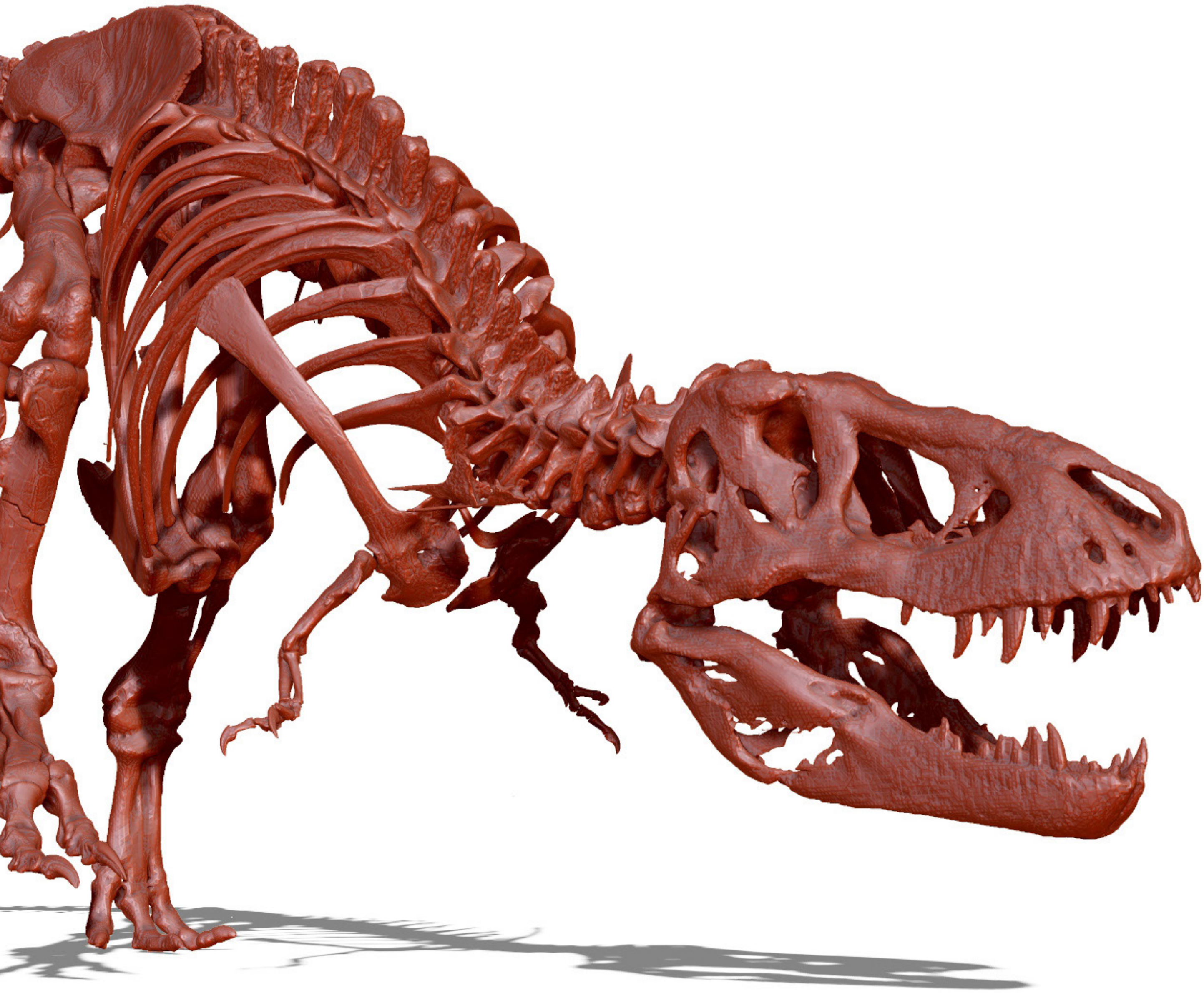
T. rex 'Trix'
reviving a fossil



Naturalis Biodiversity Center

3D Printing
Teacher's guide

In this guide

Target audience
Upper primary education (grade 4-7).

Duration
Students will spend a total of half a day on the activity.
Depending on the choices made and which and how many parts are printed, the activity can be spread over a whole week. Partition the lesson as you see fit. Engage in another activity while the printer is in operation.

Objectives
- Students learn about the form and function of dinosaur bones.
- Students are able to describe broadly how *T. rex* lived.
- Students learn how scientists research dinosaur fossils.
- Students learn about the possibilities of 3D printing.

Connection to Dutch core objective
The lesson is consistent with core objective 41: students learn about the construction of plants, animals and humans and about the shape and function of their parts.

Keywords
Dinosaurs, fossils, inquiry-based learning, asking questions, comparing, designing, 3D printing

Short description of the activity
How did *T. rex* live? And how do we reconstruct a dinosaur skeleton? Using 3D prints, students learn more about the functions of different bones, how the skeleton of *T. rex* is put together and how this animal lived many millions of years ago. The activity ends with the construction of a small exhibition with the printed *T. rex* model (scale 1:15).
In the process, the many background stories and videos give a unique insight into the world of *T. rex*.

Videos
All videos referred to in this activity are in Dutch. However, most of them have either English subtitles embedded or they can be turned on.

Structure of activity

Download the 3D scans of Trix's bones in small format here. Print the bones in the classroom. Consider in advance which of the scenarios below will form the context of the activity*:

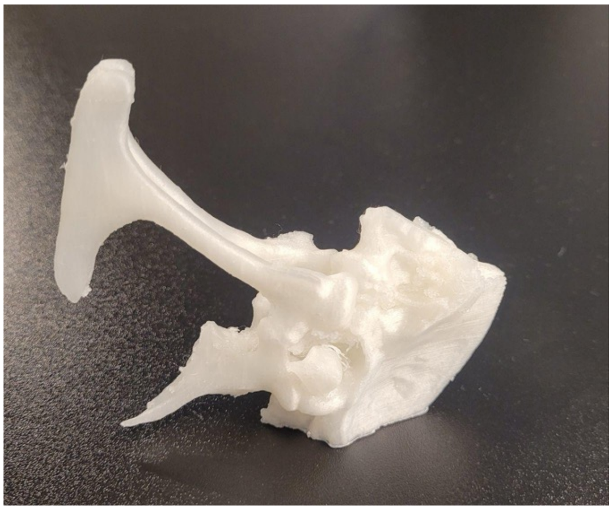
- **A** Print each part of the skeleton. This can be used to build a complete model.
- **B** Print only part of the skeleton. Decide which parts. This option touches more on reality, as no complete skeleton of *T. rex* has ever been found.

*The choice made affects step 7 of the activity.

Step 1 Length: +/- 3 hours

Print the underside of the pelvis (e.g., 'the hips', see Figure). Tell the students that they are going to participate in a 3D printing activity. 3D scans of real bones are used for this purpose.

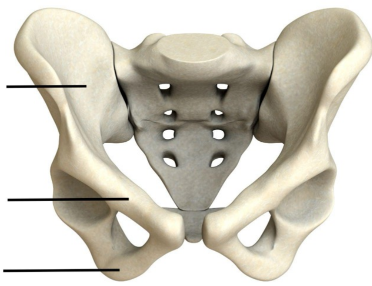
Without giving any further substantive information to the students, they wonder what is being printed. They are curious, but only know that the print is the beginning of a fun activity, during which more will be printed.



Step 2 Length: +/-15 minutes

Let the printed bone circulate in the classroom. Discuss this first print with the students. What stands out? What does it look like? What is its function? The answers are not yet provided. After a short discussion, indicate that it is a piece of dinosaur bone that is actually more than a metre high. Let students discuss in small groups what part of the skeleton it is and let them find out if we humans have this bone as well.

At the end of this section, use a human skeleton to show that our hips are almost identical to those of this dinosaur, but that they are in a slightly different position in the body.



De heup van een mens bestaat uit drie onderdelen: het darmbeen, schaambeen en zitbeen.

Stap 3 Length: +/- 8 hours

Print three parts: arms/shoulder blades, hind legs, and a tail piece.

Step 4 Length 1 hour

Students learn more by examining the individual prints in groups and gather information on them. Everyone gets to see and examine all four components. They draw/craft how they think the animal looked according to their bones. The drawings will differ. You show them that there are many possibilities. How do we find out what the animal really looked like?

Additional information to provide

Scientists often have to conduct their research on the basis of an incomplete fossil. The more information there is, the more accurate the reconstructions are. Ask students: how scientists reconstruct the entire animal? Palaeontologists often compare their finds with fossils uncovered in another excavation. They also compare fossils with skeletons of animals living today*. Students discovered in Step 2 that humans have largely the same bones as this dinosaur (at least concerning the hips). In other words, the blueprint (article in Dutch) or bone shapes of modern vertebrates, is largely similar to those of animals from the distant past.

*Show some examples of modern vertebrate skeletons (e.g. those of a rhino or an elephant), so that students can compare the prints (fossils) with those.

Step 5 Length: 30 minutes

In reality, not all bones are found. Briefly discuss the reason for this with students. Bones may have been washed away, or may have been moved and eaten by scavengers and other carnivores.

Tell students that the printed bones are from *T. rex*. What do they already know about this animal? Watch one or more of the videos below (featuring paleontologist Anne Schulp, among others) that explain this animal and the excavation of fossils. The videos below are in Dutch, but English subtitles are embedded or can be turned on:

What does a paleontologist do?

What has been found of Trix' skeleton?

Trix under construction

How hard could T. rex bite?

Step 6 **Length:** length: depending on the number of prints

The students now know more about the construction of the skeleton and how Trix was found. Which parts are the students still missing?

Extra information to provide

T. rex *Trix is exceptionally well preserved. About 60% of the total number of fossils have been recovered. Because the fossils were buried in relatively loose sand, they have hardly been deformed. This puts T. rex Trix in the top 3 most complete t. rexxes ever found. An extraordinary skeleton!**

Trix's skeleton was not assembled at Naturalis, but at the Black Hills Institute in South Dakota, America. At the time, Naturalis did not have a dinolab and therefore no place to prepare the bones and assemble the skeleton. Watch this vlog, in which biologist and expedition member Matthijs Graner takes students to the Black Hills Institute where Trix was mounted.

Choose one of the options below:

A Print the remaining parts of the skeleton.

B Print only a few more parts. Note that the skeleton remains incomplete. This is the most realistic option as the skeleton of Trix has been found incomplete.

* For more information on this research, read 'The story of T. rex Trix'' later in this guide.

This is what the complete model of *T. rex* 'Trix' looks like (scale 1:15).

Step 7 Length: 1 hour

When chosen to print the complete skeleton (option A):
Each time a part is printed, students adjust their creation accordingly. Have some students assemble the T. rex skeleton when all parts have been printed. The parts can be glued together. As a concluding task, students rebuild Trix's habitat using many different materials (paper, sand, wood, etc.) in which the printed skeleton can eventually be 'displayed'.

When chosen to print only part of the skeleton (option B):
When only part of Trix has been printed (about 60% to be as realistic as possible), the excavation site can be reconstructed, where the bones lay scattered and half-buried on display. Divide the prints among the groups. Let students also add miniature tools that they craft themselves. Students present the result to each other. All exhibitions together form a beautiful natural history museum.

Alternatively, this activity can be concluded in class with a discussion about Trix. How did she live? In what kind of environment? What did she eat, etc. Would you like to see Trix in real life? Visit Naturalis (with the class or on your own)!

Step 8 Optional

Do students want to learn more about Naturalis and dinosaurs? Then check out Triceratops TV. This online platform features many videos on digging up dinosaurs, preparing bones and assembling a skeleton. Triceratops is the focus of the videos, but they are also definitely interesting to watch in light of this activity, if only because these animals lived in the same time and environment.

Also fun to watch is the Klokhuis (in Dutch) episode about *T. rex*

The story of T. rex Trix

From August 30 to September 8, 2013 Naturalis dug up a *Tyrannosaurus rex*. This happened in Montana, USA, in collaboration with the Black Hills Institute.

Expedition

Naturalis went on an expedition for the first time in the spring of 2013, from April 29 to May 18. In Wyoming, a few nice fossilized bones of the left foot were found. This find was promising, even the small phalanges were still neatly together. These are usually the bones that are lost first. Despite this promising discovery only parts of the left foot and leg of Tyrannosaurus rex were found. Why the small bones were preserved, but not the rest of the skeleton, remains a mystery. The whole hill that should have held the rest of the skeleton was excavated. “The layer of sand where the bones should have been, was getting thinner and eventually disappeared,” says Anne Schulp. “Perhaps the carcass was eaten at the time, or was taken much further by the river that ran through the area. We do not know.”

Fortunately, the chances of a *T. rex* for Naturalis was not lost. Pete Larson, paleontologist at the Black Hills Institute in America, pointed aturalis to another place in Montana, America, where a couple of amateur paleontologists had found remains of *T. rex*. The lower jaw, loose teeth and a part of the hip joint and tail bone were found by them. The expectation was that there was more material of *T. rex* buried in the ground (Figure 1).

More bones

Initially, 600 bone fragments were excavated. But there were indications that there were more fossils lying around. The Naturalis team therefore travelled back to Wyoming every year until summer 2019 to excavate the rest (Figure 2). In total, more than 1,000 bone fragments were found. A very complete skeleton!

Paspoort

Nickname:	Trix
Species:	*Tyrannosaurus rex* (king of the tyrant lizards)
Gender:	Unknown
Length:	up to 11 meters
Weight:	possibly up to 8000 kilo
Time period:	Late Cretaceous: 67,5 to 66,0 million years ago
Habitat:	Western North America

Figure 1. Paleontologist Anne Schulp is working on the skull of T. rex.

Figure 2. Paleontologist Jimmy de Rooij works the rock around the fossils.

Exceptional find

Skeletons of *T. rex* are among the world's rarest fossils. Our *T. rex* Trix is extra special: the fossils are very well preserved! Not squashed or in a thousand pieces, but beautifully in 3D (Figure 3).

Figure 3. The upper leg (femur) of T. rex Trix still has almost exactly the same shape as 67 million years ago.

What paleontologist doesn't dream of someday finding a tooth or bone of this terrifying predatory dinosaur? Even better: a complete skeleton. But you can keep dreaming: complete Tyrannosaurus rex skeletons have never been found and are the world's most coveted fossils. So far, less than ten were found, one more complete than the next. "So far" has been quite some time, if you know that Barnum Brown had the good fortune in 1902 to dig up the first skeleton. If anyone wants to try his luck, they should search the west of North America, home of *T. rex*, just as Brown.

Male or female?

The skeleton (Figure 4) has unofficially been named Trix. A tribute to (then) Queen Beatrix. After all, 'Rex' means king or queen in this case. Although it should be mentioned right away that it is now unclear what gender Trix is.

At the time (around 2013), it was scientifically assumed that t. rex females were more sturdily built than males. But after comparative research in 2020, this argument does not appear to hold water. In addition, females created an extra layer of bone (so-called medullary bone) on the inside of the thighs, among others. This extra calcium would be used for laying eggs. Unfortunately, no such bone was found in Trix and so the chances of Trix being a female are significantly reduced.

Figure 4. T. rex Trix' skeleton in Naturalis.

How did T.rex live?

During which period did *T. rex* exist, and what insights do we have into its daily behavior? Through which methods have scientists uncovered this information? Explore the known aspects of the life history of this remarkable animal.

Time period

Tyrannosaurus rex lived at the end of the Cretaceous. To be exact, in the Maastrichtian, named after the chalk layers of the Mount Saint Peter in Maastricht, approximately between 67.5 and 66 million years ago. He is one of the last dinosaurs. The species was around the moment a meteorite impact wiped these unique reptiles off the face of the earth. The impact took place not too far south of the habitat of *T. rex*, to be exact at the Mexican Yucatán Peninsula. The meteorite impact also meant the end for other life forms: other species of dinosaurs on land, reptiles, ammonites in the sea and pterosaurs in the sky.

Habitat

Tyrannosaurus rex was only found in North America. At least, no fossils of this species were unearthed in any other places. North America was still occasionally connected to Eurasia. This allowed Tyrannosaurus-like species to also conquer this continent. Even in Asia species from the tyrannosauridae family were found. These dinosaurs are similar to the 'real' Tyrannosaurus in many respects. For example, we know about the Tarbosaurus from excavations in Mongolia. This dinosaur is also a robber and is closely related to T. rex.

Lifestyle
Little is known about the daily life of *T. rex*. After all, behavior can only be linked to bones indirectly. For example, it is not clear whether *T. rex* lived alone (solitary) or in a group of family. So far, there are no indications of *T. rex* living in a herd, such as multiple skeletons grouped together. Tracks, for example, tell us more about this, but, unfortunately, not many tracks of *T. rex* have been found. One find of a few tracks in Canada is indicative of herd behavior, although this is not certain at all.

Figure 5. T. rex tooth with distinct serrations.

Nevertheless, a few things can be learned from the construction of the skeleton. *T. rex* was one hundred percent meat eater, a hyper-carnivore. With such teeth (Figure 5), he simply ate nothing but meat. Grinding plants would not have worked with those pointy teeth.

Interestingly, the front legs were too short to bring food to the mouth, but they were heavily muscled. Possibly *T. rex* used them during mating. They would use them to hold each other. Another theory states that they used their feet to press up and get up from a lying or squatting position. Possibly they also kept struggling prey at bay, like a lion holding a wildebeest down. The comparison with the lion might continue. Would *T. rex* also have administered a lethal bite to his victims, or constricted the throat until they choked? Did he let other predatory dinosaurs do the work and feed himself with the remains?

The science behind T. rex
Few fossil finds of *T. rex* are known. Each bone of a *T. rex* that is found, however small or large, can be of vital importance for science. There was much left to explore about our T. rex. When and where did *T. rex* live exactly? What was the age of the *T. rex* of Naturalis? How fast could T. rex run? We want to get insight in the medical file: which bones did *T. rex* break? Which diseases did she possibly have? What was T. rex's diet like? And how did *T. rex* migrate; for instance, did the animal reach mountainous areas or the coast?

By examining the fossils, Naturalis researchers gain new insights and contribute to solving these issues. “Each bone of every *T. rex* provides us with more knowledge”, says our director Edwin van Huis. “We have years of scientific research ahead of us.”

Visiting the Naturalis' collection
Paleontologists Dylan Bastiaans and Martijn Guliker, who were working on the bones of the herd of triceratops in the dinolab, visited Naturalis' collection tower. Here the bones of *T. rex* that came from the Americas, were temporarily stored. Both Dylan and Martijn were deeply impressed by what they saw. The bones were very nicely preserved. Dylan, as a trained medical paleontologist, noticed that one of the bones seemed to have abnormal structures that might indicate that the *T. rex* was suffering from an infection. It was therefore interesting to compare the scans of a healthy bone with those of an abnormal bone.

To the hospital
How do scientists find out more about diseases Trix may have had? Just take the bones to a hospital! The medical equipment we use for humans is also very useful for fossil bone research. At the LUMC hospital in Leiden, for example, CT scans have been made of three bones from the tail of *T. rex*.

Figure 6. A *T. rex* bone (chevron) is being scanned at the hospital.

These were the haemapophyses, also called chevron bones. These Y-shaped bones were located on the underside of the tail vertebrae and gave the tail more strength. As a result, we now know that *T. rex*'s tail did not drag on the ground. Furthermore, they protected blood vessels and formed an attachment surface for muscles of the tail. Dylan collaborated on research into the medical history of *T. rex*. Studying a previous CT scan of a tail vertebra, he found a pattern similar to osteoporosis in humans. To be more certain about this, it was be important to scan more bones (Figure 6).

Diagnosis

The scans, which were made at the LUMC, show the structure of the inside and outside of the fossil tail bones in detail using a computer program. The scans show that the bones are relatively hollow (just like those of birds, once again confirming their kinship). A similar pattern is observed with osteoporosis, so for a while it was thought that Trix suffered from this disease. After more bones were scanned, including the vertebrae, it was found that all bones showed this pattern. This ruled out osteoporosis, as the bones would have differed in thickness.

So in this area, there appeared to be nothing wrong with Trix. Nevertheless, we now know that Trix did have health problems. Inflammation of the tail vertebrae was found, for instance. Some tendons were torn off the vertebra there, taking a piece of bone with them. This has led to inflammation and the creation of new (irregularly shaped) bone. A possible cause lies with the first tail vertebra. This was never properly developed so the tail may have been somewhat crooked. As a result, the tail muscles on the left and right side may not have pulled on the tail with equal force, resulting in torn tendons.

Trix additionally fractured several ribs on the right side that subsequently healed quite well. She did not die from the injuries, because then no healing would have occurred.

A lethal inflammation?

What Trix could possibly have died of, however, was a nasty inflammation in the snout that left an ugly large hole in the bone (Figure 7). Daan van den Elzen, a student veterinary and paleontology, researched this inflammation. Although the exact cause of such an infection is difficult to determine when the patient died 66-67 million years ago, Daan has proposed two possible theories. One possibility is trauma from an external source, which then led to inflammation and a secondary (bacterial) infection. This trauma could have been the result of a fight between Trix and another *T. rex*. Evidence of such intraspecies combat has been found in multiple *T. rex* fossils. For example, round puncture wounds in the bones of the lower jaw are commonly observed.

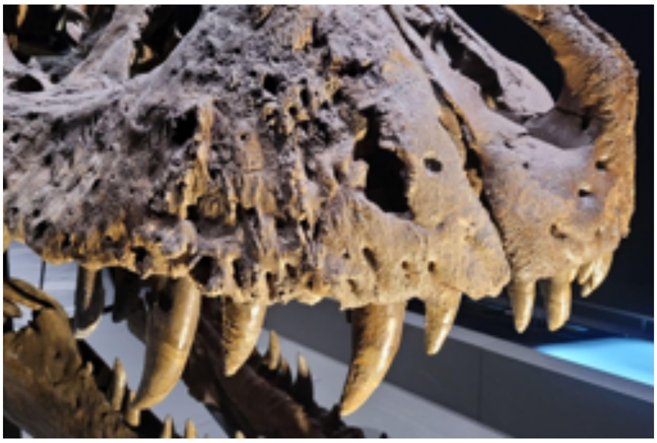


Figure 7. A large gaping hole in Trix's jawbone indicates considerable inflammation.

Another possible cause of the snout infection is internal trauma. Dinosaurs, including *T. rex*, continuously replaced their teeth. This was useful for *T. rex*, as they were meat-eaters who enjoyed gnawing on bones, something that easily caused teeth to break. A broken tooth could lead to inflammation of the surrounding gum tissue and bone. Considering T. rex's carnivorous diet, their mouths likely hosted a wide variety of bacteria, so a secondary bacterial infection following an oral injury wouldn't be surprising. The infection was so severe that it eroded the jawbone and eventually broke through to the outside.

Daan was able to determine that the tooth Trix had in the area of the infection didn't have enough bone tissue to stay firmly in place. As a result of Trix's injury, the tooth either fell out or broke off. In any case, the tooth was no longer present at the time of her death. While the exact cause of the infection remains uncertain, Daan does know that birds and reptiles (and likely dinosaurs as well) didn't have liquid pus like we do, but rather caseous or "cheese-like" pus. A bit of a gross detail—but it refers to thick, yellow pus that looks like soft to mature cheese. Yuck!

What exactly caused Trix's death may forever remain a mystery, but it's clear that she led a very adventurous life and died with an ugly, aggressive wound on her snout.

What age did T. rex reach?

Researching Trix's age is complicated. Sifra Bijl is a paleontologist and has been working on Trix's bones for years. By using growth lines in the bones (Figure 8A), it should be possible to determine the age. While in trees the growth lines (annual rings) are clearly visible, it is unfortunately not so easy in dinosaurs. As these animals age, new bone grows over old bone (Figure 8B). As a result, only the minimum age can be determined. *T. rex* Sue is so far the oldest *T. rex* found. She lived to be about 28 years old. Twenty-three growth lines were counted, this was extrapolated to 28 years. Sifra's initial results were obtained from the fibula and indicated that Trix was even older than Sue, possibly at least 30 years old. It was later found that the fibula showed much newly formed bone that had grown over the old bone, a pattern not found in the other bones. This makes it not representative of age. Now that more results have been obtained from several other bones, Trix's age is estimated to be much lower: at least 17 years.

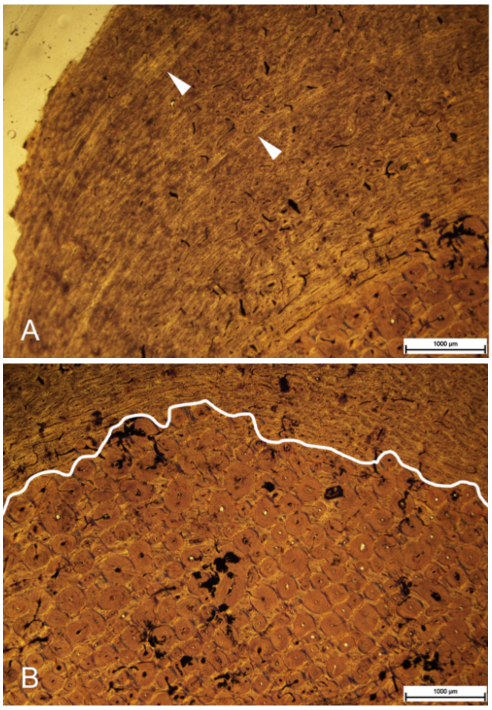


Figure 8. A thin-section of the rib of T. rex Trix. In some places, clear growth lines are visible (A, white arrows). In other places (B), new bone (below line) grows over old bone (above line).

To drill or saw?

But how are those growth lines visible in a bone? Naturalis has a unique *T. rex* that is attended to with great caution. So as to apply the least possible damage to the bone, a drill core from the fibula was obtained (Figure 9). A thin section is made from this. The drill core is then placed back into the bone. This thin section makes it possible to count the growth lines. When a 'slice' would be cut out of the bone, a seam would appear in the bone, which would be a shame.

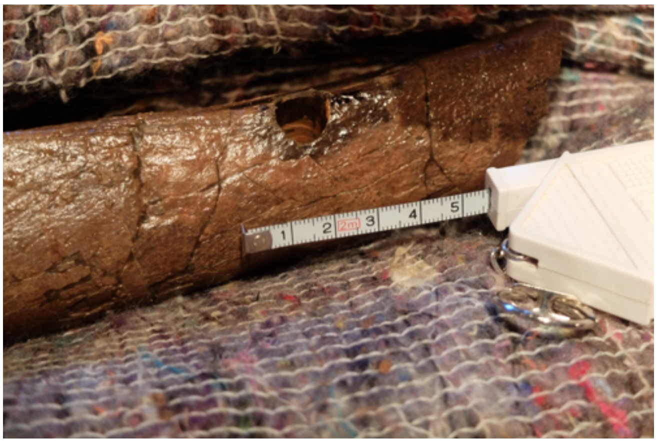


Figure 9. A piece of bone from which a drill core was extracted for examination.

Verification
During the research, a drill core will probably be taken from other bones as well, such as the thighs or ribs. By counting the growth lines in more places, something can be said about the age of our *T. rex* with more certainty.

Taking a stroll
Carnivores tend to be good hunters. You would therefore expect these animals to be able to run fast. However, little was known about this from the hypercarnivore *T. rex*. Nothing could yet be said about its average walking speed either. When *T. rex* took a walk, what speed did the animal maintain? Naturalis researcher Pasha van Bijlert dove into this question. He used Trix's tail bones for this purpose. This is because the tail muscle drove the hind legs and thus determined how *T. rex* walked. Pasha made a computer model based on which physics calculations were made (Figure 10). He assumed a walking speed at which the animal uses as little energy as possible. For this, the movement of the tail has to be synchronised with that of the legs. In addition, the step length must also be included in the calculation. In other words, how big were the steps made by T. rex? This information was obtained from several fossil paw prints that have been found.

Figure 10. The model of T. rex with the tail muscle (red) driving the hind legs.

Based on this data, Pasha calculated that *T. rex* had a preferred walking speed at about 4.5 kilometres per hour. Imagine taking a walk in the woods with *T. rex*. You would be walking at the same speed (Figure 11)! This, however, does not mean that *T. rex* could not run. The animal certainly could, but how fast is not yet clear. At least 20 kilometres per hour could have been reached, but that is still pretty slow for a *T. rex*. The top speed of T. rex is still unknown and is currently under investigation.

Figure 11. Screenshot from an animation of a walking T. rex. The preferred walking speed was just 4.5 km/h. Animation by: Rick Stikkelorum and Arthur Ulmann.

A pleasant surprise

Let's go back to 2013, when Naturalis paleontologists traveled to Wyoming in search of *T. rex* bones - they found more! A skeleton of a triceratops was also found. Two years later an expedition was organized to dig it up. The excavation surprised everyone: instead of one skeleton, paleontologists found no less than six! In the years that followed, all the bones were excavated, prepared and assembled into new skeletons. One individual ('Dirk'), stands in Naturalis' dino exhibition, while the other five skeletons are displayed together as a herd. For more information, see the guide 'Triceratops: breathing new life into six fossils' on the Naturalis website.

Updates from the field

Planning to visit Naturalis in the summer? Then chances are the dinosaur team will be in America digging up fossils. If so, keep an eye on Naturalis' agenda, as a live connection to the dig may be established in the LiveScience exhibition. During these moments, visitors can ask the excavators live questions.

At other times, we would like to keep every dino fan updated on our dino adventures. Matthijs Graner, biologist and expedition member has therefore been vlogging during the excavations. He takes you out onto the plains, shows you how fossils are dug up and tells you all about life on the prairie. The vlogs can be found here. In addition, Matthijs made Triceratops TV in which various experts talk about their work. He also dove deeper into the world of Triceratops with vlogs and explainers.

Print files

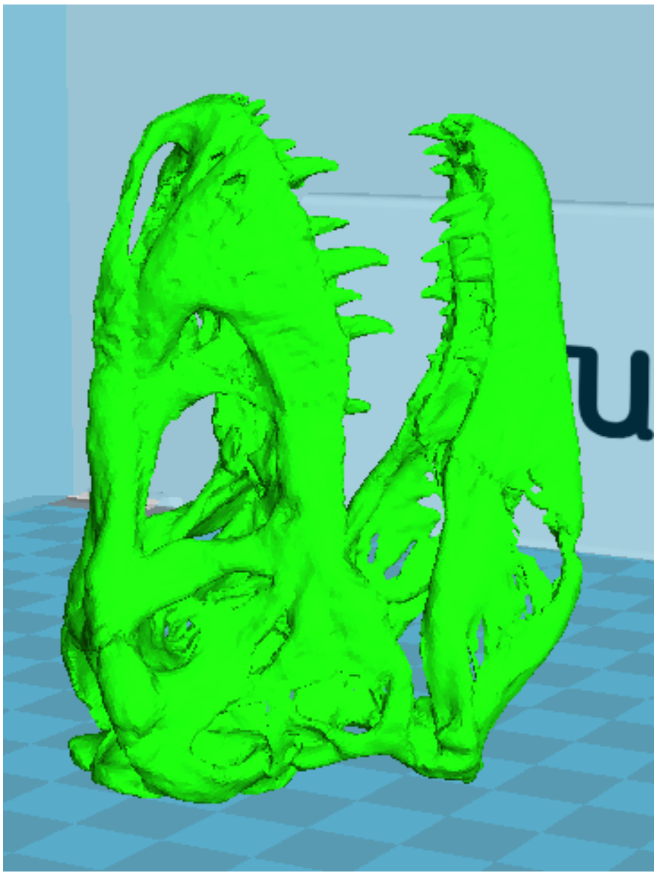
Here is the list of the seven objects that can be printed. The pictures are placed in the orientation in which they are best printed.

The head of Trix

Print time: +/- 4 hours

This is the head of Trix. In reality, the skull is one and a half meters long. In the lower jaw, you can see big holes. Scientists have discovered that it is highly likely it was bitten there by another *T. rex*. On the front of its snout (on the right) you can see a small hole below the nostril.Trix has probably had a nasty infection that never healed properly, but was there for a long time.

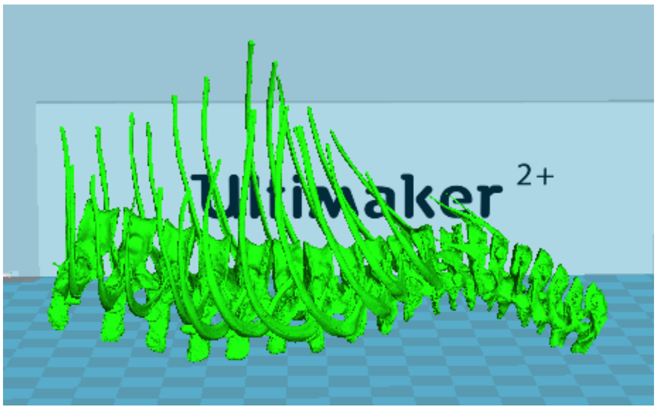
Trix is probably a female, as she is robustly built. Males were a lot smaller. In addition, *T. rex* females had bone cells on the inside of their bones that could hold and release extra calcium. From this extra calcium the shells of the eggs could be made. Unfortunately, we did not find these kinds of bone cells in the bones of Trix. So we are also not 100% sure that she is an female. The bite force of a *T. rex* is about 6000kg. So it would feel like the weight of six cars standing on top of you! The latest research indicates that Trix was at least 18 years old.



Vertebrae and ribs

Print time: +/- 7 hours

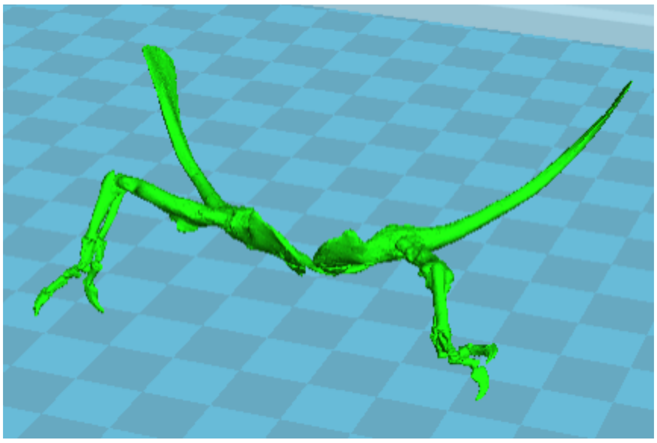
A lot of Trix's vertebrae and ribs were found. *T. rex* also had so-called belly ribs (not present in the print). These belly ribs protected the animal from e.g. the horns of *Triceratops*.



Arms and shoulder blades

Print time: +/- 1 uur

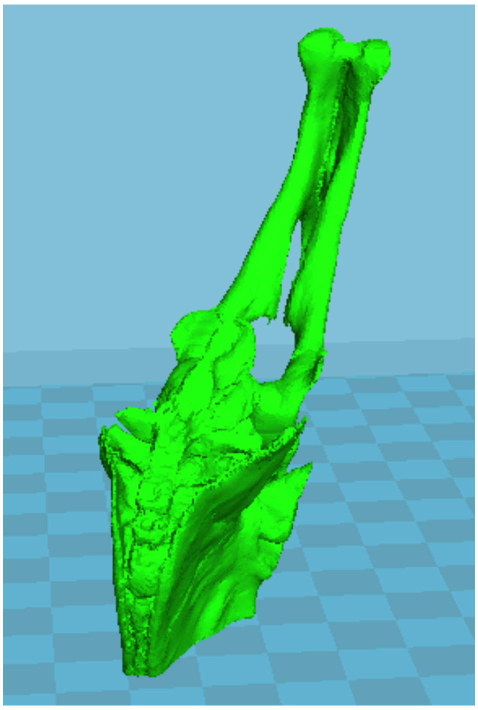
The arms of *T. rex* were very small, about the size of the arms of a 7-year-old child. Nevertheless, they were very strong. They could lift up to 300kg! The muscles needed for this were attached to the long shoulder blades. There were two sharp claws on each arm, which could probably be used to rip open prey. Researchers think the arms were also used to hold a partner during mating.



Hips

Print time +/- 6 hours

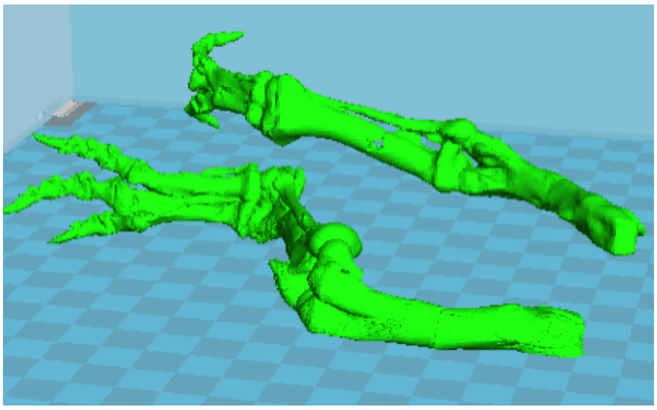
The hips of *T. rex* were huge. It consists, as with humans, of roughly two times three parts (left and right): the ilium, pubis, and ischium. The ilium is located at the top and clasps the vertebrae. The ilium is called that way because, with humans, it holds the intestines as a sort of bowl, in a *T. rex* this is not the case. The pubis is situated at the front in humans, but in a *T. rex* it sticks almost straight down like an anchor and is very large. The ischium protrudes to the back and is located underneath the tail. It possibly offered protection of the buttocks and may have served as a kind of protection for the eggs, so they would not smash to pieces on the ground. With humans, the ischium can be felt when you sit on someone's lap. It sits at the bottom of our buttocks.



Legs

Print time: +/- 4,5 hours

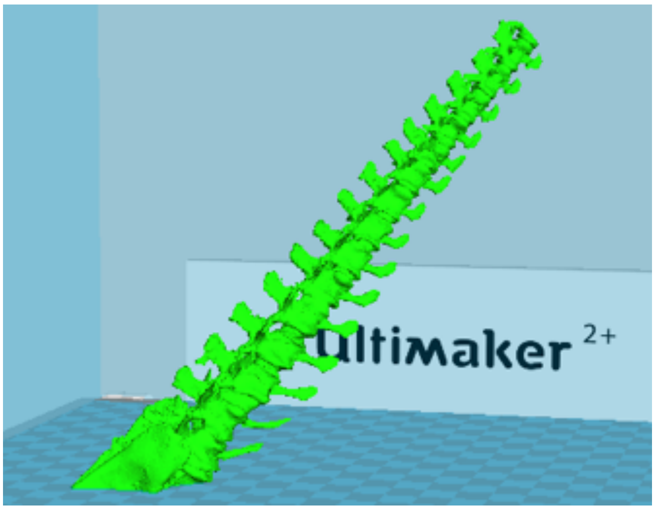
The hind legs of *T. rex* were huge and roughly similar to the shape of a chicken leg. Scientists have discovered that the average speed at which *T. rex* walked was about 4.5 km/hour, comparable to that of humans! At top speed, *T. rex* was obviously faster. How fast cannot yet be said with certainty, but T. rex could certainly reach speeds of 20 km/hour. This means a human could stay ahead of *T. rex* when riding a bike.



Tail origin

Print time: +/- 7 hours

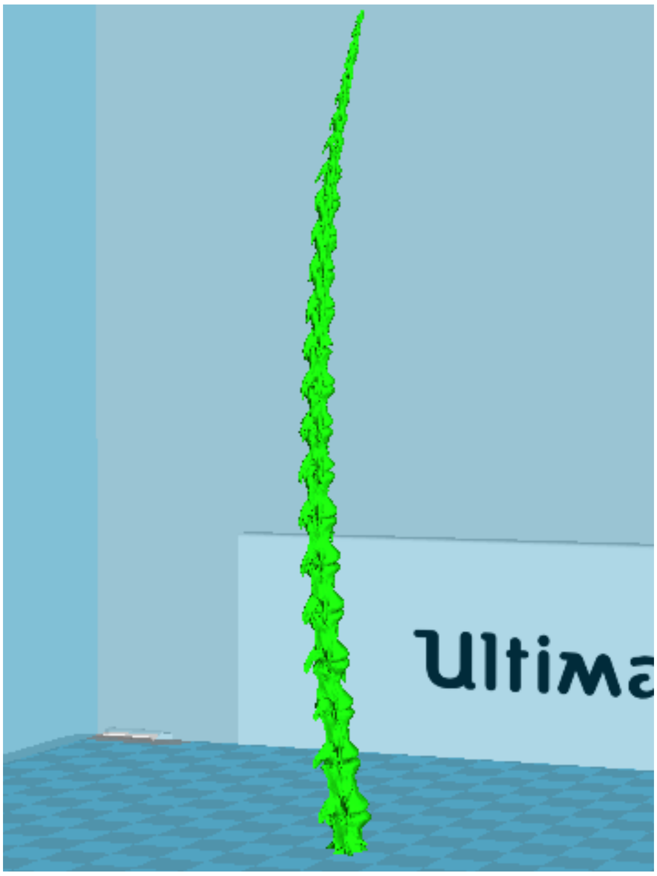
De staart van *T. rex* is heel lang om in evenwicht te blijven. Haar kop is namelijk enorm zwaar. In dit deel van haar staart heeft Trix een vervormde wervel. Hierdoor liep haar staart mogelijk een klein beetje scheef. Misschien had ze daardoor ook wel pijn en moeite met lopen.



Tail end

Print time: +/-2 hours

This is the end of Trix's tail. We're not sure how many tail vertebrae a *T. rex* had, since a complete tail has never been found. We looked at other skeletons of *T. rex*, where more of the tail was found. We think Trix had 42 tail vertebrae, but the bones at the end of the tail and some vertebrae in the middle were never found.



Assembly instructions

List of parts

Tail 1

Tail 2

Leg 1

Leg 2

Upper Body 1

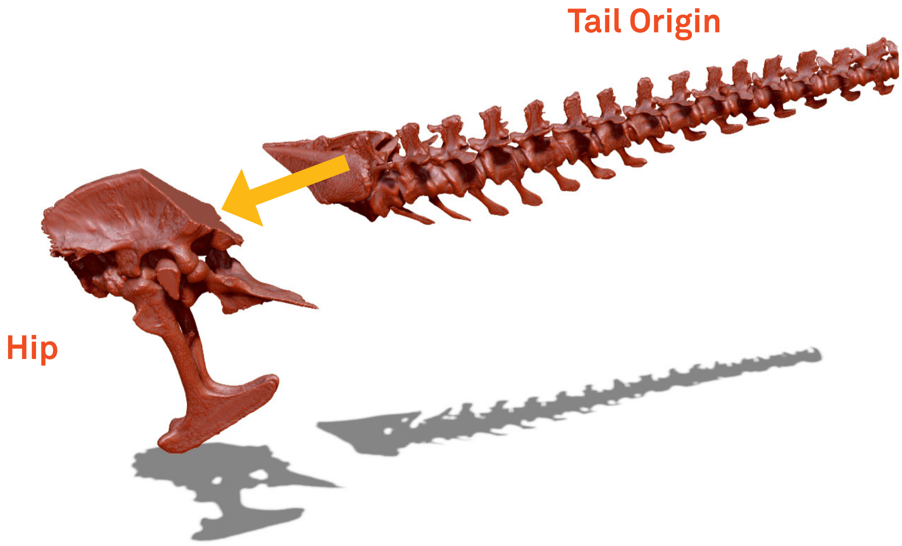
Upper Body 2

Upper to Lower Body Connection

Trix Skeleton

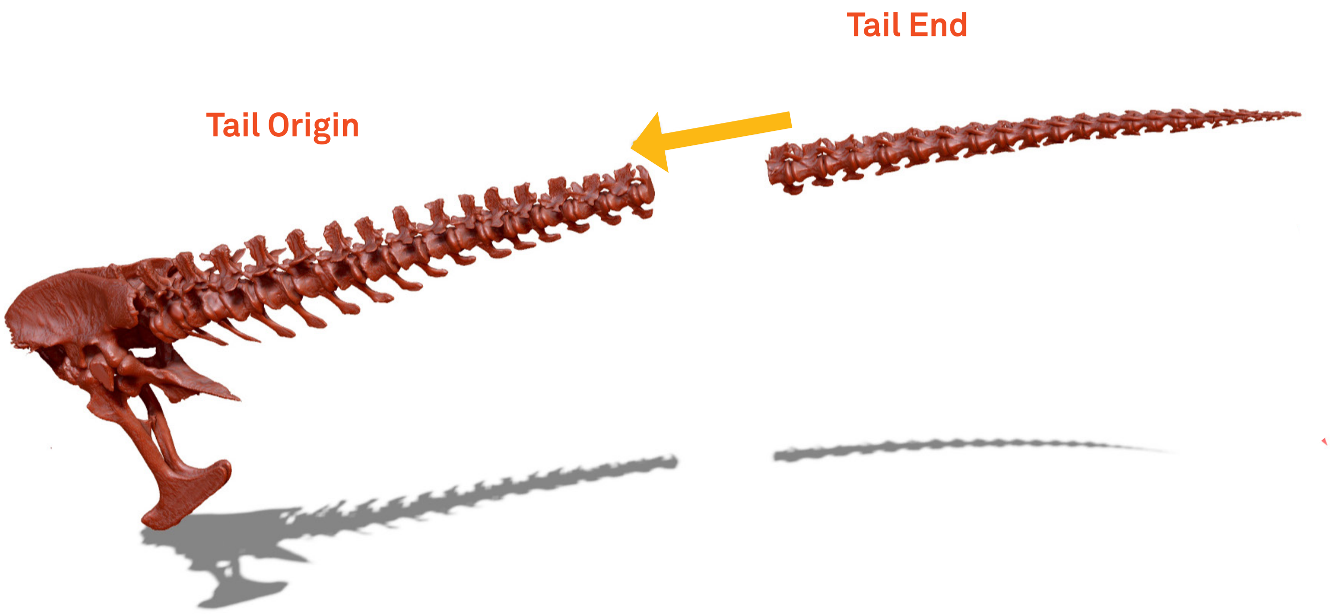
Tail 1

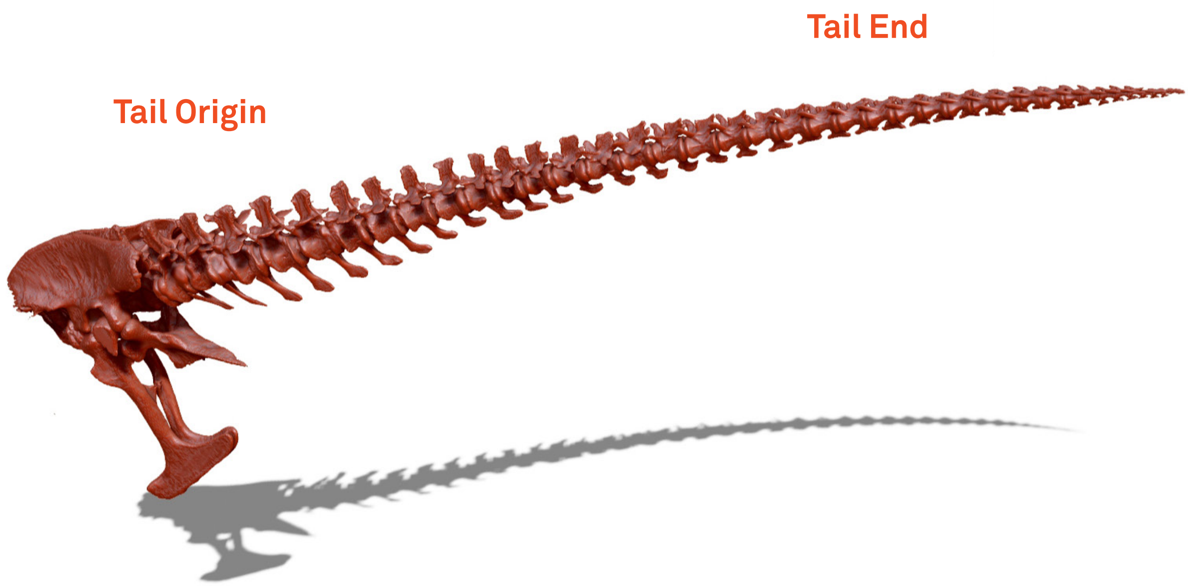
Attach the **Tail Origin** to the **Hip** part using a glue



Tail 2

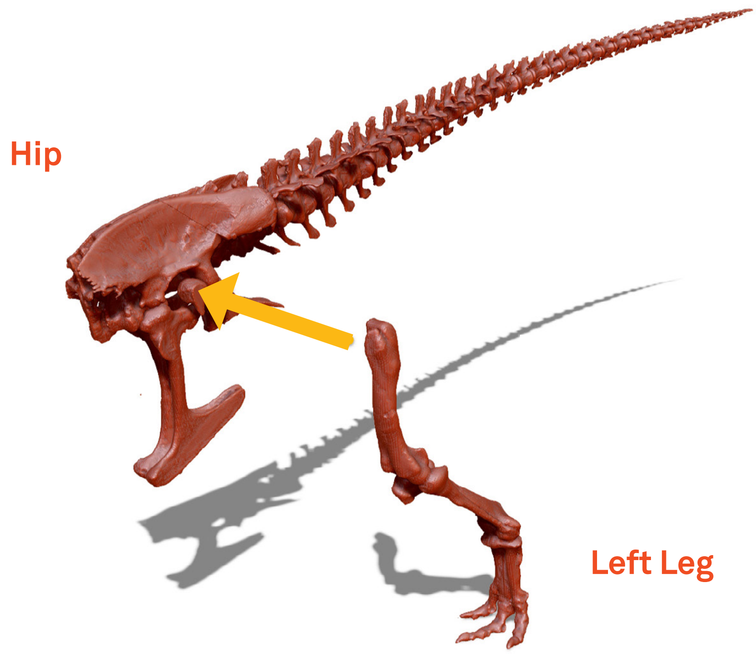
Attach the **Tail End** to
the **Tail Origin** using glue

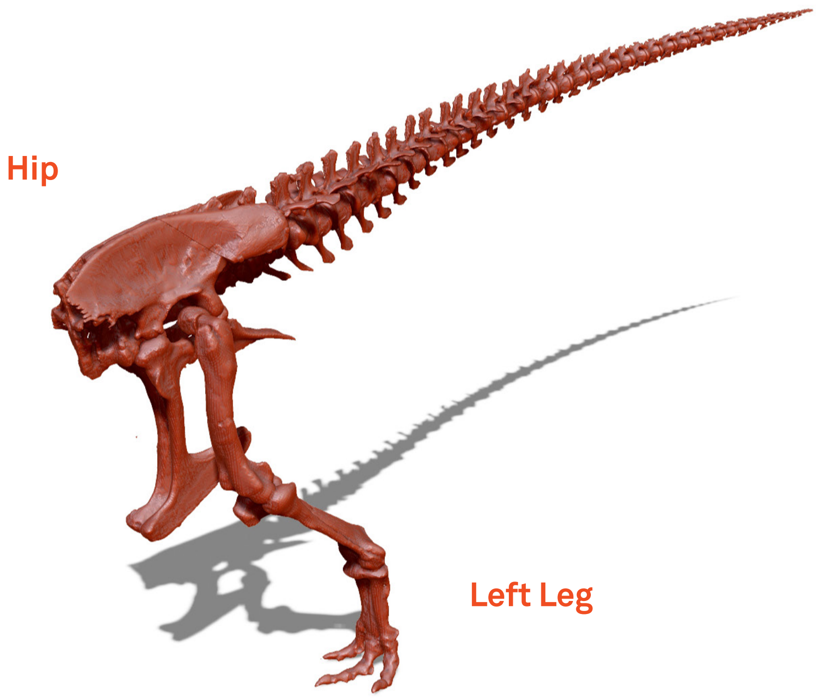




Leg 1

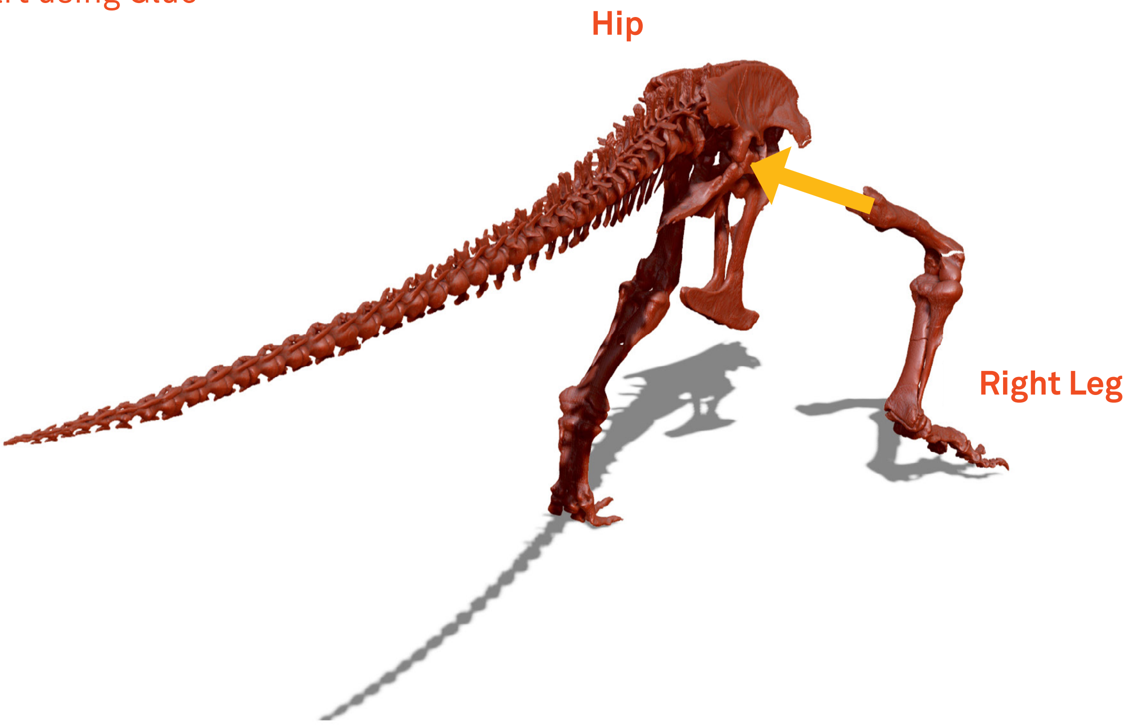
Attach the **Left Leg** to
the **Hip** part using glue

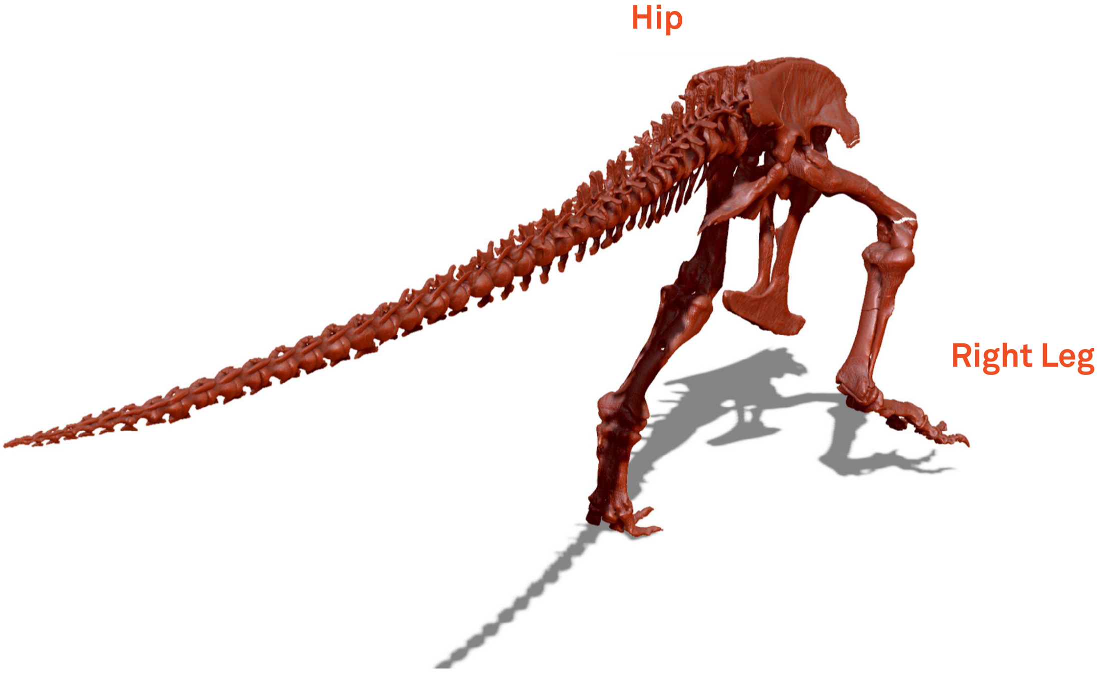




Leg 2

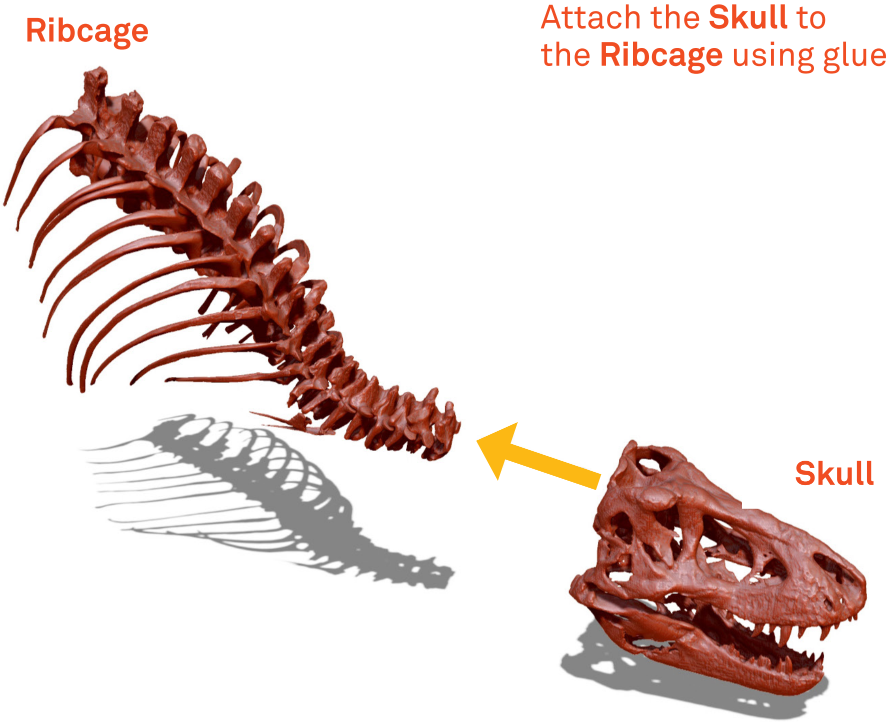
Attach the **Right Leg** to the **Hip** part using Glue

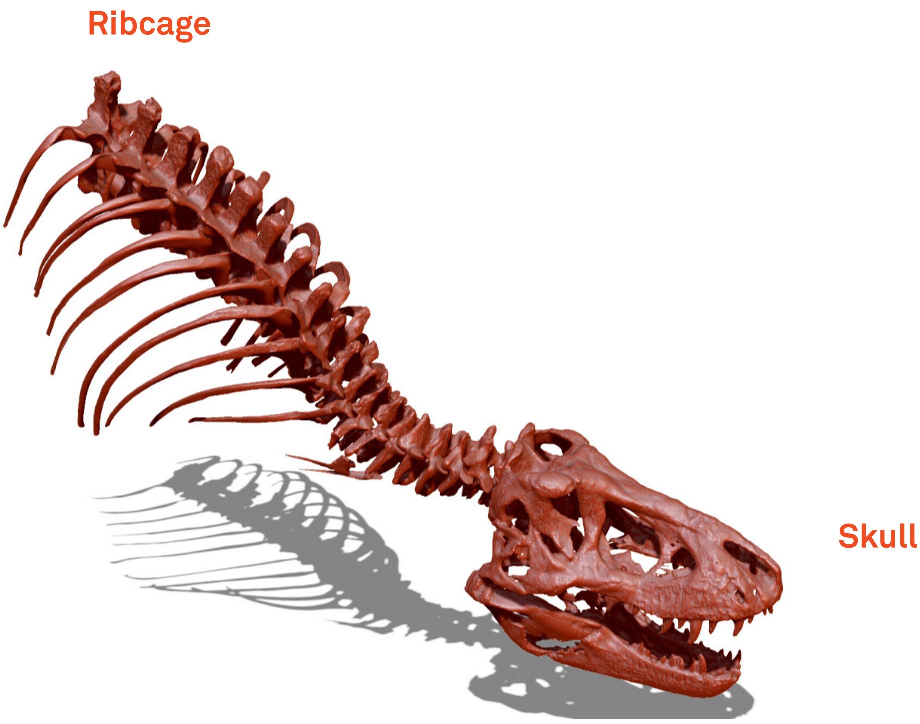




Upper Body 1

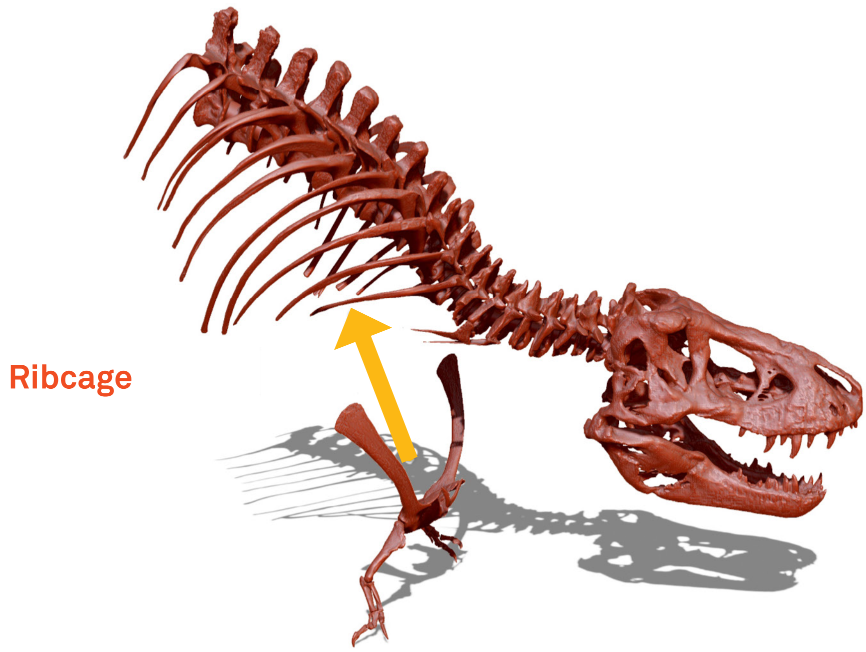
Attach the **Skull** to
the **Ribcage** using glue

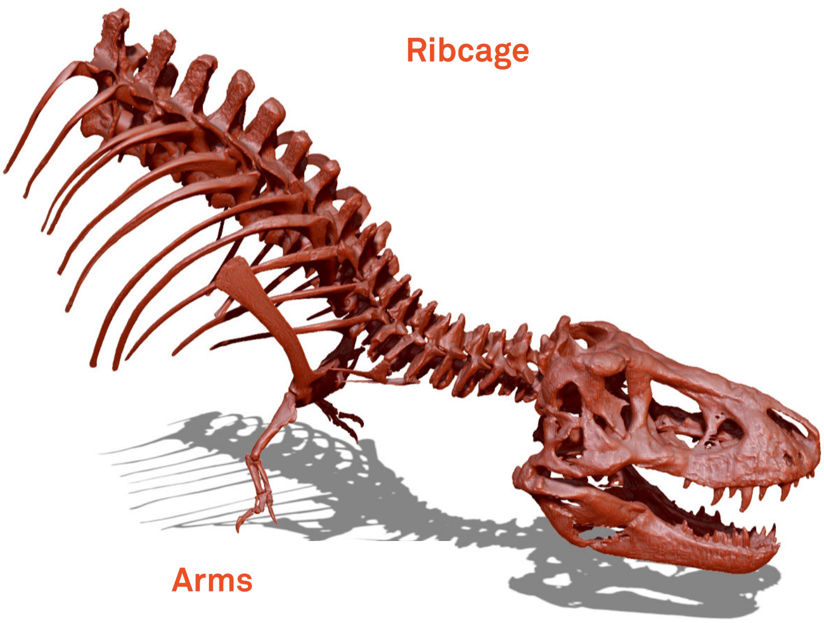




Upper Body 2

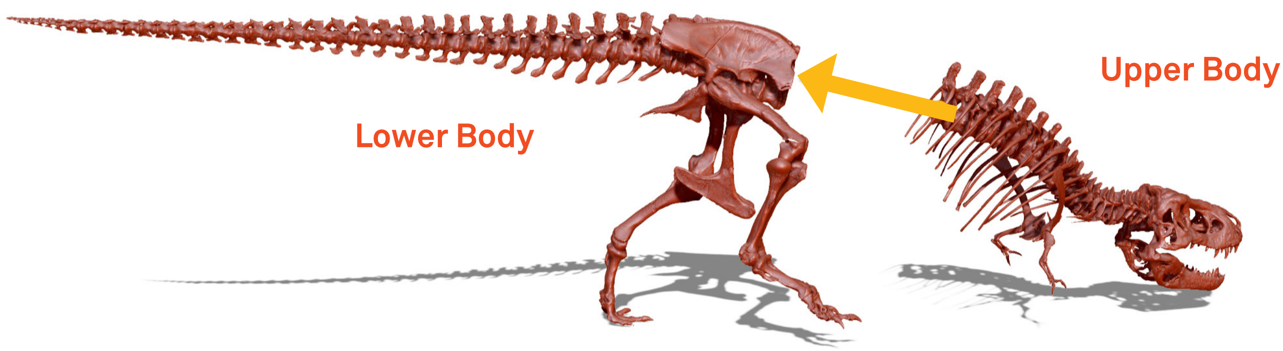
Attach the **Arms** to the **Ribcage** using glue

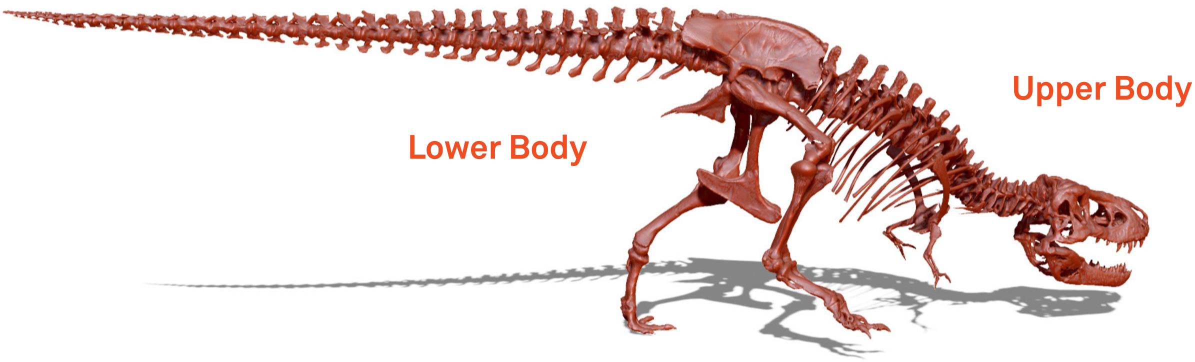




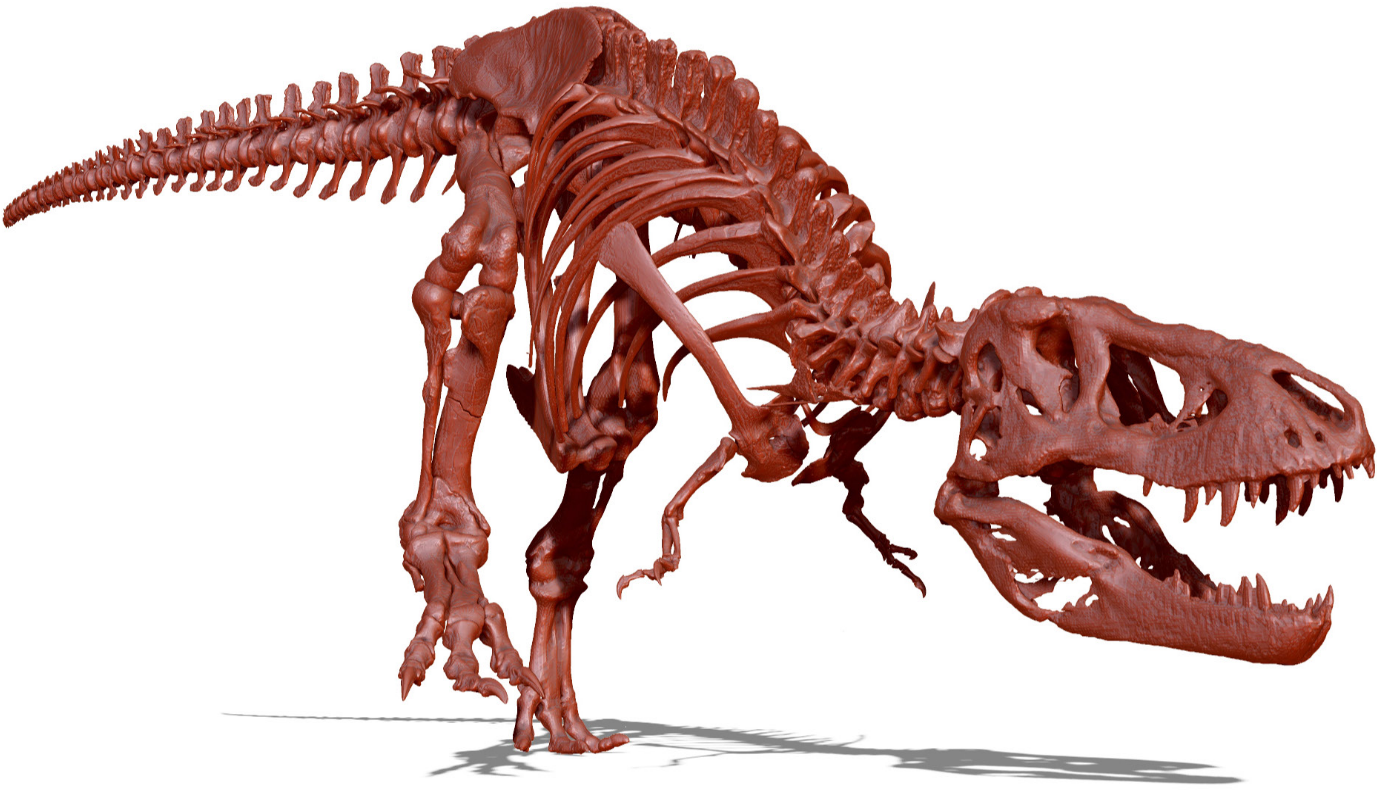
Upper to Lower Body Connection

Attach the **Upper Body**
to the **Lower Body**
using glue





Trix Skeleton



Source material

Needed for printing:
Printmateriaal

Videos (all in Dutch):
What does a paleontologist do?
What has been found of Trix' skeleton?
Trix under construction
How hard could T. rex bite?
This is our Dinolab

Extra footage:
Why Trix is so beautifully preserved (in Dutch)
Timelapse building Trix (in Dutch)
Vlogs Triceratops excavation (in Dutch)
Triceratops TV: (all films)
Triceratops TV: meet the experts

Articles:
Natuurwijzer (in Dutch)

Naturalis Biodiversity Center