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RESEARCH IMPACT

DISCOVER — **ENGAGE** — IMPACT

'POLLEN PACKAGE' PACKING A PUNCH

Inspired by nature, UQ researchers are mimicking the structure of pollen to create more effective antimicrobial medicines, helping to tackle one of the biggest threats facing humanity – antibiotic resistance.

Antimicrobial resistance – where microorganisms such as bacteria and viruses are no longer susceptible to antibiotics and antivirals – is described by the World Health Organization (WHO) as "one of the biggest threats to global health, food security and development today".

"Systematic misuse and overuse of these drugs in human medicine and food production have put every nation at risk," says Dr Margaret Chan, Director-General of the WHO.

"Without harmonised and immediate action on a global scale, the world is heading towards a post-antibiotic era in which common infections could once again kill."

The *Global action plan on antimicrobial resistance* was developed by the WHO in 2015 to help tackle this problem. Alongside this plan, the Australian government also developed the *National Antimicrobial Resistance Strategy 2015–2019*.

A key objective of each plan is to optimise the use of antimicrobial medicines in both humans and animals.

Now, Professor Chengzhong (Michael) Yu from the Australian Institute for Bioengineering and Nanotechnology (AIBN) is pioneering technology inspired by pollen to make antimicrobial delivery more effective..

"If we can ensure a better way for medicines to be administered during the early stages of disease, we can wipe out infections before they get stronger, and so prevent a whole new breed of 'super-bugs'."

With this in mind, Professor Yu and his team looked to nature for inspiration – particularly the design of pollen. They had noticed that the rough surface of pollen particles allows pollen to adhere to the hairy legs of bees, which then helps with pollination.

Professor Yu and his team worked at the nanoscale to engineer hollow silica nanoparticles with rough surfaces similar to pollen, enabling them to adhere to pili, the hair-like appendages found on the surface of most bacteria.

The team developed a simple approach for nanoparticle fabrication, starting by creating polymer cores, followed by assembling a shell of silica and polymer. When these nanospheres are heated to high temperatures, they form a sticky, spiky surface with a hollow interior – perfect for being filled with antibiotics or antimicrobials.

"The hollow design lends itself to carrying antibiotics, which could provide a synergistic effect to overcome more resistant bacterial infections," says Professor Yu.

One such antimicrobial enzyme they are investigating is Lysozyme, which forms part of the immune system in animals and humans, and is found in solutions such as tears, saliva and mucus.

"Lysozyme is a naturally occurring enzyme existing in our bodies, which means it has minimal side effects," says Professor Yu.

But one of the problems with using lysozyme is that it is quite unstable, making it difficult to use as an antibacterial agent. However, Professor Yu and his team found that by protecting the lysozyme inside the nanoparticles, it could be delivered more effectively.

"We compared the performance of lysozyme-loaded spiky nanoparticles to smooth nanoparticles as well as free-floating lysozyme and tested all three on *E. coli* bacteria in culture.

"While the smooth particles and the free-floating lysozyme only partially inhibited bacterial activity over the course of three days, the spiky nanoparticles were able to completely inhibit bacterial growth.

"Considering the number of deaths caused by infections globally, the potential implications of this finding for healthcare are significant."

From the lab to the paddock

Professor Yu and his research team are now testing the nanoparticles on livestock.

The livestock industry is highly important in Australia, making up 45 per cent of the gross value of Australian agricultural output, according to the Animal Farm Institute. The industry directly employs 140,000 people, with another 72,000 people employed in downstream sectors.

In Australia, antibiotic use in livestock is tightly regulated, but in many other countries antibiotics are routinely added to feed to improve productivity, both by promoting growth and by decreasing susceptibility to infection and disease.

Not only does antibiotic resistance in animals have implications for animal health, welfare and production, it can also pose risks in transferring food-borne infections to humans.

Resistant bacteria can spread directly from animals to the people who work with them, such as farmers, and can also be transmitted through food, as well as groundwater contaminated with farmyard run-off.

According to the *National Antimicrobial Resistance Strategy 2015–2019*, minimising the development of resistance in livestock and companion animals is an essential component of Australia's response.

"The development of natural and biocompatible antibacterial nano-formulations holds great promise for replacing the current antibiotic supplements in animal feed, which is one of the main causes of 'super-bugs' that threaten human health," says Professor Yu.

Professor Yu's team has partnered with Australian animal feed and nutrition company Ridley to conduct the field trials.

"As a manufacturer of animal feed and ingredients, we are proactively pursuing a number of strategies including alternatives to traditional antibiotics," says Dr Louise Edwards, Technical Business Development Manager at Ridley.

"Professor Yu's work is exciting and innovative, and has significant potential within the animal health and agricultural sector."

Professor Yu says his ultimate goal is to develop an animal feed formulation that is completely free from synthetic antibiotics.

"It's a promising strategy to use a natural product as an alternative, and nanotechnology to enhance its performance."

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Progress to date:

2015: WHO publishes the *Global action plan on antimicrobial resistance*, and the Australian government publishes the *National Antimicrobial Resistance Strategy 2015–2019*

2016: AIBN researchers publish the results of their study into silica nanopollens in the *Journal of the American Chemical Society*

2017: Professor Yu and his team start livestock formulation studies

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