



## Activity 2

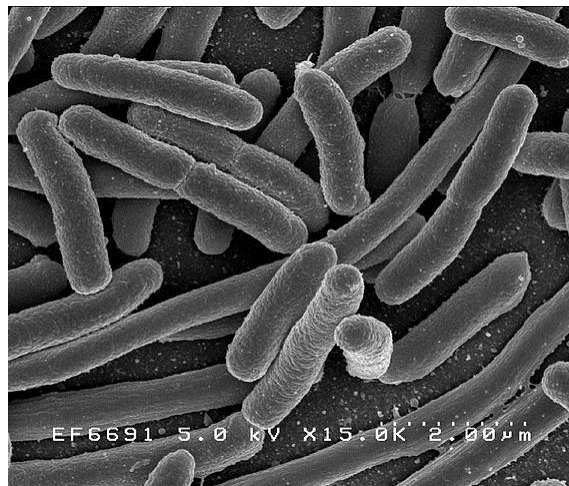
### **Where does antibiotic resistance come from?**

If antibiotics come from natural sources, it can hardly be surprising that the bacteria have evolved their own countermeasures to combat them.

Consider this discovery:

<http://www.nature.com/nature/journal/v477/n7365/full/nature10388.html>

Why would antibiotic resistant bacteria be found in samples of permafrost that are 30,000 years old? Because bacteria evolved to overcome the anti-bacterial weapons used by fungi and other bacteria long before humans were around.



[https://en.wikipedia.org/wiki/Bacteria#/media/File:EscherichiaColi\\_NIAID.jpg](https://en.wikipedia.org/wiki/Bacteria#/media/File:EscherichiaColi_NIAID.jpg)

Scanning electron micrograph of Escherichia coli

This seems to beg the question of why or how these natural antibiotics work in the first place. The answer is 'evolution'. In the natural world, there are always disadvantages to both developing 'weapons' and 'defences' and so if they are not needed individuals which don't possess them will have a selective advantage and thus be more likely to survive and breed.

Bacteria adapt relatively quickly as they have a short reproduction cycle and therein lies the problem. Many of the bacteria that cause disease have evolved to live in environments where they are not exposed to fungi (e.g. on mammalian skin, or in the mammalian gut) and so had no need to develop defenses. However, once we started using antibiotics we provided a new selection pressure and the bacteria have not been slow in responding.

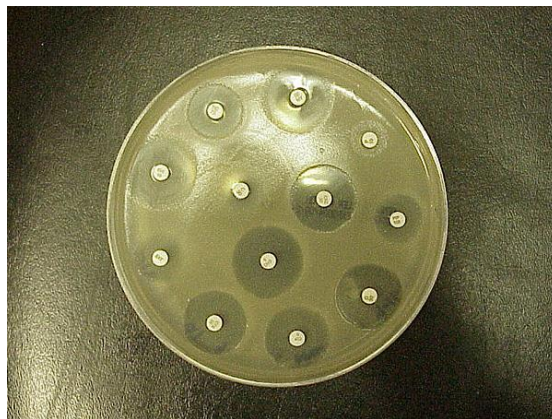
When antibiotic resistance emerges it is often not due to the development of *new* resistance genes, but the natural selection of bacteria harboring *existing* resistance genes.



Antibiotic resistance genes may be present in nature but how do they end up in bacteria that cause disease? The following video gives some insight into how once a gene that provides resistance to an antibiotic exists, it can spread:

[https://www.youtube.com/watch?v=7sZ5Nz8\\_cfc](https://www.youtube.com/watch?v=7sZ5Nz8_cfc)

With binary fission (the reproduction of bacteria) we get clonal expansion: the growth, in the presence of antibiotic, of a population from a single common ancestor which had the resistance gene, and was then able to outcompete any 'un-weaponized' bacteria.



[https://en.wikipedia.org/wiki/Antibiotic\\_sensitivity#/media/File:KB\\_test.jpg](https://en.wikipedia.org/wiki/Antibiotic_sensitivity#/media/File:KB_test.jpg)

*Testing the sensitivity of a bacterial culture to a variety of antibiotics. Thin wafers containing antibiotic have been placed on an agar plate growing bacteria - which are not able to grow near those around antibiotics to which they are sensitive*

Horizontal gene transfer, often resulting from the transfer of DNA on a plasmid, enables susceptible bacteria to acquire the necessary gene from an antibiotic resistant neighbour. If there are no antibiotic resistance genes, or very low numbers of bacteria with resistance genes, the antibiotic is likely to be effective but then may proliferate more bacteria with the gene as a result.