Biological Sciences update
MARCH 2018
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Bugs be gone

Superbugs — bacteria resistant to the antibiotics currently in use — are on the rise. **Liz Sheffield** describes two new weapons in our armoury

Bacteria resistant to antibiotics are currently responsible for more than 700 000 human deaths each year. They could lead to the deaths of 10 million people per year globally by 2050, according to a recent report commissioned by the UK government. This estimate is based on the antibiotics currently approved for use to treat disease, most of which have been in service for more than 50 years. During that time, their use in humans and other animals (see Box 1) has exerted selective pressure on bacterial populations, favouring the survival of those with genes conferring resistance. After more than 30 years during which no new classes of antibiotics were discovered, 2015 saw one new class identified and this year has already seen two new breakthroughs in the fight against superbugs.

Nano bugtrap

If harmful bacteria enter the bloodstream, they can multiply so rapidly as to cause life-threatening conditions including organ failure and sepsis. There are two ways to treat infected patients. One is to administer antibiotics, the other is to pass their infected blood through a filter in a dialysis machine. This second method is the only option with antibiotic-resistant infections but has until now relied on carbon foam-based filters, which capture only 10% of the bacteria in the blood. Now researchers in China, inspired by the Venus flytrap, have devised a claw-like filter that grabs 97% of the bacteria passing through. The claws of the filter are made from flexible polycrystalline nanowires tipped with concanavalin A. This protein binds to certain carbohydrates, including the sugars that coat the surface of bacteria such as *Salmonella*. The nanowires stick to and close over the bacteria, trapping them in a delicate cage and preventing them from re-entering the patient's bloodstream when the blood returns to the patient (see Figure 1).

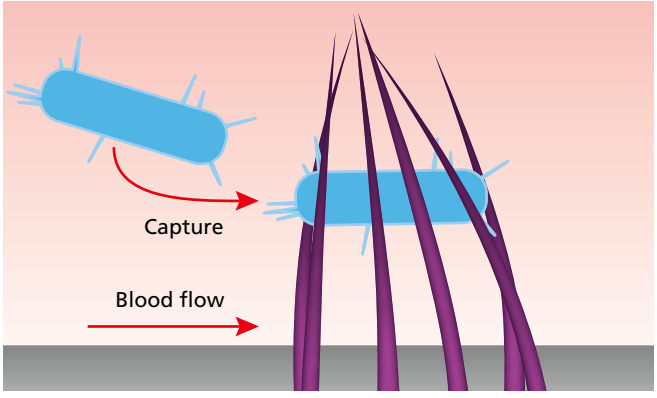

Figure 1 Diagram showing how nanoclaw filtering removes bacteria from blood

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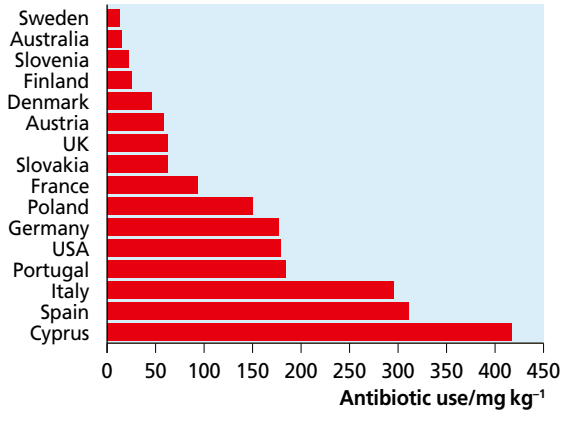
New antibiotic unearthed

Most of our best known antibiotics were originally obtained from fungi or bacteria cultivated in laboratories. The most renowned example is penicillin, which was derived from a fungus. We know that there must be many more antimicrobial compounds produced by microorganisms in the natural environment, but finding conditions and media suitable for cultivating them has proved challenging.

Molecular biology techniques now allow researchers to avoid the need to cultivate organisms and go straight for the genes that carry the information necessary to make compounds of interest. A team in the USA recently extracted DNA from 2000 different soils, and used the polymerase chain reaction to amplify DNA sequences known to be associated with the production of bacterial-wall-busting compounds. They found a sample from a desert region that fitted the bill. They cloned the relevant genes and rearranged them to insert into the host bacterium *Streptomyces*, which grows readily in the laboratory. The bacteria made a novel compound, which the researchers called malacidin (from Latin words for 'killing' the 'bad') and which works differently from any current antimicrobials. It has already been used to clear infection from rats with the superbug methicillin-resistant *Staphylococcus aureus* (MRSA). Even better news is that after 20 days of continuous exposure, MRSA bacteria showed no signs of developing resistance to the new antibiotic.

Box 1

Antibiotic use in animal-based food production varies considerably from country to country. The graph below shows what the situation was in 2011, since when some countries have set targets to reduce usage. In the UK the target was to reduce usage to 50 mg kg^{-1} by 2018 — the target was reached 2 years early.



Activities

Go to the 'Superbugs: the fight for our lives' (free) exhibition at the Science Museum in London (on until spring 2019):
https://tinyurl.com/ybhmamne

Consider entering the Longitude prize competition:
https://longitudeprize.org/challenge

Play the superbugs game:
https://tinyurl.com/y9eyygew

Further viewing and reading

Find out what causes antibiotic resistance from the TedEd movie here:
www.youtube.com/watch?v=znnp-Ivj2ek

Find out how antibiotics are used in animal-based food production in the TedX movie 'Factory farms, antibiotics and superbugs':
www.youtube.com/watch?v=ZwHapgrF99A

'Nanoclaw "flytraps" catch bugs in the blood', *Chemistry World*, 14 February 2018:
https://tinyurl.com/ybf3rbh3

'New antibiotic family discovered in dirt', *BBC News*, 13 February 2018:
www.bbc.co.uk/news/health-43032602

'UK supermarkets "contributing to antibiotics crisis"', *The Week*, 14 November 2017:
https://tinyurl.com/hacaw8u