One Health: An ecological/public health perspective on industrial food animal production

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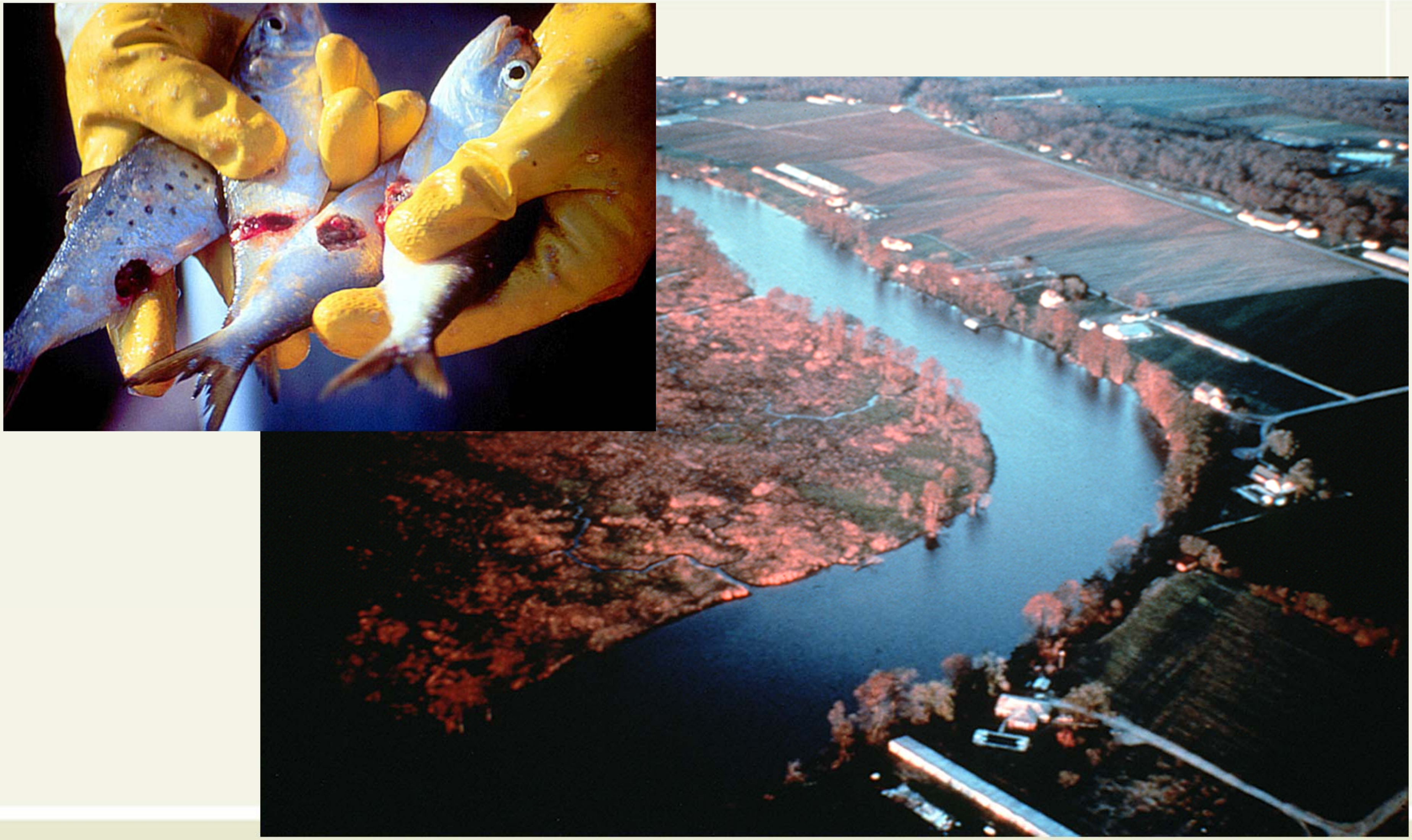
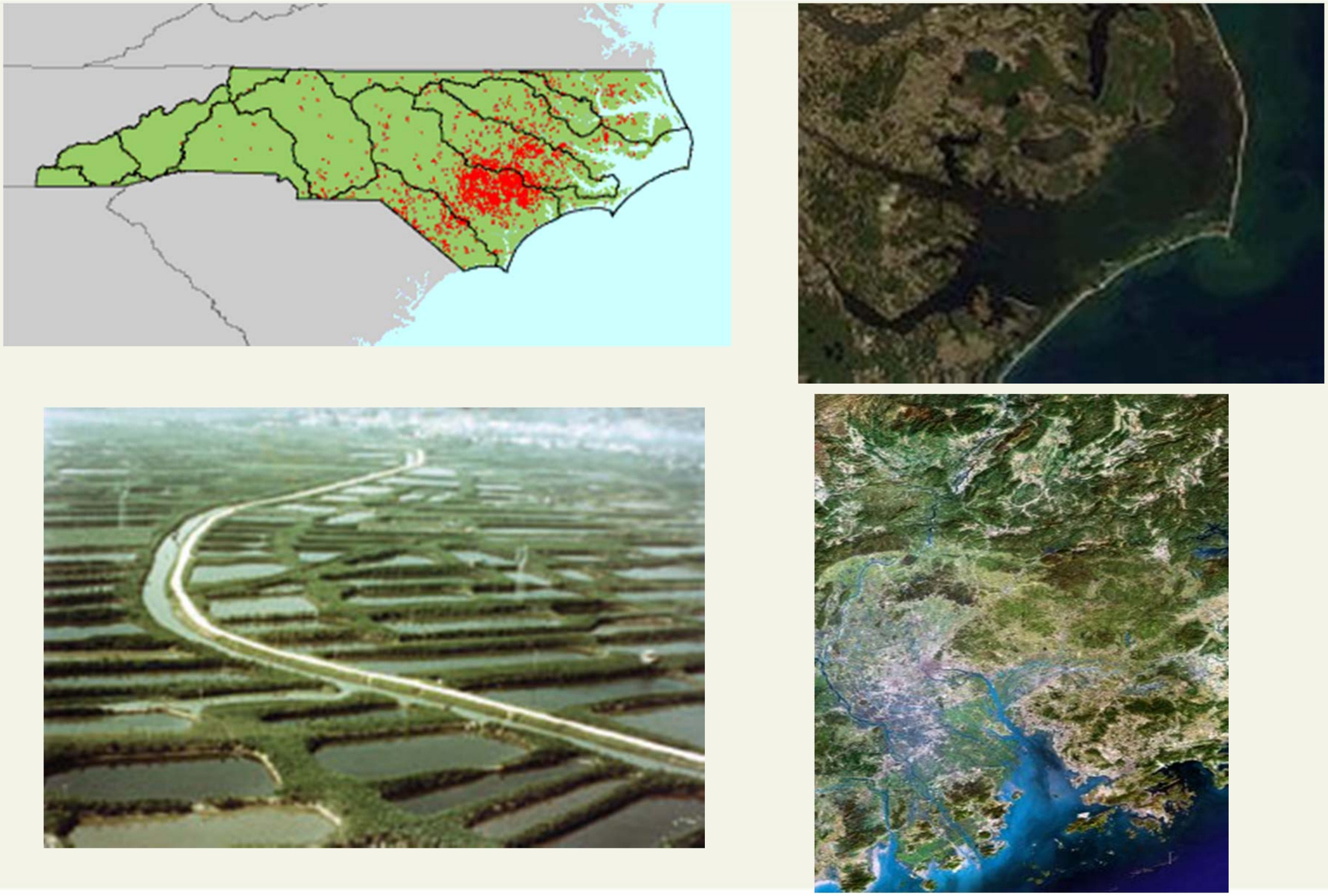
Outline of this presentation

- One Health and intensive food animal production – organization and ecology
  - Ecological impacts
  - Health impacts
- Thinking ecologically
  - Spatial analyses
  - Materials flow
  - Micro and macrobiomes
- Critical questions and research

Ecological impacts of intensive food animal production: surface water degradation, harmful algal blooms, loss of ecosystem services



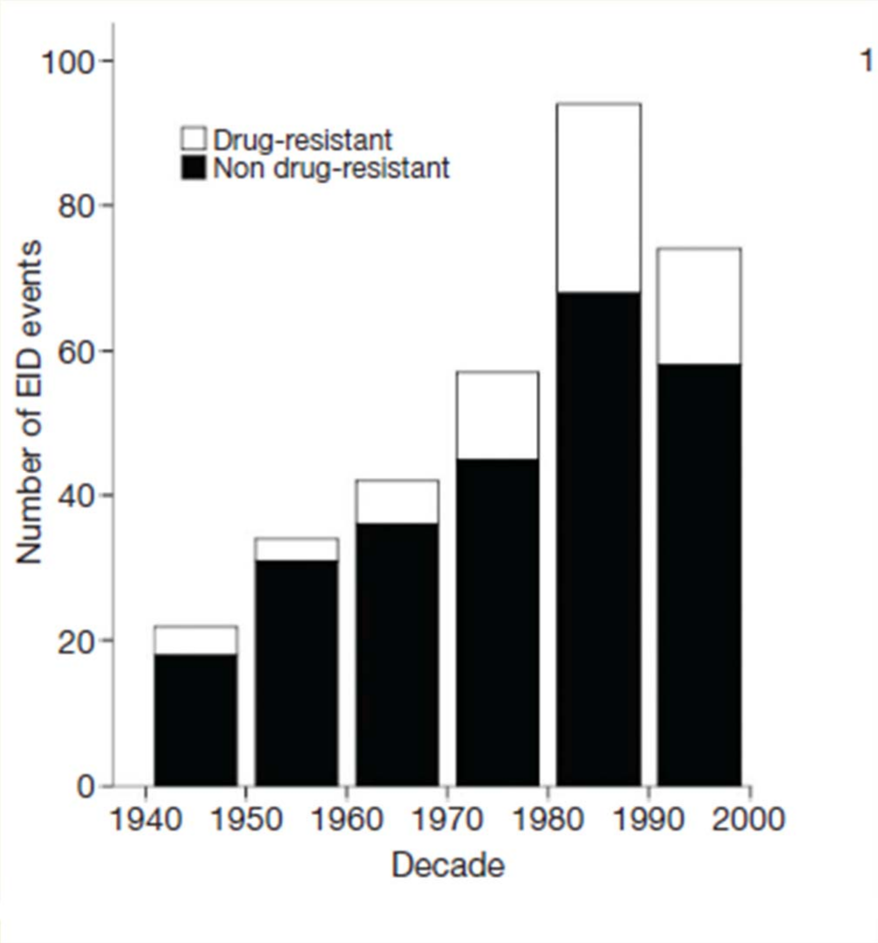
High density of industrial agriculture (hogs and fish) in sensitive coastal ecosystems: US and China

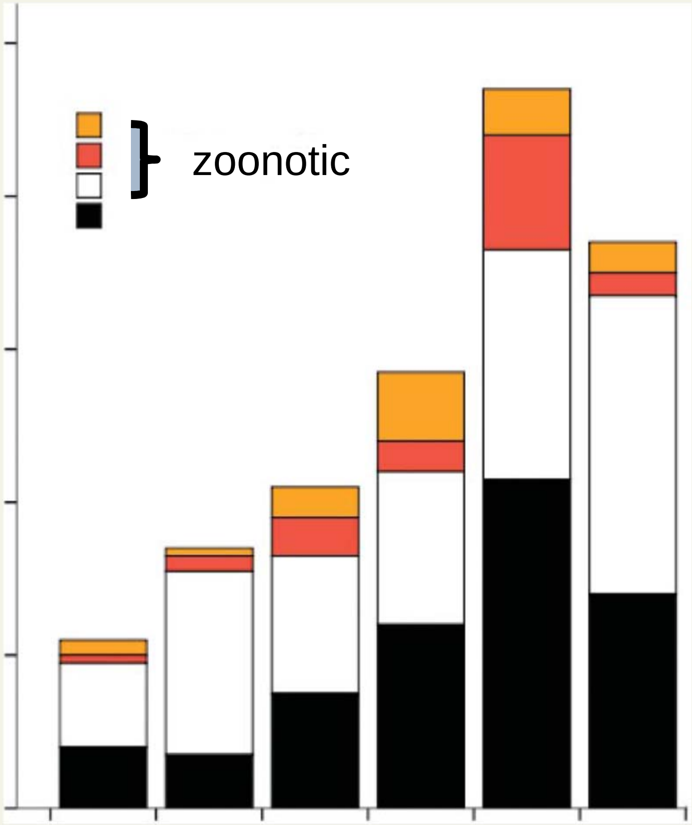


Animals, humans, and food

- Most emerging infectious diseases are zoonotic in origin
- The most intensive and extensive animal:human contacts involve agriculture and human interactions with domesticated animals, not wildlife
- Production methods disrupt shared ecosystems
- Use of antimicrobials in food animal production drive antimicrobial resistance in the microbiome of animals, humans, and ecosystems

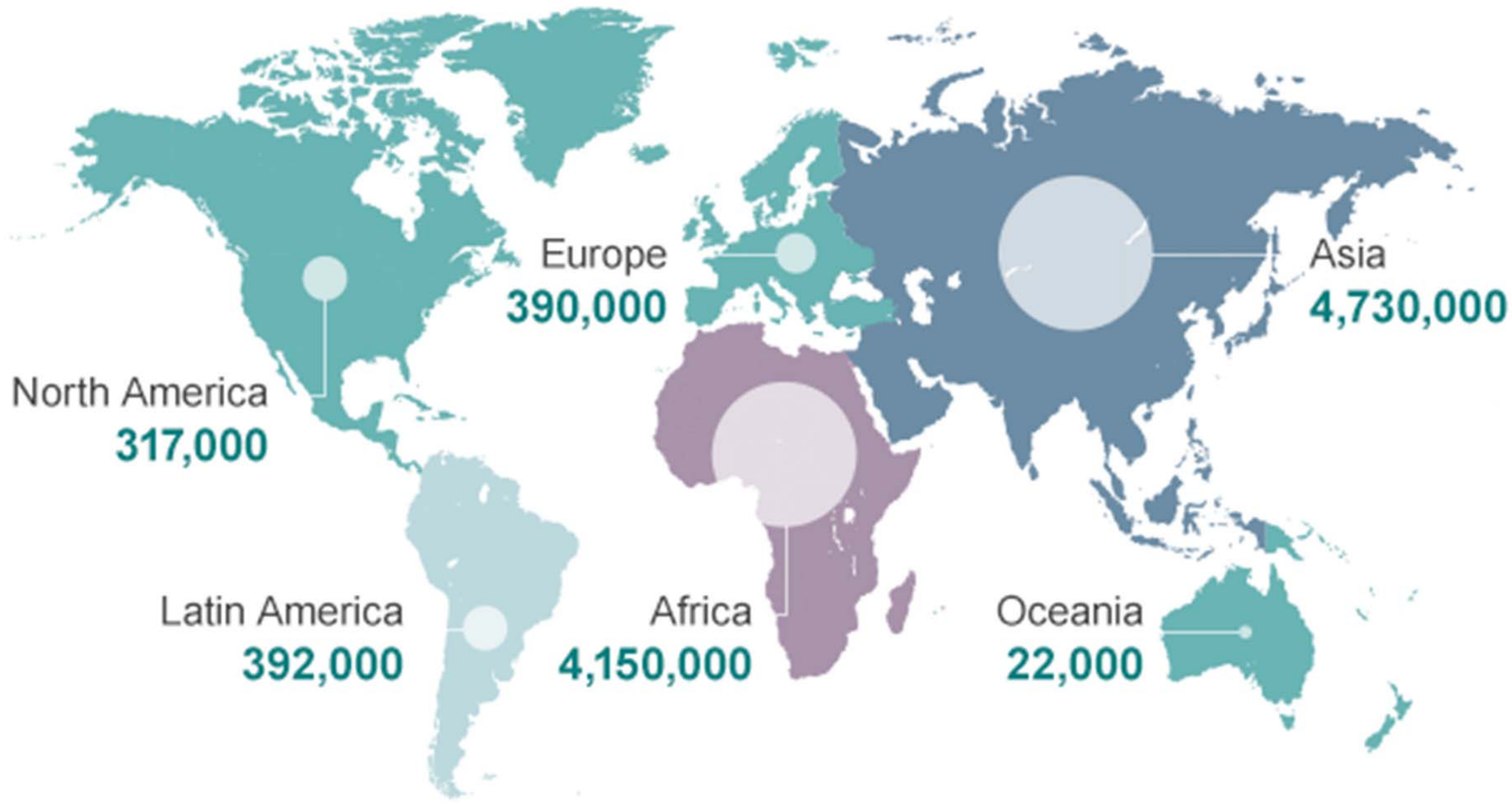
Emerging infectious diseases are largely zoonotic and antibiotic resistant [Jones et al Nature 451: 990,2008]





The burden of antibiotic resistance 2014

Deaths attributable to antimicrobial resistance every year by 2050



Source: Review on Antimicrobial Resistance 2014

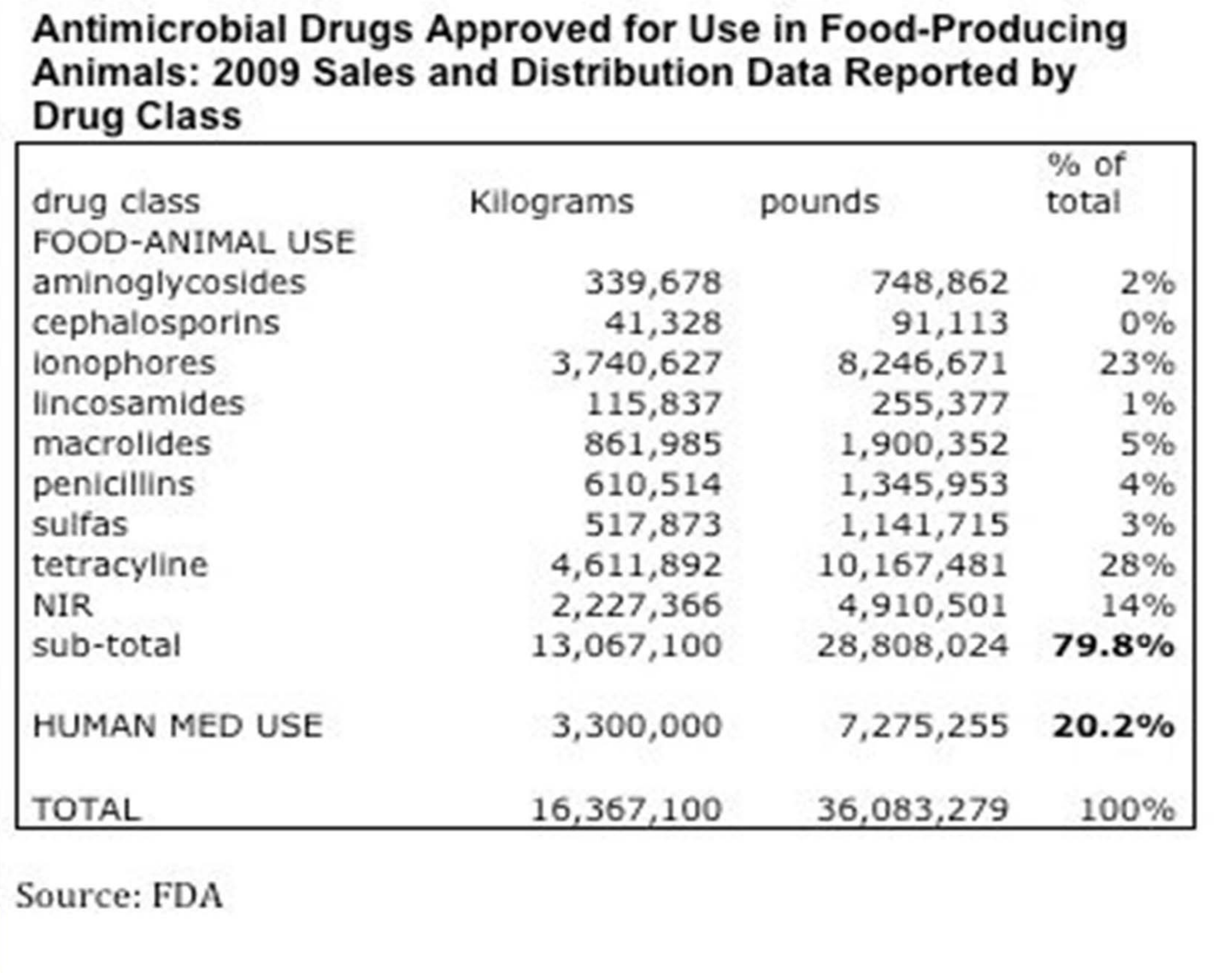
What are the drivers of antimicrobial resistance

- All antimicrobial use → selection for resistance and horizontal gene transfer (Fleming; Lederberg)

- Intensity of antibiotic use → resistance

- ***Inappropriate antibiotic use →selects and disseminates resistance***

Inappropriate use: antimicrobial use in animal feeds (FDA 2011)

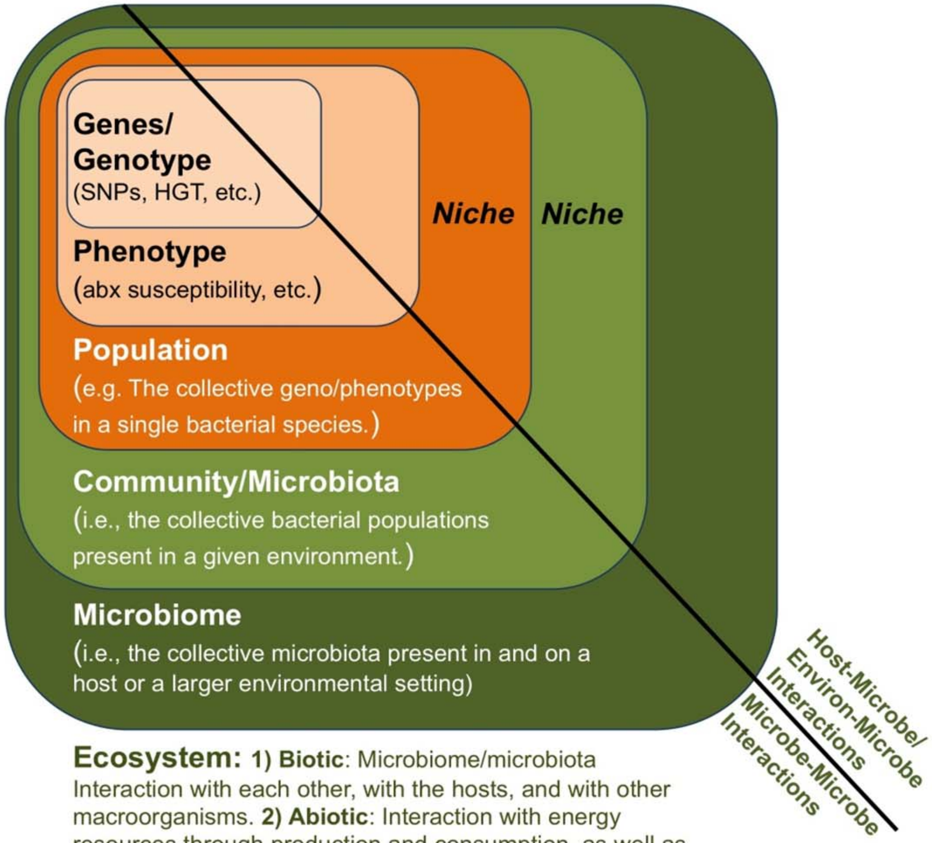


Antimicrobial Drugs Approved for Use in Food-Producing Animals: 2009 Sales and Distribution Data Reported by Drug Class

drug class	Kilograms	pounds	% of total
FOOD-ANIMAL USE			
aminoglycosides	339,678	748,862	2%
cephalosporins	41,328	91,113	0%
ionophores	3,740,627	8,246,671	23%
lincosamides	115,837	255,377	1%
macrolides	861,985	1,900,352	5%
penicillins	610,514	1,345,953	4%
sulfas	517,873	1,141,715	3%
tetracyline	4,611,892	10,167,481	28%
NIR	2,227,366	4,910,501	14%
sub-total	13,067,100	28,808,024	**79.8%**
HUMAN MED USE	3,300,000	7,275,255	**20.2%**
TOTAL	16,367,100	36,083,279	100%

Source: FDA

The ecological perspective: from genes to the microbiome (Davis et al COM 2011)



Genes/ Genotype
(SNPs, HGT, etc.)

Phenotype
(abx susceptibility, etc.)

Population
(e.g. The collective geno/phenotypes in a single bacterial species.)

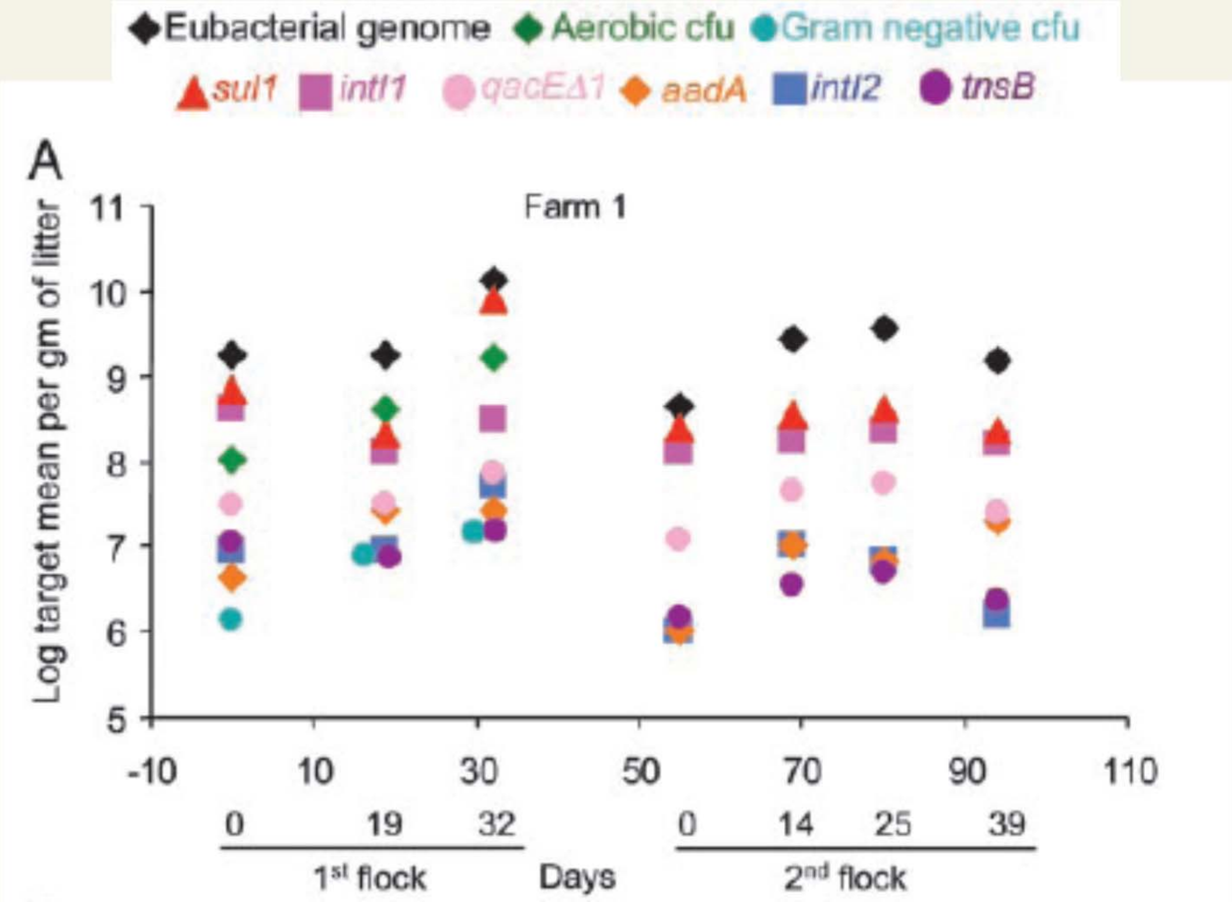
Community/Microbiota
(i.e., the collective bacterial populations present in a given environment.)

Microbiome
(i.e., the collective microbiota present in and on a host or a larger environmental setting)

Ecosystem: **1) Biotic**: Microbiome/microbiota Interaction with each other, with the hosts, and with other macroorganisms. **2) Abiotic**: Interaction with energy resources through production and consumption, as well as with environmental factors that impact microbial growth.

Webs of ABR transfer: on site waste pits and wild birds, Peru (photo C Arriola)

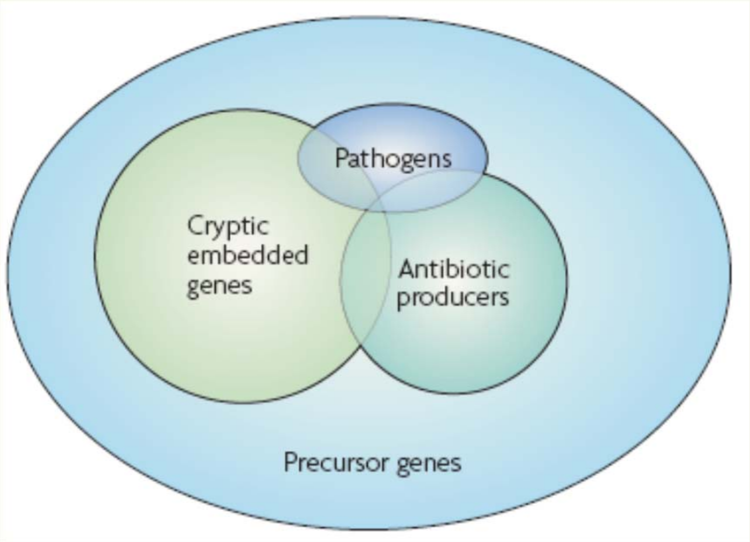
Building the resistome: resistance genes move from poultry litter into soil



Nandi et al (2004) PNAS 101:7108

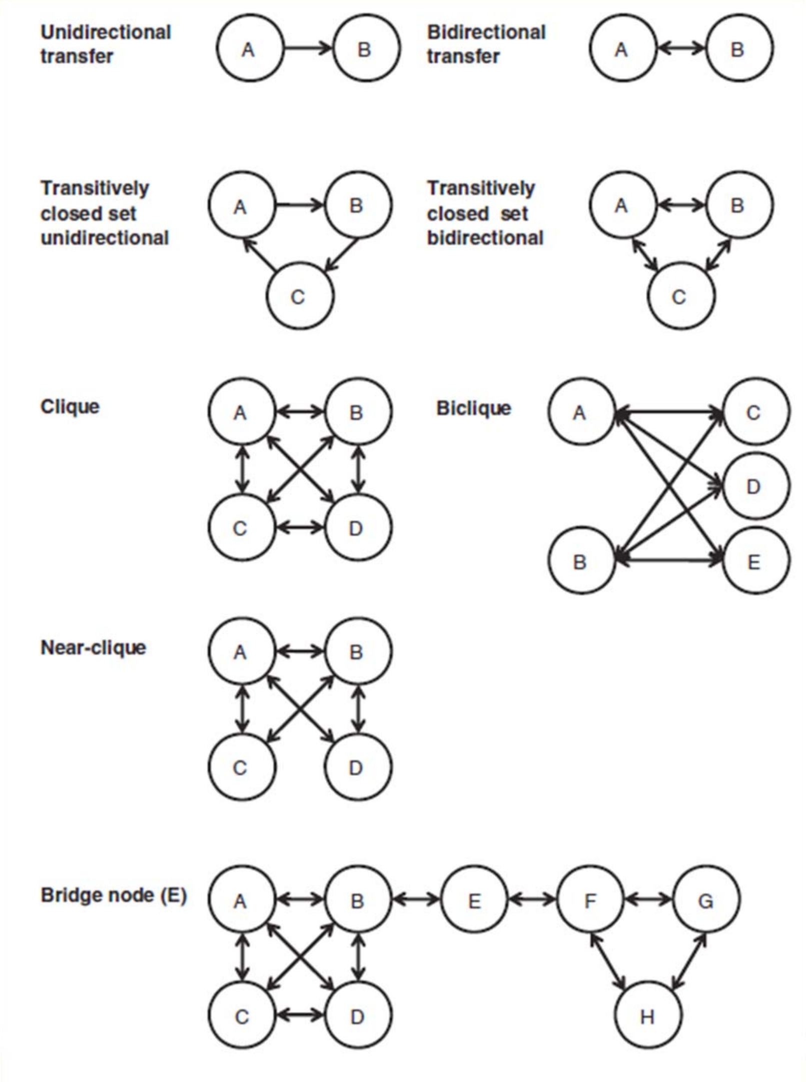
Going beyond bad bugs and good drugs: into the resistome

- Wright: the collection of all the antibiotic resistance genes and their precursors in the microbial community of both pathogenic and non-pathogenic bacteria.



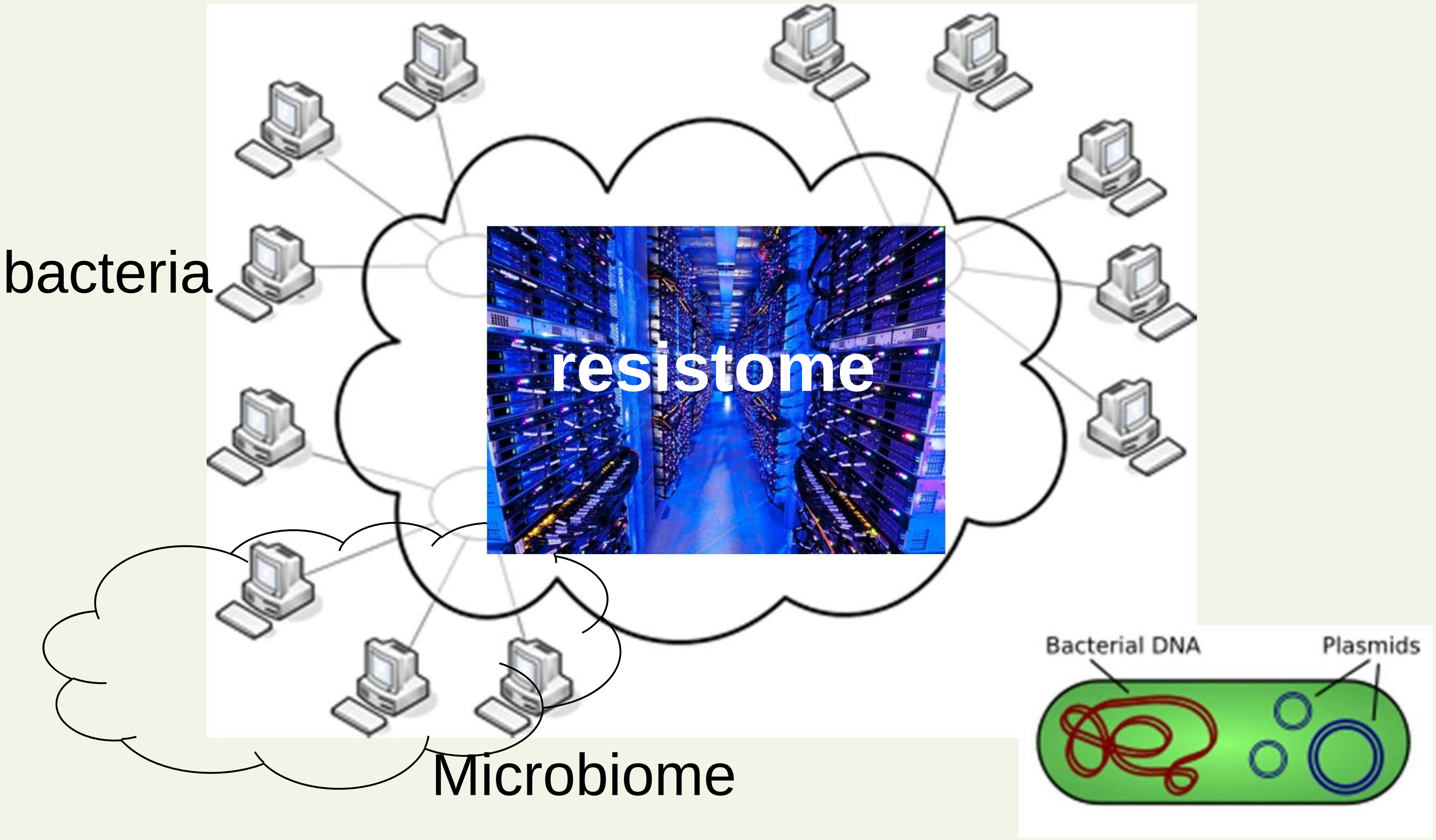
Wright GD (2007) Nat Rev Microbiol 5: 175

"Genetic exchange communities" (Skippington and Ragan FEMS Micro Reviews 2011



- A collection of organisms that can share genes by HGT
- Not necessarily in close physical proximity
- Cliques and frenemies

The resistome as cloud computing



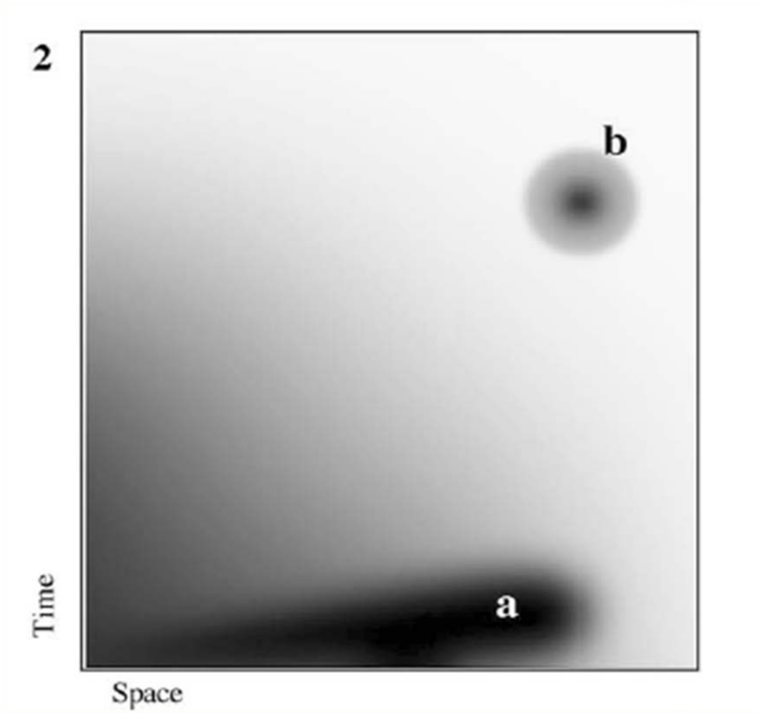
bacteria

resistome

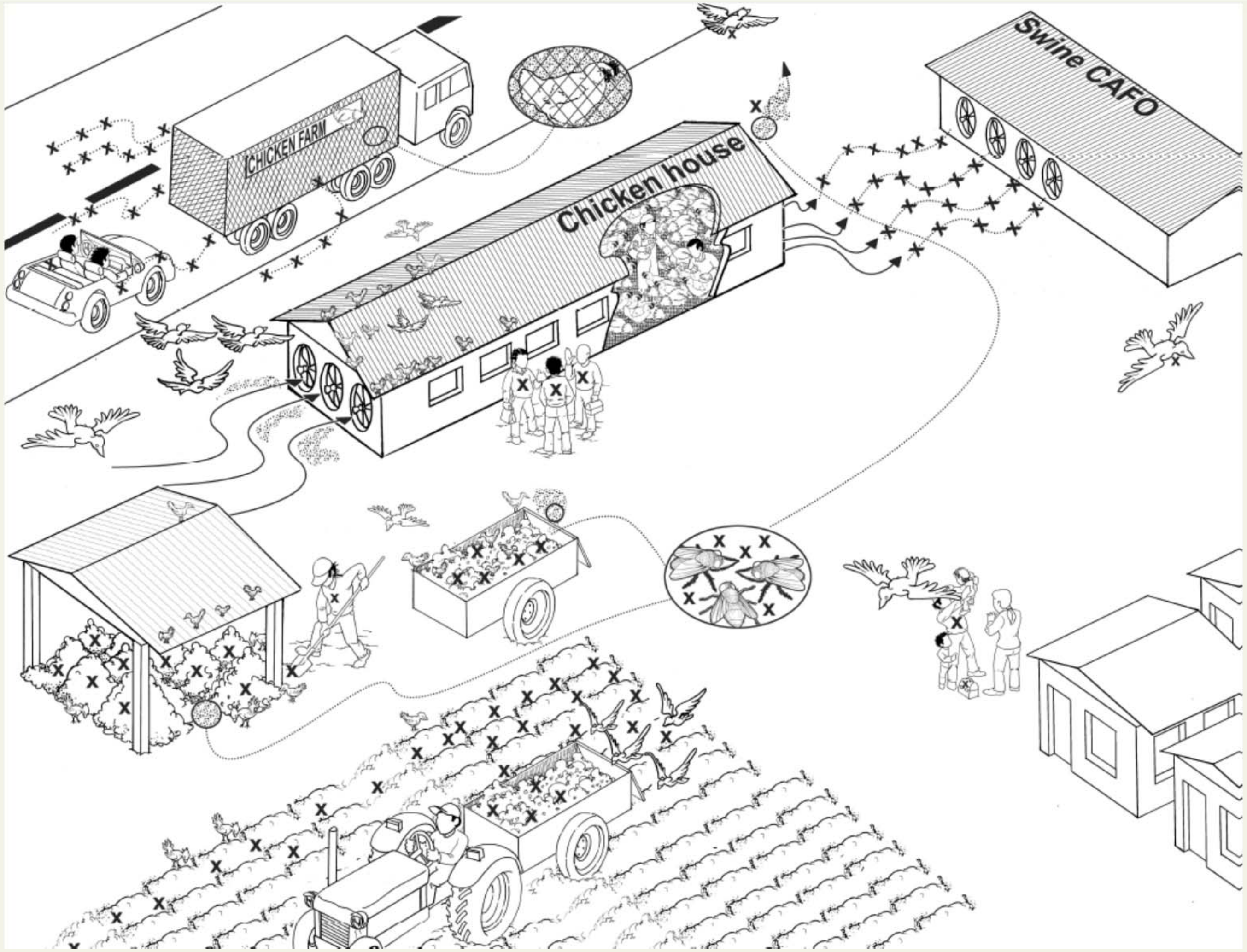
Microbiome

Antibiotics and antibiotic resistance genes as environmental pollutants (Martinez 2009)

- Antibiotics are mostly short lived in the environment but may be continuously added
- Antibiotic resistance genes are more stable
- AR genes may be “bioaccumulated” by microbiomes and persistent within the microbiome
  - The “cost of resistance” can be compensated for
  - Maintaining the resistome is prudent in a (human-made) sea of antimicrobial pressures



It's not just food: "From farm to populations" – before and after production of consumer products



Many microbiomes