The genetic diversity makes the difference: researchers unravel reasons of global success in the calcified alga Emiliania huxleyi

Bremerhaven, 12 June 2013. In collaboration with an international team of researchers, scientists at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, have sequenced the genome of the calcified alga *Emiliania huxleyi* and have found an explanation for the enormous adaptive potential and global distribution of this unicellular alga. As the researchers report in an online prepublication of the scientific journal *Nature*, the microalga’s “trick” is genetic diversity. It has a particularly large so-called pan-genome which means that the unicellular algae share a certain set of common genetic information present in all strains. The remaining gene pool varies and depends on the geographic location and the respective living conditions of the algae. The calcified *E. huxleyi* is the first alga in which scientists have been able to detect this special characteristic.

It is only five thousandths of a millimetre in size. The shape of its shield made of thin calcified platelets is reminiscent of a soccer football. Nevertheless, the calciferous microalga *Emiliania huxleyi* is one of the most interesting organisms in our oceans. Without such calciferous microalgae there would be no impressive chalk cliffs in Dover (England) or on the island of Rügen. Both natural wonders are nothing other than huge piles of calcified platelets from algae of this type. Without “Ehux”, as *Emiliania huxleyi* is fondly referred to by scientists, it would also probably be considerably warmer on the Earth. “The calciferous microalgae counteract climate change. Viewed in the long term, they absorb and fix considerable quantities of carbon from the atmosphere through photosynthesis and in the production of their calcified platelets”, says the biologist and co-author of the study Dr. Uwe John from the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI).

However, another characteristic of the microalga is even more interesting to him and his colleagues: “Ehux is able to adjust to a broad range of living conditions in the sea. It occurs in almost all regions of the oceans – from near the Equator to cooler latitudes, also here in the North Sea. However, we only now understand why this is”, says AWI algae researcher Dr. Klaus Valentin.

Uwe John, Klaus Valentin and their AWI colleagues Prof. Dr. Stephan Frickenhaus and Dr. Sebastian Rokitta are four of 75 scientists from the USA, Germany, Canada, France, United Kingdom, Belgium, and Chile, who together have succeeded in sequencing the genome of the calcified alga *Emiliania huxleyi*. “The genome, so to say, is the “hard drive” of an organism. All properties are encoded there – how it looks, how it can adapt, how it competes with others. If we know the data on this hard drive, we can learn a great deal about what this organism can do and how it reacts to changes as a result of climate change, for example”, says Klaus Valentin.

The genome of the microalga was a great surprise for the scientists. “The Ehux genome is incredibly variable. For example, if the genetic information of two humans is compared, an agreement of about 99 per cent is found. However, if, for example, we take two Ehux strains from different ocean regions, we find a degree of similarity of only 70 or 80 per cent. The rest of the genome differs. This means that all of the algae possess a certain basic set of genes, the “core genome”, which is supplemented by different genes, i.e. is interchangeable to a certain extent, depending on the habitat of the algae. In the scientific world, we call this phenomenon ‘pan-genome’, which was only known from bacteria until we conducted our study. We have now demonstrated the pan-genome in a calcified alga for the first time”, explains Uwe John.

This genetic diversity also explains the great adaptive ability of the calcified algae. “Ehux can live almost everywhere at the ocean surface because the entirety of all genetic information of this species is huge as compared to other unicellular organisms, and this is probably the reason why it is able to quickly adjust to many possible conditions and to be successful in
virtually all oceans of the world. One example: when Ehux blooms, then frequently in such large number and over a sea area of thousands of square kilometres that this algae bloom can even be seen from space as milky white clouds”, adds Klaus Valentin.

These new findings have been facilitated by a close international cooperation of researchers. Whilst scientists from the US-American Department of Energy Joint Genome Institute in Walnut Creek, California, almost completely sequenced the genome of the Ehux strain CCMP1516, the German biologists and bioinformatics specialists did sequencing of 13 further strains from different regions of the world. Subsequently the AWI researchers, together with colleagues from the Ruhr University Bochum, the University of Cologne, the Bremerhaven University of Applied Sciences, the Leibniz Institute for Age Research, the Leibnitz Institute of Freshwater Ecology and Inland Fisheries, and the Alexander Koenig Zoological Research Museum determined the function of individual genes or groups of genes in comparative and detailed investigations.

During their work in the laboratory and on large computers, the researchers identified groups of genes which permit the calcified alga to prosper in water with a low phosphorous, iron or nitrogen content. Another gene set ensures that Ehux is not damaged even with an unusually high level of solar radiation. Uwe John: “This great genetic diversity will hopefully also permit the alga to cope with the current changes in the seas such as the rise in the water temperature and the carbon dioxide content."

The genome data are now providing the AWI scientists the foundation for further detailed investigations. “We intend to understand how exactly the microalga reacts to the altered living conditions. For this purpose, we conduct gene expression studies, for example, which show how the increasing acidification of the ocean influences the metabolic processes inside the alga”, says Uwe John.

An insight into this area of Ehux genome research at the Alfred Wegener Institute is provided by Sebastian Rokitta’s video introduction “Die Auswirkungen der Ozeanversauerung auf die Kalkalge Emiliania huxleyi” on the AWI YouTube channel.

Glossary:
Emiliania huxleyi

Emiliania huxleyi is a unicellular, calcifying microalga from the group of haptophyta (species of coccolithophorida) which, for example, is related to diatoms and brown algae. It reaches a diameter of five to ten thousandths of a millimeter (0.005 – 0.01 mm) and is therefore eight times smaller than the diameter of a human hair. Its cell wall is covered with a shield of calcified platelets which protects it from outside influences.

Emiliania huxleyi occurs in all oceans of the world, with the exception of the very cold Polar seas. The alga occurs primarily in very large quantities during the blooming period in spring and summer and during this period forms a substantial part of the sea plankton. Primarily during this period it counts among the most important primary producers in the ocean ecosystem.

Scientists are interested in Emiliania huxleyi because it fixes carbon during photosynthesis and in the creation of its calcified platelets. Once the alga dies, the remains are transported into the deep sea. Around five percent of this descending mass reaches the sea bed and is stored here, thereby keeping fixed carbon away from the global cycle for thousands of years. Experts therefore refer to an “organic carbon pump” in this context. To learn more about Ehux, go online and click: http://www.awi.de/en/news/background/species_of_the_month/april

Notes for Editors:
The study is published in the online issue of Nature under the following original title: Betsy A. Read et al: Pan genome of the phytoplankton Emiliania underpins its global distribution. Nature. DOI: 10.1038/nature12221

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Printable Images

**Emiliania huxleyi**
Scanning microscope image of the calcite-forming algae Emiliania huxleyi. Photo: Gerald Langer, Alfred Wegener Institute
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**Satellite image algal bloom**
Satellite image of the mass development of coccolithophorides, a so called algal bloom, off Southwest England. Image: NASA
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**Different Morphotypes of Emiliania huxleyi**
Morphotypes of the calcifying micoralgae Emiliania huxleyi. Extremely calcified coccolithophores in the foreground, decreasing degree of calcification towards the background. Image: Luc Beaufort, CEREGE (Univ. Aix-Marseille/CNRS)
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