

BACTERIA EVOLVING:

Tracing the Origins of a MRSA Epidemic

PASSAGE TWO

How Did MRSA Evolve?

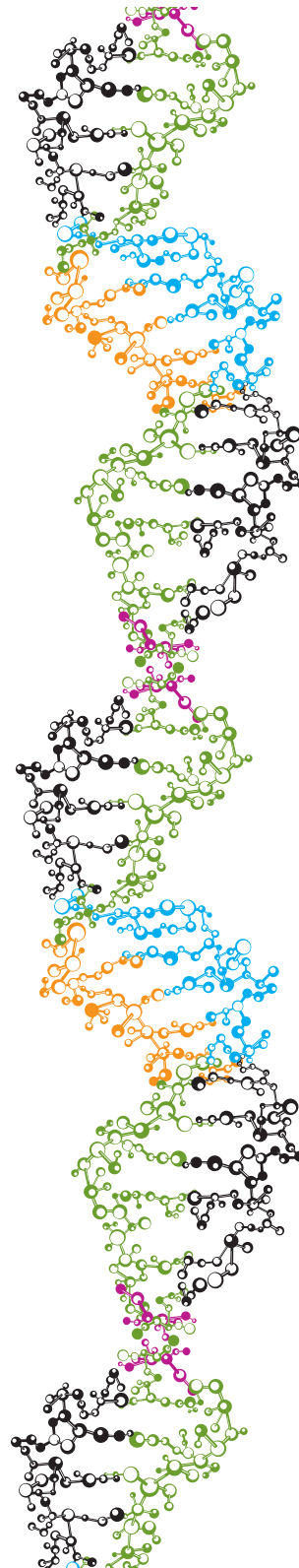
What allowed USA300 to thrive outside a hospital setting, and with such **virulence**? Scientists knew the answer lay in the bacteria's genome, the sum of all its genetic material. Within the bacteria's genome were the clues that could explain how the USA300 strain of MRSA had evolved.

Different Types of Mutations

Like all organisms, bacteria can acquire new traits through mutations. Mutations are any change in the sequence of DNA nucleotides within an organism's genome. The main cause of mutations are exposure to foreign chemicals or radiation, errors during DNA replication, and from insertion or deletion of DNA segments. If a mutation is beneficial, it gives the organism an evolutionary advantage by helping it and its descendants to survive in a new environment. This is the process of *natural selection*.

These types of mutations can happen in any organism. In bacteria, DNA can also be acquired through the process of DNA transfer. That means that bacteria can get whole new sets of DNA from other bacteria, creating sudden and dramatic changes in their genome. They can even do this with bacteria that are distantly related, the equivalent of a human being getting new genes from a cat.

This ability to pick up entire sets of foreign DNA is what makes bacteria evolution so sudden and unpredictable. Twenty-five percent or more of a bacterium's genome might be acquired in this way. It gives them a unique way of picking up genes that other bacteria have already tried out. That's a great evolutionary tool.



DEFINITIONS

DNA: Deoxyribonucleic acid is the organic molecule that forms the genetic material of an organism. Chromosomes are made of DNA.

gene: a section of DNA on a chromosome that encodes, individually or as part of a group of genes, for a specific hereditary trait.

genome: the complete genetic material or base sequence of an organism or species.

genotype: the genetic makeup of an individual or species.

phenotype: the observable characteristics of an organism or species, including its appearance, structure, behaviors.

selective pressure: a factor that affects the reproductive success of individuals in a population.

virulence: ability of some bacteria to cause serious illness.

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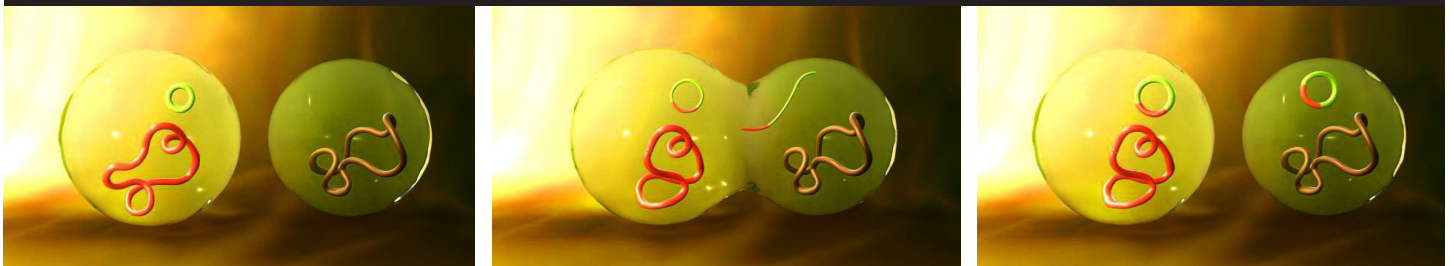
Figure 1: BACTERIAL TRANSFORMATION



Figure 2: BACTERIAL TRANSDUCTION



Figure 3: BACTERIAL CONJUGATION



DNA transfer in bacteria can happen in several ways.

- Bacteria can recognize loose pieces of DNA that are floating nearby. These pieces might come from a bacterium that ruptured. In a process called **transformation** (Figure 1), the bacterium can actively reach out and pull the loose DNA through its membranes.
- Viruses called bacteriophages can enter a bacterium and replicate inside it. At the same time, the virus can pick up DNA from the infected cell, move it over and inject it into another cell. The DNA becomes part of the second organism's genome. This process is called **transduction** (Figure 2).
- Bacteria can also trade DNA with each other, in a process called **conjugation** (Figure 3). In conjugation, two cells come close to each other and form a bridge or link between them. Then one of the bacteria transfers a bit of DNA to the other.

STEP BY STEP
These still images from an animation show three ways that DNA can be transferred in bacteria.

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How Did MRSA Evolve?**The Evolution of USA300**

In order to develop ways to combat MRSA infections, scientists needed to study its genetic material. They were especially interested in finding out what made the most virulent of the community-acquired strains of MRSA, USA300, different from the older, hospital-acquired strains.

The genome of USA300 had already been mapped, so the researchers were able to compare the DNA of USA300 with the genomes of other strains of *S. aureus* bacteria. When researchers did that, important differences jumped out at them. The USA300 MRSA had genes that had never been seen before in *S. aureus* bacteria, including a set of 34 genes called the Arginine Catabolic Mobile Elements (ACME) region. One of those 34 genes is one they called *speG*.

STOP AND THINK*Based on the text:*

- What kind of data are the scientists collecting? How does this compare to your answer from Passage 1?
- What are the implications of DNA transfer for the development of antibiotic resistance in bacteria?
- How does natural selection explain the development of antibiotic resistance?

Looking ahead:

- What experiments could the scientists design to find out whether the *speG* gene is responsible for USA300's unique characteristics?

**HOW ANTIBIOTICS CREATE
DRUG-RESISTANT BACTERIA**

Natural selection explains how the overuse of antibiotics leads to new strains of drug resistant bacteria. In all organisms, members of the same population have slightly different genes or DNA. Because of genetic variation within bacteria populations, some members can be easily killed off by antibiotics, while others will not. If the population is repeatedly exposed to an antibiotic, the **selective pressure** in the population will allow the most drug-resistant bacteria to survive. Over time, you have a population in which all the members are drug-resistant.