Universal mechanism of methane formation discovered

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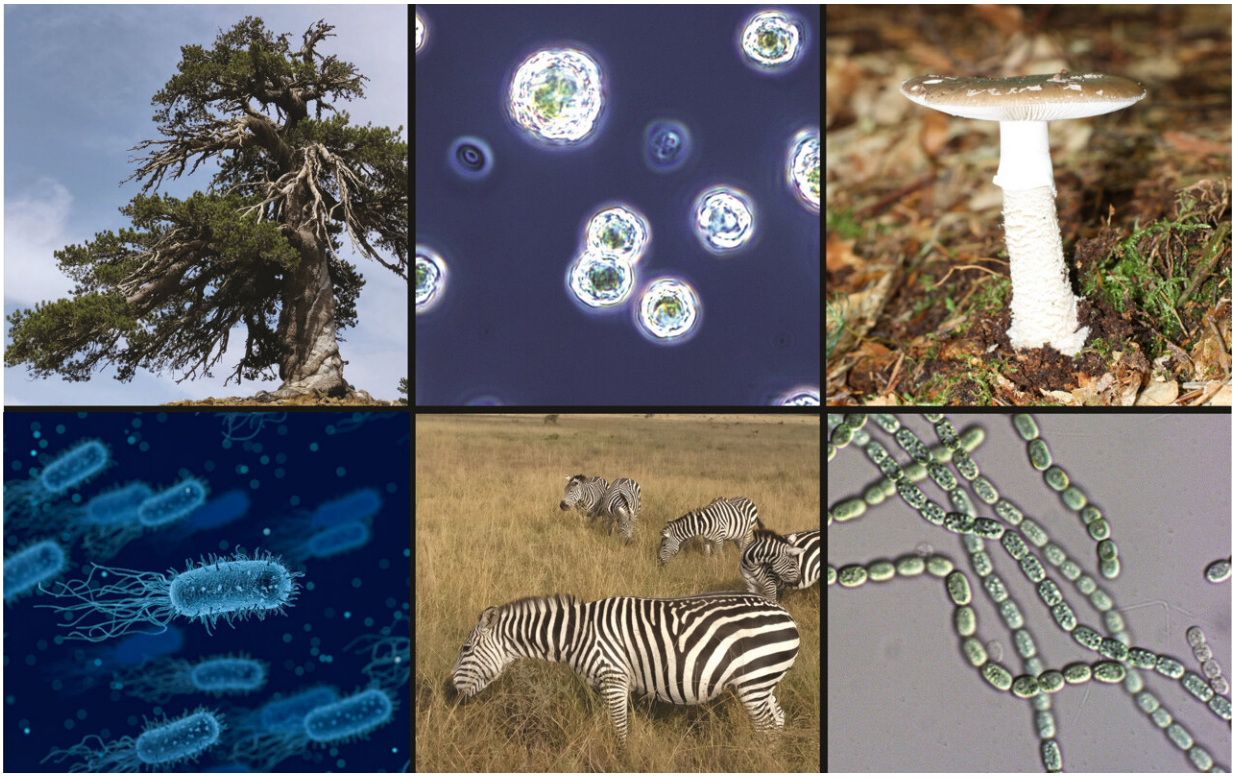

Scientists from Heidelberg and Marburg prove that the greenhouse gas methane is formed chemically in the cells of organisms. Credit: Frank Keppler / Pixabay

The formation of the greenhouse gas methane is based on a universal mechanism. Scientists at Heidelberg University and the Max Planck Institute for Terrestrial Microbiology in Marburg have made this

discovery. The interdisciplinary research team under the direction of Prof. Dr. Frank Keppler from the Institute of Earth Sciences and Dr. Ilka Bischofs from the BioQuant Center of Ruperto Carola found out that methane arises in the cells of organisms by a purely chemical process. The studies provide, inter alia, an explanation for why methane is released not only through the activity of special microorganisms but—as observed for quite some time now—also by plants and mushrooms. The current findings are an important step towards understanding aerobic methane formation in the environment.

Methane contributes to global climate change as a greenhouse gas. That is why the natural and human-induced causes for its emergence are of special scientific interest. "It was long assumed that methane is only formed through so-called ancient bacteria or archaea when they decompose organic substances in the absence of oxygen. When scientific observations showed that plants, mushrooms, algae and cyanobacteria also form methane in the presence of oxygen, this was initially attributed to enzymatic activities," explains Leonard Ernst, first author on the study. Up until now, however, no enzyme responsible for doing that has been found in any of these organisms. Now the scientists have succeeded in showing that methane can also be formed without such a catalyst—with the aid of a purely chemical mechanism.

This mechanism is driven by reactive oxygen species (ROS) that arise through the metabolic activity of cells. In interplay with the essential element iron, such oxygen compounds, in all organisms, are involved in a chemical reaction which, through various steps, leads to the formation of highly reactive metabolites. These substances promote the splitting-off of a methyl radical of sulfur and nitrogen compounds. Methane is formed through the subsequent reaction with hydrogen atoms. With the aid of the bacteria Bacillus subtilis, the researchers were able to show that the extent of methane formation directly relates to metabolic activity: "The more active the cell, the more methane is formed,"

explains Dr. Bischofs, leader of a joint research group at the BioQuant Center of Heidelberg University and at the Max Planck Institute for Terrestrial Microbiology.

The study was able to show the ROS-related formation of methane in over 30 model organisms—from bacteria and archaea to yeasts and plant cells to human cell lines. Consequently, to quote Leonard Ernst, it is very probable that this purely chemically triggered methane formation takes place in all organisms. Prof. Keppler says: "Our findings could prove to be a milestone for understanding aerobic methane formation in the environment, since this universal mechanism can also explain our earlier observations on the release of methane from plants."

In addition to increased metabolic activity, oxidative stress, which is caused by higher ambient temperatures or the addition of ROS-forming substances, also led to increased methane formation in the organisms studied. When counteracted by the scientists with the aid of antioxidants, the methane formation declined—an interplay of factors that could regulate the emergence of methane in organisms. "This interaction with physical and chemical stress factors would also explain why an individual organism can release very different quantities of methane," says Frank Keppler. "Accordingly, methane fluctuations in a person's breath could deliver indications of the oxidative stress level or point to immune reactions." Furthermore, it is also assumed that the impacts of climate change on environmental and temperature conditions influence the stress level of many organisms and lead them to release more methane.

More information: Leonard Ernst et al, Methane formation driven by reactive oxygen species across all living organisms, *Nature* (2022). DOI: 10.1038/s41586-022-04511-9

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