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THE SECRETS IN OUR TEETH

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Your dentist can tell a lot about your health and daily habits just by looking at your teeth. But did you know that archaeological scientists have discovered that there is a lot more information hidden in teeth? We can study the chemical composition of teeth and can find out what types of food a person ate, and even where that food was growing. When we find teeth in archaeological sites, a method called isotope analysis can be used to reconstruct the movements and diets of people, even when no written records are available. In this article, we will discuss what our teeth are made of and how isotope analysis can be used to learn more about ancient people. We will then look at an archaeological site in France, where children discovered bones and teeth on the playground behind their kindergarten.

WHAT CAN WE LEARN FROM TEETH?

Think about the teeth of a lion compared to those of a cow. Lion teeth are sharp and long, made for gripping prey and cutting through meat. Cow teeth are large and flat, perfect for chewing plant material. The teeth tell us about which types of food the animals eat and how they eat it. What about human teeth? Since we eat both meat and plants, we have both sharp teeth (canine teeth) for cutting, and flat teeth (molars) for grinding plant material.

What else do your teeth say about you? Have you chipped or lost one? Do you have braces? Do you brush your teeth regularly? However, it is not just the characteristics of your teeth that you can *see* that tell a story about you! Archaeological scientists can find out even more by measuring the chemical composition of teeth. We can work out what kind of food a person ate and where that person was living during the time the tooth was forming.

DECIDUOUS TEETH

The first set of teeth to appear. They erupt when you are a baby and fall out during childhood. They are smaller and less tough than adult teeth.

Over your life, you will grow 52 teeth. First, 20 **deciduous** (baby) teeth and then later 32 permanent (adult) teeth. You have four different types of teeth: incisors, canines, premolars, and molars. These teeth all form at different times, from before birth, up until the teenage years. Teeth incorporate the chemical elements from the food and water a person consumes while those teeth are developing. Teeth can be really useful for archaeologists, because each tooth is essentially a time capsule: once a tooth forms it does not change. Have you ever broken a bone and had to wear a cast? Your body can slowly repair a broken bone because the cells in a bone are constantly being replaced to ensure the bone remains strong. If you break a tooth though, it does not fix itself—you need to see a dentist. This is because, after your teeth form, the cells die. Your teeth are made of the same material now as they were the day they were formed. This means the chemical signature of your childhood environment is locked into each of your teeth! This helps archaeologists to study an adult's childhood from examining the skeleton.

As archaeologists, we study the human past, and we want to find out where people were living, where they were moving to, and what kinds of foods they ate. Looking at the chemistry of teeth gives us an amazing opportunity to find out some of this information. Tooth data is very useful because, as we go further back in time, there are fewer and fewer written records of what people were doing, where they were living, and what their main foods were. In this article, we will explore the secrets in our teeth and how researchers around the world use teeth to better understand human history.

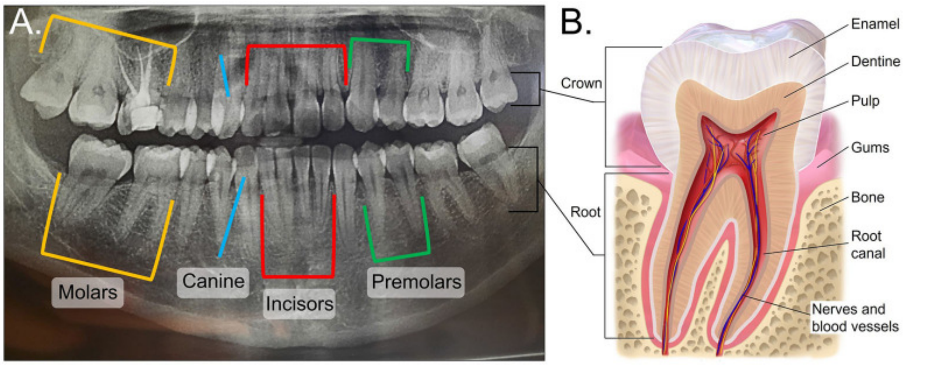

Figure 1

Figure 1

(A) An x-ray of a human jaw showing individual teeth. This individual is missing a few teeth, can you spot the gaps? **(B)** A diagram of the structure of a human tooth. Can you identify these structures in the x-ray image? (Image credit: [2]).

THE ANATOMY OF OUR TEETH

A human tooth consists of a crown and a root [1]. When you look at your teeth in the mirror, you see the crowns, whilst the roots are under your gums, fastening your teeth securely into your jaw (Figure 1). The outside of the crown is called **enamel** and that is what you can feel if you touch your teeth with your finger. Underneath the enamel is **dentine**, which forms the inner structure of the crown and the root. At the center of a tooth is the pulp chamber, which contains nerves and blood vessels.

ENAMEL

The thin, tough protective layer that covers the tooth's crown. It is the hardest material in the human body.

DENTINE

Bone-like tissue which forms the structure of the tooth, lying beneath the enamel, and also making up the root.

Both enamel and dentine are made of a strong, dense mineral called **hydroxyapatite**. Enamel is the hardest tissue in the human body; by weight it is made of over 95% hydroxyapatite. Dentine is not quite as tough and is more similar to bone. By weight, dentine is about 70% hydroxyapatite.

HYDROXYAPATITE

The mineral that forms your bones and teeth and makes them hard and strong.

MEASURING ISOTOPES IN TEETH

Archaeologists can use the chemistry of teeth to identify the diets and movements of ancient people [3]. This is done by measuring the ratios of certain **isotopes** within the enamel and dentine of archaeological tooth samples. Isotopes are variations of atoms that are the same element and contain an identical number of protons but have a different number of neutrons. For example, most of the carbon on Earth contains six protons and six neutrons (called carbon-12), but about 1% of the carbon contains six protons and seven neutrons (carbon-13). Carbon-12 and carbon-13 are both carbon, but carbon-13, with its extra neutron, is slightly heavier. This extra weight means isotopes behave slightly differently in environmental and biological processes. The measurements of these very small differences between two isotopes can give researchers vital information about the diets of ancient humans and their movements from one location to another. To measure isotopes, we first drill out a small sample of enamel or dentine. This powder is then chemically

ISOTOPES

Variations of atoms that are the same element and contain an identical number of protons but have a different number of neutrons.

cleaned to ensure we are only measuring the chemical elements we are interested in. The cleaned sample is then analyzed on a large machine called a **mass spectrometer**, which counts the numbers of each isotope in the sample to give us an isotope ratio.

MASS SPECTROMETER

A scientific instrument that measures the chemical elements in a sample using the charge and mass of the atoms.

UNCOVERING DIETS FROM TEETH

Carbon isotopes tell us about the types of plants that someone ate. This is because the ratio between carbon-13 and carbon-12 changes with the type of photosynthesis used by plants. Plants adapted to dry conditions (such as maize, sorghum, and millet), those adapted to *very* dry conditions (cacti or pineapples), and all other land plants have different methods of photosynthesis, which lead to different carbon isotope ratios. So, the carbon isotope ratios of a person's teeth will reflect those of the plants that person mainly ate. Nitrogen isotopes (nitrogen-14 and nitrogen-15) are another isotope system that can tell us about diet. Nitrogen isotopes are useful to understand where in the food chain a person's food comes from. This is because the ratio between nitrogen-15 and nitrogen-14 increases with each step in a food chain. A carnivore, like a lion, will have a higher ratio than an herbivore, like a cow, which will have a higher ratio than a plant, like grass. As ocean food chains are longer than terrestrial food chains, we can tell if someone was eating ocean animals (higher values), terrestrial animals (lower values), or no animals (lowest values) (Figure 2A).

UNDERSTANDING HOW PEOPLE MOVED AROUND FROM TEETH

To uncover where people were living in the past, we can use two additional isotope systems: oxygen and strontium. Oxygen isotope ratios (oxygen-16 and oxygen-18) in rain change with climate. As drinking water often comes from rain, the oxygen isotope ratios in human teeth reflect the region that people were living in. Strontium isotopes (strontium-87 and strontium-86) are found in different amounts in different types and ages of **bedrock**. As the bedrock erodes, these isotopes get into the soil and into plants, so when humans or animals eat, the environment's strontium isotope ratio is incorporated into their teeth. Before we can make sense of the oxygen or strontium isotope ratios measured in a human tooth, we need to understand how these isotope ratios vary in a region. To do this, archaeologists measure the isotopes in soils, plants, water, or animals to create a baseline map (Figure 2B) [4]. A baseline map shows how oxygen and strontium isotopes vary across the landscape, and we can then compare the isotope ratio in teeth to these maps. If a person's isotope ratios match with that of the environment, then this person may have spent their whole life in that area. If the ratios do not match the environment where the person's remains were found, we can use the isotope values and other information to try and work out where they moved from.

BEDROCK

The solid rock the lies under loose surface material, such as soil.

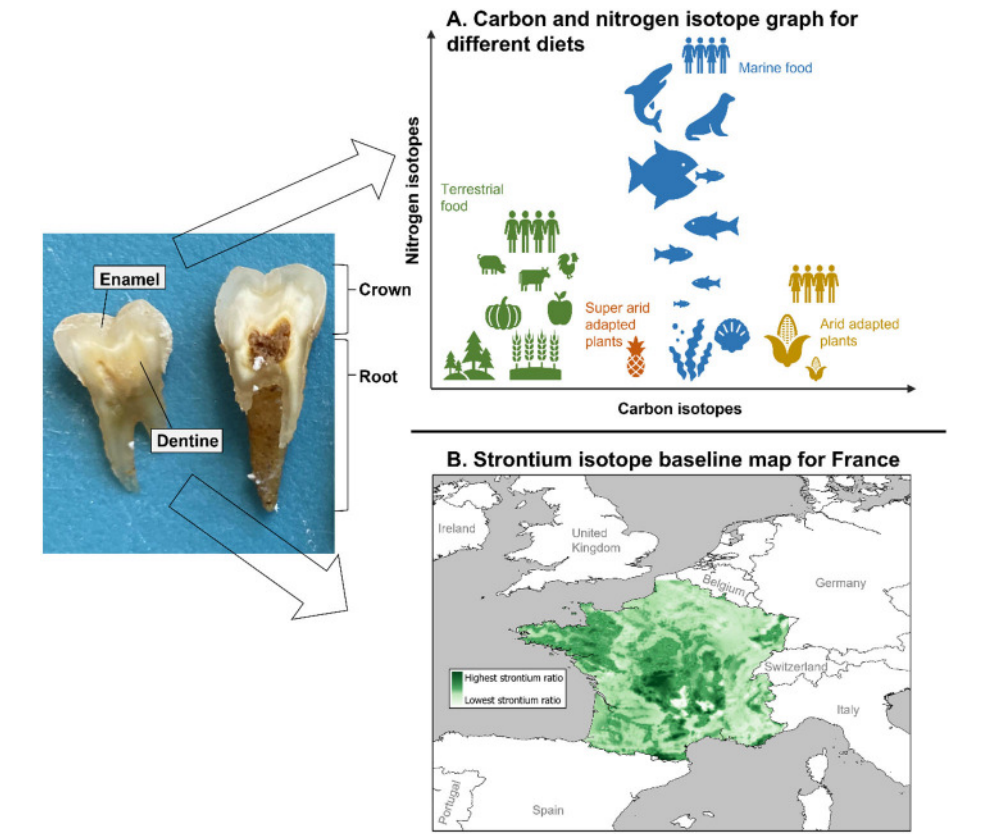

Figure 2

Figure 2

To find out where people were living and what kinds of diets they ate, we need to compare the isotope ratios from archaeological teeth to baselines. **(A)** The carbon and nitrogen isotope values for different diets. Carbon isotope values reflect the environment the plant is growing in. Nitrogen isotope values reflect one's position in the food chain. Where do you think your diet would sit on this graph? **(B)** An example of a strontium isotope baseline. This one covers France and was created using over 800 samples of soil and plants (data from www.irhumdatabase.com).

TEETH TELL FORGOTTEN STORIES

The archaeological site of Le Tumulus des Sables provides a good example of how useful isotopes can be for archaeologists [5]. This site was a burial mound uncovered by children in the playground of their kindergarten, near the city of Bordeaux in southwestern France. When archaeologists excavated the site (Figure 3), they uncovered pottery, arrow heads, animal bones, and human remains, all jumbled up. Ancient humans had used this site as a burial place for a very long time, starting about 5,600 years ago and ending about 3,200 years ago. Because the human remains were all mixed together, it was impossible to know who was who. To try to understand who was buried in the mound, scientists measured carbon, nitrogen, oxygen, and strontium isotopes from 25 molars, including both permanent and deciduous teeth.

Carbon and nitrogen isotope ratios showed us that these people were eating mainly terrestrial foods, even though they lived close to the ocean and close to the large Gironde River, both of which could have provided them with fish. Oxygen and strontium isotopes showed that almost all the individuals spent their childhoods in the surrounding region. Two individuals had different oxygen and strontium isotope ratios. One probably came from an area about

Figure 3

Figure 3

Archaeologists excavating the burial mound called Le Tumulus des Sables near Bordeaux in France. The bottom right photo shows some of the archaeological material excavated at the site (Photograph credit: Professor Patrice Courtaud).

50 km from the burial site, and the other spent his or her childhood in a much colder region, perhaps in the mountains in France (Pyrenees, Alps, or Massif Central), further inland in Europe, or north in Britain.

SUMMARY

As you can see, isotopes are useful for archaeologists because they allow us to reconstruct the lives of ancient people, like those at Le Tumulus des Sables. Such information was previously thought to be lost to time! Teeth are a very strong and useful tissue and, by measuring isotopes in teeth, we get important information about what humans were doing in the past. These measurements have been done on a whole range of different people from different time periods across the whole world. Taken together, these measurements can help us to understand how ancient people lived, what they ate, and where they moved throughout their lives. This can give us important information about how populations of modern humans came to be where they are today!

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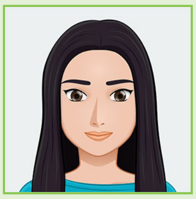

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I am Hrishika and I love animals. I like reading realistic fiction and I want to become a doctor when I grow up.

PRIYANKA, AGE: 12

My name is Priyanka and I enjoy reading, drawing, and imagining creative stories about fantasy and magic. My favorite animals are dragons and snakes and other reptiles. When I grow up I want to become a children's book author and illustrator.

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