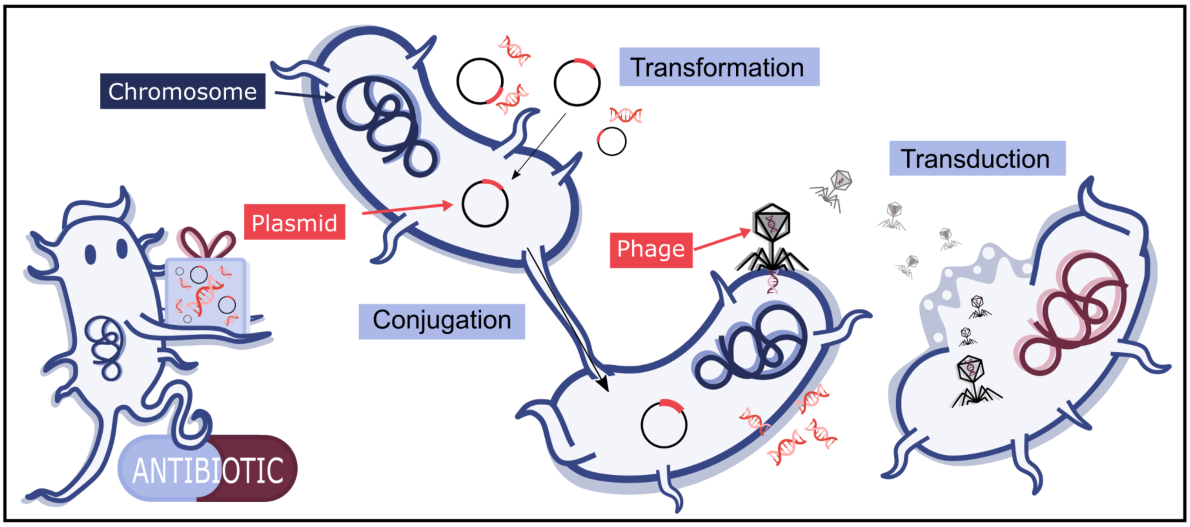
Antimicrobial Resistance Gallery

Genetic elements encoding and transferring resistance among microbes: Plasmids

(Ada Muñoz-Cazalla, Ignacio de Quinto, Paula Ramiro-Martínez, Laura Álvaro-Llorente)



Different strategies for obtaining antibiotic resistance genes by horizontal gene transfer. Plasmids carrying resistance genes can be captured from the environment as free DNA by transformation, or obtained directly from a neighbor cell by conjugation. Phages can also steal some resistance genes from bacteria, introducing them in a new one when infection occurs.

The problem of antibiotic resistance. Bacteria are everywhere, from the tops of mountains in Antarctica, to deep-sea vents, and even inside you! That is what we call the **microbiome**. The microbiome is made up of all bacteria (and other microorganisms) that live inside us (for example, in our gut) and on us (on our skin). While most of the bacteria living with us are harmless, a few of them can sometimes become harmful. When these harmful bacteria grow inside us, we get sick (that's what we call a **bacterial infection**). When we have an infection caused by bacteria, we have to treat it with medicines called **antibiotics**. Antibiotics kill harmful bacteria and make us feel better, but they don't always work. Bacteria, as small as they are, are incredibly complex and, sometimes, some of them are not killed by these antibiotics. When this happens, it can make it harder for us to treat infections and illnesses.

Plasmids. When bacteria are not affected by an antibiotic, we say that these bacteria are **resistant** to that antibiotic. They can become resistant in various ways. One crucial way bacteria become resistant is by swapping genes, like trading cards. These "trading cards" usually give them superpowers to resist antibiotics because these genes contain the instructions for the bacteria to be resistant. Resistance genes are often part of genetic elements called **plasmids**. Plasmids are independent circular DNA molecules that carry accessory genes: bacteria don't need them to live, but they give extra benefits to survive in some conditions, like in the presence of antibiotics. Because of that, they are one of the main drivers of resistance gene transfer across bacteria since plasmids can be transferred among different bacteria!

Horizontal gene transfer. Bacteria are pretty generous among themselves, and swap genes all the time. For example, when a bacterium dies, it leaves its genes and plasmids in the environment and other bacteria can capture them. This is known as **transformation**. Apart from catching genes from the outside, bacteria can obtain new genes from their neighbors. When they are close to one another, sometimes they can extend a kind of "pipe", called a pilus, through which these genes are exchanged. That's what we call **conjugation**. They can also gain foreign DNA thanks to bacteriophages (or "phages"): viruses that infect only bacterial cells. Viruses consist of their own genomes – DNA or RNA – and various proteins that provide the virus 'coat' and other functions, like making the virus genome. During an infection, the virus multiplies by taking over the host cell metabolic machinery to make virus genomes and proteins, which are then 'packaged' into mature virus particles that are then released to infect new host cells. During virus multiplication, newly-forming virus particles sometimes incorporate not only their own genomes but also bits of the host genome

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These different ways of gene-sharing among bacteria are collectively known as **horizontal gene transfer**, because it happens between all the microbes within an environment. So, horizontal gene transfer is when bacteria share their genetic secrets, like how to resist antibiotics. This means that even if only one single bacterium learns how to survive against antibiotics, it can spread this knowledge to other bacteria, making the antibiotic resistance spread more quickly. This is a big problem because no matter how many antibiotics the scientists develop, bacteria are going to find a way to survive them sooner or later. Our only chance is to continue developing new antibiotics and therapies to stay in the fight with resistant bacteria.

Exploiting HGT to curb resistance

The scientific community is exploring different ways to stop the spread of antibiotic resistance among bacteria. For example, **phages**, as we saw before, can spread antibiotic resistance, but we can use specific phages to kill only the bacteria that carry antibiotic resistance. We do this by tuning the virus through genetic engineering so that it will only kill harmful bacteria.

Another promising method involves using a tool called **CRISPR/Cas**, which acts as DNA scissors that we can control. CRISPR/Cas can find, cut, and eliminate resistance genes, preventing the spreading of antibiotic resistance to other bacteria in the environment. And we can use HGT to deliver designed CRISPR/Cas modules to pathogenic bacteria. Finally, when bacteria become resistant to one drug, they sometimes become more vulnerable to another. It seems that they get distracted focusing on fighting against one drug, and they forget about the rest. If we exploit this, we can use combinations of antibiotics to treat infections better. This is what we call **collateral sensitivity**, and is currently the more straightforward approach.

These methods still need to overcome challenges before they can be widely used in hospitals and there's still much to learn about how resistance spreads in natural environments. We need better tools to track resistance genes as they move between bacteria so we can focus our efforts on where they'll be most effective. By understanding these processes better, we can develop **new strategies to combat antibiotic resistance** and protect human health.

In the meantime, remember that even though antibiotic resistance looks pretty complicated to tackle, you can help to stop it. The first option is to only take antibiotics when necessary and to finish the medicines when the doctor says so. Also, you should always throw away unused antibiotics in the medication's specific containers. This will prevent them from spreading to nature.