Baker's yeast cells provide information on how organisms could cope with global warming

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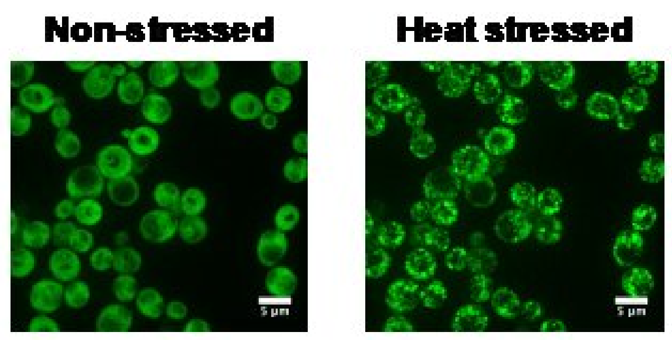

Ded1p protein of baker's yeast © BIOTEC The Ded1p protein of baker's yeast changes from a diffuse state (unstressed green cells, left) to a state in which it forms dense structures (heat-stressed green cells, right). The transition is caused by the process of phase separation and is triggered by an increase in ambient temperature. The Ded1p protein was genetically labeled with a green fluorescent dye. Credit: Technische Universitaet Dresden

The conditions in the environment are subject to large fluctuations. In Germany, for instance, temperatures can range from a freezing minus 20 degrees Celsius in the winter to a hot 40 degrees Celsius in the summer. Organisms that are unable to adapt to such temperature changes will not survive and thus will not pass on their genetic information to the next generation. In a world in which we are confronted with constantly rising average temperatures due to global warming, we must ask ourselves:

How do organisms react to changing temperatures? What molecular mechanisms do they use?

Decades of research have shown that different organisms respond very similarly to temperature changes. When organisms are exposed to heat, their cells cease to grow, they shut down the production of housekeeping proteins that are required for growth and reproduction. Instead, they start to produce proteins that protect the cells from heat-related damage. In other words, the cell factory changes its protein production. However, it is not known how cells recognize heat stress and which mechanisms trigger the production change.

Baker's yeast as model organism

Scientists at the Biotechnology Center (BIOTEC) of the TU Dresden and the Max Planck Institute for Molecular Cell Biology and Genetics (MPI-CBG), together with partners in Heidelberg and Toronto, Canada, investigated these fundamental questions. They used a popular model organism in cell research: baker's yeast as we know it from baking bread or brewing beer. This single-celled organism provides us with insights into the basic processes of life because it has almost the same composition as human and animal cells. If we understand the molecular processes within the yeast cell, we can also better understand the development of diseases in complex organisms such as humans.

"In yeast, we were able to identify one critical protein, Ded1p, which changes its structure upon heat stress and then reprograms the cell machinery. In the laboratory, we simulated the behavior of Ded1p with purified components and observed the following: Under normal conditions, Ded1p is evenly distributed in the cytoplasm of cells, but when the temperature rises, it assembles into dense structures, using the process of phase separation," explains Christiane Iserman, the lead author of the study. "The fact that Ded1p is able to sense temperature suggests that this protein is a kind of thermometer inside the cell."

Furthermore, the scientists have investigated the consequences for the cell when Ded1p forms these dense structures. "They are telling the cell to downregulate the production of housekeeping proteins, and to ensure that the production of stress-protective proteins is upregulated," explains Chrisitine Desroches Altamirano, second author of the study.

Results may help to better understand neurodegenerative diseases

This very elegant mechanism does not seem to be limited to baker's yeast. The researchers found that the Ded1p proteins from other organisms are well adapted to the temperature of the respective habitat. "This suggests that evolution has endowed our cells with a high thermal sensitivity so that living organisms can adapt to temperature fluctuations. This gives us hope that organisms will be able to cope with global warming," explains Prof. Simon Alberti, who led the study.

Alberti: "However, our discovery may have an even more general relevance: We have discovered a mechanism within the cell that helps the organism to deal with a variety of changes in the environment, not just heat stress. Cells seem to be able to deal with a wide variety of environmental signals by using proteins that phase separate to run different gene expression programs. In further studies, we want to determine whether this mechanism can help us understand human diseases—primarily those in which our cells do not process certain stress situations properly, as it appears to be the case in age-related neurodegenerative diseases."

More information: Christiane Iserman et al. Condensation of Ded1p Promotes a Translational Switch from Housekeeping to Stress Protein

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