ISSN 1977-4028

European Commission

research eu

RESULTS MAGAZINE

N°58
DECEMBER 2016 – JANUARY 2017

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RESULTS MAGAZINE

Published by
The Community Research and Development Information Service (CORDIS) managed by the Publications Office of the European Union
2, rue Mercier
2985 Luxembourg
LUXEMBOURG
cordis@publications.europa.eu

Editorial coordination
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ISSN 1831-9947 (printed version)
ISSN 1977-4028 (PDF, EPUB)

EDITORIAL

by the editorial team

CLOSING IN ON THE WORLD'S FROZEN TIME CAPSULES

In the early 1950s, a handful of pioneering scientists initiated the first ice core drilling in the likes of Alaska, Antarctica and Greenland. The practice, which is now commonplace, has allowed for the analysis of ice samples dating back 130 000 years in Greenland and 800 000 years in Antarctica. Just like tree age rings, these ice cores feature annual layers which can easily be dated, and provide invaluable information about past climate and atmospheric conditions.

Even though they have been studied for almost seven decades, ice cores still have much to tell us. Not only about our planet's past, but also indirectly about its future. In the face of rising concerns over the consequences of unbridled CO_2 emissions and the resulting climate change, scientists indeed hope that ice core-related revelations will allow for the design of better climate models.

The EU is no stranger to ice core science. The European Project for Ice Coring in Antarctica (EPICA), which was partly supported by the European Commission, notably helped to obtain full documentation of the climatic and atmospheric record archived in Antarctic ice and compared it with that of Greenland — thereby revealing precious information about natural climate variability and mechanisms of rapid climatic changes during the last ice age.

'Even though they have been studied for almost seven decades, ice cores still have much to tell us.'

These efforts have been pursued under FP7 and now under Horizon 2020, with a total of 21 projects funded under the two framework programmes. As winter comes and some of these projects get very close to their end, the CORDIS editorial team decided it was time to put the spotlight on seven of them. From traces of cosmic dust to forest fires, abrupt climate changes and oceanic carbon storage, these projects provide a great insight into ice core science's added value for the scientific community.

As usual, this special feature is followed by eight other sections focusing respectively on biology and medicine, social sciences and humanities, energy and transport, the environment, IT and telecommunications, industrial technologies, food and agriculture, and physics and mathematics. 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 Galileo applications: what lies ahead

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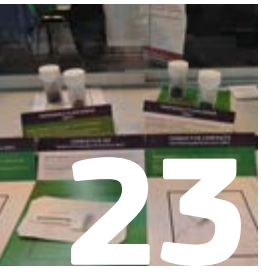

SPECIAL FEATURE

DRILLING IN THICK ICE: LESSONS FROM THE PAST

INTERVIEW

HOW ANTHROPOGENIC FOREST FIRES MAY HAVE IMPACTED EARTH'S CLIMATE OVER 10 000 YEARS AGO

Recently paleoclimatologist William Ruddiman suggested that humans may have had a significant impact on the Earth's climate already thousands of years ago — through carbon and methane emissions originating from biomass burning and deforestation associated with early agriculture. The EARLYHUMANIMPACT project set out to verify this hypothesis.

Whilst global warming means more forest fires, the opposite is also true. Forests store about 30% of the carbon found on the planet's surface, and each forest fire not only releases this carbon into the atmosphere but also other climate-impacting substances such as aerosols. The impact of these aerosols on climate change, however, is not yet well understood.

The EARLYHUMANIMPACT project builds upon the idea that the answer might lie in Earth's history books. Over 10 000 years ago, human agriculture started to thrive at the expense of forests, and the project team believes that anthropogenic aerosols resulting from this process may have altered the global climate system for thousands of years.

To verify this, Prof Carlo Barbante and other researchers from the University of Venice examined data from ice and lake core climate records of seven continents and compared it with parallel histories of fire regimes. They used a new technique for determining a specific molecular marker of biomass burning — known as levoglucosan — which can record past fire in ice cores and lake sediments. With the project soon coming to an end, Prof Barbante discusses the process and the main outcomes of his work.

★ **Why did you choose to focus your research on fire reconstruction?**

Prof Barbante: The role of aerosols in the climate system is still poorly understood and even less is known about the relative role of biomass burning.

Fire affects the climate system by releasing carbon, which would otherwise be stored in woody vegetation. It contributes to the levels of several aerosols and atmospheric gases in the air and is an important cause of their variability over the years. It also influences regional and global climate through the emission of greenhouse gases, mainly carbon dioxide and methane.

The decrease in the spatial extent of forests which started around 7 000 to 5 000 years BP may be related to early agricultural activity, including forest clearance through burning which should leave a quantifiable signal in climate proxies. Under this ERC Advanced Grant, we are aiming to provide essential insight into the interplay between climate and human activity, especially with the advent of agriculture, as well as the role of aerosols through time.

★ **How do you explain that we know so little about aerosols' past influence on climate change?**

Anthropogenic and natural aerosols may have altered the global climate system for thousands of years as suggested by

PROF CARLO BARBANTE

comparing late-Holocene greenhouse-gas (GHG) concentrations to those from previous interglacial periods. Now, human activities including fossil fuel burning are currently altering the composition of the atmosphere and the global climate system at rates faster than ever recorded in geologic time.

The problem is that, for most of the climatic and environmental archives that paleoclimatologists study (e.g. three rings, marine and terrestrial records), it is difficult to find the right transfer functions that link the concentration of a specific marker in the record with its atmospheric occurrence in the past. It is therefore of paramount importance to look at past atmospheric composition through the use of paleoclimatic records and appropriate proxies for which the cause/effect relationship is known.

★ How did you proceed to verify Ruddiman's hypothesis?

His hypothesis is centred on the observation that atmospheric carbon dioxide and methane levels were at their minima around 7000 to 5000 years before the present day, respectively, and then slowly increased until the rapid rise in GHGs caused by the Industrial Revolution. The increase in methane is attributed to biomass burning and rice cultivation in the tropics. The carbon dioxide increase is more difficult to ascribe to human activity, but Ruddiman argues that deforestation and biomass burning may be a primary factor.

Ice and lake core proxy records provide quantifiable data on past fire regimes across all possible spatial and temporal scales. We aim to quantify the temporal and spatial changes in Holocene biomass burning in ice and lake core records from seven continents which correspond with centres of the origin of agriculture. We have developed for this a novel technique for measuring a globally-present molecular marker of biomass burning (levoglucosan, 1,6-anhydro-β-D-glucopyranose) in ice cores and lake sediments. We supplemented these pyrochemical analyses with palynological evidence of the impact of past fire regimes.

★ What are the main takeaways from the project so far?

For example, recent studies of the Greenland ice sheet have shown that climate changes including summer North Hemisphere insolation and temperature affect boreal fire activity over millennial timescales.

Our results on fire reconstruction in the Holocene show an important peak in fire activity 3–2 ka year ago. However Northern Hemisphere temperatures and especially summer fire season temperatures remain stable or decrease between 3 and 2ka. Therefore, major climate parameters and environmental changes alone cannot explain the levoglucosan flux reaching Greenland during the middle to late Holocene.

Given the lack of a plausible climate control for this pattern, coupled with the absence of paleoclimate evidence for any synchronous global climate change at this time, we argue that human activity associated with agriculture and land clearance provides the best explanation for observed trends in fire activity during the late Holocene. Extensive deforestation in Europe between 2.5 and 2 ka is synchronous with the Greenland levoglucosan fire peak, demonstrating a quantifiable early human impact on the environment beginning about 4000 years ago.

★ Did you manage to differentiate between natural and anthropogenic fires?

This is certainly one of the most challenging tasks of the whole research project and we are working on this. The links between biomass burning and increased agriculture (and therefore increased GHGs including carbon dioxide and methane) and the prolongation of interglacial climate are only valid if measured increases in burning demonstrate a quantifiable relationship with increased temperature, as can be measured in ice cores. In addition, lake cores contain necessary palynological evidence for human-induced fires such as the anthropological pollen index, pollen indicators of slash-and-burn cultivation, the presence of fire-tolerant species suggesting frequent fire activity, and changes in the arboreal pollen influx.

The multi-proxy nature of ice and lake cores makes them the perfect material to investigate the linkages between early agricultural activity and climate change, as temperature, palynologic evidence, and levoglucosan are measured from the same depth and time within the surrounding matrix.

★ What are you planning to do until and after the end of the project?

We are actually concentrating on a part of the project that was not originally foreseen in the implementation of the proposal. Novel organic molecular proxies are proposed for the reconstruction of fire events in association with anthropic activities. Namely, faecal sterols and a suite of polycyclic aromatic hydrocarbons were individuated and tested as suitable molecular markers of human presence and fire activity, in addition to the levoglucosan that we already use. These are very promising proxies in paleoclimatic reconstructions and we aim to pursue on this research direction in the near future. This ERC grant has been a great opportunity to study a poorly understood and often neglected part of the climate system.

EARLYHUMANIMPACT

★ Hosted by Ca'Foscari University of Venice in Italy.
★ Funded under FP7-IDEAS-ERC.
★ http://cordis.europa.eu/project/rcn/99498

SEEING UNDER ANTARCTICA'S ICE

EU-funded researchers have used a new process called comminution dating to better understand Antarctica's geological and climatic history.


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"With this information, researchers can reconstruct the history of continental weathering, sediment transport mechanisms and timescales."

Although scientists have been studying Antarctica for many years, most research has focused on the conditions of Antarctica as they currently are. Based on this information, scientists have been able to make predictions on both what caused these conditions and how they are likely evolve in the future. But because our understanding of the icy continent is essentially limited to what happened over the last 100 years, our overall knowledge is surprisingly limited. To truly understand Antarctica, scientists must 'see' the continent's geological and climatic history dating back to the late Quaternary period — a history that is literally frozen from sight.

Due to the Antarctic Ice Sheet (AIS) that covers the continent, land-based observations into its geological past remain largely unknown. However, scientists from the COMANT (Comminution dating of glacio-marine sediments in Antarctica and the Southern Ocean) project discovered that this geological information can be retrieved by studying the origins and transport times of eroded materials found in the marine sediment cores surrounding Antarctica. With this information, researchers can reconstruct the history of continental weathering, sediment transport mechanisms and timescales.

'This project uses an innovative approach called comminution dating to determine spatial and temporal changes in the transport time of fine clastic sediments produced by Antarctic subglacial erosion during the late Quaternary period, which can be seen in the flux of ice and sediment discharged into the Southern Ocean,' explains Project Lead Adi Torfstein.

Determining the comminution age

The COMANT project builds on recent results coming from the Weddell Sea showing that, depending on glacial-interglacial timescales, sediment transport times range between tens to hundreds of thousands of years. 'Building on these preliminary results, I studied the comminution ages of a large number of glacial-marine deposits at sites across the Southern Ocean,' says Torfstein. 'This in turn allowed me to conduct a comprehensive study of natural and analytical biases on the comminution dating approach.'

The project focused their efforts on U-series disequilibrium in detrital material, which is a measurement of weathering and transport time. Once a rock fragment is ground to a small particle of only a few microns in diameter, which is something that happens very quickly in glacial settings, one of the isotopes of uranium (234U) is continuously lost from the rim of the particle due to radioactive decaying. 'This loss of 234U is measurable and depends, amongst other things, on the known decay rate of uranium isotopes,' says Torfstein.

According to Torfstein, this change, or loss of 234U, is a geological clock that can be used to estimate the age of formation of a particle (rather than the age of formation of a rock or mineral). The time elapsed between the formation of the particle and the present is known as the 'comminution age'.

Better understanding Earth's history

Although the project is ongoing, researchers expect results to provide the first systematic and wide-scale study of comminution ages in the Southern Ocean. As such, the study will expand the possibilities of dating continental deposits, leading to a better understanding of the fundamental aspects of sedimentology, glaciology and landscape evolution.

'This is important because the comminution age of a particle is controlled by the interplay between climate change, the tectonic evolution of the continents and the efficiency of transport mechanisms on the continents and in the oceans,' adds Torfstein. 'Thus, comminution ages reflect the cumulative impact of processes that govern the shaping of the Earth's surface over time, and by reconstructing these ages, we can better understand its history.'

COMANT

- Coordinated by the Hebrew University of Jerusalem in Israel.
- Funded under FP7-PEOPLE.
- http://cordis.europa.eu/project/rcn/109554

INTERVIEW

ABRUPT CLIMATE CHANGE EVENTS FROM THE PAST COULD HELP PREDICT THE ONES AHEAD

Coping with climate change will already be difficult enough without worrying about Dansgaard-Oescheger (DO) events that could come on top of it. However, their possible occurrence cannot be dismissed: We need to know more about these events, how they impacted our planet in the past, and how they could continue to do so in the future. The world's most well-preserved ice cores could provide all this information while allowing for improved climate models.

There is a risk that increasing atmospheric greenhouse gas levels could trigger abrupt changes in the climate system — that is, changes so abrupt that they could seriously challenge the ability of humans, plants and animals to adapt. Ice core records can help us better understand this risk: they notably show that, during the last glacial period (around 100 000 to 20 000 years ago), temperature over the Greenland ice sheet could change by up to 16°C within a few decades.

With his INTERCLIMA (Inter-hemispheric Coupling of Abrupt Climate Change) project, Dr Joel Pedro of the University of Copenhagen has been trying to advance understanding of the governing mechanisms and inter-hemispheric coupling involved in abrupt climate change. By doing so, he hopes to help scientists trying to understand the extent and nature of the anthropogenic climate change we are witnessing to improve their climate predictions.

DR JOEL PEDRO

★ How can past climate change events inform us on future risks?

Dr Joel Pedro: The Ice Age temperature jumps, termed Dansgaard-Oeschger events, are thought to be associated with natural instabilities or 'tipping points' in ocean and atmospheric circulation. A crucial distinction between anthropogenic climate change and these natural events is that today land and ocean temperatures are increasing almost everywhere, whereas during the Dansgaard-Oeschger events temperature quickly warmed in Greenland and the North Atlantic while at the same time cooling in large parts of the Southern Hemisphere. There was basically a redistribution of heat in the climate system. Trying to understand whether anthropogenic climate change could push the climate system over similar tipping points is an important motivation for studying the Dansgaard-Oeschger events.

By studying ice cores and other climate records from around the world, we gain information on the potential triggers of such abrupt changes, the processes which are involved, and their global impact.

Accurately documenting past abrupt climate change events also helps with testing climate models. We can gain more confidence in models used to make predictions about future climate if our models are able to simulate the full range of what climate has done in the past.

★ Why did you specifically base your research on Law Dome and Greenland ice cores?

For my research I selected ice cores which preserve the most detailed records in time (the highest temporal resolution). Abrupt climate change occurs by definition extremely quickly so to really get to the details of the where, how and why of past abrupt climate change, high time resolution records are essential. On the polar ice sheets the time resolution of an ice core is set by how much snow falls every year and then how much those annual layers are later compressed and smeared out by ice flow. The North Greenland Ice Core Project ice core (drilled by Danish researchers) and the Antarctic Law Dome and West Antarctic Ice Sheet Divide cores (drilled by Australian and US researchers, respectively) are amongst the highest resolution climate records available for the past tens of thousands of years.

However, my research was not restricted to ice cores. I also reached out to communities working with lake, marine and cave sediment records. Bringing in data from these sources was important to gain information about climate variability at lower latitudes during Dansgaard-Oeschger events.

★ How did you proceed to get the information you wanted?

The project greatly benefited from networking and data-input from many research groups in Europe, Australia, New Zealand, South America, Africa and the US. I used ice core data from my previous research group in Australia and I collaborated with colleagues in the US to obtain data from the excellent West Antarctic ice core record. At my host institute, the University of Copenhagen, I had access to data and expertise on the Greenland Ice cores.

Once the project built momentum, via presentations at international conferences and research trips, I was able to obtain input from researchers working with lake, marine and cave records. For the modelling component of the research I collaborated with researchers at the University of Wisconsin Maddison and Kiel University.

★ What can you tell us about the results from the project?

Making well-informed decisions on how to best adapt to future climate change and how to mitigate the worst effects of climate change requires information on what the climate system is capable of.

The INTERCLIMA project has improved our understanding of how abrupt climate change signals are communicated to different parts of the climate system. It showed that changes in meridional atmospheric heat transport drive abrupt climate variability in the southern hemisphere tropics and that slower ocean heat transport changes and sea ice feedbacks are more important in communicating abrupt climate change signals to the southern high latitudes.

★ How are you/do you plan to build upon the project's results for future research?

I'm working on the influence of abrupt climate variability on the Southern Ocean. The Southern Ocean is currently responsible for the uptake of around 75 % of the ocean storage of anthropogenic heat and around 40 % of the storage of anthropogenic carbon.

Whether the Southern Ocean will continue to take up so much heat and carbon in the future is not well known. I think that one way to try and close this knowledge gap is to use examples of how past abrupt climate change influenced heat and CO_2 uptake and storage. To do this I am working with paleoclimate observations, mainly ice cores and marine cores, along with model results and results from experiments and theory on Southern Ocean physical oceanography. I hope this work will improve our understanding of past and future sea ice, ice sheet–ocean interactions and CO_2 storage in the Southern Ocean.

I'm also working on an 'adjoint modelling' project in which we aim to directly input paleoclimate data to model simulations.

INTERCLIMA
★ Coordinated by the University of Copenhagen in Denmark.
★ Funded under FP7-PEOPLE.
★ http://cordis.europa.eu/project/rcn/108394

RECONSTRUCTING GREENLAND'S CLIMATE

Using ice-cores and a new isotopic method that can provide more precise temperature information, Marie Curie Fellow, Takuro Kobashi, has gained an insight into Greenland's climate history. His data suggests Greenland's temperatures and global-sea-levels may increase faster than current climate projections.

It is not easy to reconstruct past temperature changes beyond the 150 year time frame of recorded observations, but EU Marie Curie Fellow, Takuro Kobashi at the University of Bern has developed a tool that can do just this. In the two-year GREENTEMP (Investigation of Greenland temperature variability over the 6000 years using trapped air in ice cores)project which ended in April 2016, Kobashi reconstructed the precise temperature of Greenland over the past millennia using ice cores. In a contrast to conventional methods, he collected data from argon and nitrogen isotopes trapped in air bubbles within ice cores.

'It has been known that Greenland temperature co-varies with North Atlantic temperature so understanding Greenland's temperature variability provides information on North Atlantic temperature and changes in ocean current change in the past.' explains Kobashi. The last period of glacial retreat occurred 6000 years ago and so being able to probe temperature changes at that time could provide useful for understanding the impact of current climate changes.

The ice core samples used in his work were collected more than 10 years ago during from the North Greenland Ice Core Project (NGRIP) which extracted 11 cm diameter ice cores stretching back to the last ice age. Kobashi's new technique measures nitrogen and argon isotope ratios within trapped air bubbles, rather than measuring oxygen isotopes ratio's which is the standard method.

The method takes advantage of the changes in air occurring in the snow layer that fell on top of Greenland's ice-sheets, which are eventually trapped in the bubbles at the bottom of the snow layer before themselves freezing into ice. Gravity and the temperature gradient that exists within the snow layer causes a variable distribution of air. The isotope ratio of two types of gasses (nitrogen and argon) in the bubbles can therefore be used to estimate the past temperature gradient of the snow layer, and the thickness of the layer, allowing Kobashi to reconstruct the past surface temperature changes.

'We have reconstructed temperature over the past 4000 years and our preliminary analyses show the variations of Greenland temperatures significantly correlate with solar activity' says Kobashi

but adds the interpretation is not what might be expected. 'When solar activity increases, Greenland's temperatures actually get colder, and vice versa'. The phenomenon seems to be related to atmospheric and oceanic changes, and is also reproduced in some climate models. Temperature changes can also be explained by changes in volcanic activity, orbital changes and greenhouse gas levels in the atmosphere.

'Whilst natural variability may mask anthropogenic influence on Greenland temperature, eventually Greenland temperature will start rising by anthropogenic influence,' Kobashi says. Greenland generally follows global temperature rises, but Kobashi's work shows the link between solar activity and temperature could help predict future temperature changes. Solar activity will be decreasing over the next decades and that means Greenland's temperature may increase faster than projected by climate models that use only greenhouse gas increases in their projections. In turn, that could result in faster melting of the polar ice-sheet, and increasing global sea-levels.

Kobashi's new method is an improvement on previous methods because it provides seasonally unbiased and more precise temperatures in a multidecadal time scale, as long as the ice core are from high snow fall areas such as Greenland, Antarctica, and possibly alpine glaciers. 'As the method is now established, we will likely be able to have highly precise temperature records from these areas in coming decades, which could revolutionise our understanding of climate changes over the past millennia,' concludes Kobashi.


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GREENTEMP

- ★ Coordinated by the University of Bern in Switzerland.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/project/rcn/186017
- ★ Project website: https://sites.google.com/site/greenlandtemperature

INTERVIEW

SALT CONCENTRATIONS IN ICE CORES COULD UNVEIL DO EVENTS' RECIPE

It is one thing to know that Earth has already faced abrupt climate changes — also known as Dansgaard–Oeschger (DO) events — in the past. But finding out the reasons for these dramatic and rather short term changes is another story, one that Dr Rachael Rhodes from the University of Cambridge is reconstructing using chemistry records from ice cores taken from Greenland.


© Rachael Rhodes

DR RACHAEL RHODES

A common assumption with past DO events is that their occurrence was closely linked to major changes in Arctic sea ice extent: such changes feedback positively on Arctic temperature, and finding out exactly how this relationship works could be key to predicting how Arctic ice will react to ongoing climate change.

Within the framework of her SEADOG (Sea ice across Dansgaard-Oeschger events in Greenland) research, Dr Rhodes is analysing records of sea salt and methane sulphonic acid in Greenland ice cores with a view to defining whether they can be used as proxies for Arctic sea ice extent. She is investigating four ice core records for spatial and temporal variability across DO events, and exploring the controls on marine aerosol deposition over the Greenland Ice Sheet thanks to the p-TOMCAT chemical transport model.

Thanks to her findings, Dr Rhodes has optimised the p-TOMCAT model to represent modern-day sea salt aerosol deposition across Greenland. Ongoing work will identify scenarios of sea ice change consistent with ice core chemistry data across DO events.

★ What are DO events and why is it important to better understand them?

Dr Rhodes: DO events are rapid and abrupt changes in the climate of the Northern high latitudes that occurred during the Last Glacial Period. They are named after two famous ice core scientists: Willi Dansgaard (Denmark) and Hans Oeschger (Switzerland) who first recognised these events in the stable isotopic ratios of water (a proxy temperature) of Greenland ice cores.

★ How come we don't know more about these events yet?

We know quite a lot about them. For example, from Greenland ice cores, we can decipher that temperatures changes of 5-16.5°C occurred within centuries over Greenland. However, we still don't understand what ultimately caused these events. Several theories involve major changes to Arctic sea ice extent but there is little evidence from the paleoclimate archives to constrain this.

★ How did you proceed to gather the desired information from ice cores?

I am using sea salt (NaCl) concentrations measured on Greenland ice cores. Sea salt concentrations are relatively easy to measure but difficult to interpret in terms of climatic or environmental changes because many other factors can influence the signal that is eventually preserved in ice cores. In particular, variations in meteorology, such as the weather systems that transport the sea salt aerosol through the atmosphere to the ice core site, are known to impact the signal.

I am using an atmospheric chemical transport model called p-TOMCAT to investigate to what extent ice core sea salt signals are influenced by sea ice area and by meteorology. This will help answer the question of whether or not the abrupt sea salt concentration changes across DO events can be linked to Arctic sea ice conditions.

★ What can you tell us about your main findings so far?

My initial work has focused on understanding the processes controlling Greenland ice core sea salt signal in the present-day. I have modified p-TOMCAT to calculate sea salt concentrations in the deposited snow and the model is doing a great job of replicating both the concentrations and seasonality of sea salt records preserved in ice cores. Results indicate that meteorology is the dominant factor affecting ice core sea salt signals at the inter-annual scale, but that sea ice conditions do exert some influence. I am testing how great a change in sea ice area is needed to override meteorology and become the dominant influence.

★ How can these results help predict the future evolution of Arctic sea ice?

This work will help us understand if/how sea salt concentration records in Greenland ice cores can be used as a proxy for Arctic sea ice extent. A positive result would disentangle the effects of sea ice-related and meteorology-related sea salt change, allowing sea salt concentrations to be employed as a sea ice proxy with confidence. Reconstruction of Arctic sea ice changes across the abrupt DO events is important because we ultimately need to understand how Arctic sea ice reacts to rapid climate change, like the one we are witnessing occurring right now.

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

Now that the processes leading to ice core sea salt signals are well-understood for present-day Arctic conditions, I am adapting the model to run tests using meteorology and sea ice typical of the Last Glacial Period when DO events occurred. It will be interesting to test how the simulated sea salt signals respond to the huge changes in climate and sea ice thought to happen during DO events.

SEADOG

★ Coordinated by the University of Cambridge in the United Kingdom.
★ Funded under H2020-MSCA-IF.
★ http://cordis.europa.eu/project/rcn/195554

CLEARING THE POLAR AIR ON COSMIC DUST

By developing several innovative experimental systems, EU-funded researchers now have a better indication of how much cosmic dust enters the Earth's atmosphere and what impact it has.

Our solar system is a dust-filled place. As comets travel around their orbits and near the sun they begin to evaporate, leaving a trail of cosmic dust in their wake. These dust particles then enter the Earth's atmosphere at a very high speed — anywhere in the range of 40 000 to 260 000 kph — where they collide with air molecules. This collision then causes flash heating and a subsequent melting and evaporation of the particles.

'Sometimes this dust is visible as meteors, which is the case of dust particles greater than 2 mm,' says CODITA (Cosmic Dust in the Terrestrial Atmosphere) project coordinator John Plane. 'But most of the dust mass entering the atmosphere is so small that it can only be observed using specialised meteor radars.' More so, Plane says that even though we know the dust is there, there is little indication of how much cosmic dust enters the Earth's atmosphere — the range of estimates being between 3 and 300 tons a day — and what impact it has.

Clearing the air

The CODITA project is working to clear the air on this question. To accomplish this, the project launched two successful experimental systems to study the chemistry of the metallic molecules and ions produced from evaporating meteors. According to Plane, the first system detected the metallic molecules using a flow tube reactor, coupled to a time-of-flight mass spectrometer. The system uses pulsed laser radiation to softly ionise the metallic molecules. 'For the first time we were able to successfully study the reactions of such metallic species as metal oxides and hydroxides, which have proved undetectable by other methods,' says Plane.

The second experiment also used a flow tube, this time with a plasma source and coupled to a quadrupole mass spectrometer. 'With this system we can study the dissociative recombination of metal-containing ions with electrons, which is the main route for neutralising ions found in the upper atmosphere,' adds Plane.


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A dust bin

These experiments — combined with an astronomical model of dust evolution in the solar system and high performance radar measurements — show that around 40 tons of cosmic dust enters Earth's atmosphere on a daily basis.

But so what? Sure, our atmosphere may look like it needs a good dusting, but what's the effect? According to the CODITA project, quite a lot: 'The metals being injected into the atmosphere from evaporating dust particles are the direct or indirect cause of an array of phenomena,' says Plane.

For example, the metals condense into very fine dust known as meteoric smoke, which plays a role in the formation of noctilucent clouds. These ice clouds occur in the polar regions at a height of 82 km during the summer months. 'The clouds first appeared in 1886, and their increasing occurrence appears to be signal of climate change in the middle atmosphere, where water vapour is increasing and temperatures are falling because of increased levels of greenhouse gas — the reverse of the lower atmosphere,' says Plane. 'Meteoric smoke also affects polar stratospheric clouds that cause depletion of the ozone layer, and the deposition of cosmic iron in the Southern Ocean provides a critical nutrient for plankton, which draw down carbon dioxide from the atmosphere.'

Now, thanks to the work done by the CODITA project, it is possible to model the effects of cosmic dust on a consistent basis and from the outer solar system all the way to the Earth's surface. But the project's scope isn't limited to Earth. To further understand the effects of cosmic dust on a planet's atmosphere, the project also explores the impacts of meteoric smoke in other solar system bodies, including high temperature chemistry on Venus, the formation of noctilucent clouds on Mars, and production of benzene on Titan.

CODITA

★ Hosted by the University of Leeds in the United Kingdom.
★ Funded under FP7-IDEAS-ERC.
★ http://cordis.europa.eu/project/rcn/102627

UNIQUE BARIUM DATASETS IMPROVE OUR UNDERSTANDING OF OCEANIC CARBON STORAGE

The West Antarctic Peninsula (WAP)'s high sensitivity to climate change makes it a perfect location for furthering scientific understanding of ocean chemistry. An EU-funded project is pursuing this objective with a focus on barium (Ba), which can provide a unique insight into both organic and inorganic carbon storage.

Ice core records indicate that atmospheric carbon dioxide varies naturally over time — a process to which the Southern Ocean strongly contributes by influencing natural carbon storage capacity. First, its deep waters take up and lock away carbon and heat from the atmosphere. Then, it exerts an important control on the distribution of nutrients to a large portion of the Earth's oceans, which in turn regulate algal population structure and thereby carbon uptake.

With the BARIUM (Barium cycling in Antarctic waters: Understanding present and past ocean processes) project, Dr Kate Hendry of the University of Bristol hopes to use Ba cycling to examine how oceanic carbon storage has varied over time.

'I worked together with my graduate students Stephanie Bates and Kimberley Pyle on making some of the most precise and accurate high-resolution measurements of seawater and marine carbonate Ba, using cutting-edge methods and instruments,' Dr Hendry explains. 'Our unique dataset allows us to test theories about how Southern Ocean circulation is linked to global climate over a range of timescales, and how nutrient cycling will respond to future climatic change.' These findings could prove to be of great interest to both policy-makers and industry.

The most climate-sensitive areas

The team's work was mostly focused on the WAP, which not only responds to more global temperature changes than other parts of the region, but is also strongly influenced by complex, interconnected, local and regional processes — from sea-ice and glacier dynamics to ocean and atmospheric circulation. 'This, along with the low levels of background man-made contamination, makes the WAP a key location for understanding ocean chemistry,' Dr Hendry points out. This didn't prevent the team, however, from expanding their work to the Drake Passage and samples from even further afield.

'We have produced a fantastic dataset of dissolved Ba from the WAP and Drake Passage regions of the Southern Ocean,' she explains. 'From the WAP shelf, our results reveal insight into the processes that control sources and sinks of Ba in seawater (sediment dissolution, sea-ice processes, ocean circulation and biology, etc.), as well as showing that there is significant variability between years as a result of changes in these processes. Our open ocean results show how the physical structure of the fronts within the Southern Ocean influences the behaviour of Ba in seawater. These results help us understand the link between Ba, nutrients and carbon drawdown in the Southern Ocean.'

In addition to this, the team produced climate records extending back through time by using sedimentary records of Ba content trapped within carbonate shells of single-celled organisms — called foraminifera — from the Southern Ocean. 'These archives


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provide us with information on changes in inputs of Ba and other aspects of ocean chemistry in the past. We have found significant differences between the Ba concentration of the Southern Ocean today and 125 000 years ago, during the last warm period (interglacial) before the last ice age,' Dr Hendry says.

Ice core records show that this period was warmer than the pre-industrial era and had a higher atmospheric carbon dioxide concentration, which makes it a potential point of comparison with the global warming expected over the next few decades. 'Our results have implications for how the circulation of the Southern Ocean may respond to a warmer world, and for our predictions of future change,' she adds.

Another key result from the project lies in the first barium isotope measurements for foraminifera and for seawater in the Equatorial Atlantic, which have tremendous value for furthering scientific understanding of the processes controlling Ba distributions in seawater and helping interpret Ba archives in marine sediments.

Lessons learned and plans ahead

Overall, BARIUM results provide valuable information about how Ba is cycled in the ocean and how it relates to biology — who is growing in the ocean and where — as well as nutrient and carbon uptake. 'This means that we can better understand how to use Ba archives locked away in marine sediments to interpret past changes in the ocean during periods of climatic change. In understanding how the ocean responds — or indeed drives — climate change in the past, we are in a better position to predict what will happen in the future,' Dr Hendry says.

For Dr Hendry and her team, the future promises more research and discoveries. 'As with most scientific research, our results have opened up more questions,' she explains. 'One such question is the role of sea-ice in Ba cycling, and how this links to carbon uptake. We have already been able to extend our project to the Arctic, via a new collaboration with colleagues at the Norwegian Polar Institute that has included a field campaign in 2015 to investigate winter sea-ice north of Svalbard. We already have some fascinating results from this new project, so watch this space!'

BARIUM

- Coordinated by the University of Bristol in the United Kingdom.
- Funded under FP7-PEOPLE.
- http://cordis.europa.eu/project/rcn/105350
- Project website: https://oceanbarium.wordpress.com/

BIOLOGY AND MEDICINE

NOVEL REGENERATION THERAPY PROMISES TO SIGNIFICANTLY IMPROVE BONE REPAIR

EU-funded researchers have pioneered a new bone regeneration therapy that promises to significantly improve bone repair and provide a realistic solution for patients who require partial bone replacement.

Currently there is no adequate therapy available that can accelerate long bone fractures and promote healing. Present solutions in this therapeutic area rely on expensive and side-effects associated bone devices. The EU-funded OSTEOGROW (Novel Bone Morphogenetic Protein-6 Biocompatible Carrier Device for Bone Regeneration) project has developed an entirely new therapy that promises to be safe and cost-effective and will decrease the need for secondary interventions.

The new therapy works by using the patient's own blood in order to create a clot when in the operating theatre. The blood is then injected with 'Bone morphogenetic protein-6' (BMP6) and placed in the spot where new bone is needed to be created. The therapy also has the advantage of reducing inflammatory reactions which are common as a result of employing currently-used bone devices.

Within several months, the new bone piece is created, taking only a decilitre of blood to create the needed clots. The bone diseases which will be treated locally with the OSTEOGROW device are acute radius fractures and recalcitrant non-unions of the tibia. These conditions are particularly widespread and highly debilitating for which this new treatment method promises to significantly alleviate associated pain. The treatment would also be employed to treat another common cause of serious pain, degenerative changes in the spinal cord.

Phase 2 clinical trials are taking place in Zagreb, Croatia (where the project is coordinated), Sarajevo and Vienna. This follows tests on rabbits and sheep, which were highly successful in generating new bone. Ten patients underwent the pioneering new therapy at the Sisters of Charity Hospital in Zagreb, which resulted in no complications or toxic effects. In Vienna, surgeons are using the new therapy to treat patients with debilitating spinal fusion. By the end of the trials, 75 patients will have undergone treatment with the new OSTEOGROW device.

The research team is also particularly proud of the fact that OSTEOGROW is the first major international collaborative project to develop an entirely new medical treatment led and coordinated by clinicians in Croatia. 'For the first time the European Commission confided the project coordination to a Croatian medical institution, with 11 European partners from six states. They all helped, but the innovation and originality come from Zagreb, while partners enabled us to do preclinical trials and move the project to clinical trials,' stated project coordinator Slobodan Vukičević.

As the project enters its final months and clinical trials have thus far proved extremely promising, the research team are now concentrating on the commercial prospects of the new treatment. Acute bone fractures are prevalent in the EU and it is estimated that by 2050, due in part to an ageing population, 12 million bone fractures will occur on an annual basis. As such, new therapies to enhance bone formation, shorten healing times and prevent non-unions will become an increasing medical requirement.

It is expected that the new therapy pioneered by OSTEOGROW will be market-ready within the next two to three years.

OSTEOGROW

★ Coordinated by the School of Medicine, University of Zagreb in Croatia.
★ Funded under FP7-HEALTH.
★ http://cordis.europa.eu/project/rcn/101812
★ Project website: http://osteogrow.eu/

GENE INJECTION PROMISES A NEW WEAPON IN THE FIGHT AGAINST ALZHEIMER'S

Research funded jointly by the European Research Council (ERC) and Alzheimer's Research UK has demonstrated that the crippling neurodegenerative disease could be stopped by an injection into the memory centres of the brain.

Published in the journal 'Proceedings of the National Academy of Sciences', the research team based at Imperial College London have shown that it's possible to deliver a gene which produces a plaque-busting protein directly into the brain. The degeneration of brain cells in Alzheimer's disease is largely due to amyloid plaques. The sticky protein build-up happens when amyloid proteins fold and divide improperly. The main component of these protein clumps are amyloid-beta peptides. Preventing these proteins from forming may help prevent the death of brain cells which causes the disease and its symptoms to escalate. Nearly 9 million people in Europe suffer from Alzheimer's.

The research team studied a gene called PGC-1a as previous research had suggested that the gene could prevent the formation of amyloid plaques. They injected the gene into mice that were in the early stages of Alzheimer's disease. The mice did not develop any plaques and performed as well in memory tasks as healthy mice after four months.

"To administer the gene, the team used a harmless lentivirus that was modified to include the gene."

Dr Magdalena Sastre, senior author of the research, commented that these findings could eventually provide a method of preventing the disease or halting it in the early stages. 'Although these findings are very early, they suggest this gene therapy may have potential therapeutic use for patients. There are many hurdles to overcome, and at the moment the only way to deliver the gene is via an injection directly into the brain,' she expanded. 'However, this proof of concept study shows this approach warrants further investigation.'

To administer the gene, the team used a harmless lentivirus that was modified to include the gene. The virus then infects brain cells and rewrites their genetic code to produce more of the plaque-fighting PGC-1a. Injections were administered in the hippocampus and cortex of the brain, as these are responsible for memory formation and orientation, and are the first to be affected by Alzheimer's disease.

Professor Nicholas Mazarakis, co-author of the study and recipient of the ERC's IRLVGTMND (Improved retrograde lentiviral vectors for gene therapy in motor neuron diseases) project grant, added: 'Scientists harness the way the lentivirus infects cells to produce a modified version of the virus that delivers genes into specific cells. It is being used in experiments to treat a range of conditions from arthritis to cancer. We have previously successfully used the lentivirus vector in clinical trials to deliver genes into the brains of Parkinson's disease patients.'

Dr Doug Brown, Director of Research and Development of the UK's Alzheimer's Society also commented: 'So far potential treatments that directly target amyloid build-ups in the brain have mostly had disappointing results in clinical trials, whereas this study could pave the way for a new plan of attack.'

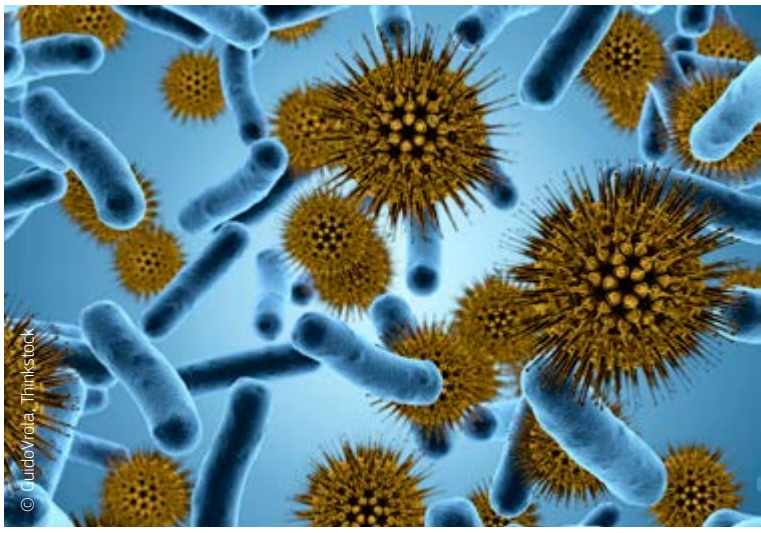
The team's results suggest that therapies utilising PGC-1a may be able to prevent Alzheimer's disease if the patient is treated early. Human trials are still a long way off but this provides new hope for the development of a treatment for a currently incurable disease.

IRLVGTMND

- Hosted by the Imperial College of Science, Technology and Medicine in the United Kingdom.
- Funded under FP7-IDEAS-ERC.
- http://cordis.europa.eu/project/rcn/89779

MICROBIAL DYNAMICS OF ANTIBIOTIC RESISTANCE

Microbial antibiotic resistance develops in the gut through the selection of pre-existing resistant bacteria and gene transfer events. Scientists investigated the dynamics of the entire collection of 'Antimicrobial resistance determinants' (ARDs), also known as the resistome, in the human gut.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The emergence of antibiotic resistance in bacteria has dramatically decreased the therapeutic options available for treating bacterial infections. To address this issue, the EU-funded EVOTAR (Evolution and transfer of antibiotic resistance) project worked to uncover mechanisms involved in the evolution and spread of antibiotic resistance in human pathogens.

The consortium employed different technologies, such as full metagenomic sequencing, functional metagenomic selections, and resistance gene capture platforms. Their objective was to

characterise the human reservoir of antibiotic resistance genes, the resistome.

Metagenomic sequencing revealed that long-term (chronic) exposure to antibiotics decreased the richness of the microbiome and increased the abundance of ARDs. It clearly demonstrated that such exposure selects species than can survive in the constant presence of antibiotics due to the ARDs they encode. The functional selections found that hospitalisation and antibiotic treatment have profound effects in some patients through expansion of their ARDs. Importantly, some of the data indicated that after six months the abundance of antibiotic resistance genes returned to the original level.

Optimised cultivation methods for the human gut microbiota were developed to capture a representative majority of the cells in a sample. These novel culture technologies in combination with whole genome sequencing revealed reservoirs of antibiotic resistant organisms and antibiotic resistance genes in soil and marine environments.

EVOTAR also developed the PLACNET tool for the reconstruction of plasmids carrying resistance genes from whole genome sequence data to track the transmission and study the natural history of these plasmids. Another new method was developed to identify ARDs in large complex datasets. This helped them to significantly expand the list of known resistance genes.

Project members introduced new mathematical models for studying the host transmission of antibiotic resistance. These models enabled the study of the spread of different diseases and antibiotic resistance through the network of hosts (i.e. patients, hospitals, farms), and identification of hosts that are at risk of becoming infected.

The consortium successfully developed an antibiotic resistance gene-capture platform, which currently consists of 80 000 targets of resistance genes and genes associated with the mobile genetic elements. This could contribute to dissecting the spread of resistance at an unprecedented level of quality and speed.

A novel intervention approach was taken in EVOTAR and was aimed at administering a compound that absorbs and inhibits residual antibiotics in the human colon. It was anticipated and proven correct that this approach minimizes selective pressures leading to the emergence of antibiotic resistance in and perturbation of the commensal flora, without changing the antibiotic's absorption rate and its potential to treat the infection for which it has been administered.

Taken together, EVOTAR provided new information on the evolution, transfer and emergence of resistance genes. Novel in vitro and in vivo models provide a platform for future studies into the efficacy of novel intervention approaches.

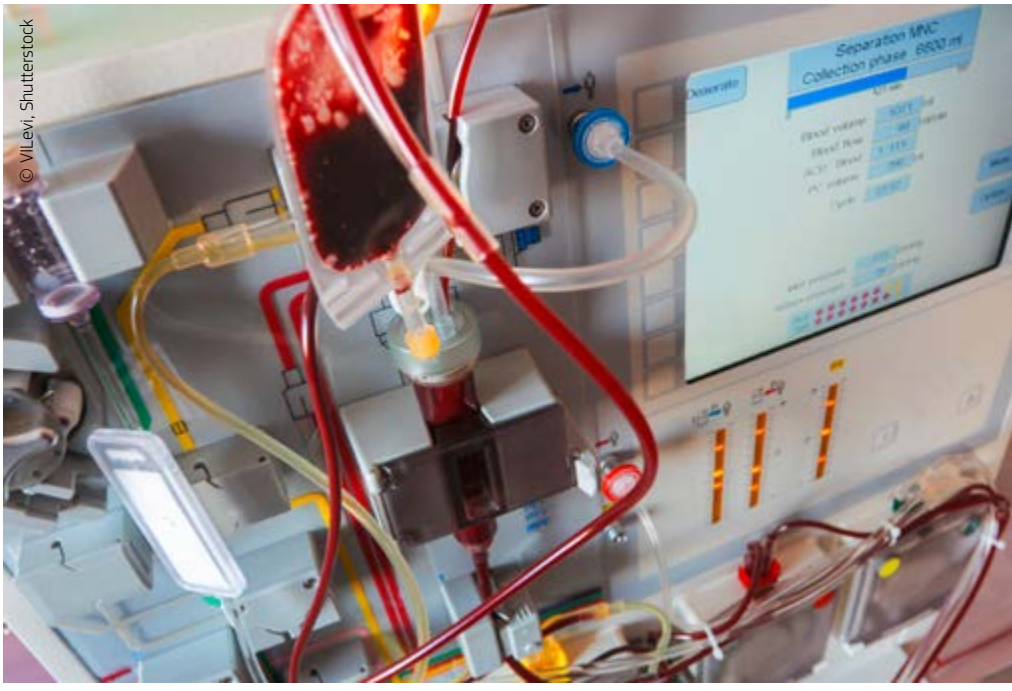
EVOTAR

- ★ Coordinated by UMC Utrecht in the Netherlands.
- ★ Funded under FP7-HEALTH.
- ★ http://cordis.europa.eu/project/rcn/100088
- ★ Project website: http://evotar.eu/

CLINICAL BREAKTHROUGHS OFFER YOUNG CANCER PATIENTS HOPE

An EU-funded project has made significant advances in treating a common form of childhood leukaemia, potentially saving thousands of young lives.

Researchers have developed new tests that could improve the diagnosis and treatment of a common form of childhood leukaemia. By tracking special structures in the blood released by cancerous acute lymphoblastic leukaemia cells, scientists believe they will be able to more accurately monitor and treat the disease, saving lives and making more efficient use of medical resources.



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What makes this discovery so interesting is that, until recently, these special structures — extracellular vesicles — were thought to be inconsequential debris. However, the INTREALL (International study for treatment of childhood relapsed ALL 2010 with standard therapy, systematic integration of new agents, and establishment of standardized diagnostic and research) project discovered that cancerous leukaemia cells not only produce but also send these structures to anywhere in the body through blood.

This discovery opens up two new research avenues in the treatment of 'Acute lymphoblastic leukaemia' (ALL): the possibility of monitoring the progress of the disease by tracking these structures; and the possibility of improving the delivery of drugs by actually combining them with the vesicles. The team also hopes that the vesicles might provide

individualised information about tumours, helping doctors to deliver personalised care in the future.

ALL is a malignant cancer characterised by an over-production of white blood cells. It predominantly affects children, with fatal relapse in some patients. It is the most common malignant disease in childhood, affecting four in every 100 000 children per year in Europe. Over the past four decades, survival has improved from less than 20 % to over 80 %.

Nonetheless, relapse remains a leading cause of mortality in childhood cancer. About 15 % to 20 % of patients suffer a relapse of the disease. Relapses are currently treated with intensive chemotherapy and 'Haematopoietic stem cell transplantation' (HSCT). Many of these drugs have toxic side-effects, and invasive surgical procedures can be painful and stressful for young patients.

The INTREALL project therefore sought to bring together European experts with expertise in childhood cancers in order to investigate novel new therapies and to facilitate the world's largest ALL-focused clinical trial. The project has successfully integrated up to 300 European hospitals as well as innovative 'Small and medium-sized enterprises' (SMEs) involved in biotechnology and IT, and has also fostered links with relevant networks for paediatric oncology, drug development and parent organisations.

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

BACTERIA SHAPE NEONATAL IMMUNE SYSTEM

The first months of life are critical for immune system development and maturation. A European study looking into this process has illustrated the central role of maternal gut microbiota.

Commensal microbiota inhabit the inner and outer body surfaces of healthy mammals, such as the skin, airways and intestine. The role of these bacteria in the intestine is well-established for the digestion of food, production of vitamins and immune protection. Changes in gut microbiota composition are associated with an increased risk of developing inflammatory bowel disease.

Colonisation with beneficial bacteria starts after birth and is intricately associated with the immediate environment. This underscores the importance of exposure to the maternal microflora during early childhood in shaping the health of the infant. Scientists in the EU-funded MICROBIOTA-NEONATE (Characterization of maternal microbiota-dependent imprinting of the neonatal immune system) project set out to investigate the phenotypic and functional effects of maternal microbiota on neonatal immunity and the mechanism behind this phenomenon.

The researchers exposed pregnant germ-free mice to the commensal strain of E. coli, HA107, and compared their offspring to those that had remained germ-free throughout pregnancy. They observed that offspring exposed to commensal E.coli while in the uterus had more immune cells responsible for maintaining homeostasis at the host-microbial interface as well as immunity against invading pathogens.

"MICROBIOTA-NEONATE scientists also demonstrated the significance of microbiota exposure during gestation."

MICROBIOTA-NEONATE scientists also demonstrated the significance of microbiota exposure during gestation. Offspring fed by germ-free mothers exhibited bacterial translocation to the lymph nodes while those exposed to maternal microbiota were protected. Furthermore, the latter expressed higher levels of genes involved in antimicrobial defence and intestinal homeostasis.

Mechanistic insight indicated that the majority of the alterations observed in the offspring immune system introduced by gestational colonisation were dependent on the presence of maternal antibodies. This takes place in the uterus via the placenta and, postnatally, via the maternal milk. Interestingly, the maternal antibodies carried bacterial-derived factors in the maternal milk that could reach the offspring by gestation.

Overall, the increased incidence of allergic diseases in children in developed countries, as well as neonate and child mortality from infectious diseases in developing countries, emphasise the need for improving neonatal immunity. The findings of the MICROBIOTA-NEONATE study will contribute to the prenatal prevention of allergic diseases and new therapeutic tools that reduce child mortality.

MICROBIOTA-NEONATE
- ★ Coordinated by the University of Bern in Switzerland.
- ★ Funded under FP7-PEOPLE.
- ★ http://cordis.europa.eu/project/rcn/188094


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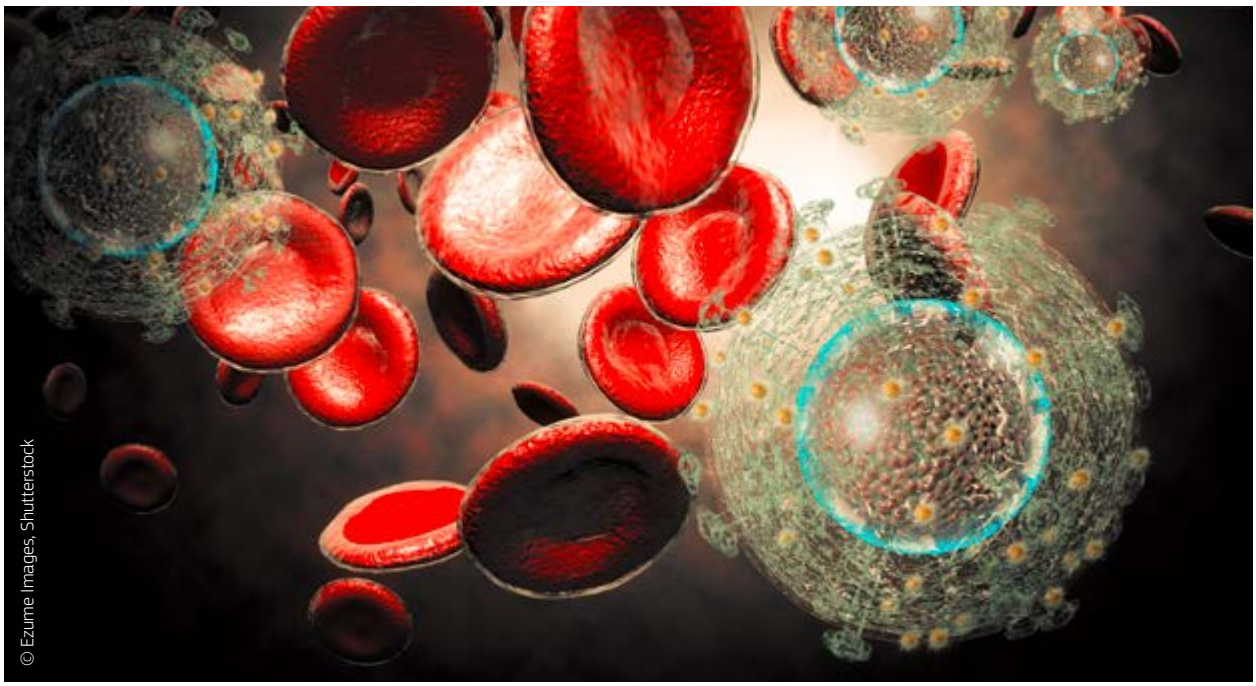
EXPLOITING HIV'S WEAKNESSES TO DEVELOP EFFECTIVE VACCINES

EU-funded researchers have made significant progress in identifying promising pathways that could lead them towards developing an HIV vaccine.



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Around 6 300 people a day are infected by HIV, the virus that ultimately causes AIDS, whilst over 25 million people have so far died overall. Finding a vaccine has been the focal point of HIV research since the 1980s. Although this remains elusive, the success of a recent study suggests that scientists are on the right path.

Part-funded through the ERC-funded SHEV (Stabilizing the exposure of neutralization epitopes on HIV-1 envelope glycoprotein trimer vaccines) project, the study, recently published in the journal 'Cell Reports', has identified a key vulnerability in the HIV molecule that could one day be targeted by an effective vaccine. Researchers are also confident that targeting a virus's precise molecular structure — in order to prompt the immune system to produce specific antibodies — could also be applied to efforts to fight other viruses, such as influenza and Ebola viruses.

The key is that every virus has a signature structure. Understanding the structure of HIV has enabled scientists to gain a better idea of exactly where HIV is vulnerable to infection-blocking antibodies. This is highly significant, because a major problem facing scientists has been the fact that HIV generally conceals vulnerable sites under a dense layer of sugars and fast-mutating parts. This is one reason why the virus has proven so difficult to neutralise; much of the body's antibody response to infection is directed against fast-mutating parts that render the body's response useless.

A major step forward was the discovery of random holes in HIV's protective outer shell of glycan molecules in the 1990s. Although scientists were initially unsure if antibodies could target these holes, this study has now confirmed that these holes could indeed be viable targets for antibodies, and thus play a crucial role in the design of an HIV vaccine.

The findings build on work pioneered at Cornell, The Scripps Research Institute (TSRI) and the Academisch Medisch Centrum in Amsterdam, which coordinated the SHEV project. A stabilised version of an important HIV protein — called the envelope glycoprotein (Env) trimer — was designed in order to encourage rabbits to produce antibodies against the virus.

The scientists then examined where the antibodies bound to the virus, revealing HIV's vulnerabilities. They found that the antibodies did indeed target holes in the glycan shield of this protein, opening the door to possible future vaccines that encourage the immune system to create hole-targeting antibodies.

While the SHEV project is due for completion at the end of 2016 EU-funded research in this field will continue. A key focus will be on evaluating possible vaccine candidates, and understanding the immune response induced by these vaccines. Much of this research will be financed by the EU's European AIDS Vaccine Initiative (EAVI2020), which brings together leading HIV researchers from public organisations and biotech companies from across the world.

The ultimate goal is to develop novel candidate vaccines that can be taken through to human trials within five years and provide a platform for discovering new vaccine candidates. The development of a protective vaccine remains the most attractive option for halting the global spread of HIV; around 34 million people are currently living with the virus.

SHEV

- Hosted by the Academic Medical Center in the Netherlands.
- Funded under FP7-IDEAS-ERC.
- http://cordis.europa.eu/project/rcn/102000