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Mitochondria influence lipid storage in cells

The powerhouse of the cells, known as mitochondria, appear to be able to influence the number of lipid droplets in the cell. Research into this previously unknown mechanism was conducted using baker's yeast. This is shown by a recent study by the University of Freiburg, the University of Bonn and the University Hospital Bonn and the University of Freiburg. The results have now been published in the journal Nature Cell Biology.

There is a strict division of labor in the human body. While the lungs, for instance, are responsible for oxygen uptake, the kidneys filter waste materials out of the blood. A similar principle also applies in the cells: They contain different types of organelles, which each perform specific tasks. One example are the mitochondria. They act as tiny powerhouses that supply the cell with energy.

Mitochondria are surrounded by two membranes, the outer and inner mitochondrial membranes. Various proteins are anchored into these two membranes. They ensure, for example, that certain molecules can enter the mitochondrion or are involved in energy generation. The proteins in the outer membrane are produced in the cytosol, the aqueous basic component of the cell, and then integrated into the membrane.

Molecular machine used for an different purpose

Many outer membrane proteins contain one or more transmembrane regions. These are areas that span a membrane and thus anchor the protein. The integration of these proteins is often carried out by a special molecular machine. In baker's yeast this is the MIM complex, which also sits in the outer membrane. "We have now been able to show that this MIM complex also carries out another task," explains Prof. Dr. Thomas Becker, Director of the Institute of Biochemistry and Molecular Biology at University Hospital Bonn (UKB) and member of the Transdisciplinary Research Area "Life & Health" at the University of Bonn. It appears to be able to influence the number of lipid droplets in the cell. Lipid droplets are fat storages in the cells."

Becker's team discovered this previously unknown mechanism in baker's yeast in cooperation with the research groups of Prof. Dr. Nikolaus Pfanner from the University of Freiburg and Prof. Dr. Maria Bohnert from the University of Münster.

Pfanner is a founding member of the Cluster of Excellence CIBSS – Centre for Integrative Biological Signalling Studies at the University of Freiburg and has made fundamental contributions to our understanding of the development and structure of mitochondria.

A key role in this newly discovered process plays an enzyme known as Ayr1. Similar to the outer membrane proteins, Ayr1 can bind to the MIM complex. Unlike these, however, it is not then integrated into the membrane. "It lacks the transmembrane domain for this," explains Becker. Instead, it remains bound to the MIM complex.

Ayr1 plays an important role in the lipid metabolism; it thus interacts with the lipid droplets present in the cell. Due to its binding to the MIM complex, the attachment of lipid droplets to the outer membrane of the mitochondria increases. "This also has an impact on the number of lipid droplets," says Becker. "The more Ayr1 molecules dock onto the MIM complex, the more lipid droplets accumulate in the cell. The binding of Ayr1 changes the function of the MIM complex to such an extent that MIM modulates the number of lipid droplets and thus the cellular lipid metabolism."

Mechanisms could also exist in humans

This mechanism has so far exclusively been found in baker's yeast. However, human mitochondria also possess a molecular machinery which integrates proteins into their outer membrane. In human cells, there are also proteins from the same family to which Ayr1 belongs.

"It is thus possible that the number of lipid droplets in our cells is regulated in a similar manner as in single-cell organisms," explains Thomas Becker, who is also the spokesperson of the Priority Program SPP2453 "Integration of mitochondria into the cellular proteostasis network" and project leader in the Collaborative Research Centre SFB1218 "Mitochondrial regulation of

cellular function." Further studies must now show to what extent similar mechanisms exist in human cells and possibly play a role in the development of metabolic disorders.

Participating institutions and funding

In addition to the University of Freiburg, the University of Bonn, the University Hospital Bonn, and the Universities of Münster and Würzburg were involved in the study. The work was funded by the German Research Foundation (DFG) and the European Research Council (ERC).

Publication
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Further information

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