

## ANTIMICROBIAL RESISTANCE AND DAIRY MANURE SYSTEMS

### 3.A. Antibiotic resistance genes (ARGs) - Prevalence in dairy manure

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#### Antibiotic resistance genes (ARGs)?

A gene is a unit of heredity - an inheritable segment of DNA that functions as a blueprint, encoding a specific protein or cellular function. ARGs are genes naturally present in bacterial populations that give a bacteria the specific ability to resist the effects of an antibiotic(s).

ARGs have several modes of action, some enable a bacteria to inactivate an antibiotics, some protect the cell from an antibiotic, and others enable a cell to rid itself of antibiotic. For example, most  $\beta$ -lactam resistance genes encode for an enzyme, a lactamase, which can cleave the  $\beta$ -lactam molecule and render it inactive. Many tetracycline resistance genes function differently, and encode for an efflux pump that actively transports tetracycline out of the cell before it caused damage.

#### Development of ARGs<sup>[1-3]</sup> (Figure 1)

1. In a population of bacteria, some will naturally possess ARGs.
2. When this population of bacteria are exposed to an antibiotic, those with the ARG can survive.
3. Exposure to antibiotics thus selects for bacteria that contain ARGs, as the surviving bacteria are able to pass the ARG on to their progeny and proliferate.
4. ARGs can also be shared between unrelated bacteria through processes collectively called 'horizontal gene transfer.'
5. There are three general mechanisms of horizontal gene transfer. *Transformation* is where a transformable bacteria is able to directly takes up naked fragments of DNA (e.g. plasmids) from the environment and incorporate them into its own DNA. *Conjugation* is where two

bacteria through cell-to-cell contact can directly transfer genes. *Transduction* is where bacterial viruses (bacteriophages) act as a gene transfer vector.

Once an ARG is acquired by a bacteria, it too becomes antibiotic resistant and can then pass the ARG on to its offspring or to other unrelated bacteria. Horizontal transfer of ARG from one bacteria to another can occur in human and cow digestive tracks, manure, anaerobic digesters, wastewater treatment plants, and in soil and water.

#### Prevalence of ARB in dairy manure<sup>[4]</sup>

More than 60 different ARGs have been found in cattle manure; tetracycline resistance genes may be the most common. A USDA-ARS study that sequenced the genome (See Fact Sheet 3.B.) of 160 antibiotic resistant *E. coli* and the entire fecal microbial community from 28 adult dairy cows, veal calves, and pre-weaned calves found that 61% of all identified ARGs encoded resistance to tetracycline, 20% encoded resistance to aminoglycosides, 8% to macrolides, 3% to  $\beta$ -lactams, 0.8% to sulfonamides, and 0.6% to trimethoprim.

There are only a limited number of studies that have investigated ARGs in dairy manure. While some of these studies have shown the prevalence of ARGs increased following the administration of antibiotics, others have found only short-term responses, and others have found no correlation. At this point the exact relationship between antibiotic usage in dairy cattle and the prevalence of ARGs in dairy manure remains uncertain.

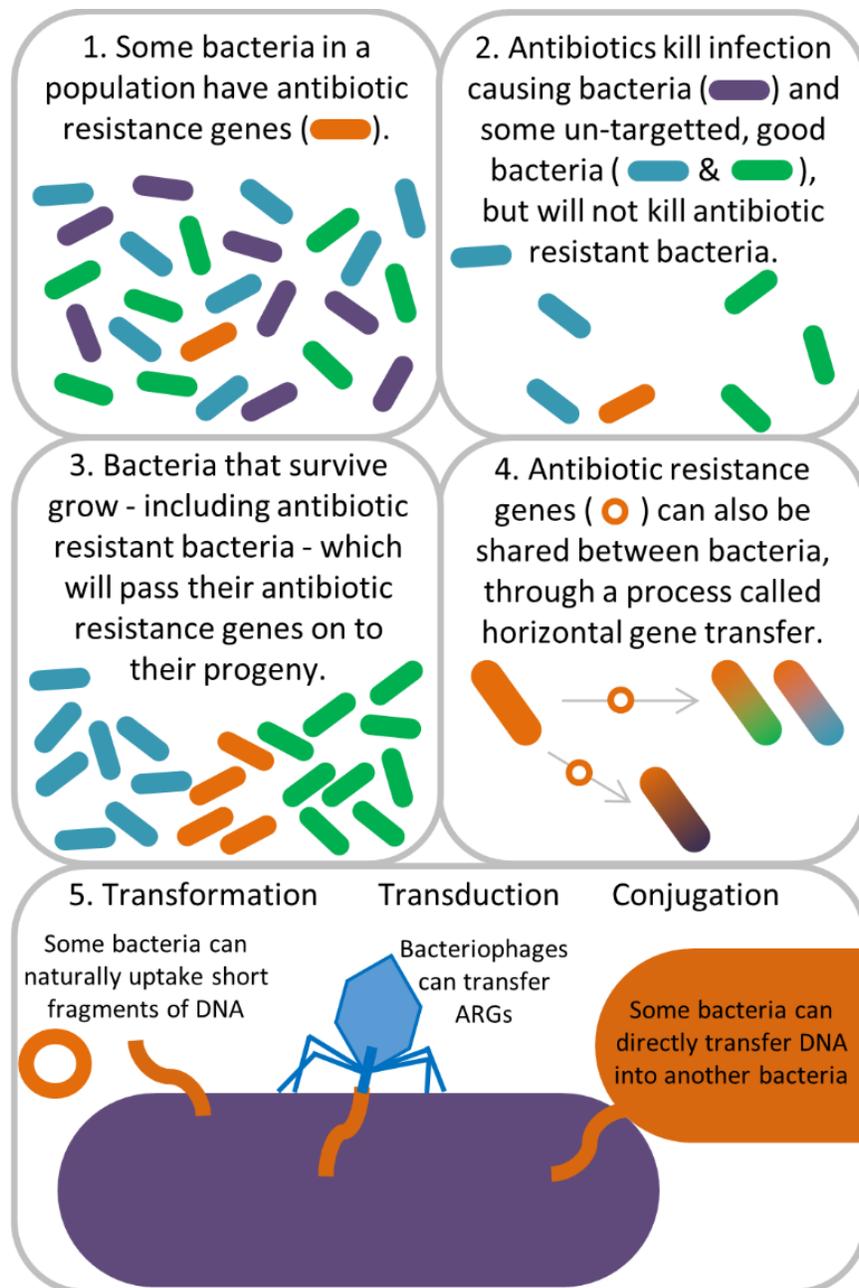


FIGURE 1. DIAGRAM OF THE MECHANISMS BY WHICH A BACTERIA MAY ACQUIRE AN ARG.

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### References

<sup>[1]</sup> Pruden et al. 2013. *Environmental Health Perspectives* 121(8): 878-885. <sup>[2]</sup> Lupo et al. 2012. *Frontiers in Microbiology* 3. <sup>[3]</sup> Chee-Sanford et al. 2009. *Journal of Environmental Quality* 38(3): 1086-1108. <sup>[4]</sup> Oliver et al. 2018. *Journal of Dairy Science*.