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GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel

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GEOMAR

AI to Uncover Marine Enzymes with Transformative Potential

25 June 2025/Kiel/Jülich. How can we discover marine enzymes that have not yet been identified, which can break down plastics or capture carbon dioxide? The new research project AI MareExplore, which is being coordinated at GEOMAR, is using artificial intelligence (AI) to identify such marine biocatalysts. Leveraging vast existing marine genome databases, the project will train AI models to identify enzymes that could address pressing societal challenges. Funded by the Helmholtz Innovation Pool for the Earth and Environment research field, this initiative brings together expertise from four Helmholtz centres and will hold its first meeting at the Forschungszentrum Jülich on 26 and 27 June.

The ocean is home to a vast treasure trove of enzymes that have yet to be discovered, and which may hold the key to finding sustainable solutions to critical environmental problems caused by humans. But how can we unlock this treasure? The AI MareExplore project, led by the GEOMAR Helmholtz Centre for Ocean Research Kiel, aims to use artificial intelligence to identify these valuable biocatalysts. The project is tapping into open-access marine genome databases to train AI models that can identify enzymes capable of breaking down plastics or sequestering atmospheric carbon dioxide.

Shedding Light on the "Dark Matter" of Life

Traditionally, the discovery of new enzymes has relied on the direct analysis of environmental samples. Microorganisms were isolated and tested for their biochemical properties. While this approach has led to significant discoveries, such as the identification of penicillin in 1928, it has several limitations.

"Many organisms cannot be cultivated in the laboratory, meaning their enzymes remain inaccessible," explains Dr Erik Borchert, marine microbiologist at GEOMAR and coordinator of AI MareExplore. Since the late 1990s, metagenomics has made it possible to analyse all the DNA in environmental samples comprehensively. However, even this method has its limitations, as only around 30-40% of the detected sequences can be linked to known functions. "We know that there's a lot more out there – a kind of functional 'dark matter' that eludes current analytical approaches," says Borchert.

This is where AI comes in. By identifying patterns in huge data sets, AI can reveal sequences that are likely to have biocatalytic functions, which would otherwise remain unknown. Borchert elaborates: "AI helps us uncover these hidden treasures because it is excellent at recognising patterns. With the right training, it can discover links between DNA sequences and enzymatic properties that are invisible to us."

Interdisciplinary Research for Sustainable Solutions

AI MareExplore brings together four Helmholtz Centres and a variety of scientific disciplines. Alongside GEOMAR, the Helmholtz Centre for Environmental Research (UFZ) and the Forschungszentrum Jülich (FZJ) are involved, as well as the GFZ Helmholtz Centre for Geosciences. The team is developing a powerful AI model with two key objectives: to identify

enzymes that can efficiently degrade plastics and those that convert CO_2 into sugars, thereby aiding carbon fixation.

The AI model will be trained using extensive marine metagenomic datasets collected in recent years. The larger the dataset, the more accurate the model will be. The next step will be to test in the laboratory whether the identified enzymes have the desired properties. "Our goal is to develop not only a novel analytical method, but also tangible biocatalysts that can help address global environmental challenges," says Borchert.

About: Helmholtz Innovation Pool Projects
The project is funded by the Helmholtz Association's Innovation Pool. The Innovation Pool's aim for the Earth and Environment research field is to strengthen cooperation between Helmholtz Centres, to promote innovative ideas within three-year projects, to support initiatives by early-career researchers and to enable flexible responses to new and socially relevant research topics.

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