Bacteria don't always work 'just in time': Scientists calculate optimal metabolic pathways in bacteria

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'Just in time' - not only cars are being built according to this principle nowadays. Aircraft, mobile phones and computers are also produced following this method, in which all components are delivered exactly at the time when they are needed. This saves storage capacity and therefore cash. Hence it is supposed to be particularly efficient.

In nature - the byword for efficiency - production processes are also following the 'just-in-time-principle' as well - at least according to the scientific consensus until now. "Living beings just can't afford to produce more substances than necessary. Only what is really necessary will be provided," Prof. Dr. Christoph Kaleta of the Friedrich Schiller University Jena (Germany) says. In a project supported by the German Research Foundation, the Bioinformatician and his team wanted to find out how organisms succeed in producing exactly the right amount of protein that they need to be optimally adapted to the prevailing environmental conditions.

The 'just in time'-principle would be risky

In doing so, Kaleta and his colleagues were in for a surprise: According to a report of the Jena scientists and their colleagues of the Ilmenau University of Technology in the Science Magazine *Nature Communications*, bacteria like for instance Escherichia coli don't always work according to the 'just in time'-principle at all. This mode of production is - as in industrial processes too - very efficient, but it would also be risky; if the delivery of only one of the components would fail to materialize, the whole chain might be in danger of failing.

"When the bacterial cell can afford it, it deviates from the successive activation of the enzymes which is necessary for the production of proteins," Kaleta explains the findings of his study. Depending on the level of demand for a certain protein, the production will be dynamically adapted. "If there is a rather low demand and if the production capacity of the cell is capable, all enzymes will be increased at the same time," the Junior Professor for Theoretical Systems Biology says. Or, to return to the image of the industrial production of goods: all components are being produced at the same time. Only when the demand for protein is so high that the simultaneous production of all 'components' would overstrain the cell, are they being delivered 'just in time'.

Tools for a better understanding of nature

For their study, the researchers applied methods which are otherwise used for the optimization of industrial processes. "Thereby we could prove that many bacteria indeed use those strategies for the optimal production of proteins which we postulated," says Kaleta. In this way, technology was for once able to deliver the tools for a better understanding of nature, the 30 year old junior scientist smilingly stresses. "Usually it is the other way around and we often develop technology along the lines of the example of nature."

Their work, the Jena Bioinformaticians are convinced, is not only interesting fundamental research; one day these findings will be useful in a very practical way. "It is easily conceivable to use it to fight pathogens," Kaleta says. This is because during a process of infection the pathogens adapt very quickly to the situation in the host organism as well. "When it becomes clear which programme the metabolism of the pathogen is based upon, we can specifically look for points of vantage for new active substances that can stop the growth and proliferation of the pathogen."

More information: Bartl, M. et al. Dynamic optimization identifies optimal programmes for pathway regulation in prokaryotes (2013), *Nature Communications*. DOI: 10.1038/ncomms3243

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