Predatory bacterial swarm uses rippling motion to reach prey

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Like something from a horror movie, the swarm of bacteria ripples purposefully toward their prey, devours it and moves on. Researchers at the University of Iowa are studying this behavior in *Myxococcus xanthus (M. xanthus)*, a bacterium commonly found in soil, which preys on other bacteria.

Despite its deadly role in the bacterial world, *M. xanthus* is harmless to humans and might one day be used beneficially to destroy harmful bacteria on surfaces or in human infections, said John Kirby, Ph.D., associate professor of microbiology in the UI Roy J. and Lucille A. Carver College of Medicine.

"It may be that we can modify this predator-prey relationship or apply it to medically relevant situations," Kirby said. "It would be amazing if we could adapt its predatory ability to get rid of harmful bacteria that reside in places we don't want them, including in hospitals or on medical implants."

M. xanthus lives in a multi-cellular unit that can change its structure and behavior in response to changing availability of prey.

This adaptive ability to control movement in response to an environmental stimulus is called chemotaxis, and the research team coined the term predataxis to describe M. xanthus behavior in response to prey.

In earlier studies, Kirby and James Berleman, Ph.D., a postdoctoral fellow in Kirby's lab, showed that the presence of prey causes M. xanthus to form parallel rippling waves that move toward and through prey bacteria. Now, how the bacteria organize to form these traveling waves in response to the presence of prey is the subject of the UI team's latest study, which was published online Oct. 24 in *Proceedings of the National Academy of Sciences (PNAS) Early Edition*.

"When an *M. xanthus* aggregate is placed inside a colony of E. coli bacteria, the *M. xanthus* proceeds to eat the colony from the inside out and creates a rippling pattern as the swarm moves through the prey cells," Kirby said. "We now know that this rippling pattern is the highly organized behavior of thousands of cells working in concert to digest the prey."

Unlike the random motion *M. xanthus* exhibits at low levels of prey, the study shows that during predation, individual *M. xanthus* cells line up perpendicular to the axis of the ripple and move back and forth. This motion of individual cells, known as cell reversal produces an alternating pattern of high and low cell density like crests and troughs of waves, and the overall motion of the wave formation is directed toward prey.

The UI team also showed that the ripple wavelength is adaptable and dependent of how much prey is available. At high prey density, *M. xanthus* forms ripples with shorter wavelengths. As prey density decreases, the ripple wavelength gets longer. Eventually, when there is no more prey, the rippling behavior dissipates.

"The rippling appears to enhance predation by keeping more *M. xanthus* cells in the location of the prey cells," Kirby said.

Finally, the UI study found that the bacteria use a chemotaxis-like signaling pathway to regulate multi-cellular rippling during predation.

Individual *M. xanthus* cells move by shooting rope-like projections called pili from either end of the cell. These pili attach to surfaces allowing cells to pull themselves forward or backward in a "spiderman" type motion known as cell reversal. The genes that regulate this cell reversal process are chemotaxis-like genes.

The UI team mutated two genes in this pathway to study their effect on the predatory ability of the bacterium. One mutant strain rippled continuously even in the absence of prey, and individual cells exhibited a hyper-reversing action. Conversely, the second mutation produced bacteria that were not able to ripple at all.

Both mutants were unable to respond to changes in the amount of available prey and both mutant strains were deficient in predation.

"Our study really connects the stimulus to the behavioral response through this molecular machinery," Kirby said.

In addition the potential medical application of *M. xanthus* to destroy harmful bacteria, what Kirby learns about the molecular mechanisms used by the bacterium may also provide insights into the workings of a rarer, but potentially useful, bacterial cousin. The related bacterium, *Anaeromyxobacter dehalogenans*, has been found at superfund sites and it can transform soluble uranium, which can leach into the water supply, into insoluble uranium, which still is radioactive, but is stable and trapped in the soil where it can be more safely stored until the radioactivity decays.

Source: University of Iowa

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