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T. Rex Assembled out of the Box

In which we enter a dinosaur workshop to watch as they recreate from the fossil remains a beast that terrorized the world 65 million years ago: This is a puzzle with 400 elements that must be put back together with welders and power tools and without any instruction manual.

Caption: *John Scott Lucas, of the Phil Fraley Production team, which is reconstructing the T-rex of the Carnegie Museum, transports the skull of the animal to the where it will be assembled.*

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From the outside, the place looks like an automobile repair shop. There's also the noise of an auto workshop: lathes, welders, drills, all joined together by a stereo [playing at] at the same volume in the classic cacophony of auto repair.

But you don't feel motors rumble. And the objects that come here to be repaired are certainly not vehicles that came out of some factory a few years ago: they are enormous skeletons of dinosaurs that walked the Planet 60-70 million years ago.

The studio of Phil Fraley Productions is situated in a former industrial area in the state of New Jersey, approximately 50 kilometers west of New York [City]. It's not the sort of place where you would want to be caught walking after dark unless you have a really muscular friend with you. Perhaps the presence of a *Tyrannosaurus rex* would be reassuring, and, indeed, it is just that. In the Fraley workshop, a great skeleton emerges from the blue light of a welder's arc.

This *T. rex* is not a native of New Jersey. Until recently, it inhabited some pleasant corner of the Carnegie Museum [of Natural History] in Pittsburgh, but after a century on display, its pose was out of date. The bones were assembled in a way that was thought correct a hundred years ago, with the end of the tail dragging on the ground, which is not only less than elegant but is also completely wrong.

Larry Lee, head of the team that is reconstructing the dinosaur, says, "Our perception of the dinosaur has changed over time. "We are reposing the *T-rex*, which was mounted almost a hundred years ago, when man felt he was the master of the planet, whereas dinosaurs were considered awkward and stupid animals. But now, we believe that dinosaurs were some of the most successful animals of all time."

Of equal importance are recent scientific discoveries. The discovery of many other specimens of *T-rex*, along with modern techniques for studying fossils, has supplied new

information on this species. However, in large part, the assembly of a dinosaur skeleton remains more art than science.

Caption: *A student of the restoration group can barely move one of the T. rex vertebra from Pittsburgh.*

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A complete skeleton of T-rex is a three-dimensional puzzle with approximately 400 bones that range from the femur, which weigh 90 kilos, to the small tail bones, called chevrons, which weigh mere grams. All the bones go together to make an animal 15 meters long and 5 meters high, and which weighs in at 7.7 tons. Many of these bones are missing or badly damaged and were replaced with replica bones. Others have been broken off [and need to be repaired]. All, however, have been packed up in Pittsburgh and shipped via an ordinary freight company to the dinosaur workshop in New Jersey.

Before starting with the first fossil, the experts must decide what pose they want for the completed dinosaur. Phil Fraley believes that dinosaurs in a museum must appear as much as possible as if they are alive. "It must be posed in a way that it looks like it could start moving at any moment," he says.

But how should it be posed? Should the action be running, or walking? With the torso straight or turning? With the head held high or low? The Carnegie Museum had another difficult issue to address: Their *T-rex* will be the first one in the world displayed [with a cast of another *T. rex*,] as if the two animals were fighting over a freshly killed carcass. And, as Larry Lee points out, a half-degree of difference in the assembly of the mount is enough to make the difference between a rampaging dinosaur and a collection of bones. But with the help of a computer simulation, the group settles on a sufficiently dynamic pose and the restoration of the animal can begin.

This particular specimen undergoing restoration in New Jersey has a unique history. It was the first ever found, excavated in 1902, in Montana, by the American adventurer Barnum Brown. Henry Fairfield Osborn, of the Natural History Museum in New York, identified it as a *Tyrannosaurus rex*, a brand-new species. This specimen is, in fact, the holotype – that is, the individual that represents the scientific standard by which other dinosaurs are measured and compared in order to determine if they are the same species.

Caption 1: *Larry Lee, team leader for the restoration of the T. rex, adjusts the alignment of the animal's bones on the metal framework which supports it.*

Caption 2: *The small tailbones of the T-rex, called chevrons, are each identified with their own progressive numbers to indicates their position on the skeleton.*

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There is a lot of activity in the workshop of Phil Fraley Productions. There are no tools created specifically for the restoration of dinosaurs; therefore, the technicians avail themselves of those used in other fields: chisels and knives from wood carvers, grinding wheels and blowtorches from goldsmiths, metal probes and pneumatic drills from dentists. A few items are created expressly for dinosaur work, including a special adhesive for fossils and a modeling compound formulated specifically to reconstruct the missing parts of fossils.

Music played at high volume and liberal doses of coffee make the work more enjoyable – it also helps replicate the atmosphere of a typical sculpture course in art school. To restore a dinosaur demands great spatial ability, an artistic eye, and a sculptor's manual dexterity. And, indeed, a great many of the workers here come from art academies. In order to put together a museum-quality dinosaur, one needs a person with that sort of sensibility -- someone who obsesses about the details even more than the scientists do.

The most complicated part of the entire operation is the creation of the metallic armature for fossils, a skeleton for the skeleton. Steel is finished entirely by hand, with the utmost precision and constant adjustments, because the armature is what animates the dinosaur. The entire reconstruction process is time consuming. It take from six to nine months to restore the fossil material and to construct the metal armature, and another two or three months in order to assemble it all. Once finished, [the entire dinosaur] will be disassembled, packed in crates and wrapped with bubble wrap and packing peanuts, and returned to the Carnegie Museum in Pittsburgh, where it will take another month or so to reassemble it one last time.

Moving the entire specimen requires 55 large boxes that fill up three trucks; and yet it's not particularly expensive to ship via Federal Express: 14 thousand dollars round-trip -- less than what it would cost to move the furniture in one house from Rome to Milan. And at any rate, it's worth spending a bit for a creature that lived 65 million years ago.

Caption 1: *Welding the metallic armature, which will support to the femur of the dinosaur. This fossil weighs more than 90 kilos.*

Caption 2: *The intersection between the armature of steel and the bone of the animal.*

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Caption 1: *"Restoring a dinosaur for a museum takes special skills. The animal must give the impression that it is alive."*

Caption 2: *Three restorers from the team begin to raise the head of the T-rex in order to decide its correct position on the neck.*

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WHY BUILDING A DINOSAUR IS NOTHING LIKE ASSEMBLING A PIECE OF FURNITURE FROM IKEA.

To take apart a dinosaur and then reassemble the piece seems, for all the world, rather like assembling a piece of furniture from IKEA, but it's not. Here's why:

1) Ikea furniture comes with clear instructions. But there is no instruction manual for assembling a dinosaur. Paleontologists often disagree on the placement of bones and their position in the skeleton, and, even if they agree on something, they all admit that there's no way to prove it. It's not like there's anybody who can say they've actually seen a live dinosaur. The assembly of every dinosaur specimen is custom work, and you make a lot of it up as you go along.

2) Anybody can put together a piece of IKEA furniture. Assembling a dinosaur, on the other hand, requires a team of experts. To begin with, paleontologists and museum curators must agree on the pose they want for the animal. Then it must go to the fabrication workshop where they will put the puzzle back together.

3) If you break a piece of IKEA furniture when you are putting it together, you can bring it back to the store for a replacement. But dinosaur fossils are rare. If a part is ruined or gets lost there's no remedy for it. There's no place where you can go to get your money back.

4) Everything you need in order to assemble a piece of IKEA furniture comes in the box. By contrast, any specimen of a dinosaur that it is more than 50% complete is considered exceptional. The holotype *T-rex* from the Carnegie Museum it is about 65% complete. A lot of work had to be done by experts to restore the missing parts. Sometimes bones must be borrowed from other dinosaurs; other times, replacement pieces must be crafted by hand. The Fraley team uses various methods to create replicas of missing bones: if, for example, they only have the left femur, they can use that as a model to create a mirror image for the right femur. Other times, they must create new replicas without the benefit of any actual bones as a reference.

5) All the parts for a piece of Ikea furniture are in mint condition and they fit together perfectly; however, with a dinosaur, nothing fits together without a problem. The bones of a *T-rex* have been in the ground for 65 million years and have been compressed, folded, deformed. The vertebrae of a *T-rex* are often squashed like marshmallows, the ribs twisted. The skull typically looks like an egg someone has sat on. Often, the bones of the dinosaur refuse to conform to your desired pose, so you have to make compromises, because none of the bones fit together the way they did 65 million years ago when the animal was still alive.

Here is a list of the 400 bones in a *T. rex*: [Omitted]