**D.E.W. : Compare Yourself to Tyrannosaurus rex**

This document describes the layout and use for the “Compare Yourself to Tyrannosaurus rex” D.E.W. kit. It also contains supplementary information that may be helpful when engaging particularly knowledgeable patrons.

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**RETURN ALL ITEMS AFTER YOU ARE FINISHED!**

The D.E.W. kit is a tool used to break the ice with the public. It serves to spark dialogue, and provide a hands-on activity for our patrons, and enables you to welcome them to the museum. They have come to see the museum and will have a bad first impression if you use your knowledge to hold them hostage at the table. If they are *keeners*, great! Chat it up! Usually, dripping a few tidbits of info and letting them go is the best approach.
How to use this kit

Set up

1. Place the tablecloth on a 6-foot table and secure it if necessary.

2. Gently remove or retrieve all of the items, and arrange them on the table.

3. Put the container under the table or otherwise out of sight. The table should be between you and our visitors.

4. Place the “Compare Yourself to a Tyrannosaurus rex” sign in one of the plastic or wooden card holders.

Operation

As patrons come to the table, encourage them to look at and inquire about each item. Touch quickly on each object until they express interest in a particular item, then drop a few interesting facts about it and send them on their way. For younger patrons, encourage them to pick up the items and compare them to their own body (e.g. step into the footprint, compare their hand to a claw, show them how to compare their brain size to that of Tyrannosaurus). If older patrons are interested, you might encourage a dialogue about some of the contentious issues surrounding this famous genus (e.g. use of arms [p.8], maximum speed [p.3], eating habits [p.5]).

Notes

1. Remember! While you have their attention, point out what else is going on or coming up: planetarium show times, dino tour times, lectures, special events, and future events.

2. DO NOT PUT ANYTHING ELSE ON THE TABLE TOP!

3. Report any damage to so and so immediately.
About the Objects

Footprint

One of the best objects in this kit for comparison in this kit may be the T. rex footprint. The striking size difference between a four-year old’s tiny foot and T. rex’s massive footprint may lead the patron to ask other questions about the dimensions and general abilities of the famous dino. See the side note on page 7 for an idea of how big T. rex is in relation to the rotunda. Below is a discussion about how paleontologists attempt to determine how fast dinos may have been.

One way to estimate an animal’s traveling speed is to measure its stride, which is itself determined by the size of the animal and how strong it is. When attempting to figure these facts out for extinct animals, paleontologists need to first observe patterns in extant animals (e.g. that speed can be determined from trackways), then apply those patterns to extinct animals. Unfortunately, it is very difficult to prove that the relationships we observe in extant animals can be applied to prehistoric animals. When trying to determine maximum speed, something every T. rex fearing person should know, we run into even more problems. The afore mentioned method is troublesome in regards to max. speed because animals rarely move at maximum speed, so fossilized maximum speed trackways are unlikely to be discovered. That leaves paleontologists with other methods such as determining running speed based on bone density, range of bone motion, and estimated potential muscle size. Based on mathematical and biophysical modeling, it is unlikely that a T. rex would be able to run faster than around 11 meters per second (24.6 miles per hour).

Arm and claw

The arm and claws of Tyrannosaurus rex were similarly shaped and sized as those of Allosaurus. One difference was that the latter has three claws where the former has only two. To help compare it to a patron’s arm and hand, consider asking questions about what we do with our arms and hands, and compare that to what T. rex would need to do. The research still seems inconclusive, but this dinosaur could very well have used its arms for holding prey, grabbing onto a mate, or rising up from a prone position. Then compare that to the myriad uses we have for our arms and hands.

For discussion regarding T. rex arms, see the relevant material from the docent manual (page 8 in this handout).

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1 Only two isolated fossilized T. rex footprints have been found to date. The first specimen was found in 1983 in New Mexico and measures 33 in long by 28 in wide.

M.G. Lockley and A.P. Hunt. A track of the giant theropod dinosaur tyrannosaurus from close to the cretaceous/tertiary boundary, northern new mexico. Ichnos, 3:213–218, 1994

2 Tyrannosaurs had a few hollow bones that may have kept it light enough to trot.


3 John R Hutchinson and Mariano Garcia. Tyrannosaurus was not a fast runner. Nature, 415:1018–21, 2002
Teeth

As you know from the docent manual and your experiences giving tours, Tyrannosaurs had many replaceable, long-rooted teeth. And like many animals, not all of the teeth were identical. The teeth near the front of the mouth (the premaxillary teeth) were curved backward away from the mid-line of the skull, D-shaped in cross section (also described as “blade-like”), and marked by ridges. The middle (maxillary) teeth differ in size, but include the largest and some of the smallest of T. rex’s teeth.

Similarly shaped, the back (dental) teeth are of relatively uniform size. Both the maxillary and dental teeth have ridges, but are more widely spaced than the premaxillary teeth. These teeth have comically been described as “lethal bananas.”

The differences among T. rex’s teeth are nowhere near as striking as those in mammalian teeth. We have incisors, canines, premolars, and molars, each specialized for a certain function. Of course, one of the wonderful bits of information we can learn from teeth is food habits. From our teeth, we can intuit that humans eat a variety of foods—we have cutting and slicing teeth, well adapted for eating meat, as well as crushing and grinding teeth, well adapted for eating plant parts like nuts and leaves. T. rex, on the other hand, has vicious cutting, slicing, decapitating teeth (though I would say that her jaws are definitely capable of crushing and grinding in a totally different way).

Brain endocast

You can easily compare the tyrant lizard king’s brain to a human brain by making fists with each hand and bringing them together. If the people you are engaging seem interested in the brain, you can talk about how we think Tyrannosaurs rex had an acute sense of smell based on the size of the olfactory bulbs (i.e. the part of the brain used for processing smells) compared to the rest of the brain. We arrive at these conclusions either by making casts of the empty spaces (like the one used in this set) or by taking CT scans of skulls and viewing the vacuities digitally.

The same method can inform us about other senses and abilities. For example, the ear canals and semi-circular tubes provide evidence that T. rex were likely better at hearing than other theropods, able to make quick movements (probably for keeping prey in sight) and kept their heads dipped down about 5° to 10°, which is indicative of animal agility.

7 Erik Stokstad. Tyrannosaurus rex gets sensitive. Science, 310(5753), 966-968, 2005
8 The olfactory bulbs were roughly the size of walnuts (the whole nut, not just the yummy part we eat.), compared to ours which are only a few cubic centimeters.
9 The length of the bones surrounding the cochlear duct relative to the overall dimensions of the skull indicate hearing ability.
10 The length of the larger loop of the semi-circular canals relative to the head is indicative of animal agility.
11 The orientation of the lateral canals relative to the skull indicate how animals tend to hold their heads while alert.
12 Erik Stokstad. Tyrannosaurus rex gets sensitive. Science, 310(5753), 966-968, 2005
**Scavenger or Predator**

Bone crushing jaws, replaceable teeth, a massive head, and years of pop culture like *Jurassic Park* have guided people to intuitively believe that *T. rex* were apex predators at the top of the prehistoric food chain. Movies aside, this morphological evidence is rather compelling; immense musculature and strong bones would make for a fearsome predator. However, some paleontologists argue that *T. rex* may have been a scavenger (see below for discussion). For this item, you might ask the patron what sorts of things they eat. To demonstrate the idea of predation vs. scavenging (as I doubt many people hunt their own food), you might ask, “Do you find or make your own sandwiches, or do you finish eating sandwiches someone else has started?”

One study, arguing that *T. rex* was a scavenger, looked specifically at the energetics of *T. rex* and found that if its habitat was similar to the present day Serengeti, large reptiles would not have needed to attempt to capture prey as carrion would be sufficiently available.¹³

On the other hand, another study looked at the ecological feasibility of *Tyrannosaurus rex* being an obligate scavenger by estimating how common and widely spaced corpses might have been in the Late Cretaceous. They also thought about how fast the carrion would have been eaten by other faster moving animals, and how often *T. rex* would have discovered the decaying food. They determined it was unlikely that *T. rex* was a scavenger generally because smaller theropods have much faster carrion searching rates than the large theropods.¹⁴

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Both of these theoretical arguments are based on extant animal comparisons and incomplete knowledge of prehistoric life, and are not quite as concrete as the *T. rex* bite marks that have been found on fossils of many species. What is more, fossils have been found with healed *T. rex* bite marks and young dinosaurs have been found in *T. rex* stomach remains. Like most carnivores, *Tyrannosaurus* likely both scavenged and hunted.\(^{15}\)

**Coprolite**

**Now you can bring** grossed out faces to your hosting shifts! Dinosaur poop is always a hit with the kids. Of course, much of the excitement from this item will come from having the visitor guess what it is. Unfortunately, we don’t know if our coprolites came from a tyrannosaur; generally, it is very difficult to identify the former owner of any fossilized feces. One enormous specimen found in Southwestern Saskatchewan can be attributed to *Tyrannosaurus*, likely *T. rex*, as no other theropod found in that area comes even close to the size of a tyrannosaur, and no other species of *Tyrannosaurus* have been found in the area.\(^{16}\)


Figure 6: "Sue" (from the Field Museum of Natural History, Chicago) in all her glory. See the side note on p. 7 for some details about Sue’s size relative to our rotunda.
Supplementary Tyrannosaurus Material

From the Docent Manual \(^{17}\)

Tyrannosaurids are known from the middle Jurassic and went extinct only at the very end of the Cretaceous. Jurassic forms were small, 5-15 feet long, predators in a world dominated by other large theropods, like *Allosaurus*. These animals were quick and agile, still had three fingers, and a few even had crests and small ridges on their heads, likely used for display. Later tyrannosaurs, including *T. rex* had species specific horns, bumps, and ridges on their heads. An early Cretaceous tyrannosaurid, *Dilong*, was found in China with a coat of fluff and even a bristling of proto-feathers at the end of the tail. Although evolutionarily tyrannosaurids were within the group that had feathers, this specimen provided concrete proof for the lineage. Over their history most tyrannosaurid lineages tended to become greater in size (though some remained modest until the K/T extinction) which is best epitomized by the famous tyrannosaurids, consisting of *Tyrannosaurus* and other large relatives.\(^{18}\)

We have *Tarbosaurus* egg casts in the drawers which some consider to actually have been an Asian species of *Tyrannosaurus*, *T. bataar*. Tyrannosaurids are renowned for their strong, reinforced jaws and skulls, massive neck muscles, relatively small arms, and long shins indicating a greater speed capability than in other large theropods. Also, the eyes were pointing forward which would allow for stereoscopic vision, which other predators did not have. Tyrannosaurs had powerful skulls that could absorb shocks and thick teeth that were better at puncturing and crushing than slicing. The fact that the neck was so massive help paleontologists reconstruct the way tyrannosaurs would attack their prey. The American West has produced Triceratops hip bones, five inches thick, and *Edmontosaurus* tails with *T. rex* tooth holes puncturing all the way through the bone! These animals could afford to slam their faces into their prey and lose a few teeth because they had reserve teeth waiting to grow in. The roots of tyrannosaurus teeth where nearly twice as deep as those of other large hunters in an attempt to compensate for this violent hunting style.

Although recent finds have produced animals longer or taller than *T. rex* (like *Giganotosaurus*, *Carcharodontosaurus*, *Spinosaurus*, and others), *T. rex* itself had much stronger jaws and was much more massive. These hunters likely left deep flesh wounds and bled their prey to death. Tyrannosaurs likely ran up to prey and crushed through the bone of the pelvis, back, or head in one bite! Tyrannosaurs lived only in the northern continents, North America, Asia, and Europe, and were top predators during the late Cretaceous, eating the cer-


\(^{18}\) For reference, “Sue” (also known by the more accurate, but frankly less endearing, name FMNH PR 2081)\(^{A}\), was 42 feet long, and 12 feet high at the hip. The rotunda is about 40 feet wide, and the top of the railing on the second floor is about 12.5 feet above the first floor. In otherwords, the rotunda would make a great hide and seek place for Sue.

\(^{A}\) As it happens, there is a surprisingly large amount of information known about Sue. For example, she was 28 when she died, she had a torn tendon in her right arm (no doubt from all that tennis playing), and she likely had an infestation of a protozoan parasite on her face (info from her Wikipedia page).
atopsians and hadrosaurs that shared their environments. It has only been in the last few decades that paleontologists realized that tyrannosaurs were different from other large predators. The closest relatives of tyrannosaurs were ostrich-dinosaurs, "raptors," birds, and compsognathids. When looking at Allosaurus with a group, you can talk about the fact that he and T. rex shared similar ecological roles, but note that T. rex is more closely related to Deinonychus and peacocks, than to Allosaurus. Saying that Allosaurus is the "uncle" of T. rex is like saying olive baboons are the "uncles" of humans (no other baboons? gibbons? orange? chimps? H. erectus?). I guess it is true in a way, but there are many other "uncles" much closer. Whatever you do, do NOT say that Allosaurus is the ancestor (grandfather or great great great grandfather) of T. rex. That is factually incorrect.

What about the arm? Tyrannosaurs are famous for their small arms, which many visitors like to say, "Couldn’t have even reached the mouth!" Paleontologists thought for a long time that the tiny arms were a result of balance. Theropods must balance their front and back ends over their hips. Because tyrannosaurs evolved such massive heads, compared to other predators that also used their arms for killing, they had to lose weight elsewhere in order to not fall forward. That makes sense! Well, in 2009 the tyrannosaurid Rapto rex was announced from the early Cretaceous of Asia. This little guy only weighed about 140 pounds but had a massive skull, two-fingered arms, and a strong neck. This animal was small enough that weight distribution shouldn’t have been much of a problem, yet his arms were very tiny! So the weight distribution hypothesis for tiny arms went out the window. It turns out that the tiny arms of all tyrannosaurs were extremely well muscled so they have to be used for something, but what?19 Many paleontologists now are discussing the feathers. Hatchling tyrannosaurs may have had fuzz for insulation, some are known from Northern Canada, but the adults wouldn’t have needed that. Did they use colorful fancy feather fans on their little arms for display or courtship? A few tyrannosaurs have fossil evidence pointing to family groups and social behavior. Time Machine [sic?].

Our Tyrannosaurus rex skull is a cast made from the mounted skeleton at the American Museum of Natural History in NYC. Our skull is just less than five feet long, but others have been found that measure almost six feet, like “Sue” at the Field Museum in Chicago. T. rex grew to around forty feet long, weighed about seven tons, and was about fourteen feet high at the hip.

19 The most recent research indicates their well-muscled arms were most likely used for arm wrestling.
Other cool Tyrannosaur information: Q&A

*Tyrannosaurs are extinct. How in the world do we know so much about their musculature, how they move parts of their body, and how they grew up?*

This is a great question that I am surprised is not asked more often; we obviously don’t have many prehistoric reptiles we can study in the wild. In the case of tyrannosaurs, much of the analyses that have been done are possible due to the high quality and large numbers of fossils. Many standard engineering tools have been used to infer information from fossils including 3-D scanning, modeling, and stress tests. Another method for determining posture and movement involves looking at constraints in range of motion and locomotion of physiologically similar extant animals, then ruling out all impossible movements. This kind of method (which has been successfully verified on two bird species) has been used to provide rather specific details on Tyrannosaur kinesthetics. See the information above about the brain endocast for details about how we can use CT scans to learn about *T. rex*.

Furthermore, we can discover information about Tyrannosaurs from fossils of other animals that may have come in contact with the two-clawed tyrant. For example, Erickson *et al.* (1996) estimated the amount of force a *Tyrannosaurus* would have needed to use to make deep bite marks found in a *Triceratops* pelvis.

*Why should we study dinosaurs?*

“Why is it important to study [insert any subject here]” questions can be tough to answer; ask a room full of scientists that question and you will get a different answer from each. Paleontology is relevant to many other areas of Biology (including molecular, evolutionary, and behavioral) and provides excellent samples with which to develop biomechanical and ecological models. Other answers to this question can be as specific as, “Something involving a better understanding of a molecular structure,” or as general as, “Having a better understanding of our history and the world around us gives us the ability to better adapt to ever-changing world.” The most convincing answer you can give as a docent is probably the one that you come up with on your own.
References


