



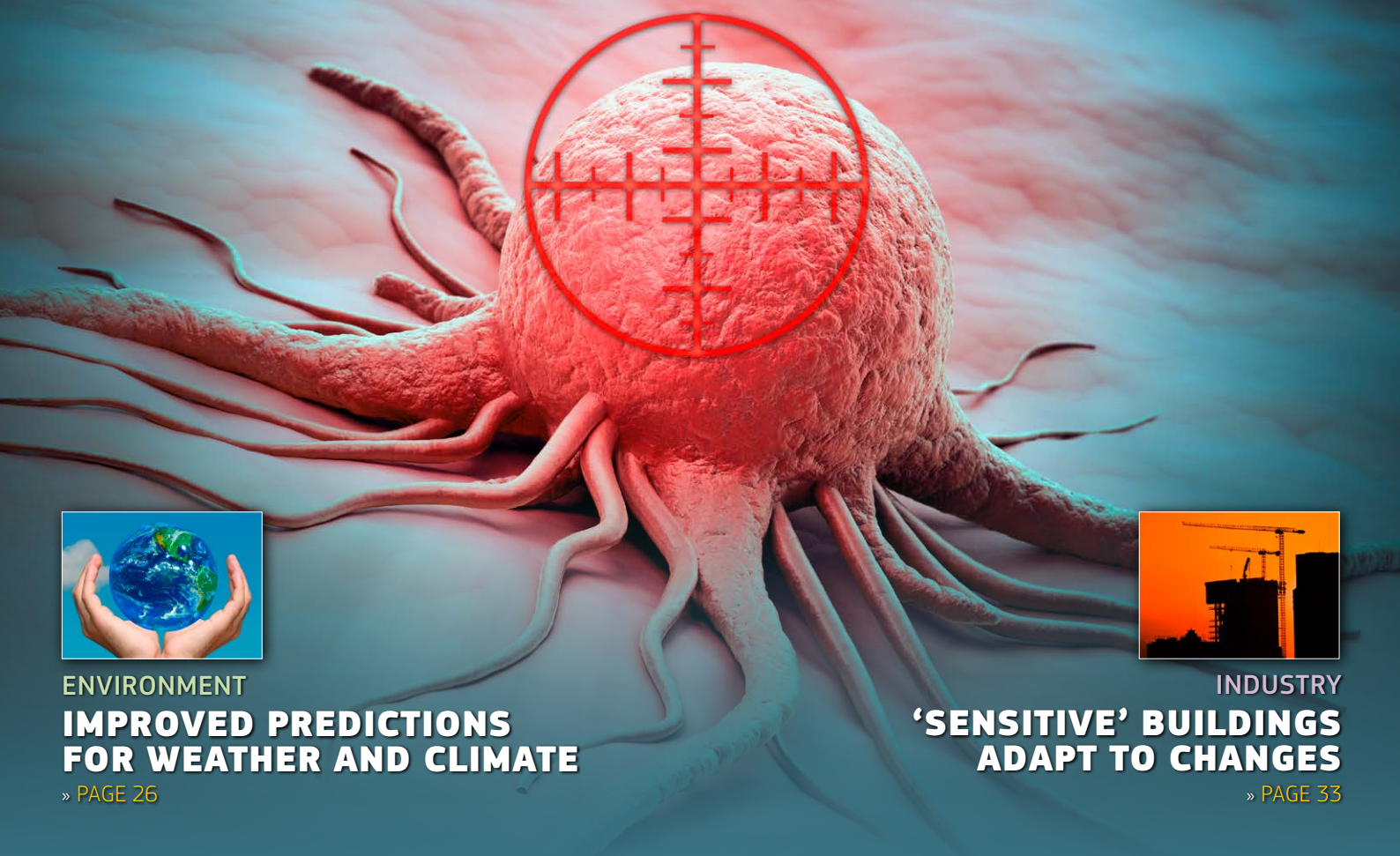
research^{eu}

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N°65
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SPECIAL FEATURE

STEMMING THE BLOOD CANCER TIDE



ENVIRONMENT

**IMPROVED PREDICTIONS
FOR WEATHER AND CLIMATE**

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INDUSTRY

**'SENSITIVE' BUILDINGS
ADAPT TO CHANGES**

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Editorial coordination

Melinda KURZNE OPOCZKY

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EDITORIAL

by the editorial team

BLOOD CANCER: EVER MORE REASONS TO HOPE

September is 'Blood cancer awareness month': an occasion for spreading information about this group of diseases affecting the blood, bone marrow or lymphatic system. Every 35 seconds, a new patient is diagnosed with either leukaemia, lymphoma or myeloma — the three main types of blood cancers. Most cancers in these sub-groups require specific and complex therapeutic strategies, yet, despite continuous scientific advances, most of them are still fatal.

There are, however, reasons to think positive. Since the 1960s, survival rates over five years have grown from 12 to 50% for myeloma, 40 to 89% for Hodgkin lymphoma, 31 to 73% for non-Hodgkin lymphoma, and 14 to 63% for leukaemia.

Haematologic oncology is rapidly evolving, and exciting treatment options are emerging thanks partly to EU-funded research efforts.

**'Haematologic
oncology is rapidly
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treatment options are
emerging thanks
partly to EU-funded
research efforts.'**

A great example of these advances is the cure found for acute promyelocytic leukaemia (APL). Through a combination of arsenic and retinoic acid discovered by Prof. de Thé — whose latest research is presented in this issue of the research*eu Results Magazine — over 95% of patients faced with this formerly incurable disease can now be cured.

Apart from these novel treatments — which include CARIPSCCTCELLS'

off-the-shelf T cell therapies for multiple myeloma and HEAL-BY-MIRNA's miRNA-based cure for B cell neoplasia — EU-funded research also helps shape the future of blood cancer therapies. It does so by opening the path towards increasingly personalised treatments (ONCOSMART, CHEMOS), facilitating clinical trials (INTREALL) or unveiling the processes driving cancer evolution (CLL_INCLONEL).

Besides these projects, which are all introduced in this magazine, others are presented across nine domains of exploitation: health, society, energy, environment, aquatic resources, industry, information and communication technologies, security and fundamental research. The magazine closes with a list of upcoming events hosted by or involving EU-funded research projects.

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



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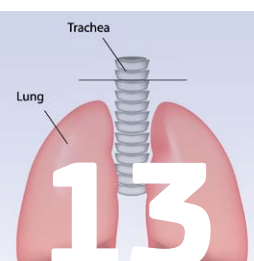


Focus on
Let there be light:
technology
for the visually
impaired

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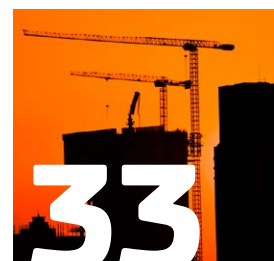


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STEMMING THE BLOOD CANCER TIDE

BOOSTING NEW THERAPIES FOR RELAPSED 'ALL' PATIENTS

To this day, relapsed acute lymphoblastic leukaemia (ALL) is still among the greatest causes of childhood mortality. An EU-wide consortium of 27 partners is hoping to help bring about new and more effective therapies thanks to a dedicated clinical trial platform.

Survival rates for ALL may have jumped from less than 20% to over 80% over the past 40 years, but it all comes at a price. Treatments are now longer and more toxic, and 50% of the patients who relapse still die in the face of failing combinations of chemotherapy and haematopoietic stem cell transplantation (HSCT).

Noting the existence of new and promising drugs waiting to be tested on patients, the INTREALL (International study for treatment of childhood relapsed ALL 2010 with standard therapy, systematic integration of new agents, and establishment of standardised diagnostic and research) project has set out to build the largest clinical trial platform for diagnostics and treatment of childhood relapsed ALL.

'By optimising the standard of care diagnostics and treatment and investigating the integration of new targeted drugs, we aim at improving survival rates and reducing toxicity. This is being done on an international level providing a benefit for all European citizens,' says Dr von Stackelberg, coordinator of the project.

One of INTREALL's most important objectives was the implementation of Phase 2 and 3 clinical trials that could serve as references for the whole world, also providing a unique platform for drug development. Separate trials for standard risk (SR) and high risk (HR) childhood relapsed ALL have been developed, and the project is notably helping investigate the use of Epratuzumab — a CD22 directed monoclonal antibody developed by project partner Immunomedics, which is currently undergoing a large, randomised Phase 3 trial.

'INTREALL allows for the conducting of prospective randomised trials in a reasonable time frame and in the best interest of the patients,' Dr von Stackelberg explains. 'By doing this, it allows for investigating the safety and efficacy of new targeted therapies in context with standard curative treatment strategies.'

Besides Epratuzumab, a notable success in this regard was the integration of a decisive Phase 3 trial on Blinatumomab into the treatment strategy for high-risk patients.

To make clinical trial results available, the consortium has developed a study database for both SR and HR trials, using a system called MARVIN that was developed by project partner XClinical. From there, patients not included in the trials due to clinical or organisational reasons can access a registry tool directing them to open clinical trials and to biologic studies.

Other project-enabled tools include standardised diagnostic procedures, reference laboratories and a virtual tissue bank for patient material that have been established in all participating countries.

The platform can also be used for future trials. In fact, Dr von Stackelberg and his team expect the project to keep going beyond its foreseen completion in September 2017, with support from national funding resources. 'The diagnostic and therapeutic platform will be available for more interested European and non-European countries and study groups. A series of the most attractive and effective new agents will be investigated within the INTREALL group, which will continue to exist in interaction with the competent authorities and industry.'

If the consortium successfully achieves all its objectives, Dr von Stackelberg expects survival rates to improve by about 15%.

INTREALL

- ★ Coordinated by Charité — Universitätsmedizin Berlin in Germany.
- ★ Funded under FP7-HEALTH.
- ★ <http://cordis.europa.eu/project/rcn/102104>
- ★ Project website: <http://www.intreall-fp7.eu/>



RETINOIC ACID/ARSENIC-BASED APL THERAPY NOW FULLY DECIPHERED

Over 30 years of hard work have enabled Prof. Hugues de Thé to turn acute promyelocytic leukaemia (APL) from one of the deadliest forms of leukaemia into the most curable one. His most recent ERC grant helped him investigate the process through which the treatment he helped develop — a combination of retinoic acid (RA) and arsenic — acts on tumour cells.

Prior to the project, Prof. de Thé and his team had already demonstrated how RA and arsenic directly bind PML/RARA — the driving oncoprotein in APL — and promote its degradation. With the STEMAPL (APL a model for oncogene-targeted leukaemia cure) project, they went a step further: they showed how this therapy-induced degradation allows for the re-assembly of distinct nuclear domains called PML nuclear bodies.

‘PML nuclear bodies act as post-translational modification factories. They participate in stress response,’ Prof. de Thé explains. ‘Using mice models, we demonstrated that, in APL, the PML nuclear body reformation induced by RA and arsenic treatment activates a senescence programme that includes the activation of the P53 tumour suppressor. Interestingly, PML are known markers of senescent cells. This RA- or arsenic-initiated PML/P53 checkpoint is absolutely required for the definitive clearance of the disease.’

Another key achievement of the project is the demonstration of mutations’ existence in PML (and not only in PML/RARA, as initially expected) in therapy-resistant patients. As Prof. de Thé points out, this is the first-ever example of a situation in which the resistance mutations are on the anti-oncogene, rather than its oncogenic counterpart. This enabled the team to fully validate in patients the physio-pathological model initially established in mice, which Prof. de Thé considers as ‘a remarkable example of the predictive power of mouse models to understand and optimise therapy.’

From APL to other types of leukaemia

The information gathered under STEMAPL is of high value to all cancer researchers, potentially beyond the sole case of APL. ‘There are not many examples where you can cure cancer knowing how this is achieved. APL is a unique system for exploring the

downstream targets of therapy, and it yielded the unexpected implication of PML. Knowing the basis of response, one can then try to transpose it to other conditions. While clearly this is not the universal pathway to cancer cure, it is possible that it is shared between more than one leukaemia,’ Prof. de Thé says.

Whilst there is still a long way ahead, the team strongly believes that their findings will not be limited to APL. In fact, other types of acute myeloid leukaemia (AML) were already found to present abnormal PML nuclear body formation.

Now that STEMAPL has come to an end, Prof. de Thé will be applying for a new ERC grant focusing on the anti-cancer properties of PML, innovative clinical trials, and other conditions with a focus on the activation of PML. ‘There is good clinical evidence that some progress may be expected,’ he enthuses.

In the meantime, the now largely understood RA/arsenic combination has now become the gold standard all

over the world. It cures over 95% of treated patients without resorting to DNA-damaging therapy, and provides a unique example of success for targeted therapy.

‘This success demonstrates that oncoprotein degradation is a feasible therapeutic goal, and it highlights one of the rare conditions where the biochemical and cellular activities of an anticancer therapy are understood in significant details,’ Prof. de Thé concludes.

STEMAPL

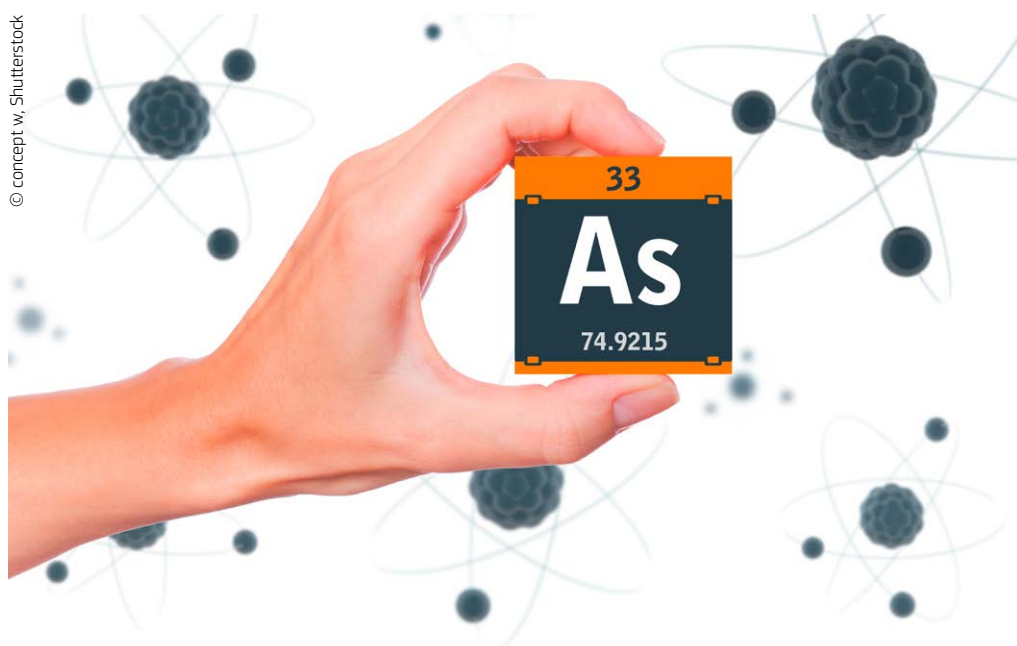
★ Hosted by Inserm in France.

★ Funded under FP7-IDEAS-ERC.

★ <http://cordis.europa.eu/project/rcn/99545>

“There are not many examples where you can cure cancer knowing how this is achieved.”

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INTERVIEW

OFF-THE-SHELF T CELL THERAPIES FOR MULTIPLE MYELOMA

Although a source of much hope among multiple myeloma (MM) patients, adoptive T cell therapies are still held back by expensive, lengthy, individual-tailored approaches. However, an EU-funded project is aiming to shake things up with off-the shelf solutions of its own.



© Maria Themeli

DR MARIA THEMELI

There are currently three main approaches for obtaining therapeutic T cells: the isolation, expansion and reinfusion of tumour-infiltrating lymphocytes (TILs); the *ex vivo* generation and expansion of tumour antigen-specific T cell lines; and the genetic engineering of autologous T cells with tumour antigen-specific T cell receptors (TCRs) or chimeric antigen receptors (CARs). But whilst the feasibility and effectiveness of these approaches have all been proven in clinical settings, all these approaches have to be tailored to the patient before they can be applied.

With this in mind, the CARIPSCCELLS (Generation of safe and efficient, off-the-shelf, chimeric antigen receptor (CAR)-engineered T cells for broad application) project has developed technology that will enable *in vitro*, unlimited, safe and broadly applicable T cells targeting MM. Dr Maria Themeli, coordinator of the project, discusses its results.

★ Why are T cell therapies so rarely used?

Dr Maria Themeli: Current strategies for obtaining therapeutic T cells have limitations. Their use is restricted to specialised institutes and specific patient populations. The isolation and *ex vivo* manipulation of autologous cells require expensive specialised equipment, good manufacturing practice (GMP) facilities and trained personnel. In many cases, the autologous T cell isolation and expansion would be problematic or impossible, for instance in immunosuppressed patients after chemotherapy or immune-deficient patients presenting malignancies.

Moreover, the production of autologous therapeutic cancer-specific T cells requires processing times which can be

“The development of ‘off-the-shelf’, applicable immunotherapeutic tools will lift immunotherapy from an individual basis and will allow the availability of controlled, validated and safe immunotherapeutics for a broad patient population.”

critical for the patient's health. Sometimes the patient dies before receiving the therapy. This all makes the production of therapeutic T cells an expensive process, which is difficult to be broadly applied.

★ How did your project aim to solve these problems? How did such solutions come about?

We thought that the development of broadly applicable cellular therapeutics, which have been manufactured, functionally validated and banked in advance, and can be applied beyond histocompatible Human leukocyte antigen (HLA) barriers, would improve the consistency and availability while reducing the cost of adoptive T cell therapy. With this goal in mind, we explored the feasibility of a novel strategy for generating unlimited, ‘off-the-shelf’, safe, antigen-specific T lymphocytes with optimised features.

We propose the use of induced pluripotent stem cells (iPSC) as a source of T lymphocytes. These cells can be cultured in the lab without limit and can be differentiated to T lymphocytes. In addition, they can be genetically manipulated easily, so that the final T cell product will possess specific desirable immunotherapeutic characteristics. For example, we can provide cancer antigen specificity through an artificial CAR and delete the expression of HLA molecules to make them histocompatible.

★ Why did you decide to focus specifically on MM?

The department of haematology at VUmc Amsterdam is one of the biggest European centres for MM patient care. What makes us so interested in this disease is that although there has been much progress in delaying the course of the disease, it still remains incurable. Therefore, we focus our research on finding novel, potentially curative therapies. To this end, we have developed and preclinically evaluated the use of CD38-targeting CAR-T cells for the treatment of MM.

★ How was the CRISPR/Cas9 system beneficial to your research?

The CRISPR/Cas9 technology has revolutionised the field of gene therapy over the last few years. With this technology, modifying the genome has become easier and safer, since it allows for highly specific gene editing. We use this system in order to genetically modify the cells in the iPSC stage and achieve specific optimised features when they differentiate into therapeutic T cells.



★ **What would you say are the most important achievements of the project?**

We have succeeded in generating genetically-modified iPSC, which give rise to broadly applicable 'off-the-shelf' T cells bearing an anti-myeloma CAR and eliciting anti-myeloma function without having histocompatibility restrictions.

★ **What do you hope will be the long-term impact on MM treatment?**

The development of 'off-the-shelf', applicable immunotherapeutic tools will lift immunotherapy from an individual basis and will allow the availability of controlled, validated and safe immunotherapeutics for a broad patient population.

MM is the second most common haematologic malignancy. Thus, a broadly applicable adoptive T cell immunotherapy would be of benefit for many patients. But most important, this project will lay the foundation for a new strategy for the broad application of iPSC-derived T cells, not only for targeting MM, but also for all CAR-based T cell therapies, since the results obtained from our studies could also be translated to other malignancies.

★ **What are your follow-up plans, if any?**

We aim to further pursue the goal of generating potent therapeutic T cells from iPSC. We will focus on further improving the therapeutic properties of the generated T cells from human iPSC by influencing and



refining the *in vitro* differentiation mechanisms of phenotypic determination and by enhancing their persistence and effector function.

CARIPSCCELLS

- ★ Coordinated by VU University Medical Centre in the Netherlands.
- ★ Funded under H2020 Marie Skłodowska-Curie actions.
- ★ <http://cordis.europa.eu/project/rcn/195614>

INTERVIEW

USING miRNA TO CURE MATURE B CELL NEOPLASIA

Almost half of patients with mature B cell neoplasia are faced with the ineffectiveness of existing treatments. However, they may soon benefit from new therapeutic tools relying on miRNA — a small non-coding RNA molecule involved in RNA silencing and post-transcriptional regulation of gene expression.



PROF. ALMUDENA RAMIRO

This strategy could save about 26 000 patients every year. Instead of multidrug R-CHOP chemotherapy for patients with mature B cell neoplasia such as diffuse large B Cell Lymphoma, Burkitt Lymphoma and B cell Chronic Lymphocytic Leukaemia, the EU-funded HEAL-BY-MIRNA (micro-RNA replacement therapy for mature B cell neoplasias) project offers an innovative approach using an miRNA specific to mature B cells whose expression is lost in mature B cell neoplasia patients.

By re-introducing this miRNA in lymphoma cells, the team led by Prof. Almudena Ramiro is hopeful that they will soon be able to treat patients resistant to R-CHOP or victims of relapses.

★ **What would you say are the main strengths and weaknesses of current treatments for B cell neoplasia?**

Prof. Almudena Ramiro: B cell neoplasia is currently treated mainly by radiation and R-CHOP multidrug chemotherapy. This multidrug therapy can be very effective, but it has a number of significant limitations, including the fact that a fraction of cases show resistance to the treatment. For instance, in the case of 'Diffuse large B cells lymphoma' (DLBCL), the most prevalent of aggressive lymphomas, around 40-45 % of patients do not respond to R-CHOP. Another major problem is that a proportion of B cell neoplasia patients relapse after an initial response to R-CHOP treatment.

SPECIAL FEATURE

Furthermore, this treatment is highly intensive and has a high level of associated toxicity.

★ **How do you explain the fact that chemotherapy is often ineffective?**

The two main reasons thought to be responsible for chemotherapy ineffectiveness in cancer treatment are the non-specificity of the cytotoxic action of chemotherapy, which also affects healthy tissue, and the capacity of the tumour to generate mutational variants resistant to the chemotherapy treatments.

★ **Why focus the search for alternative therapies on miRNAs specifically?**

miRNAs are targeted, biologically active molecules that have certain characteristics that make them very attractive candidates as anti-tumoural therapeutic tools: their small size and stability, the fact that they can easily be chemically modified, and the fact that they are less susceptible to drug-resistance development because they

modulate gene expression networks rather than individual genes. They are also less likely to show toxic effects, as miRNAs target clusters of genes based on a specific nucleotide sequence.

★ **What can you tell us about the project's results so far?**

Unfortunately we cannot comment on specific results here because they are currently in the process of being protected by a patent, but I can say that we are really excited about the results obtained so far and we believe that they can lead to the development of a novel and more effective therapeutic protocol for the treatment of B cell neoplasia in the future.

★ **Did the effectiveness of the proposed approach meet your initial expectations?**

Yes, we think the approaches of the proposal are adequate for performing preclinical assays to test the effectiveness of miR-28 analogues for lymphoma treatment.

★ **When could this proposal lead to a new treatment option for patients?**

The development of new clinical drugs is a very well established and regulated process that consists of three different stages. We believe that the promising results we have obtained with miR-28 synthetic analogues in blocking lymphoma growth

in preclinical *in vivo* models justify the initiation of a phase I clinical trial.

In this sense, we are perusing the interest of biotech companies in the development of a new product based on synthetic miR-28 analogues to start this first phase. Phase I clinical trials usually involve the engagement of 20 to 100 volunteers. Depending on the results obtained in this initial trial, the product would be assessed in subsequent phase II and III clinical trials, which involve larger numbers of individuals and a period of time that ranges from two to six years.

★ **Are you already planning for any follow-up research?**

Absolutely, we are planning on assessing different aspects of an miR-28 analogue therapy for lymphoma treatment in preclinical *in vivo* models of lymphoma: its efficacy on chemotherapy-resistant lymphomas, its effectiveness in different protocols of sequential or combined administration with chemotherapy and the characterisation of the molecular processes that lead to the generation of treatment-resistant lymphoma cells.

HEAL-BY-MIRNA

- ★ Hosted by CNIC in Spain.
- ★ Funded under H2020 European Research Council.
- ★ <http://cordis.europa.eu/project/rcn/203333>

"We believe that the promising results we have obtained with miR-28 synthetic analogues in blocking lymphoma growth in preclinical in vivo models justify the initiation of a phase I clinical trial."





NEW, *EX VIVO* DIAGNOSTIC SYSTEM HELPS PREDICT CANCER PATIENT RESPONSE TO TREATMENT

The accurate prediction of patient response is a prerequisite to personalised cancer treatment. Italian SME Cellply has developed the first fully-automated diagnostic system to achieve that, *ex vivo*, from tumour specimen obtained in a clinical setting.



© Cellply

Cellply's product, developed through the EU-funded ONCOSMART (ONCOlogic patient profiling and personalised treatment through SMART bedside diagnostics) project, provides a response to a long-standing issue. Until now, we have known that about 30-40% of cancer patients present specific mutations that could be the focus of targeted therapies and immunotherapy. Information about this mutational status is precious: for instance, physicians have known that KRAS mutation could be targeted by anti-EGFR antibodies, but KRAS itself is not a good biomarker for predicting tumour response to therapy. Similarly, the efficacy of anti-PD1 immunotherapies has a poor correlation with the expression of PD1. As a result, mutational profiles are rarely useful as biomarkers for predicting therapy outcome.

'More complex strategies are being investigated, such as next-generation sequencing, demonstrating that the combination of multiple information is needed to achieve biomarkers with higher predictive power, but results of the application of such an approach are still not satisfactory in many clinical situations. On the other hand, chemotherapies are still widely in use, both in the remaining 60-70% of patients and in refractory or relapsed patients. But patient stratification in these cases is mostly based on risk assessment or prognostic factors, and other approaches for guiding therapy selection are lacking in the clinic,' Massimo Bocchi, CEO of Cellply, explains.

For Mr Bocchi, the solution lies in *ex vivo/in vitro* analysis of drug response, to extract a new layer of information which relies on phenotype more than genotype. The latter is applicable to both new-generation drugs and chemotherapies, and it allows for investigating the effects of dosage or combinations of drugs on the clinical outcome. And whilst such an approach had already been explored with limited success, recent advances in life sciences allow for the development of effective test methods which are sometimes even superior to molecular approaches. By combining the two, Bocchi believes that his company may have a winning, hybrid approach in its hands.

A groundbreaking, lab-on-a-chip device

'Cellply is developing the first fully-automated diagnostic system to evaluate the response of fresh tumour specimens to anticancer drugs in the clinical setting,' Andrea Faenza, CTO of Cellply, enthuses. The system allows for conducting drug testing in the clinical setting just a few hours after obtaining the tumour specimen, thus minimising drifts in cell function that typically increase with time from sampling. The result is provided within the following 24 to 48 hours.

'By integrating an entire laboratory procedure in a lab-on-a-chip device, we can test three to four drugs or drug combinations in

parallel at different dosages with only one biopsy. Moreover, lab-on-a-chip automation standardises sample preparation and analytical procedures, allowing us to overcome the limitation of other lab-based drug testing assays which are difficult to compare to each other and to be deemed as a possible reference diagnostic procedure,' Faenza says.

Thanks to funding under the SME Instrument, the company was able to preliminarily assess the impact of our approach on both the healthcare system and the pharmaceutical industry. The team held discussions with haemato-oncologists, laboratory technicians and stakeholders from the pharmaceutical industry as well as experienced entrepreneurs, and identified their needs. Cellply was then able to adjust its business model and go-to-market strategy, taking into account the use of their system both for personalised medicine applications and for supporting pharmaceutical companies during the development of new anti-cancer drugs.

'We found that clinicians, in particular in clinical situations where chemotherapies are used, need to support their decision with new personalised tests indicating which therapeutic options are more likely to be effective on a patient-by-patient basis,' Laura Rocchi, Head of Biology at Cellply, explains. 'Pharmaceutical companies, on the other hand, see the approach as possibly valuable for designing better clinical trials, for example by discarding non-responding patients from the trial or by stratifying patients according to expected dosage information.'

Several drug developers also seem interested in getting a pre-view of drug efficacy on human samples at late-preclinical stage, before moving on with a first-in-man trial. Finally, the technology was considered of interest for possibly identifying other biomarkers through analysing the correlation between *ex vivo* response and mutational status.

So what's next for Cellply? 'A prototype system was implemented and tested on 10 acute myeloid leukaemia (AML) patients, showing a correct prediction of patient response in 90% of cases. The next step would be to industrialise and clinically validate the platform on a first large set of patients in 2018-2019, in order to achieve regulatory clearance in Europe and the USA. In parallel, Cellply will keep working with pharmaceutical companies to support their drug development processes,' Bocchi explains.

ONCOSMART

- ★ Coordinated by Cellply in Italy.
- ★ Funded under H2020 SME Instrument.
- ★ <http://cordis.europa.eu/project/rcn/207113>



CLL EVOLUTION UNDER THE MICROSCOPE

How do initially indolent forms of cancer evolve to become aggressive? In a quest to answer this long-standing question, an EU-funded project has studied the growth and clonal evolution of chronic lymphocytic leukaemia (CLL) — a blood and bone marrow cancer that mostly starts asymptomatic but can become very aggressive over time.



© Wolfgang Dauble_CeMM

DR MICHAELA GRUBER

Cancer evolution is a complex process. Whilst we know that tumour growth is enabled by a continuous process of clonal expansion, genetic diversification and clonal selection, there are still many open questions related to this process. Answering them could be the key to preventing tumour progression and relapses.

According to Dr Michaela Gruber, whose research was funded under the CLL-INCLONEL (Identification and functional dissection of key genetic events in early chronic lymphocytic leukaemia) project, CLL is a valuable model for studying this process due to its high prevalence, initially slow progression and easy access to samples.

Dr Gruber studied the clonal dynamics of a cohort of 21 CLL patients, who were recurrently sampled from diagnosis until the time of first treatment. Her objectives were to identify events leading to disease progression using next-generation sequencing of patient samples. She also developed *in vitro* models to assess the functional impact of these genetic events on B cell biology, studied their impact on CLL and gathered valuable information on the effects of drugs on potential CLL sub-populations.

Dr Gruber agreed to discuss the project's outcomes and how they could one day lead to individualised diagnostic and therapeutic management of CLL.

★ **What kind of knowledge did you aim to gather from this project?**

Dr Michaela Gruber: The key aim of this project was to gain a better understanding of the early dynamics of growth and clonal evolution, as cancer progresses from diagnosis to the need for treatment. CLL is a highly informative model system for studying such natural cancer growth patterns: It typically has a relatively indolent beginning, with potentially long timeframes (in the order of years) before treatment becomes necessary.

★ **Why is it so important to better understand clonal evolution? How can it help prevent tumour progression and relapse?**

Insights from recent cancer sequencing studies indicate that the occurrence and expansion of cancer-driving mutations follows a specific sequence. Certain mutations generally appear to occur early in the disease and could be cancer-initiating. Other mutations tend to occur late and appear to have variable impact on tumour expansion. Moreover, different cancer sub-types show different patterns of mutations.

Together, these findings indicate that it could be possible to anticipate the specific evolutionary potential (i.e. plasticity) of a patient's cancer, which actually fuels progression, treatment resistance and relapse. Based on such understanding, therapeutic strategies could be shaped directly against this plasticity of cancer. This would be a major milestone towards overcoming current obstacles to cancer cure.

★ **What would you say were the most important findings from the project?**

Our data show that key mutations driving the progression of CLL are established very early in the course of the disease, years before symptoms warrant treatment initiation. For the first time, we were also able to

quantify the impact of individual sub-clonal driver mutations on *in vivo* tumour expansion.

Another important discovery is that of clearly distinguishable growth patterns among patients, both globally as well as on a sub-clonal level. Finally, our data indicate that different patients have different potentials for clonal evolution and growth, and that these patterns remain throughout the entire course of the disease up to the event of relapse.

★ **Can you tell us more about the genome editing technologies you employed?**

Suitable experimental models are much needed in order to test the functional impact of observations made in CLL sequencing studies. Thus, we employed novel genome editing strategies, initially using TALENs and then switching to the recently emerged and more easily programmable CRISPR/Cas9 technology. Thanks to the latter, we established an array of isogenic B cell lines, which are used to test the molecular impact of mutations on cellular biology and — most important — treatment response.

★ **What are your plans now that the project is completed?**

We have initiated several follow-up projects in Vienna, which aim to integrate an understanding of epigenetic modifications and tumour microenvironments, as well as their role and dynamics in CLL evolution.



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★ **What do you hope will be the impact of the project on future diagnostics and treatments?**

Our hope is to establish cancer evolution as a predictable process. With sufficient understanding of the forces that drive evolution and

“Our hope is to establish cancer evolution as a predictable process.”

selective advantages of sub-clonal mutations, we hope to develop prognostic schemes that anticipate individuals' evolutionary trajectories.

Treatments based on these schemes would directly aim to target the cancer plasticity that underlies progression, treatment resistance or relapse. CLL provides us with a unique opportunity to better understand cancer evolution. The conceptual insights about cancer

that can thus be gained from CLL would have a high potential for being translated across other haematologic and solid malignancies.

CLL_INCLONEL

- ★ Coordinated by the Medical University of Vienna in Austria.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/186119>

INTERVIEW

A SMALL DROP OF BLOOD FOR AN OCEAN OF INFORMATION

Patient response to treatment — especially personalised medicine — can be very difficult to predict. To overcome this issue, the CHEMOS project has been advancing a new method for screening thousands of single-cell drug responses from small blood samples.

The new method, called pharmacoscopy, combines automated microscopy and single-cell image analysis to provide over 20 million cells worth of data. Thanks to the I-FIVE project, which ran from 2010 to 2015, it had successfully been used to screen for novel anti-viral or immune modulating drugs. The project team had also demonstrated that the approach could help haema-oncologists to make therapeutic decisions in a concrete clinical setting using primary myelofibrosis and lymphoma as test diseases.

With CHEMOS (Chemical Haematology: breaking resistance of haematological malignancies through personalised drug trials), Prof. Dr Giulio Superti-Furga and his team aimed to bring their screening method closer to market: the project looks to obtain clinical data through retrospective trials and use results to attract potential investors.

Prof. Superti-Furga agreed to discuss the project results ahead of its completion in September.

★ **How would you explain the fact that personalised medicine for blood cancer has so far failed to deliver on its promises?**

Prof. Superti-Furga: For the most part, personalised medicine for both blood and solid cancers relies on functional screening technology that focuses on the average characteristics of response to drugs. This generalisation does not discriminate against target effects — whereas we believe that such discrimination is very important in predicting patient response.

Besides, prior functional assays have measured early- or late-stage cytotoxicity using readouts such as global ATP levels, which have not provided robust enough responses to be used routinely within a clinical setting. On top of that, these assays require a lot of material to get above detection limit thresholds, and assays such as automated flow cytometry pose the additional problem that they require a hands-on component. Of course, these functional assays have paved the way for our research. But work on these approaches focused on patient stratification, *ex vivo* response profiling, drug discovery and



© Giulio Superti-Furga

PROF. SUPERTI-FURGA

mechanism of action elucidation: they have yet to become clinical routine.

Another issue lies in the fact that genetics — which really has shown the path towards personalised treatment of solid tumours — may prove more difficult to apply to haematological malignancies due to the diversity of clonal evolution during cancer progression and treatment. We find that our work combines very well with genetics, be it focused genetics and or more global genetic approaches, and should lead to mechanistic insights and new targetable pathways.

★ **How does your new screening method provide a solution to these problems?**

We believe that discrimination of drugs' effect on healthy versus cancer cells — an idea that is lost upon averaging a read-out in prior assays — is key to predicting response. Therefore, in our programme, we use high-content microscopy to determine — at single-cell resolution — the effects of drugs on each individual cell. In most cases, these effects imply cell death, as determined by nuclear disintegration of each cell measured in microscopy images.

The cancer cell phenotypes can be separated from the healthy cell phenotypes using fluorescent antibodies against diagnostic markers, just like a pathologist would do it. By performing this assay at single-cell resolution and on a large-scale, automated manner, each cell becomes an assay. This enables us to gather a differential cell response and to track precisely the drugs that kill cancer cells while leaving all other healthy cell material viable.

We can do this over thousands of cells per drug, and hundreds of thousands of drugs per patient sample. This all results in very robust measurements with dramatic

statistical power, gathered with little human intervention, as the setup can be fully automated and the need for material is minimal.

"We can do this over thousands of cells per drug, and hundreds of thousands of drugs per patient sample."

The images are also unique in that they provide a treasure-trove of data for us to dig into.

★ **How do you proceed exactly?**

Each well, part of a 384-well screening plate, is coated with a drug. Patient cells are put into each plate, and we create a monolayer of the cells which we view under an automated confocal microscope. This results in about 2 000 images per 384-well plate, and a total of 20 million cells worth of data. These images are then placed into an image analysis pipeline that extracts features of interest.

★ **What would you say makes the project outcomes so innovative?**

We found a solution where a 384-well plate doesn't imply 384 tests, but a single one that contains the data from approximately 20 million cells. This is really the basis, we think, of a 'big data' era for medicine, and we may just be scratching the surface of what data is contained in these images, and what part of that data can be translated. This is a major finding. From a more conceptual point of view, we found that some 10% of commonly used therapeutics bear the property for modulating the immune system.

★ **Which diseases could be targeted by this method? How so?**

We have focused on haematological malignancies because of the ease at which samples can be extracted from patients during routine visits (much of the sample we get is left over from routine pathology). We have also started to look at other types of diseases, such as autoimmune diseases, starting with rheumatoid arthritis, albeit for other types of personalised medicine programmes.

★ **What has been the feedback from potential investors so far?**

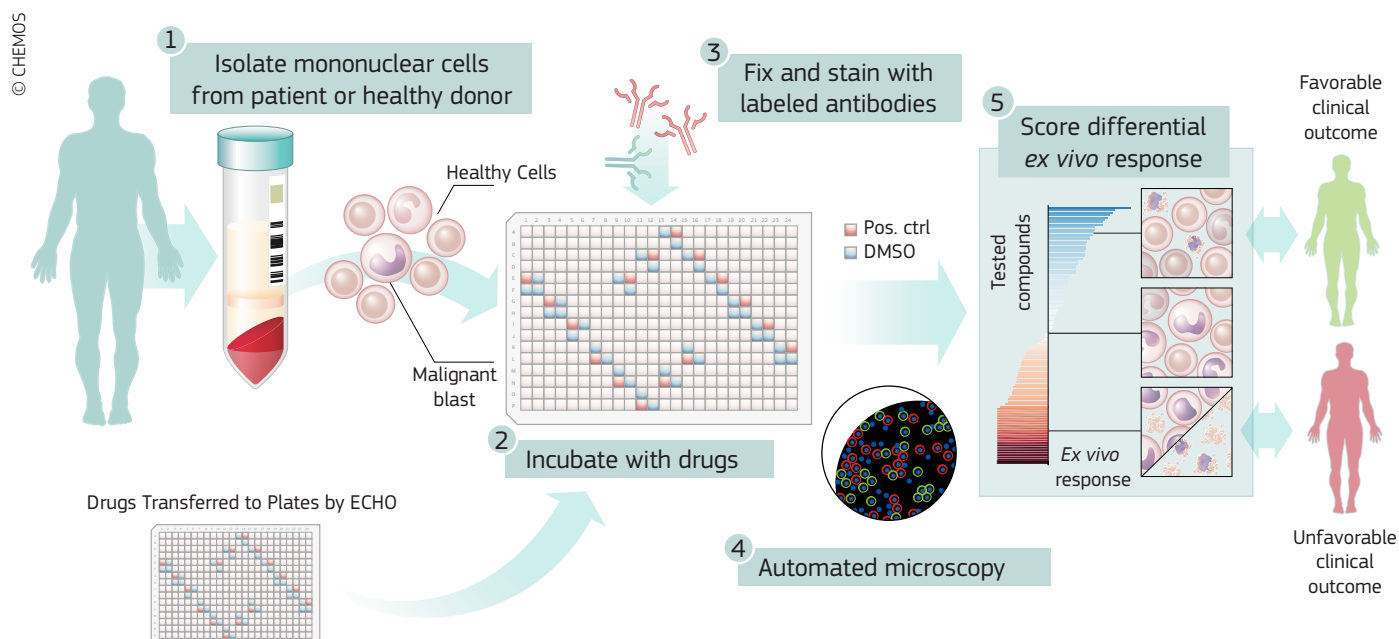
Feedback has been very positive from both business and strategic investors, as well as government-backed programmes here in Austria.

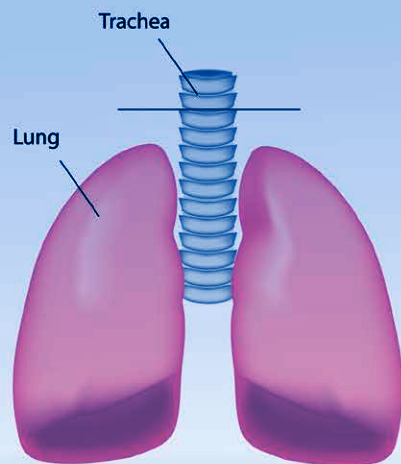
★ **How do you plan to get CHEMOS results to the market?**

We have founded a company, Allcyte, here in Vienna that will focus on bringing this technology to market.

CHEMOS

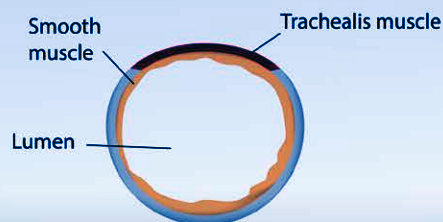
- ★ Hosted by CeMM in Austria.
- ★ Funded under H2020 European Research Council.
- ★ <http://cordis.europa.eu/project/rcn/205773>



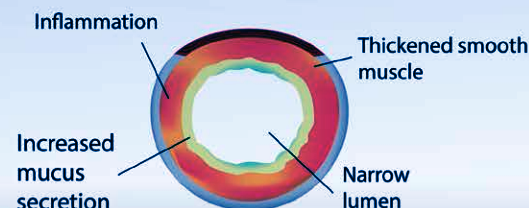


HEALTH

Healthy



Cystic Fibrosis



ORAL IMMUNOTHERAPY FOR CYSTIC FIBROSIS

Cystic fibrosis (CF) is an inherited disorder often associated with fatal bacterial infections. A pioneering intervention therapy based on chicken antibodies is about to change that.

CF, caused by a mutation in the CFTR gene, leads to mucous accumulation in the lungs, predisposing individuals to infections, and ultimately, fatal pulmonary obstruction. More than 1700 mutations have been identified with an overall prevalence of one in every 2500 people.

The vast majority of CF patients become infected with the gram negative bacterium *Pseudomonas aeruginosa* (PA). Antibiotic treatment is only effective in the initial stages of the disease; inevitable recurrent infections will culminate in chronic pulmonary infection. Intriguingly, PA strains from CF patients are more resistant to antibiotics than PA strains isolated from other patient groups.

As CF is fatal and faces the growing threat of antibiotic resistance, it is of utmost importance to find effective alternatives to current antibiotics. Ten European countries collaborated to develop therapeutic avian antibodies IgY against PA with orphan drug designation. This was made possible through the EU-funded IMPACTT (Immunoglobulin IgY *pseudomonas A* clinical trial for cystic fibrosis treatment) project.

Antibodies produced in the egg yolk

Avian IgY antibodies were produced in the egg yolk of laying hens vaccinated against PA. The antibodies were purified from the egg yolk by water extraction, to produce a formulation containing only egg proteins and water. 'When administered orally, the risk of serious

adverse events should not be larger than the risk associated with eating eggs,' explains IMPACTT project coordinator Prof. Larsson.

Previous phase I clinical studies have shown that if patients gargle with the IgY solution every evening, it prevents PA from entering the lungs. A single daily gargle was sufficient to prevent recurrent and chronic infections. The IMPACTT consortium wished to extend anti-*Pseudomonas* IgY antibody immunotherapy into a pharmaceutical treatment that will benefit the CF community within the EU and worldwide.

Pre-clinical work by IMPACTT scientists indicated that oral administration of anti-*Pseudomonas* IgY is well tolerated and does not damage the gastrointestinal tract nor does it affect the normal and pathogenic bacterial microflora of treated mice. Mechanism of action studies revealed that IgY opsonises the bacteria and augments their internalisation into polymorphonuclear neutrophils. In turn, this implies a faster bacterial clearance in the CF airways and suggests that IgY antibodies could be used to boost innate immunity against PA.

Furthermore, the consortium investigated over 20 strains of PA, including some of the antigens used for immunisation. 'Anti-*Pseudomonas* IgY was shown to be immunoreactive against all of the tested strains strengthening its potential use as a prophylactic treatment against PA,' Prof. Larsson continues.

Clinical trial

The primary aim of the IMPACTT project was to conduct a randomised, placebo-controlled, double blind phase III clinical trial in various centres across Europe. 164 CF patients were recruited to investigate the critical preventive and therapeutic effects of anti-*Pseudomonas* IgY in CF patients. The trial assessed the recurrence of PA in the sputum of the patients who received oral anti-*Pseudomonas* IgY or a placebo formula for two years. In addition, it demonstrated that these antibodies were present in the oral cavity of patients for up to 24 hours without producing any adverse immune or allergic reaction.

Chronic PA infection is the most common cause of morbidity and mortality in CF patients. The IMPACTT antibody-based intervention constitutes a valid prophylaxis that minimises the risk of antibiotic resistance. The findings of this study extend beyond CF, supporting the development of IgY-based oral immunotherapies to replace existing antimicrobials. A similar approach could also be used for the prevention of bacterial infections in animals.

IMPACTT

- ★ Coordinated by Uppsala University in Sweden.
- ★ Funded under FP7-HEALTH.
- ★ <http://cordis.europa.eu/project/rcn/98326>
- ★ Project website: <http://impactt.eu/>

FRUITFUL RESEARCH ON TACKLING FOOD ALLERGIES

An EU-funded project has led to a better understanding of why certain proteins can cause strong allergic reactions, while at the same time providing a bright female researcher with the opportunity to resume her career.

Identifying the role and behaviour of certain proteins in triggering allergic reactions could lead to new ways of modifying allergens, new diagnostic tools and ultimately improve the lives of millions of people who suffer from food allergies. A key milestone in this effort has been the recent Marie Curie-funded CAMEL (Impact of food matrix interaction and post-translational modifications on the allergenicity of Mal d 3, a major apple allergen) project, which brought researchers together to focus on Mal d 3, a non-specific Lipid Transfer Protein (nsLTP) found in apples.

Focus on fruit allergies

'Millions of people live with food allergies, with reactions that range from the slightly uncomfortable to the life-threatening,' explains CAMEL project coordinator professor Karin Hoffmann-Sommergruber from the Medical University of Vienna. 'For those with fruit allergies, healthy eating can be a challenge, as avoiding fruit can result in an unbalanced diet.'

For apples — the most frequently consumed fruit in Europe — four apple allergens have been officially identified, including Mal d 3. 'Mal d 3 and its homologues from other fruits have attracted scientific interest because they can induce severe, potentially life-threatening, systemic reactions,' explains Hoffmann-Sommergruber. 'What makes Mal d 3 (and other nsLTPs) so hazardous is that they reach the gut only slightly modified and can induce severe systemic reactions in sensitised individuals.'

The project began by isolating and purifying Mal d 3 from apple peel. In order to obtain the target protein in high quantities for further experiments, the recombinant protein was also produced in yeast. Hoffmann-Sommergruber and her team successfully demonstrated that this was an efficient way to produce large amounts of soluble and immunologically active Mal d 3.

Next, the purified recombinant Mal d 3 was tested for its application as a diagnostic tool to detect specific IgE antibodies in apple allergic patients. These studies showed that

"A key project finding was that Mal d 3 interacts with certain fatty acids, and thus changes its surface exposed structure."

the recombinant Mal d 3 displayed a high sensitivity. 'This could allow medical professionals to differentiate patients at risk of developing severe allergic reactions (Mal d 3-sensitised) from those with a low risk of severe food allergic reactions,' explains Hoffmann-Sommergruber. 'This in turn will help to fine tune dietary recommendations for fruit allergic patients.'

A key project finding was that Mal d 3 interacts with certain fatty acids, and thus changes its surface exposed structure. This in turn affects its allergenicity. 'Based on these molecular data, new strategies on how to modify



certain allergens can be developed,' says Hoffmann-Sommergruber. 'For instance, protein variants low in allergenicity could be designed for immunotherapeutic aspects.'

Finally the interaction of Mal d 3 with pectin, an abundant component in apples, was investigated with regard to changes in protein structure and potential effects on allergenic activity. Nitration of the protein was performed and the effect on structure and stability analysed.

A career boost

In addition to increasing our knowledge about fruit allergies, this Marie Curie project, which funded an Intra-European Fellowship, enabled Dr Roberta Aina to resume her research career after a four-year break. 'The programme focused on many different aspects of education and training for Dr Aina,' says Hoffmann-Sommergruber. 'It enabled her to acquire new scientific and technical competencies (i.e. in recombinant protein production, purification and characterisation) and develop complementary skills such as project management and supervision skills. The project has also boosted the number of active and highly trained women in science, thus decreasing the still existing gender gap in this field.'

CAMEL

- ★ Coordinated by MedUni Wien in Austria.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/192499>

NEW MEDICAL SOFTWARE THAT TRACKS HEART DISEASE IN INDIVIDUAL PATIENTS BROUGHT CLOSER TO ROLL-OUT

An EU-funded project has tested cutting-edge medical software in clinical trials, helping to prove its efficacy and improve its user-friendliness.

State-of-the-art software that can model and predict how diseases behave in an individual patient may be part of the future of medicine, but implementing it in hospitals remains a challenge.

Hampered by a lack of testing in real clinical environments as well as the complexity of the programmes for healthcare professionals, cutting edge medical technology can find it hard to become established.

The EU-funded CARDIOPROOF (Proof of Concept of Model-based Cardiovascular Prediction) project has helped to bridge the gap between the successful development of new computer-modelling technology and its deployment in a hospital or clinic. 'Our project helped to boost confidence in predictive computer models, as well as their acceptance by healthcare professionals,' says Edwin Morley-Fletcher, CARDIOPROOF project coordinator.

The project focused on aortic valve disease and aortic coarctation in paediatric patients which, if left untreated, can result in irreversible heart failure. Researchers tested computer programmes that can help achieve an early diagnosis of the diseases, predict disease behaviour and evolution, and predict treatment outcomes.

CARDIOPROOF tested four tools: advanced modelling solutions for heart electro-mechanics, modelling of the blood flow through the aortic arch using the Smooth Particle Hydrodynamic approach, a Fluid-Structure interaction model and modelling of the aortic coarctation simulating the relevant treatment options.

It sought to validate these tools in clinical trials held at three European centres of excellence in cardiac treatment: The Ospedale Pediatrico Bambin Gesù in Rome, University College London's Great Ormond Street Hospital (GOSH) for Children NHS Foundation Trust, and the

Deutsches Herzzentrum Hospital in Berlin.

CARDIOPROOF developed a randomised experiment to assess the impact of the modelling tools within clinical decision making. It involved 172 cardiologists who were guided through three different decision-making scenarios and were divided into two groups. One group received data currently used to determine treatment paths, and the other group received model-based data, in addition to 'normal' data.

'This experiment showed the potential positive impact of being supported by computer-modelling in clinical decision-making. By providing useful insight to choose the best treatment options and the correct timing for the intervention we have encouraged further research in this field,' says Morley-Fletcher.

In addition, CARDIOPROOF boosted the evidence of the clinical benefits of using computer-based models for a virtual stenting tool which assesses optimal treatment options. It also showed the benefits of a computational pressure mapping tool which helps avoid risky and invasive use of catheters to detect blood pressure.

The project also worked on ways to improve the user-friendliness of the computational tools and ways to reduce relevant hardware requirements. It also

"This experiment showed the potential positive impact of being supported by computer-modelling in clinical decision-making."

developed web-based tools accessible from a normal internet browser, without any installation required, greatly enhancing usability in clinical settings.

Since the end of the project in December 2016, some of the tools tested have been integrated in commercial software. Meanwhile, the datasets and the data management platform developed during the CARDIOPROOF project will be used in a new EU-funded project, MYHEALTHMYDATA. This project aims to create a computer-based architecture for secure patient data storage, management and exchange.

CARDIOPROOF

- ★ Coordinated by Lynkeus in Italy.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/110561>
- ★ Project website: <http://www.cardioproof.eu/>



MONITORING DRUG-LEVELS IN TRANSPLANT PATIENTS

Getting the levels of immunosuppressive drugs right in transplant patients is not a simple task, but the EU-funded NANODEM project has created a point-of-care device that could make it that little bit easier.



"The system developed by NANODEM is extremely efficient and can achieve very low detection limits."

How do we make sure transplant patients are receiving the right medication levels? If levels of immunosuppressive drugs are too low, there is a danger of organ rejection, but too high and the patient may be unable to fight off infections. The NANODEM (NANOphtonic DEvice for Multiple therapeutic drug monitoring) project has come up with a new device to monitor drug levels in transplant patients. 'At the heart of the device is a biochip that measures the concentration of immunosuppressants in a patient's blood,' explains project coordinator, Francesco Baldini from the Institute of Applied Physics in Florence, Italy. 'The miniaturisation of the device and minimally-invasive sampling approach allows therapeutic drugs to be monitored more accurately and at shorter time intervals than existing methods.'

Currently, immunosuppressant drug levels are monitored by standard blood tests, but they don't provide information quickly enough or give detailed information about the drugs' activity in the patient, which varies. 'Our point-of-care testing (POCT) device is a big step forward. It allows frequent monitoring close to the patient, without samples being sent to a central laboratory,' says Baldini. The NANODEM team is made up of academics and SMEs from five EU countries and has used expertise from chemistry, biochemistry, optics and medicine as well as micro and nanotechnologies in their design.

Their device is able to measure very low immunosuppressant drug concentrations, in the order of picograms per millilitre, and in addition detects only the free drug concentration — the relatively small fraction (2-8%) of the drug in the blood stream not bound to proteins, considered more closely related to the drug's efficacy and also toxicity.

Using an intravenous microdialysis catheter, a patient's sample can be continuously drawn and mixed with the necessary reagents in microchannels, each devoted to the detection of a single immunosuppressant. 'In this way it is possible, using few microlitres, to simultaneously measure multiple

substances, which is important from a clinical point of view,' explains Baldini.

The system developed by NANODEM is extremely efficient and can achieve very low detection limits. Drug molecules are first captured on the surfaces of antibody coated polystyrene nanoparticles containing magnetic granules and fluorescent molecules. The antibody molecules are able to capture a specific immunosuppressant drug and on reaching a sensing layer, the fluorescent nanoparticles fluoresce, illuminated by a light beam. Being also magnetic, an applied magnetic field speeds up their arrival at the sensing surface.

So far detection limits have been achieved for two important immunosuppressant drugs: cyclosporin A and mycophenolic acid. Another important achievement, adds Baldini, has been making the biochip regenerable — so a patient can use it continuously for multiple readings with the final target of a measurement over a 48-hour period. Tests showed the device could be regenerated for 30 measurement cycles.

For the future Baldini says, there is a considerable interest in the technology from the large-scale medical industry. Currently trials are being planned at the Klinikum rechts der Isar hospital of the Technical University of Munich (TUM) to investigate the importance of the free fraction in patients after kidney transplantation. 'These trials will make use of the body interface module developed within the project and will allow us to compare our new device to standard laboratory methods and we are confident that we can show its enhanced performance addresses a clear medical need,' concludes Baldini.

NANODEM

- ★ Coordinated by the National Research Council in Italy.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/104915>
- ★ Project website: <http://nanodem.ifac.cnr.it/>

POWER FOR RESEARCH INTO MITOCHONDRIAL DISEASE AND TREATMENT

A dynamic EU project has researched the clinical and social importance of cell mitochondrion diseases. Highlighting the challenge in some European countries where these conditions are not treated under national healthcare, the project collaborated with patients, their organisations and families.

At the very heart of the MEET (Mitochondrial European Educational Training) project lies a team of 14 young researchers and a consortium of 10 partners that investigated the wide range of diseases and disorders of the mitochondrion. Work packages spanned broad horizons — cancer, DNA mutations, regulation of respiratory complexes and therapeutic strategies.

Impressive array of scientific results

‘The project completion has brought about a number of key results, whose applications span from diagnosis to therapy development,’ states Dr Giuseppe Gasparre, MEET project coordinator. Notable is the discovery of novel genes for diagnostic procedures to classify so-far undiagnosed mitochondrial disease phenotypes.

Gasparre continues, ‘At the end of MEET, we now have available an unprecedented number of animal models to study mitochondriopathies — *Drosophila* models that recapitulate impaired respiratory complex I conditions as well as murine models developed during the programme.’

‘One strength of this project has been to scientifically merge canonical mitochondrial diseases, mainly neuromuscular pathologies, with those related to cancer (the mitochondrial and metabolic aspects of it),’ remarks Gasparre. ‘This has worked really well as the two medical fields are only apparently unrelated.’

The MEET global approach also offered the opportunity to extend outreach and dissemination activities to cancer research associations. The icing on the cake is a new consortium, the TRANSMIT project, which will enrol 11 PhD fellows to specifically address the mitochondrion in relation to cancer under a European Training Networks Marie Curie Programme funded for four years.

Patient power

‘Patient participation has been the hallmark of the programme, and also what

made us most proud,’ emphasises Gasparre. ‘Under their own initiative, for example, they [the researchers] started a campaign to raise funds from runs all over Europe for the International MitoPatients association.’

At the MEET Symposium 2016, Nijmegen, the Netherlands, the unique scope focused on strengthening the bonds between patients and their families and all lab scientists, rather than just a conference. For Gasparre this approach has a two-pronged advantage. ‘The fellows became aware of the gaps needing to be filled to solve patients’ practical problems, which in turn redirected their research. Equally, as patients were the centre of attention, we obtained valuable input.’

On the road to the clinic

Drug discovery activity has been carried out by the main industrial consortium partner, Khondrion, using high-throughput screening and development of compounds for mitochondriopathy therapy. Additionally, thanks to this work, novel molecules have entered trial phases, so results are being translated directly from bench to patient’s bedside.

Patients who are still without a genetic diagnosis with symptoms of a mitochondrial disease can now undergo genetic testing to verify whether the newly discovered gene may be implicated. ‘This is a pivotal step in deciding therapy, as when a gene is identified as responsible, it is at least possible to understand the molecular basis of the phenotype, and reveal pharmacological targets,’ explains Gasparre.

Stressing just one of the many impacts of the MEET project, Gasparre sums up its holistic approach — ‘By attempting to bridge the gap between scientists and families, we hope we have managed to considerably shorten the distance and to humanise science, bringing it back to its primary role: a service.’

MEET

- ★ Coordinated by Alma Mater Studiorum — University of Bologna in Italy.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/105675>



SOCIETY

EXPANDING THE PREVENTATIVE ARCHAEOLOGY TOOLBOX IN EASTERN EUROPE

With archaeological sites often suffering from the competing drives of preservation and economic development, the EU-funded CONPRA project offers some collaborative solutions.

Large infrastructure projects that came about as a result of the late 1980s European economic boom also presented an opportunity for integrated thinking about sustainable spatial planning. This was especially applicable within formerly socialist countries.

As recognition of the implications for archaeology, the Valetta Treaty of the Council of Europe, signed in 1992, sought to codify the protection of archaeological heritage at risk from development projects. 'Preventive archaeology', as it has become known, now accounts for more than 90% of all archaeological practice throughout Europe.

Setting out procedures which work in harmony with development-driven archaeology was at the heart of the ambitions for the EU-funded CONPRA (Contributing the Preventive Archaeology: Innovativeness, Development and Presentation) project. It set out to outline adaptive responses to the economic and technological environment surrounding archaeology, looking especially at the circumstances in emerging markets, where support for entrepreneurship and SMEs is often prioritised. The

project focused on knowledge transfer from archaeological fieldwork of techniques which had proven advantages of efficiency, accuracy, time and labour.

Knowledge transfer between partners

The project was predicated on a system for the efficient transfer of expertise, which it enabled through a series of secondments between academic and private sector entities. Four partner institutes — experts in different aspects of non-invasive digital technologies — were responsible for maximising the potential of each across the consortium. As the project coordinator, Dr Milan Hornak expounds, 'It is not by chance that most of them are well suited for non-invasive archaeological research (various surveys, remote sensing and other types of reconnaissance), since it is these methods and techniques which are crucial for making the ultimate decisions for complete excavations. In a certain sense, it is successful testing and sampling, which is the ultimate proof of preventive archaeology.'

Via Magna Ltd tested 3D photogrammetry on selected sites containing torsal architecture. Terra Verita Ltd evaluated large archaeological data-sets, acquired by non-destructive research to explore storage, retrieval and presentation issues. The University of Ljubljana involved SMEs in its programme of aerial reconnaissance (in Slovenia and elsewhere), whilst the University of Belgrade utilised 3D virtual reconstructions for the site at Vinča, a 10 m deep Neolithic site of extreme international importance for its evidence of the appearance of early farming in Europe.

A concern for the local as much as the global

The key outputs from CONPRA included freely downloadable manuals, containing guidance gleaned from the archaeological knowledge, experiences, methodologies and techniques explored during the project. According to Dr Hornak, these publications are intended for 'general field archaeologists and describe major concepts, categories and working procedures in all the areas of preventive archaeology that our project dealt with.' Additionally, scientific publications are available for free download from the project website to spread findings to a professional public beyond Europe. From this point of view Dr Hornak asserts that 'the success of CONPRA comes not so much in the generation of advanced technology but more in the integration and modification of existing technologies.'

The team also intends to submit their ArchaeoPax fieldwork assistance software, developed during the project, for further testing in various types of excavation and environments. Likewise, the interactive Web Map Server, created within CONPRA and currently presenting Slovakian data, will be regularly updated with the growing number of

archaeological excavations there, maximising its use value to the state administration.

By focusing on the economic and technological circumstances in emerging markets, the project was able to increase the capacities of small institutions and SMEs to adapt to changing conditions in their respective countries. As Dr Hornak summarises, 'Whilst major archaeological centres were able to follow ICT developments, this was not so much the case with a great number of locally-based enterprises, smaller museums, and institutes who were in fact much more involved in preventive archaeology.' Indeed, these smaller concerns were also previously less likely to be part of professional networks (academic, business, research etc.) outside of their immediate area and so had limited access to further development opportunities. A situation improved by the project.

"The success of CONPRA comes not so much in the generation of advanced technology but more in the integration and modification of existing technologies."

CONPRA

- ★ Coordinated by Via Magna in Slovakia.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/106182>
- ★ Project website: <http://www.conpra.eu/>
- ★  <http://bit.ly/2sPJpC7>

FINNISH STUDY REVEALS LINK BETWEEN UNEMPLOYMENT AND DIABETES

A study conducted in Finland has analysed the oral glucose tolerance tests of 1970 men and 2544 women in relation to their preceding three-year employment records. It found that men with high exposure to unemployment had a higher risk of pre-diabetes and screen-detected type 2 diabetes than employed men.

Research, partly supported by the EU-funded DYNHEALTH (Understanding the dynamic determinants of glucose homeostasis and social capability to promote Healthy and active aging) project, established that, in the men involved, pre-diabetes was found in 19.2% of those employed, 23.0% who'd been unemployed for less than a year and 27.0% of those unemployed for more than a year. The corresponding figures for screen-detected type 2 diabetes were 3.8%, 3.8% and 9.2%.

In women the results were less dramatic, although the numbers did go up slightly in relation to employment. The analogous figures for pre-diabetes were 10.0%, 12.6% and 16.2% and

for screen-detected type 2 diabetes 1.7%, 3.4% and 3.6%. In both cases the data were adjusted for education, smoking, alcohol intake, physical activity and body mass index. Among women, associations were attenuated in the adjusted models.

Diabetes is a growing global epidemic which impacts negatively on economies and involves complex interplay between biological, psychological and social factors. As we now know that progression towards type 2 diabetes can be prevented, or delayed, by lifestyle changes in high-risk individuals, identifying those people early enough is vital for timely diagnosis and treatment. The research presents another parameter to be taken into consideration when identifying those at risk.



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What is the relation between unemployment and diabetes?

There is a suggestion of a causal link between stress and the onset of type 2 diabetes. Physiologically this is probably provoked by the over-activity of the hypothalamo-pituitary-adrenal (HPA) axis and cortisol production. Behavioural factors will also be playing a role. Occurrence peaks in those from 40-64 and it has been hypothesised that employment-related stressors and the impact of shift work, could underlie its development.

In their paper published in the journal 'Primary Care Diabetes', the researchers observe that while stress relating

to employment has been studied, not much work has been done on the impact of unemployment, a known risk factor for poor health. To their best knowledge, say the team, this is the first study to test for the association with objective data for both the exposure to unemployment (national registers) and the outcome of glucose metabolism (OGTT).

The authors outline what they believe to be the key strength of their study as being, '(...) the objective register-based quantification of exposure to unemployment during a precise three-year follow-up period preceding an OGTT, capturing the important acute exposure to unemployment-related hardships during the early stages of diabetogenesis. Since the participants are of the same age, the analysis is not biased by temporal macroeconomic fluctuations in general unemployment rates, which may affect the health effects of unemployment.'

Useful pointer for early diagnosis

High exposure to unemployment may predispose middle-aged men to type 2 diabetes. For clinicians, awareness of the patient's unemployment status may be helpful in recognising undiagnosed cases. DYNAHEALTH, which supported the research, is also capitalising on a number of existing studies harnessing the health, biological and social resource of 1.5 million Europeans. In so doing it is boosting the development of risk-based prevention tools and policies and providing policy-makers with the necessary information on the best periods to invest in cost-effective and sustainable healthcare strategies.

DYNAHEALTH

- ★ Coordinated by the University of Oulu in Finland.
- ★ Funded under H2020 Health.
- ★ <http://cordis.europa.eu/project/rcn/193247>
- ★ Project website: <http://www.dynahealth.eu/>

"This is the first study to test for the association with objective data for both the exposure to unemployment (national registers) and the outcome of glucose metabolism (OGTT)."

SOCIAL SUSTAINABILITY IN COMPACT NEIGHBOURHOODS

EU-funded researchers have examined how a compact urban form can promote the social sustainability of intermediate neighbourhood areas in cities facing socio-cultural challenges. The results look set to help enhance policy related to the design of neighbourhood spaces.



The COMPACTABILITY (Contribution of compact neighbourhoods to social sustainability) project investigated the social sustainability of compact neighbourhoods in four case study neighbourhoods in Germany and the United Kingdom. The main research questions centred on: key qualities of the compact

neighbourhood and social sustainability, measurement of the indicators, and their interconnectivity.

Researchers collected data on two areas in Berlin (Klausenerplatz and Samariterkiez) and two in London (Kilburn and Bethnal Green). The three main topics related to urban form, social activity and social sustainability.

Urban form analysis generated in-depth knowledge about the basic qualities of neighbourhood space. Social activity mapping offered insights into spatial, gender and age patterns of social activities within neighbourhood public spaces. For the third topic, various analyses revealed the inhabitants' perceptions and ratings regarding different qualities of social sustainability.

All four cases show considerable differences in terms of urban form. For example, the German cases have higher population densities and have more mixed land use than the British cases.

Moving was, in all cases, the most dominant activity by far. No significant gender difference was found regarding

"Elderly people and teenagers use neighbourhood space the least when compared to adults."

total number of activities in the neighbourhood space, but COMPACTABILITY did find significant age differences: elderly people and teenagers use neighbourhood space the least when compared to adults.

In relation to the seven indicators used to measure social sustainability, basic urban facilities were deemed very accessible in all of the case study neighbourhoods. Walking and cycling were by far the most frequently used means for errands. Safety and security followed by home quality came in second and third, respectively.

Indicators and related measures were scored from 0-200, giving a 'social sustainability value' for each neighbourhood. Boasting a social sustainability value of 128.40, Klausenerplatz was found to be the most socially

sustainable neighbourhood, followed by Kilburn (122.02), Samariterkiez (121.53) and Bethnal Green (119.84).

COMPACTABILITY's outcomes shed light on different aspects of neighbourhood living. The research efforts have led to practical recommendations for promoting social sustainability in neighbourhoods.

COMPACTABILITY

★ Coordinated by Oxford Brookes University in the United Kingdom.

★ Funded under FP7-PEOPLE.

★ <http://cordis.europa.eu/project/rcn/187874>

FRENCH MIGRATION AND FERTILITY DECLINE

An EU team has studied French domestic migration in relation to national fertility for the period 1861-1911. Overall, fertility declined as a result of people moving from high- to low-fertility regions, and emigration to Paris explained one quarter of the total change.

France is an anomaly according to the theory that a decline in fertility is a key factor in the transition to modern economic growth. Although French birth rates had reached uniformly low rates prior to World War I, economic changes were not enough to explain the demographic transition.

"Fertility declined most in areas of high migration where the migrants moved to low-fertility regions, particularly Paris."

The EU-funded TCDOFT (The cultural diffusion of the fertility transition: Internal migrations in nineteenth century France) project offered a new theory. The team argued that although few French people migrated to the New World during the 19th century, many migrated within the country. Researchers investigated the hypothesis, focusing on specific patterns of migration among the French provinces between 1861 and 1911.

TCDOFT surveyed historical records of 3 000 families, including places of birth and death, of individuals whose surnames started with T, R or A. The data, combined with fertility records for each province, allowed for the reconstruction of fertility norms of emigrants and immigrants for the various provinces. The team

estimated migrants' contributions to demographic transition as weighted averages of fertility rates in the migrants' home and destination provinces.

In parallel, researchers traced the development of the French rail network and consequent lowering of transportation costs. Such development increased domestic migration.

Results indicate that fertility declined most in areas of high migration where the migrants moved to low-fertility regions, particularly Paris. The data was robust in accounting for confounding factors, including declining child mortality, rising education levels, industrialisation and religiosity. Researchers interpreted the findings as follows: Migrants who moved from high- to low-fertility regions would have communicated the new fertility norms and costs of raising children to acquaintances back home. Such information may have affected the motivations of potential immigrants.

The interpretation is supported by the following fact. Emigration to Paris accounted for over one quarter of migration within France during the study period, which explains half the national decline in fertility. Child mortality was the only other variable having a significant correlation to fertility decline.



The TCDOFT results contribute to related academic debates and to modern state policy. The study has shown the importance of migration in fertility decline.

TCDOFT

★ Coordinated by Bar Ilan University in Israel.

★ Funded under FP7-PEOPLE.

★ <http://cordis.europa.eu/project/rcn/107086>

ENERGY

NEW GRIDS ON THE BLOCK: SPARKING THE ENERGY EVOLUTION

Responding to increasingly complicated electricity demand, the EU-funded EVOLVDSO project outlines approaches to ensure a more proactive and flexible supply.

Within the electricity supply system, distribution system operators (DSOs) are broadly speaking responsible for delivering high-quality services to grid users by developing, operating and maintaining the network efficiently, while ensuring safety for people and assets. With the integration of Renewable Energy Sources, (intermittent and non-predictable by nature), the fast development of decentralised production, along with the changing uses of electricity (e.g. for electric vehicles), the system has become increasingly complex. Yet, despite these growing challenges DSOs have been slow to evolve.

EVOLVDSO (Development of methodologies and tools for new and evolving DSO roles for efficient DRES integration in distribution networks) set out to create a more active distribution management approach, which maximised investment. It did so by developing a menu of improved approaches on offer to DSOs which addressed the needs for priorities such as: The improvement of network planning and operation processes, flexibilities at different timeframes to solve specific network constraints and regulated services based on data management. The project defined the roles of DSOs based on future European electricity systems scenarios, as well as plugging research and technological knowledge gaps.

Developing a future-proofed system

Key to the success of the EVOLVDSO project was the creation of realistic future scenarios. The team analysed the electricity generation mix, the evolution of demand and the degrees of technological flexibility. As the project coordinator, Marco Baron recalls, 'Each scenario was developed according to a set of parameters, which vary with time. Since the development of quantities over time is uncertain, the definition of a scenario funnel helped describe the uncertainties. For example, with renewable energy we accommodated "under expected", "most likely" and "over expected" scenarios. Three time horizons were defined: Short-term (1 to 4 years), mid-term (8 to 10 years), long-term (20 years).'

These scenarios enabled the project to develop 10 innovative tools, focused on planning, operations, maintenance and coordination needs. For example, the interval constrained power flow (ICPF) tool estimates realistic values of active and reactive power, for the power flow exchanged at the boundary nodes between the transmission and distribution networks (primary substations). As the project's dissemination leader, Mr Jaime Rodrigues summarises, 'The ICPF was successful in that it was able to forecast the ideal operating point for a predefined time horizon while optimising costs.'

The project was able to map each tool's capability to fulfil the services linked with the new and evolving DSO roles. It also outlined the replicability and scalability potential of each of the tools, as well as performed a high-level cost-benefit analysis. For the tools tested in real environments, the team charted both the enabling and limitation factors pertaining to each of the countries involved (Belgium, France, Germany, Ireland, Italy and Portugal), as well as providing a forecast for their anticipated adoption timelines.

Offering smart and sustainable choice

By catering for flexible capacity and distributed generation, the results of EVOLVDSO will drive the implementation of the European Electricity Grid Initiative (EEGI). Additionally, through the integration of renewables — helping Europe meet its environmental targets — alongside consumer

empowerment initiatives, the project significantly contributes to wider public policies such as those striving for sustainable economies and smart cities.

For each tool, a technology readiness level (TRL) was created as an index to help potential adopters establish the maturity and usability of the tools. Also, with the exception of the software code and the dataset collected in the field tests, all the tool development results and the adoption recommendations are publicly available. It is hoped that these results can be used as input for future research activities.

EVOLVDSO

- ★ Coordinated by e-distribuzione in Italy.
- ★ Funded under FP7-ENERGY.
- ★ <http://cordis.europa.eu/project/rcn/109548>

SMART NEIGHBOURHOODS EXCHANGE ENERGY

Across the globe, local communities are increasingly starting to implement small-scale grids, showing how smart technologies can revolutionise future energy use. EU-funded scientists successfully developed an innovative technology system to cover electricity requirements on demand, enabling fluctuating solar energy to be partially balanced out and providing more self-sufficiency.

Solar power is a fast-growing source of renewable energy around the world. However, the combination of solar power's rising market share and its inconsistency of supply places heavy demands on the electricity supply grid. In addition, it limits self-sufficiency of residential or commercial buildings with electricity-generating solar panels mounted on the rooftops. Therefore, grid operators are required to maintain variable back-up systems of which most are currently coal-fired power plants that counteract the real benefits of using renewable energy.

Coordinated load shifting, storage and exchange of excess power in buildings of the same neighbourhood can provide a remedy to these problems and bring about reduced power bills for

consumers, as well as reduced peak loads on the public grid.

Focusing on these important issues, the EU-funded COSSMIC (Collaborating smart solar-powered micro-grids) project introduced an innovative solution that can control energy consumption and production of distributed energy resources, adapting energy use to different criteria such as availability, price and weather conditions.

Internet of energy

Researchers developed an innovative autonomic ICT system that can control energy usage, production and storage. It facilitates both peer-to-peer collaboration between microgrids in a neighbourhood and collaboration with the public power grid. Just as information is transported and exchanged over the internet, microgrids that act as a data

network can function on their own and exchange energy with neighbours for mutual benefit. For example, one microgrid cell that has too much power can transfer power to a neighbour building that has little.

'The system is governed by preferences and constraints set by inhabitants, and tries to adapt consumption to the local energy production through coordinated load shifting,' says Mr Hallsteinsen, project coordinator. He then explains in further detail that each building is equipped with a home gateway that monitors and controls its electric energy-consuming devices. Communicating with other residential gateways, it tries to solve the problem of scheduling flexible loads to match the total neighbourhood consumption to the expected neighbourhood production.

The system architecture is based on a highly distributed agent-based peer-to-peer approach where each consuming and producing device in the neighbourhood is represented by an agent. Batteries are represented by a coupled pair of agents, one responsible for the charging and one responsible for the discharging. The agents of a neighbourhood negotiate with each other to adapt consumption to the predicted production by shifting loads in time within constraints set by the inhabitants. The system automatically learns the consumption profile of



electricity consuming devices and uses weather forecasts to predict the production of connected solar panels, thereby enabling optimal coordination.

Storage can be provided either by batteries or even battery-powered units connected temporarily for charging (e.g. electric vehicles).

Smart eco-neighbourhoods

COSSMIC's new system allows consumers to procure power in real time at significantly lower costs, with improved return on investment on

their photovoltaic installations. Beyond reducing costs, microgrids that optimally combine and control renewable energy, conventional fossil energy, energy storage and load management can mitigate the environmental impact of electricity production. They also contribute to the transition to a more sustainable and smarter electric power supply system.

The monitoring part of the new system was installed in 12 buildings in the City of Konstanz (Germany) and in five buildings in the Province of Caserta

(Italy). Simulations of the coordinated load shifting based on the collected data support the feasibility of smart neighbourhoods with self-sufficient, energy-efficient buildings as proposed by COSSMIC.

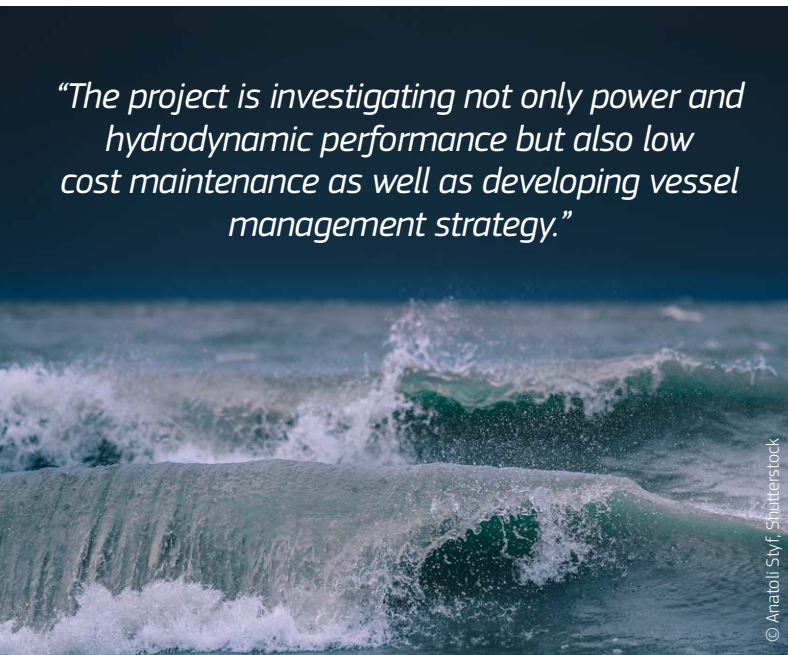
COSSMIC

- ★ Coordinated by SINTEF in Norway.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/110134>
- ★ Project website: <http://cosmic.eu/>
- ★  <http://bit.ly/2uec8Ey>

TIDAL ENERGY REACHES ANOTHER MILESTONE

The EU-funded FLOTEC project's tidal turbine has now matched the performance of established offshore wind turbines, generating over 18 megawatt-hours (MWh) within a continuous 24-hour testing period and heralding an age of more competitive tidal energy supply.

"The project is investigating not only power and hydrodynamic performance but also low cost maintenance as well as developing vessel management strategy."



The currents of coastal tidal waters provide a source of energy, exploitable by devices which function much like submerged wind turbines. Yet owing to high water density, the blades of these devices can be smaller and turn more slowly. Additionally, topographical features, such as inlets, can amplify the kinetic energy produced by the fast sea currents creating funnels and channels through which water is forced. Despite this potential, the industry has faced a number of challenges and so hasn't yet achieved comparable progress to other renewables, such as wind and solar. Operating at sea means that equipment has to be durable and resistant to salt corrosion and there remain concerns for marine life safety.

The EU-funded FLOTEC (Floating Tidal Energy Commercialisation) project was set up to exploit the ocean's energy supply potential by using floating tidal stream turbines, demonstrating how the technology could: reduce cost and risk, improve reliability, while also

setting out a commercial framework for its introduction to the European grid.

Setting a new tidal industry benchmark

Key to FLOTEC's operation is the SR2000 tidal turbine, reputed to be the largest and most powerful in the world. Designed for a 20-year lifespan, it can be deployed in any water with depths of at least 25 m, and with its agile anchoring system is adaptable to most seabed types. The floating platform holds two horizontal axis turbines mounted just below the sea surface where tidal flow is at its strongest.

In April this year, the SR2000 reached peak power at 2 megawatt (MW) rated capacity. The project team have since built on this achievement by generating over 18 MWh within a continuous 24-hour testing period. This performance puts it at the same level as that achieved by established offshore wind turbines.

Further optimising energy extraction

The FLOTEC project had improved on the SR2000 tidal turbine with the Mark 2 iteration by increasing the rotor diameter from 16 m to 20 m, which the project anticipates will increase energy capture by 50%. In its quest to reach flexible, base-load energy generation the project also harnesses innovations in automated steel fabrication, integrated energy storage, centralised Medium Voltage power conversion, mooring load dampers and composite blade manufacturing.

To help facilitate ease of access and maintenance, the platform hull contains most of the internal components of the turbines above the waterline. A key feature to aid maintenance, and reduce draught while being towed, was designing the turbine blades so that they are retractable under the hull. The test programme is being conducted at the European Marine Energy Centre (EMEC) in Orkney, Scotland where the patented technology has been connected to the Orkney grid for phased power export. The project is investigating not only power and hydrodynamic performance but also low cost maintenance as well as developing vessel management strategy.

Charting a course forwards

The SR2000 Marks 1 and 2 will be deployed alongside each other at EMEC, forming a 4 MW floating tidal array demonstrating energy extraction in locally varying tidal resources. The project aims to reduce the levelised cost of energy (LCOE) which calculates investment against output, across energy assets of floating tidal energy. The hope is to bring the LCOE down from the EUR 250/MWh currently estimated, to EUR 200/MWh.

To support the industry, last year the EU's DG for Environment announced a roadmap, alongside a proposal

for a EUR 320 million investment plan, towards meeting 10% of the EU's energy needs through tidal and wave energy by 2050. The money is intended to help companies bridge the gap between demonstrations and entering the marketplace.

FLOTEC

★ Coordinated by Scotrenewables Tidal Power in the United Kingdom.

★ Funded under H2020 Energy.

★ <http://cordis.europa.eu/project/rcn/199964>

MILESTONE REACHED IN GEOTHERMAL DEEP DRILLING PROJECT

The EU-funded DEEPEGs project has managed to drill 4659 metres into a geothermal field in what is being described as a 'significant milestone' for the geothermal industry.

The results and lessons learned from the drilling process, which took 168 days, have just been published by the EU-funded DEEPEGs (Deployment of Deep Enhanced Geothermal Systems for Sustainable Energy Business) project whose well now has the deepest casing of any in Iceland. The work was done in two phases, the first to deepen an existing 2500 metre well to 3000 metres and then to drill still further to an ultimate depth of 4659 metres.

The project's long-term goal is to use deep wells for highly efficient energy production, opening up new dimensions in the use of geothermal as a source. DEEPEGs needed to find supercritical fluid at the bottom of their well as this has a much higher energy content than conventional high-temperature geothermal streams resulting in a more efficient energy source — the project was able to report that it had done so.

Surmounting obstacles and gaining valuable experience

DEEPEGs explains that drilling a well this deep and hot presents challenges that are hard to overcome. As they drilled further down the complexities developed, and since this well went deeper than any that preceded it, DEEPEGs gained new insights into the type of problems that arise.

Extracting drill cores proved particularly difficult, it took 13 attempts to extract 27.3 metres and the last core to remove was at the bottom of a shaft of about 4500 metres. Conventional drilling methods were not an option, so the

project had to develop new means of tackling the challenges. All obstacles apart from the last, circulation loss, were overcome.

The project found the complete loss of circulation below 3060 metres could not be dealt with through lost circulation materials, or by sealing the loss zone with cement. As a result, drill cores were the only deep rock samples recovered. However, as DEEPEGs set out to drill deep and extract cores, measure temperatures, search for permeability and find fluids at supercritical condition, the main objectives were reached.

So how viable is the source?

DEEPEGs believes the scope for potential utilisation will not be known until the end of 2018 when all research, including substantial well simulation and flow

testing, has been conducted. But, says the project, initial indications are positive. The temperature at the bottom of the well has already been measured at 427 °C, with fluid pressure of 340 bars, drill cores were retrieved, and the rocks appear to be permeable at depth. If deep, supercritical wells can produce more energy than conventional geothermal wells, fewer will be needed, resulting in the same amount of energy capture for less environmental impact.

DEEPEGs

★ Coordinated by HS Orka in Iceland.

★ Funded under H2020 Energy.

★ <http://cordis.europa.eu/project/rcn/199917>

★ Project website: <https://deepeg.eu/>



ENVIRONMENT

IMPROVED PREDICTIONS FOR WEATHER AND CLIMATE

Never before has so much information concerning the global atmosphere, oceans and land surface been available but large gaps in the data still exist. These gaps, together with imperfect forecasting models and complexity of climate processes, prevent an accurate understanding of both the current and future state of the atmosphere and climate system.

Weather forecasting depends on the accuracy of the initial conditions (called analysis) and numerical representations of the atmosphere. Analyses are prepared using temperature, wind speed and moisture measurements taken between the Earth's surface and a height of about 60-80 kilometres. At present, the main missing component of the global observing system is wind observations, particularly over the oceans.

'Numerical weather prediction' (NWP) models apply mathematical formulations of the atmospheric processes to make predictions based on current conditions as provided by the observations. These models generate weather forecasts on hourly to weekly time scales and on many spatial details. For the climate prediction, models need to include both the atmosphere, ocean and land predictions as well as the atmospheric composition and its variations. The climate model results are being widely used to understand current and future climate change.

A lack of observations and imperfections in the models result in uncertainties in the analyses and forecasts. However, even with the perfect models and accurately known initial states, forecasts grow increasingly uncertain with forecast length due to inherent non-linearity in the flow.

These challenges were addressed by the EU-funded MODES (Modal analysis of atmospheric balance, predictability and climate) project, which provided a global perspective of the predictive capability of NWP models.

'Atmospheric scientists investigated the dynamic properties of the atmosphere and climate dynamics over different spatial and temporal scales, showing the larger the spatial scale the greater the level of uncertainty in the initial conditions on which the weather prediction is based,' says project coordinator Prof. Nedjeljka Žagar.

Researchers developed and implemented a novel software tool (named MODES) for analysing atmospheric balance and predictability in weather and climate models. This innovative approach is used to validate and improve climate models.

'MODES provided a scale-dependent, three-dimensional global view of atmospheric predictability associated with analysis uncertainties in balanced and unbalanced circulation,' comments Prof. Žagar. 'Results showed that the majority of uncertainties are in the tropics due to unbalanced or inertio-gravity waves,' she explains.

The study looked at atmospheric balance and predictability in terms of the energy associated with various types of waves: balanced or Rossby-type waves and unbalanced or 'inertio-gravity' (IG) waves. Known as the normal-mode function representation, this approach is at the heart of the methodology proposed in MODES.

'Energy levels associated with IG waves are much lower than the Rossby wave energy and their spatial scales are usually smaller, making them hard to model. However, their role is very important, strongly affecting both weather and climate, therefore it is crucial to validate their properties in NWP and climate models,' claims Prof. Žagar.

Therefore, MODES provided a method for estimating temperature and wind perturbations associated with IG waves in the global data. This method can be used to validate the IG waves in NWP and climate models by directly comparing them to observations of gravity wave fluxes available from periods of intense observations.

Project results will benefit the NWP and climate model community and all those dependent on their work. MODES software was made available to the atmospheric research community and applied to the leading weather prediction model, that of the European Centre for Medium-Range Weather Forecasts. Selected outputs of the modal analysis are published on a daily basis on the project website.

MODES

- ★ Hosted by the University of Ljubljana in Slovenia.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <http://cordis.europa.eu/project/rcn/99858>

HOW STUDYING CONTAMINANT FLOWS THROUGH RIVER SYSTEMS CAN HELP CUT POLLUTION

An EU-funded project has been training the next generation of scientists to understand the processes behind river and wetland industrial and agricultural pollution, paving the way for new and innovative solutions.

Humans are increasingly impacting European rivers and wetlands. As we urbanise, build new factories and continue to farm the land extensively, more and more contaminants from intense industrial and agricultural activities are being released into freshwater bodies.

The EU-funded HYTECH (Hydrodynamic transport in ecologically critical heterogeneous interfaces) project trained 11 doctoral and four post-doctoral fellows to investigate innovative solutions to environmental problems in natural water systems.

The project delved into the processes that are behind the transport of contaminants and nutrients through water ecosystems. 'The idea was to form specific competences at the European scale to face urgent problems posed by the impact of humans on natural aquatic ecosystems,' says Andrea Marion, HYTECH project coordinator.

The project's researchers were from many different fields including engineering, ecology, water biochemistry, hydrology, computational methods and photonics. Using an interdisciplinary approach, they focussed on the role of water 'interfaces' — or the zone between water and river and wetland sediments.

One zone studied by the project is known as the 'hyporheic zone'. It lies under the river flow, in the porous sediment river bed and is home to plant roots, bacterial colonies, micro-invertebrates, fish eggs and other life. 'These locations are where ecosystem quality is determined,' explains Marion.

In a bid to uncover how pollution flows through a natural water ecosystem, HYTECH developed novel distributed sensing technologies and innovative tracer methods to measure the transport of contaminants in rivers. It invented a new movable field station, and an innovative annular experimental flume. The project



also built new hi-tech instruments to evaluate the status of ecosystems in natural rivers.

It also employed innovative research methods by collecting integrated datasets of physical and chemical quantities to evaluate ecosystem status and organism traits in natural rivers.

'The project activities and findings represent a significant step forward towards the integration of interdisciplinary competences, and this is what is most needed in environmental research to address societal problems,' says Marion.

HYTECH's results have been published in major international journals and in the GeoPlanet book series. The project also produced a scientific documentary called 'INTERFACES' aiming to show the importance of HYTECH's work to the public.

The project's fellows are now going to enter either a research or a professional career where they are expected to play a role in addressing and solving environmental problems.

Meanwhile, HYTECH's instruments and software will be marketed once a user-friendly version has been developed.

"The project also built new hi-tech instruments to evaluate the status of ecosystems in natural rivers."

With the project now over Marion hopes to continue working on natural aquatic environments and on producing new audio-visual material targeting the public and decision-makers. 'I am convinced that the work of scientists must be made accessible to non-experts so they can see the necessary role of science and scientists for the protection of the environment and of our own species on planet Earth,' he concludes.

HYTECH

★ Coordinated by the University of Padua in Italy.

★ Funded under FP7-PEOPLE.

★ <http://cordis.europa.eu/project/rcn/106576>

★ Project website: <http://hytech.dii.unipd.it/>

★  <http://bit.ly/2u95cc0>

IN-DEPTH ANALYSIS OF LONG-TERM TRENDS FOR SEVERE WEATHER AND CLIMATIC EVENTS

Extreme weather and climate-related events caused by natural hazards have been on the rise over the last decades. An EU initiative sought to better understand such extreme events for more optimal prediction and planning.

Scientific research continues to look into the causal link between catastrophes and weather and climate. One focus is on the short-term prediction of extreme events by weather forecast providers. Another concerns detecting and attributing anthropogenic climate change (global warming) to the past, and assessing potential changes to extreme event behaviour and characteristics for possible future climate developments.

Exploring the potential of future climate developments

More insight is needed on variability steering factors and processes involved in modulating the frequency and intensity of extreme events on timescales ranging from days up to 30 years and beyond. With respect to mechanisms steering the variability of extreme events, knowledge of decadal (natural) variability that interacts with potential long-term anthropogenic climate change will be crucial in providing reliable information to stakeholders and end users from industry and society. 'Such information is important as it could be linked to long-term anthropogenic forcing factors,' says principal project investigator Dr Gregor Leckebusch. 'This will provide more realistic estimates on potential extreme event behaviour for the coming decades until the middle of the century.'

The EU-funded EVE (Extreme events variability over Europe) project explored causes for the variation in different timescales during meteorological and climatological extreme events over the European and North Atlantic regions. It focused on severe extra-tropical cyclones as the major meteorological hazard to Europe. For beyond 2040, scenario-based simulations were studied to determine estimates on long-term developments. In addition, the project estimated the damage potential of wind storms on various timescales.

Predicting extreme event scenarios over time

EVE extensively investigated various timescales, from a few days up to decades, involved in the development of extreme events. According to Dr Leckebusch, such analyses delivered notable results that have already drawn interest from the finance industry. 'Being able to predict frequencies of severe winter storms in Europe a season ahead can have an immense impact on the financial sector, especially the insurance industry,' he explains. A model was also developed to predict the amount of clustering of damage-prone windstorms and European heatwaves.

"Being able to predict frequencies of severe winter storms in Europe a season ahead can have an immense impact on the financial sector, especially the insurance industry."

The project showed that well-known variability modes such as El Niño-Southern Oscillation in the Western Pacific need to be supported by additional anomalies in order to have an impact on the storm activity over the North Atlantic-European sector. 'This understanding is fundamental to the development of more conceptual models for tropical and extra-tropical interactions with respect to extreme events,' notes Dr Leckebusch. 'This could be further developed into early warning types of extra-tropical storm activity estimates.'

By analysing historical trends derived from different state-of-the-art reanalysis data, EVE demonstrated the necessity for further studies into the drivers of multi-decadal variability. In particular, long-term trends before the 1970s are sensitive to these data sets. 'We contributed to the discussion and identification of historical trends in storminess,' adds Dr Leckebusch.

'The insight gained from EVE should help to provide more realistic estimates for needed adaptation strategies for anthropogenic climate change impacts, and their timely planning and introduction,' concludes Dr Leckebusch.



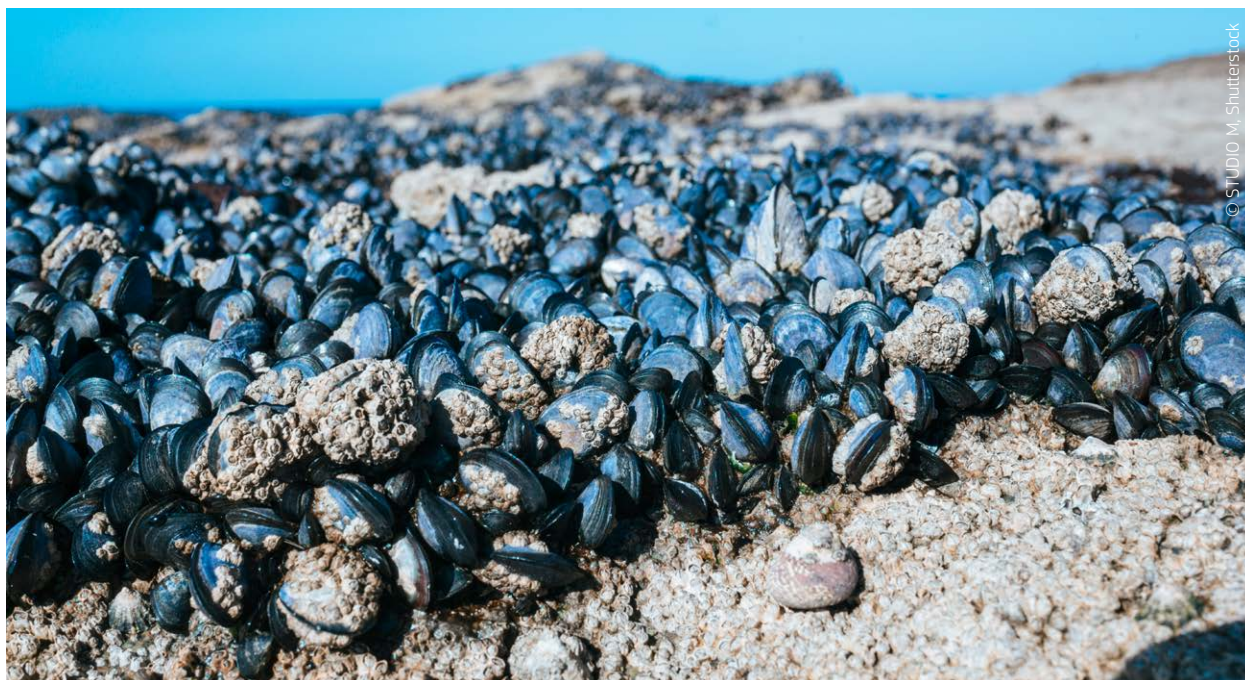
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EVE

- ★ Coordinated by the University of Birmingham in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/105499>

THE IMPACT OF SUNSHINE ON MUSSEL BEDS

Identifying the environmental factors driving larval settlement is crucial to understanding the population dynamics of marine invertebrates. EU-funded research feeds into a new study that takes three environmental factors into consideration in an attempt to predict larval presence and intensity.



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The impact of three environmental factors — solar irradiance, wind regime and continental runoff — on *Mytilus galloprovincialis* settlement patterns was analysed by researchers who have recently published their findings in Scientific Reports. Results show solar irradiance indirectly influences the settlement process, leading the team to suggest the use of this meteorological variable to predict settlement occurrence.

Marine benthic invertebrates have synchronised reproductive cycles to produce larvae under optimal conditions for survival. The longer the species remain at larval stage the more threats to their survival they face, such as predation and transportation to unsuitable places. Establishing the factors impacting on cycle timing and density can aid in the understanding of how environmental changes may affect population dynamics.

Influence of solar irradiance

The team managed to establish a functional generalised additive model (designed for association studies between a scalar response and a functional predictor). This considered the

influence of the three environmental factors above and can provide a prediction of settlement. Results, to which the EU-funded CLIMEFISH (Co-creating a decision support framework to ensure sustainable fish production in Europe under climate change) project contributed, indicate solar irradiance allows the prediction of the beginning and end of a settlement cycle a month in advance. Solar irradiance during the late winter indirectly drove the intensity of the onset of the settlement.

The team conducted weekly monitoring over a five-year period on *Mytilus galloprovincialis* settlements situated around artificial, suspended substrates, to establish interannual variability in the settlement patterns. Previous studies have focused on the link between dispersal and hydrodynamics and have connected the temporal pattern of settlement to reproductive cycles. The paper, 'Solar irradiance dictates settlement timing and intensity of marine mussels', shines further light on larval settlement, a vital phase in the animal's lifecycle as it links larval and benthic stages and plays a pivotal role in population density.

Impact of findings

Mussels are dominant organisms on many rocky shores around the world, playing a significant role as both habitat and prey for a variety of organisms. Mussel culture is also important commercially, for example, the paper explains the northern boundary of the Iberian-Canary Current upwelling system is characterised by high mussel production.

The CLIMEFISH project aims to help ensure that the increase in seafood production comes in areas and for species where there is a potential for sustainable growth, given the expected developments in climate, thus contributing to robust employment and the sustainable development of rural and coastal communities.

CLIMEFISH

- ★ Coordinated by the University of Tromsø in Norway.
- ★ Funded under H2020 Food.
- ★ <http://cordis.europa.eu/project/rcn/200477>
- ★ Project website: <http://climefish.eu/>
- ★  <http://bit.ly/ZuR6bep>

AQUATIC RESOURCES

NEW RECOMMENDATIONS FOR GROWTH OF ORGANIC AQUACULTURE

Europe's organic aquaculture industry has received a boost, thanks to an EU-funded initiative that revised the current EU regulatory framework. Not only will this improve the sector's sustainability, but it will increase its customer appeal.

Organic aquaculture is a holistic method of organic farming that ensures the sustainable, environmentally friendly production of healthy fish, shellfish and seaweed, produced according to organic principles. Managing aquaculture in this way is growing more popular as consumers become increasingly aware about the positive effects of organic products on the environment and human and animal health and welfare.

The ORAQUA (European organic aquaculture — science-based recommendations for further development of the EU regulatory framework and to underpin future growth in the sector) project was established to advance the scientific basis of organic aquaculture at the Europe-wide level.

This initiative provided advice for the possible revision of EU regulations on organic aquaculture, taking into account different fish species and production systems, animal welfare and veterinary treatments, and environmental aspects. The project also increased understanding of fish farm economics and the competitiveness of organic aquaculture products in the EU markets.

Seeing the big picture

'One of the hallmarks of organic aquaculture is that it takes a holistic view, which considers all the aspects that production might have on the environment, farmed fish and society itself,' explains Dr Åsa Maria Espmark, the coordinator of ORAQUA.

A holistic approach also accounted for other aspects of organic aquaculture including the role of European regulation, scientific knowledge and stakeholders' opinions. The project's recommendations have successfully considered a range of viewpoints.

Consortium members reviewed the relevant scientific knowledge available on fish health and welfare, organic aquaculture production and economics. An assessment was also made of consumer confidence and public perception of organic aquaculture.

In addition, project partners explored critical issues concerning the regulatory and legal framework at both the national and EU level. These findings were used to better inform regulatory bodies that are developing systems and standards for organic aquaculture across the EU.

The results also helped to identify those socio-economic issues and bottlenecks that must be addressed to ensure the successful implementation of organic aquaculture. 'We uncovered some knowledge gaps and other challenges that need to be addressed if we are to increase organic aquaculture turnover,' says Dr Espmark.

Engaging with stakeholders

A multi-stakeholder platform was established to ensure maximum interaction with all relevant stakeholders, thereby benefiting the organic aquaculture industry and society as a whole. They included producers, consumers, retailers, feed and services suppliers as well as national and international regulatory bodies, environmentalists and non-governmental organisations.

According to Dr Espmark: 'There is a lack of public understanding about organic aquaculture and what an organic fish is. Awareness of the Euro-leaf logo, which is carried by products that are legally qualified as organic, is also limited.'

The team drew up recommendations to optimally enhance the economic development of the European organic

aquaculture sector. This included the use of renewable energy, recyclable materials and waste reduction schedules, plus environmentally friendly packaging. The importance of actions that reduce the environmental impact of organic fish farms was also emphasised.

ORAQUA also proposed a model structure for the continuous assessment and improvement of organic aquaculture in the future. This will take into account new scientific knowledge and changing competitive market environments.

The work will thereby inform EU regulations on organic aquaculture to facilitate better health and welfare for cultivated species and the reduction of environmental impacts.

ORAQUA

- ★ Coordinated by Nofima in Norway.
- ★ Funded under FP7-KBBE.
- ★ <http://cordis.europa.eu/project/rcn/111330>
- ★ Project website: <https://www.oraqua.eu/>
- ★ <http://bit.ly/2udYAZt>

IMPACT OF HUMAN PRESSURES ON THE MEDITERRANEAN SEA'S ECOSYSTEM

The Mediterranean has been described as 'under siege' because of the intense pressure it is under from a variety of human activities. But more information is needed to see what impact the activities are having on the ecosystem and its resources. An EU-funded project has published a report to help plug the information gap.

Around the world marine ecosystems are being stressed by a diversity of anthropogenic activity. Fisheries and aquaculture, pollution (including agricultural run-off), habitat loss and degradation, and species invasion are all putting the ecosystems in seas and oceans under pressure. Human activity is increasing rapidly and the EU-funded MERCES (Marine Ecosystem Restoration in Changing European Seas) project aims to further our understanding of the changing interaction between humans, the environment and marine species.

The Mediterranean Sea is a highly diverse marine ecosystem that hosts 7-10% of the world's marine biodiversity. Using trend data from 1950 to 2011, the MERCES project has investigated the whole of the Mediterranean Sea and found that anthropogenic activities have played an important role in driving species dynamics. The project recently published a paper in 'Scientific Reports' in which they present their findings, including their observation of a reduction in abundance of important fish species amounting to a decrease of 34% in both commercial and non-commercial species and 41% in top predators. The team explains that community biomass,

trophic levels, catch and diversity indicators all show that the ecosystem has been degraded over time.

MERCES evaluated the temporal responses of species abundance and ecosystem dynamics to changes in primary productivity and fisheries using the Ecopath with Ecosim (EwE) food web model approach. The team focused on 'Eco-system based management' (EBM), rather than an evaluation of single resources and threats, using models that allow for the quantitative assessment of the role of different stressors.

The study, 'Historical changes of the Mediterranean Sea ecosystem: modelling the role and impact of primary productivity and fisheries changes over time', quantifies temporal dynamics and then calculates a series of ecological indicators to analyse past ecosystem dynamics. Their specific goals were to investigate the sea's temporal evolution by developing a hind-cast scenario, to establish differences and similarities in historical ecosystem dynamics through modelling, and to analyse the structural and functional historical changes of the sea's ecosystems using specific model-based indicators.



They describe their study as a 'baseline reference', which can play a role for future research in the face of increasing pressure on the Mediterranean due to the combination of climate change and human activity. Since the intensity of these stressors is increasing throughout most of the Mediterranean basin, temporal analyses are increasingly needed to inform effective current and future marine policies and management actions.

MERCES

- ★ Coordinated by Marche Polytechnic University in Italy.
- ★ Funded under H2020 Environment.
- ★ <http://cordis.europa.eu/project/rcn/203265>
- ★ Project website: <http://www.merces-project.eu/>
- ★ <http://bit.ly/2sQ78SH>

EFFECT OF VEGETARIAN FEEDS ON FARMED FISH

Fish caught at sea are used as feed for Europe's growing aquaculture sector. An EU-funded initiative addressed this unsustainable use of marine resources by examining the effect of plant-based nutrition on farmed fish.

In Europe, most farmed species of fish are carnivorous; their feed contains 'fish meal' (FM) and 'fish oil' (FO) derived from wild stocks caught at sea. However, demand for this 'raw material' is now increasing from the expanding aquaculture sector and the human health sector that uses FO in food supplements. There is a growing need for sustainable alternative ingredients, such as plant-based feeds to reduce pressure on marine resources.

Biologists from the ARRINA (Advanced research initiatives for nutrition and aquaculture) project investigated the nutrient requirements of the five most commonly farmed fish species in Europe: Atlantic salmon, Rainbow trout, European seabass, Gilthead seabream and Common carp. This information was used to develop sustainable plant-based aquaculture feeds tailored to the requirements of each species, but containing lower levels of FM and FO.

'The aim was to provide flexibility in the use of cost-efficient and environmentally friendly ingredients in the formulation of feeds in order to produce seafood of high nutritional value and quality,' explains Dr Sadasivam Kaushik, the coordinator of ARRINA. He adds, 'Beneficiaries will include all those linked with the European fish farming sector, from suppliers of feedstuffs to feed producers and farmers.'

Biomarkers measure effects

Project partners developed tools based on relevant biomarkers to measure and predict the effects of alternative feeds on fish metabolism and to identify the nutritional requirements for each species over the whole life cycle. Researchers measured the long-term effects of changes in dietary formulations on fish performance, including thresh-

old effects, nutritional intervention in early life stages and the impact of maternal diet on larvae.

According to Dr Kaushik, 'Developing exploitable predictive biomarkers to

"Developing exploitable predictive biomarkers to assess the effects of nutrients was a key result."

assess the effects of nutrients was a key result. Furthermore, novel data was obtained on nutrient requirements, especially in the context of using feeds rich in plant protein and oil sources.'

Scientists established new ways to deliver specific micro-nutrients to modify egg composition or enhance the growth performance of fish-larvae, thereby improving the efficiency of the production process. They could significantly reduce the levels of FM and FO in the feeds of the five species studied without adversely affecting key performance indicators or nutrient utilisation.

Greater productivity and improved performance

The use of nutritional programming to improve alternative diets in the selected fish species was also investigated. Nutritional programming is based on the idea that



differences in nutrition during critical periods in early life can programme an organism's development, metabolism and health for the future.

In addition, a web-based tool that assesses the possible nutrient loadings into the environment was created and made available to all stakeholders. Project partners also designed and delivered training courses in fish nutrition to increase research capacities and expertise, particularly in countries of the enlarged EU.

By developing applied tools and solutions of technological interest in collaboration with 'Small and medium-sized enterprises' (SMEs), ARRINA generated new knowledge and strengthened the links between the scientific community and the EU feed industry. This will contribute to the increased productivity and performance of the aquaculture sector, leading to a competitive advantage to the whole sector at a global level.

ARRINA

- ★ Coordinated by INRA in France.
- ★ Funded under FP7-KBBE.
- ★ <http://cordis.europa.eu/project/rcn/101744>
- ★ Project website: <http://www.arraina.eu/>
- ★  <http://bit.ly/2vcATxN>

INDUSTRY

‘SENSITIVE’ BUILDINGS ADAPT TO CHANGES

A highly innovative construction system promises freeform and flexible structures via technological solutions never before used in architecture.

Construction is one of the most traditional and less technified industries, a situation that has negative consequences in many areas, including product quality and the ability to export. To become more competitive, the construction sector needs support in research and development.

The EU-funded HYPERMEMBRANE-DEMO (Demonstration of an adaptable structure for architecture applications) project was launched to provide the construction market with a standardised technology for the erection of lightweight architectonic structures that can reproduce complex geometrical surfaces.

The extremely innovative technology has been under development since 2003 and, over the years, has been recognised through many awards and exhibitions. In 2011, it was chosen for funding under FP7. The project eventually ended with a prototype system

on which validation tests were carried out.

Hypermembrane has a flexible self-supporting structure exploiting the elastic properties of thermoplastic composite materials. With the incorporation of intelligent actuators, construction can take on an endless list of shapes, starting from even the most basic elements.

Among its many applications, this revolutionary architectural solution can be used for covering stages and in smart buildings. The ethylene tetrafluoroethylene membranes used are lightweight compared to glass and, importantly, allow the structure to react independently to changes in temperature.

By combining physical and digital elements, Hypermembrane proved able to support geometric shapes that are malleable to spatial requirements, light conditions and energy needs. Through dedicated software, the

“This revolutionary architectural solution can be used for covering stages and in smart buildings.”

roofing system has also achieved a bending capacity similar to that of human muscles.

The HYPERMEMBRANE-DEMO team demonstrated the new technology through a 20-metre long adaptive installation at the Design Hub Museum in Barcelona. The installation is a unique example of biomimetic architecture.

HYPERMEMBRANE-DEMO

- ★ Coordinated by Eurocomercial de Nuevas Tecnologías in Spain.
- ★ Funded under FP7-SME.
- ★ <http://cordis.europa.eu/project/rcn/111439>

A SUSTAINABLE WAY TO TREAT MANUFACTURING EFFLUENT

Metal finishing and coating operations in Europe produce over 300 000 tonnes of waste. EU-funded scientists have developed a new way to treat the industry's wastewater that recovers valuable metals and generates energy and clean water.

The metal and plastic surface processing industry treats the surfaces of metals and plastics to make them stronger and more tolerant of wear. However, the effluent this processing generates is contaminated with oil and grease, organic materials, salts and heavy metals.

Each year, European metal finishing and coating operations produce more than 300 000 tonnes of hazardous waste and consume over 100 million cubic metres of water. Stringent EU legislation and the growing costs of water and discharges are encouraging the industry to find better ways to treat its effluent.

With EU funding, the ECOWAMA (Eco-efficient management of water in the manufacturing industry) project developed a new way to treat wastewater, combining effluent treatment with the recovery of clean water, valuable metals and energy.

The method the researchers devised is a chemical-free, closed-loop process that is cost-effective and sustainable. The innovative system harnesses hydrogen produced during the treatment process to feed fuel cells that generate electricity. This reduces the energy requirements — and carbon dioxide emissions — of the entire process.

Pre- and post-treatments remove oils, grease and conductivity. On top of this, a novel process that involves concentrating wastewater separates heavy metals from the effluent and reduces them to a solid, highly purified state.

The treatment method developed by ECOWAMA will reduce water consumption, increase efficiency, avoid the use of



hazardous chemicals and help recover valuable materials. The success of the initiative will also serve to encourage the acceptance and wider use of electrochemical and physical wastewater treatment in the surface processing industry.

ECOWAMA

- ★ Coordinated by Fraunhofer in Germany.
- ★ Funded under FP7-ENVIRONMENT.
- ★ <http://cordis.europa.eu/project/rcn/105524>
- ★ Project website: <https://www.ecowama.eu/>
- ★ <http://bit.ly/2vcXhav>

NEW INSIGHT INTO NATURAL SLATE SOLVES ROOFING MARKET'S PROBLEMS

Many historic buildings throughout Europe were built with slate, yet little is known about these building rocks used for roofing. An EU initiative shed important light on this stone, and proposed solutions to some of the European roofing slate industry's pressing issues.

Since the dawn of time, slate has been the most important natural stone and virtually the only one used for roofing. However, there is a lack of knowledge about this valuable material, in contrast with the abundant scientific literature for other stones such as marble or granite.

The EU-funded TOMOSLATE (New uses for X-ray tomography in natural building stones: Characterisation, pathologies and restoration of historical and recent roofing slates) project aimed at 'filling the knowledge gap, while identifying the main problems of the roofing slate industry in Europe and providing answers,' says principal project investigator Dr Víctor Cárdenes. The characteristics of roofing slate were examined

using X-ray 'Micro-computed tomography' (MCT), together with other analysis techniques.

Novel methods to tackle roofing slate industry problems

'Today, no standard classification exists for the different varieties of roofing slate,' notes Dr Cárdenes, a researcher at Belgium's Ghent University. The roofing slate industry uses commercial names, instead of the petrological denominations for each rock. This leads to overall confusion about the nature and characteristics of roofing slates. TOMOSLATE characterised and classified the existing roofing slate lithotypes. According

to Dr Cárdenes, this is the first ever classification of roofing slates to be performed anywhere in the world.

The project defined the pathologies that affect roofing slates in order to propose a methodology that mitigates the incidence of weathering on the stone. 'This is vital to preserve Europe's architectonic heritage,' stresses Dr Cárdenes. The method to prevent iron sulphide oxidation — the main weathering culprit — is based on a new concept. Instead of applying a chemical product to the roofing slate during the production chain, this innovative technique is employed when the slate on the roof begins to show oxidation. A protective coating paint is applied

using a spray can. The approach is easy to use and environment friendly.

TOMOSLATE analysed the standardised tests applied to roofing slates. 'These tests are mandatory for the roofing slate market,' he adds. 'However, they can be optimised to improve the information obtained from assessments.'

Dr Cárdenes says that the project also yielded an unexpected result. The use of MCT on slates highlighted a pyrite framboid POPULATION. Measuring and analysing these populations in a fast and reliable way has opened up a new line of research which has important implications for other fields of geology, including palaeoecology and ore mining.

Unlocking the mystery of what roofing slate actually is

'TOMOSLATE will help the roofing slate industry, builders and architects to better understand their products,' explains Dr Cárdenes. When he and others visited slate quarries and gave talks at dedicated conferences, the overall impression was that nobody really knew exactly what roofing slate was. Some producers didn't even know what kind of stone they were quarrying.

'We now have greater awareness of a very important natural stone that's used abundantly in Europe and the rest of the world,' concludes Dr Cárdenes. Ultimately, TOMOSLATE

"We now have greater awareness of a very important natural stone that's used abundantly in Europe and the rest of the world."

outcomes will revitalise the economy of European slate-producing areas because of the added value given to their slates.

TOMOSLATE

- ★ Coordinated by Ghent University in Belgium.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/187735>

NEW POLYMER COMPOSITES FOR ORGANIC BIOELECTRONICS

The evolution of materials science is on fast forward with scientists taking inspiration from nature. Reflecting this, an EU-funded project has developed new materials for novel applications in the broad area of organic bioelectronics.

The POLYMED (Novel conducting polymer composites for applications in medicine) project has forged a collaboration between expert research teams in Europe, the United States and Canada to foster progress in organic bioelectronics through the development of new materials. Targeted technologies could be used in biological sensors for healthcare and prosthetics.

Strong communication and collaboration between students and partners from the very outset meant exceptional progress throughout the project period. POLYMED achieved all of its objectives and technical goals.

Organic electrochemical transistors (OECTs), where ions penetrate a polymer film and modulate its conductivity, can transduce ionic into electronic signals. As a result, they make ideal biological sensing elements and can be constructed using biocompatible materials.

Researchers under the POLYMED umbrella successfully developed a first-generation materials platform for organic semiconductors. Incorporating crown ethers, specific ion flow can be controlled.

Criteria for the design of materials were also developed for single component systems that enable ion flow. Blending strategies of materials further promoted the passage of ions. To assess the rate of ion and proton flow, scientists developed a method for organic-based materials systems.

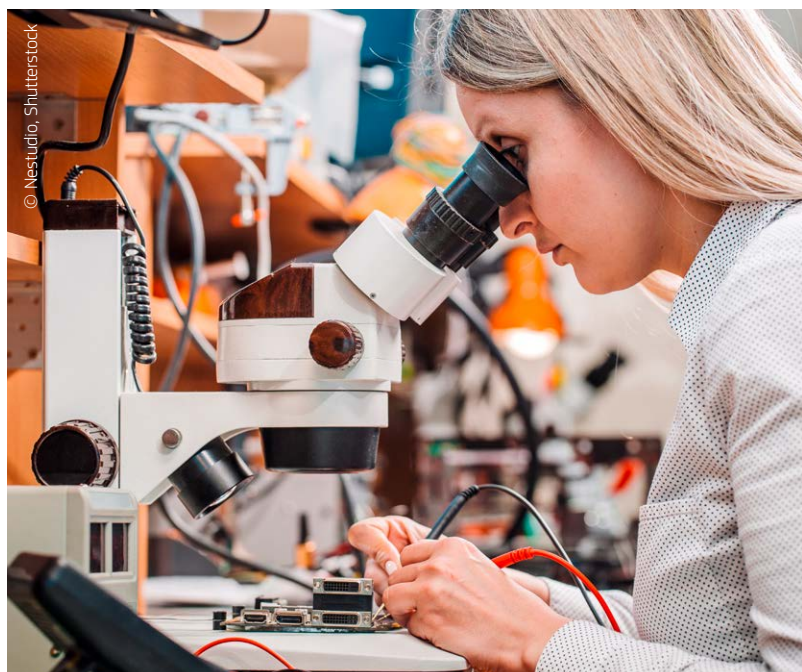
The new materials system will provide the basis for producing OECTs that operate in accumulation mode. The benefits in comparison to depletion mode include accelerated performance and stability in an aqueous environment.

High-profile journals Nature Communications, Royal Society of Chemistry and Nature Scientific Reports published papers

from POLYMED's research results. Disposable paper breathalysers for alcohol, organic light emitting diodes and high-efficiency solar cells are just some of the areas where POLYMED technology can make a difference.

POLYMED

- ★ Coordinated by the Imperial College of Science, Technology and Medicine in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/110346>



INFORMATION AND COMMUNICATION TECHNOLOGIES

COMBINING OPERATIONAL AND ANALYTICAL DATABASES IN A SINGLE PLATFORM

EU-funded project LEANBIGDATA has produced a real-time big data platform able to halve the cost of data analytics and enable it in real time.

A Spanish-led project aims to enable companies to do far more with their Big Data and use far fewer resources to do so. LEANBIGDATA (Ultra-Scalable and Ultra-Efficient Integrated and Visual Big Data Analytics) has developed a platform for managing Big Data which is ultra efficient and highly scalable.

Big businesses and organisations process ever-increasing amounts of data. But the techniques they use to do this are often inefficient and consume large amounts of resources. Organisations typically use two databases, one for operational data and a second for data warehousing. In order to analyse the data, it must be copied from the first to the second and, seeing as data quickly becomes stale, this must be done regularly — usually every day.

Such a process, known as extraction-transform-load (ETL), is expensive to set up and maintain. 'This accounts for 75% to 80% of the cost of data analytics,' says Ricardo Jiménez, LEANBIGDATA's technical coordinator and CEO & co-founder of LeanXcale, a spin-off set up to commercialise the project's core results. What is more, big data analysis tends to run in batch mode rather than real time, so users cannot react quickly to events.

Two for the price of one

The LEANBIGDATA team has designed an architectural solution which can deliver the

two capabilities, operational and analytical, in one, thus greatly increasing efficiency. They have come up with a transactional management system which scales up linearly to very large volumes — enabling the operational part of the database to bear the analytical load.

They have created three new management systems. The first is a key value data store, a kind of NoSQL technology used to store the data of combined databases. The second, a complex event processing system, allows users to stream data from real-time events. The third is a distributed SQL query engine which can harness multiple computers to tackle a single query. 'This means we can answer a query in online response time, that is the time a typical online user would be prepared to wait,' says Dr Jiménez.

The team has tested their technology through case studies. These included studying the feelings of voters in US and Spanish elections by analysing their tweets in real time. This showed how sentiments were evolving, but also allowed analysts to see what was behind those feelings — for instance by looking at which words were used most frequently. 'When the emails scandal erupted, you could use the system to see how many tweets were about Clinton's reputation,' says Dr Jiménez, 'our goal wasn't to predict the results but it would have provided useful information for analysts.'

A second trial conducted in Italy used people's social media footprints to build profiles of customers and help banks detect cases of identity fraud.

Business analytics in real time

The LEANBIGDATA team are confident their unified platform can address the different data needs of big organisations. It could reduce the cost of doing data analytics by half by avoiding the need to set up and maintain ETL. 'Businesses can gain a lot of agility because they will be empowered to do real-time business analytics,' says Dr Jiménez.

LeanXcale, set up by LEANBIGDATA lead institution, the Technical University of Madrid, is aiming for commercial launch in autumn 2017. It is already building proofs of concept with banks, telecommunications companies, large retailers and travel tech companies.

LEANBIGDATA

- ★ Coordinated by the Technical University of Madrid in Spain.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/191643>
- ★ Project website: <http://leanbigdata.eu/>
- ★  <http://bit.ly/2u9fhWm>

REVOLUTIONISING OPTICAL COMMUNICATION NETWORKS

EU-funded researchers have created new system and device concepts for low-energy, high-capacity optical interconnects between large data centres.

In the Information Age, the rapid growth of data traffic demands radically new approaches for high-speed data transmission — requiring an increase in bandwidth and power efficiency by orders of magnitude. Optical frequency combs, a precise tool for measuring different colours — or frequencies — of light, have the potential to also revolutionise throughput of optical communication networks.

Along these lines, the generation of frequency combs in chip-scale devices represents a promising option, in particular when combined with further optical microchips that encode information on each comb line. The EU-funded ENTERAPIC (Energy-Efficient Multi-Terabit/s Photonic Interconnects) project has shown the enormous potential of this approach, creating new system and device concepts for low-energy, high-capacity optical interconnects within and between data centres. 'Optical interconnects providing multi-terabit(s) data rates are the most promising option for overcoming transmission bottlenecks in warehouse-scale data centres and world-wide communication networks,' says project coordinator Christian Koos.

At the heart of this project was the development of energy-efficient electro-optic modulators — devices that translate electrical signals into optical ones. 'Our devices combine conventional silicon photonic waveguides with organic materials that have been optimised on a molecular level,' explains Koos. 'These devices are the most energy-efficient ones currently available, and they offer an attractive solution towards chip-scale terabit/s transceivers, for which power consumption is becoming increasingly crucial.'

Important achievements made

During the course of the project's work, a series of important achievements were made. With respect to electro-optic modulators, the team demonstrated not only low energy consumption, but also record-high transmission speed. In

addition, novel chip-scale frequency comb sources based on electro-optic modulators, gain-switched semiconductor lasers, and Kerr-nonlinear micro-resonators were realised and experimentally tested at terabit/s data rates.

To assemble all the components into a useable communication system, researchers developed the concept of photonic wire bonding. 'Photonic wire bonding relies on 3D-printing of nanoscale waveguides — roughly 100 times smaller than a human hair,' says Koos. 'We came up with this idea during the project, and we were surprised to see how well it works.'

Taken together, these approaches allow researchers to realise transceiver systems with unprecedented performance and efficiency. 'Such systems are urgently needed to put the growth of data traffic on a sustainable base,' says Koos.

Spin off company launched

Following the project's conclusion, researchers recently launched a high-tech spin-off company offering services and technologies in the area of large-scale photonic integration. 'Vanguard Photonics aims to exploit the breakthroughs achieved in the ENTERAPIC project, particularly as they apply to additive nanofabrication techniques for packaging and assembly of photonic integrated circuits and photonic multi-chip modules,' says Koos. 'As a result, we hope to serve a wide range of applications in information and communication technology, medical applications, the life sciences and industrial metrology and sensing.'

ENTERAPIC

- ★ Hosted by Karlsruhe Institute of Technology in Germany.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <http://cordis.europa.eu/project/rcn/100363>



BIOINFORMATICS FOR NEWBORN INFECTIOUS DISEASES REACHES THE CLOUDS

An EU project has contributed to the future of computational biology in the neonatal care clinic. Harnessing cloud computing, researchers developed new big data analysis techniques to diagnose newborn diseases and provide the best possible therapy.

Newborn babies, especially premature and low birth weight ones, can become infected with harmful pathogens, which accounts for almost 30% of neonatal deaths globally. Lab culture techniques do not identify all bacterial strains, nor do they give valuable details on immune response. The answer to this health threat has been addressed by the CLOUDX-I (Cloud based software solution for next generation diagnostics in infectious diseases) project.

As Prof. Roy Sleator, project coordinator, explains, 'The CLOUDX-I project focussed on developing new computational techniques to aid diagnosis and prognosis for neonatal infection. Traditional wet-lab culture techniques often lack specificity and sensitivity, frequently leading to false diagnostic outcomes. Furthermore, they do not incorporate the resulting host response, providing little prognostic data.'

Biomarkers with bacterial infection relevance discovered

The project selected 10 key bacteria for DNA sequencing using single nucleotide polymorphism (SNP) analysis. Species included *Enterococcus faecalis*, an opportunistic pathogen, and *Staphylococcus aureus* (*S. aureus*), notorious for its increasing antibiotic resistance. Both bacteria can cause sepsis in neonates.

Researchers have identified robust biomarkers specific to the key neonatal pathogens. Importantly, these link specific genetic loci to significant physiological features and mechanisms of these pathogens, including biofilm production and antibiotic resistance.

Cloud computing at top speed

CLOUDX-I tackled big data analysis of the sequencing results by implementing the cloud-based Hadoop. In addition, the speed of analysis of *S. aureus* was increased 10 times. Computer clusters were also engineered to run sequence assemblies simultaneously.

For improved efficiency in memory and processing, the researchers developed a



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novel parallel version of CloudBlast, a community resource for massive sequence alignment tasks. 'It can run on commodity hardware with very moderate memory requirements and works well with the biggest databases like NCBI NR/NT and UniProt,' Prof. Sleator points out. NCBI is a collection of sequences from several sources including GenBank and the Protein Data Bank, while UniProt is a resource for protein sequence linked to function.

Blasting the news worldwide

Six specialist 'transfer of knowledge' workshops were delivered to research fellows in both molecular diagnostics and cloud computing. Two international research conferences have also been organised around CLOUDX-I where all partners participated. Overall 50 internationally peer-reviewed publications were produced along with press articles, six international conferences and trade shows and three educational outreach events.

Notable are two papers with particular relevance in the field matched by their success. The first, 'Big data, Hadoop and cloud computing in genomics' was published in the Journal of Biomedical Informatics and was the fourth most downloaded article from the journal in a three month period.

Second, and ironically as a result of time constraints, the team in collaboration with two other labs studied the feasibility of using a mouse model instead of a neonatal human system for host response to bacterial pathogens. The work has been submitted to, and is under review, at Nature Medicine as 'Recapitulation of human neonatal immune signatures in newborn infected mice'.

Prof. Sleator sums up the impact of the CLOUDX-I project: 'As well as developing a robust, user friendly, cloud-based computing platform for more effective and rapid diagnosis and prognosis of neonatal infections, the project has succeeded in training biologists in computer science and providing computer scientists with a deeper knowledge of clinical issues. This training has produced a cohort of young scientists with a unique skill-set which will likely contribute to other clinically important software packages — with the potential to save lives.'

CLOUDX-I

- ★ Coordinated by the Cork Institute of Technology in Ireland.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/106255>
- ★ Project website: <http://www.cloudxi.eu/>

NAVIGATING THE RAPIDS OF BIG DATA STREAM OPPORTUNITIES

Fully exploiting the business and social opportunities from smart technologies requires a new approach to Big Data processing, which the EU-funded FERARI project set out to deliver.

Big Data processing technologies are typically built to respond to human generated data emanating from web-based systems, such as Facebook. Consequently, the standard approach is to batch data stored across distributed file systems. However, with 'smart' technologies such as car-to-car communications, the data volume generated from machine-to-machine (M2M) interactions far outstrips that coming from people.

There is a need for a new approach with global scalability, speed, usability for non-experts, and able to implement complex analytic tasks in real-time over distributed data sources. The EU-funded FERARI (Flexible Event processing for big dATA aRchitectures) project was set up to provide such a fit-for-purpose system.

Developing a powerful, modular and elastic architecture

One of the most significant challenges for processing M2M data is its continuous data stream generation at a very high volume, precluding storage. This means that the transient data is often processed on-the-fly, without being stored. Even if data could be sent to a central location (or to a cloud system) there would still be bottlenecks along the network, incurring further costs and delays. These hurdles are likely to become even more pronounced as the size of local sensors for collecting data also increases.

The project's answer was to break its approach into a series of related objectives. Firstly, to cultivate '*in-situ* processing' which the project coordinator Dr Michael Mock describes as, 'Data stream processing which takes place close to the site where the data is generated, hence avoiding network congestion and delays.' Allied to this, the project adopted complex event processing (CEP). By collating data from multiple sources, patterns were detected which led to identification of pre-determined situations (events), which then immediately triggered programmed responses.

Yet combining these two objectives, CEP technology with *in-situ* processing, proved to be one of the biggest challenges of the project. As Dr Mock explains, 'Existing CEP technology is not suited to run on distributed Big Data systems, instead, it is intended for use on single, mostly very powerful computers'. The project's solution was to run the CEP engine (processing with Proton — IBM's PROactive Technology Online) on top of the Big Data streaming platform, Apache Storm. Additionally, it developed a Query Planner that optimised the CEP engine to translate a single, global CEP 'expression' into a set of CEP expressions that can be distributed throughout the FERARI system for evaluation.

To enable flexibility, the FERARI architecture is modular, with its framework components separate from the underlying Big Data streaming platform. Thus, the framework can be adapted to any underlying platform.

From scenario testing to machine learning

The FERARI approach was applied to two challenging test scenarios; the analysis of mobile phone fraud in telecommunication networks and real-time health monitoring in clouds and large data centres. As Dr Mock concludes, 'The scenarios have been successfully evaluated on real-world data. For instance, it was shown on anonymised mobile phone records, provided by the project partner HT Croatian Telekom, that fraud detection can be achieved with the FERARI system in sub-second latency.' He goes on to say, 'These achievements will enable European industry to build leading products in various application domains, in which it is crucial to evaluate and monitor huge amounts of data being produced continuously, such as in the Internet of Things or in Industry 4.0.'

The FERARI framework has been released as open source with docker software containers for easy installation on any machine, from a personal computer to a cluster or cloud system, allowing scientific and business communities to explore and use it. The team have also made a guide available to explain installation and usage, as well as providing an instructive running example.

Despite the superiority of this system over other technologies, it still relies on manual input from domain experts to create the algorithmic rules. Pointing to the future Dr Mock posits, 'Another step forward would be to learn relevant rules with machine learning techniques from the data. Similarly, for configuring the *in-situ* processing methods. This is where we now want to put our energies.'

FERARI

- ★ Coordinated by Fraunhofer in Germany.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/191637>
- ★ Project website:
<http://www.ferari-project.eu/>



SECURITY

INNOVATIVE METHOD AND TECHNOLOGICAL SOLUTIONS TO FOIL CYBERATTACKS ON UTILITY COMPANIES

Recent cyberattacks that target critical infrastructure (CI) are cause for alarm, particularly when such malicious acts are becoming increasingly dangerous. An EU initiative has introduced a methodology and tools to shield gas, water and electricity companies.

There is strong evidence to suggest that harmonising risk and vulnerability assessment methods can greatly enhance existing methodological security and prevention frameworks aimed at minimising cyber risk in the water, gas and energy sectors. What is more, research fails to recognise the importance of the relationship between Industrial process misbehaviour (IPB) and Communication and software-related threats (CATH) methods. Combined, the two techniques can have an impact on fighting off growing cyber threats.

IPB takes place when an attacker gains user access rights and performs actions that look legitimate but are intended to disrupt industrial processes. In CATH, an attacker hits computers, networks, sensors, Programmable logic controllers (PLCs) or radio signals in order to trigger failures in the Supervisory control and data acquisition (SCADA) system. This is accomplished by leveraging software vulnerabilities. To date, researchers have addressed these two complementary techniques separately, without drawing any parallels.

'The innovation proposed was to combine both techniques in improving prevention and detection capabilities against cyberattacks where hardware and software system networks are used alongside cyber networks,' says Dr Giorgio Sinibaldi, Project Coordinator for the EU-funded PREEMPTIVE (Preventive methodology and tools to protect utilities)

project. 'Applying this innovative approach to utility facilities that rely heavily on industrial networks and automated control systems should dramatically reduce network vulnerability.'

Overall, the project addressed the prevention of cyberattacks against hardware and software systems such as SCADA, PLC and networked electronic sensing. It also focused on monitoring and diagnostic systems that are used to support the critical services of utility networks.

Novel tools in security risk assessments and intrusion detection

PREEMPTIVE designed and developed a suite of prevention and detection tools to boost security for SCADA utility networks based on this dual approach that takes into account both IPB and CATH. 'The biggest strength of the project is the simultaneous analysis of the industrial processes in the physical domain and the cyber assets in the cyber domain,' explains Dr Sinibaldi.

One set of tools detects anomalous and malicious activities against critical systems. The other detects abnormal behaviour at the industrial process level. Guidelines have been produced to assist with the identified legal and ethical requirements of the tools and their implementation.

Enhancing existing security frameworks to mitigate cyber risk

The PREEMPTIVE team created a methodology framework to improve current risk and vulnerability assessment methods, standards policies, procedures and guidelines for securing utility networks from cyberattacks. They also delivered a report on the components, communication protocols and information assets of industrial control systems used by electricity, gas and water utilities.

Project partners successfully validated the software tools at an energy company's laboratory and the framework at a gas utility.

Thanks to PREEMPTIVE, 'future attacks on utility companies and related industries should be minimised,' concludes Dr Sinibaldi. 'This is a new approach with solutions for CI which has different problems compared to "classic" ICT systems.' The methods and tools should fill the existing gaps among security policies, practices and technologies. Operators managing CI assets and legal and regulatory organisations will have a better overall understanding of the challenges, problems and opportunities involved in CI environments.

PREEMPTIVE

- ★ Coordinated by Vitrociset in Italy.
- ★ Funded under FP7-SECURITY.
- ★ <http://cordis.europa.eu/project/rcn/185482>
- ★ Project website: <http://preemptive.eu>

IMPROVEMENTS TO MACHINE-INTELLIGENCE FOR BETTER ACCURACY AND FASTER POLICE INVESTIGATIONS

Police in the UK and Belgium have started testing a semi-autonomous criminal intelligence analysis system designed to speed up investigation, improve precision and even pre-empt crimes by detecting connections that people often miss.



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Against a backdrop of increasing crime and security concerns across Europe, the West Midlands Police force in the UK, along with police in Antwerp, Belgium, have started putting machine-intelligence technology through its deductive paces.

The EU-funded VALCRI (Visual Analytics for Sense-making in CRiminal Intelligence analysis) project has set up trials that make use of three years' worth of actual but anonymised crime data, equating to 6.5 million records. The VALCRI system performs crime scene analysis by scanning millions of mixed format information sources — such as records, interviews and pictures — within seconds. The system detects suspicious patterns and reconstructs scenes, pointing to promising investigative leads and presenting the findings on interactive touchscreen displays for analysts.

This methodology holds out the hope of removing the laborious and time-consuming aspects of analysts' jobs, so that they can more proactively pursue lines of enquiry, building cases with more speed and precision. Crucially, the expectation is that the system will also identify connections that might be missed by a human, through error or bias. To counter objections about the replacement of human bias for machine bias, the system renders the process transparent so that reasoning steps can be retraced.

Visual analytics for investigative insights

What makes VALCRI especially powerful is that it capitalises on advances in artificial intelligence combined with visual analytics, to enable real-time analytic data interaction. The system also uses facial recognition software to identify individuals from sources such as CCTV.

Recently covering the project, the New Scientist reports project leader Professor William Wong of Middlesex University, London as saying, 'Everyone thinks policing is about connecting the dots, but that's the easy bit... The hard part is working out which dots need to be connected.'

Currently, one of the first steps in criminal investigations is to trawl police databases for similar incidents. Links could be made based on criteria such as timing, people involved, location or signature features, such as modus operandi. Another person in the project team, researcher Neesha Kodagoda, also quoted in the New Scientist article, states that, 'An experienced analyst needs 73 individual searches to gather all of this information, before manually putting it into an easily digestible form... VALCRI can do this with a single click.'

However, previously machine intelligence often struggled to make connections between some phenomena which for humans is straightforward. For example, the descriptive

SECURITY

phraseology people often use is subjective and varying, with words like 'dirty' or 'messy' describing much the same thing. Now an advanced algorithm enables the system to make better conceptual links. VALCRI also integrates machine learning capability which means its analytical faculties improve with increased data and criminal profiles exposure.

Investigators view the analytical results on a touchscreen display, described as a 'Reasoning Workspace'. This workspace comprises three areas which allow interaction with the available data, the computational analysis (which can include imported data) and the resultant conclusions based on the evidence assembled. By allowing for the manipulation and organisation of data through selection and dragging, the display is more intuitive than traditionally more static sources, such as lists. In this way the system encourages more imaginative, creative and insightful sense-making and problem solving. Additionally, investigative overviews can be presented in various visual formats such as maps or graphs.

Building the case for deployment in realtime criminal investigations

While there is broad agreement that taking VALCRI to the next stage of development requires access to non-anonymised

data generated during a live investigation, there are also predictably a range of concerns about doing this. From a legal standpoint, use of the system could be challenged in court which could make it counter-productive in criminal prosecutions. Additionally, with transnational investigations, countries differ in their data protection laws making the sharing of actionable intelligence fraught. And there are, of course, ongoing high-profile societal debates around police and security services access and use of personal information.

Yet, in an era of heightened security concerns with pressure mounting for those charged with civil protection, any approach which increases the speed, precision and pre-emptive nature of that response is highly likely to be on the table for further exploration.

VALCRI

- ★ Coordinated by Middlesex University in the United Kingdom.
- ★ Funded under FP7-SECURITY.
- ★ <http://cordis.europa.eu/project/rcn/188614>
- ★ Project website: <http://valcri.org/>
- ★  <http://bit.ly/2tJbq12>

FLEXIBLE DISASTER MANAGEMENT

EU-funded researchers have developed an innovative emergency management platform that integrates space-borne assets to support early detection of natural and man-made hazards.

Current emergency management tools are hazard-specific and cannot be easily adapted to support management of other types of disasters. Furthermore, the potential of space-based technologies, such as Earth observation and satellite navigation, is not fully exploited.

The EU-funded PHAROS (Project on a multi-hazard open platform for satellite based downstream services) project was initiated to address the need for tools that allow systematic integration of different information sources. The modular design approach adopted promises flexibility and scalability.

The newly developed system has a broad range of functionalities, but also allows for adding and removing system elements corresponding to the hazard. In addition, its deployment can be adapted to different organisational structures — at local, regional, national and international levels.

System assets include tools covering the entire emergency management cycle, starting with data collection, processing and distribution. In addition to detecting risks and emergencies and forecasting how disasters may evolve, it provides decision support services

and communication services for alerting the public.

The PHAROS platform enables information sharing among different jurisdictional and organisational levels, identifying relevant information items and supporting data sharing. Its functionalities were demonstrated in Solsona, Spain in March 2016 during a prescribed fire.

The demonstration was carried out in cooperation with the Catalan fire brigades. Aerial images were collected by helicopters and presented to users along with satellite data from moderate-resolution imaging spectroradiometers (MODIS) for situation assessments.

The feedback received from the users was translated into recommendations to advance the development and implementation of PHAROS. Although initially focused on the forest fire scenario, the pre-operational system has the potential to become a multi-hazard management platform.

PHAROS

- ★ Coordinated by DLR in Germany.
- ★ Funded under FP7-SPACE.
- ★ <http://cordis.europa.eu/project/rcn/188829>

"System assets include tools covering the entire emergency management cycle, starting with data collection, processing and distribution."



FUNDAMENTAL RESEARCH

GRAPHENE-BASED SPINTRONICS FOR NEXT-GEN MOLECULAR ELECTRONIC DEVICES

Spintronics, molecular electronics and graphene have a common trait: they are all considered as key enablers in the future of computing beyond the limitations of Moore's and Kryder's laws. The ACMOL project is contributing to their joint advancement with proof-of-concept devices.

Not so long ago, spintronics — the development of nanoscale electronics for the fabrication of hard drives based on the detection and manipulation of electron spin — and molecular electronics — the use of molecules as the primary building block for electronic circuitry — were considered separately. By developing a switchable, room-temperature spin-polariser employing electro-active and magnetic molecules and integrating them into graphene-type electrodes modified with ferromagnetic materials, ACMOL (Electrical spin manipulation in electroACTIVE MOlecules) provides a new route for spintronics research.

'Despite the fast progress in spintronics, "molecular spintronics" still presents great challenges,' explains Dr Núria Crivillers, coordinator of the project for ICMAB-CSIC in Spain. 'Whilst the market demands a continuous reduction of the size of the magnets forming hard disk drives, the question of how the spin of molecule interacts with an electrical current still had to be answered.'

ACMOL is contributing to this answer with a proof-of-concept whereby an electrical current can interact with the spin of the molecule that can be switched between different states. The project enabled measurement and controlled charge transport across electrode-molecule-electrode junctions, developed a novel graphene-based technology for molecular spintronics, and compared its performance with that of standard technology based on coinage metals.

'Gold is the preferred material for building nanometre-spaced electrodes for model experiments in molecular electronics, but these electrodes are not stable at room temperature, provide poor reproducibility and do not allow for spin injection. Graphene, on the other hand, can provide such stability. It combines high mechanical strength, exceptionally high electronic and thermal conductivities, impermeability to gases, and stability at room temperature, and its 2D structure has the potential for more reproducible molecular junctions,' Dr Crivillers says.

Thanks to ACMOL, the technology for realising such stable electrodes and related molecular devices has been considerably advanced. And that's just one of its many achievements. The project also notably: made a thorough characterisation of graphene-based molecular devices from room temperature down to cryogenic temperatures; demonstrated how molecules covalently grafted onto mechanically robust graphene substrate could be ideal candidates for next-generation molecular electronic devices; developed a new methodology for mass fabrication of nano-spaced electrodes with nanometre-scale spatial confinement and low-power consumption; came up with an all-carbon break-junction technique in the scanning tunnelling spectroscopy (STM) configurations introducing novel STM graphite tips; and created new advanced computational methods for treating quantum electron transport that were implemented in Smeagol software.

'Our devices may contribute to catalysing the development of a new generation of high-performance, cost-effective, non-volatile, versatile, ultra-fast and low-power consuming electronic devices in fields such as high-density data storage, microelectronics, (bio)sensors, quantum computing and medical technologies,' Dr Crivillers points out.

Although the project didn't aim to venture beyond fundamental research, the understanding and control of the molecule spin / electron interaction and the development of graphene-based technology will certainly contribute to the scientific and technological revolution of molecular spintronics. 'We believe that the ACMOL results help towards the development of new concepts guiding hybrid technologies which might reach beyond the limits of current silicon-based technology,'

Dr Crivillers says. In the future, she notably foresees applications in layered materials other than graphene, such as MoS₂, BN or MoSe₂.

All in all, ACMOL's technical, experimental and computational achievements can make Europe more competitive in the fields of molecular spintronics and graphene technologies.

ACMOL

- ★ Coordinated by the Spanish National Research Council in Spain.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/110509>
- ★ Project website: <http://acmolproject.eu/>

IMPROVING THE SENSITIVITY OF ATOMIC SENSORS

Using quantum physics, EU-funded researchers have improved the sensitivity of an atomic magnetometer, thus opening the door for using super-precise measurements in a number of fields.

Researchers with the EU-funded AQUMET (Atomic Quantum Metrology) project had an ambitious goal in mind: to demonstrate and record the sensitivity of atomic sensors — and then improve on that sensitivity — using quantum physics in general and, specifically, entanglement. Examples of atomic sensors include atomic clocks and atomic magnetometers. What researchers achieved is a truly ground-breaking accomplishment, opening the door for using super-precise measurements in a number of fields.

'This work is technologically interesting as magnetic fields are omnipresent, and nearly everything either produces or modifies the magnetic field in some way,' says project coordinator Morgan Mitchell. 'In practice, having access to super-precise measurements is beneficial to mineral exploration, for example, as it provides access to precise measurements of the earth's magnetic field as distorted by underground mineral deposits. It also means various biological processes in the heart and brain can now be observed by the magnetic field they produce.'

Squeeze play

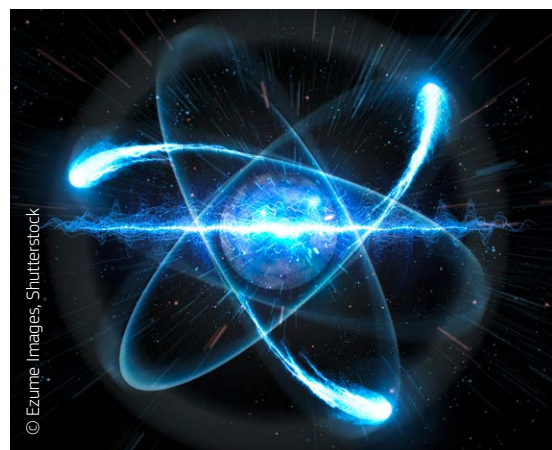
The sensitivity of an atomic magnetometer is defined by the smallest signal it can reliably resolve, a definition that is fundamentally limited by quantum noise. For example, if a laser detects the atoms and their response to the magnetic field, this sensitivity will be limited by shot noise, otherwise

known as the source of the quantum noise. To reduce this shot noise, and thus improve magnetic sensitivity, one can use quantum optical techniques known as squeezing — which is what AQUMET did.

'Our research demonstrated the first improvements in magnetic sensitivity due to squeezing — both the squeezing of light, where shot noise is reduced, and by squeezing atomic quantum noise,' explains Mitchell. 'What we discovered is that quantum noise in atoms is significantly different than quantum noise in light and, by understanding this, we are able to identify several new squeezed states, including macroscopic singlet states and planar squeezed states.' According to Mitchell, the planar squeezed state is of particular interest as it has been shown to reduce quantum noise in a way that improves the sensitivity of more complicated sensors, including magnetic resonance imagers that need to be able to simultaneously detect multiple atomic properties.

Right on time

The AQUMET research has proved to be very timely. 'By studying the quantum limits of atomic sensing and developing new methods to overcome the usual quantum noise limits in these sensors, the project has laid the foundation for the use of quantum sensing technologies in an array of initiatives and sectors,' says Mitchell. 'This includes its role in the upcoming EU Quantum Technologies Flagship



Initiative and in enabling sensing technologies to benefit medical research.'

Although the project is now closed, researchers continue their efforts to push the fundamental limits of atomic sensing by applying the system developed in AQUMET. Furthermore, the insights gained in AQUMET are now being applied to new physical systems, including small-scale atomic magnetometers used for detecting bio-magnetic fields, and the new squeezed states discovered by AQUMET are being studied for application to other advanced technologies such as atomic clocks.

AQUMET

- ★ Hosted by ICFO in Spain.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <http://cordis.europa.eu/project/rcn/100262>

TAILORING LIGHT-MOLECULE INTERACTION AT THE NANOSCALE

EU-funded researchers provide an unambiguous demonstration of the influence the photonic environment has on the FRET rate in plasmonic nanostructures.

Förster 'Fluorescence resonance energy transfer' (FRET) is one of the most popular methods for measuring distance, structure and association between molecules at the nanoscale. However, it is far from perfect. Its application is severely limited in several fields of physical and analytical sciences, particularly in measuring a short distance range below eight nanometres.

To extend the use of FRET, the EU-funded EXTENDFRET (Extended fluorescence resonance energy transfer with plasmonic nanocircuits) project developed an innovative way of using nanophotonics to tailor the light-molecule interaction at the nanoscale. 'Although nanophotonics has enabled several successes in controlling the fluorescence properties of single emitters, prior to our research it was still an open question as to whether or not it could actually enhance FRET,' says project coordinator Jerome Wenger. 'Answering this question was crucial to unlocking the application of nanophotonics for enhancing the FRET process broadly used in life sciences and biotechnologies.'

An unambiguous demonstration

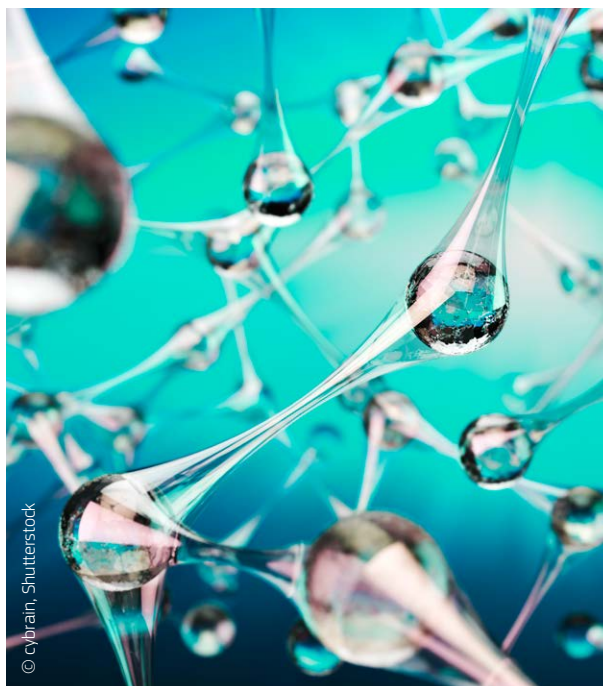
Energy transfer between molecules — an essential phenomenon for photosynthesis, photovoltaics and biotechnology — is promoted when they are set in an environment that confines light. The objective of the EXTENDFRET project was to control and enhance this energy transfer between molecules using optical structures etched at the nanoscale.

To accomplish this, researchers performed experiments at the single molecule level, monitoring both the donor and the acceptor emissions for a broad range of experimental conditions. For example, they prepared pairs of energy donor and acceptor molecules linked by rigid double stranded DNA. These pairs were then inserted into apertures milled in a gold film with nanoscale dimensions. By accurately measuring the radiation properties of pairs of molecules, researchers were able to demonstrate that the rate of energy transfer between molecules is six times greater when placed in a nanoaperture.

EXTENDFRET provides an unambiguous demonstration of the influence the photonic environment has on FRET rates in plasmonic nanostructures. Specifically, this research has led to a significant enhancement of the FRET rate, showing that nanophotonics is especially relevant to enhancing FRET in the case of large donor-acceptor separations. 'At the beginning of the project it was widely believed that it was impossible to control energy transfer between molecules using nanophotonics,' says Wenger. 'Our research has conclusively proved otherwise.'

New doors opened

These promising results have cleared a new path to improving the energy transfer process widely used in life sciences and biotechnology, with optical nanostructures having potential applications for biosensors, light sources and photovoltaics. For example, using long-range FRET, researchers can



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"These promising results have cleared a new path to improving the energy transfer process widely used in life sciences and biotechnology."

now better understand the folding structure of large DNA and protein molecules. 'This will improve the understanding of gene expression and regulation, and improve drug development,' says Wenger.

On the one hand, these results clearly establish that FRET can be tuned with nanophotonics, paving the way towards the nanophotonic enhancement of such FRET applications as photovoltaics, organic lighting sources and bio-sensing. On the other hand, the novel observation of high FRET enhancement for large donor-acceptor separations or perpendicular orientation between donor and acceptor dipoles provides a new paradigm for investigating biochemical structures with donor-acceptor distances far beyond the classical FRET range.

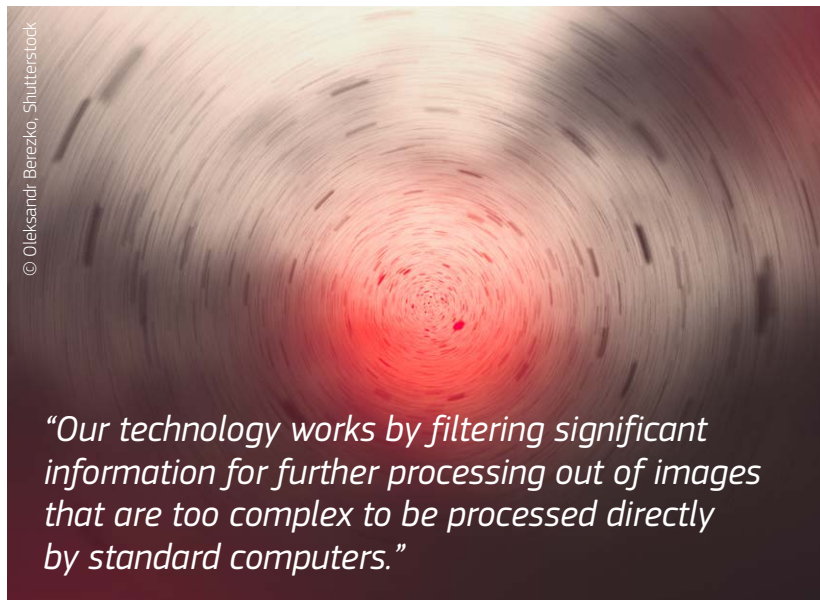
The project is currently working on applying its proof-of-concept towards more biologically-oriented applications, including investigating protein dynamics for molecular association and structural changes. In addition, the project has filed for two patents on optical microscopy.

EXTENDFRET

- ★ Hosted by CNRS in France.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <http://cordis.europa.eu/project/rcn/101990>

HUMAN BRAIN INSPIRES NEW ERA OF BIG DATA PROCESSING

The ability of the human brain to select only relevant data for a given task has inspired EU-funded researchers to develop new processing technologies for the world of Big Data. The breakthrough could lead to quicker medical diagnoses, more effective security measures and more accurate climate modelling.



Advances in ICT have transformed our economic and social lives. We are now able to bring distant people together in an instant, remotely coordinate disaster response, implement new medical diagnoses and treatments and achieve more accurate weather predictions and climate modelling. While all this — and much more — has been made possible by sustained computer performance improvements, standard processors simply cannot keep up with the exponential growth of data. This has pushed demand for the development of new fast, compact, low consumption processors.

Applying brainpower

'New processing and computing methods and storage devices are needed to tackle the increasing gap between data growth and processing power,' explains FTK (Fast Tracker for Hadron Collider Experiments) project coordinator Prof. Chiara Roda from the University of Pisa in Italy. 'Our approach to this has been to develop image processing technology that emulates the architecture of the brain, which we then tested at

the Large Hadron Collider (the world's largest and most powerful particle accelerator) at CERN near Geneva in order to solve a specific Big Data problem.'

Some of the most interesting subatomic processes generated by Large Hadron Collider particle collisions are very rare and lie hidden within an extremely large amount of irrelevant events. Selecting interesting events from this 'background noise' in real time is therefore essential in order to fully exploit the potential of these experiments.

The project team built 'accelerators' for algorithms that usually take up a large amount of processing time and resources. 'Our technology works by filtering significant information for further processing out of images that are too complex to be processed directly by standard computers,' explains Roda. 'This is how the brain processes images. For higher-level processing and long-term storage, it only selects data that matches a particular set of memorised patterns. Our technology emulates this low-level brain function.'

Unlocking Big Data potential

This capability opens up a large number of other potential applications ranging from astrophysical and meteorological calculations to robotic automation and security applications. 'Communication with potential end users in the high energy physics environment was very good,' says Roda. 'ATLAS, an experiment at CERN designed to uncover the secrets of the universe, approved our technology to carry out a huge amount of online processing, which was initially expected to be done with commercial "Central processing units" (CPUs). Outside of high energy physics, our objective was to accelerate and automate data processing for medical diagnosis.'

Indeed, the FTK project consortium has also been in discussions with companies interested in using the technology for smart camera applications and medical imaging. A young researcher who was awarded a Marie Curie scholarship to work in Pisa on 'Magnetic resonance fingerprinting' (MRF) is studying the possibility of applying this technology in order to speed up algorithms based on pattern matching.

'By increasing computing efficiency and power, we have shown that this technology can bring advantages to many areas of society,' says Roda. 'It can also save energy and space, and is less expensive than large CPU farms. I think that the smart use of combined technologies should be able to solve the Data Deluge problem that we all face, without the need for a huge amount of resources.'

FTK

- ★ Coordinated by the University of Pisa in Italy.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/106069>

EVENTS

SEPTEMBER
27►28

Novi Sad, Serbia

CONFERENCE

LEGATO/EUROLEGUME FINAL INTERNATIONAL CONFERENCE

The EU-funded LEGATO and EUROLEGUME projects will be holding their final international conference in Novi Sad, Serbia, from 27 to 28 September 2017.

The conference is an opportunity for the LEGATO and EUROLEGUME projects to disseminate the highlights of their research as it marks the final year of the two projects.

Over 100 researchers have been involved in the projects' outcomes and their findings will form the basis of sessions exploring domains such as: genetics and breeding; defining legume isotopes, root phenotyping and symbiotic interactions; legumes in cropping systems; and coping with environmental stresses and climate change.

Poster sessions with flash presentations will be on the agenda, along with two round-tables on increasing legume consumption and increasing legume cultivation. With all the talk of increasing consumption, delegates may be pleased to visit the legume show cooking event, which will be the fruit of the labour of leading chefs.

For more information, please see:

<http://www.legato-fp7.eu/FinalConference/>

OCTOBER
03►05

Amsterdam, The Netherlands

SHARED BOOTH

SUCCESS AT EUROPEAN UTILITY WEEK 2017

The EU-funded SUCCESS project will be hosting a shared booth during European Utility Week, Amsterdam, the Netherlands, from 3-5 October.

European Utility Week brings together experts from utilities, network operators, vendors, consultants, startups and system integrators covering the entire smart energy value chain. The 2017 event will welcome 600+ exhibitors, 400+ speakers and 12000 visitors from more than 100 countries.

The focus will be on regional and global developments in Grid Optimisation, Renewables, Energy Storage, Smart Metering, Smart Cities, Smart Homes, Energy Services & Efficiency, Energy Trading, Intelligent Buildings, Data Management, Analytics and IoT, Cyber Security, Smart Gas and Smart Water.

Innovation underlines every element of the show with a special focus on connecting people from all levels of the utility value chain, from technology giants to startups and from senior-level experts to young talent.

The EU-funded SUCCESS project is setting out to develop an overarching approach to threat and countermeasure analysis with a special focus on the vulnerabilities introduced by smart meters. It will present its goals and achievements so far at a shared booth during the event.

For more information, please see:

<http://www.european-utility-week.com/Visit>

OCTOBER
05►06

Hannover, Germany

CONFERENCE

NUCLEUS CONFERENCE 2017

The EU-funded NUCLEUS project will be hosting a conference to update participants on the project's Responsible Research and Innovation (RRI) roadmap and strategy for the development of 30 NUCLEI sites, taking place in Hannover, Germany, from 5 to 6 October 2017.

The conference will include presentations of results from the second year of the project's life which has included testing new strategies for embedding RRI in academic environments.

The Horizon 2020-funded NUCLEUS project acknowledges that research institutions do not exist in isolation, but interact with many other stakeholders in society, including policymakers, the media, the economy, public engagement and civil society. Each stakeholder group in society has unique specialisations and goals, but can have productive interactions that enable them to address more complex challenges and tasks together.

The project addresses how RRI can be implemented by the 'nucleus' of a university or research institution; the governance that directs the policy and culture of an organisation.

For more information, please see:

<http://www.nucleus-project.eu/event/nucleus-conference-2017/>

EVENTS

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

OCT.
24►26

AMSTERDAM, THE NETHERLANDS

MEETINGS

CORBEL MEDICAL INFRASTRUCTURE/USERS FORUM MEETING AND 2ND ANNUAL GENERAL MEETING

The EU-funded CORBEL project will be holding its Users Forum Meeting and its 2nd Annual General Meeting in Amsterdam, the Netherlands, on 24 October and 25-26 October respectively.

The CORBEL (Coordinated Research Infrastructures Building Enduring Life-science services) project aims to enable the translation of biomedical discoveries into innovative and cost-effective treatments. This goal is all the more pressing given the social and economic challenges of ageing populations and chronic diseases. If this is to be achieved, Biological and Medical Research Infrastructures (BMS RI) will underpin every step in the process.

Research into these challenges spans a variety of scientific and user communities, making the role of BMS RIs a central, facilitating one. The Medical Infrastructure/Users Forum meeting will provide a platform for discussion and identification of how to further the foundation of collaborative scientific services for biomedical research.

The 2nd Annual General Meeting will bring together members of the project and its network to review developments so far.

For more information, please see: <http://www.corbel-project.eu/news-events.html>





research[★]eu Results Pack

Safer air transport

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