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The Effect of Heavy Metals on Antibiotic Resistance in the Environment

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Microorganisms develop strategies to cope with their environment; for example, by genetic exchange and selection, bacteria can become increasingly resistant upon exposure to toxic substances like metals. The unfortunate consequence is that environmental exposure to metals can have an impact on other resistance traits (e.g., to an antibiotic). Often, the two traits are linked genetically, and a selective pressure to one may maintain resistance to another substance, even when the toxicant is not present. This means that heavy metals can contribute to the antibiotic resistance problems we currently face clinically. The role of metals, and how microorganisms respond to them, is needed to fully understand public-health risks, such as antibiotic resistance. This may aid in the development of new strategies to combat drug resistance.

Two set of experiments were conducted to investigate relationship. Firstly, resistance genes were quantified in Scottish soils with various background metals. It was found that certain metals (e.g., copper) correlated with various antibiotic resistance gene abundances.

Secondly, to get a better idea of the effect metals have on antibiotic resistance, it was decided to run controlled microcosm experiments to see if pollution has a direct role. Here, we decided to investigate wastewater treatment plants (WWTP), since they provide the interface between the urban pollution and the environment. Further, they act as a heavy metal sink and microorganisms are densely populated. Looking at the interactions between bacteria and metals in WWTP and seeing the effect this has on resistance could provide valuable information on the effect metals are having on antibiotic resistance in the wider environment.

Eight microcosms mimicking the activated sludge process in (WWTP) were set up. Based on the results from the soil experiment, it was decided to focus on copper (Cu), tetracycline (Tet) and ampicillin (Amp). Each reactor was inoculated with activated sludge and provided synthetic wastewater for 22 weeks. Each pair of reactors (except the controls) had their feed amended with either Cu, Cu+Amp+Tet, or Amp+Tet. Resistance in the bacterial communities were examined using a combination of molecular and phenotypic analysis.

Results suggest that copper exposure, in both a ‘natural’ setting and in ‘contaminated’ systems, increases tetracycline resistance, a greater impact than tetracycline alone. Current work is underway to investigate the relationship between copper and tetracycline resistance; however, it suggests that one must reconsider the risks of metal exposure to microorganisms in terms of public and clinical health.