Mechanical forces control the architecture of bacterial biofilms

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As hide-outs for bacteria, biofilms cause problems for antibiotic treatment or the cleaning of medical tubes. They contribute to the spreading of antibiotic-resistant bacterial strains. A biofilm is created when bacteria attach to surfaces and multiply. Gradually, bacterial subpopulations can develop different properties although they originated from the same cell. However, very little is known about how this heterogeneity contributes to the development of structure in such biofilms.

At the University of Cologne, biophysicists in the lab of Professor Berenike Maier were now able to show how differential mechanical forces can lead to cell sorting in biofilms, thereby determining their architecture. In their publication in the journal eLife, the team headed by the biophysicist Enno Oldewurtel showed how specific mechanical forces can be the key to the structure of a biofilm. Bacteria with different surface structures organized themselves in a "tug of war": the cells actively moved in the direction in which they could pull the strongest onto neighboring bacteria.

The bacterium Neisseria gonorrhoeae controls mechanical interactions among cells with extensions called pili. These rod-shaped structures function like grappling hooks between cells: the pili of different cells get caught and then shortened. This creates mechanical forces between cells. By means of targeted genetic modifications, the research team succeeded in steering the degree of entanglement between pili and hence the interaction forces between cells. These forces were measured using nanotechnology. In a mix of bacteria that interact with each other to different degrees, the cells sorted themselves according to the mechanical forces they exerted among one another.

All in all, the research showed that different mechanical interactions among bacteria can determine the architecture of biofilms. Similar mechanisms have already been identified in the positioning of cells in embryonic development. Hence the research has uncovered a fundamental similarity in the development processes of biofilms and embryos: differential physical interactions between the cells are important for their sorting. In the future, the question will be in how far this cell sorting strengthens the biofilm's resilience towards external stress.

More information: Enno R Oldewurtel et al. Differential interaction forces govern bacterial sorting in early biofilms, *eLife* (2015). DOI: 10.7554/eLife.10811

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