Review Article

Evolution of drug resistance in bacteria

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ABSTRACT

This article explains the evolutionary mechanisms behind bacterial resistance to drugs. It uses *Klebsiella pneumoniae*, rod-shaped bacteria found in human and animal flora of the mouth, skin, and intestines, as an example of antibiotic-resistant bacteria.

Darwin's Theory of Evolution by Natural Selection

- When Darwin visited the Galapagos Islands in 1833, he discovered that there were several different species of finches, all closely related but with different sorts of beaks. Each type of finch was found on a different island with different food sources, and their beaks were seemingly adapted to those different food sources. These finches were the basis of Darwin's evidence of natural selection [Figures 1 and 2].

Applying Darwin's Theory to Drug Resistance in Bacteria

- In a colony of bacteria, a few individuals will have a natural resistance to an antibiotic drug caused by random genetic mutation. When an antibiotic such as penicillin is used, some of the bacteria will survive as a result of this resistance.
- When the surviving bacteria breed, they will pass on their property of resistance to the next generation of bacteria.
- This means that more and more of the bacteria will have a resistance to the drug [Figure 3].

Dangers of Drug Resistance in Bacteria

- Having drug resistance in bacteria is dangerous because it means infections are a lot harder to cure.
- It also means that the bacteria can spread more easily in ideally sterile environments, such as hospitals.
- One of the worst problems is that as bacteria become more resistant, you need to give them stronger doses of antibacterial drugs to kill them off – some people do not realize this and use weaker doses to treat already resistant bacteria, which just gives them a stronger resistance by means of the selection process.
- Antibacterial drugs are also sometimes mistakenly used against viruses, which have no effect on the viruses and instead make bacteria in the surrounding body more resistant to that type of drug.

Case Study: *Klebsiella pneumoniae*

- In August 2000, at Tisch Hospital in New York, a bacterium called *Klebsiella pneumoniae* was found that was resistant to almost every

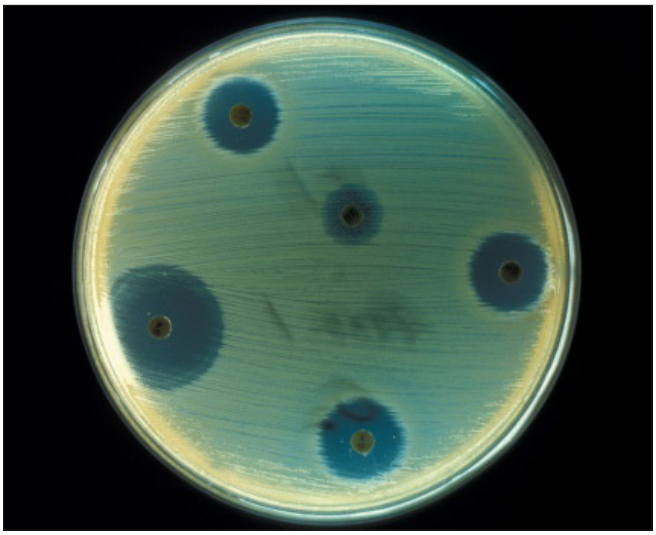

Figure 1: Antibiotic test plate containing *Staphylococcus aureus* (Available from http://upload.wikimedia.org/wikipedia/commons/5/59/Staphylococcus_aureus_%28AB_Test%29.jpg)

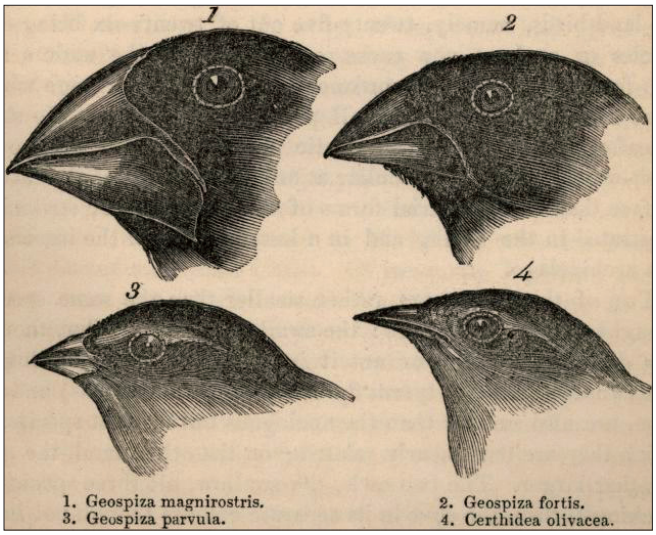

Figure 2: Darwin's finches (Available from http://upload.wikimedia.org/wikipedia/commons/a/ae/Darwin%27s_finches_by_Gould.jpg)

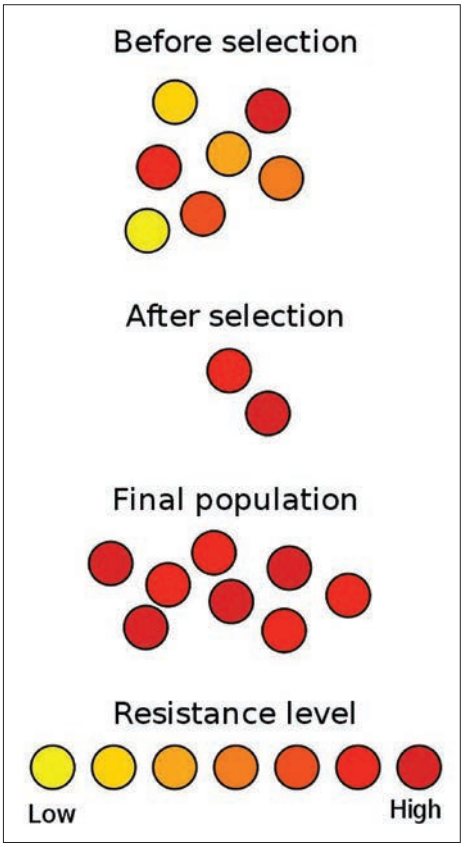

Figure 3: Antibiotic resistance as a result of natural selection (Available from http://upload.wikimedia.org/wikipedia/commons/thumb/f/f6/Antibiotic_resistance.svg/500px-Antibiotic_resistance.svg.png)

meaningful antibiotic Tisch Hospital had.[1] The only drug it was sensitive to was colistin, which had been abandoned as a treatment because of its potential to damage the kidneys [Figure 4].

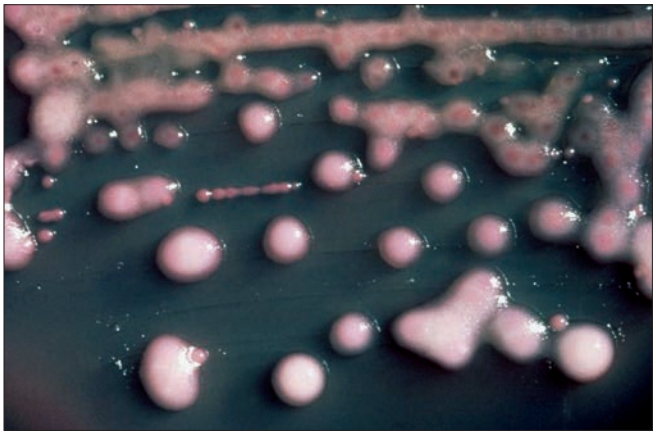

Figure 4: *Klebsiella pneumoniae* (Available from http://upload.wikimedia.org/wikipedia/commons/9/9e/Klebsiella_pneumoniae_01.png)

- *K. pneumoniae* can survive in water and on inanimate objects. As humans, we can carry it on our skin and in our noses and throats, but it is most often found in our feces, and this is the most common method of infection in intensive care units.
- *Klebsiella bacteria* have a sugary coat, which makes it difficult for white blood cells to engulf them in order to destroy them.
- *K. pneumoniae* does not usually harm healthy people, but people who have conditions such as liver disease or severe diabetes, or those who are recovering from major surgery, are more likely to fall ill from a *K. pneumoniae* infection.
- The bacteria can travel deep into the lungs where they destroy the alveoli, resulting in hemorrhages. *Klebsiella* can also attach to the urinary tract

Figure 5a: Salmonella

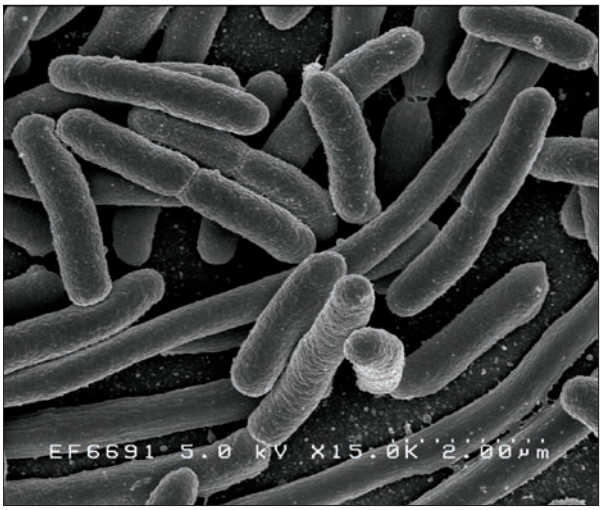

Figure 5b: *Escherichia coli*

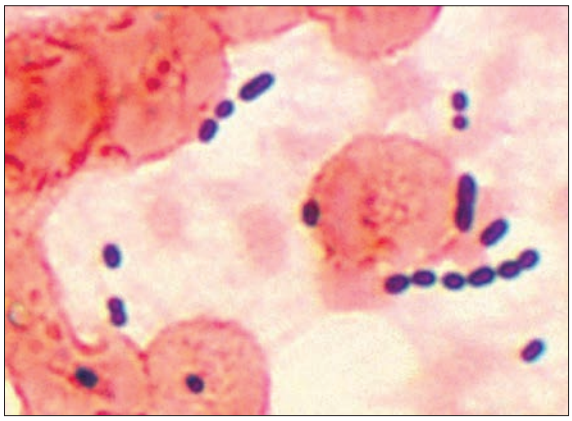

Figure 5c: Enterococcus_histological_pneumonia

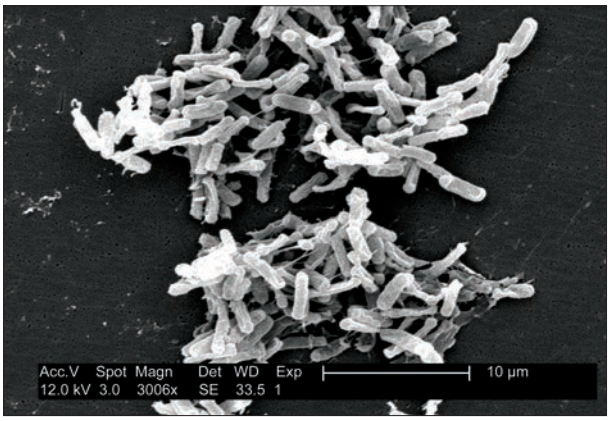

Figure 5d: Clostridium difficile

and infect the kidneys. When the bacteria get into a person's bloodstream, they release a fatty substance known as an endotoxin, which damages the lining of the blood vessels and can cause a fatal shock.

Other Bacteria that are Resistant to Drugs [Figures 5 a-d]

- *Salmonella*
- *Escherichia coli*
- *Staphylococcus aureus*
- *Streptococcus*
- *Enterococcus*
- *Pseudomonas aeruginosa*
- *Clostridium difficile*
- *Acinetobacter baumannii*

Reference

1. Woodford N, Tierno PM Jr, Young K, Tysall L, Palepou MF, Ward E,*et al*. Outbreak of Klebsiella pneumoniae producing a new carbapenem-hydrolyzing class A β-lactamase, KPC-3, in a New York Medical Center.Antimicrob Agents Chemother 2004;48:4793-9.

About the Author

Jake is 16 and is a student of The King's School, Canterbury, in England. He enjoys all three sciences as well as maths, and hopes to become a veterinarian later in life. Jake is not particularly into sports, although he does love non-competitive swimming, skiing, and water skiing. Jake also enjoys reading as well as the natural world (birds, insects, etc.), having grown up in the countryside. He also plays the violin and piano.