



Investigating bacterial communication

Signal molecules

Narrator

These small molecules are closely linked with cell numbers and light production in bioluminescent bacteria.

Even a low population of bacteria has a few signal molecules.

As the population get bigger, more signal is produced.

Zoom in to the level of a single cell, and it's clear that signal molecules pass freely through the bacterial wall and membranes.

The signal locks on to a receptor and forms a complex. The complex makes its way towards the cell's DNA.

This stimulates a set of genes to produce two different proteins. One of these proteins gives rise to light; the other spits out more signal molecules.

So the concentration of signal molecule increases, both inside and outside the cell.

Where there's more signal, it's more likely that there'll be another encounter with the receptor.

The pattern repeats itself and the reaction builds up speed. Resulting in even more signal molecule, and brighter light.

Moving back out to the population as a whole, more and more cells switch on in response to the increasing signal.

And the lights go on all over the colony.

Gordon's team had cloned the bioluminescence gene and inserted it into a laboratory strain of *E. coli*. This gave them a tool to test for quorum sensing in other bacteria. The time was right for the two groups to join forces.

Paul Williams

And so what we did was to actually go out and find around our laboratories as many microorganisms as we could get our hands on, we sent the guys out into the fieldS to go and take soil bacteria, we had a look at every organism that we could get our hands on to find out whether they could light up the sensor that we had.

Narrator

And this is how they did it.

Miguel Camara

Here, I'm adding some extract from different bacteria, to test them to see whether they have quorum sensing molecules. I'm adding these extracts to cells that have been engineered with the genes from *Vibrio fischeri*.

Narrator

The engineered organisms act as sensors. The extracts come from various species of bacteria.

By repeatedly diluting the liquid Miguel will be able to see how much quorum sensing is going on.

Miguel Camara

If these extracts contain quorum sensing molecules, when I put this plate under the bioluminescence camera I should be able to detect bioluminescence.

Here we can see bioluminescence, and this bioluminescence is caused by the presence of quorum sensing molecules in the extract we've incubated before. The dark ones haven't got any quorum sensing molecules. In contrast, we can see one example, the one in the middle, the dilutions go down quite high, and this means that this organism is a very good producer of quorum sensing molecules.

Narrator

When the scientists looked, they found bacteria were putting quorum sensing to all sorts of different uses.

Barrie Bycroft

There is advantage to switch on antibiotics together. There is advantage to switch on light together, and it was this recognition that then lead us to suggest that it would also be an advantage to a pathogen to be able to do exactly the same.

Narrator

It all boils down to a deadly game of strategy. Paul meets up with Professor David Pritchard, an expert in immunology.

They are about to replay the battle that goes on between pathogen and patient.

David Pritchard

The game of Risk is very much like quorum sensing. We look at the risk board as the environment and it's full of bacteria, and here we've got the human host in this brown area of Africa here.

Paul Williams

Now I'm going to play the pathogen, so I'm the purple soldiers and we've found a way into the host. But arrayed against us is the army of the host which is the immune system.

David Pritchard

The reason I'm still alive today is because of this system. So I will now attempt to expel Paul and his purple soldiers from the body.

Paul Williams

But I have a trick up my sleeve. I can use quorum sensing to gain a foothold, and what I'm going to do is to get my army in without alerting Dave's army that I'm there, before I deploy my weapons. And I won't do that until I've got sufficient numbers to make those weapons effective.

Narrator

The pathogens use quorum sensing to check up on numbers. They'll only attack when their forces are strong.

Paul Williams

So now I'm in a very much better position to deal with Dave, my numbers are up I can now get my lines of communication in place, my quorum sensing is working, and I can deploy my toxins to deal with Dave's army.

David Pritchard

Now I find my body's infected, but I don't give up so easily because I need to survive. Paul has breached my first line of defence, but I now have a second and more specific line of defence waiting for this infection.

Paul Williams

But my bacteria have yet another trick up their sleeves. Not only can they use their quorum sensing signalling system to control toxin production, but they can use the same signal molecules to manipulate the second line of Dave's host defences to deal with the host.

Paul Williams

The intriguing thing about quorum sensing is that the molecules involved not only signal between bacteria, but signal between the bacteria and the host's immune system. As a result, the second line of defence of the host's immune system is breached, and the bacterium in this case establishes a successful infection.