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How can we find out about ancient Egyptian germs?

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Abstract

Microbes are everywhere on Earth. They're in the soil, the rocks, the oceans, and in your body! The organisms living on you are called your microbiome. Your microbiome is important for your health. We wanted to know if we could use DNA to learn about the microbiome of mummified ancient Egyptian people. We used a new technique that matches up broken pieces of DNA. On the mummies, we found microbes that can cause gum disease. We also found evidence of germs that cause leprosy, hepatitis, and other infectious diseases.

Introduction

Your health depends on your *microbiome*. This is all the *bacteria*, fungi, *viruses*, and other microorganisms that live on and in your body. Some of these microorganisms help you digest food. Some of them make you sick. Some of them are mysteries!

? for the curious

Pathogens are organisms that can cause diseases. These usually don't live on your body, but are spread through infection. Knowing what pathogens existed long ago also helps us know how they evolved.

Most scientists studying the microbiome focus on people who are alive. But learning about the microbiome of people from long ago could help us understand what challenges those people faced. We can use *ancient DNA* (aDNA) to study the ancient human microbiome.

The mummies of the people we studied came from Abusir el-Meleq, Middle Egypt.

It is hard to work with aDNA! Heat, humidity, and age make DNA molecules fall apart. That's why aDNA usually only exists in fragments (broken pieces). For a long time, the technology to read DNA wasn't good for reading aDNA. Methods that work for modern, intact DNA don't work well for ancient, fragmented DNA. But new methods and more powerful computers make it possible to reconstruct *genomes* from aDNA. Other scientists used this method to study aDNA from humans and animals. But until now, no one had ever used this method to identify ancient microorganisms in *mummified* ancient Egyptian people!

Methods

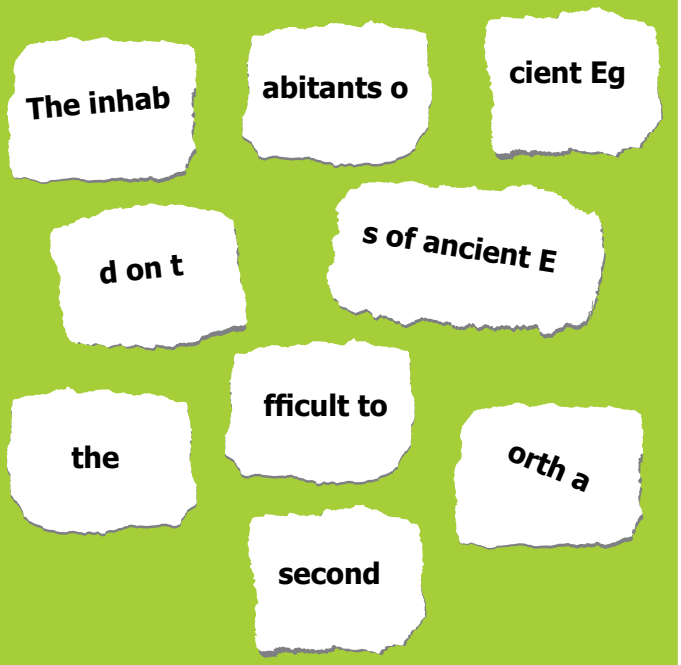
We extracted DNA from tiny samples of the bones, soft tissue, teeth, and *tartar* of mummified people. We analyzed a total of 133 samples from 119 mummies. The archeologist Otto Rubensohn excavated these people's mummified remains between 1902 and 1905. These people lived in Abusir el-Meleq, Middle Egypt, which was inhabited at least from 3,250 *BCE* to 700 *CE*.

Can you imagine shredding a whole bookshelf and trying to put the books back together again? Reconstructing the full *DNA sequence* from an ancient bacterium is a bit like that.

We used a new technology designed to reconstruct DNA from mixed-up pieces. It reads the genetic code in each fragment, starting at each end. The two ends of the sequence are merged together. The computer compares the merged pieces to a library of known genetic sequences. With enough matches (and a powerful enough computer), we can identify the species. We can also reconstruct the majority of its genome!

Since this method reads all the DNA sequences it can find, we needed to make sure we weren't just finding microbes from the environment. We compared the DNA we found on the mummies with DNA found in soil from Egypt. We also wanted to be sure the DNA was actually ancient. Just like paper turns brown and crumbly with age, there are signs we can look for in DNA to help us know how old it is. Seeing damaged DNA in our samples gave us confidence that we really were finding ancient DNA.

Let's say you pick up several shredded pieces of a document. You think there might be the following two sentences somewhere in the document:
"The inhabitants of ancient Egypt relied on the Nile floods."
"The desert sands make travel difficult."
To test your hypothesis, you can look at the bits of words that you can see clearly enough on the document. Imagine that you can see all these pieces:



Which sentence could these come from? The idea is that if enough of the pieces match, you can confidently say whether each sentence is there.
From this example, you can see that the only match to the second sentence is "the" but there are many matches to the first sentence.

Results

We successfully reconstructed the genomes of *Mycobacterium leprae*, the bacterium which causes *leprosy*. The leprosy bacterium that we found is 2,200 years old. As far as we know, that makes it the oldest ever found! We compared it to other *strains* of the bacterium. The leprosy bacterium strain we found is related to modern strains found in West Africa and Brazil.

We also reconstructed the genome for the *hepatitis B virus* (HBV). By our estimate, the HBV we found is 2,000 years old. We found 3 other bacteria in the samples of bone and soft tissues. *Proteus mirabilis* causes urinary tract infections and wound infections. *Enterococcus faecalis* and *Enterococcus faecium* live in the intestines of healthy people, but they can cause serious illness if they get somewhere else in the body.

In the tooth and tartar samples, we identified many *oral* bacteria. We found evidence of three bacteria that cause gum disease.

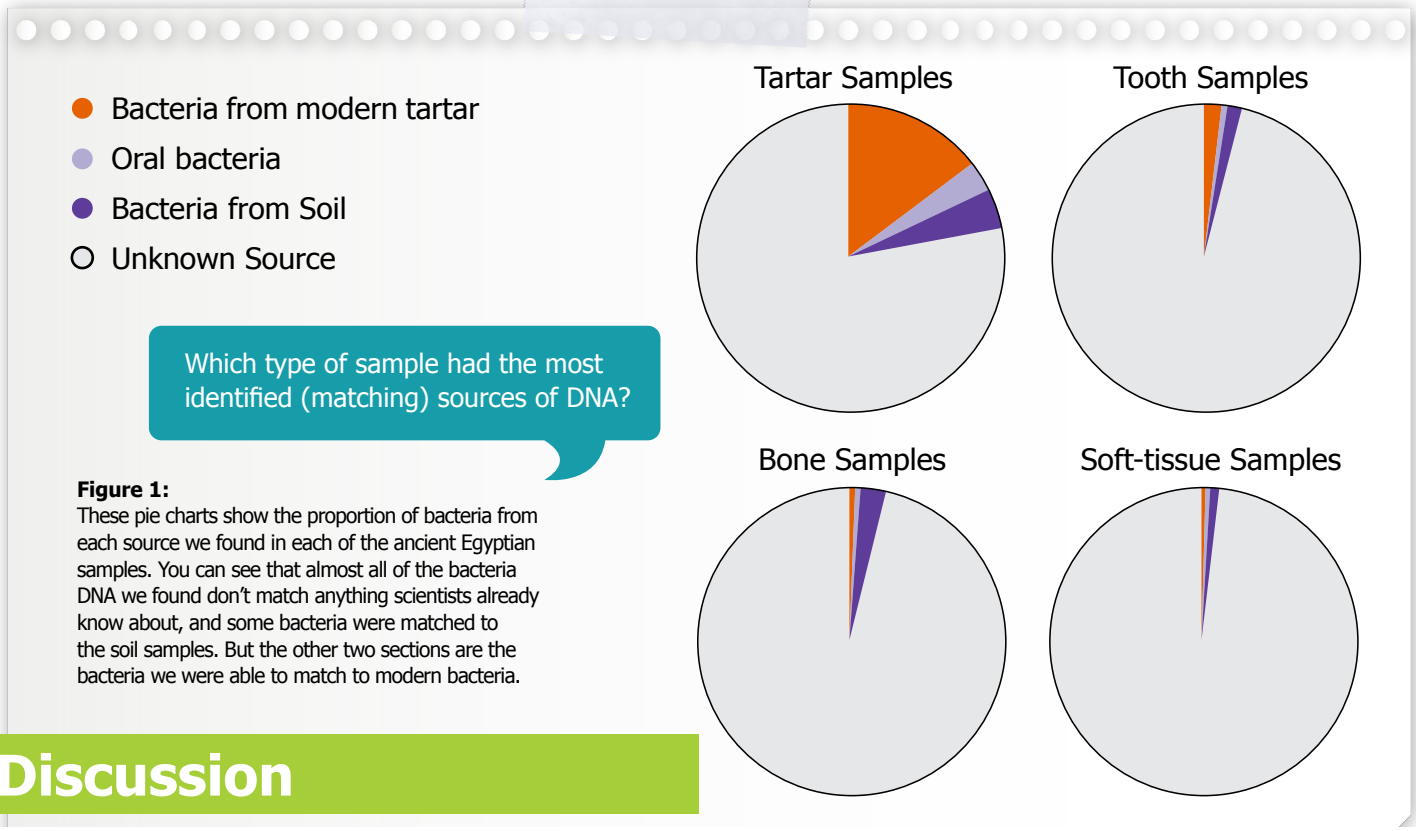


Figure 1:
These pie charts show the proportion of bacteria from each source we found in each of the ancient Egyptian samples. You can see that almost all of the bacteria DNA we found don't match anything scientists already know about, and some bacteria were matched to the soil samples. But the other two sections are the bacteria we were able to match to modern bacteria.

Discussion

We showed that it is possible to sequence DNA from mummified ancient Egyptian people. We reconstructed the genome of two ancient pathogens. We found signs of other bacteria as well, including some common species that live in the mouth. Much of the DNA we found didn't match anything in the library of known DNA sequences. This is because no one has studied the vast majority of microorganisms in the *environmental microbiome* yet.

We found other microorganisms that help with decomposition. They would not have been on the people we studied while they were still alive. Some of the unknown DNA could be from microorganisms that were common 2,000 years ago in Egypt but are less common now. We hope that our success in finding ancient pathogens helps other scientists find out about the germs of the past.

Conclusion

When you see Egyptian mummies in books and museums, it's important to remember that they are mummified people who lived long ago. Like us, they lived in a world of microbes. They struggled with many of the same diseases that people today suffer from.

We are lucky to live in a world where vaccines and antibiotics exist! For example, the vaccine against Hepatitis B is available to almost all children in the world, and leprosy is now curable by antibiotics. You can help make sure you and your family stay healthy by getting all recommended shots and taking antibiotics only the way your doctor prescribes.

Glossary of Key Terms

Ancient DNA (aDNA) – DNA from long, long ago.

Bacteria – single-celled organisms with cell walls but no nucleus.

BCE and CE – Before Common Era and Common Era. This article was written in 2021 CE. If something is older than 2,021 years, we write the year as the number of years before Year 0. Something that is 2,022 years old would be from 1 BCE.

DNA – deoxyribonucleic acid. DNA is a complex molecule that contains genetic code. The genetic code in DNA contains the instructions for making an organism.

DNA sequence – the exact order of the bits of DNA. DNA sequencing is the process of working this out.

Environmental microbiome – the set of microorganisms living in soil, air, and water.

Genetic – related to genes, which are sections of DNA.

Genome – the complete set of genetic information in an organism.

Hepatitis B virus (HBV) – a virus that infects the liver.

Microbiome – the set of microorganisms living in an organism.

Leprosy – an infectious disease that mainly affects the skin.

Mummy – the preserved body of a dead organism. Mummification can happen naturally, like in desert caves or ice. Egyptian mummies are the remains of people whose bodies were cleaned and treated with chemicals after death to prevent decay.

Oral – involving the mouth.

Pathogen – any organism that causes disease; also known as germs.

Strain – a distinct variety within a species.

Tartar – a hard substance that builds up on teeth.

Virus – a small piece of DNA inside a protein coat that replicates inside other cells.

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Check your understanding

1 Why do scientists want to know what was in an ancient person's microbiome?

2 What makes ancient DNA hard for scientists to work with?

3 How did the researchers make sure that the microorganisms they found were ancient?

4 This study showed that it is possible to find DNA from ancient microorganisms on Egyptian mummies. Where do you think scientists should look next for ancient germs? Why?