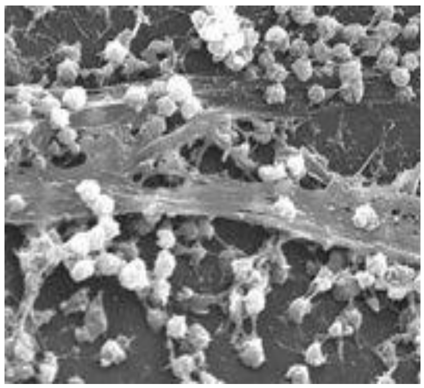
COOPERATING BACTERIA ARE VULNERABLE TO SLACKERS

Any attempt to cooperate for a common good creates windows of opportunity for slackers. Even bacteria colonies have their own layabouts. Recently, two new studies have found that some bacteria reap the benefits of communal living while contributing nothing in return.



Bacteria may not strike you as expert co-operators but at high concentrations, they pull together to build microscopic ‘cities’ calledbiofilms, where millions of individuals live among a slimy framework that they themselves secrete. These communities provide protection from antibiotics, among other benefits, and they require cooperation to build.

This only happens once a colony reaches a certain size. One individual can’t build a biofilm on its own so it pays for a colony to be able to measure its own size.

To do this, they use a method ‘quorum sensing’, where individuals send out signalling molecules in the presence of their own kind.

When another bacterium receives this signal, it sends out some of its own, so that once a population reaches a certain density, it sets off a chain reaction of communication that floods the area with chemical messages.

These messages provide orders that tell the bacteria to secrete a wide range of proteins and chemicals. Some are necessary for building biofilms, others allow them to infect hosts, others make their movements easier and yet others break down potential sources of food. They tell bacteria to start behaving cooperatively and also when it’s worth doing so.

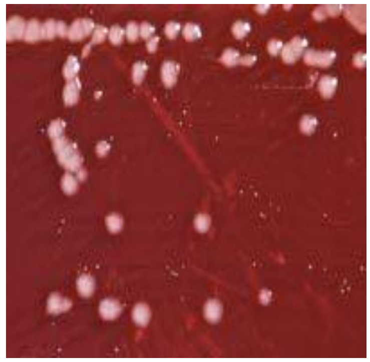
The importance of communication

Steve Diggle and colleagues from the Universities of Nottingham and Edinburgh have found that bacterial slackers can exploit this system. They studied an opportunistic species called *Pseudomonas aeruginosa*, that preys on the weak. It’s a major cause of hospital infections, setting up shop in burn victims, cystic fibrosis patients and others with weakened immune systems.

The bug’s success hinges on quorum sensing, which allows it to thrive in limited environments by cooperating.

When Diggle cultured the bacteria in a nutritionally poor liquid containing only proteins as the only food source, they grew happily nonetheless.

That's because the chemical signals exchanged as part of quorum sensing also triggers the release of proteases, enzymes that can digest proteins.



Diggle then tested two mutant forms of*P.aeruginosa* that are commonly found in nature. The first – the **'signal-negative'** version – can't produce signalling molecules but can react to them. It obeys orders to secretes the right chemicals but never passes the orders along. As such, it doesn't secrete enough proteases and grows poorly in a protein-only solution. However, it picked up the pace if it was artificially doused in signalling molecules to cope with its deficiency.

The **'signal-blind'** mutant is even more of a slacker – it can't react to signals at all, so it doesn't help *or* communicate. This strain also grew poorly in the protein-only liquid and only matched the normal strain if it was artificially given extra proteases.

The benefits of slacking

If quorum sensing provides such obvious benefits, you might expect all bacteria to take part. But there is a catch – it's also quite draining.

Making signals and proteases takes up energy, and when Diggle placed the different strains in a rich, nutritious solution, the mutants vastly outgrew the normal strain. With an abundance of easily digested food, it was every bacterium for itself and the mutants, that weren't busy making expensive signals and proteases, did better.

Quorum sensing may be good for the group, but for each individual bacterium, it pays to sit back and let your peers do all the work. Diggle demonstrated this by allowed the normal and mutant strains to compete in the protein-only liquid, in a real-time experiment in evolution. The mutant strains were engineered with luminescent genes so that the team could track their growth by the light they gave off.

At first, the signal-blind cheats made up just 1% of the population but after 2 days, they accounted for 45% of it. In a separate culture, the proportion of signal-negative cheats went from 3% to 66%. Among *P.aeruginosa,* cheaters can indeed prosper and then some – they outgrew their cooperating cousins by 60 to 80 times.

In a separate study with the same species, Kelsi Sandoz from Oregon State Universityfound that cheaters evolve naturally. Like Diggle, she grew a normal strain of*P.aeruginosa* in conditions where they needed to make proteases to survive.

After 12 days, she managed to isolate specific colonies that weren't pulling their weight. All of them had developed mutations in a key gene involved in quorum sensing which meant that they were only secreting a very small amount of protease. Within 20 days, these cheats made up 40% of the cultures. (More on this study from Ford at This Week in Evolution)

Why work at all?

Why then, do any individuals bother cooperating at all? If slacking is so profitable, why doesn't everyone do it? For a start, cheating pays fewer dividends if you do it at the expense of your relatives who share your genes. This is especially true for bacteria colonies that reproduce asexually and spawn genetically identical clones.

In this case, helping your neighbour pays off because it ensures that your genes are passed on to the next generation. Diggle found that when the bacteria were very closely related to each other, mutants were much less likely to gain a foothold in a population of co-operators.

There is another reason though, and it's probably more important. Both studies found that as the proportion of cheaters increased, their growth rate dropped because the*value* of cheating diminished.

Slackers only prosper if they can cadge of a hard-working population – if every bacterium took the easy way, there would be no proteases and no food. Sandoz found that when this happened, the entire population suffered and overall growth plummeted. If there were enough cheaters, the signalling molecules became too dilute, the 'quorum' fell apart and the population crashed.

However, Sandoz also found that the bacteria usually evolved compensatory measures in time to stop this from happening. During her study, she saw that many cheaters developed further mutations that restored protease production. Faced with a sinking ship, there was strong evolutionary pressure for them to swap sides and start cooperating again.

Source: https://notexactlyrocketscience.wordpress.com/2007/11/15/cooperating-bacteria-are-vulnerable-to-slackers/