Task 5: Time Scale

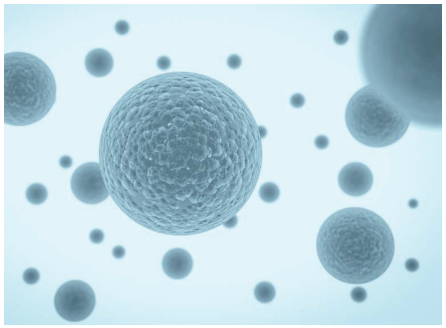
LT: I can describe the time it takes for evolutionary change.

Goal: Sort the Structure Change Cards using your ideas about how long evolutionary changes take to happen.

Instructions

- Read each card with your partner.
- Discuss how big you think the evolutionary change on each card is.
- Decide whether big changes take a long time or a short time.
- Sort the cards according to how long you think the changes took, with the longest times to the left and shortest times to the right.

Structure Change Card 1

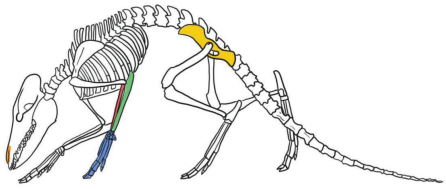


Time Point 1: First living things

Time Point 2: Earliest mammals

tissues and nerve cells develop
backbone develops
limbs with digits develop

Structure Change Card 2

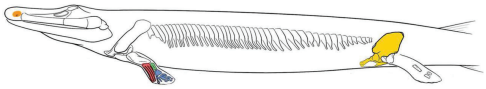


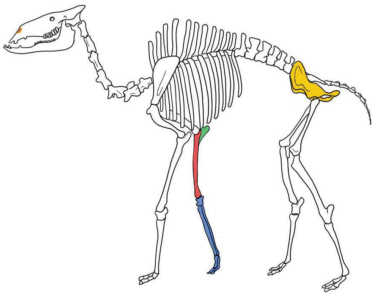
Time Point 1: One of the earliest species of whale. This species walked on four limbs and had well-developed front limbs and back limbs.

Time Point 2: The first whale ancestors to live entirely in the ocean. Their front-limb bones became shorter, and their hind limbs and pelvis became too small for them to walk on land.

back limbs get smaller and smaller
nostrils move farther and farther up

Structure Change Card 3





Time Point 1: The first vertebrate animal with a neck. This animal could move its head without moving the rest of its body.

Time Point 2: Early camel relatives develop long necks with multiple vertebrae. This animal could use its neck to move its head in nearly all directions.

limbs with digits start to develop
mammals first appear
neck gets longer and longer

Structure Change Card 4

Time Point 1: Animals develop eyespots. Organisms with eyespots, such as the flatworm above, use these tiny spots to detect day and night and to move toward or away from light.

Time Point 2: Organisms develop complex eyes that can see shapes, colors, and motion. Birds of prey, such as the red-tailed hawk, can spot mice from over 100 meters away.

eye structures (lens, cornea) develop
cones that can perceive color develop
more and more sensitive vision

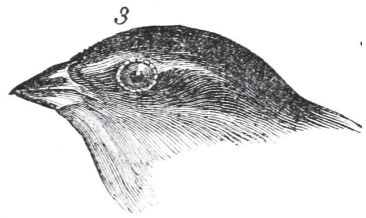
Structure Change Card 5

Time Point 1: A group of tortoises from the South American mainland became separated from the population and floated to the Galápagos Islands.

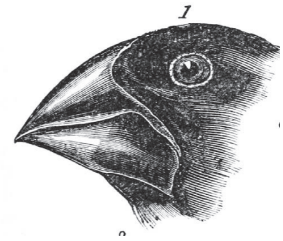
Time Point 2: The descendants of the mainland tortoises developed specialized shells and other differences that made them different species. If they were taken back to the mainland, they would not reproduce with their relatives that live there.

neck gets longer and longer
legs get longer and thicker
shell changes shape

Structure Change Card 6



Time Point 1: Many finches on an island have small beaks and eat small seeds.



Time Point 2: Over time, the environment on the island became dry, and food became more scarce. Larger and stronger beaks became more common. These beaks could eat harder seeds that smaller beaks could not.

beaks get larger and larger
beaks get stronger and stronger

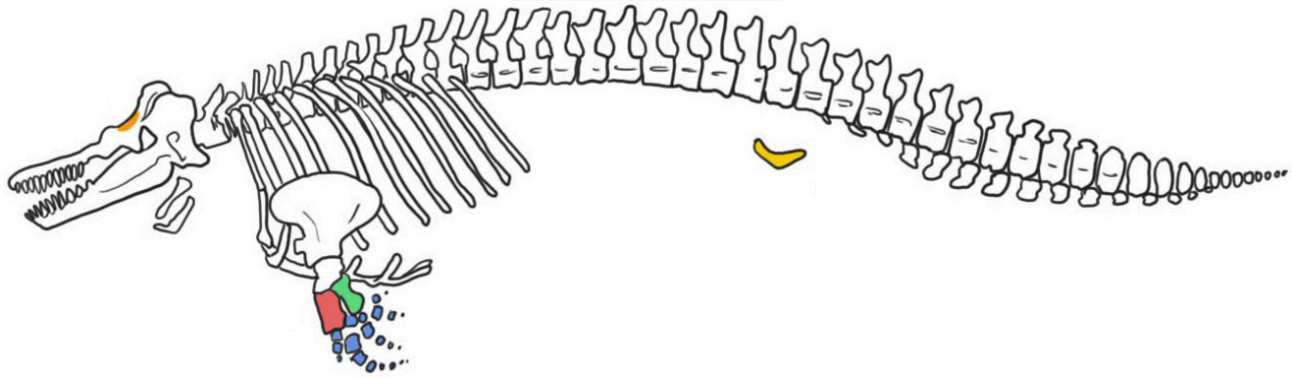
Task 6a: Considering Structures

LT: I can make careful observations on the structural similarities and differences of two organisms in order to find the relatedness of a third organism.

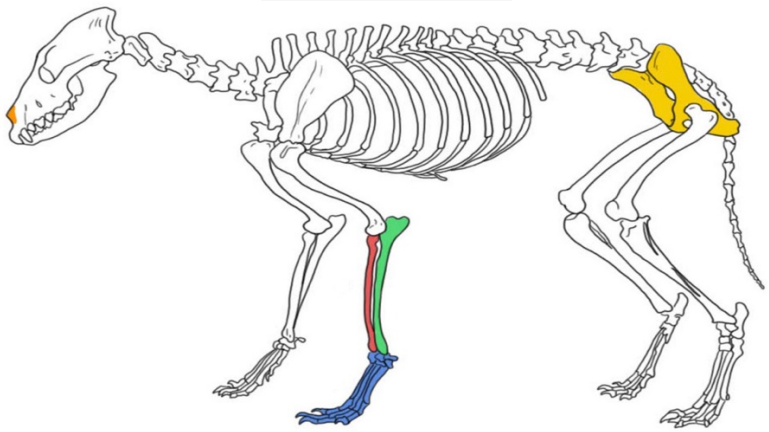
Watch the following video link to learn about the process paleontologists use to determine how closely related different species are when they are comparing three or more different species.
https://sites.google.com/a/ps207tigers.org/207sci/diagnostic-structures

When we want to determine which type of organisms are more closely related among three that share many common structures (like these do), we need to do a more careful analysis and look at the important structures that they do not share. These diagnostic structures can help us determine which type of organism the Mystery Fossil is more closely related to.

Orca Whale Skeleton



Gray Wolf Skeleton



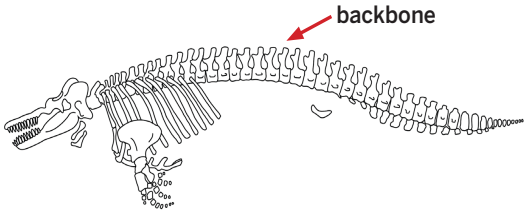
Use the set of cards about different body structures that whales and wolves have. Sort these cards in order to figure out which structures are unique to the whale and to the wolf, so that they will know which structures to look for in the Mystery Fossil in order to determine if it is more closely related to whales or to wolves.
Record your information in Table 1

Table 1: Sorting Information About Whales and Wolves

Only whales have this structure	Only wolves have this structure	Whales and wolves both have this structure

Card A: Backbone

All whales are vertebrates (have a backbone).

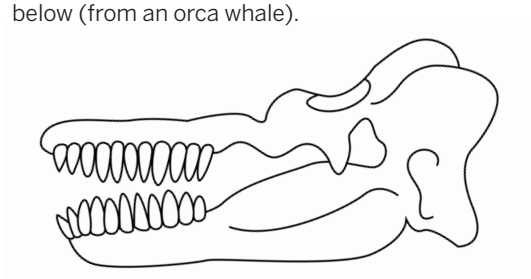


Card B: Mammals

All whales are mammals. They have live birth and give milk to their babies.

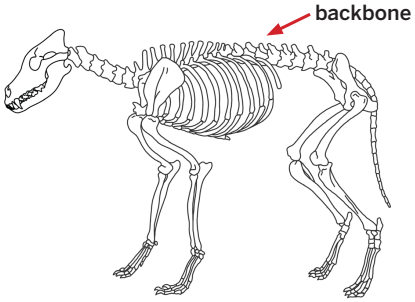
Card C: Skull Shape

Whale skulls can differ in shape, but all have long jaws and most have a similar shape to the skull below (from an orca whale).



Card D: Backbone

All wolves are vertebrates (have a backbone).



Card E: Teeth

Toothed whales evolved teeth that are adaptive for eating small fish in the water. Their teeth are all cone-shaped and evenly spaced throughout the mouth.

Card F: Skull Shape

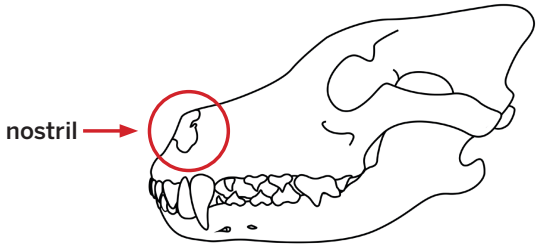
Over evolutionary time, wolf skulls have kept a relatively stable shape, with shorter jaws that look similar to the one below (from a gray wolf).

Card G: Teeth

Wolves evolved teeth that are adaptive for eating the bones and tendons of animals. They have large teeth in the front of the mouth and wide, slicing molars in the back of the mouth.

Card H: Nostrils

Over evolutionary time, wolf nostrils have always stayed at the front of the snout. This is a stable body structure that all wolves share.

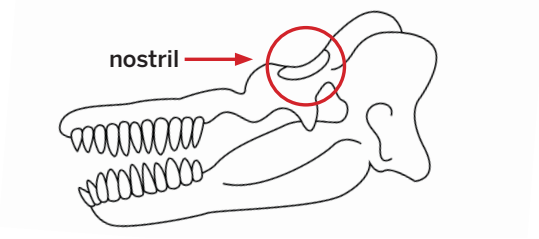


Card I: Mammals

All wolves are mammals. They have live birth and give milk to their babies.

Card J: Nostrils

The common ancestor of all whales had its nostrils at the front of the skull. Over time, whales gradually evolved to have nostrils at the top of the skull. This is a body structure that has changed.



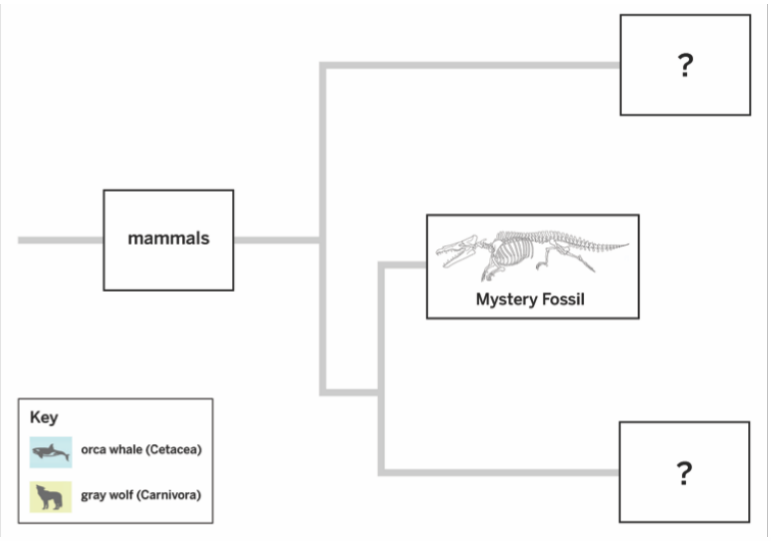
1. Focus on shared structures between whales and wolves. Which cards were placed in the column for shared structures for both whales and wolves (Column 3)?

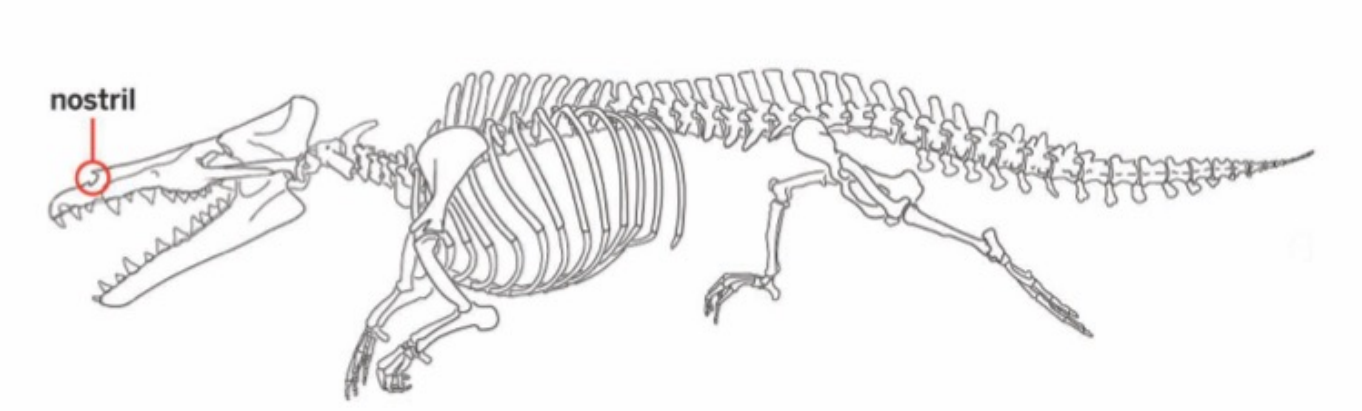
2. What does the presence of these shared structures mean?

3. If both whales and wolves share these structures, are they useful for figuring out where to place the Mystery Fossil?

4. We can see clear ways to group whales and wolves together (evidence in Column 3), and we know that this means they are related. But we also found some structures that show how whales and wolves are different (Columns 1 and 2 in the table). What are the diagnostic structures (structures of the whale and the wolf that are different)?

You will now work to make careful and precise observations about each of the Mystery Fossil's structures. After you do this, you will be able to compare to see whether the Mystery Fossil's structures look more like the whale's structures or more like the wolf's structures.





Use your findings from the previous assignment and the evidence about the Mystery Fossil to decide which structures shared with whales or wolves belong in each Table 2 column. For example, backbones are shared between all three, so you should put the information from Cards A and D in the third column.

Table 2: Sorting Shared Structures Among the Mystery Fossil, Whales and Wolves

Whales and the Mystery Fossil share this structure	Wolves and the Mystery Fossil share this structure	Whales, wolves and the Mystery Fossil share this structure

After analyzing the Mystery Fossil's structures and comparing them to the structures of whales and wolves, which claim do you think is more strongly supported by the evidence?

Where in the museum does this new fossil belong?

- Claim 1: The Mystery Fossil belongs with the whales, in the Whale (Cetacea) exhibit.
- Claim 2: The Mystery Fossil belongs with the wolves, in the Carnivore (Carnivora) exhibit.
- Claim 3: The Mystery Fossil belongs with the crocodiles, in the Reptile (Reptilia) exhibit.

Task 6b: Considering Structures (Written Argument)

LT: I can use structural evidence to prepare an argument about where to place the Mystery Fossil in the Natural History Museum, based on whether the Mystery Fossil is more closely related to whales or wolves.

Making an Argument About Where in the Museum to Place the Mystery Fossil

Prepare your argument about where to place the Mystery Fossil in the Natural History Museum, based on whether you think the Mystery Fossil is more closely related to whales or wolves.

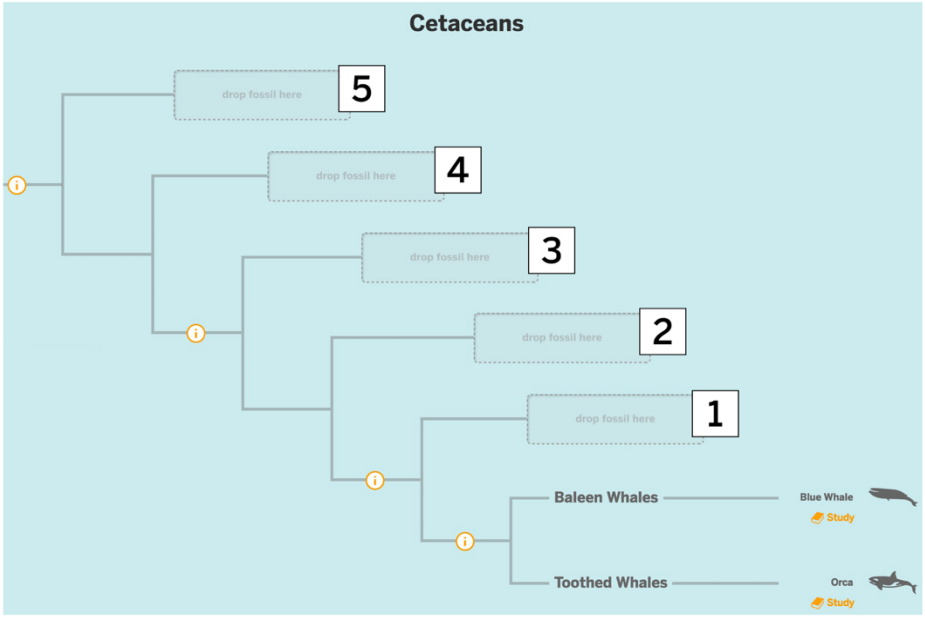
I can tell the Mystery Fossil shares a common ancestor with both whales and wolves because . . .

I believe the Mystery Fossil is more closely related to _____. This supports the claim:

Use evidence to write an argument explaining where you think the Mystery Fossil should be placed in the museum.

Task 7: Extension

LT: I can observe species structures in order to place them on an evolutionary tree to show evolutionary relatedness.



Do:

1. Open Cetaceans mode of the Sim https://apps.learning.amplify.com/evolutionaryhistory/#/

2. Press TREE to open Tree View and navigate to the Cetaceans branch of the tree.

3. Study the Blue Whale and Orca structures.

4. Read the first question below and place a fossil species into Location 1 (see image above), then repeat this for each of the locations.

Tip:

- Use the Structures tab in the Study windows and the "i" icons to help you make your decisions.

a. **Which of the two species belongs in Location 1? (Hint: Investigate hind limbs and skulls.)**
b. **Which of the species belongs in Location 2? (Hint: Investigate limb sizes.)**
c. **Which of the species belongs in Location 3? (Hint: Investigate limb sizes.)**
d. **Which of the species belongs in Location 4? (Hint: Investigate hind limb structures.)**
e. **Which species is Dorudon more closely related to: the blue whale or Ambulocetus? Which diagnostic structure(s) could you use to show this?**

Task 8:
LT: I can analyze and describe evidence that supports a claim about an evolutionary relationship.

From: Dr. Zhang
To: Student Paleontologists
Subject: The Tometti Fossil

My name is Dr. Zhang, and it was suggested that you might be able to help our museum in China.
We'd like help with a puzzle we've never been able to solve about a fossil found in a nearby dig site.
Dr. Michelle Tometti, a visiting paleontologist, found this fossil several years ago, brought it to our museum, and assembled it. Unfortunately, this fossil has been sitting in our storage area for the last few years. It has never been displayed on the museum floor because it was never identified. You can help us by determining which type of organism the Tometti fossil could be most closely related to: the ostrich or the crocodile.

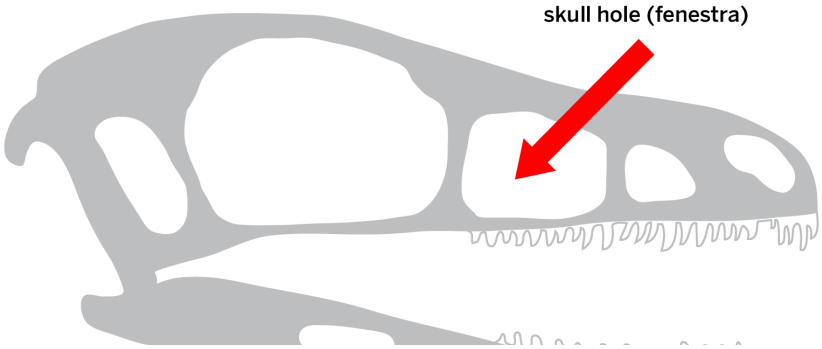
As Dr. Tometti analyzed the fossil, she noticed something important: a specific type of hole in the skull. A hole found in this location can be found in the skulls of a specific group of reptiles—all the species in this group of reptiles have this hole.

Paleontologists call this hole a fenestra. This particular hole, in combination with other shared structures, led Dr. Tometti to conclude that her fossil shared a common ancestor with all other reptiles that have this hole.

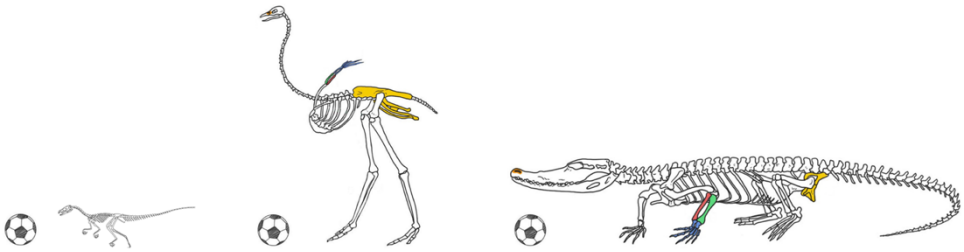
The Tometti fossil was very small compared to both of these modern species, but, as you know, structures and sizes can change a lot over evolutionary time. This is interesting information, but size probably won't help us determine which the Tometti fossil was more closely related to. We will need more specific diagnostic information to make this determination.

Dig Site in China

The Tometti Skull



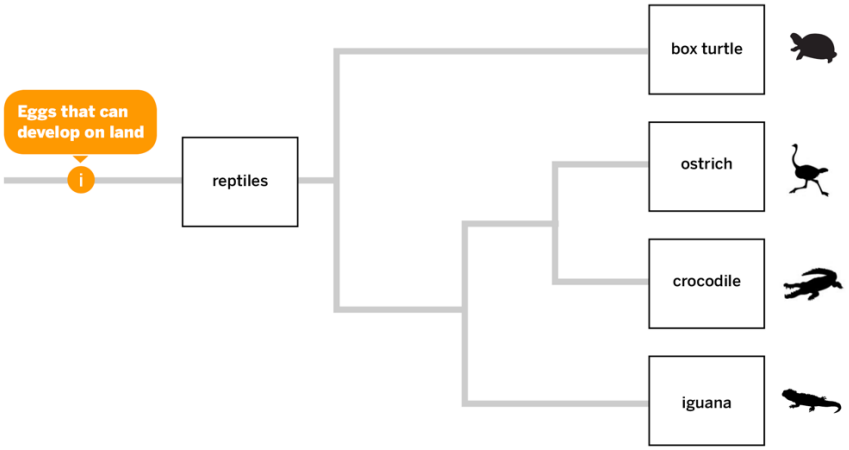
Tometti Fossil, Ostrich, and Crocodile



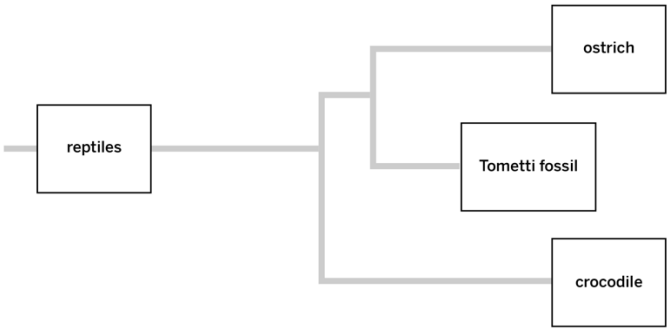
Paleontologists have actually narrowed down the list of species the Tometti fossil could be related to, making your job easier.

Is the Tometti fossil more closely related to an ostrich or a crocodile?
Use the evidence cards on the following pages to support either claim:

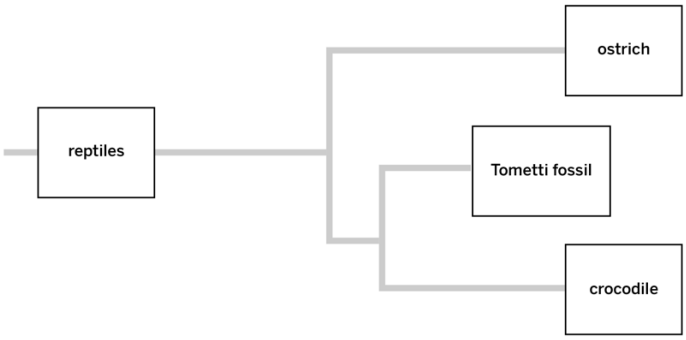
Reptile Evolutionary Tree



Claim 1: The Tometti fossil is more closely related to ostriches.



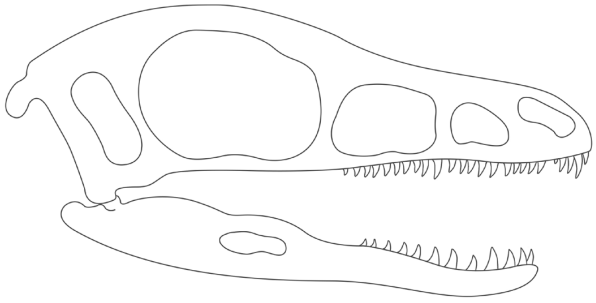
Claim 2: The Tometti fossil is more closely related to crocodiles.



Many people have taken a look at the Tometti fossil since Dr. Tometti uncovered it. Most of the observations were made by student paleontologists. Some were carefully made while others were sloppy or rushed. Your job is to determine which of the observations are the most precise. Once you have determined this, you will keep these observations as evidence.

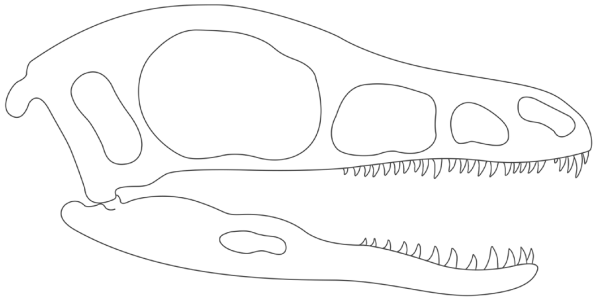
Examine the evidence cards with paleontological observations made about the Tometti fossil. Place these cards into two groups determining which observations are stronger and which are weaker.

Evidence Card A: The Tometti Skull



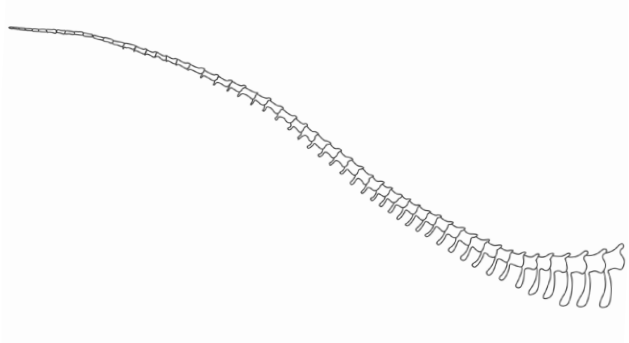
The nostril hole is at the front of the skull. There is one huge hole on top of the skull. There are also many other holes throughout the skull. The Tometti's mouth has sharp, pointy teeth.

Evidence Card B: The Tometti Skull



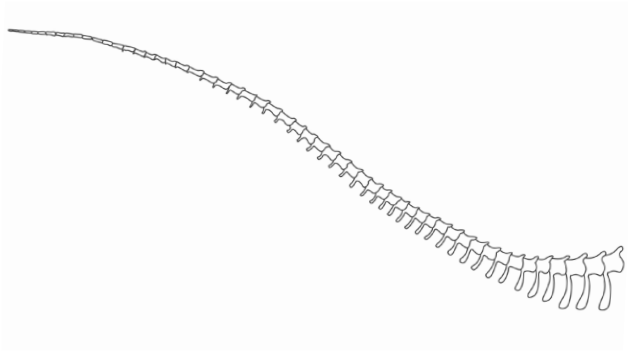
This skull is long. The top half of the skull has five holes while the bottom part of the skull has one hole. Each hole is a different size, with the largest hole found on the top half of the skull. There are many sharp, pointy teeth on both the top and bottom of the jaw.

Evidence Card C: The Tometti Tail



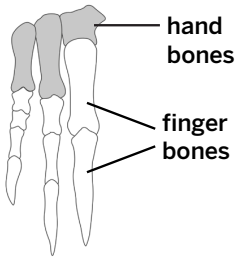
The tail is about 0.8 m long. The tail is very long compared to the body. It is made of 55 different bones, which are connected together. Most of the bones are about the same size, but toward the end of the tail the bones are much smaller.

Evidence Card D: The Tometti Tail



This fossil has a very long tail. The tail has many bones. The bones are mostly all the same size, but some are smaller than others.

Evidence Card E: The Tometti Hands

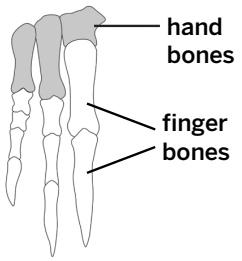


hand

The Tometti fossil has three fingers on each hand (front limb).

- Each finger has a different number of bones. The number of bones on each finger (from left to right) is 4, 3, 2.
- The bones on the finger to the far right are thicker than the bones on the other fingers.

Evidence Card F: The Tometti Hands

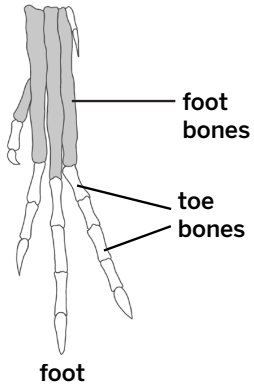


hand

The Tometti fossil has three fingers on each hand.

- Each finger is a different size.
- The bone at the end of each finger is pointy.
- There are several bones for each finger.

Evidence Card G: The Tometti Feet

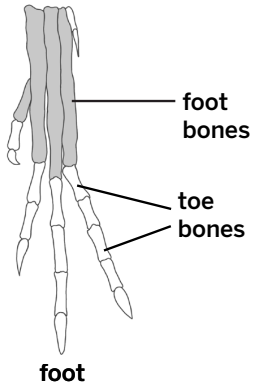


The Tometti fossil has four toes on each foot.

- Each toe is a different size.
- The end bone for each toe is pointy.
- Each toe has several bones.

Evolutionary History—Tometti Fossil Mystery Evidence Cards: Set 1—Lesson 4.1

Evidence Card H: The Tometti Feet

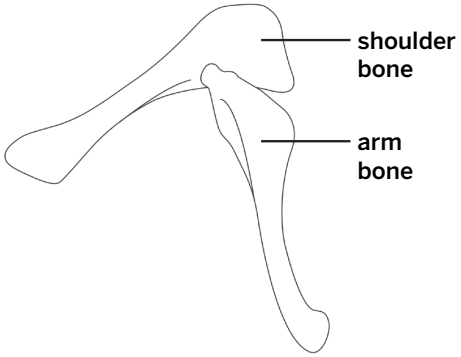


The Tometti fossil has four toes on each foot (back limb).

- The bones on the left toe are very small.
- Each toe has a different number of bones.
- The number of toe bones (from left to right) is 2, 3, 4, 5.
- On all the toes, the bone at the end is pointy and short compared to the other bones.

Evolutionary History—Tometti Fossil Mystery Evidence Cards: Set 1—Lesson 4.1

Evidence Card I: The Tometti Shoulder Bone



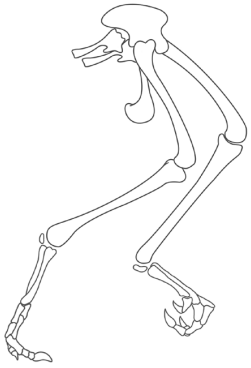
The shoulder bone of the Tometti fossil is curved at the point where it meets the arm bones. The shoulder bone is a short, thin bone that connects the arm to the rest of the bones in the body.

Evolutionary History—Tometti Fossil Mystery Evidence Cards: Set 1—Lesson 4.1

Evidence Card J: The Common Ancestor of the Tometti Fossil, Ostriches, and Crocodiles

- The common ancestor of crocodiles, ostriches, and the Tometti fossil was a reptile with four holes in its skull.
- It had five digits (fingers) on each of its front limbs.
- It had five digits (toes) on its back limbs, but one of the digits (the pinky toe) evolved to be much smaller than the others and wasn't used for walking.
- The common ancestor's back limbs were longer than its front limbs. It mostly walked on four legs, but it could probably move on two legs for short periods of time.

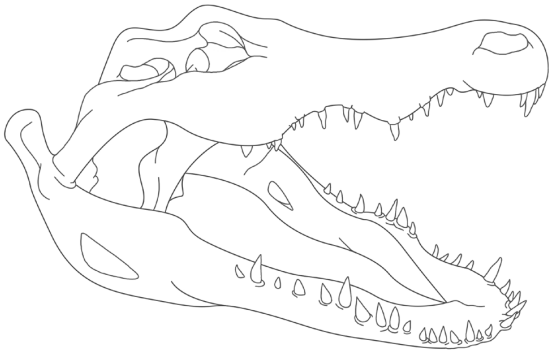
Evidence Card K: The Tometti Back Limbs



The Tometti fossil walked on its back limbs. It walked on its toes instead of its whole foot.

Even though the Tometti fossil had four toes on each foot, one of the toes was much smaller than the others. It only used three of its toes for walking.

Evidence Card L: The Crocodile Skull



Crocodile skulls have changed to become heavier over time. The crocodiles' ancestor had four holes in the top half of its skull, but modern crocodiles only have three holes.

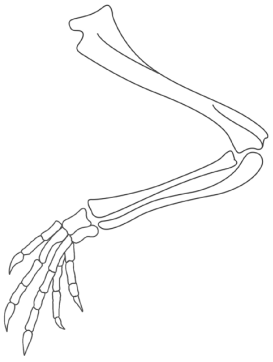
The crocodile group's (Crocodilia) teeth have been a stable body structure over time. Crocodiles' teeth are pointy and sharp, and there are large gaps between teeth.

Evidence Card M: The Ostrich Skull

The skull in ostriches and other birds has evolved so many of the holes in the skull have merged together. Now, there is much less bone in birds' skulls, making the skulls very lightweight.

The bird group's (Aves) teeth have been a changing body structure over time. The earliest birds had teeth, but all modern birds, including ostriches, do not.

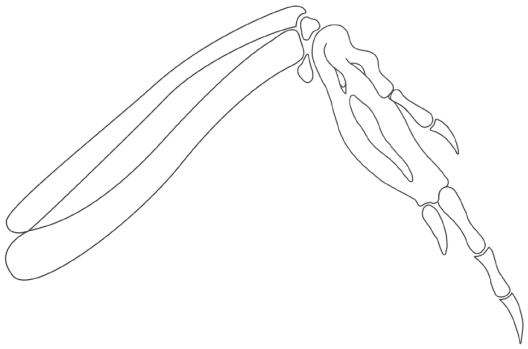
Evidence Card N: The Crocodile Hands



front limb

There are five digits (fingers) on each front limb of the crocodile.

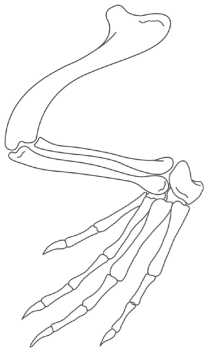
Evidence Card O: The Ostrich Hands



front limb

There are three digits (fingers) on each front limb of the ostrich.

Evidence Card P: The Crocodile Feet and Back Limbs



back limb

All modern crocodiles walk on all four limbs, but in the past there were some crocodiles that could walk on their back two limbs.

Crocodiles walk on their whole foot, not just their toes.

There are four digits (toes) on each back limb.

Evidence Card Q: The Ostrich Feet and Back Limbs

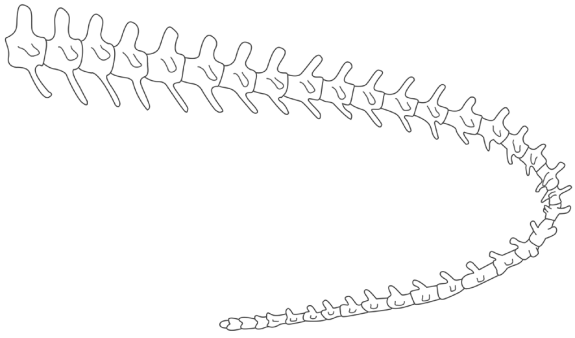
back limb

Ostriches use only their back limbs to walk.

They walk on the digits (toes) of their back limbs, not on their whole foot.

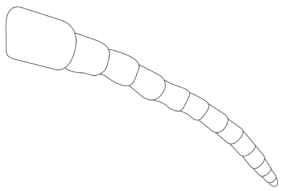
There are two digits (toes) on each back limb of the ostrich.

Evidence Card R: The Crocodile Tail



Crocodiles have a long tail made of 30–40 bones. The bones are connected together.

Evidence Card S: The Ostrich Tail



Ostriches have a very short tail. The tail is made of one bone that has many different segments.

Evolutionary History—Tometti Fossil Mystery Evidence Cards: Set 2—Lesson 4.2

Write a scientific argument to Dr. Zhang that addresses the question:
Is the Tometti fossil more closely related to ostriches or to crocodiles?

As you write:

- Include your strongest, most convincing evidence.
- Use the Scientific Argument Sentence Starters and the Word Bank below to explain your thinking.

Scientific Argument Sentence Starters	
Describing evidence: *The evidence that supports my claim is . . .* *My first piece of evidence is . . .* *Another piece of evidence is . . .* *This evidence shows that . . .*	Describing how the evidence supports the claim: *If _____, then . . .* *This is important because . . .* *Since _____, . . .* *Based on the evidence, I conclude that . . .* *This claim is stronger because . . .*

Words to Use			
body structure	evolutionary time	speciation	common ancestor
population	paleontologist	related	species
stability	descendant species	evolution	shared
structure	diagnostic structure		

In your argument be sure to

- State your claim.
- Use evidence from your Tometti Fossil Mystery Evidence Cards to support your claim.
- Explain how paleontologists use body structures to conclude how two different species are more closely related to each other than they are to a third species.

You can use the following template to organize your argument:
Paragraph 1: The Tometti fossil is more closely related to _____. Then provide evidence.

Paragraph 2: Even though the Tometti fossil is more closely related to _____, there are some differences between them. This is because _____. Then describe how they are different.

Paragraph 3: The Tometti fossil is not more closely related to _____. Then provide evidence.