

Evolution = Change in the genetic composition of a population over generational time

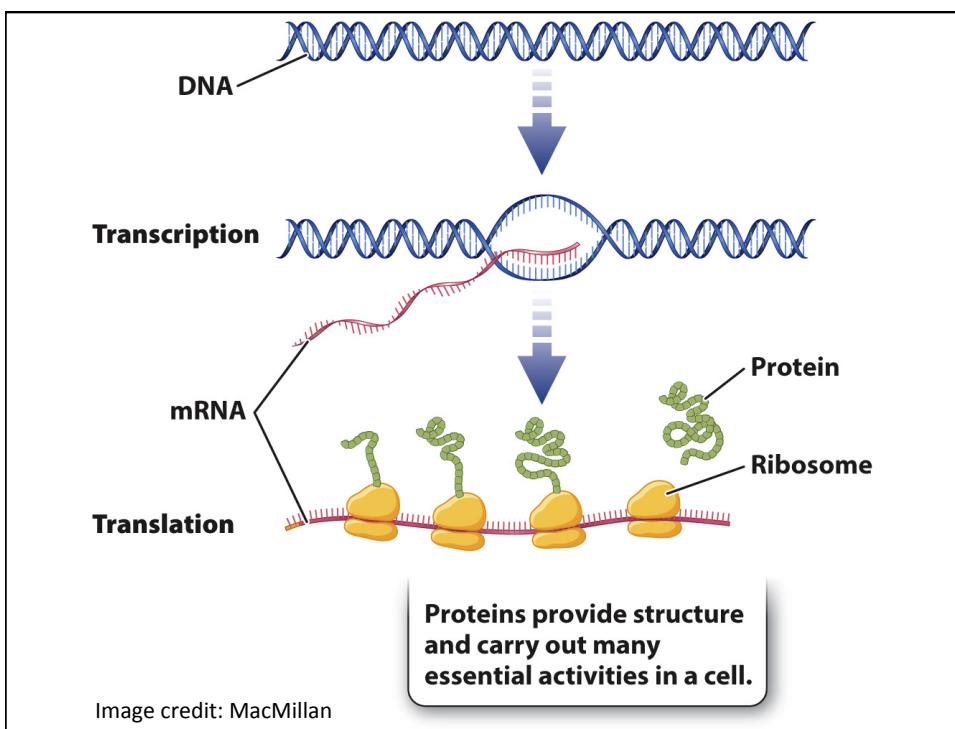
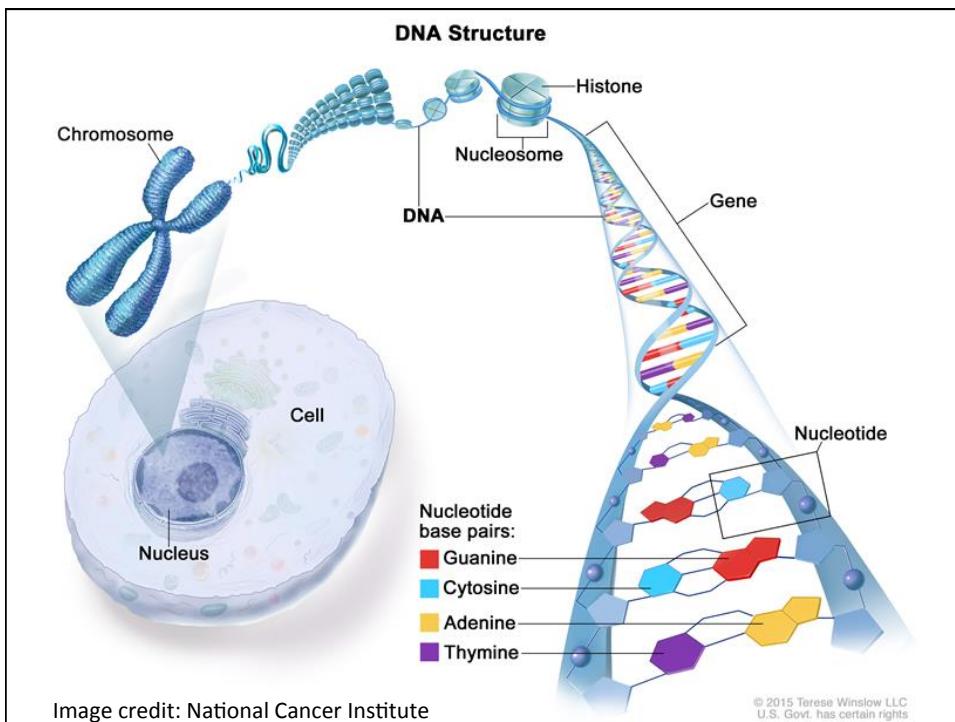
Evolution = Change in the genetic composition of a **population** over generational time

Population = group of individuals of same species coexisting in the same time and place with the potential of interbreeding

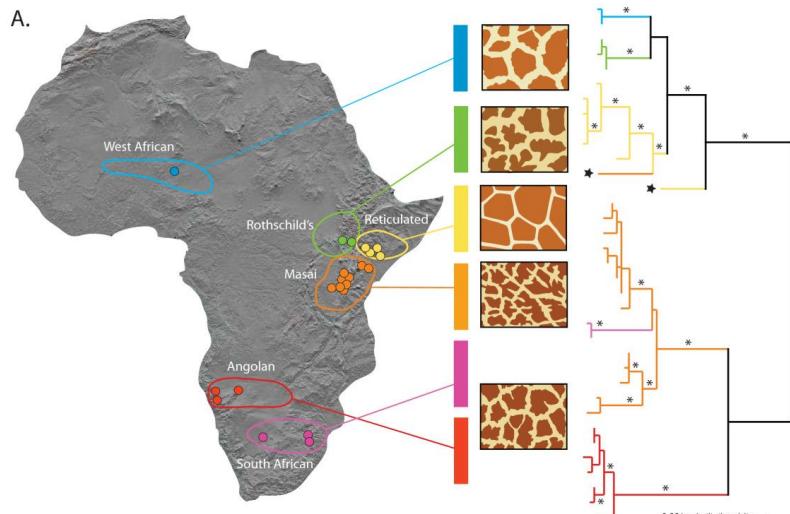


Emperor penguins (*Aptenodytes forsteri*). Image credit: Michael Van Woert / NOAA

Evolution = Change in the **genetic composition** of a population over generational time

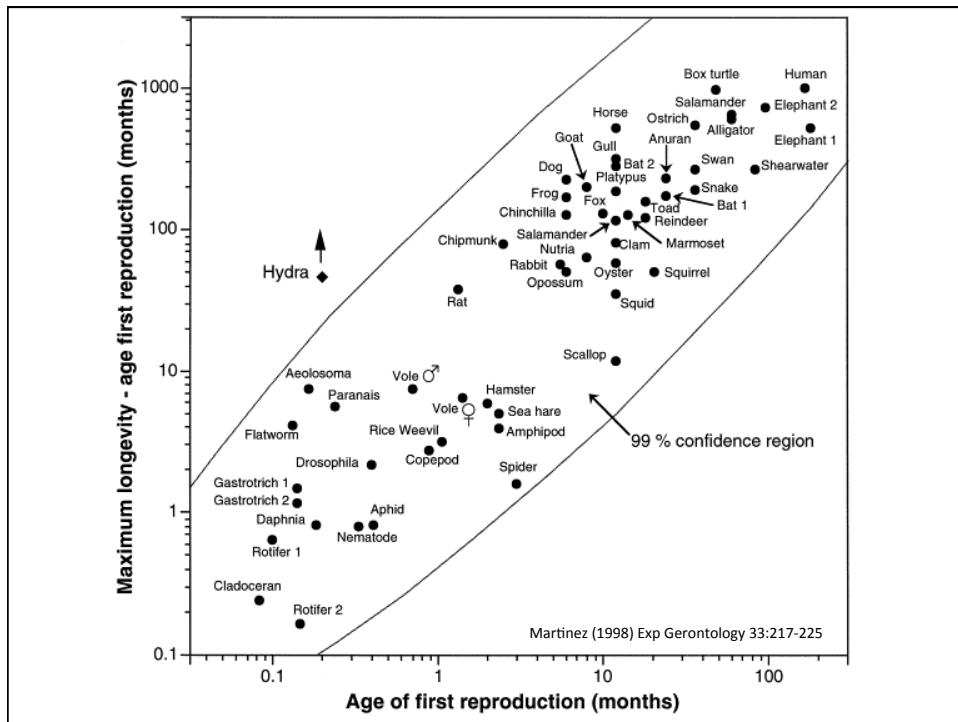


Six genetically distinct lineages of giraffes in Africa (mitochondrial DNA)



Brown et al. 2007. BMC Biology 2007

Evolution = Change in the
genetic composition of a
population over
generational time



Evolution by Natural Selection

1) If individuals in a population vary with respect to a trait that has a genetic basis, and ...

Trait = characteristic / attribute = morphological, behavioral, physiological, psychological, etc.

Evolution by Natural Selection

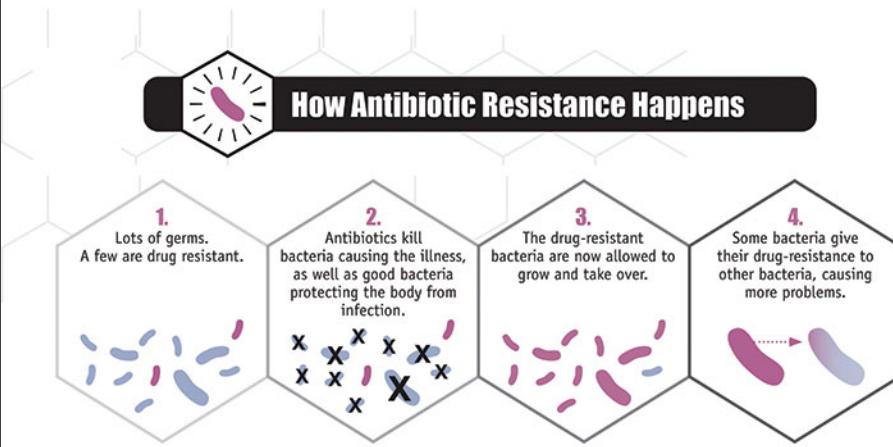
2) If variation in that trait is associated with variation in reproductive success, then ...

Reproductive success = viability, fertility, fecundity

Evolution by Natural Selection

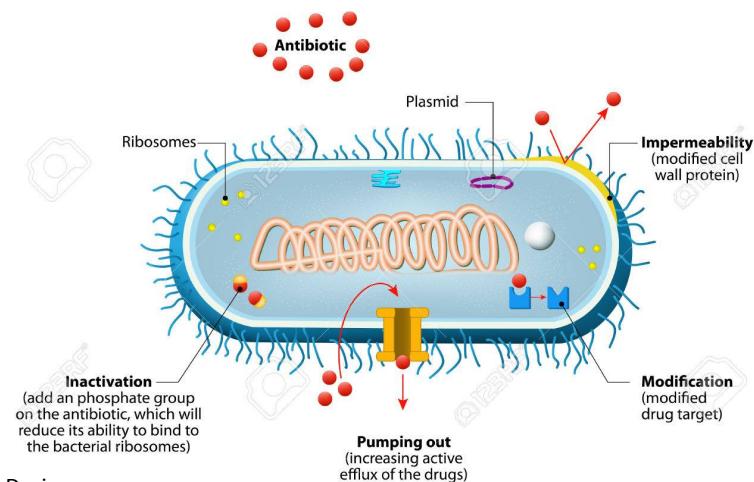
3) There will be an increase in frequency of those individuals having traits that increased reproductive success in the next generation.

Evolution happens



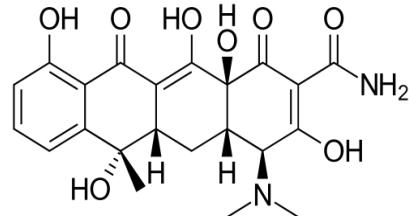
Evolution happens

MECHANISMS OF ANTIMICROBIAL RESISTANCE



Evolution happens

Tetracycline family



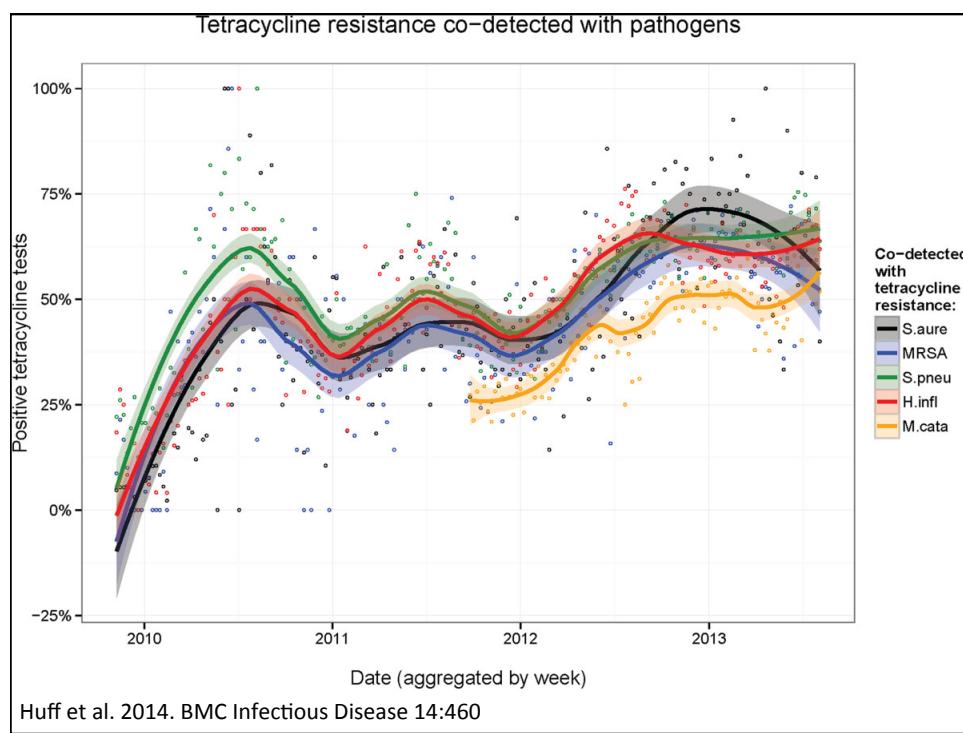
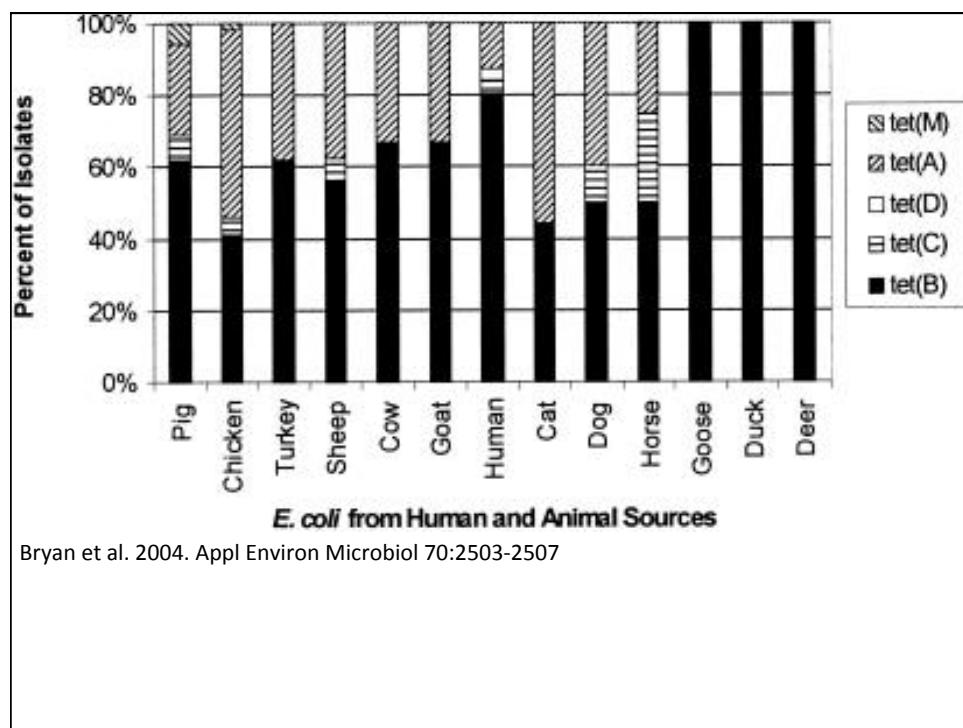
Passive and active transport

Binds to a 30S ribosomal subunit
and blocks binding of tRNA (so no
protein synthesis)

Evolution happens

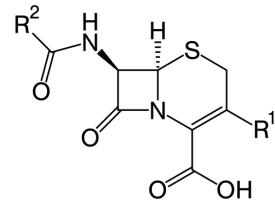
Tetracycline resistance?

- 1) Altered efflux pumps (*tetA*, *tetB*, *tetC*, *tetD*)
- 2) Altered ribosome structure (*tetM*, *tetO*, *tetS*)
- 3) Inactivation of tetracycline (*tetX*)



Evolution happens

Cephalosporins

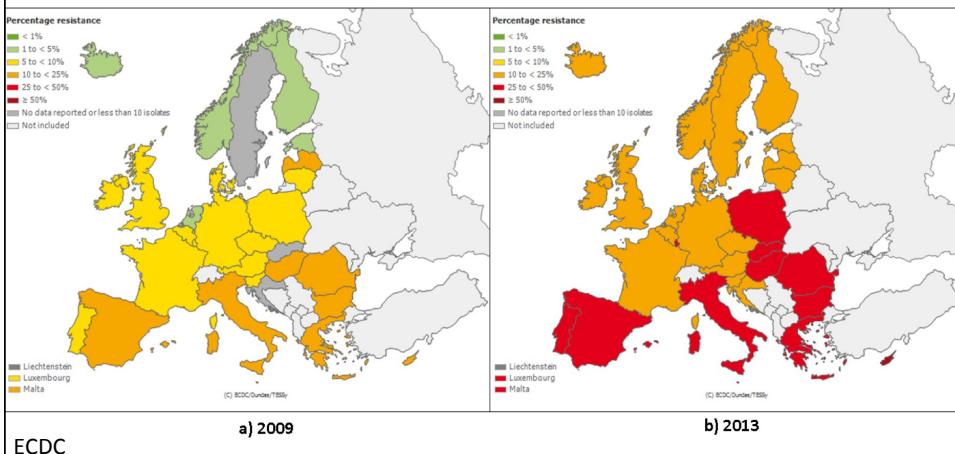


Passive and active transport

Binds to a transpeptidase and prevents cell wall synthesis

Evolution happens

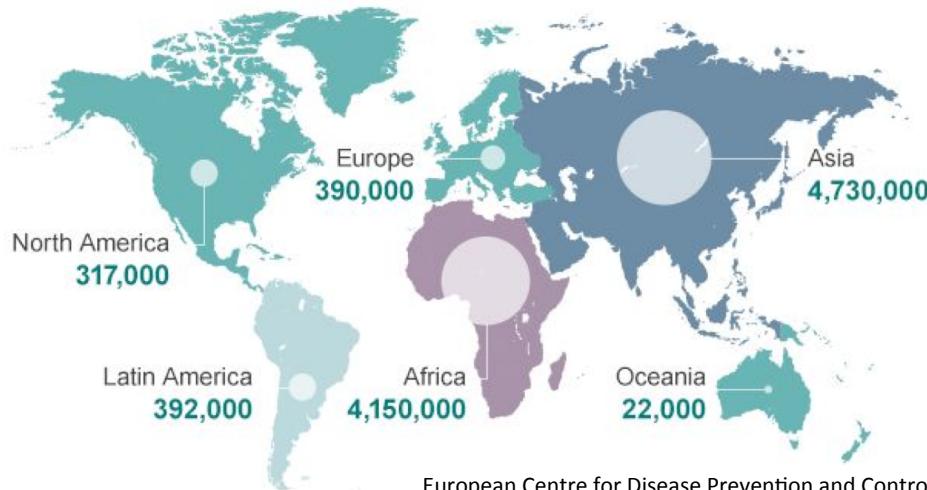
Escherichia coli resistant to cephalosporins across Europe in a) 2009 and b) 2013



Beta lactamases

Evolution happens

Deaths attributable to antimicrobial resistance every year by 2050



ECDC

- 1) Reduce selection pressure
- 2) Reduce transmission
- 3) Develop new antibiotics

Teixobactins (2015) & Malacidins (2018)

First new antibiotics in 30 years

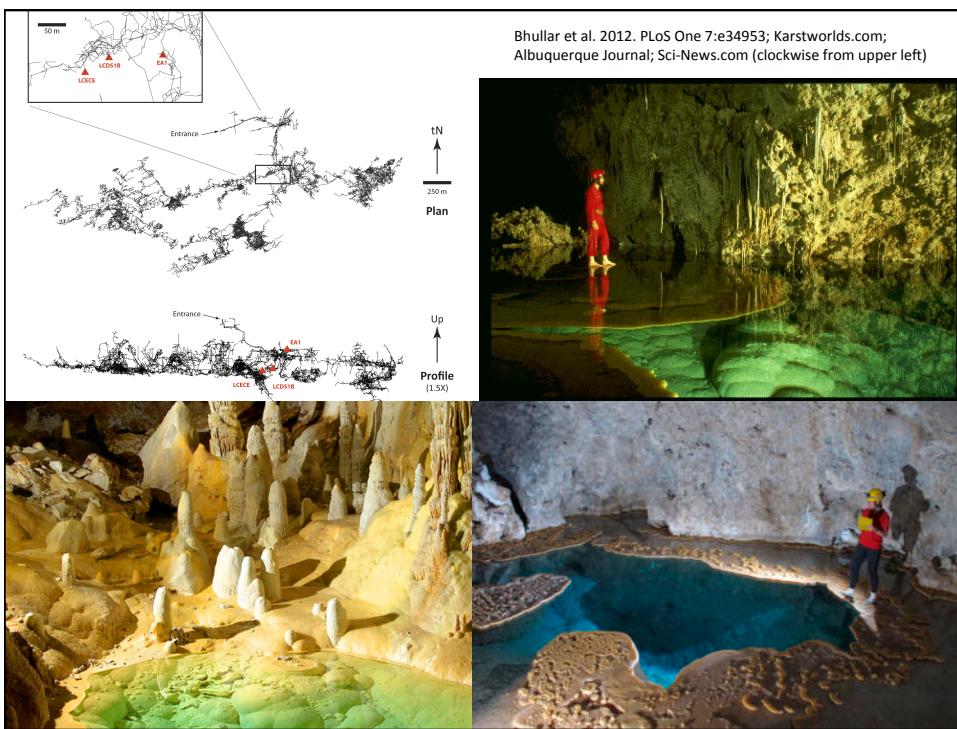
Discovered in soil bacteria

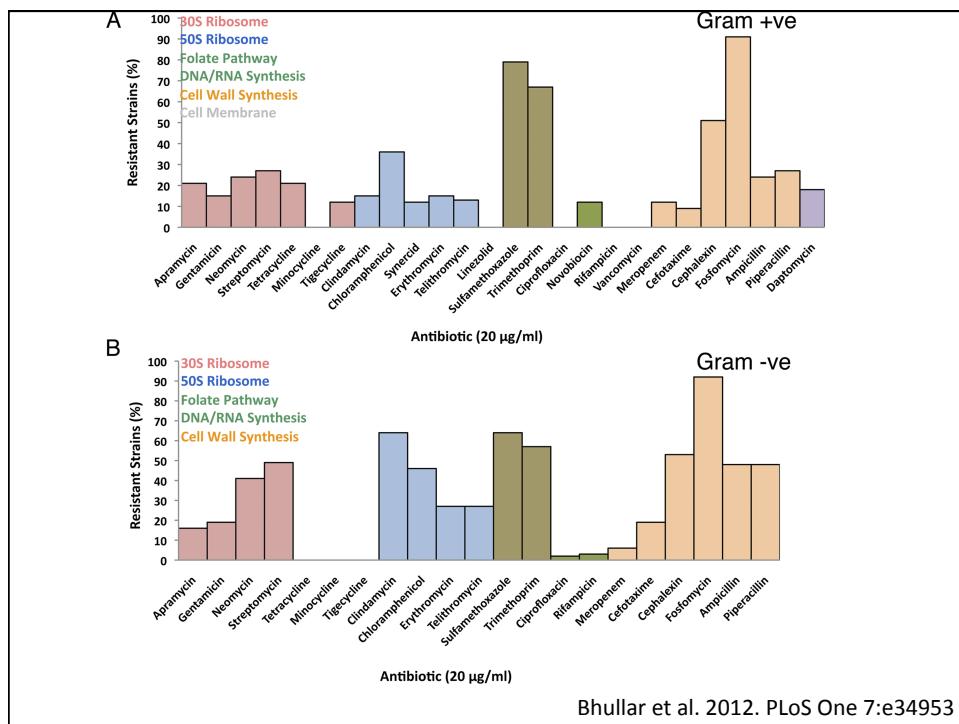
Inhibit cell wall synthesis

So far, no known resistance

Lechuguilla cave

Isolated from surface contact for 4MY





Here we use whole-genome sequencing, functional genomics and biochemical assays to reveal the intrinsic resistome of *Paenibacillus* sp. LC231, a cave bacterial isolate that is resistant to most clinically used antibiotics. We systematically link resistance phenotype to genotype and in doing so, identify 18 chromosomal resistance elements, including five determinants without characterized homologues and three mechanisms not previously shown to be involved in antibiotic resistance.

Pawlowski et al. 2016. Nature Communications 7: 13803

Generational time...

If we were a bacteria, today is 2018.

You entered class as sexually reproductive adults, and will leave class welcoming your great-grandchildren

Generational time...

If we were a bacteria, today is 2019.

Yesterday:

Emperor Hadrian built wall across England

Start of Classic Period for Maya

China's Three Kingdoms reunified under Emperor Jin

Warrior Queen Zenobia breaks with Roman Empire

Pyramid of the Sun and Moon completed

Birth of Prophet Mohammed

Generational time...

Humans = 25 years (estimate)

Bacteria = 20 minutes

~3 generations per hour	75 years
~70 generations per day	1,750 years
~500 generations per week	12,500 years
~2000 generations per month	50,000 years
~25000 generations per year	625,000 years

Drug development = 10 years...

Evolution of super resistant bacteria in 10 days (17,500 years)

E. coli vs. trimethoprim or
ciprofloxacin