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Science and archaeology – how chemistry can tell us about the human past

Q: Instead of using human remains to find out about diet, why aren't methods like pollen dating used instead?

A: Pollen can tell us about what sort of vegetation there was around a particular site, but it can't tell us directly about what people were eating.

Q: How do you know that the abundance of the different isotopes is the same now as it was then?

A: Good question! There are general trends in isotope ratios (like the difference between carbon isotope values in marine and terrestrial organisms) that we can expect to be the same in any time period, but we can also test this by directly measuring the isotope values of animals from archaeological sites if they are present.

Q: What chemical methods did you use to analyse the volumes of the different elements?

A: We use an elemental analyser-isotope ratio mass spectrometer to measure the relative amounts of different isotopes. This works in the same way as other mass spectrometers, in that molecules of different masses are deflected to differing degrees in the magnetic field, but it can detect really small differences in mass, allowing us to distinguish between, for example, $^{14}N^{14}N$ (m/z = 28) and $^{15}N^{14}N$ (m/z = 29).

Q: Is chemistry most related if I want to go into archaeology?

A: It depends what area of archaeology you are interested in. Chemistry can be really useful because it can help to reconstruct past diet and mobility (using isotopes) but can also be used to find out the source of different metal ores, raw materials of glass, and even identify pigments used in rock art. A good book to look at if you're interested in archaeological chemistry is: Archaeological Chemistry by A.M. Pollard, C. Heron & R. Armitage (https://books.rsc.org/books/monograph/569/Archaeological-Chemistry).

Q: Why was there expected migration during the times at which the individuals lived?

A: Another study by Hamerow et al. (2024) has found that between AD 600 and 800 in Britain, around 30–40% of people have isotope values that indicate they spent their childhood more than 100 km from where they were buried, which is consistent with a lot of movement away from their place of birth.

Q: How did you determine that the woman was pregnant?

A: The bones of an unborn foetus were found within her grave, in the region of her abdomen.

Q: What properties does ocean contain for heavier Nitrogen isotopes to be released nearer to the shore and how does that impact people who swim closer to the shore?

A: You might be thinking about sulfur; the ocean has sulfur isotope values of about 20 per mil. This is because the sulfate in seawater has a sulfur isotope value of about 20 per mil. When water evaporates from the ocean, the clouds formed from this water vapour blow across the land and the rain that falls close to the ocean has similar isotope values to the ocean.

Q: What equipment is used to measure the isotopes?

A: We use an elemental analyser-isotope ratio mass spectrometer to measure the relative amounts of different isotopes. This works in the same way as other mass spectrometers, in that molecules of different masses are deflected to differing degrees in the magnetic field, but it can detect really small differences in mass, allowing us to distinguish between, for example, $^{14}N^{14}N$ (m/z = 28) and $^{15}N^{14}N$ (m/z = 29).

Q: What other factors affect the validity of the results?

A: There are a lot of factors that can affect isotope values. Biology is messy, so the general trends I talked about can also be affected by differences in people's metabolism, isotope values can also be affected by subtle environmental differences that will change the isotope values of plants that people eat, like the amount of water they receive and the addition of fertilisers like manure. Working with archaeological material, we also have to be aware of the potential for contamination of bones and teeth with carbon and nitrogen from the soil, and also the decomposition of the protein in bones and teeth, which can affect the isotope values.

Q: Other than oxygen nitrogen carbon and sulphur how else can we use isotopes to find out about the lives of ancient populations?

A: Strontium is commonly used to find out whether were buried where they were born/spent their childhood because strontium isotope ratios vary with the underlying geology. We can also use the carbon isotope values of individual fatty acids extracted from pots to distinguish between meat and dairy fats and so understand whether people were processing dairy products. Another

example is using lead isotope values to trace where metal objects may have come from and reconstruct past trade networks.

Q: What is used to properly measure the different atoms?

A: We use an elemental analyser-isotope ratio mass spectrometer to measure the relative amounts of different isotopes. This works in the same way as other mass spectrometers, in that molecules of different masses are deflected to differing degrees in the magnetic field, but it can detect really small differences in mass, allowing us to distinguish between, for example, $^{14}N^{14}N$ (m/z = 28) and $^{15}N^{14}N$ (m/z = 29).

Q: How long does it take approximately for the teeth to completely decompose?

A: This completely depends on the burial conditions. Bones and teeth with dissolve in acidic soils, so they won't survive long in these conditions at all. Protein doesn't survive as well in hot places or where the water level changes a lot. For this reason, in tropical environments we often only have well preserved protein from the last 2000 years. Teeth are particularly resistant to decomposition, however, and if they become fossilised, the carbon and oxygen isotope values can be preserved for hundreds of thousands of years.

Q: What are some examples of other things that you learned about and if so from which other main isotopes?

A: Another of my research interests is how people grew their crops and how they changed the environment in the past. I have used carbon and nitrogen isotope values of charred plant remains to reconstruct past agricultural practices and understand how people were able to increase crop yields to make sure that people had enough food when they started living in cities rather than villages. I have also used the carbon isotope values of hazelnut shells from archaeological sites to reconstruct how dense woodlands were at different times in the past.

Q: How can you determine the difference between C4 plants and a marine diet?

A: Another way is to use the nitrogen isotopes because someone eating a lot of marine resources will have a higher nitrogen isotope value than someone eating a lot of C4 plants (because of the difference in trophic level).

Q: How do you discover the ages of the people that were excavated?

A: Osteologists look at the bones and teeth of the people that are excavated and can estimate how old they were when they died. There are lots of different signs, but the main ones involve looking at whether the ends of bones are fused (which happens at different points in childhood), which teeth have erupted from the jaw and how worn down the teeth are. It is easier to define a

narrow age range for children and adolescents because there is a relatively set order by which bones fuse and teeth erupt. Once you get into adulthood, you have to rely on how worn down the teeth are, which can vary with the type of diet.