Thesis Project Portfolio

Proposed Methods to Optimize Growth, Imaging, and Analysis of Bacteroides Thetaiotaomicron Biofilms

(Technical Report)

Implications of antibiotic resistance caused by interspecies bacteria interactions.

(STS Research Paper)

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Sociotechnical Thesis

Antibiotic resistance is a global health crisis that complicates the treatment of once-manageable infections. In an insightful exploration of the emergence and spread of antibiotic resistance, this paper emphasizes the critical role of interspecies bacterial interactions in facilitating this phenomenon. The research highlights the mechanisms through which bacteria hinder antibiotic effectiveness, primarily through horizontal gene transfer, which enables the spread of resistance genes within a species, and also across various species and environments. These mechanisms include transformation, conjugation, and transduction, each contributing to the adaptive capacity of bacterial communities under antibiotic pressure.

The excessive use of antibiotics in healthcare and agriculture has been pinpointed as significant accelerators of this resistance spread. Water bodies and soil also act as conduits for the development of resistance genes which increases the impact on human health. The paper advocates for a comprehensive approach to managing this issue by integrating environmental care into strategies aimed at preventing the spread of antibiotic resistance.

The repercussions of antibiotic resistance are substantial as they affect both individual treatment outcomes and broader public health. Resistance evolution also leads to an increase in healthcare challenges, as infections become harder to manage, and surgical and cancer therapy complications increase due to diminished antibiotic efficacy. The rise of multidrug-resistant pathogens, or "superbugs," presents an urgent need for global cooperation in development of new therapeutic agents and reevaluation of antibiotic use.

Within the human body, the impact of antibiotics extends to the disruption of microbial communities within the gut microbiota. These disturbances can have lasting effects on human

health as the gut microbiota is integral to digestion and metabolism. This paper highlights the interconnectedness of bacterial interactions within this microbiota, and how that contributes to the horizontal gene transfer.

The spread of antibiotic resistance within healthcare settings poses an additional threat, as it leads to challenging-to-control healthcare-associated infections. These infections can result in increased hospitalizations, prolonged illnesses, and the potential emergence of multidrug-resistant pathogens.

The societal and economic implications of antibiotic resistance are significant and strain healthcare systems with increased costs associated with longer hospital stays, and the requirement for more complex treatments. Economically, the resistance leads to productivity losses due to increased sickness which impacts public health infrastructure and economic stability. This paper underlines the importance of ensuring access to effective antibiotics while also managing resistance development.

From a global health perspective, antibiotic resistance disproportionately affects low- and middle-income countries, and highlights the necessity for international collaboration in research and policymaking. Initiatives such as the World Health Organization's action plan on antimicrobial resistance are crucial for fostering a unified approach to combating this public health threat.

The exploration of antibiotic resistance through the Actor Network Theory (ANT) offers an expansive view as it portrays it as a complex network that includes a range of human and non-human actors. Each participant, whether a bacterium, a pharmaceutical agent, or a healthcare practice, plays a critical role in the development and spread of antibiotic resistance. This

framework moves beyond the oversimplified antagonist perspective of bacteria versus drugs, and reveals a web of interactions that span across different ecological domains and societal practices.

Bacteria are at the center of this network as they are not just passive receivers of antibiotic pressure but active participants that exchange genetic material to enhance their survival. This adaptability is driven by interactions within their environment, which include not just the physical spaces they inhabit but also the presence of other organisms and their activities. Antibiotics are implicated in a challenging dynamic with bacteria that evolves continually, leading to strains that resist the antibiotics' action, and also thrive despite their presence.

Human actors such as patients, who often demand antibiotics for viral infections, and healthcare providers, who may overprescribe these medications, contribute significantly to the misuse and overuse of antibiotics. Additionally, agricultural policies permitting the prophylactic use of antibiotics in animals have widespread effects which contributes to the prevalence of antibiotic residues in the environment and the food chain, which further promotes the emergence of resistance.

The interconnectedness of these factors demonstrates that the spread of resistance is not merely a biological issue but also a societal one that breaks through traditional boundaries and shows the need for comprehensive policy approaches. Solutions to this crisis must embrace the diversity of the network's actors, and must call for effective actions by healthcare providers, and the agricultural sector. These efforts can include the responsible prescription and use of antibiotics, and the strict regulation of antibiotics in agriculture.