# Antibiotic resistance found in ancient bacteria

By Emily Chung, CBC News

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*Modern soil bacteria make a variety of compounds,some of which generate the colours shown above and some of which have antibiotic activity. Gerard Wright/McMaster University*

The same genes that make disease-causing bacteria resistant to today's antibiotics have been found in soil bacteria that have remained frozen since woolly mammoths roamed the Earth.

“We’ve shown for the first time that drug resistance is a really old phenomenon and it’s part of the natural ecology of the planet,” said Gerard Wright, a biochemist at McMaster University in Hamilton, Ont.

He led the study that was published online Wednesday in the journal Nature.

Wright said this evidence of ancient genes may explain how today's disease-causing bacteria have so quickly become resistant to modern antibiotics.

He also suggested that these findings, which involved the study of one type of bacteria that lived in one location, in the Yukon, 30,000 years ago, might just be the tip of the iceberg.

“Surely this history goes back millions of years,” he said. “We just don’t have those samples yet.”

## DNA analysis technology

The type of DNA analysis traditionally used in archeology, forensics and genetic screening is polymerase chain reaction or PCR, which amplifies short sequences of DNA that are later pieced together. The problem is that DNA degrades over time, so that ancient DNA tends to be in very small fragments, which are difficult to piece together.

"It’s like taking Wikipedia and chopping all the words into two-letter words and then trying to reassemble it,” says McMaster researcher Hendrik Poinar.

More recently, researchers have developed a technique called targeted enrichment, which was used to probe for the antibiotic resistance genes in the Gerard Wright study.

“It's like a fishing rod that has bait specific for a type of fish,” Poinar said.

Designed specifically to hunt for a particular bacterium, this approach will pull up many small, overlapping pieces of DNA from different parts of the genome of that bacterium.

Wright had conducted a study five years ago to see how prevalent antibiotic resistance was among common soil bacteria called Actinobacteria, which do not cause disease in humans.

“You know how dirt has that dirty dirt smell? That smell of earth? Well, that’s caused by [this type of] bacteria,” he said.

What he found in that study was that many of these bacteria were resistant to multiple antibiotics. That was true of both bacteria in urban and agricultural sites, as well as those in remote parts of northern Ontario. Still, to be certain the bacteria had never been exposed to human antibiotics, he needed to find bacteria from a pristine environment isolated from the modern world.

Duane Froese, a geologist at the University of Alberta, and Grant Zazula of the Yukon government's paleontology program, had a solution. They gathered samples of permafrost in the Yukon that was buried under a layer of ash from a volcanic eruption 30,000 years ago.

"Samples taken immediately below that are essentially the same age," Froese said.

The permafrost contained ice wedges, which form when the ground is so cold that it cracks open allowing water to freeze inside. The wedges can only form at the surface and their presence deep underground shows that the permafrost had never melted since it was buried.

The researchers tested the samples in the lab of Hendrik Poinar, a McMaster University anthropologist who specializes in DNA analysis. They found it contained DNA from ancient mammals, like the mammoths and horses that roamed the Yukon 30,000 years ago, but no modern mammals such as moose or elk. That confirmed that the bacteria was not contaminated with soils from above the ash layer.

The samples also contained DNA for at least a hundred species of bacteria, including Actinobacteria. And the Actinobacteria DNA contained genes that made it resistant to beta-lactam, tetracycline and glycopeptide antibiotics, including vancomycin.

### 'Remarkable little chemists'

Wright said that's not surprising, since that type of bacteria is the source of many of those same antibiotics.

"They make probably 80 per cent of the drugs that are currently used today – they also make anti-cancer agents, they make immune suppressants, they are remarkable, remarkable little chemists."

*Permafrost sediments deposited 30,000 years ago in the Klondike area of the Yukon contained bison, horse and mammoth DNA as well as bacterial genes associated with antibiotic resistance. D.G. Froese/University of Alberta*

That antibiotic resistance likely jumped from the soil bacteria to disease-causing bacteria.

"These environmental bacteria are actually the wellspring of resistant genes that eventually make their way into disease-causing bacteria."

Wright said scientists don't yet know why soil bacteria have a tendency to make antibiotics and be resistant to antibiotics, but they speculate it may help them compete with other bacteria in an environment crowded with millions of bacterial species.

He said most disease-causing bacteria evolved in the more isolated environments of animals' guts or skin, where they may not have had a need for antibiotic resistance.

The researchers don't yet know how widespread antibiotic resistance is among other kinds of bacteria.

"We're very keen to broaden our view of what the sources of resistance are," Wright said. "This is very probably the source of our problems – all the [antibiotic resistance] genes that have emerged in these disease-causing bacteria. So we really need to understand the diversity that exists out there so that we can be prepared for it if and when it emerges in pathogens."

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