Bacteria Evolving:

Tracing the Origins of a MRSA Epidemic

STUDENT VERSION

PASSAGE FOUR

The Human Microbiome

To solve the mystery of the origins of USA300, researchers looked to the microbiome that lives on human skin. They knew that within this vast, microscopic ecosystem lives a network of organisms that compete with each other, co-exist with each other and are constantly evolving. If USA300 acquired the speG gene, it was most likely from some other bacterium or organism that is part of this ecosystem. And that is exactly what they found. USA300 had gotten its new abilities from another staph species, *Staphylococcus epidermidis*.

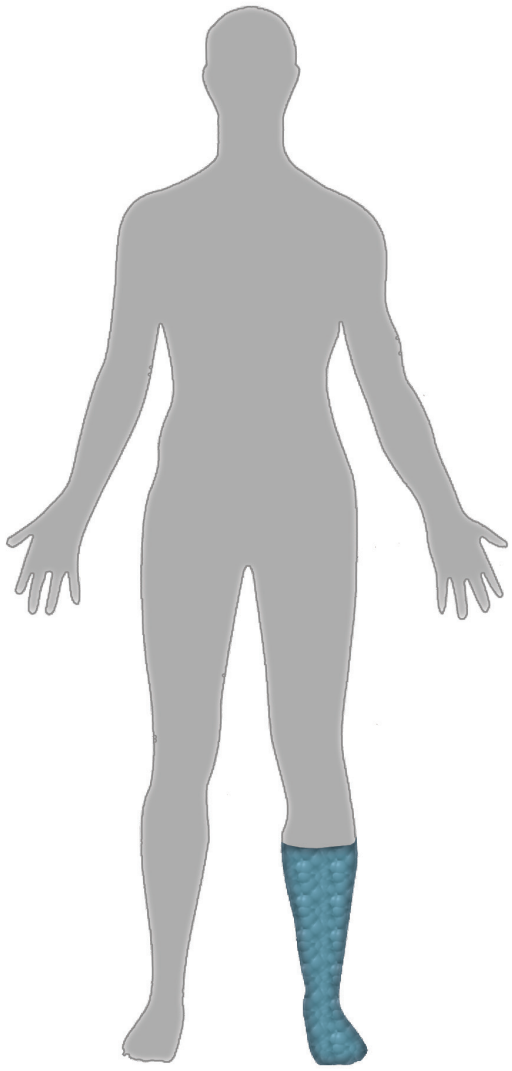
The Source: *S. epidermidis*

Staph epidermidis is a type of *Staphylococcus* that is closely related to *Staphylococcus aureus*. Like *S. aureus, S. epidermidis* has adapted to live on human skin. Although it's quite common, it usually causes no health problems. One reason that *S. epidermidis* can colonize human skin so effectively is that it has the ACME region, the mobile element of DNA made of 34 genes. This is the set of genes that includes the speG gene.

Thanks to its genome, *S. epidermidis* is resistant to methicillin and related antibiotics. However, *S. epidermidis* rarely infects us, so the fact that it is drug resistant is usually not a problem. But what seems to have happened is that *S. epidermidis* bacteria were living in close contact with *S. aureus* bacteria on human skin and at some point *S. epidermidis* transfered the ACME DNA, including the speG gene, to *S. aureus*. This might have made it possible for *S. aureus* to spread more easily from person to person, and made MRSA infections harder to fight.

Co-Evolving with Humans

S. epidermidis and *S. aureus* are just two of the many microorganisms that colonize human skin. In addition to thousands of types of bacteria, our skin is home to viruses, fungi, mites and other microscopic organisms. These microorganisms are adapted to live in a variety of different environments in and on



ONLY 10% OF YOU IS ACTUALLY YOU!

There are ten times more bacterial cells than human cells in your body. Bacteria cells are much smaller than human cells, but if all cells were the same size, your human cells would fit in your foot and lower leg, as illustrated here.

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The Human Microbiome

our bodies. In addition, the microbiome varies from person to person. In other words, different people are home to different sets of microorganisms.

Most of these organisms are not invaders. They have evolved over millions of years to live with human beings. For example, most bacteria cannot survive direct sunlight, but many of the bacteria that live on us have pigments that protect them from ultraviolet light. At the same time, humans have evolved to live with bacteria. We have *co-evolved* or evolved together and formed complex relationships.

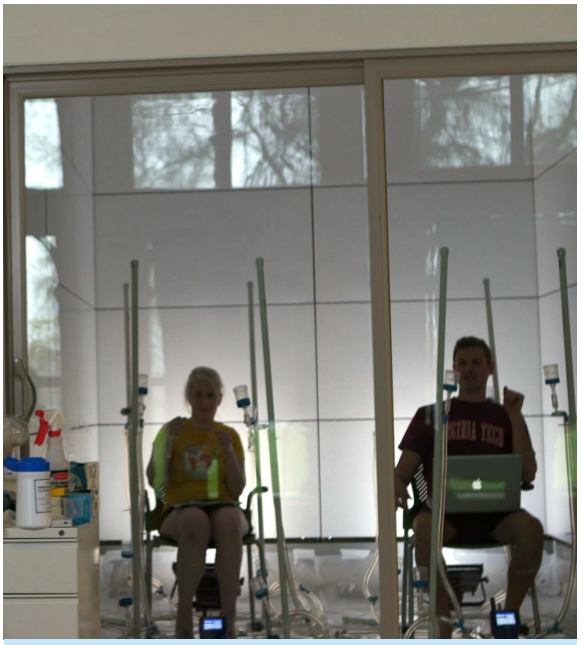
Scientists are still trying to understand what roles these organisms play, if any, but it seems that most are benign or even beneficial to us. Scientists call these *commensal* bacteria (if they are harmless) or *mutualistic* (if they offer a benefit). For example, some types of *Staphylococcus* produce fatty acids that inhibit the growth of fungi and yeast on our skin.

Sometimes bacteria that are harmless or even beneficial in one place can become harmful in another. *Propionibacterium acnes* lives on the skin but if it becomes trapped in a hair follicle, it causes inflammation and acne. *S. epidermidis* is usually harmless but it can travel into the body on catheters and other medical equipment and cause infection.

Competition in the Biome

At the same time, all of these microorganisms within the microbiome are competing with each other, just as organisms do in any ecosystem, and bacteria are just one part of these interactions. For example, fungi compete with bacteria for space and resources. Tiny mites that live in our pores eat the fungi. Some of this competition is beneficial to us because our resident microorganisms fight off potential invaders.

The competition between fungi and bacteria is why we have antibiotic medicines. These anti-bacterial chemicals were not invented by human beings but were developed by fungi as they competed with bacteria over millions of years of evolution. Scientists discovered these chemicals and learned how to produce



HUMAN BACTERIAL CLOUD

How do scientists study the human microbiome? How can they get a good picture of which organisms are residents of our bodies? One way is to create a sterile environment or "clean room," place a person in that room, and then find out which microorganisms have been brought in by the human being.

James Meadows, a researcher at the University of Oregon, helped construct a "clean room" experiment. Scientists sealed off a room, sterilized it as much as possible, filtered the air coming in, and then divided it into two chambers. One chamber was kept empty while a person entered the other chamber and sat down.

The scientists found that after repeating the experiment multiple times, they could always tell which chamber the person had entered by measuring the bacteria that had come off his or her body. Not only could they always tell which chamber had been occupied, they could also identify different people from their bacterial "clouds."

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The Human Microbiome

them. But now we may be overusing these chemical weapons and destroying helpful bacteria along with the harmful.

Being Human Means Having a Microbiome

Although hand sanitizers and antibiotics have saved millions of lives, their overuse can wreak havoc on our microbiome.

We are covered in bacteria and other microorganisms from the time we are born. And there is mounting evidence that a healthy microbiome is essential for a strong immune system. Some scientists think that preventing infants from developing a balanced microbiome through lack of exposure to microorganisms might lead to increased allergies, asthma, eczema and other health problems.

Of course, we have to find ways to stop dangerous bacteria like MRSA and other infectious organisms. But as scientists like James Meadows point out, we have to learn to do this in a selective, balanced way. A blanket approach to fighting bacteria creates health risks we still don't understand.

So rather than think of all bacteria as dangerous or harmful, we have to understand that they have always been with us and are an essential part of our microbiome, which is an essential part of our bodies.

STOP AND THINK

Based on the text:

- **Describe how the scientists at the University of Oregon study the human microbiome?**
- **What are the benefits of having a diversity of microorganisms living in and on our bodies?**

Wrap-up:

- **Consider all four passages and the science practices listed below. By giving specific examples, explain how the scientists in the videos and reading passages apply each of the practices.**
  - **Asking questions**
  - **Developing and using models**
  - **Planning and carrying out investigations**
  - **Analyzing and interpreting data**
  - **Using mathematics and computational thinking**
  - **Constructing explanations**
  - **Engaging in argument from evidence**
  - **Obtaining, evaluating, and communicating information**