The Rise of Superbugs and Antibiotic Resistance

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The theory of evolution, conceptualised by Charles Darwin in the 19th century, is fundamental to our understanding of life on Earth. In short, evolution is the process by which organisms adapt over generations due to random variations in their genetic material, leading to the gradual development of certain characteristics in pressured environments. While there are many aspects in which studying evolution is intrinsically valuable, such as explaining the diversity of species and their adaptations through natural selection, it is perhaps most useful in offering critical insights into the development of antibiotic bacterial resistance, or "superbugs", as well as understanding the necessary measures to resolve the issue.

As one of the most perilous phenomena of our time, such resistance undoubtedly has dire global repercussions, and poses a significant challenge to scientists today.

Firstly, however, the anthropological enhancement of this problem cannot be understated. From agricultural practices to medical treatments, human activities have significantly accelerated the issue of evolutionary bacterial resistance, with the widespread, often indiscriminate use of antibiotics being a primary driver.

In healthcare, their unnecessary prescription, as well as the tendency to choose broad-spectrum antibiotics, can not only induce collateral damage by wiping out beneficial bacteria, but excessive usage fosters an environment where resistant strains can thrive, while increasing the risk of them evolving to begin with. Furthermore, hospitals, with their amplified antibiotic exposure and dense populations of vulnerable patients, can become hotspots for the evolution and spread of these superbugs. For instance, Methicillin-Resistant *Staphylococcus aureus* (MRSA) has become a notorious example; having disseminated globally after initially developing in medical centres. [1]

Additionally, antibiotics are aggressively used for disease prevention as well as growth promotion in livestock. The European Medicines Agency (EMA) highlights that up to 80% of all antibiotics sold in some countries are used in animals [2], and such reckless distribution enables resistant bacteria to thrive, proliferate, and eventually even spread to humans through direct contact, food consumption, and environmental contamination.

So how does such resistance occur to begin with?

When bacteria are exposed to antibiotics – as per the theory of evolution – in rare instances, those with genetic mutations that enable them to survive the drug's effects are naturally selected. These 'resistant' strains can then asexually reproduce at alarming exponential rates beginning at 15 times an hour [3], thereby rapidly passing their advantageous traits to subsequent generations; forming new, considerably more dangerous pathogens.

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[1] (Centers for Disease Control and Prevention, 2019)
[2] (European Medicines Agency, 2017)
[3] (Pacific Northwest National Laboratory, 2010)

The rise of such antibiotic-resistant bacteria is a threat that - according to the World Health Organization (WHO) – "is one of the biggest threats to global health today," even warning that "a post-antibiotic era, in which common infections and minor injuries can kill, far from being an apocalyptic fantasy, is instead a very real possibility for the 21st century [4]."

This has far-reaching implications, ranging from longer hospital stays and higher medical costs to soaring death rates and the collapse of entire healthcare systems. To add to this, the Centres for Disease Control and Prevention (CDC) reports that each year in the US, there are more than 2.8 million cases of superbug infections, of which over 35,000 concluded in death [5] - underscoring the urgent need to address antibiotic resistance through an evolutionary lens.

This challenge, however, requires innovative solutions and advancements across multiple disciplines. One of the most promising developments is the research and application of bacteriophage therapy, which utilises viruses to target and kill bacteria. Unlike antibiotics, bacteriophages are highly specific to their bacterial hosts, reducing collateral damage and minimizing the likelihood of developing resistance. Moreover, a proposed synergistic method; combining bacteriophages with antibiotics, can enhance treatment effectiveness, lower antibiotic doses, while maintaining low rates of bacterial evolution. For instance, a study by the American Society for Microbiology (ASM) demonstrated improved outcomes using combined phage and antibiotic therapy for resistant *Acinetobacter baumannii* infections [6], representing significant progress in resolving the issue of superbugs.

Despite the arduous challenge presented by antibiotic resistance, by understanding the invaluable insights offered by the evolutionary mechanisms behind it, this crisis can potentially be solved by our generation. As long as we adhere to navigating its complexities with the utmost caution and resilience, I believe that we can develop effective strategies to combat bacterial resistance and preserve the efficacy of antibiotics for future generations.

[4] (World Health Organization, 2020)
[5] (Centers for Disease Control and Prevention, 2019)
[6] (American Society for Microbiology, 2017)

Bibliography

American Society for Microbiology, 2017. *Antimicrobial Agents and Chemotherapy.* [Online]
Available at: https://journals.asm.org/doi/10.1128/aac.00954-17#tab-contributors

Centers for Disease Control and Prevention, 2019. *Antibiotic Resistance Threats in the United States.* [Online]
Available at: https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf.

European Medicines Agency, 2017. *Sales of Veterinary Antimicrobial Agents in 31 European Countries in 2017.* [Online]
Available at: https://www.ema.europa.eu/en/documents/report/sales-veterinary-antimicrobial-agents-31-european-countries-2017_en.pdf.

Pacific Northwest National Laboratory, 2010. *Just How Fast Can Bacteria Grow? It Depends..* [Online]
Available at:
https://www.pnnl.gov/science/highlights/highlight.asp?id=879#:~:text=Why%20it%20matters%3A%20Bacteria%20are,every%204%20to%2020%20minutes.

World Health Organization, 2020. *Anti-Microbial Resistance..* [Online]
Available at: https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance.