

Triceratops

reviving six fossils



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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.

Learning goals

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

Connection to Dutch core objective

The lesson connects to 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 activity

How did *Triceratops* live? And how do we reconstruct a dinosaur skeleton? Using 3D prints, students learn about the functions of different bones, how the skeleton of *Triceratops* is put together and how this animal lived many millions of years ago. The activity ends with the construction of a small exhibition with triceratops model (scale 1:8). In the process, the many background stories and videos give a unique insight into the world of *Triceratops*.

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

The 3D scans of the bones of *Triceratops* in low resolution can be found and downloaded [here](#). The connectors to join the parts will be printed automatically along with the bones. Consider in advance which of the following scenarios will be the context of the activity*:

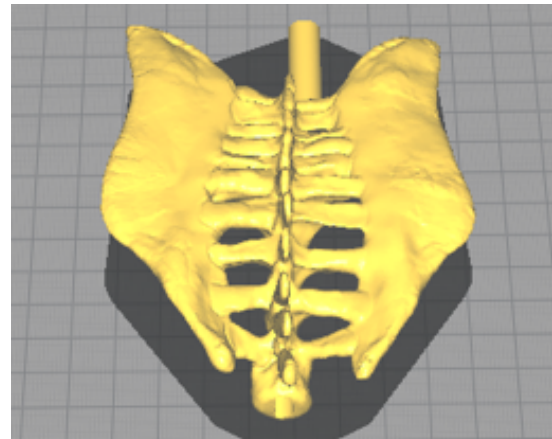
- A** Option 1: print each part of the skeleton. This will result in a complete *Triceratops* model (scale 1:8).
- B** Option 2: print several parts of the skeleton. This option is the more realistic one, since a complete skeleton of *Triceratops* has never been found.

*The choice made affects step 7 of this activity.

Step 1 Print time: +/- 9 hours

Print the 'Sacrum' (see Figure). Tell the students that they are going to participate in a 3D printing activity.

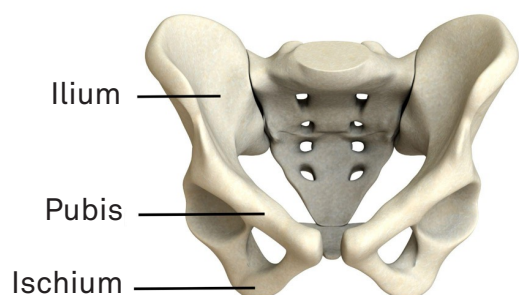
Without giving further information to the students, they wonder what is being printed. They are curious, but only know that the print is the beginning of a fun activity, during which more will be printed.



Step 2 Length: +/- 20 minutes

Let the printed sacrum circulate in the classroom. Discuss this first print with the students. What stands out? What does it look like? What is its function? After a short discussion, indicate that it's a piece of bone from a dinosaur that's actually over a meter long. Show the [photo's](#) of a real sacrum (without the ilium) as prepared in the dinolab at Naturalis. 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. The printed bone contains only the ilium

(pubic bone and ischium is a separate print).



A human's hip bone consists of three parts: the ilium, pubis and ischium.

Stap 3 Print time: +/- 9 hours for both prints together

Print two parts: 'Clavicles' and 'Tail'.

Stap 4 Length: 1 hour

The groups of students examine the individual prints. Everyone is given the opportunity to examine all the printed parts. They gather additional information about bones, fossils, muscles and dinosaurs. Based on this information each pupil draws or crafts the animal belonging to these bones. What do they think this dinosaur looked like? The creations will differ. It shows that there are many possibilities.

Additional information to provide

Scientists often have to conduct their research based on 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) of the modern vertebrate skeleton is largely similar to that 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.

Stap 5 Length: 30 minutes

In reality, not all bones are found. Briefly discuss the reason for this. Bones may have been washed away with water, or moved and eaten by scavengers and carnivores. Tell students that the printed bones are from *Triceratops*. What do they already know about this animal? Show one or more of the videos below that explain what kind of animal *Triceratops* is and how things work at an excavation. The videos below are in Dutch, but English subtitles can be turned on:

[A short history of Triceratops](#)

[Life on the prairie](#)

[Nosebone of Triceratops](#)

[Plastering fossils for transport](#)

What did the students learn? What questions do they have? Can they collectively come up with answers to their questions?



Step 6 Length: depending on the number of prints

Students now know more about skeleton construction and how fossils are unearthed.

Additional information to provide

A total of not one, but six Triceratops were found, five of which were lying together. The skeleton of the individual who lay separate from the group has been unofficially named 'Dirk'. Scans of the bones from this activity belong to Dirk.

*None of the skeletons is complete and all the fossils of the remaining five individuals were mixed up. All the bones were excavated, prepared in Naturalis' [dinolab](#) and assembled into skeletons that are on display. In the meantime, researchers tried to uncover how these animals lived. One of their main questions: did Triceratops live in herds?**

Choose one of the options below:

- A** Print the remaining parts of the skeleton. Also print the base on which the skeleton rests.
- B** Print only a few more parts. Make sure that the skeleton remains incomplete and that some bones are printed twice. This is the triceratops Dirk version.
- C** Print several bones multiple times (e.g. six shoulder blades/upper arms). In addition, print some new parts (not previously printed). This is the version of the group of triceratops.

Note: the latter two options are most based on reality.

* For more information about this research, read 'the story of the six *Triceratops*' further on in this guide.



This is what the complete model of *Triceratops* looks like (1:8 scale).

Step 7 Length: 2 hours

When chosen to print the complete skeleton (option A):

Each time a part has been printed, the students adapt their creation based on this new part. Have some students assemble the *Triceratops* skeleton when everything is printed. The parts can be connected to each other. As a final assignment, the students (in groups or together as a class) recreate the **living environment** of *Triceratops* with many different materials (paper, sand, wood, etc.) in which the printed skeleton can eventually be 'exhibited'. Have students look up missing information. They present the result to each other.

When chosen to print only part of the skeleton(s) (option B/C):

When one or more incomplete skeletons have been printed to mimic reality, students recreate the excavation site in groups, where the bones can be interspersed and half-buried. To do this, divide the prints over the groups. Have the students add miniature tools that they can tinker themselves. They present the result to each other.

Step 8 Length: 1 hour

Students have now learned a lot about digging up fossil dinosaur bones and reconstructing a skeleton and its habitat. Now they will discover more about the animal's **way of life**. What did the animal look like when it was still alive?

Finish the activity with a little research. The students answer a number of open questions about *Triceratops*, such as: How did he live? What did he eat? How did this group of animals die? And the most important research question: 'were they herd animals?'

Divide the students into a number of groups. Each group answers a different question by writing the answer on a large sheet of paper with arguments for it. After 5 to 10 minutes, each question is passed on to another group. This group gives its own opinion and arguments. Finally all questions are answered and a classroom discussion takes place, in which students name and discuss the arguments for the given answers. For this discussion use the information from The story of *Triceratops* 'Dirk' at the end of this manual.

Stap 9 Optional

Do the 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. Also fun to watch is the episode of 'Klokhuis' about dinosaurs. In addition, there are many fun and accessible articles on [Natuurwijzer](#) about the dinosaur era (all in Dutch).

Tip!

Now that the students have created their own exhibition around the bones and have learned a lot about *Triceratops*, come visit Naturalis and experience what it is like to stand next to these mighty animals. Visit our [website](#) for more information.

You can also see our preparers at work in the dinolab in the LiveScience hall. Here the real fossils are processed and finally assembled into new skeletons. The students are allowed to ask their questions directly to the preparer. **LiveScience is always freely accessible!**



In het dinolab van Naturalis kijk je mee met een preparateur. Stel al je vragen!

The story of the six *Triceratops*

The fossils found come from the Upper Cretaceous (100.5-66.0 million years ago), to be exact from the Maastrichtian age (72-66 million years ago). At that time many dinosaurs like *T. rex*, hadrosaurians (e.g. *Edmontosaurus*) and of course *Triceratops* lived in North America.

America in the dino era

At the time, North America was split in two by a large sea from north to south: the Western Interior Seaway (Figure 1). At the edge of this sea, which had already shrunk 66 million years ago, lived the group of *Triceratops* that Naturalis excavated. Rivers flowed into this sea. One of those rivers ran close to what is now the site of the fossils found by Naturalis.



Figure 1. The Western Interior Seaway existed from about 100 to 66 million years ago. (c) Wikipedia CC-BY-4.0

Passport



Soort:	<i>Triceratops horridus</i> (Three-horned-face)
Geslacht:	probably male
Lengte:	up to 9 meter
Gewicht:	4000 - 7500 kilo
Leefperiode:	Late Cretaceous: 69 to 66 million years ago
Leefgebied:	Western North America

The climate

The climate was subtropical with open forests (see Figure 2). It was warm and it probably rained a lot (tropical storms). Researchers conclude this based on plant fossils and soil layers. Because of the storms the rivers flooded regularly. This was also the case at the spot where the *Triceratops* bones lay. Researchers know this because the fossils lay on top of a clay layer. It was probably a swampy area that was sometimes completely flooded when the river flowed outside its bed.

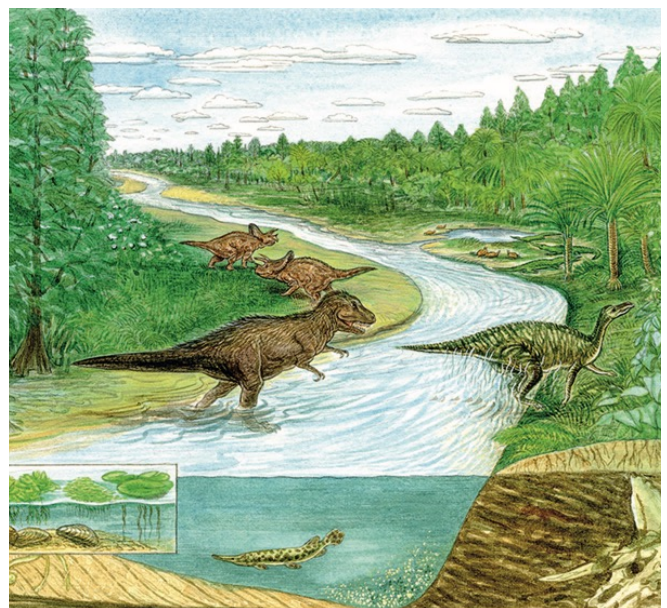


Figure 2. Impression of the flat river landscape in Montana where *Triceratops* walked 67 million years ago, drawn by Inge van Noortwijk.

The location

The fossil site of *Triceratops* (Figure 3) is situated in the state of Wyoming, America, near Newcastle. The site can be divided into two parts: a lower part (A) and an upper part (B). In the upper part, remains of one *Triceratops* have been found (Dirk), while on the lower site the remains of five individuals have been uncovered. The difference in height between the sites is about six metres, which corresponds to roughly about 5,000 to 15,000 years of difference in time. A total of around 1800 bone fragments have been found.

Figure 3a. Both sites seen from the air. The height difference of 6 meters indicates that the animals at site A did not live at the same time as Dirk (B).

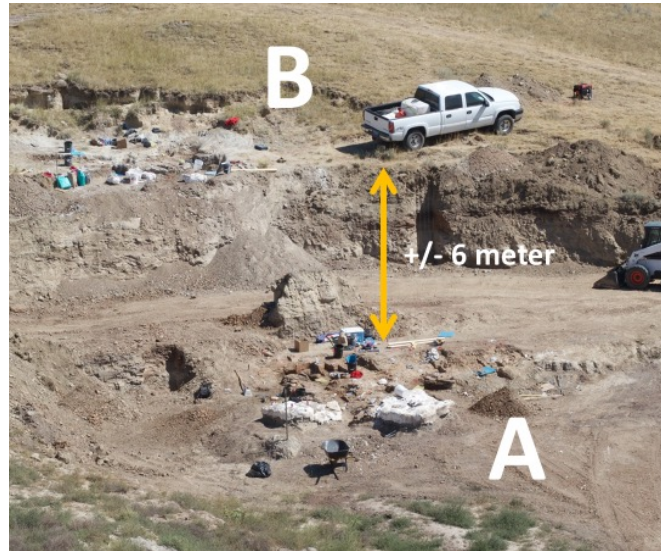


Figure 3b. Site A.



Figure 3c. Site B.

How did the site come to the surface?

At the time, the country was pretty flat. To the west of the site, forces from the earth drove up the Rocky Mountains. Thanks to this mountain formation a lot of erosion took place and over millions of years hundreds of meters of river deposits (sand, silt, clay from river systems) were deposited over the triceratops bones and the mass grave was well preserved. From about 30 million years ago, these layers were also subject to weathering and erosion.

Thus, more and more sand disappeared and the dinosaurs eventually reappeared on the surface. The sedimentary layer in which the bones were found is part of the so-called 'Lance Formation'. Although this layer is similar to the layer in Montana in which *T. rex* was found ('Hell Creek formation'), researchers do not yet know if both layers are of the same age.

How are the remains so well preserved?

The soil layers around the fossils are quite distinct (Figure 4). The fossils were found on top of the clay layer. The layer above it covered the remains of *Triceratops*. It consists of homogeneous sandstone, almost without stratification. This was most probably deposited all at once on top of the clay layer during a breakthrough of the river (this event is also called a 'crevasse splay'). There was probably a second breach of the dyke, both from different directions. This can be deduced from the thicknesses of the deposited sand layer at different locations around the fossils. As a result, this has left the fossils all mixed up (Figure 5).



Figure 4.

The triceratops fossils were found in a layer of clay and were quickly covered by a layer of sandstone. The green line indicates the boundary between the two layers.

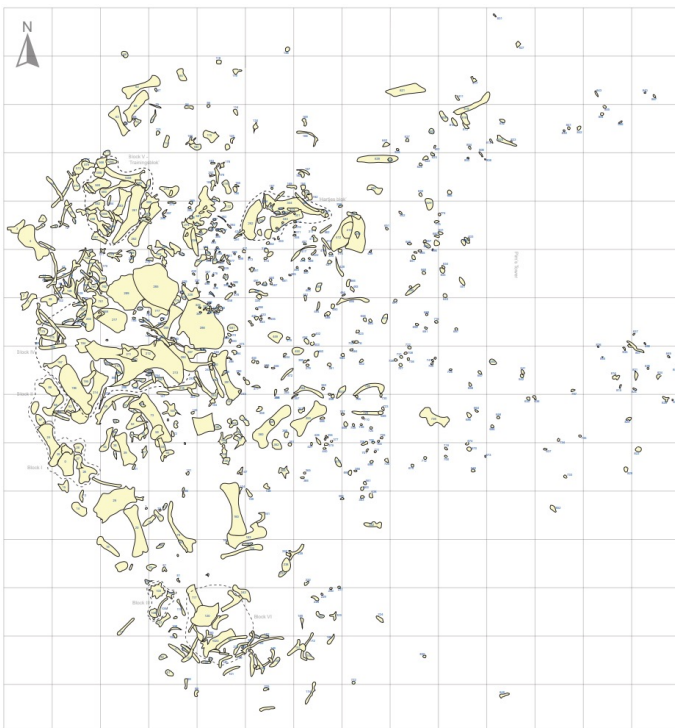


Figure 5.

The distribution of fossils in the field.

How did these triceratops die?

It is not known how *Triceratops* Dirk died. Researchers have mainly been trying to determine the cause of death of the group of triceratops from the lower site. It is likely that these animals died at the site where they were discovered, but how? The researchers are not sure, but something happened that drove the animals into the water just before their death. Something startled them (e.g. a lightning strike), but this is not certain (Figure 6). The animals eventually got stuck in the marshy riverbank and probably drowned.

Is the exact cause of death known?

Although it is now broadly clear what happened to the animals just after their death, the exact cause of death is still unclear. Several hypotheses have been raised. For instance, there could have been a big fire.

A swamp contains water and there are few trees around so the triceratops might have been safer here, not knowing they would get stuck. This should be evident from remnants of charcoal in the soil layers. In other words, burnt wood and plant material. Yet, finding a lot of charcoal does not necessarily mean that there was a fire, as wood can also turn into (petrified) charcoal due to the high pressure in the earth.

Lightning strikes that killed a herd all at once or drought that caused all the animals to gather around a well, where they starved to death, are also possibilities. However, no evidence has been found to support these hypotheses. It is therefore still unclear whether the animals died from fire, lightning strikes, drought, famine or something completely different.



Figure 6.

The group of *Triceratops* may have been startled by something and accidentally got stuck in the water. Drawing by Nadia de Waal.

Did they die together?

Yes, the clay layer around the fossils consists of very fine-grained material. This indicates that there was weak to no hydrodynamic activity at the *Triceratops* location in the water. In other words, the water was stagnant. So the animals most probably got stuck in this marsh. In addition, all the bones were found in the same (clay) layer. Moreover, the lack of fossils of other dinosaurs indicates that the group died in one fell swoop, otherwise more species should have been found. This proves that the animals were together at the time of their death and therefore did not wash together from different locations after their demise.

Did the animals get covered immediately after their death?

The remains of the animals were not immediately covered with sand. We know this because teeth were detached from the jaws and found dispersed. Did the animals then lie on the surface for years? No, neither. In fact, most of the bones are very well preserved

and no teeth marks have been found in them. This means that they nevertheless became (at least partially) covered relatively soon after their death, probably by the crevasse splays mentioned before.

How did *Triceratops* live?

The fossils found give clues about how these animals lived. Were they herd animals or not? Our find causes much debate about whether triceratops were herd animals or not: in fact, never before have so many individuals been found together. It has only happened twice before that several triceratops were found together. The fact that a group has now been uncovered for the first time does not immediately mean that they were always gregarious either: it is possible that the animals were temporarily together because of their mating season or because they drank from the same watering hole. A complicated research question, but with the discovery of so many fossils, solid research could finally be conducted.



Figure 7. Could *Triceratops* have lived in a herd? The latest research indicates that this is very plausible.

What research has been conducted?

The main research question is: was *Triceratops* a herd animal? To answer this question, several studies have been done.

Bone research (histology)

Bone research can be used to estimate the age of a *Triceratops*. For this, the growth pattern of the fossils was mapped. The researchers drilled a piece of bone from a leg bone and examined it under the microscope. Sometimes growth lines can be seen in these bones (Figure 8). These mark periods of slower growth. It is somewhat similar to the annual rings of a tree, but with one big difference. Whereas a tree never breaks off layers, an animal breaks off some

material on the inside of the bone, whereas new bone grows on the outside. Additionally, new cells replace old ones to maintain the bone tissue. This so-called secondary bone remodelling masks the information about growth that can potentially be extracted from the bone. This makes age determination difficult.

The neck shield (frill) of *Triceratops* also helps in determining ages. This is because it shows which growth phase the animal was in. Very young animals have a small, slightly backward-sloping frill with small protrusions (a kind of tilt) loosely attached to it. These are also called 'epi-bones' (epi means 'on top' or 'above' in Latin). When the animal became sexually mature, these epi-bones became clearly visible at the edge of the frill (Figure 8). In older animals, these crenellations disappeared. They were retracted into the bone, so to speak. It is possible that *Triceratops* had these crenellations to stand out to other *Triceratops*. In addition to this research, bone size is also examined. The results showed a difference in the age of the animals. The researchers divided the group in two age categories: young adults and adults, and estimated that the oldest animal in the group lived to be around 25 years old.

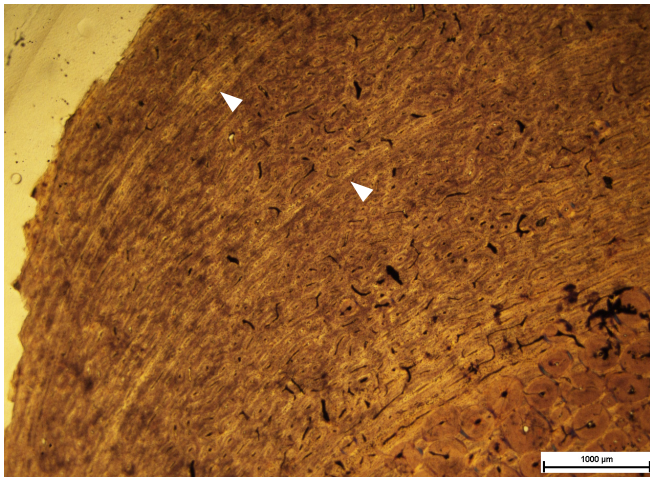


Figure 8. Visible growth lines in bone.

Figure 9. Protuberances (tilts) on the frill of *Triceratops* (A). A piece of frill with an 'epi' magnified (B) This is most probably a young adult animal. In the frill of an older animal (C), hardly any crenellations are visible. Based on the results, two age categories were found: young adults and adults.



Teeth (isotope research)

'You are what you eat.' A saying that also applies to *Triceratops*. By examining the teeth of *Triceratops*, researchers have found out whether the animals lived together. This is because the teeth store information about the food that was eaten.



Figure 10. Tooth of a *Triceratops*.

Enamel

In a living *Triceratops*, a small layer of enamel deposited itself daily on the outside of a new molar. A tooth consists of about eighty to ninety layers. This allows one to 'see' back in time for up to ninety days. The 90th layer was broken off when a new layer emerged, otherwise the tooth would have grown bigger and bigger. When the tooth was fully grown, the layers slowly wore off.

Isotopes

The composition of the layers of tooth is also important. When a new layer is made, the tooth absorbs certain substances. These substances are called isotopes. They are different forms of certain substances. For example, carbon and oxygen can have different forms. One carbon or oxygen particle weighs more than the other. By measuring these different isotopes, we can find out what the animals ate.

Depending on what the animal ate or drank, each layer of tooth consists of a different amount of isotopes. By comparing the isotopes of one individual with those of another, one can find out whether they lived together during the last 90 days of their lives.



Figure 11. Part of a *Triceratops* Jaw (upper left).

Migration

The isotope strontium was used in the herd study. This is because the ratio of different strontium isotopes differs from one type of soil to another. If different ratios of these isotopes are found in the different layers of one tooth, it is very possible that *Triceratops* was a migrating animal.

Conclusion

The results of these studies make it very plausible that *Triceratops* lived in herds:

- The bone study shows that the animals differ in age.
- The isotope study shows that the animals spent the last 90 days of their lives together.
- The geological study shows that the animals died and were buried together.
- The migration study shows that the animals did not travel long distances.

Whether *Triceratops* really formed herds cannot yet be said with certainty, but the results of the studies do show that these five animals lived together.

Want to know more? Watch the [interview](#) with researcher Jimmy de Rooij or the [explainer](#) (in Dutch) on the dental study.

Can its DNA be examined?

DNA research is not possible when it comes to dinosaurs. DNA is a very unstable molecule that breaks down relatively quickly after death. With luck, one can still find a piece of usable DNA from, for example, a mammoth that lived a few thousand years ago. However, looking further back in time than around 800,000 years ago is not yet possible. Perhaps with better techniques in the future researchers will be able to find more DNA.



Figure 12. 'Dirk' the *Triceratops* in museum Naturalis.

The result

All triceratops fossils have now been prepped and assembled into skeletons. *Triceratops* Dirk (named after volunteer Dirk Cornelissen, who worked a lot on these fossils, Figure 13) is on display in Naturalis' 'Dinosaur Age' exhibition. The herd has been given its own temporary exhibition. Afterwards, they will go on a world tour before finding their final resting place at Naturalis.



Figure 13.
Volunteer Dirk using glue on a broken fossil of *Triceratops*.

A complete skeleton?

Complete skeletons of dinosaurs have never been found. There are always bones missing that were eaten or washed away at the time, or were lost in the course of time due to shifting of the ground. This also applies to the skeletons found by Naturalis. Dirk is about 55% complete in terms of bone volume and 20% in terms of number of bones. The skeleton consists of about 300 bones. Of those, 61 have (partly) been recovered (Figure 14). For the group of five individuals, about 1,500 bone fragments were found. A large proportion of these comprise the large bones from the legs, but many pieces have also been recovered from the ribs and horns. In contrast, almost nothing was recovered from the toe bones (Figure 15).

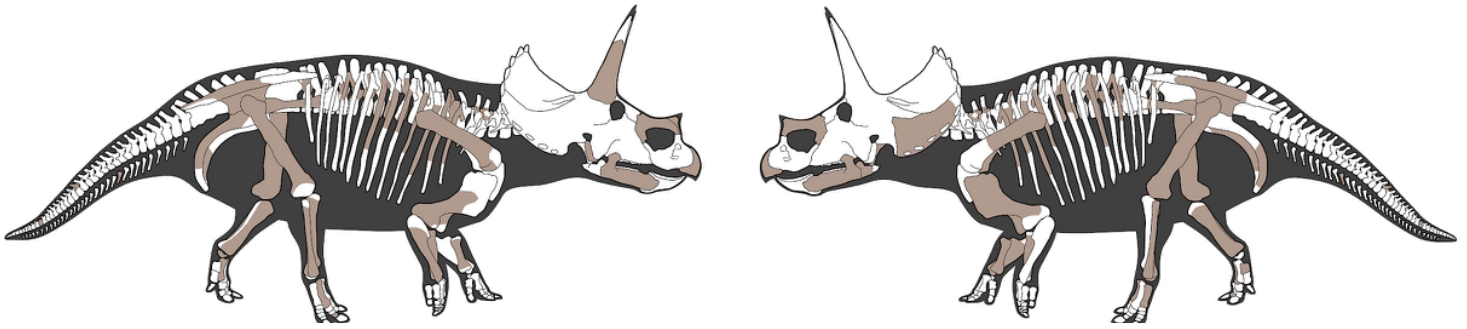


Figure 14. Schematic representation of all the found bones of *Triceratops* Dirk. Drawing based on a model from Scott Hartman and adapted by Olof Moleman.

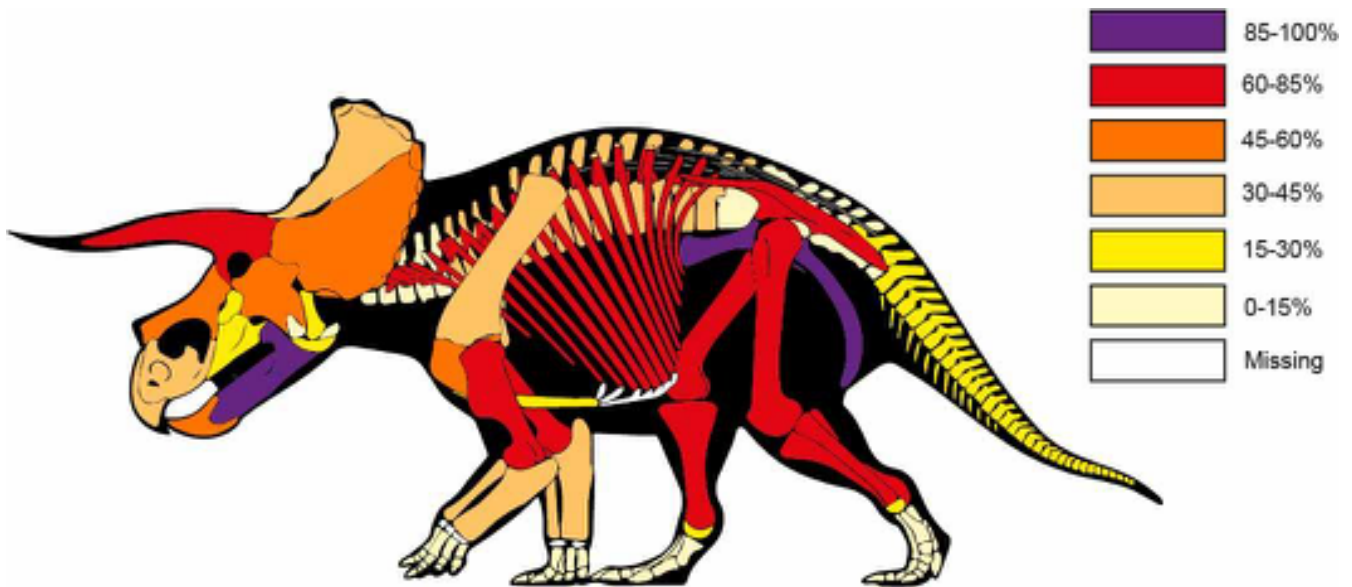


Figure 15. Schematic representation of the bones found from the group of triceratops. The higher the percentage, the more of these bones were found. Drawing based on model by Scott Hartman and adapted by Pim Kaskes.

3D printing

Nowadays, bones that have not been found are often 3D printed. This does not require real bones, as 3D scans have to be made. Fortunately, many *Triceratops* fossils have been found in the Americas to make use of. Consequently, the printed part of Dirk's skull (Figure 16) consists of four different individuals. Not all the printed material comes from other *Triceratops*. We try to use as many of the fossils found as possible. Take for example the right horn of *Triceratops* Dirk. Naturalis excavated part of it. This was scanned and then mirrored and 3D printed as the left horn. So although this horn is not real, it has been recreated as real as possible. In the end, almost half of the skeleton consists of copied and 3D printed bones. Even for the herd, most of the bones are 3D printed.

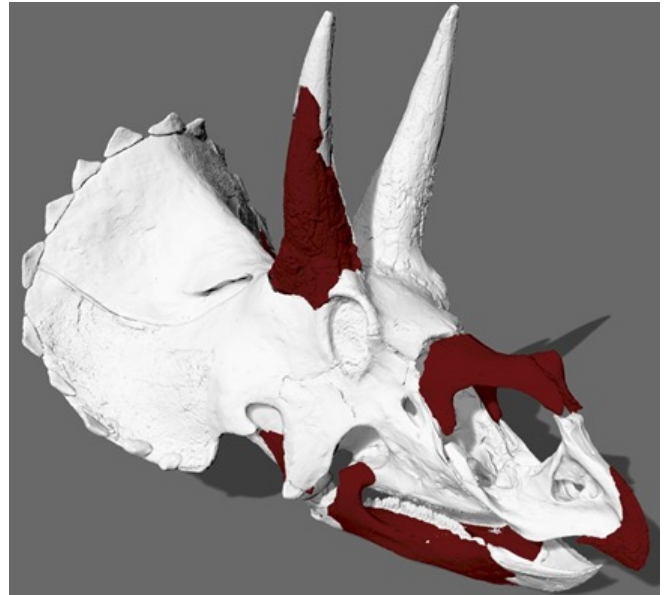


Figure 16. 3D model of *Triceratops* Dirk with the real parts indicated in brown. Model by Pasha van Bijlert.

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.



Part of the excavation team (2019).

Print files

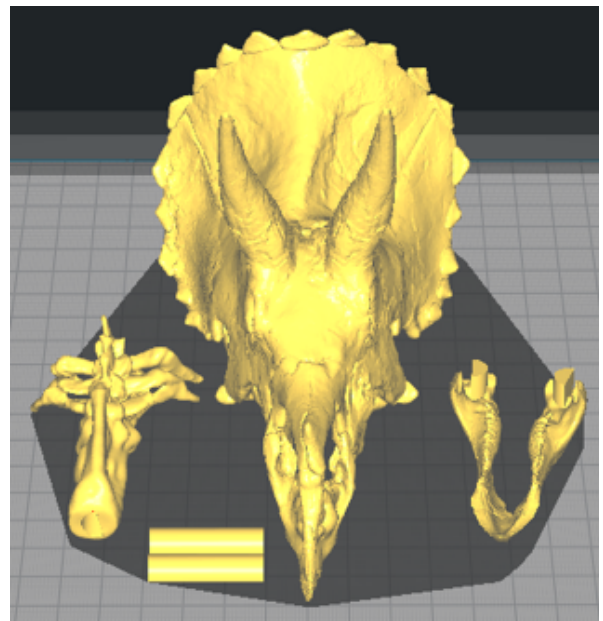
Below you will find an overview of the ten prints. The photos are placed in the orientation in which they are easiest to print. Some prints include small connectors. These are used to connect the skeleton parts together. The print times are based on the settings from the supplied Cura-profile. The prints were tested on Ultimaker printers and printed with pla filament.

Tip: Recycled pla can be bought [here](#), for instance. Try to [recycle](#) residual filament as much as possible.

The head of Dirk

Print time: +/- 16 hours

This is Dirk's head. In reality, the skull is one and a half metres long. On the head there are three horns, two above the eye sockets and one on the nose. This made *Triceratops* look dangerous and it could potentially scare off *T. rex*. At the back of the head there is a large neck shield (frill). Although this frill may have had a protective function of the neck, there are now more and more scientists who suspect that the frill was used to show off and attract a partner.

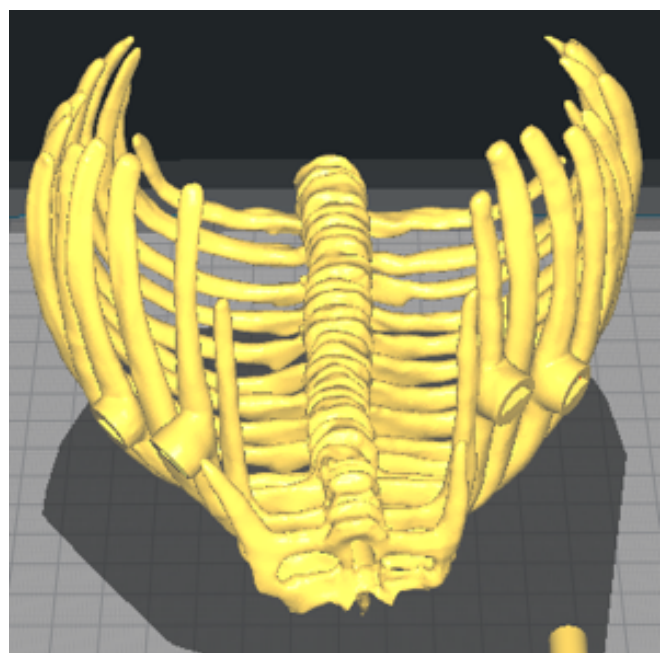


Vertebrae and ribs

Print time: +/- 33 hours*

The rib cage consists of 14 pairs of ribs. Thus, *Triceratops* had a total of 28 chest ribs protecting the underlying organs.

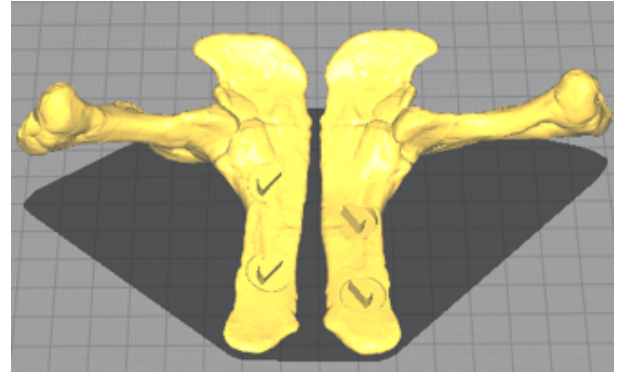
*because this is a large, complicated print, the print time is relatively long.



Shoulder blades and upper arms

Print time: +/- 6 hours

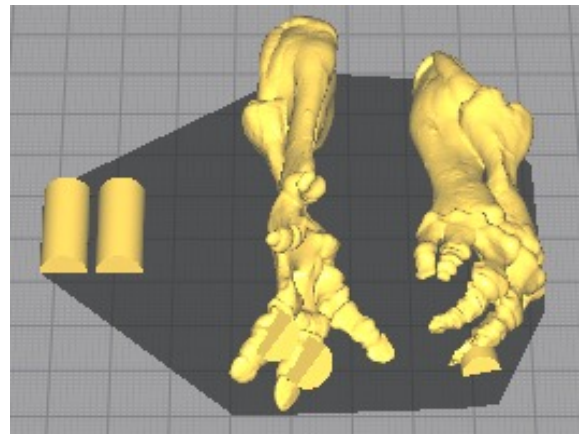
The front legs of *Triceratops* are very solidly built, as they must be able to carry the great weight of the skull. Each leg has two lower arm bones and one upper arm bone. The shoulder blades are very elongated and run along the body. At the front, the shoulder blades run into the ravenous bones that touch each other in front of the body.



Arms

Print time: +/- 4 hours

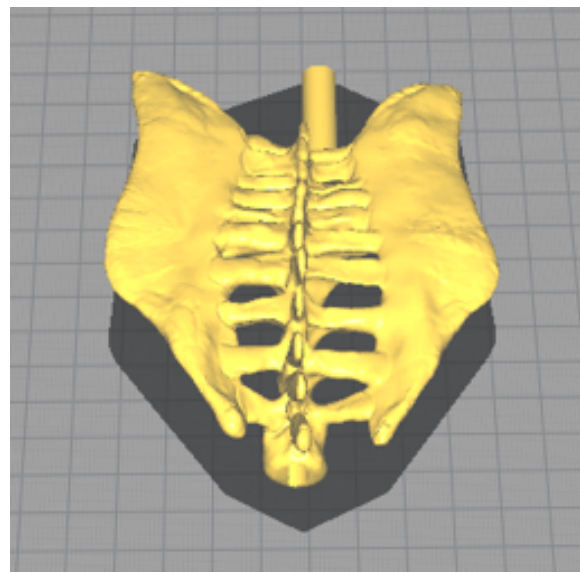
The front legs of *Triceratops* were robustly built. Each leg had five fingers. This makes the blueprint of all legs almost identical to that of humans. The sturdy bones ensured that the weight of the heavy head with horns and frill could be carried effectively.



Sacrum and ilium

Print time: +/- 6 hours

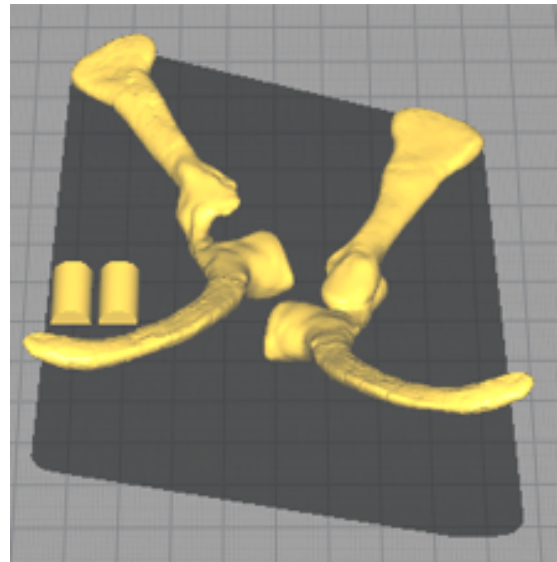
The hips of *Triceratops* were huge. The blueprint is almost identical to that of human hips, with the only difference being the orientation of the bones in the body. It consists of roughly three parts: the ilium, the pubic bone and the ischium. This print concerns the ilium. It is located left and right in the lower back and clasps the vertebrae in between (the sacrum). In this position it gives protection to the back.



Pubic bone and ischium

Print time: +/- 4 hours

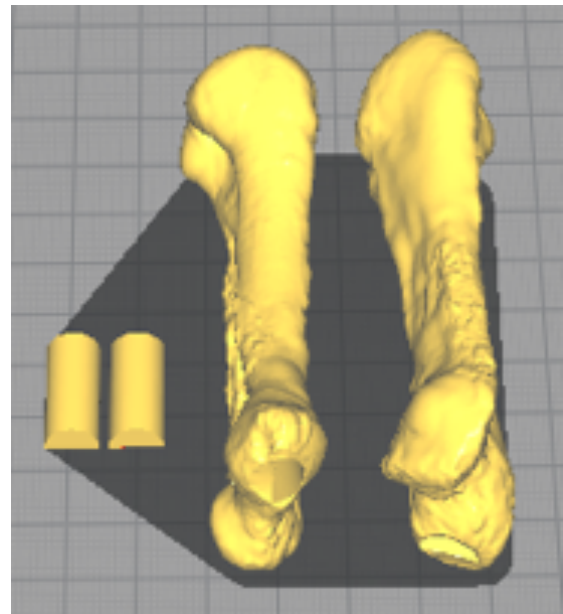
The pubic bone and the ischium are part of the hips, just like the ilium. In humans, the pubic bone is at the front, but in *Triceratops* it protrudes diagonally downwards and forward. The ischium protrudes backwards and is situated under the tail. It may have protected the buttocks and served as some kind of protection for the eggs, so they didn't fall apart on the ground. In humans, the ischium is easy to feel when sitting on someone's lap. It's located at the bottom of our buttocks.



Femurs

Print time: +/- 5 hours

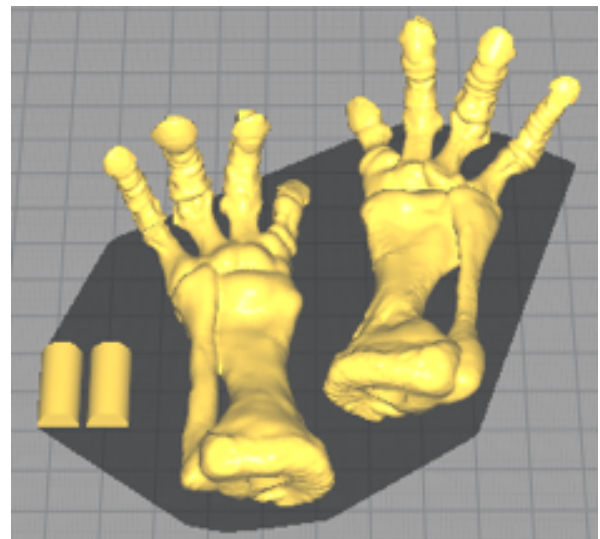
The thighs are relatively long and slender compared to the upper arms. The back of the animal usually protruded above the head.



Legs

Print time: +/- 7 hours

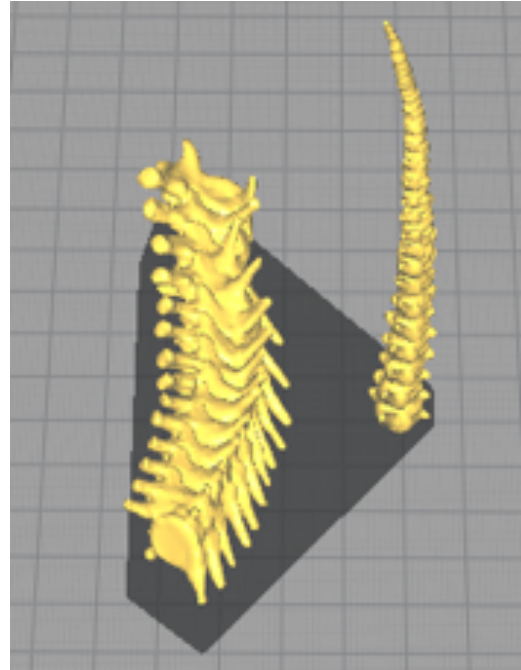
The hind legs of *Triceratops* were robustly built and consist of the same bones as in humans. It is not known how fast the animals could walk. Most likely not very fast, because it was a heavily built animal.



Tail

Print time: +/- 3 hours

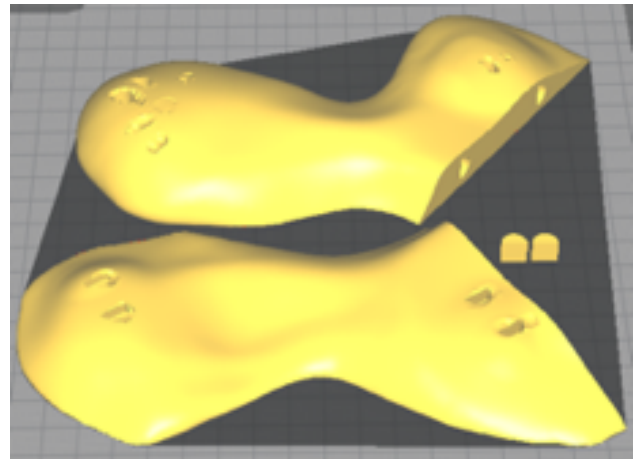
The tail of *Triceratops* is quite long and counterbalanced the heavy head. This kept the animal in balance. It is not known how many bones the tail consists of, since a complete tail has never been found. Not very surprising, as the bones in the tail are the smallest in the whole skeleton and they easily washed away with the water or were eaten by other animals.



Base

Print time: +/- 2 hours

This is the basis on which the skeleton can be placed.



Assembly instructions

List of parts

Base

Ribcage

Shoulder Blades 1

Shoulder Blades 2

Arms 1

Arms 2

Head 1

Head 2

Head 3

Head 4

Hips

Tail 1

Tail 2

Femurs 1

Femurs 2

Femurs 3

Pubic Bone 1

Pubic Bone 2

Legs 1

Legs 2

Upper Body

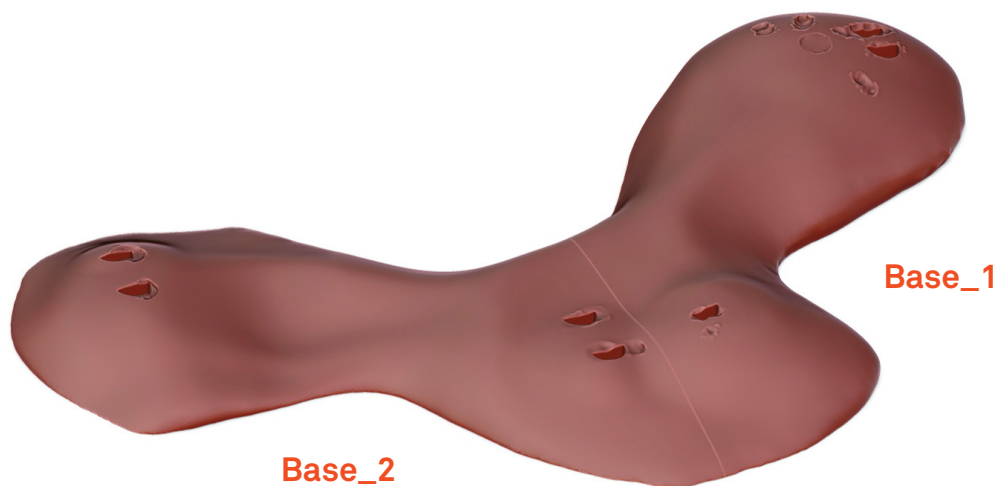
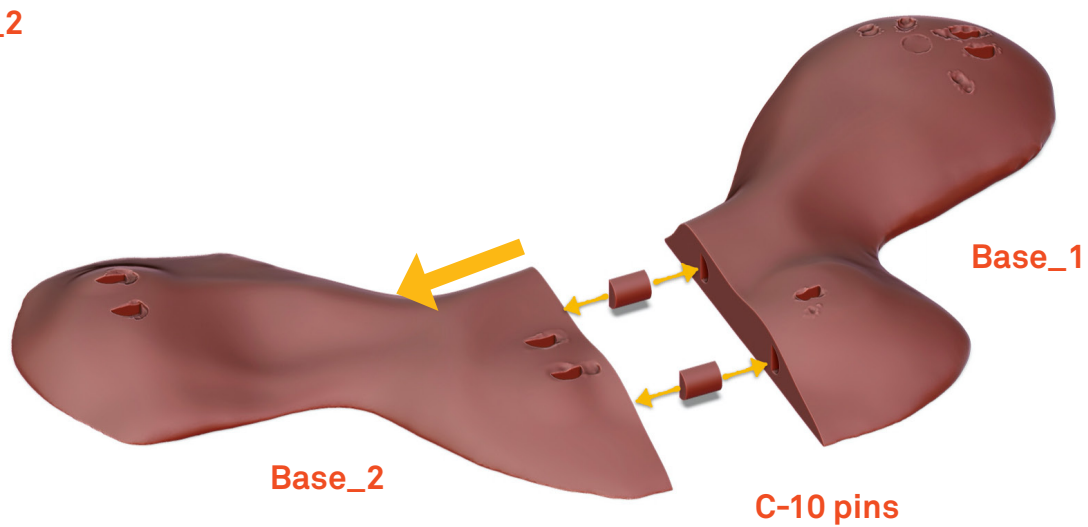
Upperbody & Hips Connection

Base Attachment

Dirk Skeleton

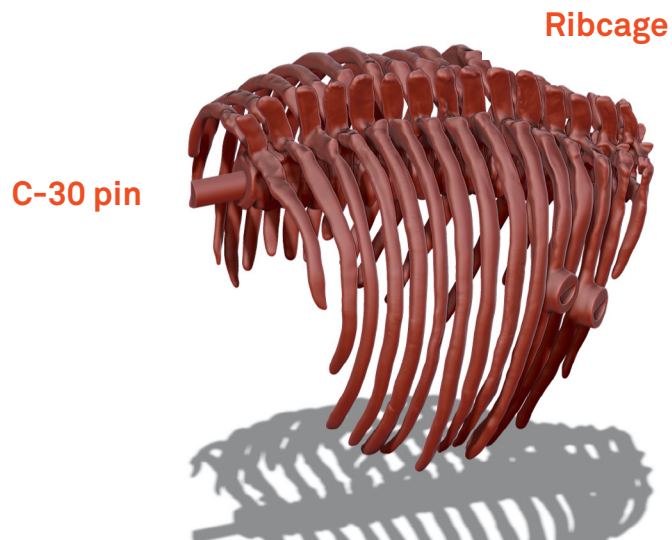
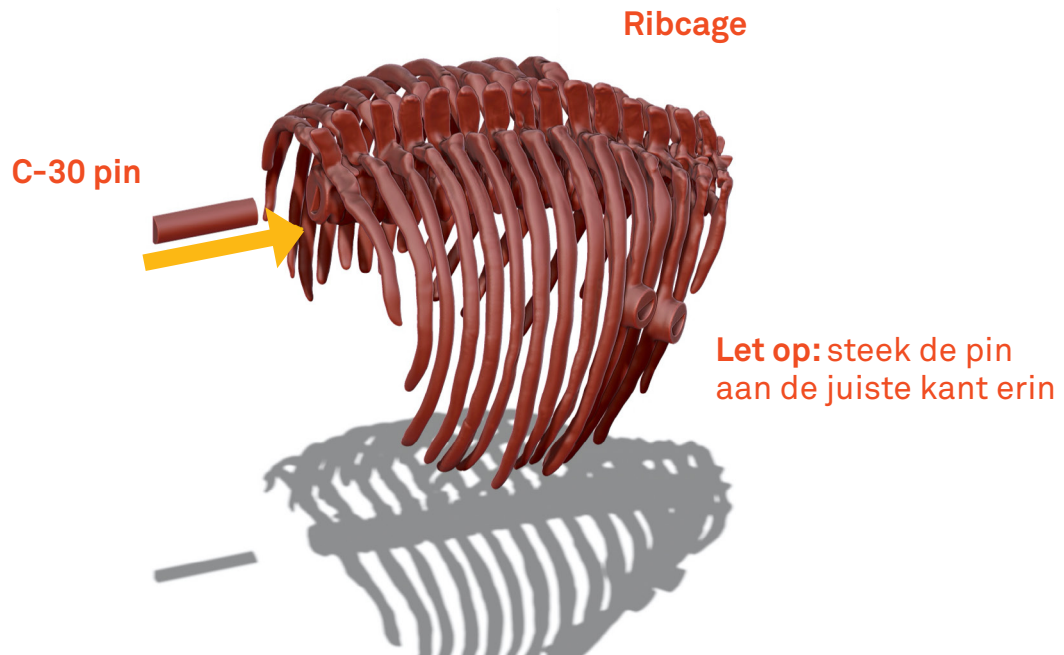
Basis

Insert the pins within the base element and attach the **Base_1** to **Base_2**



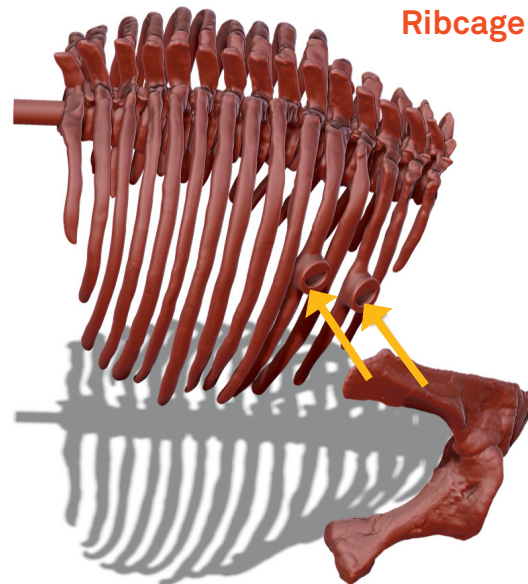
Ribbenkast

Insert the **C-30 pin** within the **Ribcage** part



Shoulder Blades 1

Attach the **Right Shoulder Blade** part to the **Ribcage**



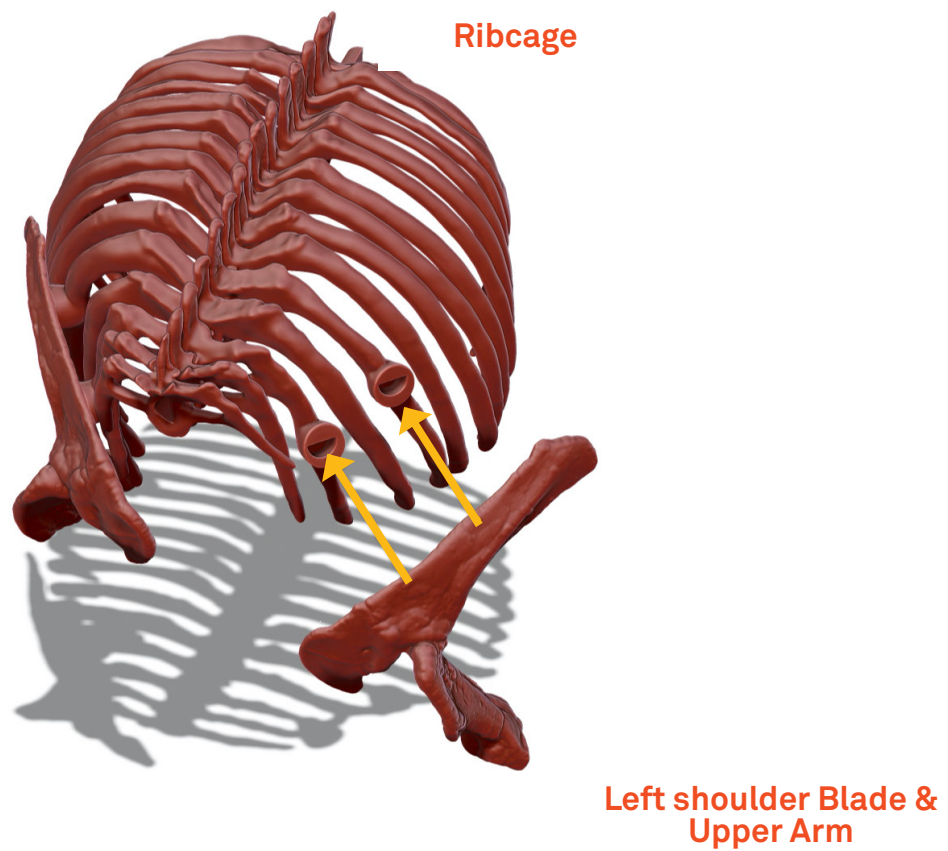
**Right Shoulder Blade
& Upper Arm**



**Right Shoulder Blade
& Upper Arm**

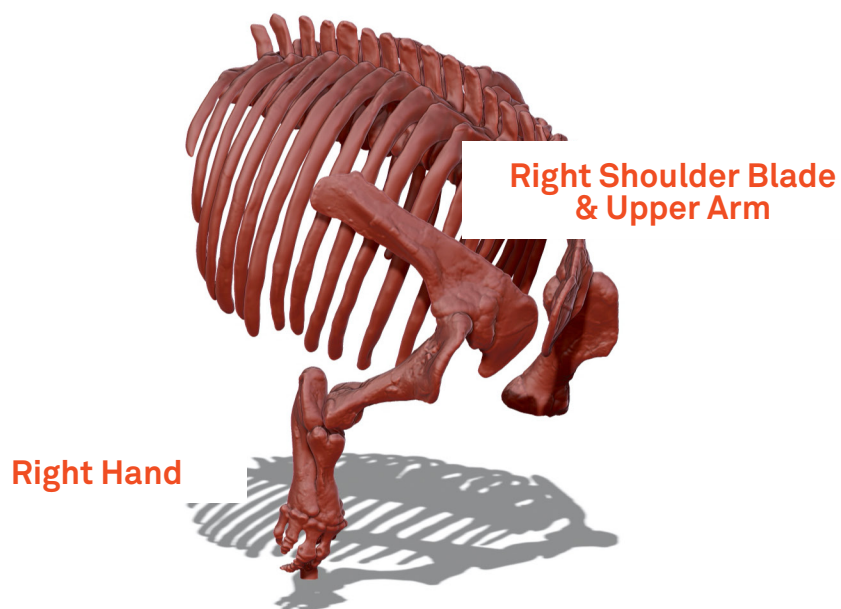
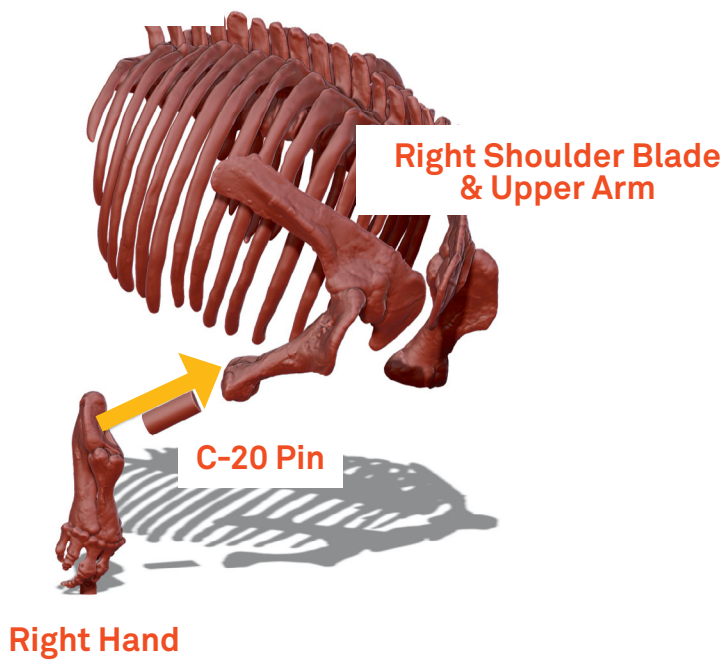
Schouderbladen 2

Attach the **Left Shoulder Blade** part to the **Ribcage**



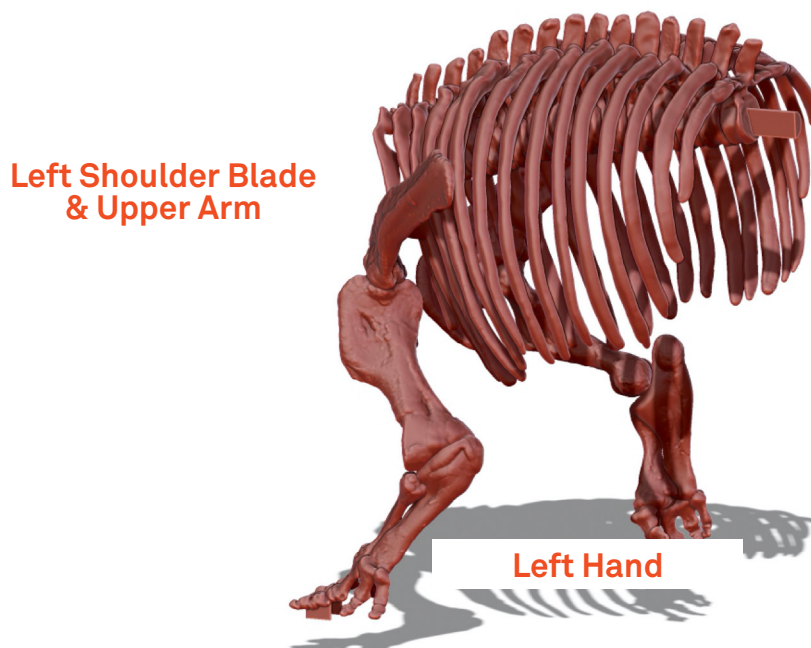
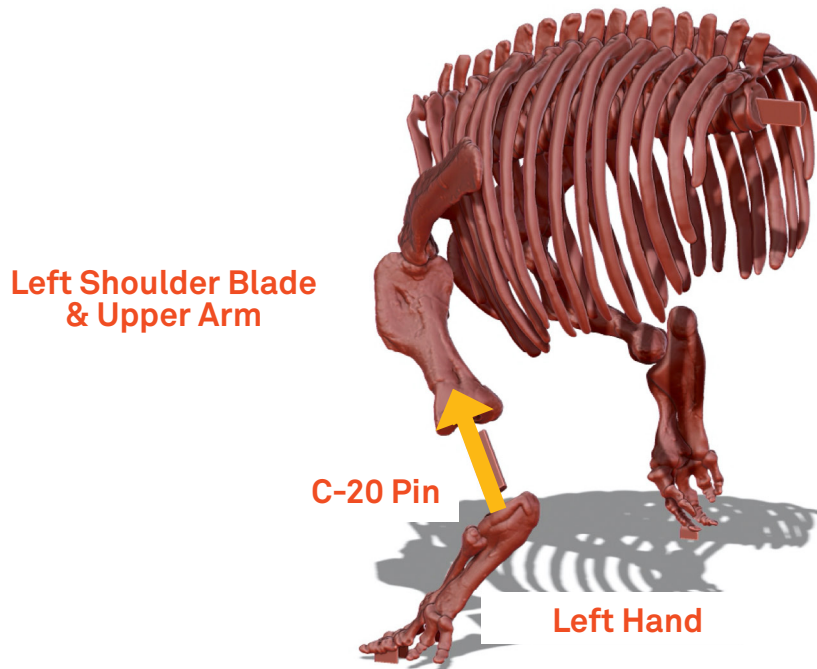
Arms 1

Insert the **C-20 pin** in the **Right Hand** and connect the **Right Hand** to the **Right Shoulder Blade**



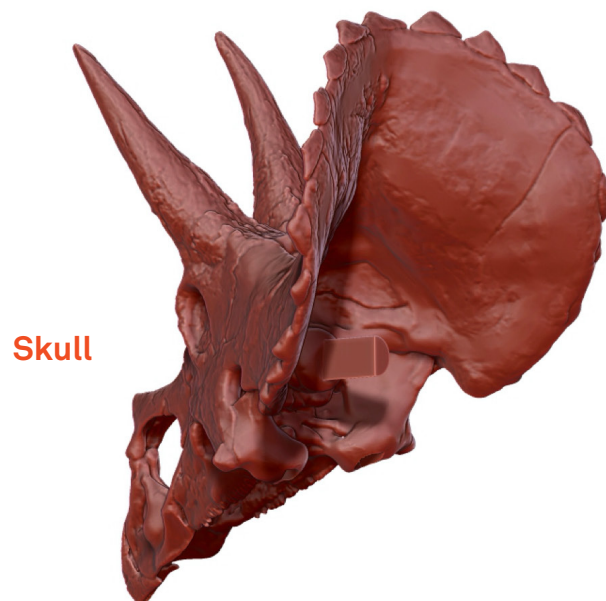
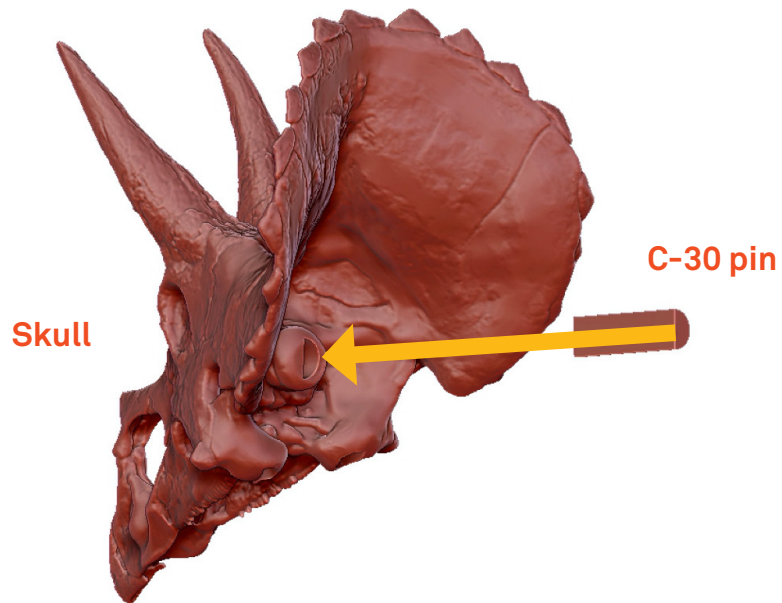
Arms 2

Insert the **C-20 pin** in the **Left Hand** and connect the **Left Hand** to the **Left Shoulder Blade & Upper Arm**



Head 1

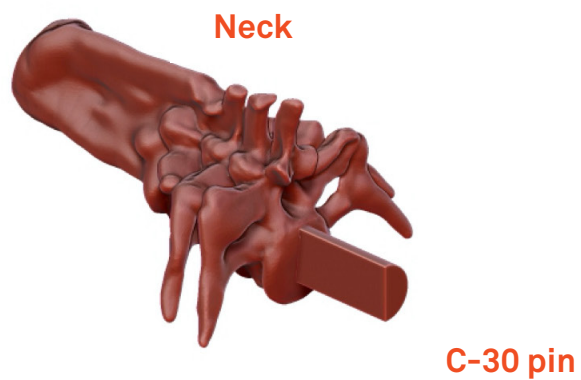
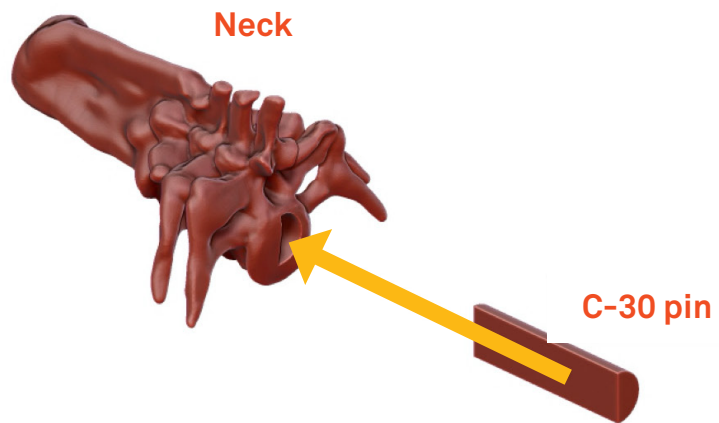
Insert the C-30 pin
in the Skull



Head 2

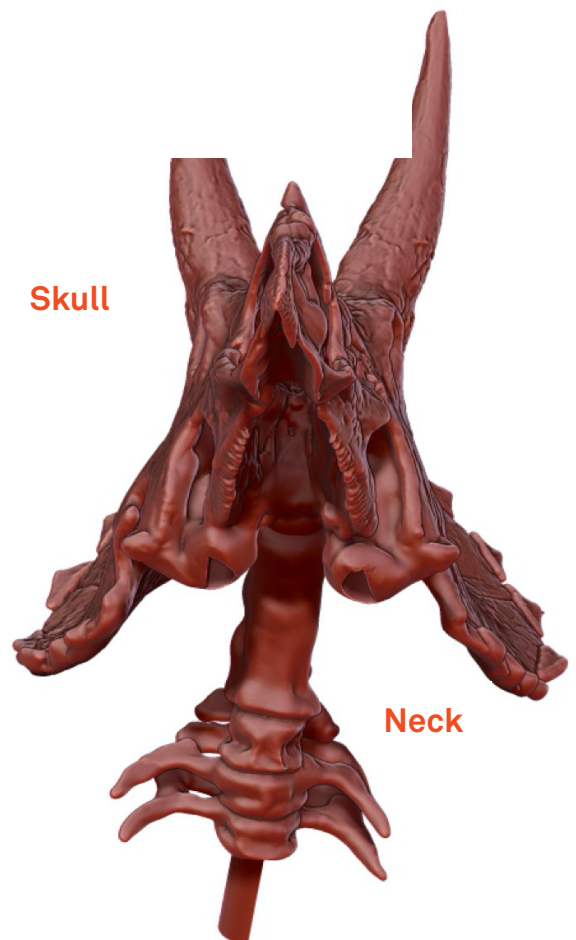
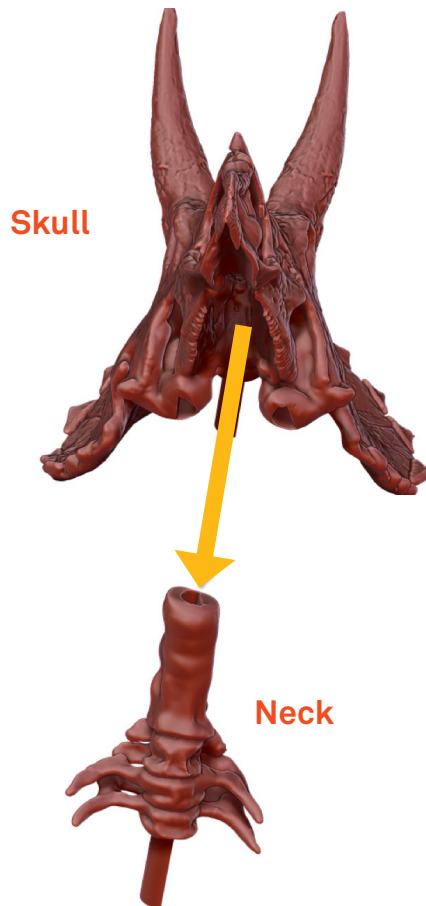
Insert the C-30 pin
in the Neck

Double check the orientation
of the parts



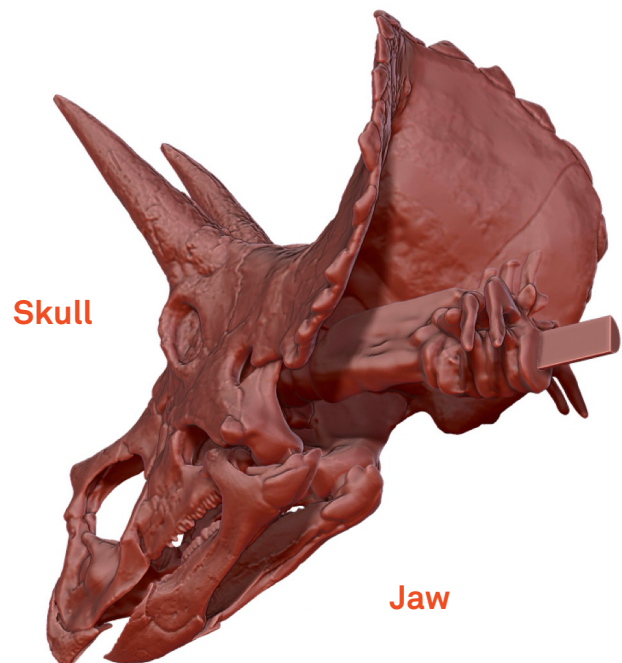
Head 3

Attach the **Skull**
to the **Neck**



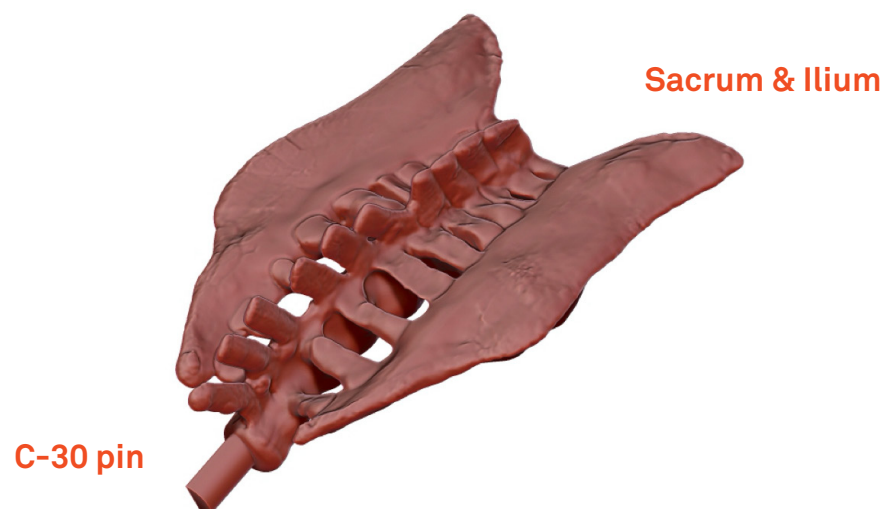
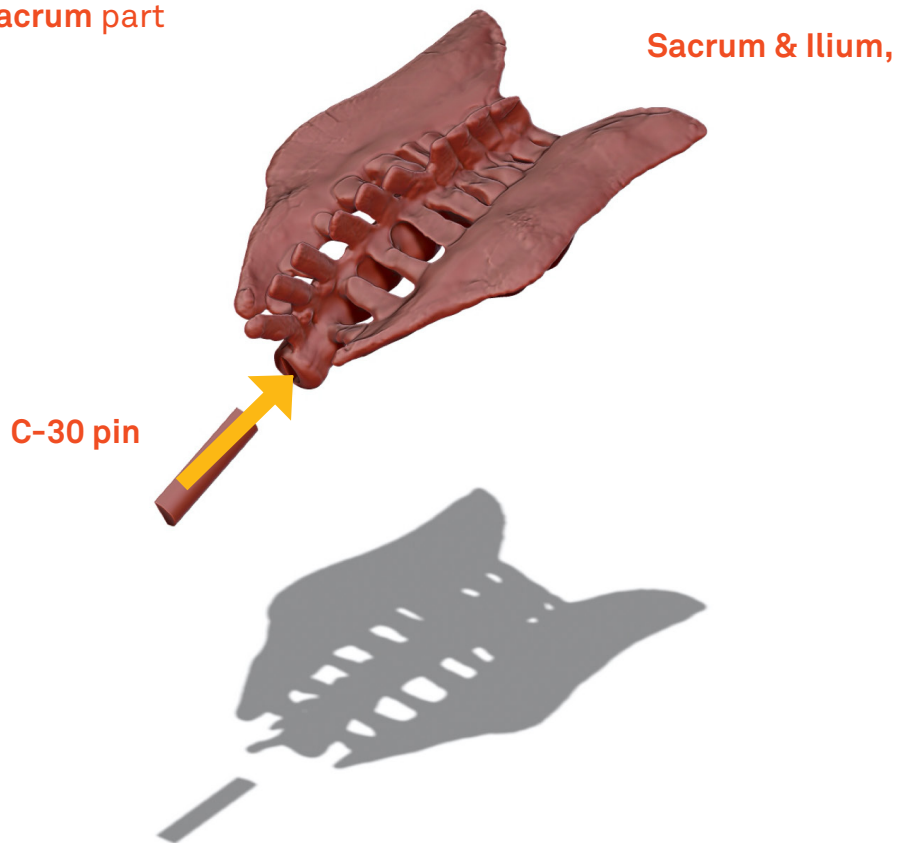
Head 4

Attach the **Jaw**
to the **Skull**



Hips

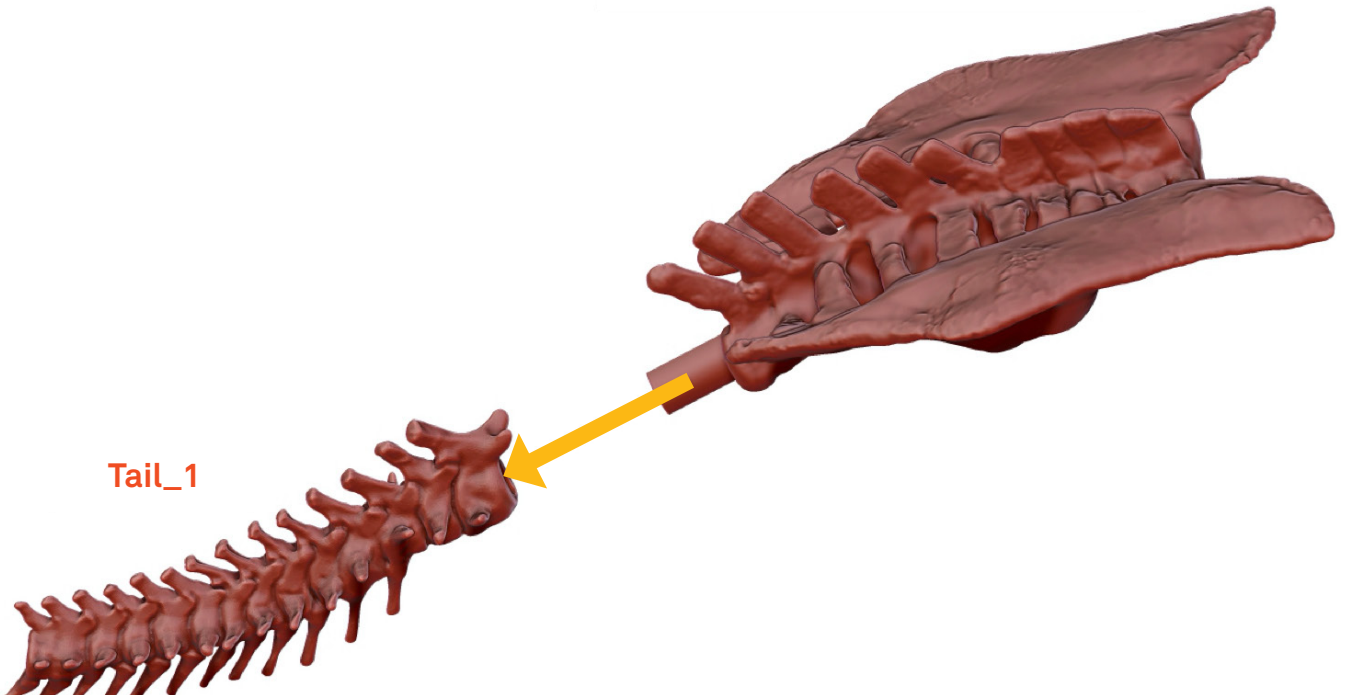
Insert the C-30 pin
in the Sacrum part



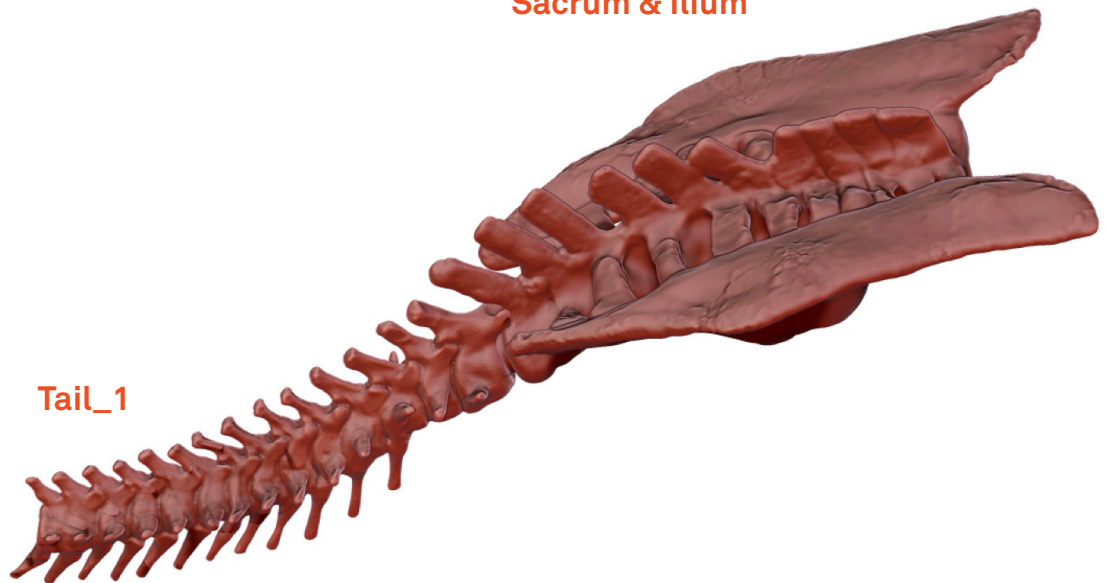
Tail 1

Attach the Tail_1 to the Sacrum part

Sacrum & Ilium



Sacrum & Ilium



Tail 2

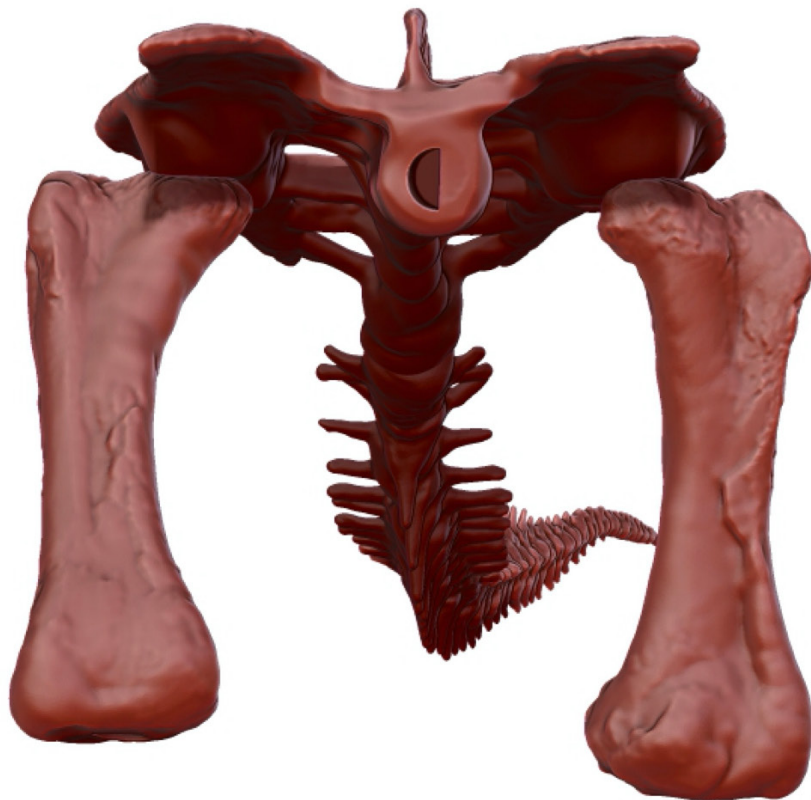
Attach the Tail_1 to Tail_2
using a glue



Femurs 1

Please double check the orientation of the **Femurs** before attaching the parts

Sacrum & Ilium



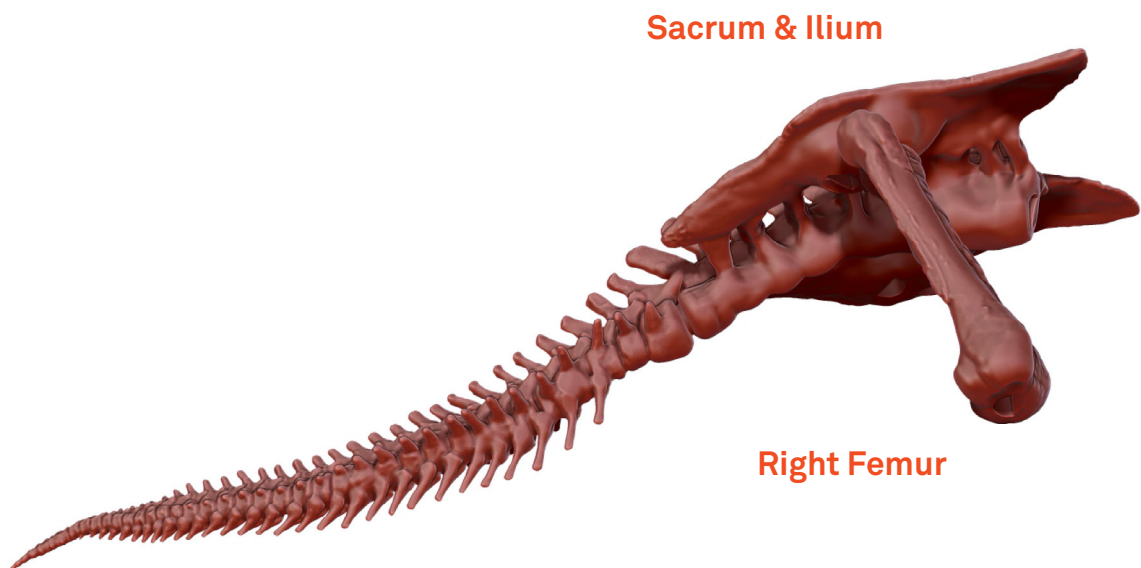
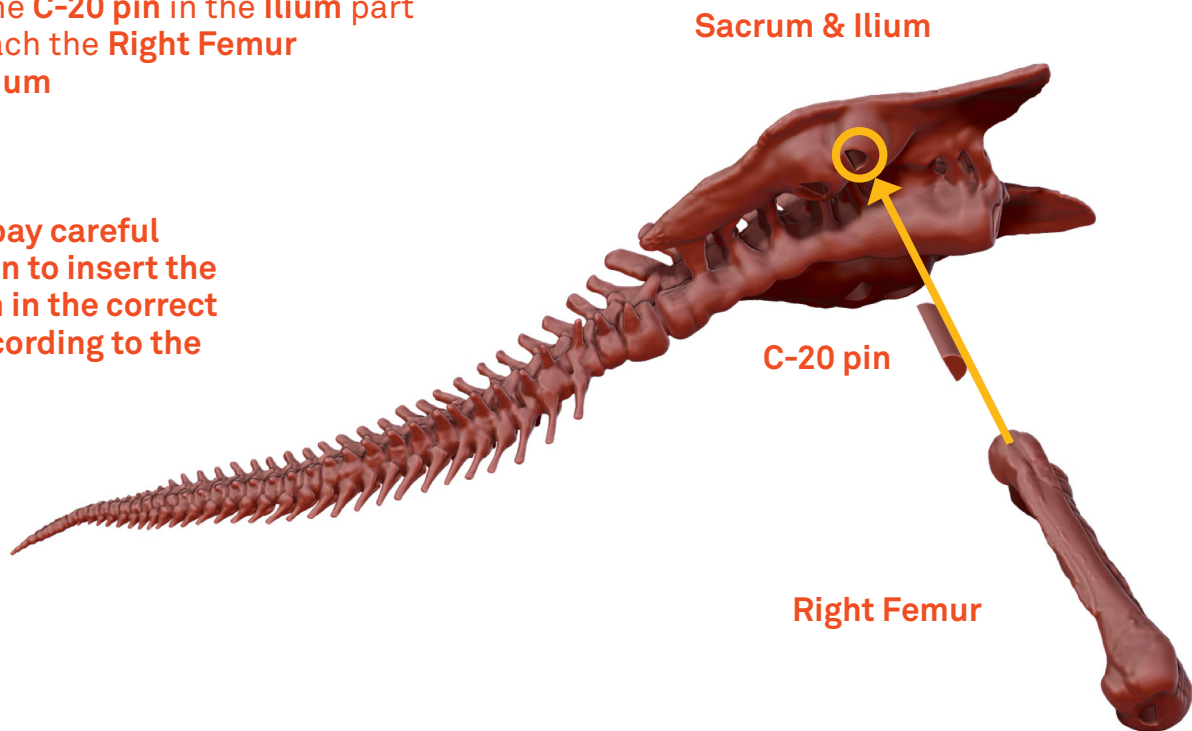
Right Femur

Left Femur

Femurs 2

Insert the **C-20 pin** in the **Ilium** part and attach the **Right Femur** to the **Ilium**

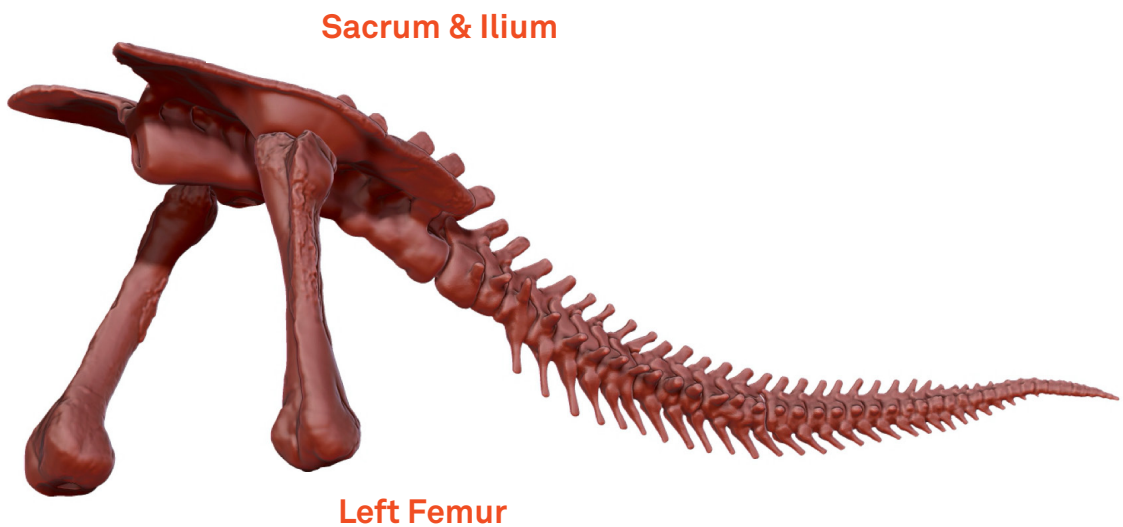
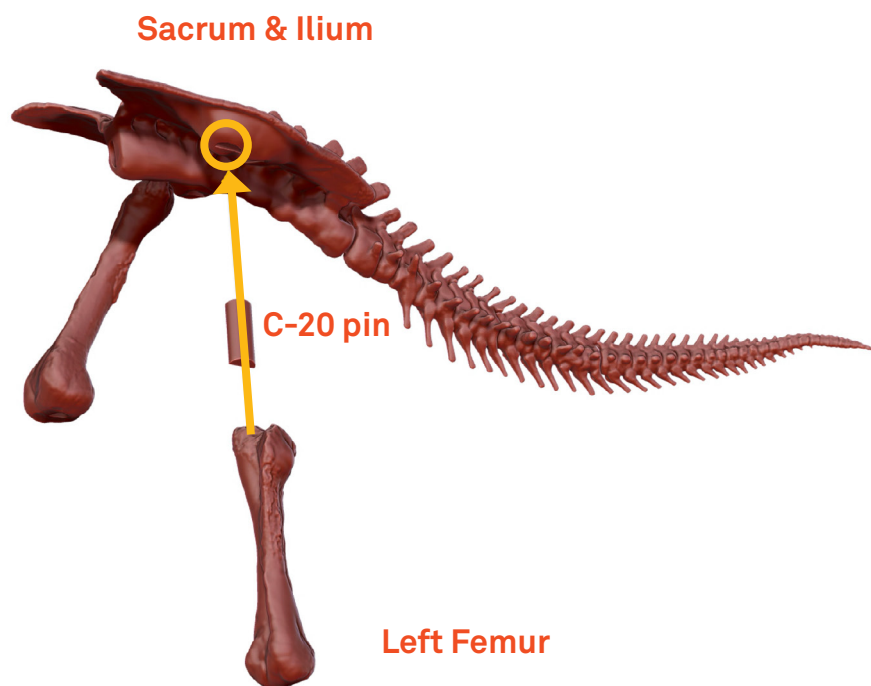
Please pay careful attention to insert the C-20 pin in the correct plug according to the image.



Femurs 3

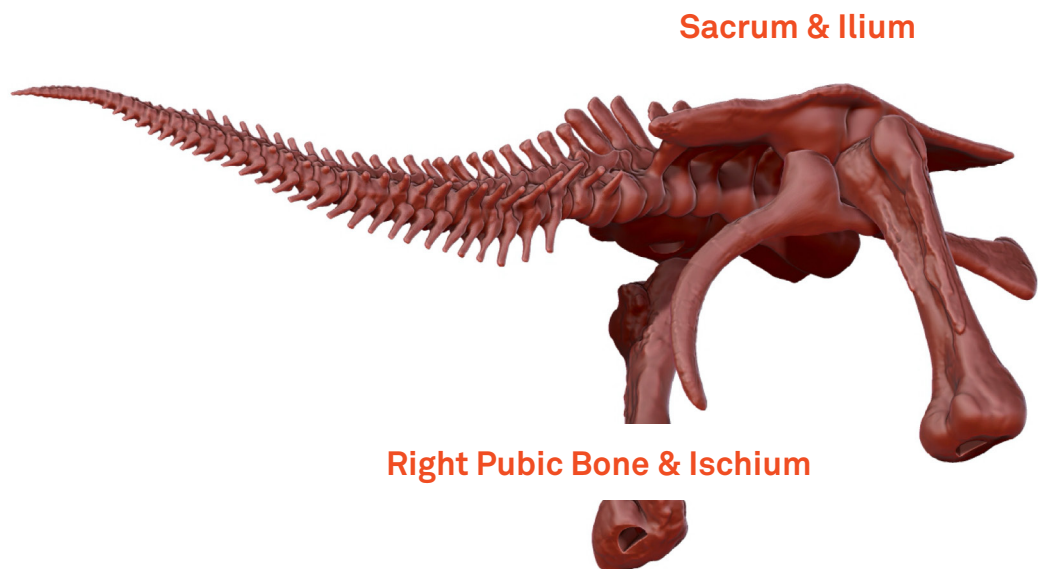
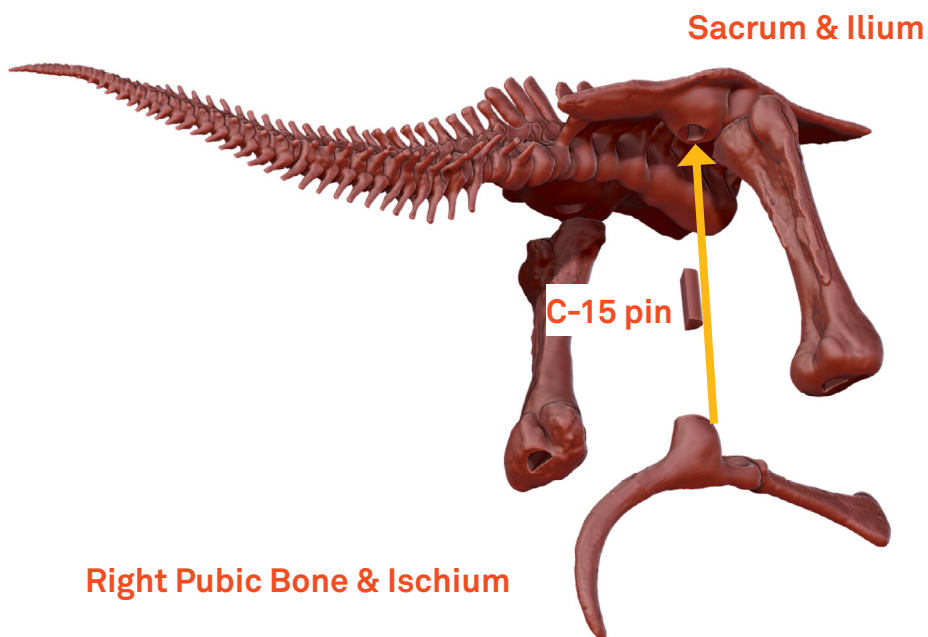
Attach the **Left Femur** to the **Ilium** using a **C-20 pin**

Note: Make sure to insert the C-20 pin in the correct opening (see image)



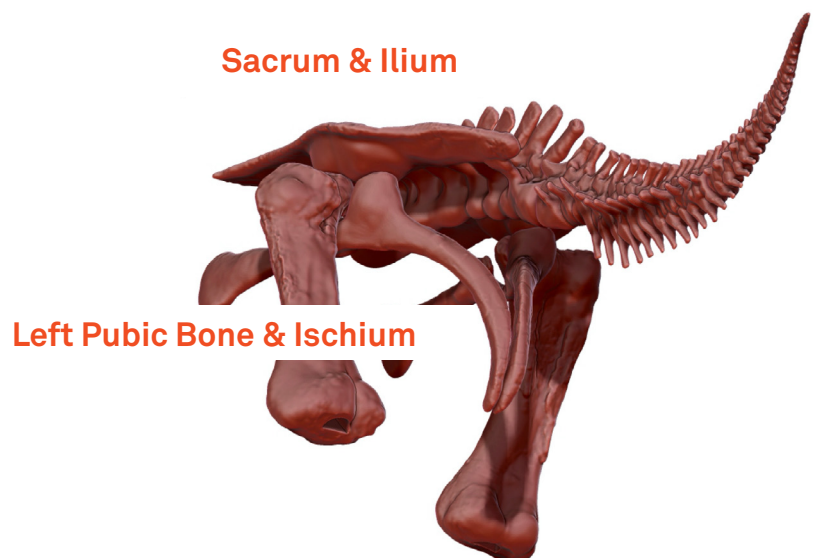
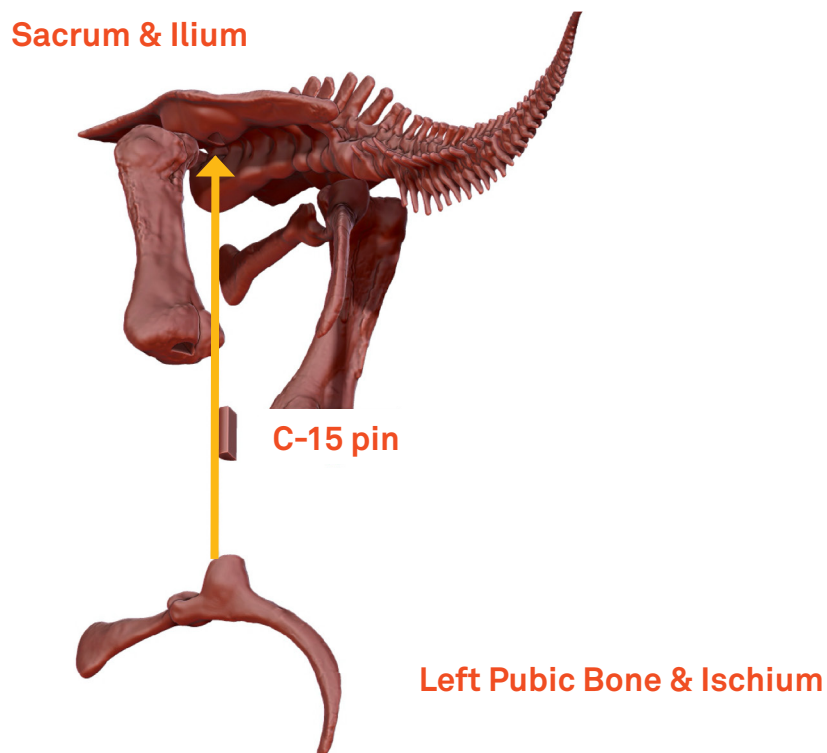
Pubic Bone 1

Insert the **C-15 pin** in the **Ilium** part and attach the **Right Pubic Bone & Ischium** part to the **Ilium**



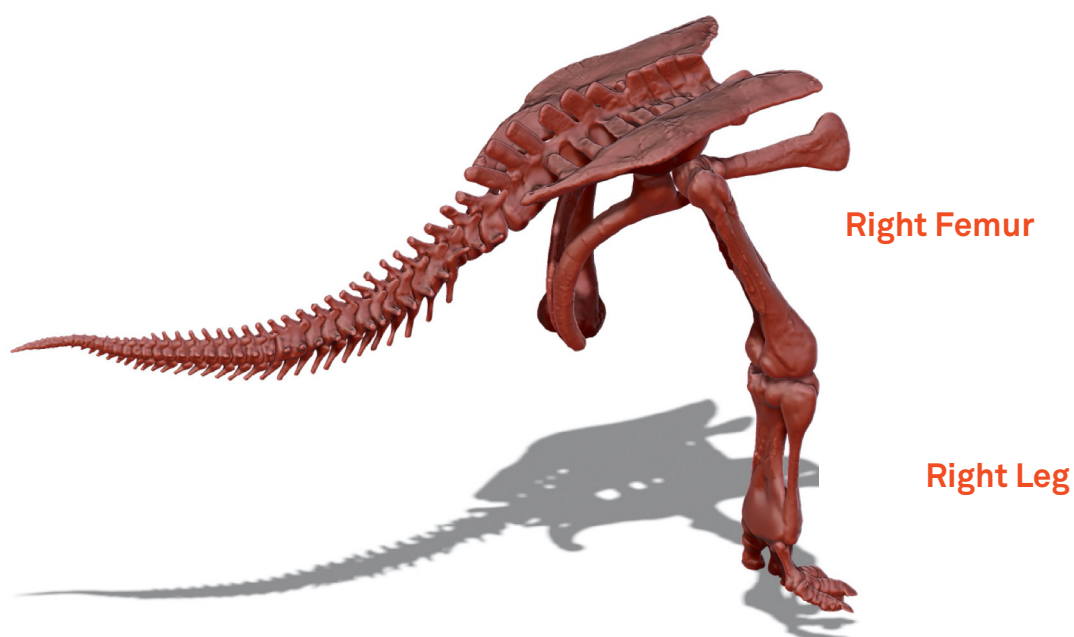
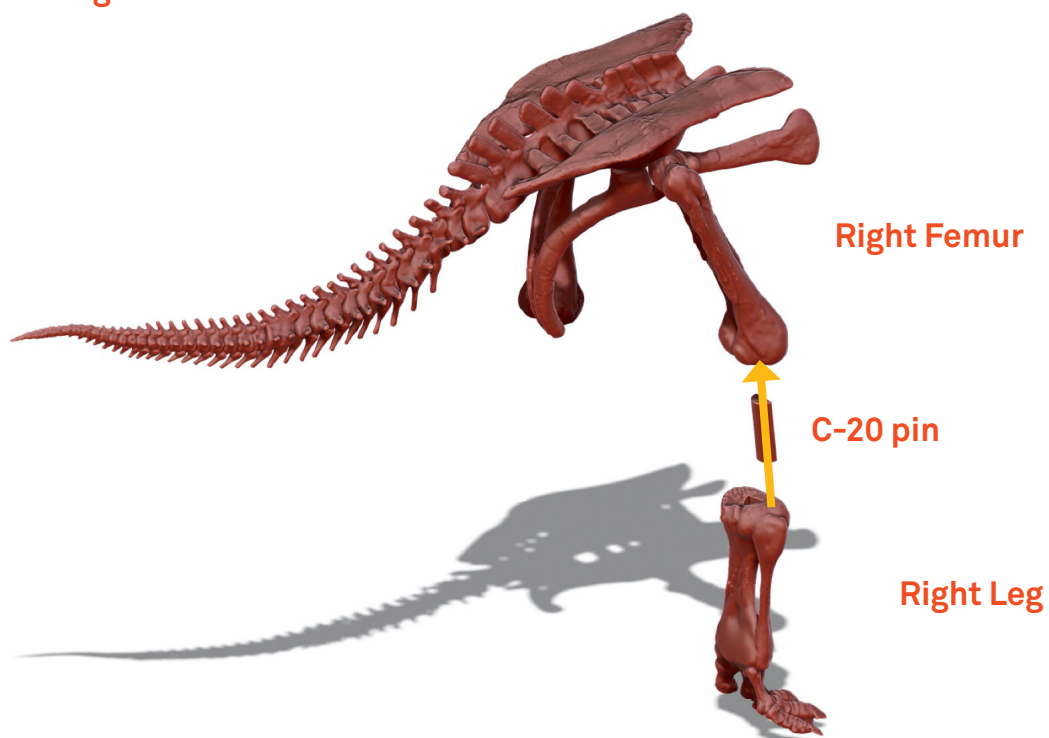
Pubic Bone 2

Insert the **C-15 pin** in the **Ilium** part and attach the **Left Pubic Bone & Ischium** part to the **Ilium**



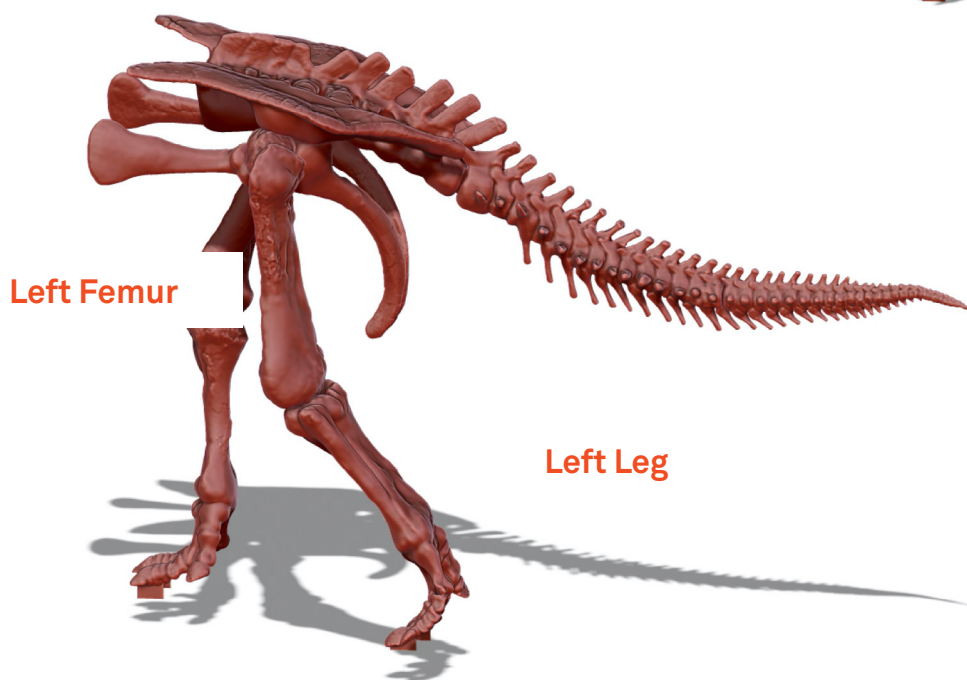
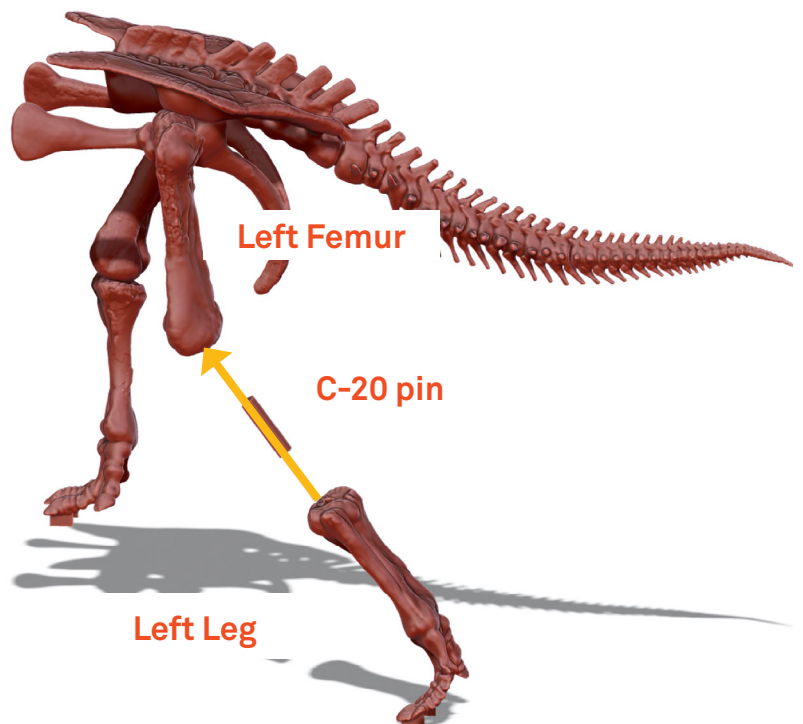
Legs 1

Insert the C-20 pin in the **Right Femur** part and attach the **Right Leg** to the **Right Femur**



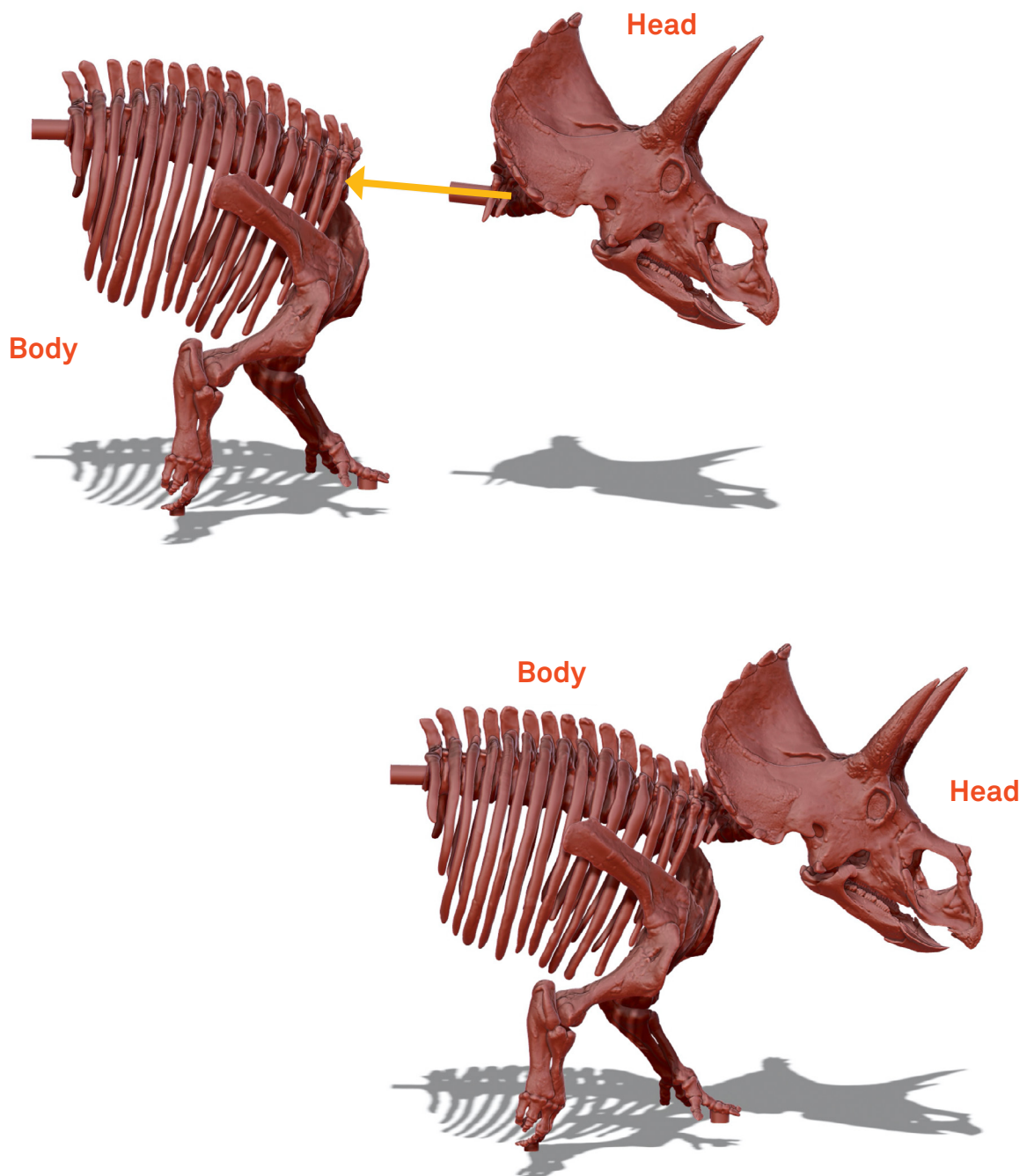
Legs 2

Insert the **C-20 pin** in the **Left Femur** part and attach the **Left Leg** to the **Left Femur**



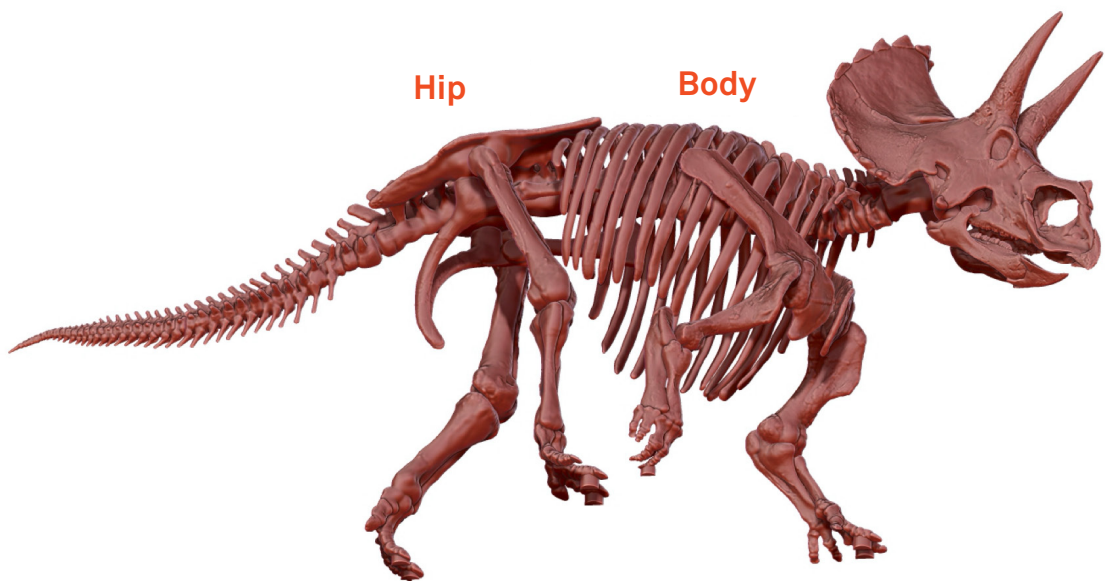
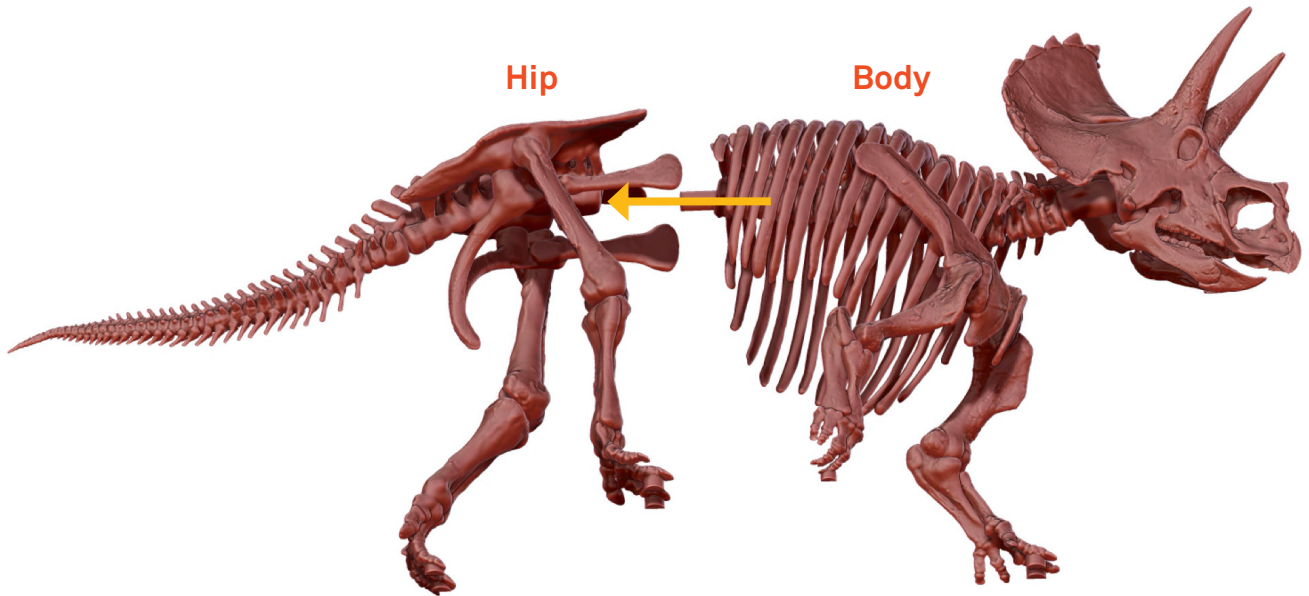
Upper Body

Attach the **Head** to the **Body**



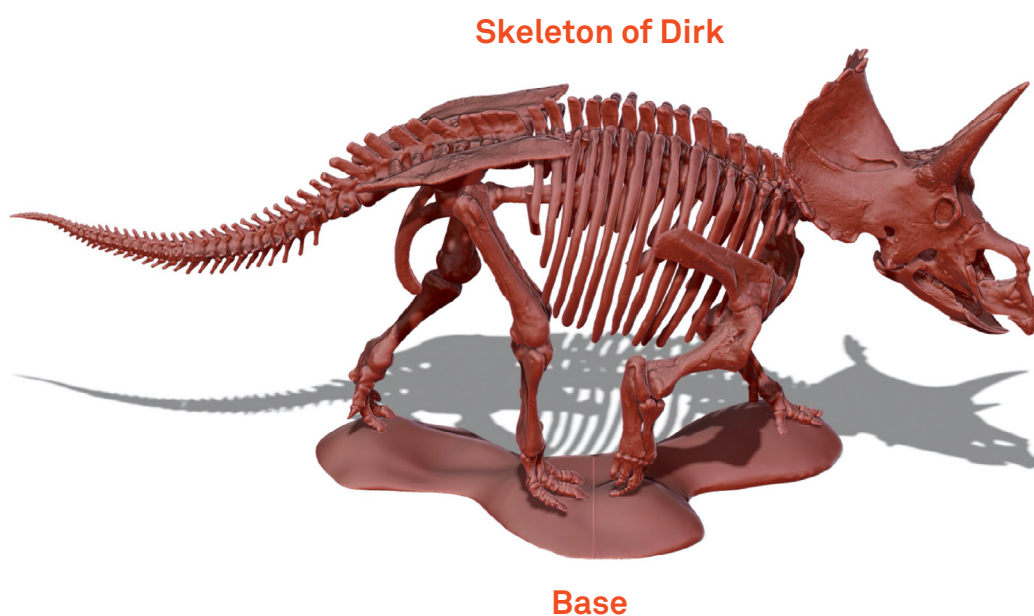
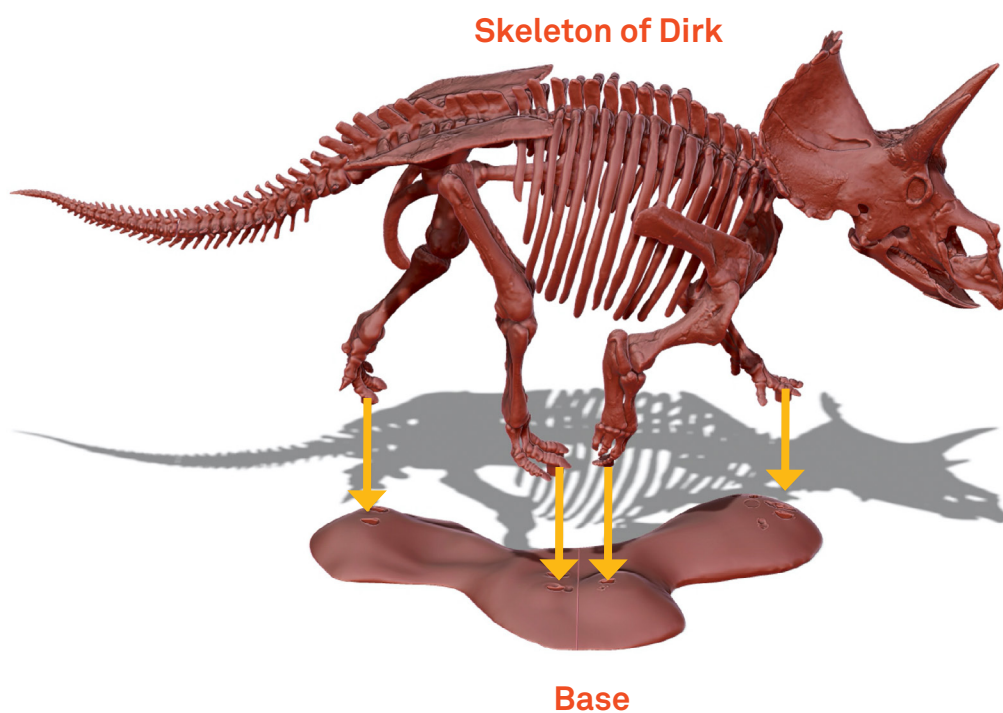
Upper Body & Hips Connection

Attach the **Body** to the **Hip**



Base Attachment

Attach the **Skeleton of Dirk** to the **Base**



Dirk Skeleton



Source material

Needed for printing:

[stl's, gcodes + profile with preferred settings*](#)

Videos:

[A short history of *Triceratops*](#)

[Life on the prairie](#)

[Nosebone of *Triceratops*](#)

[Plastering fossils for transport](#)

[This is our Dinolab](#)

Extra footage:

[Vlogs *Triceratops* excavation](#)

[Triceratops TV: \(all films\)](#)

[Triceratops TV: meet the experts](#)

Articles

[Natuurwijzer \(in Dutch\)](#)

* These profiles can only be used in Cura, Ultimaker's free downloadable software and can be used when you want to configure stl's yourself. Please note: this software does not need to be used when the enclosed gcodes are used directly for printing.