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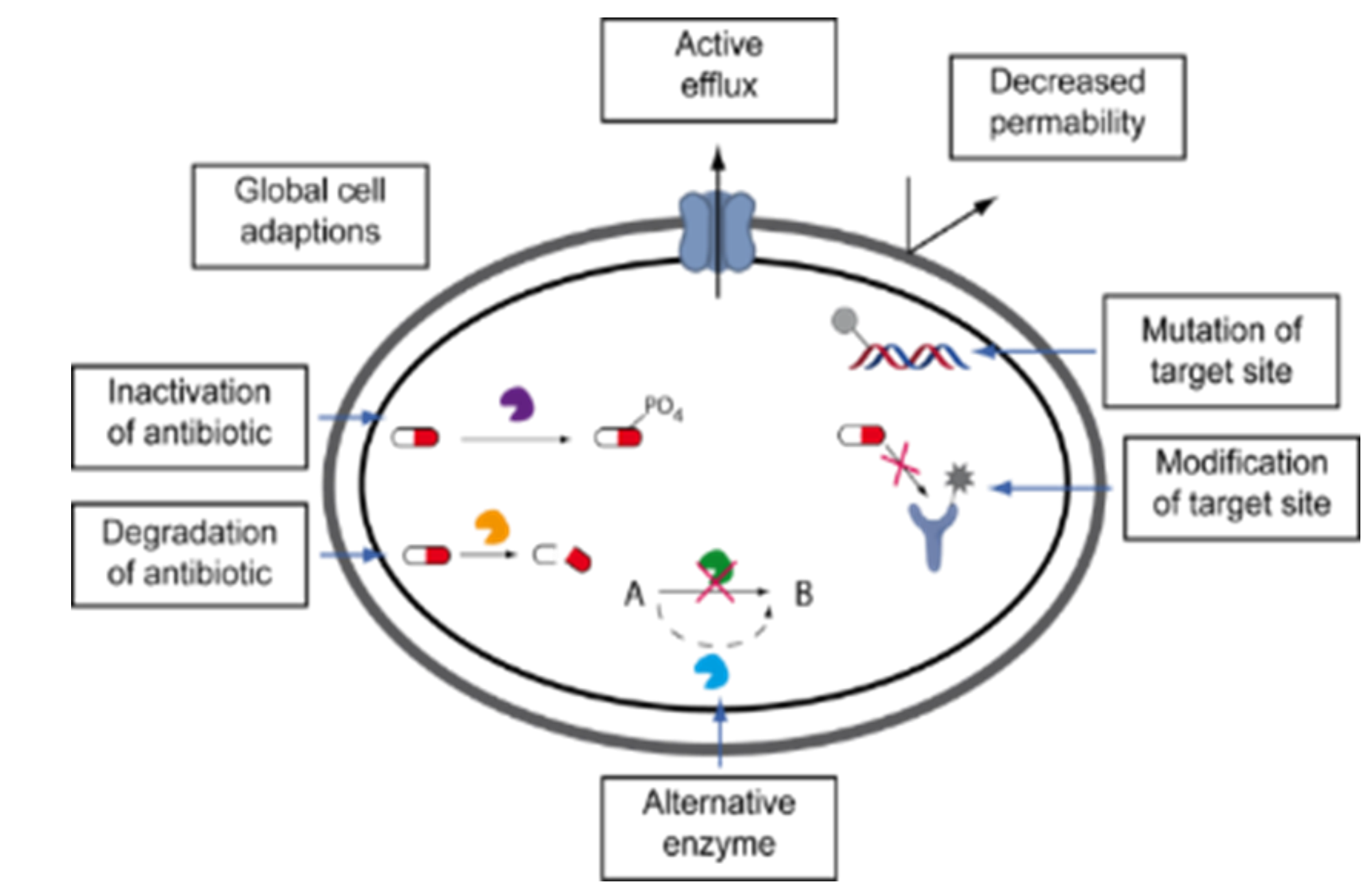
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Introduction

- ❖ Antimicrobials (AM) play a critical role in the treatment of human and animal diseases.
- ❖ Globally, about 700 000 deaths/year arise from resistant infections because AM drugs are less effective at killing resistant pathogens.
- ❖ AM chemicals that are present in environment can trigger the development of antimicrobial resistance (AMR).
- ❖ A better understanding of how AMR moves from agricultural areas to the environment through soil and water is important to develop guidance to managing it cost effectively.
- ❖ We examined the potential of nuclear techniques—the application of compound-specific stable isotope analysis (CSIA) to determine the origin, production process and transport of AM through soil and water to the environment.



Antimicrobial movement from agricultural areas to the environment

- ❖ Antibiotic resistance can originate from: (1) the transformation of antibiotics; (2) changes in bacterial target site; (3) active efflux or decreased permeability; and (4) general cell adaptation (Figure 1).
- ❖ Antibiotics enter the environment when discharged into wastewater or into surface water, or through human and veterinary medicine.
- ❖ Soil is the most important vector when antibiotics are used as pesticides, or when manure and slurry used as fertilizers contain antibiotics from veterinary medicine.
- ❖ Important knowledge gaps exist on interdependency of antibiotics concentrations, antibiotic resistance genes (ARGs) concentrations and the abundance of pathogenic antibiotic-resistant bacteria (Figure 2).

Figure 1. Overview of different resistance strategies of microorganisms

Existing conventional methods for monitoring antimicrobials

- ❖ Liquid chromatography, mass spectrometry, and bioanalytical quantification of antibiotics are currently some of the conventional methods used for monitoring antimicrobials.
- ❖ The quantification, detection, typing and characterization of ARGs in environmental samples are possible using molecular biological methods that are based on nucleic acid amplification tests (NAATs), DNA sequencing, or DNA hybridization.

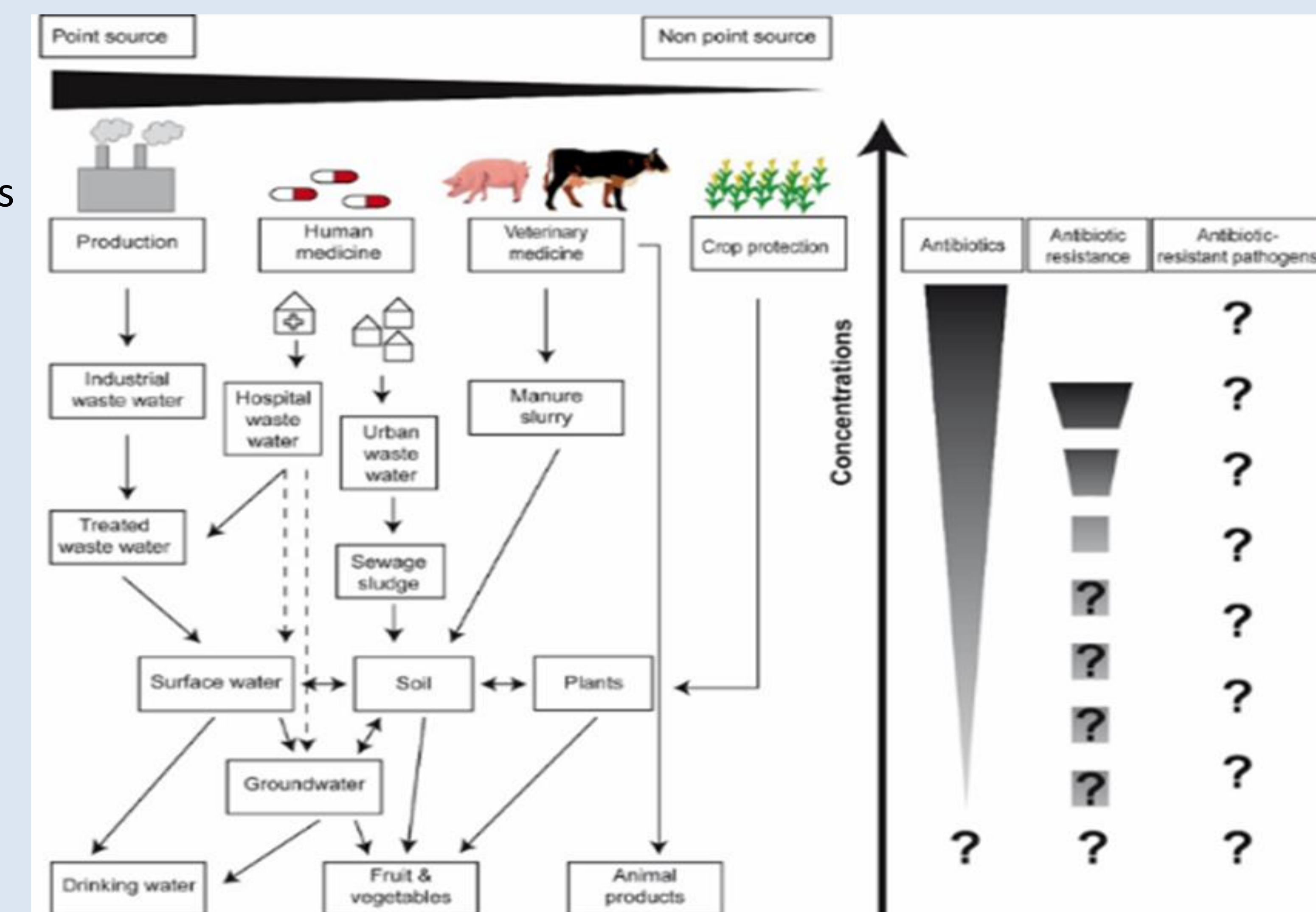


Figure 2. Pathways for antibiotics, antibiotic resistance and antibiotic-resistant pathogens into the environment and the food chain (left) and current knowledge gaps about their concentration behaviour throughout the process (right).

Nuclear techniques and tools for determining the source and transport of AM

- ❖ Nuclear techniques trace the antibiotic medicine – the chemical, not the antimicrobial resistance which is the pathogen in question. Once a selection pressure is imposed, AMR genes may potentially originate, amplify and distribute.
- ❖ CSIA is a powerful tool that provides answers when existing monitoring methods fall short. It may reveal different sources of an identical chemical and may detect when a given chemical has been transformed or degraded.
- ❖ Successful applications have focused on the sources and fates of many common groundwater contaminants such as chlorinated solvents and BTEX (benzene, toluene, ethylbenzene, and xylene) compounds (Fischer et al., 2016).
- ❖ A decrease in concentration of a contaminant can result from transformation, dilution or sorption, pronounced changes in the stable isotope composition of a contaminant (Elsner et al., 2005).
- ❖ Observed isotope fractionation in situ is compared with laboratory observations, to determine a pathway-specific enrichment factor.
- ❖ An analysis of stable isotope patterns can be used to determine the source of a contamination, because the ground stocks and synthesis pathway used during production can leave a typical ‘stable isotope fingerprint’ (Nijenhuis et al., 2016).

Conclusions and the way forward

Antibiotics kill bacteria, healing infections that cause diseases and death, hence an urgent need to understand the sources and environmental fate of antibiotics, antibiotic resistance genes and the pathogens carrying the resistance genes and develop a stepwise methodology to monitor AM and AMR in the environment.

References

- Fischer et al (2016) *Curr Opin Biotech*, 41: 99-107.
 Elsner et al (2005) *Environ Sci Technol*, 39: 6896-6916.
 Nijenhuis et al (2016) *Trends Environ Anal*, 11: 1-8.