How to make trillions of bacteria shut up, and what this means for medicine

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Bacteria can talk to each other, according to Princeton University professor of microbiology Bonnie Bassler. Bacteria are the world's oldest living organisms, and a bacterium consists of just one cell with a few bits of DNA. Bassler's discovery of the mechanism behind how the simplest organisms on the planet—organisms that live virtually everywhere, including on and inside every person—are capable of communication could yield revolutionary medical advances.

Scientists have classically assumed that bacteria are asocial, if they ever even bothered to consider bacteria and the complex interactions of socializing in the same thought. But 40 years ago scientists discovered that bacteria are capable of "quorum sensing," a form of communication that allows bacteria to know when they're alone and when they've amassed in high numbers, and then act accordingly. Bassler, a microbiologist, conducts research with the aim of puzzling out how bacteria "know" when their fellows are nearby and the mechanisms by which they work to change their behaviors on a population-wide scale.

One of her model organisms—the bacteria that she works with to draw broader conclusions about bacterial communication in general—is *Vibrio fischeri*, a bacteria that are found inside Hawaiian bobtail squids. *V. fischeri* and the squid have a symbiotic relationship: the squid feeds the bacteria, and the bacteria populate the squid's light organ and produce bioluminescence, which helps camouflage the squid at night. Quorum sensing was discovered when scientists noticed that when *V. fischeri* are alone, they don't produce light, but when they're clustered together in a large population they abruptly all produce light at once.

Why did the bacteria do together what none of them did alone? The light, or lack thereof, is a direct result of quorum sensing. The bacteria's language is a chemical one—"a very complicated chemical lexicon," as Bassler described it in her lecture for iBioSeminars, a site that hosts seminars and talks from top scientists around the world.

In 2002, Bassler discovered the basis for quorum sensing when she isolated the molecule AI-2, which all *V. fischeri* produce. When the bacteria are alone or in a low density, AI-2 is only present in small amounts. When many *V. fischeri* are together, however, lots of AI-2 is produced too. The bacteria recognize AI-2, and when the molecule reaches a certain concentration, all the *V. fischeri* produce bioluminescence in unison. A single *V. fischeri* bacterium is far too tiny to produce visible light, but many bacteria working together are able to light up a squid.

This chemical communication is not unique to *V. fischeri*. Rather, quorum sensing is now understood to be a common behavior among bacteria. The exact mechanism by which quorum sensing is achieved differs between bacteria species, while some differing species of bacteria can use quorum sensing as a generalized form of communication.

To understand the enormous implications Bassler's discovery has for human health, you must first grasp the extent of the millennia-long relationship between humans and bacteria. A human being is composed of about a trillion cells—and each of us has about 10 trillion bacteria living on and in us right now. Most of these bacteria, thanks in part to our bodies' immune systems, are harmless. Many act like the squid's *V. fischeri*, living in symbiosis with us and helping to digest foods or synthesize vitamins. But some of these ten trillion bacteria are pathogens capable of infecting us with diseases, and these bacteria kill millions of people each year.

Understanding quorum sensing allows scientists to begin to manipulate bacterial communication. If successful, we could improve quorum sensing in some species, such as those that help lactose-intolerant individuals tolerate lactose. At the same time we could impede quorum sensing by interrupting the production or reception of signalling molecules like AI-2, disrupting communication in pathogenic species and hopefully saving lives in the process. Currently our ability to fight bacteria is restricted to antibiotics, which inevitably produce drug-resistant strains of bacteria as the few antibiotic survivors replicate and pass their resistance on to their descendents.

"The goal of the field is moving toward being able to disrupt quorum sensing," said Bassler. Preliminary experiments on disrupting quorum sensing in the pathogenic *Vibrio cholerae* in animal hosts have already been successful. Given bacteria's predominance in every facet of human life, being able to control how and when they affect us could truly revolutionize medicine.