Cell membrane is patterned like a patchwork quilt

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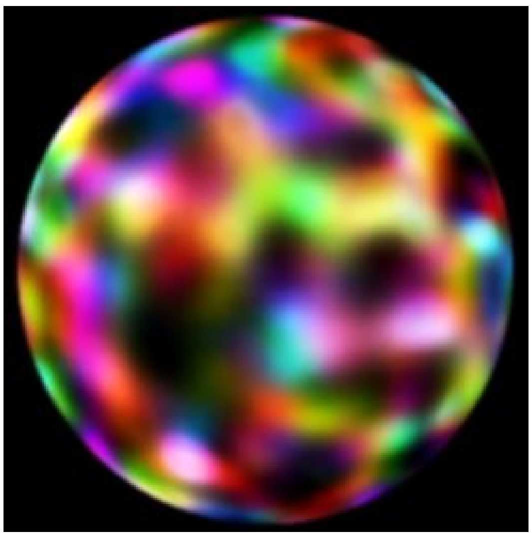

The membrane of the yeast cell is divided into different domains (highlighted in colour), giving it the appearance of a molecular patchwork quilt. © MPI f. Biochemistry/Wedlich-Söldner

(Phys.org) -- As the interface between the cell and its environment, the cell membrane, which consists of fats and proteins, fulfils a variety of vital functions. Scientists at the Max Planck Institute of Biochemistry in Martinsried near Munich have performed the first comprehensive analysis of the molecular structure of this boundary layer, and revealed precisely how it is organised. In yeast cells, the entire membrane is made up of independent domains, each containing just one or a few protein types. If a protein is relocated to an inappropriate domain, it may even fail to function. The study shows that the membrane is a kind of patchwork quilt and should help scientists to gain a better understanding of basic cellular processes.

The cell membrane must process numerous signals from the environment and the cell interior in order to initiate apposite molecular responses to changing conditions. For example, if certain messenger substances bind to the membrane, this can trigger the growth or division of a cell. The cell membrane has long been the focus of scientific research. One aspect that has remained largely unexplained, however, is exactly how its various components organise themselves. According to an early model, the fats (lipids) and proteins anchored in the membrane are in constant flux and do not form fixed structures. That at least some are organised in bounded domains was only proven quite recently, and only for a small number of proteins.

Researchers working with Roland Wedlich-Söldner, a group leader at the Max Planck Institute of Biochemistry, have now carried out the first comprehensive analysis of the molecular structure of the cell membrane. They used advanced imaging technologies for the purpose, enabling them to obtain much sharper images of the cell membrane and the marked proteins within them than were previously available. They discovered that domain formation in the cell membrane is not the exception, but the rule. Each protein in the cell membrane is located in distinct areas that adopt a patch- or network-like structure. The entire cell membrane thus consists of domains – like a kind of molecular patchwork quilt.

“Some areas contain more than one type of protein,” says Roland Wedlich-Söldner. “Even if these molecules fulfil entirely different functions, they generally have one thing in common: they are attached to a shared domain in the membrane by a similar or identical molecular anchor.” In another experiment, the scientists succeeded in demonstrating the extent to which the protein function depends on this specific environment: they replaced the original anchor in some proteins with another molecular variant. The modified proteins then relocated to a “foreign” domain that matched the new anchor. However, they were no able longer to function correctly in their new surroundings.

How then do proteins find the appropriate domain and remain associated with it, despite being relatively mobile in the plane of the membrane? The researchers were able to show that the lipids in the cell membrane play a central role in this process. Different lipids prefer to accumulate around certain protein anchors. Therefore, areas arise that are particularly attractive to proteins with a similar type of anchor. This could explain how cell membranes self-organise – another previously unanswered question in biology. The highly ordered structure of the cell membrane could help scientists to gain a better understanding of its many functions. “One may assume that many processes only function efficiently thanks to the formation of domains in the cell membrane,” says Wedlich-Söldner. “It is possible that the cell exploits a principle that also applies in everyday life: a certain degree of order makes it much easier to get things done.”

Provided by Max Planck Society

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