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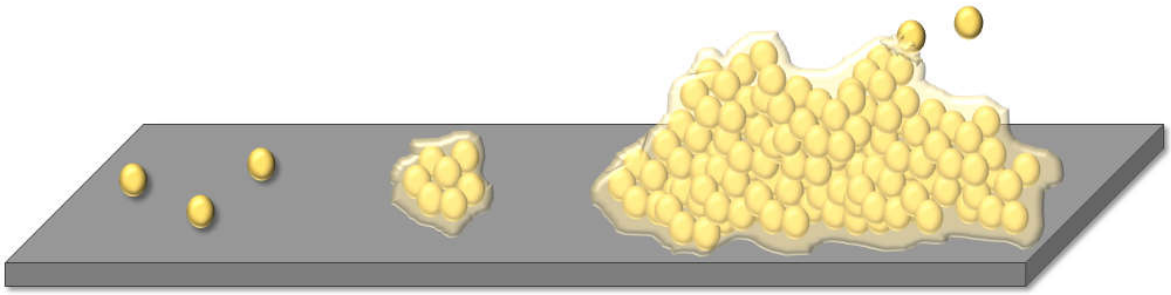
Living together - understanding microbial biofilm formation under spaceflight conditions

Microorganisms have the ability to form biofilms, which are complex, heterogeneous, multicellular communities that adhere to surfaces. Biofilms are one of the most successful forms of life on Earth and exist in nearly all habitats. This lifestyle presents numerous advantages compared with that of free-living planktonic microorganisms, including increased nutrient availability and protection from predators and xenobiotic stresses. Microbial biofilms are ubiquitous and are present on biotic and abiotic surfaces exposed to bulk liquid environments in natural, industrial and medical settings. They are communities of microorganisms that stick together and grow within a self-produced matrix of extracellular polymeric substances. Over the past decades, efforts aiming to understand microbial biofilms have mainly focused on bacteria of medical importance and their role in persistent and chronic infections.

Space agencies such as ESA and NASA plan missions in which humans are supposed to stay in space for a prolonged period. In these missions, astronauts will be exposed to unique and special conditions such as microgravity, space radiation, disturbed sleeping rhythms, stress, insufficient nutrition, and confined living. Exposure to these conditions may compromise health of astronauts, considering that the function of the immune system is reduced in space. The microbial composition within the space station and also the microbiome of the human skin can change in response to different environmental conditions. Biofilms are of special interest because they can cause damage to spaceflight equipment and are difficult to eliminate due to their increased resistance to antibiotics and disinfectants. The introduction of antimicrobial surfaces for medical, pharmaceutical, and industrial purposes has shown a unique potential for reducing and preventing biofilm formation.

The Space Microbiology Research Group is currently in the preparation phase of the ESA spaceflight experiment BIOFILMS. The main goal of the project is to evaluate the biofilm formation on non-inhibitory and antimicrobial metal surfaces under spaceflight-relevant conditions. Preliminary tests with Staphylococcus capitis within the BIOFILMS hardware revealed that the hardware is biocompatible and allowed studying biofilm formation on different surfaces and materials. The use of nanostructured copper- or brass-containing surfaces led to a significant reduction in growth and biofilm formation. This data generated will be of immense importance for understanding on microbial biofilm formation as well as for the evaluation of different antimicrobial materials for present and future astronaut-/robotic-associated activities in space exploration.



Schematic image of biofilm formation: displaying the attachment of cells on a surface, accumulation of cells and production of a biofilm matrix composed of extracellular polymeric substances (EPS), aging of the biofilm, formation of a dense multilayer biofilm, and the dispersal of single cells from the biofilm.