

Hello! We are palaeontologists from the Royal Tyrrell Museum and are currently studying the best preserved armoured dinosaur in the world. Ask us anything!

RoyalTyrrellMuseum<sup>1</sup> and r/Science AMAs<sup>1</sup>

<sup>1</sup>Affiliation not available

April 17, 2023

### Abstract

Hello, we are scientists from the Royal Tyrrell Museum of Palaeontology in Drumheller, Alberta Canada. The Royal Tyrrell Museum is Canada's only museum dedicated exclusively to the science of paleontology and has one of the world's largest collections of fossils, with over 160,000 specimens in our research collection. Dr. Donald Henderson is the Curator of Dinosaurs. Donald's research focus is all about dinosaurs. His research has focused on a variety of different subjects, such as the rates of fossil erosion in Dinosaur Provincial Park, biomechanical comparison of the bite force and skull strengths in ceratopsian dinosaurs, and dinosaur buoyancy. Dr. Caleb Brown is the Betsy Nicholls Post-Doctoral Fellow. Caleb's research investigates taphonomy, specifically the role of depositional environments in shaping our understanding of ancient ecosystems, and the morphological variation in the horns and ornamentation structures of horned dinosaurs. In 2011, a worker at the SUNCOR Millennium Mine near Fort McMurray unearthed a significant specimen and contacted the Museum. We dispatched a team to extract it and discovered that it was a dinosaur. This was unusual because the rock around Fort McMurray is part of the Clearwater Formation, which is the sediment of an inland sea that covered Alberta during the Cretaceous Period. Generally, only fossils of marine reptiles and other marine species are found in that area. We discovered that the specimen was a nodosaur, a type of armoured dinosaur that does not have a tail club. It took five and a half years to prepare the specimen and it is the best preserved armoured dinosaur ever found, as well as being the oldest dinosaur known from Alberta at approximately 112 million years old. Named *Borealopelta markmitchelli*, this nodosaur is preserved in 3-Dimensions with the body armour and scales in place, as well as organic residues that were once part of the skin, giving us an idea what it looked like when alive. National Geographic has done a 3D interactive model of the specimen that shows you how well preserved this specimen is. We assembled a research team with colleagues from the US and UK, bringing in geochemists to help analyze the fossil skin. Geochemical tests showed an abundance of preserved organic molecules. Among them is benzothiazole, a component of the pigment pheomelanin, suggesting that *Borealopelta* might have been reddish-brown when alive. These findings were published in *Current Biology* this past August and are open access. New research by Caleb published in *PeerJ* (open access) on November 29, analyzes the bony cores and keratinous sheaths that make up the body armour. Due to the unique preservation of soft tissue, Caleb was able to analyze the relation between the horn core and the keratinous sheath, and compare the horn sheaths to the horns of living mammals and lizards. Ask us anything about *Borealopelta*, our research, palaeontology, dinosaurs, or the Royal Tyrrell Museum! We will be back at 2 p.m. EST to answer questions. EDIT: Thank you for all your questions! We will be checking back over the next week to answer any new ones.

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ROYALTYRRELLMUSEUM [R/SCIENCE](#)

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What is your best guess as to how the nodosaur ended up in the Clearwater Formation?

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[drsjsmith](#)

CORRESPONDENCE:

DATE RECEIVED:

Our current favoured idea is that the carcass was transported out into the western interior seaway by

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rivers. There have been rivers flowing east and north out of the rising mountains in the west for the past 120 million years (at least). We have many 1000s of trackways left by unidentified armoured dinosaurs in northeastern British Columbia. The combination of these tracks, their proximity to the Fort McMurray area and the Clearwater Formation, and the riverine sediments, make this the best hypothesis. The buoyancy of the carcass of *Borealopelta* would have enabled it to float long distances.  
- DMH

What is your most memorable dig or find? Whether it be for good or bad reasons, why was it so memorable?

Thanks for doing this AMA!

[babacano](#)

My most memorable dig would have to be a large ceratopsian (horned dinosaur) from the foothills of Alberta. It was a very large and exciting specimen combined with beautiful scenery and a great crew, so a very positive experience. My most memorable find is the holotype of the pachycephalosaur (dome-headed dinosaur) *Acrotholus audeti* that I found in the Milk River Formation of Alberta. It was a beautifully persevered dome (skull roof), and turned out to be a new genus and species, and the oldest pachycephalosaur in North America, possibly the world. - CMB

My most memorable excavation would have to be the *Borealopelta* one. It was a very intense 17 day experience with 12-14 hour days every day without break. The SUNCOR mine people were amazing in their enthusiasm and support and assistance. We would never have considered extracting the specimen from the cliff if we didn't have the support of the mine people and infrastructure. We didn't have to wait for anything, except plaster of paris which was impossible to obtain in Fort Mac. - DMH

How did you get started in paleontology? Where did you go to school?

Does the Royal Tyrrell Museum allow volunteers to assist at dig sites?

[BoyMayorOf2ndLife](#)

As a university student at the University of Calgary I got two summer jobs at the Royal Tyrrell Museum. I was able to make a name for myself, which no doubt helped when I applied many years later for the position of Curator of Dinosaurs. I originally had obtained a degree in geophysics, but wanted a change to palaeontology. After studies at Calgary, I went to the University of Bristol to work towards a PhD combining biomechanics and dinosaurs. - DMH

I grew up in southern Alberta and was exposed to the Province's rich fossil history at the young age. This got me interested in natural history and palaeontology. During high school I volunteered preparing fossils at the Royal Tyrrell Museum. I pursued an undergraduate degree in zoology at the University of Calgary, and had summer jobs at the Museum. I did a MSc and PhD in palaeontology at the universities of Calgary and Toronto, before starting my research position back at the Royal Tyrrell Museum. - CMB

The Royal Tyrrell Museum does take volunteers in several areas, including working on preparing fossils in the lab and working out the field. Interested volunteers should inquire at [tyrrell.info@gov.ab.ca](mailto:tyrrell.info@gov.ab.ca). Not all applications are accepted depending on skill set and how many current volunteers we have.

The Royal Tyrrell Museum is an incredible place and I have very fond memories of touring it as a kid.

I'm curious if there are any exhibits or programs that hold a special excitement or inspiration for you. Is there something a trip to the museum should be planned around to get the most out of the experience?

[theluketaylor](#)

We are glad that you have fond memories of the Museum as a child. Hopefully we will see you again soon.

The exhibit that I think holds the most excitement for me is one of the newest exhibits -*Grounds for Discovery* (opened May, 2017). This is for two reasons: Firstly it contains the exceptionally preserved nodosaur *Borealopelta markmitchelli* which I have a soft spot for, and is one of the coolest dinosaur specimens in the world. Secondly, the scope to the exhibit focuses on recent industrial finds - highlighting the important contributions that ordinary members of the public can make to palaeontology.

In term of programs, my favourite is [Dinosite](#). This is a unique program where visitors can hike into the badlands with one of our educators and find real fossils in the badlands. This program highlight the unique position of the Royal Tyrrell Museum, being situated in the badlands where the fossils are found, not in a large urban area. - CMB

What was your most memorable human interaction while getting this specimen from excavation to preparation? Can be anything.

[heavyarmoire](#)

There were many weird coincidences associated with the discovery the specimen, but the most memorable human interaction happened right at the beginning. We were first sent pictures of the specimen, and realized that we had to get up to the mine near Fort McMurray (800km away) as soon as possible. I was on the phone several times to one of the mine geologists debating how we could get there as there was a major snowstorm here in the southern Alberta. After a few calls with Steve Hill, one of the mine geologists, the voice started to sound familiar. I asked "Did you do your undergrad at Waterloo University?". "Yes" he said. It turns out that way back in 1988, Steve and I both had summer jobs with the Geological Survey of Canada based in Ottawa. We ended up being sent to do a geophysics survey across the Gaspé Peninsula in eastern Quebec. We shared a motel room for two weeks, but after that job ended we never saw or heard from each other again. Then 23 years later we met up again on the other side of the continent due to the discovery of *Borealopelta*. - DMH.

Would it ever be possible to see what a dinosaur looked like? I know we know what colors some were by looking at pigmentation in things like feathers and comparing them to birds but is it possible to have a realistic recreation of a dinosaur or to bring back a dinosaur?

[nid666](#)

As we find more specimens and do more research our understanding of how dinosaurs looked continues to evolve and become more accurate. Generally we have to infer how dinosaur looked in life by examining their bones and comparing them to living animals. If we are lucky, we can get soft tissues like skin and feathers preserved that can give us an idea of their external coverings. Add to this the recent discovery of preserved pigments also allows us to more accurately portray how they animals looked. *Borealopelta* is a great examples of this, and we have a fairly good idea what this particular dinosaur looked like in life. However, our knowledge for all dinosaurs will likely continue to evolve, and we will never settle on a 'final' or 'most accurate' portrayal.

Bringing extinct dinosaurs back to life for real is another matter. Because their genetic material is lost,

will not be able to recreate them. This is a possibility for animals that have gone extinct more recently (e.g., mammoths), but dinosaur fossils are just too old.

It should also be brought up that we DO still have dinosaurs living today - they are just small, covered in feathers, and called 'birds'. So if you really want to see what a dinosaur looks like, just look in your backyard. - CMB

Can we infer anything about Ankylosaurus or other ankylosaurs from the find?

#### [DinoGarret](#)

I think the best aspect of *Borealopelta* is that all the armour is in place and complete. Except for a few other specimens, the configuration of the armour in other ankylosaurs is a bit of guess. The sizes, shapes, composition of the bony elements in *Borealopelta* and their keratinous covers will enable a better understanding of the growth and evolution of the armour in other ankylosaurs, both members of Ankylosauridae and Nodosauridae. The age of specimen is early in the history of these animals, and also provides a nice starting point for tracking the evolution of the armour. - DMH

To add, one of the most exciting aspects about this particular specimen is that it is so well preserved, with scaly skin and armour preserved in 3D. The result is that you don't really need to use much imagination to figure out what the animal looked like back in the Cretaceous. In that sense it helps us understand how these iconic animals actually appear. The results are largely consistent with what we had thought before, which is a nice internal confirmation. - CMB

Could there potentially be other dinosaur fossils in the Clearwater Formation or do you suspect that *Borealopelta* was just a one in a million find?

#### [Xenoprimatology](#)

Just to clarify, we claim that the *Borealopelta* is a one-in-a-billion ( $10^9$ ) find. The mine people told us that as of 2011, when the specimen was found, they had shifted  $1.3 \times 10^9$  cubic metres of rock. The specimen occupies a bit over 1 cubic metre. I think the chance of finding another dinosaur in the Clearwater is very slight, but not impossible. We have been getting plesiosaurs, ichthyosaurs, fishes, and invertebrates (ammonites, bivalves, starfish, crustaceans, etc) regularly from the Clearwater for the past 30 years, but *Borealopelta* has been the only dinosaur. We all thought in 2011 that now that everybody knows what to look for, we would get more reported finds of the marine reptiles AND dinosaurs, but so far no new dinosaurs, and only a couple of new marine forms. - DMH

Thanks for this AMA! I've browsed through the PeerJ article, and my question is this:

Looking at the preservation state, is it worth conducting something like transmission electron microscopy to check how the detailed structure compares with extant animals? I don't know if this has already been done - and if we would learn something unique about how nodosaurs create their armour.

#### [pokerchen](#)

We have used a scanning electron microscope to investigate the microstructure of the fossil's scaly skin and the keratinous sheaths. Unfortunately, although *Borealopelta* is well-preserved and the skin and sheaths are preserved at the macroscopic scale, it looks like the majority of the original cellular structure in these soft tissues has degraded and has not provided useful data. We have not given up hope, and as research continues on the specimen we will use a variety of technologies to investigate the preserved soft tissues. These techniques include destructive techniques (those that cause damage to

a small portion of the specimen), and non-destructive techniques (those that due no damage). Our use of destructive methods to investigate the animal must be balanced with our obligation to conserve the specimen for future research and for future generations. - CMB

Can you say anything about its color?

[texasguy911](#)

Geochemical tests showed an abundance of preserved organic molecules. Among them is benzothiazole, a component of the pigment pheomelanin, suggesting that *Borealopelta* might have been reddish-brown when alive. There is a higher concentration of dark residue on the top *Borealopelta*, with less on the belly. This is called countershading.

Countershading is one of the most common forms of camouflage seen in the animal kingdom, and can be seen from deer and rabbits to penguins and sharks. It works as camouflage by a process known as self-shadow concealment. To explain this, imagine the 3D form of an animal in sunlight from above, the back of the animal will be well lit, while the belly will be in shadow. With countershading the pigment of the skin is the opposite to this pattern, such that the two will cancel out, and the 3D form of the animal will be less obvious.

This form of camouflage is beneficial to both predators (to sneak up on prey) and prey (to hide from predators). When prey species get large enough to no longer worry about predation (elephants, rhinoceros), they are generally not countershaded, and more solid in color. The presence of countershading on *Borealopelta markmitchelli* therefore suggests that despite is weighting 1,300 kg and being cover is body-armour like osteoderms (some up the half a metre long) it would have still experienced predation stress from large theropods. - CMB

If we could bring dinosaurs back from the dead, do you think we could coexist?

[globaltourist](#)

Dinosaurs (non-avian dinosaurs) lived in a great variety of environments, across all continents and over a period of about 160 million years. Because they diversified to fill such an array ecological niches, and experienced such a great variety of environmental conditions, there is no reason to think that at least some dinosaurs wouldn't be able exist, or even thrive, in today's ecosystems. Birds are dinosaurs that are alive today, and they also thrive across all continents, and across a wide range of ecosystems (e.g., terrestrial, arboreal, marine), so in that sense, Yes, dinosaurs are doing just fine today. CMB

I don't think plant-eating dinosaurs would fare well today. Plants are in a constant battle with plant-eaters and use various compounds in their tissues to be eaten (eg. we can't eat raw potato because of toxins). I doubt extinct dinosaurs could tolerate the toxins in modern plants. - DMH

The more difficult to answer question is whether humanity and dinosaur could co-exist. I am not sure that palaeontologist are the best people to answer this questions. It is worth noting that we are currently is a biodiversity crisis caused by humans, and this is particularly apparent for large bodied animals. Given this, it may be more relevant not to ask if humanity could live alongside dinosaurs, but if dinosaurs could live alongside humanity. - CMB

Thanks for doing this AMA! Since it seems that the organic molecules were well-preserved, is it possible that DNA sequences can be identified? This is a pretty sci-fiey question, but it would be great to hear an answer :)

Also, why did it take 5 years for the specimen to be prepared? What processes were done to it for the preparation to take that long, and what is the purpose of it?

Again, thanks a lot! May your current study be very fruitful!

[MsS\\_C4rM3n](#)

DNA is not stable in geological time-frames and starts to break down quickly after death. Given how old the specimen is (110 million years) there is no hope of recovering DNA. Although we do find preserved organics they are not pristine or in their original form. Heat, pressure and time have altered their structure, and what we can detect are often break-down products of the original organic molecules. Pigments are more stable than DNA, and as such, when we look we are starting to find them preserved more frequently in exceptionally preserved fossils. - CMB

It took five years because the concretion that entombed the fossil was EXTREMELY hard, and this evil rock was right next to EXTREMELY soft fossil material. The concretion grew around the carcass of *Borealopelta* soon after death. This strong, thick concretion prevented the specimen from being squashed flat like most fossils, but also prevented minerals dissolved in groundwater from permeating and precipitating in the bone. The fossil of *Borealopelta* is not your typical dinosaur fossil. The organic component of bone decayed away, but the bones are not mineralized and solidified like we see in most other dinosaur bones. Mark Mitchell described the bones as being like "compressed talcum powder". It was a very challenging fossil to prepare. Also, the specimen is big, and there was LOTS of surface area to prepare. After using some heavy duty pneumatic tools (air-scribes in particular), Mark would use a small scalpel blade to flick away a square millimetre or two of rock to expose some of the fossil. The exposed square was then immediately hit with a drop of glue. Every single square millimetre of the specimen that you see had to be done this way. - DMH

How many people said "Borealopelta disproves feathered dinosaurs" (a common sentiment on Reddit)?

Also, what's your favourite non-avian theropod?

[lamnotburgerking](#)

I have never heard the statement that "*Borealopelta* disproves feathered dinosaurs". (Maybe I need to come down from my ivory tower). Feathers are only known from a select group of dinosaurs - theropods, and SOME ornithischians (and these are of uncertain homology). Sauropod fossils have not presented any evidence for feathers, and the sauropods are more closely related to theropods than something like some of the heterodontosaurids which have simple filamentous, feather-like dermal structures. The group that *Borealopelta* belongs to has not shown any members that have feathers. Dinosaurs were a very diverse group of animals that occupied a range of continents and different environments. Feathers would not be needed in all cases by all dinosaurs. Saying that *Borealopelta* disproves feathered dinosaurs is like saying that naked mole rats disprove mammals had hair. - DMH

My favourite non-avian dinosaur is *Carcharodontosaurus*. I really like the allosauroids, and *Carcharodontosaurus* is like *Allosaurus* on steroids. They are a much more elegant group of large predators. I also like the fact that they have awesome clawed hands that could DO something, unlike the wimpy anterior appendages of certain over-hyped Hollywood celebrity animals. - DMH

If forced to choose a favourite non-avian theropod, I would have to choose a therizinosaur. These are such odd-looking almost unimaginable creatures that they really highlight the dramatic forms created by evolution. - CMB

Hey, this is great! I remember seeing this a while ago and I got so excited! It's beautiful! I was wondering, since it's so well preserved, would it be possible to grow a sample of it's organs, similar to how it's done for humans?

[DarwinApprentice](#)

Yes, we have organic residues from the once living tissues, but none of the genetic information to grow an organ is even vaguely preserved. Nor are any of the organs themselves preserved, or even any trace of them. The best we in the way of any organ is we have the stomach contents. This mass of pebbles and ground up plant matter is in a constrained volume that we can measure, but we don't have any trace of the stomach wall preserved. Also, no other parts of the digestive tract have been seen. - DMH

I'm greedy and have two questions.

How does the Jurassic Park movies influence interest in dinosaurs? I remember our small museum being flooded in our small town when the first movie came out. Is this still something noticeable today?

Two, what guesses do we have about their general behavior/defensive behaviors? Did they evolve the way they did because of the predators around them were just that powerful? And how successful were attacks on them? I can't imagine anyone wanting to attack ankylosaur for instance willingly.

[A Fhaol Bhig](#)

I think the first Jurassic Park movie appeared when it did because of what is called the "Dinosaur Renaissance" that began very slowly in the 1960s with the work of John Ostrom, and was gathering steam in the 1980s. Combined with the rise in computational power and 3D graphics, the time was right for a realistic portrayal of dinosaurs in movies. The first film certainly opened up the public's eye to the new views of dinosaurs as successful, diverse creatures and not as losers in evolutionary game. Attendance here at the Royal Tyrrell Museum also jumped in the summer after the first JP film was released. On the down side, it has made some wild speculations about the behaviour and appearance of extinct dinosaurs seem as if we know for certain that it is all true. People in the science game are much more cautious about what we think we can know about extinct animals. Media people come to us with ideas influenced by the JP movies, and we often have to bring them back down to earth.

Your second question is very broad brush, so I can only give some general comments about inferring behaviour in extinct forms. There does seem to have been an evolutionary "arms race" between predator and prey for a very long time on Earth. Big herbivores such as elephants and rhinos are basically attack proof from lions that are smaller than them. Large dinosaurs, such as sauropods MAY have got big to avoid predation, but the food quality of Mesozoic plants was low (no flowering plants except in the Late Cretaceous). Big animals can have big digestive tracts to extract the maximum amount from ingested food. Big sauropod carcasses would be a great resource for a predator, but need a big body, head, teeth, limbs, etc. to access that resource. People have tried to examine the predation pressure between dinosaurs by examining the frequency of theropod tooth marks on the bones of other dinosaurs, but I don't think the results can be conclusive as the victims may have died from other causes, and were scavenged later by opportunistic predators. - DMH

I'm a Science teacher at the Pace Center for Girls in Immokalee. If you have any spare fossils I would appreciate any donations. PM me for the address. Google us to learn about our mission. Thanks for considering us.

[IsUserNamelsntTaken](#)

Fossils in Alberta are protected under the *Historical Resources Act* which is one of the strictest fossil protection laws in the world. This prohibits the sale or removal from the province of fossils collected in Alberta without special disposition from the Government of Alberta. This protects precious fossil resources and ensures their proper care and conservation for all citizens of Alberta. More information about the *Historical Resources Act* can be found [on our website](#).