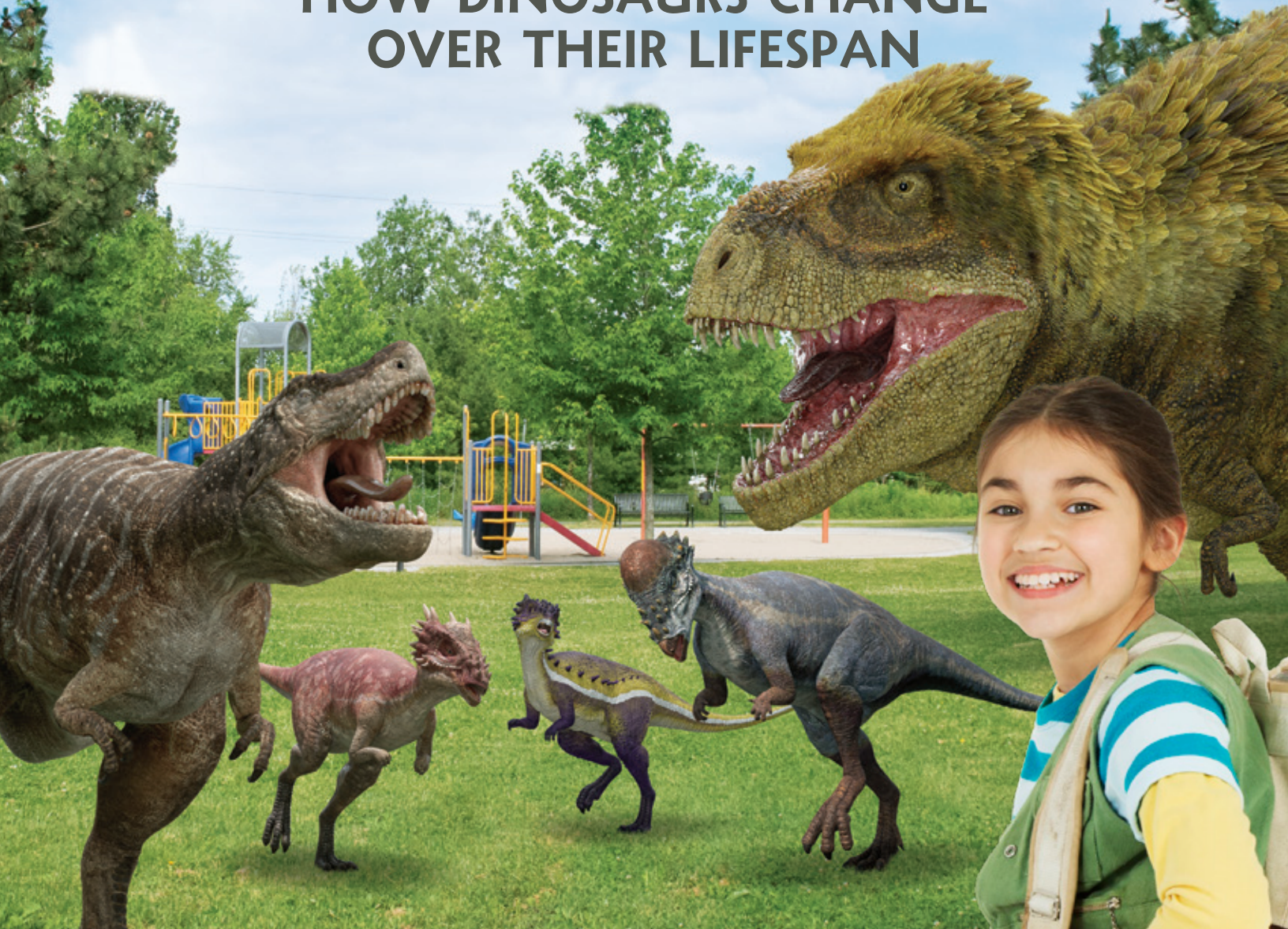


SHAPE-SHIFTING DINOSAURS

HOW DINOSAURS CHANGE
OVER THEIR LIFESPAN



**DINO
DANA**

THEORY: Fossils thought to belong to different dinosaurs might actually belong to the same dinosaur, just at different ages!

ABOUT THIS THEORY

Much of the information presented in this lesson came from research reported by Dr. Jack Horner and colleagues. The theory posits that certain dinosaurs changed shape so dramatically over the course of their development that paleontologists mistakenly identified them as different dinosaurs rather than the same dinosaur at different ages. This “shape-shifting dinosaur” theory is relatively new and not one that all paleontologists agree with. Like all science, it is a process of presenting new ideas and theories and examining the evidence, which is what children will do here.

NEXT GENERATION SCIENCE STANDARDS



NGSS 1-LS3-1: Make observations to construct an evidence-based account that young animals are like, but not exactly like, their parents.

NGSS 3-LS3-1: Analyze and interpret data to provide evidence that animals have traits inherited from parents and that variation of these traits exist in a group of similar organisms.

See movie website for additional NGSS from the Dino Dana series



DINO DANA: THE MOVIE

From multiple Emmy award-winning Sinking Ship Entertainment comes an action-packed dinosaur adventure aimed at kids and their families. Based on the popular TV series, Dino Dana: The Movie follows 10-year-old paleontologist-in-training Dana as she imagines dinosaurs into the real world to solve her dinosaur experiments.

DINO DANA CREATED BY
J.J. JOHNSON

MOVIE SCREENPLAY BY
J.J. JOHNSON & CHRISTIN SIMMS

EDUCATIONAL GUIDE CREATED BY
DR. COLLEEN RUSSO JOHNSON

PALEONTOLOGIST CONSULTANT
DR. DAVID EVANS

SINKING SHIP
ENTERTAINMENT 

TERMINOLOGY

DINOSAUR (*die-no-sore*)

A group of animals that became extinct around 66 million years ago.

SCIENCE (*si-uhns*)

A system of studying, testing, and experimenting to build knowledge.

PALEONTOLOGIST (*pay-lee-un-tol-uh-jist*)

Scientists who study dinosaurs.

THEORY (*theer-ee*)

An explanation for why something happens.

HYPOTHESIS (*high-poth-uh-sis*)

A prediction that can be tested.

DINOSAURS FEATURED

(AND HOW TO SAY THEM!)



TYRANNOSAURUS REX
(TIE-RAN-OH-SORE-US REX)



NANOTYRANNUS
(NANO-TIE-RAN-US)



PACHYCEPHALOSAURUS
(PAH-KEY-SEF-AH-LO-SORE-US)



STYGIMOLOCH
(STIJ-EH-MOLL-UIK)



DRACOREX
(DRAY-CO-REX)

ANIMALS

COMPARE AND CONTRAST

Some animals, like cats, look very similar as babies and adults. Can you compare and contrast the baby kitten and adult cat? To start, answer “yes” or “no” to each of these questions:



Are they the same size? _____

Are they the same color? _____

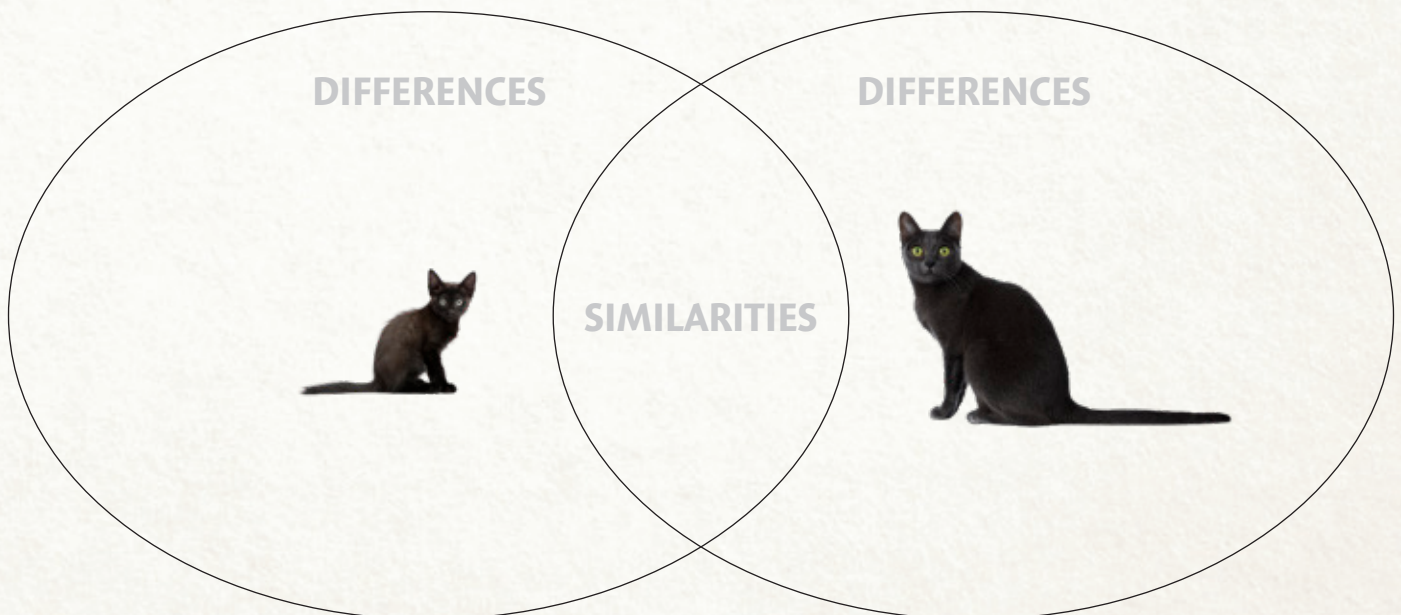
Are they the same shape? _____

Do they both have a tail? _____

Do they both have ears? _____



NOW PUT THE SIMILARITIES AND DIFFERENCES IDENTIFIED ABOVE INTO THIS VENN DIAGRAM. IF YOU THINK OF MORE, ADD THEM IN!



Are there more similarities or more differences between the kitten and cat?

More similarities More differences

There are other animals that change a lot as they grow. For example, flamingos change color as they get older! And baby frogs (called tadpoles) look VERY different than adult frogs!



CAN YOU COMPARE AND CONTRAST THE BABY FROG AND ADULT FROG?

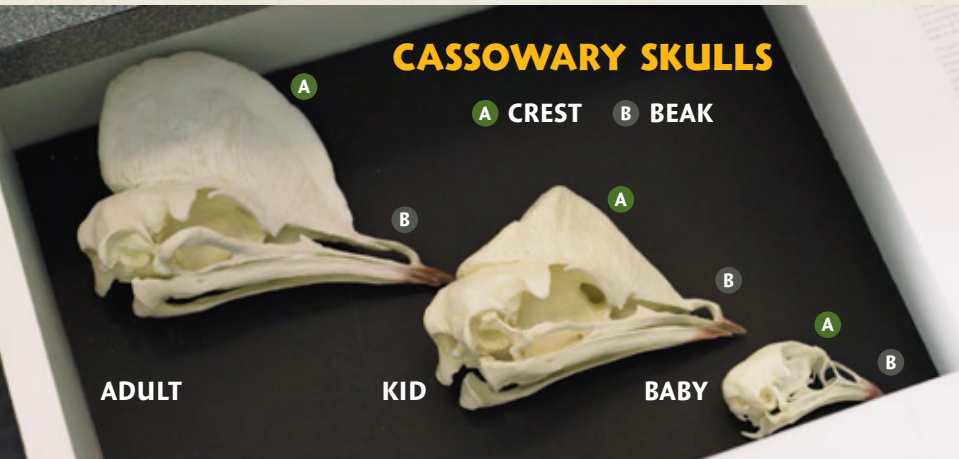
Answer the questions, then decide whether there are more things the same or more things different.



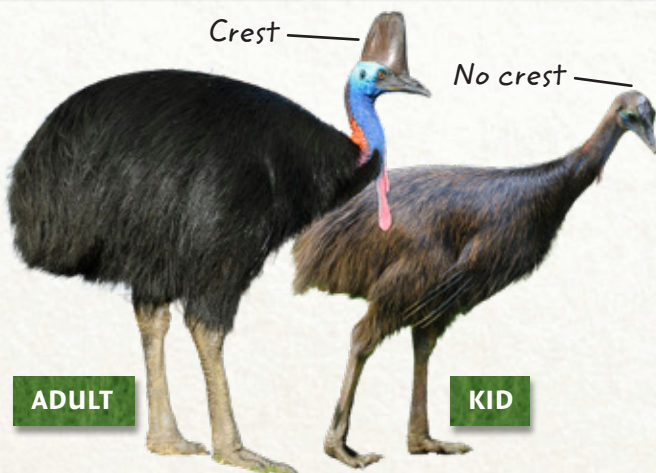
- Are they the same size? _____
- Are they the same color? _____
- Are they the same shape? _____
- Do they both have a tail? _____
- Do they both have legs? _____

Are there more similarities or more differences between the baby frog (tadpole) and adult frog?

- More similarities More differences



Cassowary birds (and other birds with crests on their heads) don't actually grow their crest until they're nearly adults. So if you found both a baby and an adult Cassowary, you would think they were two different bird species!



If we only looked at the way that the Cassowary birds were different as they grew, we might not realize they were the same bird. We have to also look at the ways they are the same.

Can you think of one way they are similar?

SIMILARITY: _____

WHERE ARE ALL THE BABY DINOSAURS?

DID SOME DINOSAURS ALSO CHANGE HOW THEY LOOKED AS THEY GREW OLDER?

I'm testing a theory to see if some dinosaurs are actually just younger versions of other dinosaurs! Can you help me?



If this theory is true, then it means dozens of different dinosaur names may no longer exist if they are actually just the same dinosaur at different ages!



DR. DAVID C. EVANS
Paleontologist

"The crested duck-billed dinosaurs from Alberta, Canada provide the best example of how paleontologists can be confused by changes as a dinosaur grows up. All of these growth stages of the *Corythosaurus* (see below) found in Dinosaur Provincial Park were named different species by early paleontologists. It wasn't until the work of Dr. Peter Dodson that we realized the smaller skulls with smaller crests were just younger examples of the bigger species. The crest gets proportionally bigger as the animal grows up!"

— Dr. David Evans

CORYTHOSAURUS CREST

No crest



BABY

Crest forming



KID

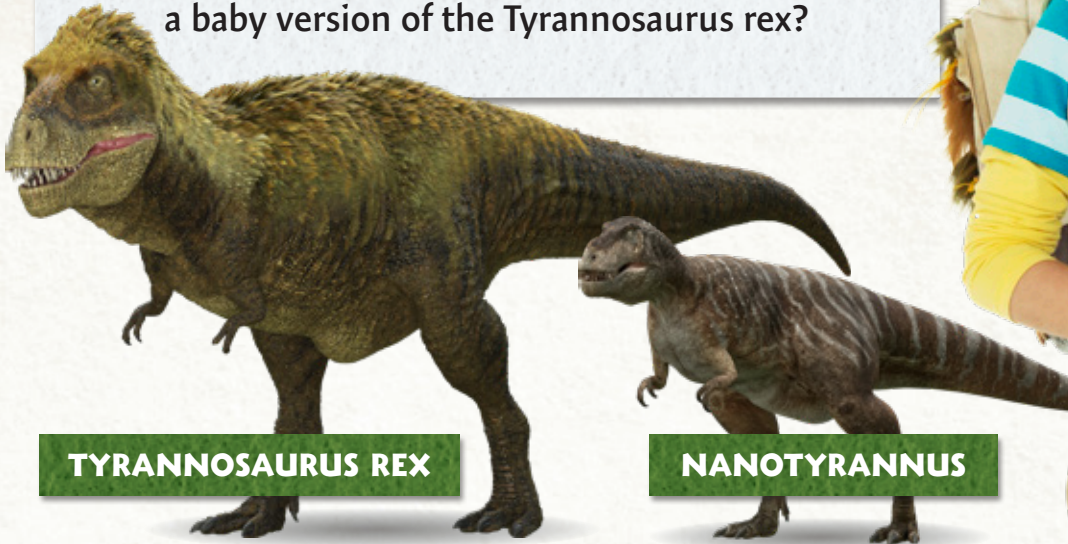
Full crest



ADULT

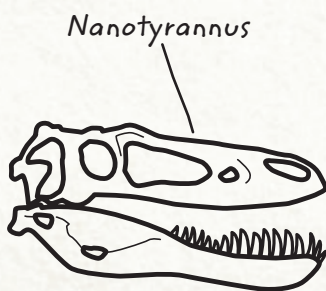
TYRANNOSAURUS REX

Time to start exploring and testing this theory!
Let's start with the KING OF THE DINOSAURS:
The mighty T. rex. Is the Nanotyrannus actually
a baby version of the Tyrannosaurus rex?



The Nanotyrannus is smaller than the T. rex, which makes sense if it was a younger T. rex. But let's take a closer look at the skulls of each dinosaur to compare them more!

COUNT THE NUMBER OF TEETH ON EACH JAW! WHICH HAS MORE!



_____ TEETH



_____ TEETH

What did you discover? I counted that the Nanotyrannus has 17 teeth and the T. rex has 12 teeth. But if our hypothesis is that the Nanotyrannus is a baby version of the T. rex, that means T. rexes LOST teeth as they got older. Let's test this new hypothesis by counting how many teeth T. rexes of different ages had!



You already counted the number of teeth on the Nanotyrannus and the full grown T. rex. This time, count the number of teeth on the younger T. rexes.

COUNT THE NUMBER OF TEETH ON EACH SKULL! WHICH HAS MORE?



17 TEETH



___ TEETH



___ TEETH



12 TEETH



Based on my counts, as T. rexes got older, they DID lose teeth! This evidence supports our hypothesis that the Nanotyrannus is a baby T. rex!

FUN FACT

MODERN PLATYPUSES ALSO LOSE THEIR TEETH AS THEY GET OLDER!

WHAT CAN WE LEARN FROM A CLOSER LOOK AT THE BONES?

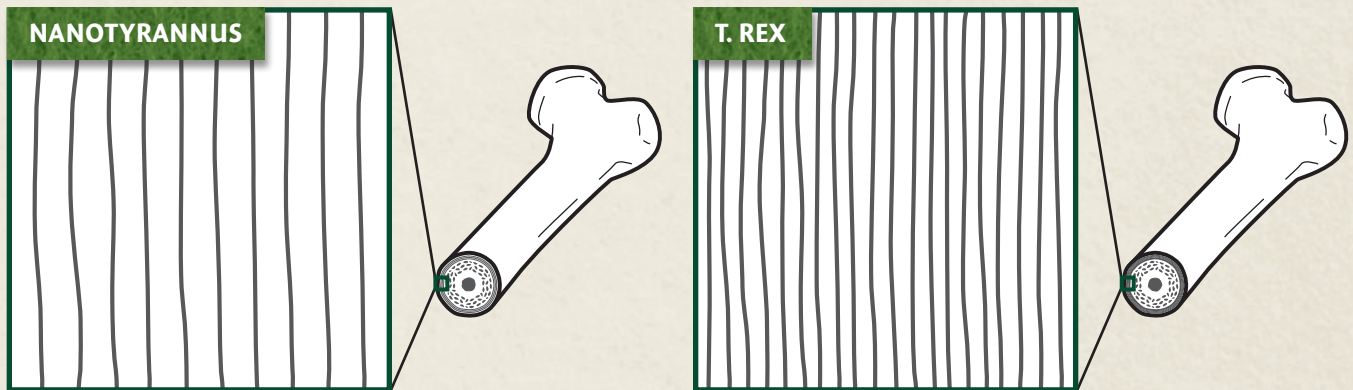
Another way that we can test whether the Nanotyrannus is a baby is by looking at the bones! Paleontologists sometimes cut into dinosaur bones, or use x-ray machines to look at the inside of the bone.



LET'S PEEK INSIDE!

Bone Histology means examining the inside of bones. We can do this to determine the dinosaur's age! Bones have growth rings, just like trees. The more growth marks, the older the dinosaur is.

COUNT THE GROWTH RINGS ON EACH DINOSAUR BONE AND CIRCLE WHICH ONE HAS MORE!

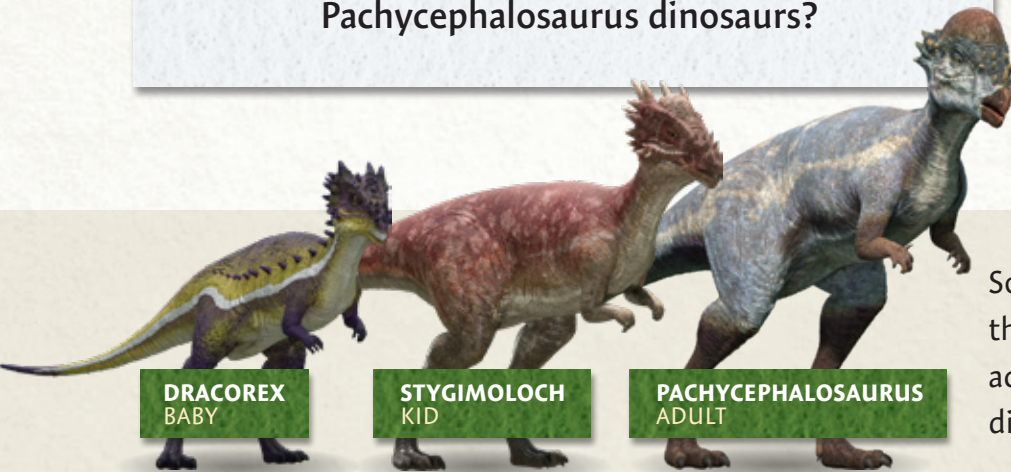


That's right! The T. rex has more growth rings, which means it's older than the Nanotyrannus. This is even MORE evidence to support our hypothesis that the Nanotyrannus is a baby T. rex!

PACHYCEPHALOSAURUS, STYGIMOLOCH AND DRACOREX



Let's continue our experiment... We know that the dome-headed Pachycephalosaurus is an adult dinosaur, but where are all the younger Pachycephalosaurus dinosaurs?



Some paleontologists believe that the Dracorex and Stygimoloch are actually the Pachycephalosaurus at different developmental stages.



What do you think? Could the Dracorex be a baby Pachycephalosaurus, and the Stygimoloch be a kid Pachycephalosaurus?

LET'S LOOK AT SOME OF THE FACTS...



All 3 are herbivores
(which means they ate plants, not meat!)



All 3 lived during the Cretaceous Period
(68 to 66 million years ago!)



All three lived in the same place
(what is now western North America)



All these similarities mean that they **COULD** be from the same family! Let's test this hypothesis by comparing more of their features.

Let's take a closer look at each of their heads to see what's the same and what's different!



CIRCLE THE DESCRIPTION THAT BEST FITS THE DINOSAUR!

The Dracorex has been done as an example!



DOME ON HEAD		
<u>No Dome</u>	No Dome	No Dome
Tiny Dome	Tiny Dome	Tiny Dome
Large Dome	Large Dome	Large Dome
SPIKES ON BACK OF HEAD		
Small Spikes	Small Spikes	Small Spikes
<u>Medium Spikes</u>	Medium Spikes	Medium Spikes
Large Spikes	Large Spikes	Large Spikes
BUMPS ON NOSE		
<u>Has bumps</u>	Has bumps	Has bumps
No bumps	No bumps	No bumps

HERE ARE THE RESULTS!



DRACOREX



STYGIMOLOCH



PACHYCEPHALOSAURUS

DOME ON HEAD

No Dome	No Dome	No Dome
Tiny Dome	Tiny Dome	Tiny Dome
Large Dome	Large Dome	Large Dome

Are they all the same or different? _____

BACK OF HEAD

Small Spikes	Small Spikes	Small Spikes
Medium Spikes	Medium Spikes	Medium Spikes
Large Spikes	Large Spikes	Large Spikes

Are they all the same or different? _____

BUMPS ON NOSE

Has bumps	Has bumps	Has bumps
No bumps	No bumps	No bumps

Are they all the same or different? _____



SO THEY HAVE FEATURES THAT ARE BOTH SIMILAR AND DIFFERENT.



WHY MIGHT THEY GROW LONG SPIKES AND HAVE THEM GET SHORT AGAIN?

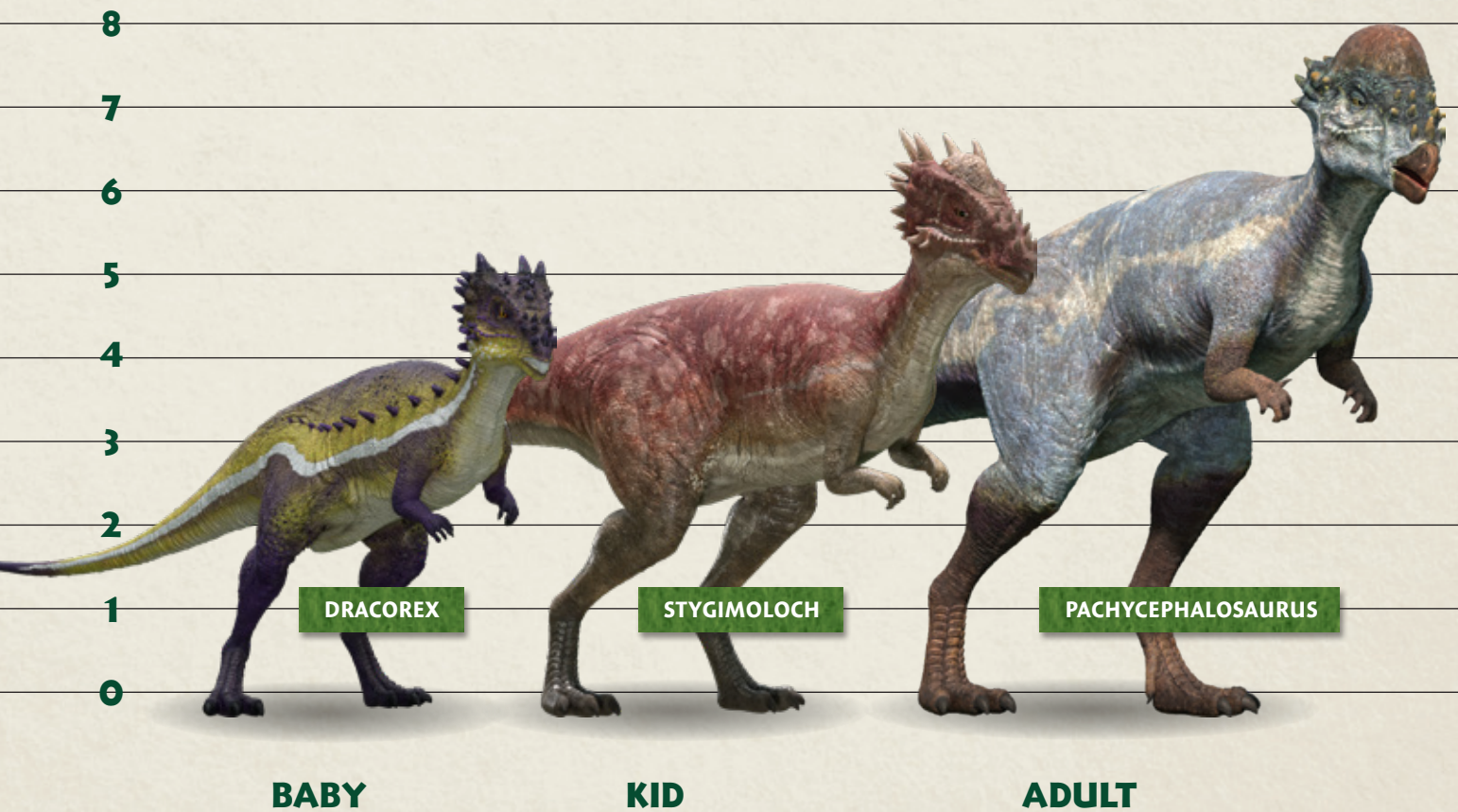
One theory is that they had different predators at different sizes and the spikes helped at the kid Stygimoloch size but not the adult Pachycephalosaurus size. Another idea is that the size of the horns signalled their age and social status to other members of their own kind.

LET'S COMPARE THEIR SIZES!

It's clear that they are all different sizes which makes them different, BUT it could also explain the Dracorex being a baby, the Stygimoloch being a kid, and the Pachycephalosaurus being the adult.



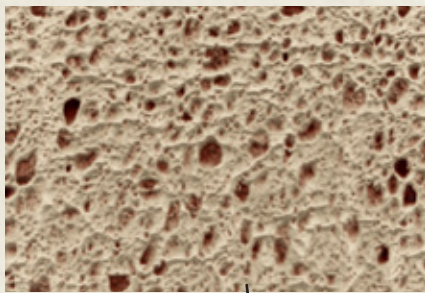
DINO LINE UP!



WHAT CAN WE LEARN FROM A CLOSER LOOK AT THE SKULL BONE?



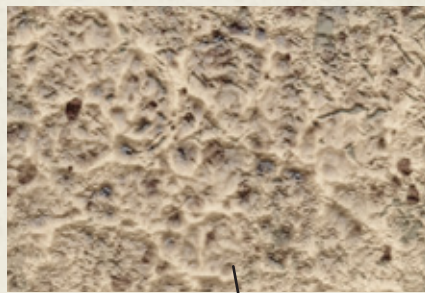
When a bone texture is 'spongy' (with more space for blood vessels), it means the dinosaur's bones were still growing when it died, which tells us it was a younger dinosaur! The more compact the texture, the older the bone was when the dinosaur died.



DRACOREX

SPONGIEST BONE

This means the Dracorex bone is still growing really fast, which means it's still a baby and will get bigger.



STYGILOCH

SPONGY BONE

This means the Stygimoloch bone is also still growing so it's likely a young dinosaur! The dome is very spongy showing that it's growing quickly.



PACHYCEPHALOSAURUS

SOLID BONE

This means the Pachycephalosaurus bone is no longer growing. This confirms that the Pachycephalosaurus is an adult!



Even though these are all differences, it is more evidence to support our hypothesis that these are the same dinosaur at different ages!



LET'S COMPARE MORE FEATURES!

We have found a lot of things that are **DIFFERENT** about these three dinosaurs. But maybe we need to stop looking at what makes things different, and start looking at what makes things the same!



If you are going to determine if you're related to a sibling, you can't do it by looking at differences. You need to look at similarities.

– Dr. Jack Horner

FILL IN THE BLANKS BELOW TO KEEP COMPARING THESE DINOSAURS' FEATURES! CAN YOU FIND SOME SIMILARITIES?



IN WHAT PERIOD DID THE DINOSAUR LIVE?

CRETACEOUS PERIOD
(68 to 66 million years ago)

CRETACEOUS PERIOD
(68 to 66 million years ago)

CRETACEOUS PERIOD
(68 to 66 million years ago)

DIET CLASSIFICATION

HERBIVORE (plant eater)

HERBIVORE (plant eater)

HERBIVORE (plant eater)

LOCATION

WESTERN NORTH AMERICA

WESTERN NORTH AMERICA

WESTERN NORTH AMERICA

NUMBER OF LEGS?

SHORT OR LONG ARMS?

FINDINGS

Let's summarize our findings!



DRACOREX



STYGILOCH



PACHYCEPHALOSAURUS



WHAT IS DIFFERENT?

No dome on head	Tiny dome on head	Large dome on head
Medium spikes on back of its head	Large spikes on back of its head	Small spikes on back of its head

WHAT IS THE SAME?

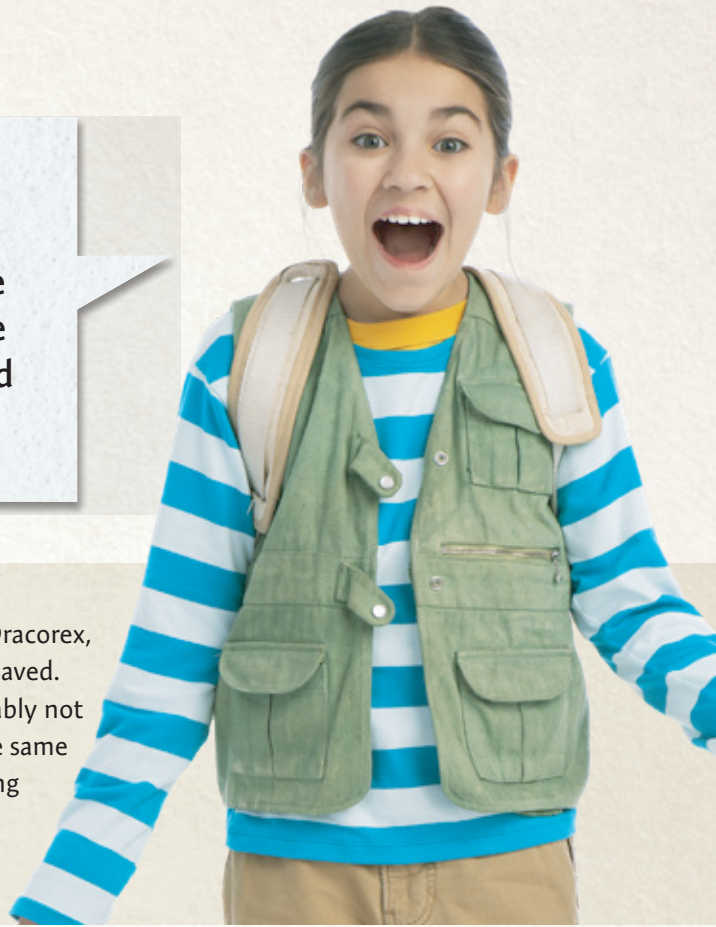
Has bumps on nose	Has bumps on nose	Has bumps on nose
From the Cretaceous Period	From the Cretaceous Period	From the Cretaceous Period
Herbivore	Herbivore	Herbivore
Two legs	Two legs	Two legs
Short arms	Short arms	Short arms
Lived in North America	Lived in North America	Lived in North America

EVIDENCE IT IS STILL GROWING

Smallest size	Medium size	Largest size
Skull bone is the spongiest texture, so still growing	Skull bone is a spongy texture, so still growing	Skull bone is a solid/mature texture, no longer growing

CONCLUSION

The data supports our hypothesis! Even though there are some differences between the three dinosaurs, there are more things that are the same than different! If we had just focused on the differences, we would have never noticed their similarities.



In the movie, Dana uses her imagination and field guide to get the Dracorex, Stygimoloch, and Pachycephalosaurus together to see how they behaved. Her hypothesis was if they tried to fight each other, they were probably not related. What she observed supports the theory of them being in the same family, because the three dinosaurs were getting along and protecting each other! This means they were likely all Pachycephalosaurus dinosaurs but at different ages: Baby, Kid, and Adult!



Every time they found something that looked a little bit different, they named it something different. And what happened is we ended up with a whole bunch of different dinosaurs.

– Dr. Jack Horner



THERE'S MORE!

Some paleontologists also believe that the Anatotitan is actually an adult version of the Edmontosaurus, and the Torosaurus is an adult version of the Triceratops! Because the Edmontosaurus and Triceratops were named first, those names remain!



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DINO DANA