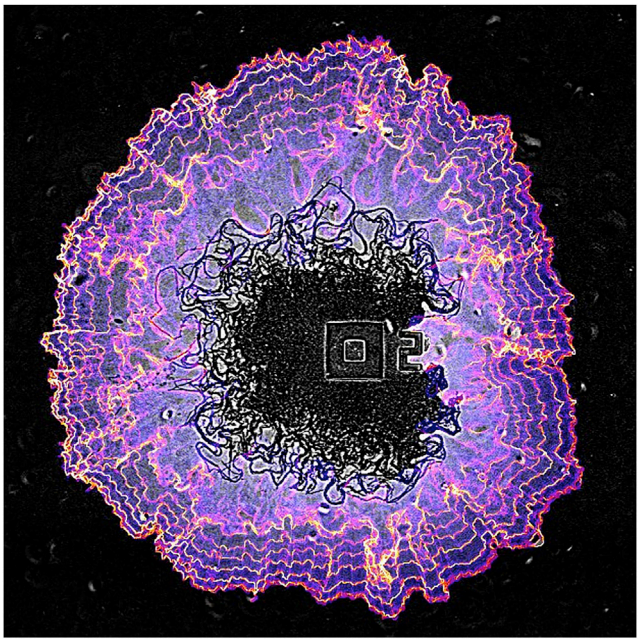
Cell

Rhythm of Prosperity

In human society, cooperation and competition are among the most important elements that drive social development. This is likely true for any community-based organization. How do we strike a balance between these two factors to maximize the benefit of the community as a whole? This question has intrigued a wide range of researchers, including biologists, economists, and sociologists. By looking into a relatively simple community, scientists now unveil the rhythm of prosperity for *Bacillus subtilis* biofilms and decode the intricate metabolic regulation behind the scene (Liu et al., 2015).

The story started with the observation that after growing to a certain size, the biofilm expansion became oscillated due to the limitation in glutamine supply. Interestingly, only the cells in the periphery contributed to the periodic expansion, and these cells were exactly the ones exposed to plenty of glutamate in the media, an essential component for glutamine synthesis. Naturally, the other key component for glutamine synthesis, ammonium, came to mind. As it turned out, the bacterial cells in the interior were responsible for feeding the peripheral cells ammonium, thereby sustaining the biofilm growth while they themselves remained non-proliferating.



A growing bacterial biofilm (dark center) and its edges over time (colored contour lines). Image courtesy of Gürol M. Süel.

Metabolic collaboration is not a unique feature in prokaryotic community. Indeed, it has been shown that cells in different regions of a yeast colony develop unique metabolic properties, and that functional metabolism of cells in the lower region provides nutrients that are important for the proliferation of their upper neighbors (Cáp et al., 2012). Yet, collaboration apparently is not the whole story here, since it does not yet explain the periodic pausing of the periphery growth. Indeed, glutamate is a substrate for the synthesis of not only glutamine but also ammonium. Mathematical modeling further revealed that peripheral cells compete with their interior neighbors for access to glutamate and that the pausing of peripheral expansion allowed the cells inside the colony access to glutamate, which was used to generate ammonium that eventually fed into another round of peripheral growth. Therefore, cells at the edge of and those inside the biofilm each control the supply of a key component for glutamine synthesis, while their missions are also interdependent (Liu et al., 2015).

Clearly, the relationship among members of this "simple" community is not that simple after all, but in this case, complexity does yield prosperity. It's easy to imagine that if peripheral cells kept growing, the interior ones would soon run out of glutamate and practically starve to death, let alone providing ammonium to their outer partners. Without the ammonium supply, the growth of peripheral cells would not be sustained, eventually leading to the collapse of the whole colony. On the other hand, since the periphery is the part most accessible to external insults such as toxin and antibiotics, when the biofilm were under attack, the casualty of the outer layer would decrease their glutamate consumption, leaving more nutrients for interior cells to grow, which would in turn replenish the loss of the periphery. In fact, that was exactly what the authors observed in the study (Liu et al., 2015).

This really is an elegant strategy for the biofilm, except that humans are frequently at odds with them. While it remains to be seen whether this metabolic interdependence-based growth oscillation strategy is widely applicable among various biofilms, perhaps next time when we think of eliminating one of those pathogenic ones, nutrient supply, rather than starving or directly attacking, would be much more effective.

REFERENCES

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