Hello everyone,

My name is Quentin Martinez and I am a postdoctoral researcher working here at the museum.

My research focuses on sensory evolution in animals in general, and I am particularly interested in olfaction and the brain. I am interested in integrative approaches merging morphology, genomics, and behavior, but most of my research focuses on morphology and therefore I rely a lot on CT technology.

Today I will give you an overview of what we can do with different CT technologies, and hopefully you will be convinced that this is cool. Then I will give you an overview of some of the projects I am working on.

As I mentioned, my research heavily relies on morphology and therefore on museum specimens that were sometimes collected hundreds of years ago. You will see that I am working with both dry skeletal elements, like some skulls here, as well as with specimens preserved in alcohol, as you can see here.

You already heard from Ilse and probably in other talks what classical CT technology is. Here you have an electric X-ray source, and here a small skull of a mouse. On the opposite side of the X-ray source you have a sensor, like in a camera, and in the middle you have your skull. The skull rotates while X-rays penetrate it and send information to the sensor.

When you finish this acquisition, you obtain raw images like radiographs at the doctor, and these images can be transformed to get a stack of thousands of single 2D slices. Then with all these slices you can reconstruct your object, here your skull.

With 3D software you can isolate areas of interest slide by slide, which is called segmentation, and at the end it gives you a 3D shape. Here in red I isolated some bone structures of the nasal cavity of the mouse. We obtain a 3D volume and then extract quantitative data from this volume to perform analyses or make final visualizations.

There are many different types of CT facilities that allow you to scan objects of different sizes. For example, we CT-scanned an elephant skull. Here is the elephant skull, and here you can see inside the nasal cavity. We found that elephants have hundreds of small lamellae inside the nasal cavity, called olfactory turbinals, that allow the elephant to smell.

Classical CT scanning is relatively safe for specimens. You do not damage the specimen much. For example, here we have a historical specimen, a cobra eating a toad. Because this specimen is fragile, it is possible to CT-scan it directly in its jar without opening it, so the specimen is not touched.

With classical CT technology, you mainly image elements with high density like bones. You can see the skeleton of the snake, the teeth, and the fangs.

This is the same technology used in hospitals. For example, this is a CT scan of my head, and I isolated my turbinals. In 2023 we worked on this particular bone found in the nasal cavity of all mammals at a large scale. Here you see hundreds of mammals where we quantified this bone. The human representative was the scan of my head.

CT scanning historical specimens can be very informative. For example, the Tasmanian tiger, a marsupial that converged with wolves and was declared extinct in the 1940s. Some skulls remain in museums. I CT-scanned some of them to isolate the braincase, called the brain endocast, a proxy for the brain. In some skulls I found metal objects, likely small bullets, and dried material that may be old blood. This species was heavily hunted.

Other discoveries relate to shrews. Here you have two shrews, one from Germany and one from South Africa. They look similar. We CT-scanned one and everything looked normal. But when we scanned the other, we found a large spine on the back of the neck. No one noticed it before because no one CT-scanned the full body.

Across Eulipotyphla, the group including shrews, moles, and hedgehogs, we found other species with smaller spines. In some there is a ring at the top of the spine. We are still studying the function.

So far I showed classical CT where we mainly see bones. But we can also image soft tissues. For that, we stain the specimen in a solution that increases soft tissue density. Then we scan it and can see the brain and isolate regions like the olfactory bulb.

Using this method we found something unusual in a common toad, Bufo bufo. When we stained and scanned it, we found fly larvae inside the nasal cavity. These are larvae of Lucilia bufonivora. They migrate into the nasal cavity and eat the toad alive, even affecting its brain. We could see that the larvae were eating parts of the brain.

Another technology is synchrotron imaging. It uses particle accelerators and provides very high resolution without staining. For example, we scanned a tiny salamander larva and could see everything in great detail, almost like histology.

We also scanned tiny parasitoid wasps. Even with such small animals, we can isolate the brain and different brain lobes. We are working on sensory evolution in Hymenoptera using these data.

Now about olfaction. It is a key sense for tetrapods. I am interested in aquatic tetrapods that independently colonized aquatic environments, about 100 times. The hypothesis is that aquatic species reduce olfactory capabilities because respiration and olfaction are linked.

To test this, we needed a good anatomical proxy. In mammals, the brain endocast mirrors the brain well, including the olfactory bulb. We CT-scanned more than 200 mammals and found that the relative volume of the olfactory bulb endocast correlates with the number of functional olfactory receptor genes. This validates this bony proxy.

We then studied aquatic tetrapods by comparing pairs of aquatic and terrestrial relatives. In mammals and reptiles, aquatic species show strong reductions of the olfactory bulb. But in amphibians, we found no reduction or even an increase.

Genomic data show that amphibians retain genes for detecting odors underwater, unlike amniotes. Reviewing paleontological evidence, amphibians retained an aquatic larval stage, while amniotes lost it. This may explain the difference.

Finally, I am very interested in caecilians. They have a special sensory organ called the tentacle. It is an erectile organ connected to the nasal cavity and sometimes linked to the eye. It likely transports odors into the nasal cavity, maybe also with a tactile role.

We performed behavioral experiments with odors. Results are still complex, but the tentacle probably helps transport chemical cues.

And that is it.

Here is my email address. Do not hesitate to contact me if you have any questions about research or academia.

If you have questions now, please feel free to ask.

Thank you.