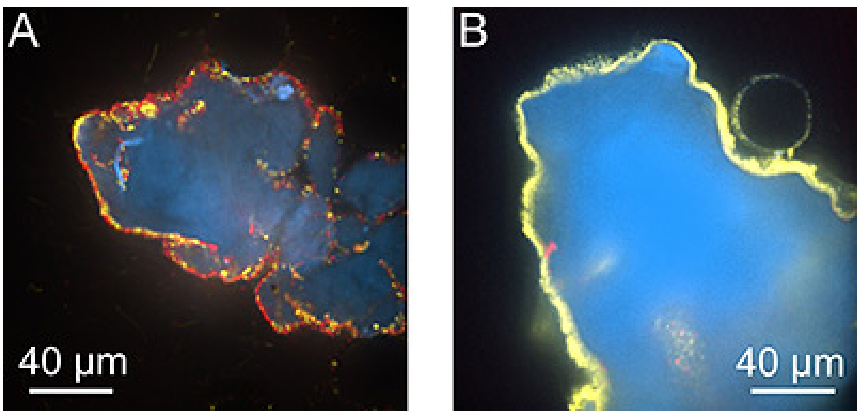
Tiny acts of microbe justice help reveal how nature fights freeloaders

January 6 2014, by Morgan Kelly



Princeton University researchers discovered that the bacteria Vibrio cholerae keeps food generated by the community's productive members away from those of their kind that attempt to live on others' leftovers. The bacteria use two mechanisms that are likely common among bacteria. In some instances, the natural flow of fluids over the surface of bacterial communities can wash away excess food before the freeloaders can indulge. In microscope images, shiftless V. cholerae (red) were in abundance under conditions of no fluid flow (left image). When the bacteria were grown in an environment with fluid flow -- similar to that found in nature -- cooperative *V. cholerae* (yellow) won out (right image). Credit: Carey Nadell, Department of Molecular Biology

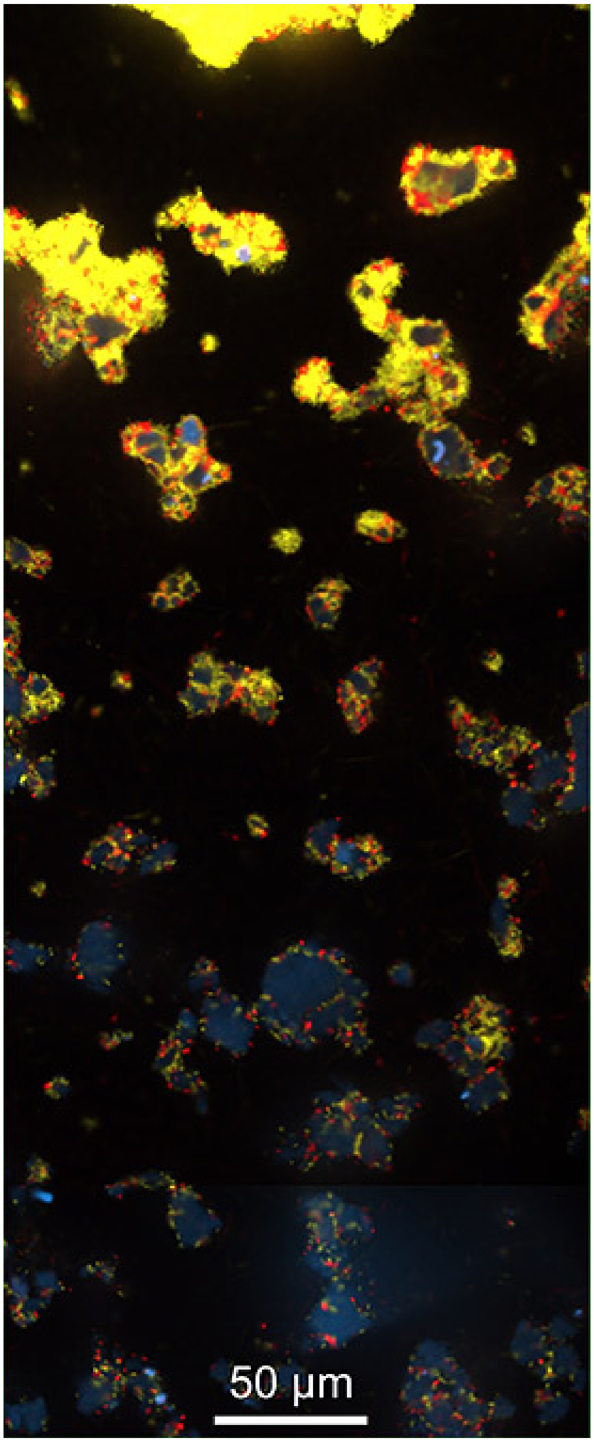
(Phys.org) —The idea of everyone in a community pitching in is so universal that even bacteria have a system to prevent the layabouts of their kind from enjoying the fruit of others' hard work, Princeton University researchers have discovered.

Groups of the bacteria *Vibrio cholerae* deny loafers their unjust desserts by keeping the food generated by the community's productive members away from *V. cholerae* that attempt to live on others' leftover nutrients, the researchers report in the journal *Current Biology*. The researchers found that individual bacteria produce a thick coating around themselves to prevent nutrients from drifting over to the undeserving. Alternatively, the natural flow of fluids over the surface of bacterial communities can wash away excess food before the freeloaders can indulge.

Likely common among bacteria, this act of microscopic justice not only ensures the survival of the group's most industrious members, but also could be used for agriculture, fuel production and the treatment of bacterial infections such as cholera, explained first author Knut Drescher, a postdoctoral research fellow in the lab of senior author Bonnie Bassler, the Squibb Professor in Molecular Biology and department chair.

By encouraging this action, scientists could increase the efficiency of any process that relies on bacteria to break down organic materials, such as plant materials into biofuels, or cellulose into paper products, Drescher said. For treating a disease, the mechanism could be counteracted to effectively starve the more productive bacteria and weaken the infection.

"We could use our discovery to develop strategies that encourage the proliferation of microbes that digest dead organic material into useful products," Drescher said. "Such an approach will be useful for optimizing nutrient recycling for agriculture, bioremediation, industrial cleanup, or making products for industry or medicine."



All bacteria frequently live in dense communities called biofilms. They secrete enzymes that break down solid organic carbon- and nitrogen-containing molecules and feast on the components within. But not every individual bacterium will produce enzymes -- some will simply feed on what their neighbors produce. The Princeton researchers found that individual bacteria also will produce a thick coating around themselves to prevent nutrients from drifting over to the undeserving. In the thicker biofilms near the top of this microscope image, productive *V. cholerae* (yellow) overtook exploitive *V. cholerae* (red). The darker communities indicate thinner biofilms and a proliferation of bacteria that will live off the work of others. Credit: Carey Nadell, Department of Molecular Biology

The Princeton findings also provide insight into how all microbes potentially preserve themselves by imposing fairness and resolving the "public goods dilemma," in which a group must work together while also avoiding exploitation by their self-serving individuals, said co-lead author Carey Nadell, a postdoctoral research associate in Bassler's lab.

"The public goods dilemma is a central problem in the history of life on Earth, during which single cells have emerged as collectives of genes, multicellular organisms have emerged as collectives of cells, and societies have emerged as collectives of multicellular organisms," Nadell said.

"At each of these transitions in complexity there has been—and remains—the threat of exploitation by single members pursuing their own interests at the expense of the collective as a whole," Nadell said. "Clarifying how exploitation can be averted is therefore critical to understanding how life has taken the various forms that exist today."

Like all bacteria, *V. cholerae*—strains of which can cause cholera—frequently lives in dense communities called biofilms. Also like other bacteria, *V. cholerae* secretes enzymes that break down the solid organic carbon- and nitrogen-containing molecules of which living things are composed so that the bacterium can feast on the components within. But not every individual bacterium will produce enzymes—some will simply feed on what their organic-compound digesting neighbors produce. The researchers found two mechanisms by which this leeching is halted.

The vigilance of *V. cholerae* and other bacteria may also carry a larger benefit. The nitrogen and carbon that make up most of the planet's breathable air largely come from the digestion of organic materials by bacteria.

The researchers studied *V. cholerae* as it feasted on its preferred victual, chitin, a sugar-based molecule and the central element of many marine cells, exoskeletons and other appendages. The researchers write that sea animals alone shed an estimated 110 billion tons of chitin each year—yet hardly any of it makes it to the ocean floor. Instead, the detritus is consumed by *V. cholerae* and other marine bacteria with its elements being recycled into the biosphere.

"If *V. cholerae*'s system of extracellular digestion were compromised by exploitation," Nadell said, "the world's supply of carbon and nitrogen would become sequestered on a rapid geological timescale."

More information: The paper, "Solutions to the Public Goods Dilemma in Bacterial Biofilms," was published Jan. 4 in the journal *Current Biology*.

Provided by Princeton University