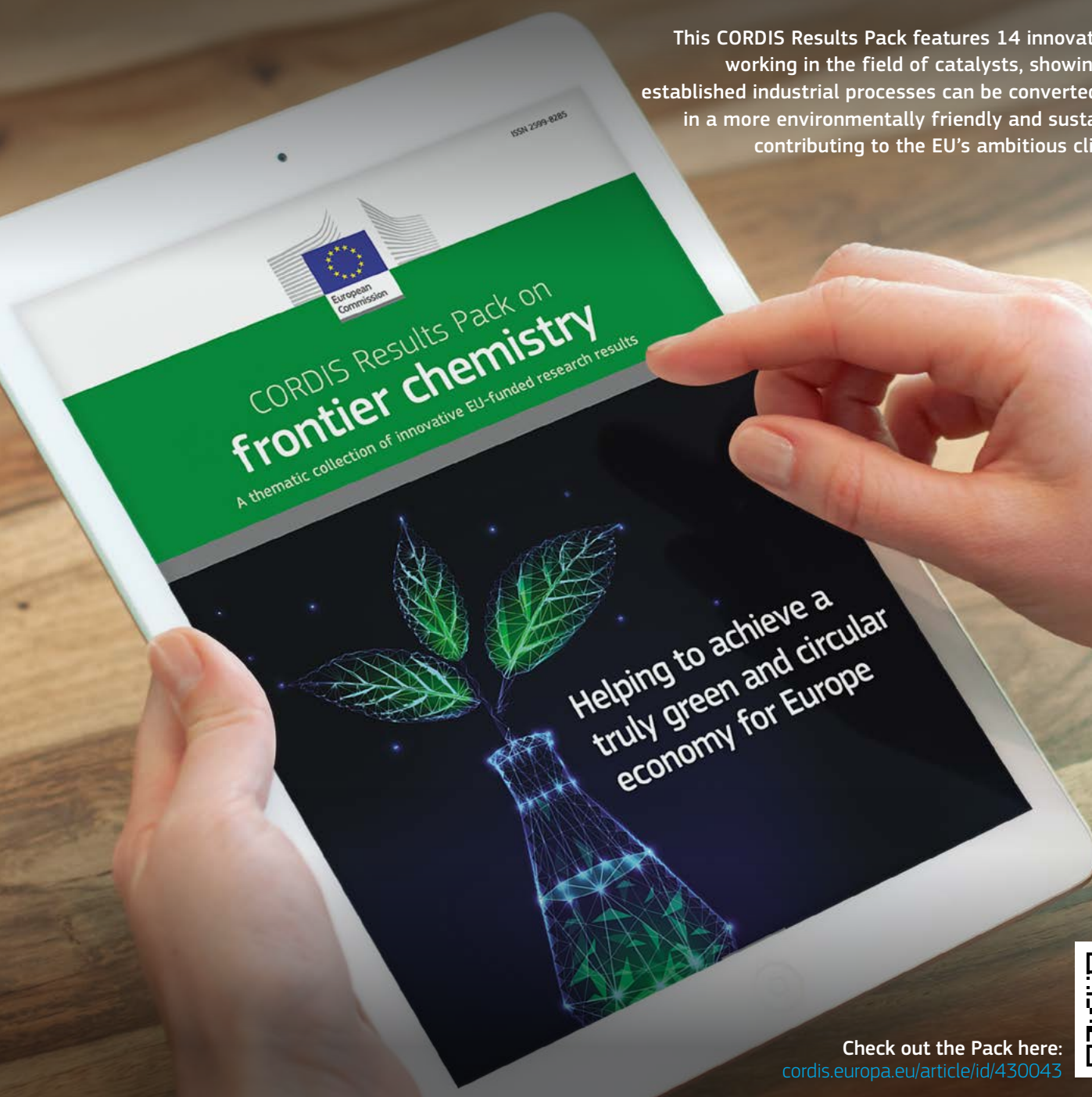
This year's ESEW, on the theme of 'Towards 2030: Reshaping the European Energy System', will again be online only. The event will comprise a three-day digital Policy Conference, the EUSEW Awards, the second European Youth Energy Day and 1:1 video meetings, virtual stands and other networking activities. Participants will also have access to online side events and Sustainable Energy Days, digital events taking place across Europe. Registration opens in September 2021.

→ eusew.eu

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

RESULTS PACK ON FRONTIER CHEMISTRY

This CORDIS Results Pack features 14 innovative projects working in the field of catalysts, showing how long-established industrial processes can be converted to operate in a more environmentally friendly and sustainable way, contributing to the EU's ambitious climate goals.



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