Lesson: “How do we know what dinosaurs looked like?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hey, it's Esther from the Mystery Science team. I love dinosaurs, and I wanna show you some of my favorites. Check this out. Look at those huge spikes on its back. We don't always think about it this way, but someone made this picture. This was drawn by an artist. Because dinosaurs aren't around anymore, and because they lived much too long ago for us to have any photographs of them, we rely on artists to draw what they look like. Drawing dinosaurs is actually a real job that people have. You may have heard of a paleontologist. A paleontologist is a scientist who studies dinosaurs. Paleo means ancient or old. So a paleontologist is someone who studies ancient living things, like dinosaurs. So an artist who makes art of dinosaurs and other ancient living things is called a paleoartist. This is Alana. Alana is a paleoartist who works with us here at Mystery Science. Take a look at this dinosaur drawing she made. And this one, so cool. You'll see more of Alanna's drawings in this lesson. But when Alana draws a dinosaur, how does she know what to draw? How do any paleoartists know what dinosaurs looked like? Maybe you're thinking that paleoartists learn what dinosaurs looked like from paleontologists. And you're right. Many paleoartists do work closely with scientists. But how do the scientists figure out what dinosaurs looked like? I wonder what you think.

EXPLORATION VIDEO 2

Scientists have been studying dinosaurs for a long time. We know a lot more about what dinosaurs look like than we once did, but for many years, scientists didn't know that these amazing creatures ever even existed. Think about it. If you'd never heard of a dinosaur before, they might seem totally made up. Like, what if I told you there was an animal that once walked the Earth that had a neck longer than a school bus? You'd be like, wait, what? No way. But then we started finding these. These are remains of an animal that lived long ago. These remains are called fossils. Scientists often find fossils buried under the ground. Some of the most common fossils scientists find used to be bones. Some fossils look familiar, like, I bet you can figure out what these fossils are from, a fish, but check this fossil out. This definitely does not look like any animal alive today and neither do these or these. These are fossil bones of dinosaurs. These fossils are evidence that dinosaurs once lived even though we don't see them today and fossils can also give us clues about what those dinosaurs were like. For example, if a paleo artist like Alana wants to know how big to draw Tyrannosaurus Rex, she might start by looking at a Tyrannosaurus Rex skull. This skull is huge. Would an animal with a head this big have a tiny body like this? Probably not. This skull gives us a clue about the size of the dinosaur it came from. This is called evidence. Like, check this out. Scientists found fossils of this dinosaur's neck bones, when they lined all the fossil bones up, the neck was 44 feet long. That's about as long as a full-sized school bus. The idea of an animal with a 44-foot-long neck might seem extraordinary but this extraordinary evidence shows it likely happened. Usually, scientists only find a few fossil bones at a time, but sometimes we get really lucky and find a nearly complete skeleton like this. But even a skeleton can't tell us everything. Take a look at this. This is a skeleton of a kind of animal alive on Earth today. What kind of animal do you think it is?

EXPLORATION VIDEO 3

Here's the thing. If you draw an animal based only on their skeleton, you miss a lot of important parts. This skeleton doesn't include an elephant's huge flappy ears or its gray leathery skin. It doesn't even include its trunk. It's hard to tell that this is a camel without its hump, and this peacock is missing its colorful feathers. Hard body parts, such as bone, shells, and teeth tend to last longer after an animal dies than soft body parts do. This leaves us with a problem. We rarely find fossils of soft stuff like fur, feathers, and skin. So how do we find evidence about those soft parts of a dinosaur's body? Check this out. This is a fossil bone from a dinosaur called a velociraptor. After observing this fossil really closely, scientists discovered something. The bone has a row of tiny bumps on it. You might not be able to see them so well in this picture. It's even hard to see them on the bone itself. The bumps are so tiny. On its own, this might not mean very much. Okay, there's a line of tiny bumps on one bone. So what? But look, this is a bone from a Turkey vulture. Notice this line of bumps, and these bumps appear on the bones of these other animals too. See? Now, take a look at the front limbs of these living animals. These animals all have those lines of bumps on their bones, and these animals don't. What do the animals with the bumps on their bones have in common? What makes them look different from these animals that don't have these bumps?

EXPLORATION VIDEO 4

Here's what I noticed. All the animals with the bumps have feathers. That's no coincidence. In a turkey vulture's body, these bumps are where its feathers attached to bone. Like this. And in this animal, same thing. And this one, same thing. Not all birds have these bumpy bones, but all the animals we found that do have these bumpy bones also have feathers. So what does this mean

for Velociraptors? For a long time, paleontologists didn't have much evidence that Velociraptors had feathers. So when paleo artists in the past drew Velociraptors they usually drew them like this. But then by looking closely at a Velociraptor fossil, scientists discovered that tiny row of bumps. By comparing those bumps to similar bumpy bones of modern animals, scientists found evidence that Velociraptors most likely had feathers. Now, we've never found a fossil of a Velociraptor feather so we don't know for sure, but based on the evidence of these tiny bumps, today, when paleo artists like Alana draw Velociraptors, they usually draw them with feathers like this or this. The more evidence there is and the stronger that evidence is, the more confident a paleo artist can be about her drawing. The strongest evidence is evidence we can see, feel, and measure in fossils themselves. That's why even a tiny detail in a fossil like a little bump can be such a big deal. Try for yourself. Observe this dinosaur fossil closely. What do you notice? Describe what you see in as much detail as possible.

ACTIVITY INTRODUCTION VIDEO

In today's activity, you and a partner are going to be paleontologists. You'll use clues from fossils to help Alana, the paleoartist, draw what an ancient dinosaur could have looked like. A few fossils of a mysterious dinosaur were just discovered. Looks like scientists are unearthing one of them now. It's a skull. This fossil will help you figure out what the dinosaur looked like when it was alive millions of years ago. But how can you figure out what a dinosaur looked like from just a few fossils? Bones of modern-day animals can help. You and your partner are going to gather evidence from modern animal bones. These bones are from kinds of animals that are still alive today. Then you'll compare them to the fossil bones of the mysterious dinosaur. The clues you find will help Alana draw what the dinosaur might have looked like based on the evidence we have today. Are you up for the challenge? We'll get you started, step by step.

ACTIVITY STEP 1

For this activity, you'll work with a partner. When you're ready to move on, click the arrow on the right.

ACTIVITY STEP 2

Get your supplies. Each pair needs Modern Animal Bone Cards A, B, and C, and each person needs one Dinosaur Decisions worksheet and scissors.

ACTIVITY STEP 3

To get started, work with your partner to cut along the dotted lines of your modern animal bone cards and sort them into three piles. Put all the cards with the letter A in one pile, all the cards with the letter B into a different pile, and all the cards with the letter C into another pile. When you're done, put the stack of cards with the letter A in front of you and move the other stacks off to the side for now. You'll use them later.

ACTIVITY STEP 4

The first thing Alana wants to know is whether the dinosaur ate meat or plants. Bones can tell us a lot about an animal. For example, the shape of an animal's teeth can give us clues about what type of food it might have eaten. To help you figure out what the dinosaur ate take a look at the skulls of some modern-day animals. Take the stack of cards with the letter A on them and spread the cards out in front of you. With your partner, make some observations about these skulls and the teeth inside of them. Look closely and try to notice as many similarities and

differences as you can. To help you remember everything you found, write notes and circle patterns you notice on the cards like this. When you're ready to move on, click the arrow.

ACTIVITY STEP 5a

Now use the observations that you and your partner just made to help you sort your modern animal skull cards into two groups. Group one, carnivores, or meat eaters. These skulls have teeth that help an animal rip through meat and group two herbivores or plant eaters. These skulls have teeth that help an animal mash up plants. Then answer question one on your worksheet. Click the arrow to move on.

ACTIVITY STEP 5b

We noticed a few things in our observations that helped us find patterns between the bones. One pattern we noticed was that skulls one and three both had long, sharp teeth while skulls two and four had shorter square teeth. We also noticed that skulls one and three were full of teeth while skulls two and four had a gap in their rows of teeth right here. You may have noticed other things too. Now let's see which animals these teeth belong to and whether they eat meat or plants. Skull one is the skull of an alligator. Skull two is the skull of a giraffe, skull three is the skull of a Komodo dragon, and skull four is the skull of a horse.

ACTIVITY STEP 6

Now that you've seen what these modern animals eat, discuss with your partner, do you want to make any changes to how you sorted your skulls? Finalize which skulls you think go in the carnivore group and which go in the herbivore group.

ACTIVITY STEP 7a

Let's take a look at the dinosaur skull fossil that scientists dug up. Now that you know more about what modern-day carnivores and herbivores look like, what do you think this dinosaur probably ate? Why? Discuss with your partner then answer question two and three on your worksheet.

ACTIVITY STEP 7b

When we looked at the fossil of the dinosaur skull again, we noticed that it had long, sharp teeth like the carnivores alligator and Komodo dragon. With the evidence that we have, we're going to tell Alana that this dinosaur probably was a carnivore. Now she knows to draw the dinosaur biting into a hunk of meat. But there's more Alana needs to know before she finishes drawing the dinosaur. Click the arrow to move on.

ACTIVITY STEP 8

Scientists just unearthed another fossil from the dinosaur. It's a fossil of one of the dinosaur's back limbs. This new discovery has got Alana thinking. How should she draw the dinosaur walking around? Can you help Alana figure out if the mystery dinosaur walked on its back two limbs, like these dinosaurs? Or on all four of its limbs, like these dinosaurs? Click the arrow to move on.

ACTIVITY STEP 9

Just like last time, you're going to look at some bones of modern animals to gather clues about how the mystery dinosaur walked. Move your skull cards off to the side. Then take the stack of

cards with the letter B on them and spread the cards out in front of you. These are bones of modern animals that walk around on their two back limbs or on all four limbs. Can you figure out which is which? With your partner look closely and find as many similarities and differences between the bones as you can. Write and circle what you noticed on the cards. Remember, no observation is too small. The more you notice now, the more clues you will have to figure out how the mystery dinosaur walked.

ACTIVITY STEP 10a

Now use the observations that you and your partner just made to help you sort the bones into two groups. Group one, animals that walk on their back two limbs. And group two, animals that walk on all four limbs. Then answer question four on your worksheet.

ACTIVITY STEP 10b

We noticed a few patterns between these bones. First, we noticed that some animals had a short front limb and a long back limb, like Animals 1 and 3, while others had both a long front limb and a long back limb, like Animals 2 and 4. Then we looked closer and could see that animals two and four both had this little bone right here. Also, the back limb bones of Animals 1 and 3 make a zigzag shape like this. Finally, we noticed that the feet of Animals 2 and 4 looked alike. They even had the same number of toes. Also, the feet of Animals 1 and 3 looked alike. You may have noticed other things too. Now let's see which animals these bones belong to and how they walk. Animal 1 is a chicken. Animal 2 is an anteater. Animal 3 is a large bird called a cassowary and Animal 4 is a bear.

ACTIVITY STEP 11

Now that you've observed these modern animals walk, discuss with your partner. Do you wanna make any changes to how you sorted your cards? Finalize which bones you think go in the animals that walk on their back two limbs group, and which bones you think go with the animals that walk on all four limbs group.

ACTIVITY STEP 12a

Let's take a closer look at the fossil of the dinosaur's back limb. Now that you know more about how these modern animals walk, how do you think the dinosaur walked? Why? Discuss with your partner then answer question five and six on your worksheet.

ACTIVITY STEP 12b

Even though we don't know what the dinosaur's front limb looks like, we could still compare this fossil to the back limb bones of modern animals. We noticed that the fossil had the same zigzag shape as the bones of the cassowary and chicken. We also noticed that the dinosaur's toes looked a lot like the spread-out toes of the cassowary and chicken. The toes of the anteater and bear were closer together. With the evidence that we have, we're going to tell Alana that this dinosaur probably walked on its back two limbs. Now she knows to draw the dinosaur standing on two legs.

ACTIVITY STEP 13

Scientists just unearthed another fossil. Let's see what it looks like. It's one of the dinosaur's front limbs. Alana needs your help to figure out what the dinosaur's front limbs look like. Did the

dinosaur use them to fly, swim, fight? Can you help Alana figure out what the dinosaur's front limbs look like and what they might have been used for?

ACTIVITY STEP 14

Move your B cards off to the side, and take the stack of cards with the letter C on them. And spread the cards out in front of you. These are some close-up pictures of the front limb bones of some modern animals. Some of these are the bones of animals with wings, some are the bones of animals with flippers, and some are the bones of animals with claws. Can you figure out which is which? With your partner, look closely and find as many similarities and differences between the bones as you can. Write and circle what you notice on the cards. The more you notice, the more clues you'll have to figure out what the mystery dinosaur's front limbs were used for. When you're ready to move on, click the arrow.

ACTIVITY STEP 15

Now, use the observations that you and your partner just made to help you sort the bones into three groups. Group 1, Wings. Group 2, Flippers. And Group 3, Claws. It's okay if you're not sure which group to sort a bone into. Try your best given the evidence that you have, then answer Question 7 on your worksheet. When you're ready to move on, click the arrow.

ACTIVITY STEP 16

Finding patterns between bones becomes even harder when you sort them into more than two groups. To help you and your partner make your decisions, you'll receive three extra front limb bones from modern animals to observe and compare. Get the extra evidence bone cards out now.

ACTIVITY STEP 17a

Cut out the extra front limb bones along the dotted lines. Then make some observations with your partner. Look for patterns across all of your front limb bone cards. Then use these observations to make your final decisions and sort the bones into three groups. Wings, flippers, and claws.

ACTIVITY STEP 17b

At first, it was more challenging to sort our cards into three groups, but with the help of the extra bone cards, we were able to find stronger patterns between the bones. Here is how we sorted our bone cards. We noticed that Animals 2, 5, and 9 had the most unique shape to them. All ended in one sharp point with no bones that look like fingers. We also noticed they all have these tiny spiky bones sticking out of them. Let's see what kinds of animals these bones belong to. Animal 2 is an eagle. Animal 5 is a parrot, and Animal 9 is a hummingbird. All of these animals have wings. Next, we noticed that Animals 3, 6, and 7 had long bones at the end that look kind of like spread-out fingers. We also noticed that they have two thick bones in the middle that makes this unique shape. Let's see what kinds of animals these bones belong to. Animal 3 is a sea turtle. Animal 6 is a seal and Animal 7 is a porpoise. All of these animals have flippers. Finally, we noticed that Animals 1, 4, and 8 have sharp curves on the ends of them that looked a lot like nails. Let's see what kinds of animals these bones belong to. Animal 1 is a bear. Animal 4 is an anteater and Animal 8 is a sloth. All of these animals have claws. You may have noticed different things than we did or sorted your cards differently. That's okay. For the purpose of figuring out what our mystery dinosaur looked like we will use these groups. When you're ready to move on, click the arrow.

ACTIVITY STEP 18a

Take another look at the fossil. Now that you know more about what modern animals with wings, claws, and flippers look like, which do you think the dinosaur had? Why? Discuss with your partner. Then answer questions eight and nine on your worksheet. When you're ready, click the arrow to move on.

ACTIVITY STEP 18b

When we looked at the dinosaur fossil again we noticed that it wasn't shaped like a wing or flipper and it did have large, sharp, curved nails on the end. Based on the evidence we have we sorted it into the claw group with the bear, the anteater, and the sloth. We're going to tell Alana that the dinosaur probably had big, sharp claws. Now she'll know to draw the dinosaur using its front limbs to tear something open.

ACTIVITY STEP 19

Discuss. Let's recap what we did. What do you know about what the dinosaur looked like? How did you figure that out?

ACTIVITY STEP 20

Discuss. Were any of the decisions you made about the dinosaur more difficult than others? Were any easier? Why or why not?

WRAP-UP VIDEO 1

The fossil bones you studied in the activity belong to a real dinosaur, only in real life, this dinosaur's identity isn't a mystery anymore. It's called a Concavenator. Paleontologists who study Concavenators have more fossil bones to study than we did but they still use many of the same strategies that you did to figure out what this dinosaur looked like. They observed the fossil bones of Concavenators closely. They compared those bones to the bones of animals alive today, then based on all the information they gather, paleo artists decide how they think the Concavenator most likely looked. They make a claim or statement supported by evidence. Based on the evidence we studied, we made three claims about our mystery dinosaur. Alana used those claims to make her Concavenator drawing and here it is. The Concavenator Alana drew for us is using his sharp teeth to tear into some meat. He's a carnivore. He's standing on two legs, and his front limbs have claws he can use to rip and slash things. If you made different claims based on the evidence, a paleo artist taking your advice might have drawn the Concavenator differently. Alana isn't the only paleo artist to ever make vivid, detailed, terrifying, spectacular evidence-based art of a Concavenator. This is a painting of a Concavenator by paleo artist Emily Willoughby, and here's another one by a different artist. Take a close look at these pictures. What's the same about them? What's different?

WRAP-UP VIDEO 2

The Concavenators in these pictures have a lot in common. Because paleontologists have found fossil bones of Concavenator skulls, arm bones, and leg bones, they have lots of strong evidence to support the claims that Concavenators had pointy teeth, sharp claws, short arms, and long legs. So all of these paleoartists drew those body parts the same way. Actually,

paleontologists have even discovered a nearly complete skeleton of a Concavenator, which gave us lots of evidence about this dinosaur's overall shape. So all three paleoartists drew this dinosaur, roughly the same shape and size, but these drawings of Concavenators also look different. Why is that? If all these paleoartists study the evidence, shouldn't they all agree about what a Concavenator looks like? The tricky part is, we don't always have as much fossil evidence as we'd like. Like, take a look at this. Scientists have found fossils of Concavenator backbones, and they notice something. Some of the bones poke up higher than the rest. But what did that look like on the outside? We don't have a lot of evidence about that yet. It's kind of like trying to draw an elephant, based only on the skeleton. If we only had its bones as evidence, we wouldn't know what its nose looked like. Instead of a trunk, we might draw something like this or this. So what's a paleoartist to do? If scientists can't find many fossils of the soft parts of a dinosaur, what evidence should a paleoartist use to draw those parts?

WRAP-UP VIDEO 3

Paleo-artists can't just leave out the parts of the dinosaur's bodies scientists aren't sure about. Instead, paleo-artists look at a similar modern animal to find evidence of what the dinosaur most likely looked like or even just what it might have looked like. Could the bump on a Concavenator's back have looked like this? Maybe. Could it have looked like that? Also maybe. We don't know for sure. Our evidence isn't strong yet. But these living animals show it's possible for an animal to look like this. So it's possible the Concavenator did too. Luckily, new dinosaur fossils are being discovered all the time. With each new fossil, we get more evidence about what dinosaurs really looked like. Sometimes new evidence changes what we think, like how the discovery of a line of bumps on a Velociraptor bone made scientists realize these dinosaurs likely looked more like this. Maybe one day, we'll discover evidence that helps us know what the

bump on the Concavenator looked like or what color it was or where it had scales, fuzz, or feathers, or any of the many other things we still don't know for certain. Maybe we'll find out that one of these drawings got it exactly right, or more likely, maybe we'll discover these drawings got a lot right and something's wrong. So you could see this is a frustrating part of being a paleo-artist. You can work really hard on a really accurate dinosaur drawing, and then new evidence comes along and shows that a part of your dinosaur isn't accurate at all. But this is also exciting. There's so much we still have left to discover about dinosaurs. That means there's also so much left to draw. In the years ahead, we're going to need a lot more paleo art, because we're going to keep searching and finding new evidence that gets us closer to understanding what these wild creatures really look like. Maybe you'll be one of the paleontologists to make a discovery that totally changes what we know about Concavenators or Velociraptors or T. rexes. Or maybe you'll be one of the paleo-artists who helps bring all those new discoveries to life, so people around the world can appreciate these strange, wonderful, detailed ancient animals that once roamed the Earth. Have fun and stay curious.