Unearthing Pterosaurs

by American Museum of Natural History
This article is provided courtesy of the American Museum of Natural History.

There is a place called the Araripe Basin in a remote, sparsely populated region of northeastern Brazil. Arid but beautiful, it can be a difficult place for farmers to grow crops. But the earth provides another bounty: fossils. And among the bevy of bones are some rare finds - including 23 species of extinct flying reptiles called pterosaurs.

More than three decades ago, a local there found some large pterosaur bones. He delivered them to the Museu Nacional in Rio de Janeiro, where they were tucked away in a drawer. As it happens, many natural history museums have a trove of unexamined fossils awaiting study in their collections - there are just too many to go through. But a few years ago, paleontologist Alexander Kellner, a research associate at the American Museum of Natural History who as a doctoral student trained with Curators John Maisey and Malcolm McKenna, found the time to examine the 30-plus-year-old fossil finds at the Rio museum, where he is now a curator.

One especially rich layer, the Romualdo Formation, produced distinctive round nodules. Here, calcium collected around dead plants and animals that sank into the soupy mud. Sometimes, a hard shell, or calcareous nodule, formed around them. These rocky coverings preserved fish, plants, even entire pterosaurs, in three dimensions.

Before studying the bones, Kellner had to dissolve the calcereous "nodules" of rock in which the bones were entombed by sinking the fossils into buckets of formic acid. Using a pneumatic hammer, specialists at the museum gradually freed a partial skeleton of the animal from its stony home.

Tropeognathus mesembrinus

It included part of the animal's skull, complete with a bony crest at the tip of its nose, vertebrae, pelvis - and, perhaps most dramatically, arm and wing-bones. The wingspan of this pterosaur was, the research team concluded, nearly 27 feet - the largest pterosaur discovered so far in the Southern Hemisphere. A model of this recently described giant specimen, from the species *Tropeognathus mesembrinus*, flies overhead at the entrance to the special exhibition *Pterosaurs: Flight in the Age of Dinosaurs*, overseen by Curator Mark Norell with Kellner as co-curator

Not a Bird, Not a Dinosaur

What is a pterosaur? It sounds like such a simple question. But the answer was by no means obvious when the first pterosaur skeleton was discovered in the mid-1700s, in the Solnhofen limestone quarry in Germany. Perhaps, early observers theorized, that specimen's long skinny arm-and-finger bones were for swimming? Or was it some kind of

toothed, clawed, winged bird? Or even a mammal? Debates raged, even after 1801, when the great French anatomist Georges Cuvier analyzed drawings of the skeleton and determined the animal to be something new to science: a flying reptile that Cuvier later named ptero-dactyle (wing finger in Greek), whose wings were composed of a shortened upper arm bone, along with a dramatically elongated fourth finger that likely supported a wing membrane.

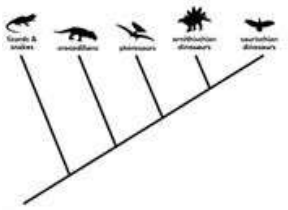
Since Cuvier's time, the fossil record has revealed much more about these extinct reptiles, which lived from about 220 million years ago to the end of the late Cretaceous period 66 million years ago, disappearing at the same time as large dinosaurs in a mass extinction event.

This fossil animal's long forelimbs perplexed early naturalists. In 1809, it was finally identified as a flying reptile and named ptéro-dactyle, meaning "wing finger."

Still, although pterosaurs may often be grouped with dinosaurs in children's picture books, they are not dinosaurs.

"Dinosaurs are characterized by a set of anatomical features pterosaurs don't have," explains Norell, including a hole in the hip socket. Today's scientific consensus is that pterosaurs are nonetheless more closely related to dinosaurs, whose living descendants are birds, than to any other group, including the next-closest, crocodiles.

What is also clear is that pterosaurs were the first vertebrates to fly - an amazing feat. Tiny, invertebrate insects had long since taken to the air, but nothing as large as a four-legged vertebrate had attempted such a thing.



This simplified cladogram shows that pterosaurs were more closely related to dinosaurs (including birds) than to crocodiles, and even more distantly to other reptiles such as lizards and snakes.

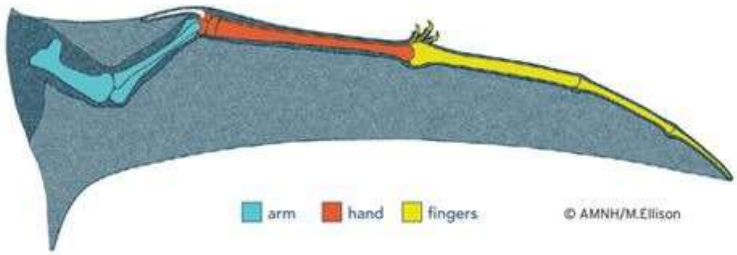
"They are the most fabulous creatures that ever existed! I am not exaggerating," says Kellner. "They made the first attempts among vertebrates to conquer the air - they were the first to develop powered flight," that is, the type of sustained flight that evolved, later and independently, in birds and bats.

Still, many mysteries remain. What type of material covered their skin? Was it hair, or feathers, or something in between? What did they eat, and how did they hunt? Many pterosaurs had flesh-and-bone crests atop their skulls - dramatic anatomical characteristics whose purpose is still debated by paleontologists.

Unlike dinosaurs, whose living descendants are modern birds, pterosaurs left no heirs when they disappeared from Earth. That means paleontologists have no living analogs to draw from as they make inferences about pterosaur behavior. Nonetheless, in the past decade or two, there has been a resurgence of pterosaur research and synthesis, as new methods of examining fossils, such as computed tomography (CT) scanning and UV lighting to discern heretofore invisible details, have become commonplace; as researchers share data digitally; and as researchers begin to find new fossils in previously unexplored locales, including China and Brazil.

Fossils Reveal Diversity

Pterosaur bones have been found on every continent including Antarctica. Although all pterosaurs share the wing anatomy in which the upper-arm bone (humerus) and elongated fourth digit form the truss of the wing membrane, the wing shapes are quite diverse: from long, thin soaring wings like those of an albatross to short, stubby wings that might have allowed for more frequent flapping flight, like that of a cardinal. Some early pterosaurs had peg-like teeth seen in living reptiles, while many others were toothless. Early pterosaurs often had long tails that they might have used as airborne rudders, while later species have a short tail or no tail at all.



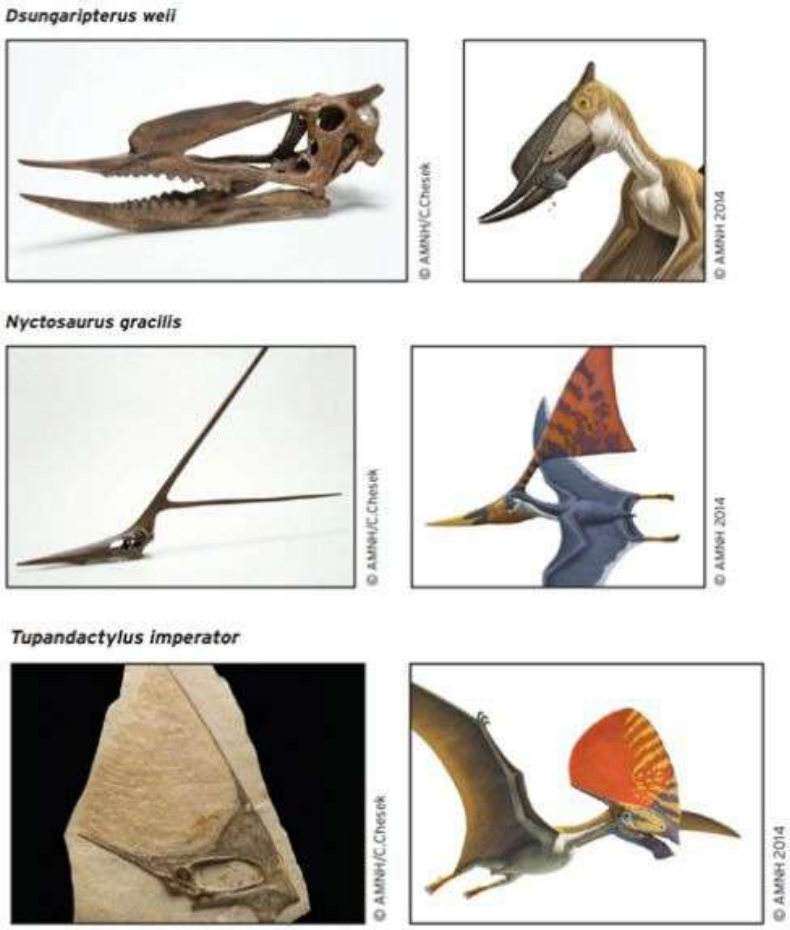
A number of adaptations made flight possible: a greatly elongated fourth finger of the hand that evolved to support a wing; flexible, hollow bones; and membranes between different parts of the body.

Crazy Crests

The incredible diversity of pterosaurs is perhaps best expressed in one of the prehistoric flying reptile's most intriguing and mysterious features: the head crest.

Akin to a rooster's comb, peacock's crown, or the frill on some lizards' necks, pterosaur crests were prominent anatomical features found across many species. But rather than flesh or feathers, these reptiles' crests were made at least in part of bone - a boon to paleontologists, as hard bone tends to be preserved as a fossil. Recent research also indicates that other horn-like material comprised part or even most of some pterosaur crests, with the thin, underlying bony structure supporting sometimes expansive membranes. Pterosaurs crests are thought to have been fairly ubiquitous, appearing in many groups of pterosaurs from the Triassic (252-201 million years ago) through the Jurassic (201-145 million years ago) and Cretaceous (145-66 million years ago) periods. In terms of size and dramatic effect, crests peaked in the Late Cretaceous, when the biggest pterosaurs also evolved.

Among pterosaur species known to have had crests, there is an amazing range of shapes and sizes. *Pteranodon sternbergi*, for example, had a high upright crest on its skull; *Pteranodon longiceps*, dagger-shaped blades at the back of its head; and *Nyctosaurus*, a fan-like structure at the rear of its head. *Dsungaripterus weii* had two: a long, low crest on its snout and a short crest rising above the back of the head. The *Anhanguera* species had rounded disk shapes on both upper and lower jaws, while *Gnathosaurus* pterosaurs had long, low ridges running down the middle of their heads. *Tupandactylus* imperator had huge sail-like extensions that dwarfed the rest of its head.



Could something so flashy be all form and no function? The heavier crests cost the reptiles a lot in energy to grow and carry around. Reason suggests if they weren't useful, they would have disappeared over millions of years of evolution. But just what that use was is a question that puzzles pterosaurologists to this day.

There are competing theories, chief among them that crests serve as a form of species identification. Other possibilities include a role in sexual selection, heat regulation, as a rudder in flight, or as a keel in the water, stabilizing the reptile as it dove or skimmed for food. The discovery in Brazil of wildly different crests among closely related species lends credibility to the theory of species identification: like a Mesozoic mohawk, a distinct crest would allow ready recognition of one's own kind and, equally important, rule out others.

Were the crests as brightly colored as shown in artists' renderings? While scientists cannot know for certain, light and dark bands of color on the rare preserved tissue of a *Pterorhynchus wellnhoferi* crest found in China led to speculation that crests might indeed have been highly colored, especially if they served to communicate identity or attract mates.

Still, without living descendants for comparison and the relative scarcity of fossils, definitive proof has been elusive - so far.

Name: _____ **Date:** _____

1. What are pterosaurs?

A. extinct flying reptiles

B. extinct dinosaurs

C. living descendants of dinosaurs

D. flying reptiles alive today

2. The author compares the wings, tails, and crests of different pterosaurs. Why does the author make these comparisons?

A. to show that pterosaurs did not really differ

B. to show how helpful fossils can be in the study of pterosaurs

C. to show how diverse pterosaurs were

D. to show that pterosaurs probably only lived in one part of the world

3. Read this sentence from the article.

"The incredible diversity of pterosaurs is perhaps best expressed in one of the prehistoric flying reptile's most intriguing and mysterious features: the head crest."

What evidence from the text supports the idea that the diversity of pterosaurs is best expressed in their head crests?

A. "Many pterosaurs had flesh-and-bone crests atop their skulls - dramatic anatomical characteristics whose purpose is still debated by paleontologists."

B. "Akin to a rooster's comb, peacock's crown, or the frill on some lizards' necks, pterosaur crests were prominent anatomical features found across many species."

C. "Pterosaurs crests are thought to have been fairly ubiquitous, appearing in many groups of pterosaurs from the Triassic (252-201 million years ago) through the Jurassic (201-145 million years ago) and Cretaceous (145-66 million years ago) periods."

D. "Among pterosaur species known to have had crests, there is an amazing range of shapes and sizes."

4. Debates about pterosaurs continued even after George Cuvier identified pterosaurs as flying reptiles in the early 1800s. Why might debates about pterosaurs in the 1800s have continued after pterosaurs had been identified?

A. Much about pterosaurs remained unknown.

B. Pterosaurs had wings made up of a short upper-arm bone and a long fourth finger.

C. The questions people had about pterosaurs seemed impossible to answer.

D. People lost interest in pterosaurs.

5. What is this article mainly about?

A. the relatives and descendants of dinosaurs and pterosaurs

B. pterosaur teeth, pterosaur wingspan, and pterosaur membranes

C. the anatomical features of dinosaurs, dinosaur extinction, and the descendantsof dinosaurs

D. what pterosaurs are, how pterosaurs were diverse, and the crests of pterosaurs

6. Read this sentence from the article.

"Still, without living descendants for comparison and the relative scarcity of fossils, definitive proof has been elusive -- **so far**."

Why might the writer have ended this sentence with the words "**so far**"?

A. to suggest that definitive proof may be discovered in the future

B. to persuade readers that definitive proof will be discovered in the next few years

C. to explain why definitive proof has not yet been discovered

D. to express surprise that definitive proof has not yet been discovered

7. Select the word that best completes the sentence.

Pterosaurs were not dinosaurs _____ they were more closely related to dinosaurs than to any other reptiles.

A. consequently

B. otherwise

C. although

D. such as

8. What were pterosaur crests made out of?

9. What is one thing that scientists still do NOT know about pterosaurs? Support your answer with information from the article.

10. Are scientists likely to learn more about pterosaurs in the future? Support your answer with evidence from the text.

THE WALL STREET JOURNAL.

Yellowstone Grizzlies to Lose Protections

By Jim Carlton
June 23, 2017

The Trump administration said it will remove endangered-species protections for the Yellowstone grizzly bear, a move that was initiated by the Obama administration after the numbers of the West's largest land predator rebounded sharply over the past four decades.

The decision, criticized by environmentalists, paves the way for grizzly-hunting to resume in some places after a 40-year ban.

Grizzly bears in and around Yellowstone National Park had plummeted to as few as 136 by 1975, when they were listed as threatened under the Endangered Species Act.

Because of a ban on hunting and other protections, the number of grizzlies in a Greater Yellowstone ecosystem that includes parts of Idaho, Montana and Wyoming has increased more than fivefold to an estimated 700, according to the Interior Department.

The federal government aimed to boost the population to 500 grizzlies. The animal can weigh up to 600 pounds.

Interior Secretary Ryan Zinke, a former Montana congressman who announced the delisting Thursday, hailed the recovery as one of the nation's greatest conservation success stories.

"As a kid who grew up in Montana, I can tell you that this is a long time coming and very good news for many communities and advocates in the Yellowstone region," Mr. Zinke said in a statement.

Environmental groups condemned the move and vowed to try to fight it in the courts.

Lawsuits filed by environmentalists succeeded in blocking efforts by the Bush administration to delist the grizzly in 2007, when their numbers already were considered recovered by the U.S. Fish and Wildlife Service.

Environmentalists say grizzlies have a slow reproduction rate and would be imperiled as a result of hunting and other dangers.

Once the rule by the Fish and Wildlife Service takes effect later this year, states will regain their authority to resume trophy hunts that have been banned for 40 years.

The grizzlies would remain protected from hunting in Yellowstone and Grand Teton national parks.

"This premature decision to remove endangered-species protections could set grizzly recovery back

by decades," said Michael Brune, executive director of the Sierra Club, in a statement. "The end result will be fewer bears restricted to an even smaller area," Mr. Brune said.

Supporters of the delisting, though, say there are so many Yellowstone grizzlies that conflicts with humans have increased, as well as attacks on livestock. "Grizzly bears have met or exceeded recovery objectives since 2003 and have long warranted delisting," Wyoming Republican Gov. Matt Mead said in a statement.

The Wyoming governor, among other Westerners, asked the Obama administration to resume the delisting process. In 2016, the Fish and Wildlife Service issued a draft notice to take the bears off the list, as states including Wyoming gave assurances they would continue to manage the grizzlies so their numbers remained healthy.

The debate over grizzlies is reminiscent of the one over the gray wolf, another iconic predator that was reintroduced to Yellowstone in 1995 under endangered-species protection.

But as the number of wolves exploded, they were delisted in both Idaho and Montana.

Name: _____ **Date:** _____

1. What did the Trump administration decide to do regarding endangered species?

A. increase endangered-species protections for the Yellowstone grizzly bear

B. allow states to hunt a variety of animals that are protected under the Endangered Species Act

C. move endangered grizzly bears out of Yellowstone National Park

D. remove endangered-species protections for the Yellowstone grizzly bear

2. Supporters of the decision to remove endangered-species protections for the Yellowstone grizzly bear argue there are so many Yellowstone grizzlies that conflicts with humans have increased, as well as attacks on livestock.

What do critics of this decision argue?

A. They argue the decision should expand to other parts of the country where grizzly bears live and search for food near human populations.

B. They argue the decision will lead to other types of animals becoming at risk of dying out.

C. They argue the decision will cause grizzly bears to stop reproducing which will lead to their populations shrinking.

D. They argue the decision is premature because grizzlies have a slow reproduction rate and could be in danger due to hunting and other threats.

3. Read the following sentences:

> Because of a ban on hunting and other protections, the number of grizzlies in a Greater Yellowstone ecosystem that includes parts of Idaho, Montana and Wyoming has increased more than fivefold to an estimated 700, according to the Interior Department.

Based on this information, what can be concluded about the effectiveness of the ban on hunting and other protections for grizzly bears?

A. They were very effective.

B. They were not very effective.

C. They were less effective than other methods used to protect grizzly bears.

D. They were more effective than other methods used to protect grizzly bears.

4. Based on the text, what may have been one reason why the grizzly bear population decreased to just 136 bears by 1975?

A. People were killing too many bears.

B. Many bears were fighting and killing each other.

C. Many bears did not have enough food to eat.

D. Many bears got an illness and died.

5. What is the main idea of this text?

A. Environmentalists argue grizzly bears have a slow reproduction rate and would be threatened by hunting and other dangers if endangered-species protections for Yellowstone grizzlies were removed.

B. Because of a ban on hunting and other protections, the number of grizzlies in a Greater Yellowstone ecosystem that includes parts of Idaho, Montana and Wyoming has increased more than fivefold to an estimated 700.

C. The number of Yellowstone grizzly bears has increased significantly, so the Trump administration has decided to remove endangered-species protections for these grizzlies, a decision that has been praised by some but criticized by environmental groups.

D. The number of conflicts between humans and grizzly bears as well as the number of grizzly bear attacks on livestock have increased as the number of grizzly bears in the Yellowstone area have increased.

6. Read the following sentences:

"The Trump administration said it will remove endangered-species protections for the Yellowstone grizzly bear, a move that was initiated by the Obama administration after the numbers of the West's largest land predator rebounded sharply over the past four decades."

What does the word "rebound" mean as it is used here in the text?

A. to bounce away after hitting something

B. to recover or increase

C. to decrease very quickly

D. to change very little over many years

7. Choose the answer that best completes the sentence below.

A ban on hunting and other protections were put in place to help grizzly bear populations recover. _____, the number of grizzlies in a Greater Yellowstone ecosystem that includes parts of Idaho, Montana and Wyoming has increased more than fivefold.

A. On the contrary

B. Especially

C. Otherwise

D. As a result

8. Why do some people support the decision to remove endangered-species protections for the Yellowstone grizzly bear? Use information from the text to support your answer.

_____

_____

_____

9. Why might the executive director of the Sierra Club have described the decision to remove endangered-species protections for Yellowstone grizzlies as "premature," or too early? Use information from the text to support your answer.

_____

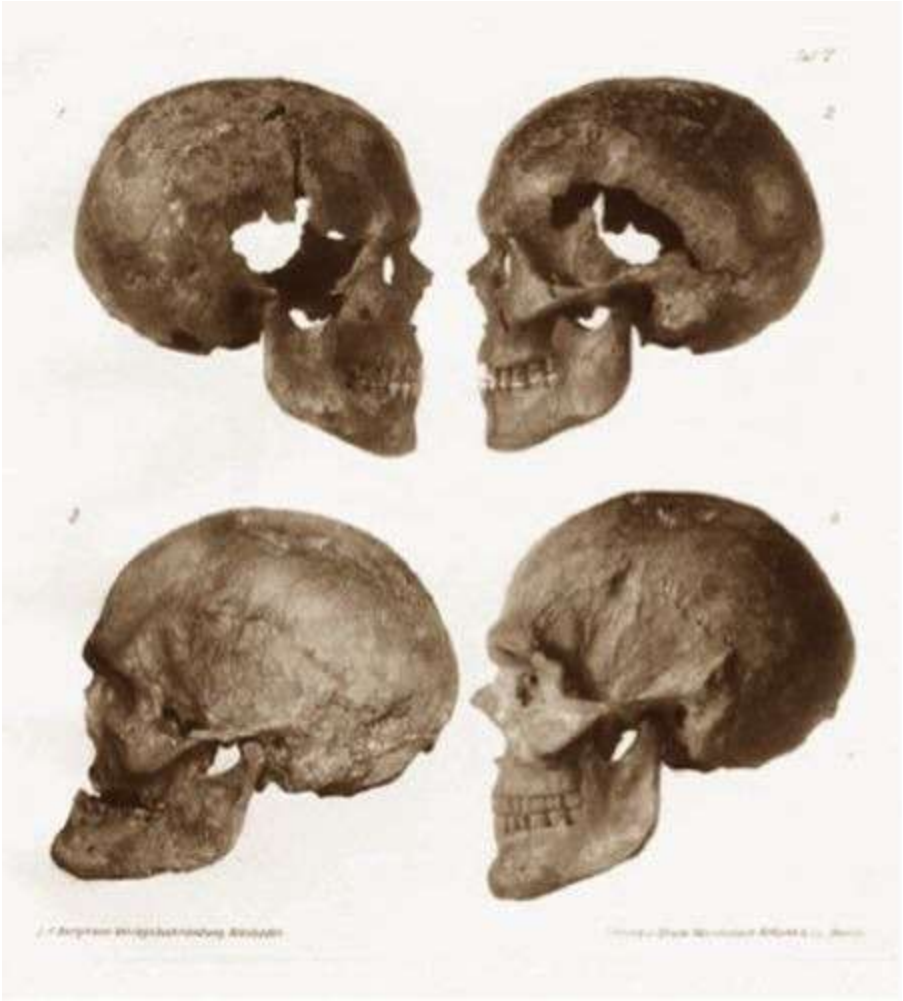
_____

_____

10. Explain whether or not endangered-species protections for the Yellowstone grizzly bear should be removed. Use evidence from the text to support your argument.

Humanity on the Record

by ReadWorks



In the summer of 2012, paleontologists working on a fossil excavation in Kenya announced that the human race, as we know it, was never alone.

Scientists unveiled pieces of skull and bone that are approximately 2 million years old. Their discovery confirmed what earlier fossil findings had introduced as a possible piece of the human origin story: that humankind is merely one of a number of human-like species, each with its own lifespan. Every other species has been long extinct, making *Homo sapiens*, our species, the sole surviving member of the extended human family. Indeed, these findings have confirmed that the family was bigger than anyone had previously imagined.

In conversations about prehistoric evolution, whether humans evolved from apes, is a common but misleading question. Evolution, at its core, is a process that spawns a diversity of species. Some are quite similar and some are quite different. Some strains of evolution take place over millions of years, while other strains (for example, microorganisms that pass through multiple generations in the span of a day) take place over a number of months, even weeks. To track the evolution of various

organisms over time is to reveal the natural world's knack for never putting all of its bones in one basket, so to speak.

Dating Prehistoric Man: Not as Awkward as It Sounds

A more revealing question, then, is scientists' inquiry into multiple branches of the *Homo* genus. Assembling a "fossil record" over the course of two centuries, scientists have amassed enough evidence to date the earliest known appearance of *Homo sapiens* to about 200,000 years ago. Their research has also proven that a number of human-like species preceded and accompanied *Homo sapiens* on the prehistoric timeline.

The creation and preservation of an accurate fossil record is no easy task. Bones dug up from the ground don't often offer much information about their own age, so paleontologists have developed several methods to analyze the earth surrounding those bones instead. By inspecting the proximity of a fossil, one can figure out approximately (sometimes precisely) when the fossil itself was actually a living organism.

Radiometric dating-the use of technology to detect radioactive elements to identify the age of whatever those elements are in-is a precise but limited technique for determining the age of a fossil. The precision of radiometric dating comes from the fact that radioactive elements have clear, well-documented decay times (or how long it takes for traces of an element to disintegrate). Using this technique, scientists can narrow down the age of a fossil, even one that's over 50 million years old, to a very close estimate. Unfortunately, radiometric dating only works when radioactive elements were present in the first place.

The alternative method of dating fossils is stratigraphy. Based in the geographic study of layers of sediment that have stacked on top of each other for ages, stratigraphy includes a host of techniques for analyzing these various layers to determine the age of objects found wedged within them.

Simply put: If people find a fossil between two layers of dirt, and they know how old those layers of dirt are, they can then say the fossil was part of a living creature between those dates.

Stratigraphy can be difficult to execute in the study of fossils, since dirt doesn't always stack up in neatly preserved layers. There are often interruptions in the layers or portions of sediment that ended up being mixed together or eroded. Furthermore, the precision of this technique is said to be relative. Every estimate based on stratigraphic analysis depends on a comparison between other samples and other estimates.

Yet, by reviewing each other's evidence and sharing their findings, researchers are able to make reasonable confirmations of the global fossil record. Radiometric dating and stratigraphic dating are used to establish prehistoric records of fossils. Those records are then used to build a logical timeline for the evolution of many species. When new fossils are dug up, a fossil record spanning the ages is there to help scientists figure out where their new discoveries fit into the stories of the earth.

To Err Is Human; to Evolve Is Much More

One of the most fascinating stories, of course, is the prehistory of the human race.

The National Museum of Natural History puts it eloquently: "While people used to think that there was a single line of human species, with one evolving after the other in an inevitable march towards

modern humans, we now know this is not the case. Fossil discoveries show that the human family tree has many more branches and deeper roots than we knew about even a couple of decades ago."

Presenting an interactive display of humanity's prehistory, the museum identifies over 15 different species related to humankind. The fossil record reaches back over 6 million years, marking the earliest known appearance of a primate species that walked upright. Two million years later, the record proves the existence of *Australopithecus Anamensis*, a bipedal species that was equally adept at walking upright and climbing trees.

Homo habilis, whose fossils date back 2 million years ago, was the earliest known species of the *Homo* genus. The age of *Homo habilis* closely follows the first known appearance of stone tools. It also coincides with the existence of at least three other human-like species, ape-like creatures that also walked upright. The stone tools discovered from these years were likely used by all of the species, following evolutionary paths that were similar but far from identical.

Even *Homo sapiens*, the species encompassing every human being on the planet right now, were accompanied by similar species. To be exact, at least four other human species have been added to the fossil record for the past million years. The simultaneous existence of *Homo erectus* and *Homo heidelbergensis*, *Homo floresiensis* and *Homo neanderthalensis* covers a period when the human races developed much larger brains and began to form the basis for modern civilization.

One by one, the other races have gone extinct. The hypothesized reasons range from an inability to adapt to climate change to murder at the hands of more advanced humans. Disease, physical disadvantages, and natural disaster have been discussed as possible causes. Some scientists argue that Neanderthals may have bred with early populations of modern humans, changing the record of their extinction to one of possible assimilation.

Thus, precise causes for the ascendency of *Homo sapiens* have yet to be proven. The fact that fossils represent less than 5% of all known living species in the history of the world makes it very difficult for even the brightest paleontologists to gather enough evidence to answer all the questions they have about the origins of man.

What the world has gained through their work, though, is less a story of primates transforming into humans than it is the story of humanity's many extinguished flames. At the moment, our human race carries the torch for millions of years of evolution-among species, across continents, and through the ages.

Name: _____ **Date:** _____

1. What are *Homo sapiens*?

A. the use of technology to detect radioactive elements

B. a fossil record that covers two centuries

C. our species, the human race

D. a species that has gone extinct

2. What sequence of events does this passage describe?

A. This passage describes the daily routine of*Homo neanderthalensis* and *Homo heidelbergensis*.

B. This passage describes the appearance and disappearance of different species related to humans.

C. This passage describes the steps that paleontologists took to find pieces of human skull and bone in Kenya.

D. This passage describes the assembly of a fossil record that dates*Homo sapiens* to about 200,000 years ago.

3. Fossils can provide information about the history of humankind.

What evidence from the passage supports this statement?

A. "Assembling a 'fossil record' over the course of two centuries, scientists have amassed enough evidence to date the earliest known appearance of *Homo sapiens* to about 200,000 years ago."

B. "At the moment, our human race carries the torch for millions of years of evolution-among species, across continents, and through the ages."

C. "Some scientists argue that Neanderthals may have bred with early populations of modern humans, changing the record of their extinction to one of possible assimilation."

D. "The simultaneous existence of*Homo erectus* and *Homo heidelbergensis*, *Homo floresiensis* and *Homo neanderthalensis* covers a period when the human races developed much larger brains and began to form the basis for modern civilization."

4. Imagine that a group of scientists has just dug up a fossil. What would probably give them the most information about the age of that fossil?

A. the fossil itself
B. the earth around the fossil
C. the air around the fossil
D. the water around the fossil

5. What is this passage mostly about?

A. the appearance and behavior of *Homo heidelbergensis*
B. the question of whether humans evolved from apes
C. the use of radiometric dating to determine the age of fossils
D. the development and fossils of prehistoric humans

6. Read the following sentence: "If people find a **fossil** between two layers of dirt, and they know how old those layers of dirt are, they can then say the fossil was part of a living creature between those dates."

What does the word **fossil** mean in the sentence above?

A. the slow development of a species over time
B. part of a living thing that has died and remained in the ground for a long time
C. a method that scientists use to determine the age of bones they find in the ground
D. an early human-like species that walked upright and probably used stone tools

7. Choose the answer that best completes the sentence below.

There are several methods for dating fossils, _____ stratigraphy and radiometric dating.

A. therefore
B. earlier
C. also
D. including

8. What did scientists discover on a 2012 fossil excavation in Kenya?

9. What did this discovery tell scientists?

10. Explain how fossils can teach scientists about the development of humans. Support your answer with an example from the passage.

Shedding Light on the Dinosaur-Bird Connection

by American Museum of Natural History
This text is provided courtesy of the American Museum of Natural History.

When people think of dinosaurs, two types generally come to mind: the huge herbivores with their small heads and long tails and those fearsome carnivores that walked on two legs and had a mouthful of teeth like kitchen knives.

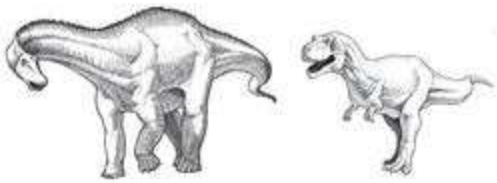


Image Credit: © AMNH

Living Dinosaurs

These large dinosaurs are no longer around, but dinosaurs still live among us today. They are the birds. It's difficult to imagine that a bird on your window sill and a *T. rex* have anything in common. One weighs less than a pound; the other was the size of a school bus, tipping the scales at eight tons. But for all their differences, the two are more closely related than you might think. Birds are living dinosaurs, and they are remarkably similar to their closest extinct relatives, the non-bird theropod dinosaurs.

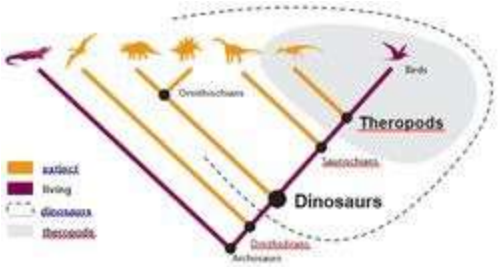


Image Credit: © AMNH

You are looking at just one branch of a cladogram, a "tree" showing the relationships among organisms. The group called dinosaurs includes the extinct dinosaurs and all their living descendants. All its members, including living birds, descended from the very first dinosaur-their common ancestor. That's why birds are a kind of dinosaur (just as humans are a kind of primate).

Finding the Evidence

When scientists study living animals, they can look at behavior, morphology, embryology, and DNA. It's a different story

altogether when it comes to long-extinct animals. Behavior cannot be observed and their DNA has long since been destroyed. So understanding extinct animals and how they are related to living ones takes a special kind of detective work. Paleontologists use the clues found in ancient rocks: fossilized bones, teeth, eggs, footprints, teeth marks, and even dung.

Photo Credit: © Pamala Wilson

To better understand the link between non-bird theropod dinosaurs and birds, scientists look for the answers to questions such as: What features do they share? What behavioral similarities are there? Scientists use the process of comparative biology to answer these questions. It's a powerful approach to understanding how birds and non-bird dinosaurs are alike and how they evolved.

Skeletal Evidence

Many similarities can be found when comparing a skeleton of a living bird to the fossilized skeleton of a non-bird theropod, like *Sinornithosaurus*. They both have a hole in the hipbone, a feature that distinguishes most dinosaurs from all other animals. This feature allows an animal to stand erect, with its legs directly beneath its body. All theropod dinosaurs, including birds, have a fused clavicle bone called a furcula, also known as a wishbone. Another shared characteristic is the presence of hollow bones. Hollow bones reduce the weight carried by an animal, resulting in the ability to run faster. This feature probably also played a role in the evolution of flight.

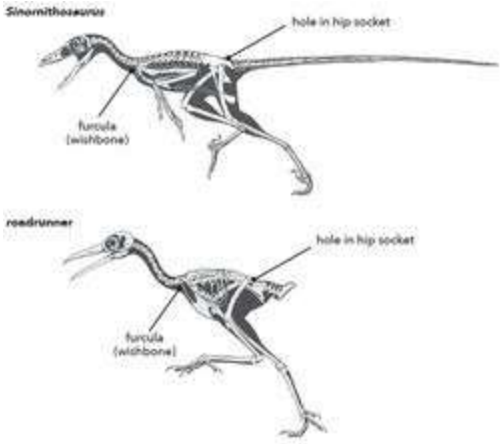


Image Credit: © AMNH / Sean Murtha

Sinornithosaurus and the roadrunner are both theropod dinosaurs.

Behavioral Evidence

When scientists look at non-bird theropod fossils they see evidence of behaviors that are common to living birds, such as nest-building, egg-laying, and brooding. These behaviors were first observed when, in 1993, an expedition to the Gobi Desert in Mongolia made an amazing discovery. Scientists unearthed a *Citipati* fossil brooding a cluster of eggs. Its limbs were folded back against its body. It is one of the few fossils ever found that demonstrates behavior-in this case, parental care. It shows that the behavior of brooding the nests that we see all around us today in living birds was already

present in the non-bird ancestors of birds.

Photo Credit: © AMNH / Mick Ellison

Citipati, like many other non-bird dinosaurs, had feathers. Yet it could not fly. Feathers were once thought to have evolved

for flight. The discovery of more and more non-flying dinosaurs with feathers dis- proved that explanation. For these dinosaurs, feathers may have served other functions, including gliding, insulation, protection, and display. Feathers play that same role in many bird species today.

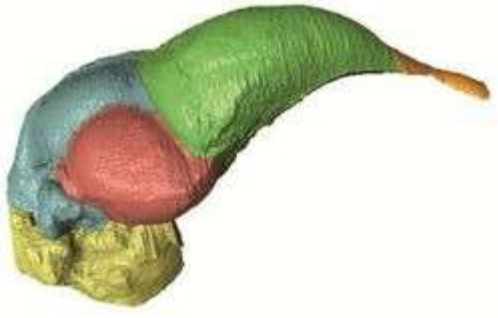
Photo Credit: © AMNH / Mick Ellison

Sinornithosaurus had feathers similar to those of modern birds-even though it could not fly.

Based on the evidence of shared characteristics, scientists have concluded that birds are a type of theropod dinosaur.

Brain Evidence

Birds are the only dinosaurs capable of flight. This is particularly interesting to scientists who want to know when the capability of flight emerged. One promising new area of research is focused on the brains of bird and non-bird dinosaurs. Soft tissue, such as brains, is almost never preserved in the fossil record. What is preserved is the imprint the brain left on the inside of the skull. Now scientists are using computed tomography (CT) scanners to create digital endocranial casts-detailed, three-



dimensional reconstructions of the interiors of fossilized skulls. In a recent study researchers were able to peer inside the braincases of more than two dozen specimens,

including birds and closely related non-bird dinosaurs. "Technology allows us to look inside these specimens without destroying them," says Dr. Amy Balanoff, a Museum research associate. "It's a non-destructive way to basically slice up a dinosaur brain and look inside and see what it can tell us about the evolution of the brain within dinosaurs. Most of us grew up thinking that dinosaurs had tiny brains, but actually some had really big brains."

Image Credit: © AMNH / Amy Balanoff

Scientists use computed tomography (CT) scans of dinosaur skulls to create detailed, 3-D reconstructions of their interiors, like this one of Archaeopteryx.

The endocranial casts allow Balanoff and other researchers to explore the outer shape of the brain in more detail. In addition, the casts also provide new information about the total volume of each digital brain cast, as well as the volume and shape of different brain regions, including the olfactory bulbs, cerebrum, optic lobes, cerebellum, and brainstem. For example, the casts have provided scientists with a detailed view of the dinosaur cerebrum, a center for cognition and coordination in the brain. They found that this region was very large in non-bird dinosaurs closely related to birds. Dr. Balanoff's research suggests that these dinosaurs developed big brains long before flight, laying the cerebral foundation that made the eventual development of powered flight possible. Just as bigger brains in primates prepared the way for them to walk on two legs, bigger brains in dinosaurs prepared the way for flight.

One of the brains sampled by Dr. Balanoff was that of *Archaeopteryx* a non-bird dinosaur that was thought to mark the transition from non-bird dinosaur to bird. "If *Archaeopteryx* had a flight-ready brain, which is almost certainly the case given its morphology, then so did at least some other non-bird dinosaurs," says Dr. Balanoff. She points out though, that there is no longer a clear boundary showing where the non-bird dinosaurs end and where birds begin. "That's how evolution works. It can be a slow and messy process, and eventually we end up with the amazing diversity of things flying around us today."

Name: _____ **Date:** _____

1. What is a dinosaur that still lives among us today?

A. a*Sinornithosaurus*

B. an*Archaeopteryx*

C. a bird

D. a reptile

2. What does the author compare to living birds in this text?

A. non-bird theropods

B. living reptiles

C. huge herbivores with small heads

D. extinct birds

3. Read this sentence from the text.

"Based on the evidence of shared characteristics, scientists have concluded that birds are a type of theropod dinosaur."

What is a piece of skeletal evidence that supports the conclusion that birds are a type of theropod dinosaur?

A. Birds brood their nests, just as non-bird theropod dinosaurs did.

B. Feathers may have been used by non-bird dinosaurs in some of the ways that birds use their feathers today.

C. The cerebrum in non-bird dinosaurs closely related to birds was very large.

D. Birds and non-bird theropod dinosaurs have a hole in their hipbone.

4. Read this sentence from the text.

"Based on the evidence of shared characteristics, scientists have concluded that birds are a type of theropod dinosaur."

What is a piece of behavioral evidence that supports the conclusion that birds are a type of theropod dinosaur?

A. Birds brood their nests, just as non-bird theropod dinosaurs did.

B. The cerebrum in non-bird dinosaurs closely related to birds was very large.

C. Birds and non-bird theropod dinosaurs have a hole in their hipbone.

D. Birds and non-bird theropod dinosaurs have hollow bones.

5. What is the main idea of this text?

A. The behavior of animals that have been extinct for a long time cannot be observed, and their DNA has been destroyed.

B. Feathers were once thought to have evolved for flight, but now scientists think feathers may have originally served other purposes.

C. Skeletal and behavioral evidence show that birds are dinosaurs, and brain evidence supports this conclusion.

D. Scientists are using technology to reconstruct the inside of fossilized skulls and learn more about dinosaur brains.

6. Read these sentences from the text.

"One of the brains sampled by Dr. Balanoff was that of *Archaeopteryx*, a non-bird dinosaur that was thought to mark the transition from non-bird dinosaur to bird. 'If *Archaeopteryx* had a flight-ready brain, which is almost certainly the case given its morphology, then so did at least some other non-bird dinosaurs,' says Dr. Balanoff. She points out though, that there is no longer a clear boundary showing where the non-bird dinosaurs end and where birds begin. 'That's how evolution works. It can be a slow and messy process, and eventually we end up with the amazing diversity of things flying around us today.'"

What does the word "evolution" mean here?

A. a sudden and unexpected increase in size or amount

B. a sudden and unexpected decrease in size or amount

C. change that takes a day or two to happen

D. change that happens over many generations

7. Choose the answer that best completes the sentence.

Bigger brains in primates prepared the way for them to walk on two legs. _____, bigger brains in dinosaurs prepared the way for flight.

A. Otherwise

B. Similarly

C. For instance

D. In particular

8. What did Dr. Balanoff and other researchers discover about the size of the dinosaur cerebrum in non-bird dinosaurs closely related to birds?

9. What might big brains in certain dinosaurs have made possible, according to Dr. Balanoff's research?

10. Explain whether Dr. Balanoff's research supports the conclusion that birds are a type of dinosaur. Support your answer with information from the text.

THE WALL STREET JOURNAL.

Trash Talk: Price of Recyclables Sinks After China Bans U.S. Scrap

U.S. companies that use recycled materials are taking advantage of the price drop

By Erica E. Phillips
October 20, 2017

Some U.S. manufacturers are turning trash into treasure after a Chinese ban on imported waste flooded American scrapyards with paper and plastic.

The import ban, announced in July, sent global prices for waste paper and plastic into a tailspin. Without access to their Chinese customers, U.S. waste and recycling firms are scrambling to find new buyers for the scrap they collect from curbside bins. But companies that use recycled materials to make things like cardboard, plastic bins, yarn and other goods are taking advantage.

"America has an endless supply of waste and it just got more endless," said Anthony Pratt, executive chairman of Pratt Industries, which uses 100% recycled material in its U.S. facilities to make boxes for Amazon.com Inc. as well as firms ranging from major manufacturers to pizza joints.

Plunging scrap prices are also driving new demand for recycled materials, which usually have to compete with growing supplies of new plastic resin made cheaply from shale oil by U.S. plants.

On Wednesday, Target Corp., Procter & Gamble Co., Keurig Green Mountain Inc., Campbell Soup Co., Coca-Cola Co's North America business and others agreed to require suppliers of industrial plastic items like crates and trash bins to use more "post-consumer" material.

Not all of those companies signed on because of China's ban, but falling scrap prices have made the requirement an easier pitch, said Dylan de Thomas with The Recycling Partnership, which organized the pledge.

"It's the definite silver lining of this scrap ban," he said.

For environmentally conscious firms like Unifi Inc., which manufactures yarn and packaging from recycled plastic bottles, China's new rules help keep down production costs.

"By having more supply, we expect the upward price pressure [on recycled material] will be mitigated," said Eddie Ingle, Unifi's vice president of supply chain.

Over two-thirds of America's wastepaper exports and more than 40% of its discarded-plastic exports ended up in China last year. Paper and plastic scrap exports to mainland China topped $2.2 billion.

China told the World Trade Organization that it wants to limit the entry of "foreign waste." Under new rules, China by year-end would ban imports of used plastics and restrict some paper-scrap imports.

U.S. buyers can't replace lost Chinese demand, said Bill Moore of Moore & Associates, a paper-industry consulting firm. It could take a while to build the domestic capacity needed to process our abundant scrap into new products, he said.

If China stands by its proposed restrictions, U.S. recycling businesses will need to invest in machinery to more stringently sort the waste they collect, said Bob Cappadona of Casella Recycling LLC, a waste-services company based in the Northeast. And it also means households will have to do a better job of sorting items headed for recycling, he added.

Waste collectors say they are seeking out new scrap customers in other parts of Asia and Latin America. Still, they say China's purchasing power is needed in the global market. If recyclers can't find new markets, or places to store the scrap they collect, some waste could end up in a landfill, Mr. Moore said.

"That's the ultimate disaster-you don't want to lose people's enthusiasm for doing recycling," he said.

Name: _____ **Date:** _____

1. American scrapyards are being filled with more paper and plastic. Who is now taking advantage of these extra recycled materials?

A. Chinese customers that have use for recycled materials and waste

B. companies that use recycled materials to make different kinds of goods

C. companies that create a lot of plastic and paper waste

D. the owners of American scrapyards and collectors of plastic and paper waste

2. What caused the amount of paper and plastic in American scrapyards to grow so quickly?

A. a U.S. regulation that rewards waste production

B. an influx in companies that recycle materials

C. a Chinese ban on importing waste

D. a change in the way households recycle

3. The lower prices for scrap could be a good thing for those who care about the environment. What evidence from the text supports this statement?

A. U.S. waste and recycling firms are working quickly to find new buyers for the extra scrap.

B. Lower scrap prices have made it easier for companies to use recycled material instead of new plastic.

C. More than two-thirds of America's wastepaper exports ended up in China last year, prior to the ban.

D. It could take a while for U.S. companies to build their ability to process all the extra scrap into new products.

4. Based on the article, what is a potential negative effect of a long-lasting Chinese ban on imported waste?

A. If recyclers can't find new buyers for all the extra scrap, they will have to invent new products that use recyclable materials.

B. If recyclers can't find new markets for all the extra scrap, the U.S. is likely to dispose of the scrap in the world's oceans.

C. If recyclers can't find different buyers for all the extra scrap, companies in the U.S. may have to shoulder the costs.

D. If recyclers can't find new markets or storage places for all the extra scrap, some recyclable waste could end up in a landfill.

5. What is the main idea of this article?

A. Because of a Chinese ban on imported waste, the price of scrap is falling in the U.S., helping companies that use recycled materials to make new products.

B. Because of a U.S. ban on exported waste, the price of scrap is falling in the U.S., helping companies that use recycled materials to make new products.

C. Because of new U.S. regulations, the price of scrap is falling in the U.S., which could have negative consequences for the environment.

D. Because of new global regulations, the price of scrap is rising in the U.S., which could have negative consequences for U.S. businesses.

Changes in Biodiversity

by ReadWorks

Hundreds of years ago, before North America was split up according to states and countries, native populations lived in the many varied areas of the continent. There were jungles, forests, riverlands, dry prairies, wetlands, and many other types of geographies where people lived. There were no cities as we know them today: humans lived in tune with nature, relying on their surroundings to build shelters, hunt and gather food, and create forms of exchange (for example, shells found on beaches could be traded for animal skins).

Each Native American tribe was attuned to the specific land on which they lived, and had certain customs that utilized their land to the utmost. Native Americans living in what is now known as the Midwest relied on hunting large animals like bison for their meat and their skins. Their meat provided an important source of nourishment for many tribes, and their skins were a valuable material that was used in the production of clothes and teepees, a type of shelter. Other tribes who lived on the eastern coast of North America made extensive use of the forests there, trapping small animals and game (like deer) that lived among the trees, and farming hearty foods that could handle the changes in weather, like corn. Still other tribes, who lived in the deserts of what is now Arizona, built homes in the rocky cliffs and hills for protection.

The variety of plant and animal life in these specific environments is called biodiversity. The tribes who lived in what is now known as Seattle fished salmon, while the tribes who lived in what is now known as Maine caught crabs and lobsters. As you can see, even though each group relied on seafood, the type of fish they ate was dependent on the type of fish that was available to them. At the

time we are thinking about, if you lived in Seattle, there were no restaurants you could go to and order lobster!

Now think for a moment about what this means. Let's say one year, a pod of whales was unable to go to their usual feeding area in Alaska because a school of sharks was inhabiting those waters during the whales' feeding time. So, looking for other sources of food, the whales swam down towards Seattle and noticed a large population of salmon. They ate all the salmon and, full and content, swam away to their next destination. The next week, the human tribes living in Seattle go to where the salmon usually are in order to get the first big catch of the season, and they find that no salmon are there. Instead of catching salmon, a staple of their diet, the humans must find another food source: their habitat has changed, and now the humans, like the whales before them, must adapt to their new situation.

This brings us to the very important idea of the ecosystem. An ecosystem is a very complex and delicate arrangement of plants and animals that provide nourishment for each other in a variety of ways. If one part of the ecosystem changes or is disrupted, it can affect the entire workings of an environment.

Humans have made changes to their ecosystems to serve a specific need. And in certain cases, the goal is to disrupt the population of another species within the ecosystem. However, there can be unintended consequences. One example is the use of pesticides. When American farmers began using pesticides (chemical insect-repellants) to get rid of bugs that decimated entire harvests of crops, they had no idea what the consequences would be-or whether there would be any consequences. As scientists began to study how people used certain types of chemicals for certain types of crops, they learned that there are some pesticides that are not just harmful for insects-they are harmful for humans too, and were making many people sick after they had eaten the crops that had been sprayed with those pesticides. With this knowledge, scientists were able to develop other pesticides that were less harmful for humans but were still useful in getting rid of the bugs that liked to eat humans' important crops. As you can see, the changes that humans made in the ecosystem-the biodiversity that the humans cut down on by making sure the insects left the plants alone-needed to be studied carefully so that the changes made were sure to be beneficial.

Name: _____ **Date:** _____

1. What does biodiversity refer to?

A. chemical replants that are used to get rid of bugs

B. the scientific study of an ecosystem

C. the variety of plant and animal life in an environment

D. the large population of salmon that live near Seattle

2. What does the author explain in the passage?

A. the author explains the terms "biodiversity" and "ecosystem," giving examples of each

B. the author explains the terms "tribe" and "Native American" without giving any examples

C. the author explains the terms "pod," "school," and "wetlands," giving two examples of each

D. the author explains the terms "nourishment" and "chemical" without giving any examples

3. Changing one part of an ecosystem can affect other parts of the environment where the change is made.

What evidence from the passage supports this statement?

A. Native Americans who lived in what is now known as the Midwest hunted large animals like bison.

B. Tribes who lived in the deserts of what is now Arizona built homes in the rocky cliffs and hills.

C. When American farmers began using pesticide to harm bugs, they harmed humans as well.

D. Tribes on the West Coast of North America fished salmon, while tribes on the East Coast caught crabs and lobsters.

4. Based on the information in the passage, what can the reader conclude about biodiversity?

A. There was very little biodiversity in North America before it was split up into states and countries.

B. There was a lot of biodiversity in North America before it was split up into states and countries.

C. Biodiversity cannot be affected by human activity.

D. Biodiversity cannot be affected by changes to the ecosystem.

5. What is this passage mainly about?

A. different Native American tribes and the ways in which they obtained food

B. natural environments and the way changes can affect those environments

C. pesticides used by farmers and the harmful effects of those pesticides on humans

D. a pod of whales that cannot go to its usual feeding area in Alaska because of sharks

6. Read the following sentences: "An ecosystem is a very complex and delicate arrangement of plants and animals that provide nourishment for each other in a variety of ways. If one part of the ecosystem changes or is disrupted, it can affect the entire workings of an **environment**."

What does the word **environment** mean?

A. a species of plant or animal

B. a group of Native Americans living in the same place

C. the damage that humans can do to their surroundings

D. an area where things live

7. Choose the answer that best completes the sentence below.

Native Americans living in what is now known as the Midwest hunted large animals; _____, Native Americans living on the eastern coast caught small animals.

A. on the other hand

B. as a result

C. as an illustration

D. most importantly

8. What happened when American farmers started using pesticides to get rid of bugs?

9. According to the passage, how could a pod of whales being unable to go to their usual feeding area affect humans? Be sure to describe the full chain of events in your answer.

10. Suppose that people living by a lake decided to put a chemical in the water to get rid of a certain type of fish in the lake. Would that action be likely to affect other living things in that environment? Use evidence from the passage to explain why or why not.

THE WALL STREET JOURNAL.

Mudslides in California Kill 15; Thousands Evacuated

Up to 4 inches of rain drench region that was hit by recent massive wildfires, sweeping away homes and killing at least 15

By Jim Carlton and Nour Malas
January 10, 2018

LOS ANGELES -- First came the wildfires, which prompted mass evacuations across Southern California last month. Then came the rains, and the mud. Thousands more evacuated again, and 15 people were killed in mudslides Tuesday.

Mud loosened by torrential rain caused havoc around the nation's second most populous region, washing away homes and cars and shutting down freeways.

Hardest hit was the area in and around Montecito, in Santa Barbara County, where all of the fatalities were reported -- along with about two dozen injuries after mud roared down from a mountain denuded of vegetation in the recent wildfire, sweeping away several dozen homes and other structures, emergency officials said. Some neighborhoods were under mandatory or voluntary evacuation orders, but it is unclear if those who died were in those areas.

The one-two punch of fire and mudslides is a common occurrence in California, where hills stripped of grass and other vegetation by flames in the fall are less able to soak up the winter rains that follow. Rains were expected to taper off by late Tuesday night, forecasters said.

In the kind of steep terrain that surrounds Los Angeles, mud and debris can begin flowing within just 15 minutes of a downpour -- rushing down the mountain as fast as 50 miles an hour, said Dennis Staley, a landslide specialist with the U.S. Geological Survey in Golden, Colo. The threat of mudslides to populated areas has grown markedly, he said, because so many more people have moved into fire-prone zones in California and other mountain states.

Mike Eliason, spokesman for the Santa Barbara County Fire Department, said the death and injury count could rise after emergency crews finish sifting through homes buried under mud and debris. Emergency crews have performed dozens of rescues of people trapped in homes and trees.

"It's a mess. The mud was so high everywhere," said Franco Rizzo, a Santa Barbara resident who drove two hours Tuesday morning -- a trip that usually takes fifteen minutes -- to pick up his friend in Montecito who had called for help.

Navigating back roads to carve the quickest path to his friend, Mr. Rizzo passed the closed 101 freeway, a muddied river empty of cars but carrying trees, fencing pried loose from yards and highway underpasses.

Name: _____ **Date:** _____

1. What natural events caused the deaths of 15 people in California?

A. wildfires
B. mudslides
C. heavy rains
D. earthquakes

2. What was one major cause of the mudslides in California?

A. earthquakes which loosened mud
B. strong winds which shifted blocks of mud
C. torrential rains which loosened mud
D. long droughts which increased the amount of dust

3. Read this sentence from the text:

"The one-two punch of fire and mudslides is a common occurrence in California, where hills stripped of grass and other vegetation by flames in the fall are less able to soak up the winter rains that follow."

Based on this evidence, what conclusion can be made?

A. Wildfires can be part of the cause of a mudslide.
B. Mudslides can be part of the cause of a wildfire.
C. Mudslides and wildfires only happen in California.
D. Without wildfires, mudslides would never happen.

4. Based on the text, what kind of terrain is most likely to have a damaging and dangerous mudslide?

A. lightly sloped terrain with many rocks and boulders
B. grassy terrain with diverse plants and trees
C. flat terrain with tall grasses and deep soil
D. hilly or mountainous terrain without much grass or vegetation

5. What is the main idea of this text?

A. Recent wildfires in California burned away all the grass and vegetation in mountainous areas.

B. Wildfires and mudslides are both common occurrences in California, and can cause much damage.

C. Mudslides, a result of wildfires that were followed by heavy rains, caused deaths and damage in California.

D. Mudslides can cause a huge mess in areas that are affected.