Talkin' bacteria blues

Name:

1 Quorum sensing

While we often consider bacteria to be "simple" single-celled organisms, they actually perform complex group tasks such as forming biofilms and manipulating their host. They perform these tasks by acting in concert using quorum sensing. Quorum sensing is "a system of stimulus and response correlated to population density." [1] When a critical density of (typically but not always) related bacteria are present, bacteria act together by generating extra-cellular products that benefit the group of bacteria.

In bacteria, quorum sensing was first shown in *Vibrio fischeri*, symbiotic bacteria in squid that bioluminescence, providing camouflage to the squid when they forage on moon-lit nights.

2 The quorum sensing operon

Molecular experiments showed that quorum sensing controlled bioluminescence in *Vibrio fischeri* involves at least the following components:

1. a signaling molecule that passively diffuses out of the cell at low concentrations
2. a constitutively-expressed receptor protein for the signaling molecule
3. a DNA-binding site for the activated receptor protein
4. an inducibly-expressed set of genes involved in generating bioluminescence

With this information, sketch your hypothesis for the bioluminescence operon(s) under conditions it would and would not be activated:

3 Manipulating bacteria

Many other bacteria species, including pathogens such as *Salmonella enterica, Pseudomonas aeruginosa* and *Yersinia* (e.g. the Plague) have been found to have quorum sensing mechanims that are involved in the antibiotic-resistance and virulence.

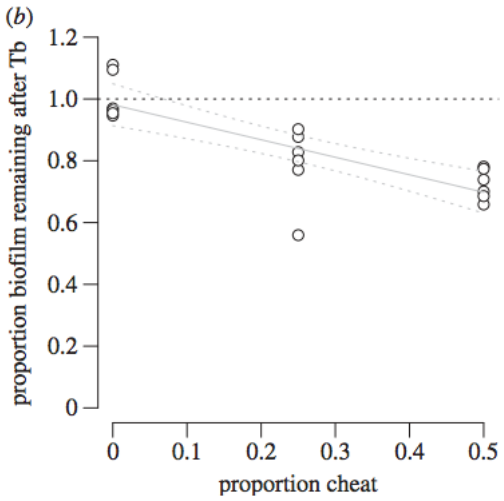
How could we use our knowledge of bacterial quorum-sensing as an alternative to antibiotics for clinical treatment of pathogens?

3.1 Cheaters to the rescue!

Hopefully you suggested something like "destroying the quorum signaling molecule using a protease"! While being investigated, ultimately this strategy faces a similar problem as antibiotics. Microbes would be under strong selection to evolve alternate signals that are not targeted by the blocker.

Evolutionary biologists have suggested an alternative strategy. The production of an extracellular "public good" (e.g. bioluminescence or virulence factors) comes at a cost to a bacteria, hence one of the reasons they are not constitutively produced. This cost poses a "tragedy of the commons" dilemma. While the population as a whole benefits from all individuals producing the "public good" in response to the quorum signal, each individual would be better off producing the signal, but not the public good: a **cheater**!

An an elegant experiment, Popat et al. (2012)[2] examined how increasing the number of "cheating' microbes could destabliize the quorum-behavior. In this figure, *Pseudomonas*, which creates a antibiotic-resistant biofilm, colonies were manipulated to have a different proportion of cheaters. The survival of the *Pseudomonas* biofilm after treatment with an antibiotic (Tb) was assayed.



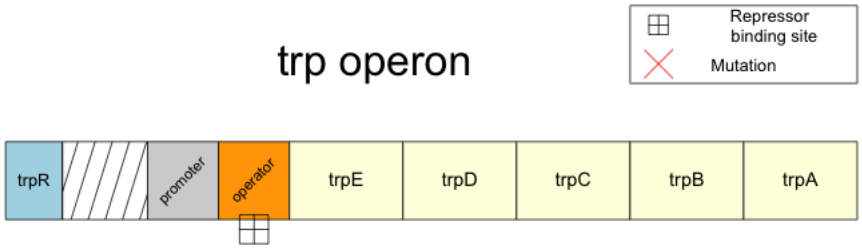
What is the conclusion from the data in this figure?

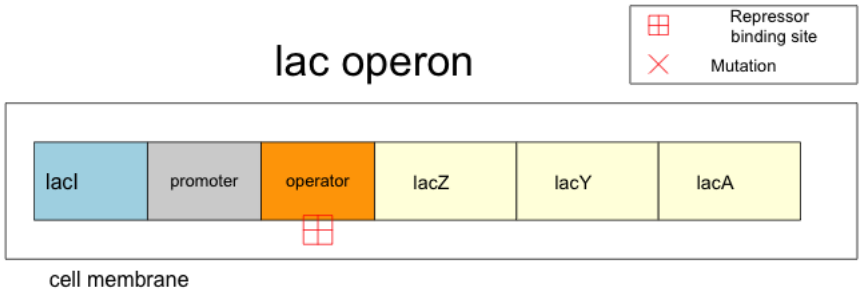
Pseudomonas is an opportunisitic pathogen that can infect a human's lungs, with potentially fatal consequences. If you were a doctor treating an aggressive *Pseudomonas* infection that was resistant to antibiotics, what therapeutic treatment might you suggest based on these results? Would there be ethical concerns?

References

(1) Quorum sensing. Wikipedia `http://en.wikipedia.org/wiki/Quorum_sensing`. Accessed 2013-10-15.

(2) Popat, R., S.A. Crusz, M. Messina, P. Williams, S.A. West, S.P. Diggle (2012) Quorum-sensing and cheating in bacterial biofilms. Proc. R. Soc. B 279: 4765-4771.


trp operon
Repressor binding site
Mutation
trpR
promoter
operator
trpE
trpD
trpC
trpB
trpA


lac operon
Repressor binding site
Mutation
lacI
promoter
operator
lacZ
lacY
lacA
cell membrane