TEACHER'S RESOURCE GUIDE

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Curriculum Resources: The Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum, K-12. Council of Ministers of Education.

Illustrations:

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ROYAL TYRRELL MUSEUM

Situated amidst Canada's dinosaur country, the Royal Tyrrell Museum of Palaeontology displays and interprets palaeontological history, with emphasis on Alberta's Late Cretaceous fossil heritage.

To assist teachers, the museum provides Chevron Discovery Suitcases for use in the classroom. Suitcases include fossils, hands-on materials and resource guides. The museum also provides teacher workshops on geology and palaeontology.

For more information, call the Royal Tyrrell Museum: (Alberta) 310-0000, 823-7707; (North America) 1-888-440-4240. Additional fees may apply to ship suitcases outside of Canada.

Introduction

T-REX: Back to the Cretaceous focuses on dinosaur digs in North America and the discoveries of the renowned paleontologist, Barnum Brown and his colleagues. However, paleontologists have made and continue to make discoveries all over the world.

The material in this guide is designed to help teachers and students enjoy and learn from the study of dinosaurs and paleontology. It offers information and activities that develop an understanding of these fascinating creatures and of how the discoveries of their remains bring a greater knowledge of what the world was like many millions of years ago.

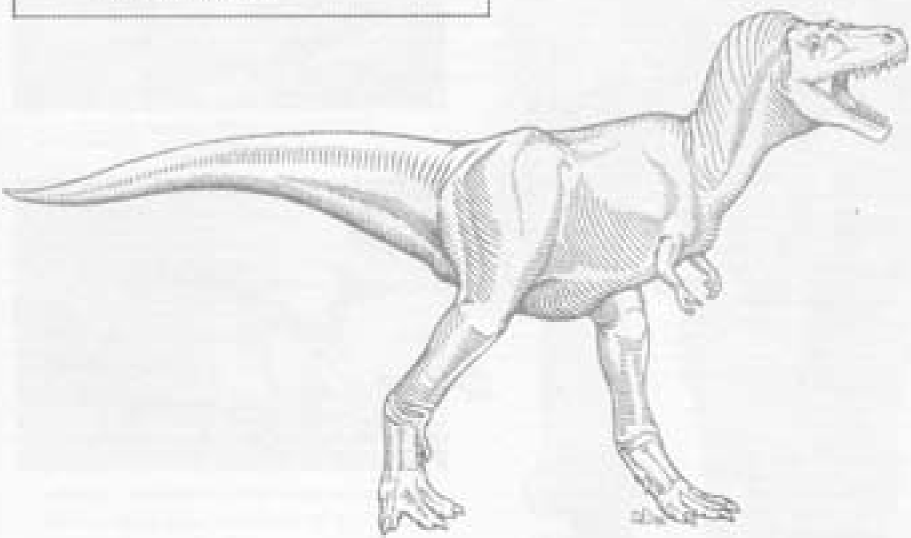
Each of the topic areas presented in this guide are linked directly with concepts that form part of life and earth sciences curricula. Key information on each topic is provided for the teacher to set a context for the activities that students can engage in. The topics and activities are non-sequential and not dependent one on the other, allowing teachers and students flexibility in what they choose to do and how they use the activities as part of their study. The activities are written in a form and language style that is accessible directly by students. For each activity, icons indicate the suggested level and groupings that could be used during implementation.

KEY TO ACTIVITIES

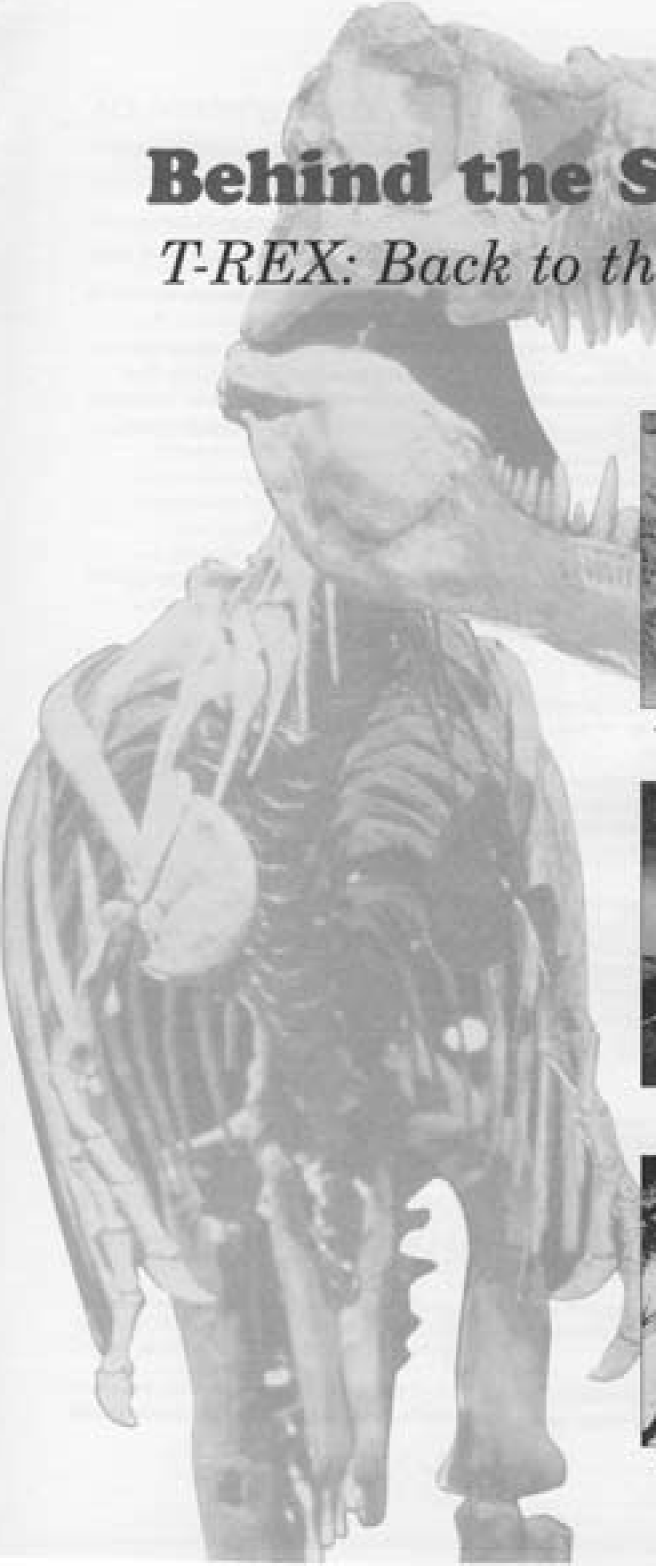
- the activity can easily be completed by less capable students and those with limited knowledge and skills
- the activity is suitable for most students and can be modified for both less and more capable students
- the activity is somewhat challenging and may be of interest to more capable or interested students

GROUPINGS

- — individual
- — pairs
- — small groups
- — whole class/large group



Behind the Scenes on
T-REX: Back to the Cretaceous



Director Brett Leonard (right) and crew film on location in Alberta.

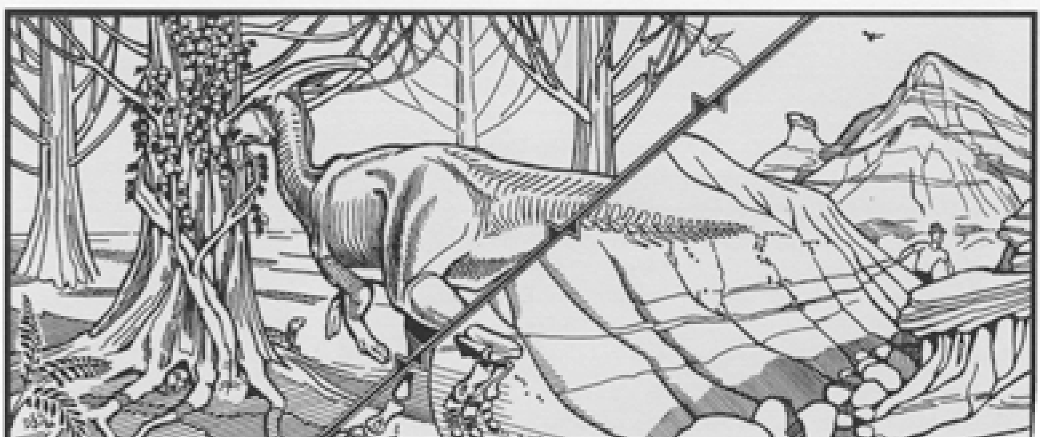
Ally meets up with an inquisitive ostrich-like Ornithomimus.

A computer-generated prehistoric Pteradon, *revealing its enormous wing span, swoops down over the audience.*

Contents

That was then:
This is now

In a scene from T-REX: Back to the Cretaceous, *Ally Hayden (Liz Stauber) travels back in time to visit pioneer dinosaur bone hunter, Barnum Brown (Laurie Murdoch) as he rafts along the Red Deer River.*



The landscape during the time of T.rex was very different from what exists in this area today.

The Environment

If you could travel back to the time of *Tyrannosaurus rex*, you would encounter landscapes and climate very different from what exists in Alberta's Dinosaur Provincial Park today.

Instead of barren hills and valleys, there was a warm, tropical sea. This sea bisected Late Cretaceous North America from Mexico to the Arctic, advancing and retreating across what are now the Great Plains. Dinosaur Provincial Park was under water when *Tyrannosaurus rex* lived. Further north and west was a flat, green landscape.

Rivers meandered to the sea across the plain, depositing sediments picked up in the mountains to the west. Swamps flourished in the wet areas and forests grew where the land rose gently.

Temperatures were warm throughout the year. There were two seasons — rainy and dry. Hurricanes periodically blew across the lowlands from the sea during the rainy season. The storms caused water levels to rise and flood the plain — hundreds of kilometers from the sea.

The plains were inhabited by many creatures: dinosaurs and other reptiles, mammals, amphibians, fish and birds.

Activities

Mesozoic Masterpiece

Working in groups, create a collage to show the environments in which dinosaurs lived. Use the descriptions and illustrations in reference books to make drawings for the collage.

In class discussion, compare these environments with those in which you live and the effects that the various forms of life have on your environment.

Think about:

- How does where you live differ from the environments in which the dinosaurs lived? How is it the same?
- How were the dinosaurs dependent on their environments?
- How did the dinosaurs affect the environments in which they lived?
- What do people depend on in their environments?
- How do people affect their environments?
- Are there any similarities?

Penpals Around the World

Write to someone in another region of the world and describe what it is like to live where you do. Tell what you think it would have been like to live in the time of the dinosaurs. Describe the land, the climate, the animals and plants, and what you did.

Ask them about their environment and how it is like and unlike yours. Invite them to tell what they think their land might have been like during the time of the dinosaurs.

Share and compare the responses you received to your letters with classmates.

Traveling the
Geologic Timeline

A scene from T-REX: Back to the Cretaceous *depicts a landscape from a prehistoric era. Life has existed on Earth for more than 3.5 billion years. In that time, our planet has seen the origin and extinction of countless species.*

Geological time is divided into units such as eras, periods and epochs. Scientists use significant biological and geological changes in the history of life on Earth to mark important periods of time. These events include mass extinctions, when large numbers of species disappeared within relatively short periods of time.

ERAS	PERIODS	YEARS AGO	EARLIEST RECORD OF ANIMALS
Cenozoic	Quaternary	1.8 mya* to present	Age of Humans
	Tertiary	64-1.8 mya	Age of Mammals
Mesozoic	Cretaceous	140-64 mya	
	Jurassic	195-140 mya	
	Triassic	230-195 mya	Age of Dinosaurs
Palaeozoic	Permian	280-230 mya	
	Carboniferous	345-280 mya	Age of Insects - first reptiles
	Devonian	395-280 mya	Age of Fishes - first amphibians
	Silurian	435-395 mya	First vascular land plants
	Ordovician	500-435 mya	First life on land
	Cambrian	570-435 mya	First hard body parts
Precambrian	Precambrian		Beginning of Life

* millions of years ago

QUICK FACTS

The first mammals appeared 200,000,000 years ago. However, it wasn't until 1,800,000 years ago that they evolved to look like the animals we know today.

Activities

From Dinosaurs to Today's Animals

On a timeline, depict the dinosaurs in the time periods in which they lived and show the evolution of today's animals. Include a brief description of other life forms.

Explain why and how the environment changed during each time period and the effect this had on the animals living then. Include ways in which the animals affected the environment.

On one of the walls in your classroom show a geological timeline starting with the Mesozoic Era. In this time period, draw the dinosaurs and the environments in which they lived. In each of the other time periods, draw the animals and plant life that formed. As a group, talk about your ideas of how and why life forms changed.

History of the World Calendar

Working with a partner, research what life was like in one of the geological time periods. Make a calendar page to share your information. You might include facts about the land, the plant and animal life and other significant events that occurred during that era such as meteorites or the appearance of the first vertebrates. Combine your calendar page with those of other pairs to create a classroom calendar.

Dinosaur

Ecosystems and Extinction

Ecosystems

Dinosaurs may look strange and otherworldly to us, but they were suited to the environment and time in which they lived. The same ecological processes dictating how animals live together in communities today dictated how dinosaurs interacted with each other and with other organisms millions of years ago.

The food chain is one of the ecological processes that transcend time and ecosystem. In the time of the dinosaurs, as now, green plants converted sunlight energy into food. Sixty-seven million years ago, herds of *Triceratops* ate the leaves of some of those plants; today herbivores such as deer, moose and elk eat plants.

T.rex was the big carnivore of its Cretaceous ecosystem; today's North American wild lands are dominated by bears, wolves and panthers. Lizards, frogs, birds and small mammals still eat insects, plants or small animals. Turtles and crocodiles have eaten fish and other water creatures for hundreds of millions of years.

Scientists suspect that during the Late Cretaceous, just like today in the Quaternary, every possible niche in every possible ecosystem was filled by some kind of creature. Such specialization allows for great diversity in species. It also makes species vulnerable. Changes in the environment may take place too quickly for a species to adapt, or a species may evolve into a new species, causing extinction.

Extinction

Extinction is another ecological process that occurred during the time of the dinosaurs and still occurs today. Causes of extinction include:

- competition by other or new species
- a better adapted predator
- depletion of resources within an environment
- introduction of disease
- changes in climate
- changes in geography

Extinction Theories

The Cretaceous-Tertiary Boundary is the layer of rock that marks the extinction of dinosaurs. Dinosaur fossils are found below the boundary; none are found above. Scientists are unsure what caused dinosaurs to disappear. There are currently two scientifically accepted theories explaining the extinction of dinosaurs.

Gradual ecological change: The fossil record indicates a gradual decrease in dinosaur diversity as the end of the Cretaceous Period approached. Some estimates put the rate of extinction at one species per day. This long period of extinctions could have been caused by climate change from a large number of erupting volcanoes, changed geography because of the lowering sea levels or competition with newly evolved species that

QUICK FACTS

All creatures need water, food and shelter. They also have enemies that they must protect themselves against. Amphibians are dependent on water. They must lay their eggs in water, so they can never travel too far from it. Reptiles don't require water for their eggs and so can live further from water sources.

more efficiently used resources in their ecosystems.

Asteroid Catastrophe: Iridium is a chemical element rare on earth but common in meteorites. Iridium is found in the layer of rock at the Cretaceous-Tertiary Boundary — evidence of meteoric impact at the end of the Cretaceous Period. Further evidence is an enormous 65-million-year-old crater in Mexico. The meteor that created this crater would have thrown clouds of dust into the atmosphere, turned the seas to acid and burnt forests across the American continents. Dust and smoke would have blocked out the sun for months, causing abrupt drops in global temperatures. Such a catastrophe and its aftermath were sure to kill millions of animals.

Activities

Survival Game

Play this game in a large area such as the gym or school courtyard. Tape cards of two colors to represent shelter and food to the wall. Place the cards high, low, close together and far apart. The wall represents water. The players are amphibians who need the water to survive. They must touch the wall at all times with some part of their bodies or they are out of the game. The players try to collect as many cards of each color as they can, from the wall and from other amphibians. To obtain cards from other amphibians, a player must tag them on the elbow and then select one card from their collection. A player cannot tag the same amphibian twice in a row. After 5 minutes, players count how many of each card they have.

The players talk together about what they learned:

- How were you able to get the number of cards you did?
- What difficulties did you have?
- How can you relate this to what amphibians need to survive?

Repeat the game with some of the players being "reptiles." Locate some of the food and shelter cards in places other than on the wall. Reptile players do not always have to be in contact with the wall to survive. They can leave to find food and shelter anywhere. After 5 minutes, players count how many of each card they have and talk about what happened:

- Did the reptiles get more cards?
- How did the reptiles' ability to move around help in getting cards?

With a partner, make another game to show how animals depend on food, shelter, and water to survive. You may wish to make a card game, a board game, or one similar to the Survival Game.

Dino Disappearance Debate

As a team, select one theory about what caused dinosaurs to disappear. Look for information to support this theory using reference books and the Internet. Present your argument to the question, "What caused the extinction of dinosaurs at the end of the Mesozoic Period?" as part of a class debate.

This landscape has been transformed by water and time.
Below: Map of present day North America and Greenland is superimposed over the same area as it would have appeared during the Cretaceous Period.

Badlands

Sedimentation and Erosion

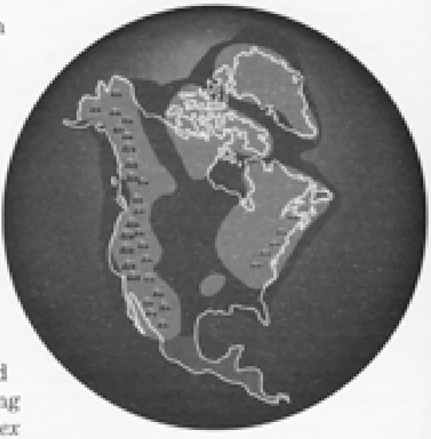
Badlands

Hidden in the badlands landscape are stories of ancient environments. These badlands tell tales of ancient rivers and ponds, of estuaries, deltas and flood plains, of forests and swamps. Thick grey sandstones, reddish siltstones, layers of coal and fragments of volcanic rock provide clues to the past.

In 1978, Dinosaur Provincial Park, where scenes from *T-REX: Back to the Cretaceous* were filmed, was designated a UNESCO World Heritage Site for its badlands, its rare plants and animals, and for the fossils of nearly 300 species of plants and animals found there. Among those fossils are more than 35 species of dinosaurs.

The rocks of Dinosaur Provincial Park are too old to contain fossils of *Tyrannosaurus rex*. However, they do contain fossils of other, older tyrannosaurs, such as *Albertosaurus*.

Sedimentation



Scientists have determined the layers of rock containing fossils of *Tyrannosaurus rex* are made of sand and silt washed down from mountains in the northwest in the Late Cretaceous Period. Some of the sediments were carried more than 900 kilometers by rivers flowing across coastal plains towards the sea that covered central North America.

Storms, floods and tides increased sediment buildup. Debris and dead animals were washed into rivers and carried towards the sea. They caught

QUICK FACTS

Rocks that are found in the badlands, such as sandstone, shale, mud stone, coal, ironstone, and gravel conglomerates are called sedimentary rocks.

on banks, sandbars and tree roots. Some of them were quickly covered by sediment… the process called fossilization began.

Over millions of years, the accumulated sediments turned into rock layers. The surface of the Earth changed. Sea levels dropped, draining the North American interior. Great ice sheets, kilometers thick, advanced and retreated, scouring away the surface of the continent and carrying rock and debris hundreds of kilometers.

Erosion

Rivers and streams cut channels through the glacial debris to the sedimentary rocks lying beneath. Then they cut through those ancient layers of rock.

The sediment carried by rivers from the western highlands that buried carcasses of *Tyrannosaurus rex* and other ancient animals is now being eroded and carried to new lowlands.

The same geological processes that had buried the dinosaurs so long ago now bring them to light.

Activities

Rock Studies

Look carefully at samples of sedimentary rocks and note how they are different. Draw and label sketches of these rocks and write a brief description of how the rocks are formed.
If you have a rock collection, you might bring it to share with the class. Compare the rocks in your collection with sedimentary rocks:

- How were the rocks in your collection formed?
- Where are these rocks found?
- Are any of them sedimentary rocks?
- How are they the same as sedimentary rocks?
- How are they different?

TEACHER'S NOTE

School science labs and libraries are sources for borrowing rock collections.

Sand to Stone

Do this experiment to demonstrate how fossilization occurs.

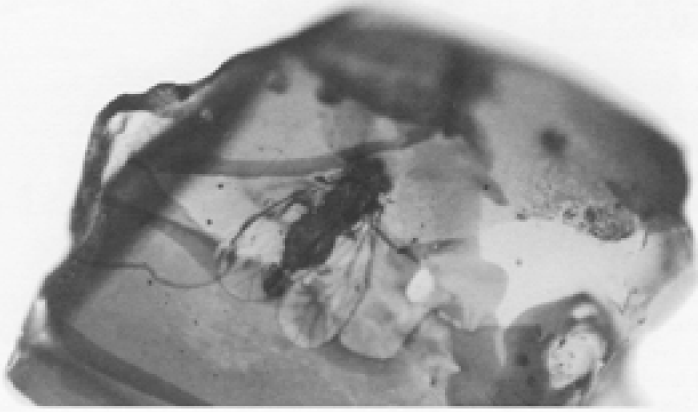
Each pair will need: a shoe box or a milk carton, a plastic spoon, plastic wrap, plaster of Paris, sand, gravel, or fine soil.

Line the inside of the box with plastic wrap. Fill the box about 2/3 full of either sand, gravel or soil. Add six heaping tablespoons of plaster of Paris to the box and mix thoroughly. Add 2 cups (500 mL) of water to the sediment and quickly stir the mixture. Place the box where it won't be disturbed for several days.
When the mixture is dry, turn the box over and tear off the plastic wrap.

Compare your rock model with your classmates' models and with samples of different kinds of sedimentary rocks:

- What kind of sedimentary rocks did you make?
- What kinds of sediment make what kind of rock? (To make sandstone, you need sand; for conglomerate, you need gravel; for shale, you need soil.)
- How are the rocks different?
- What three main steps are needed to make real sedimentary rock? (sediment deposition, pressure, drying)
- Which step didn't play a part in making the model rocks?
- What do you think would happen if water constantly ran over your rock models?

Fossilization



Fossils are the remains and traces of ancient life more than 10,000 years old. The most common fossils are bones, shells, teeth and plants, but fossils can take many other forms — skin impressions, footprints and trackways, eggshells, dung, burrows, seeds, pollen … .

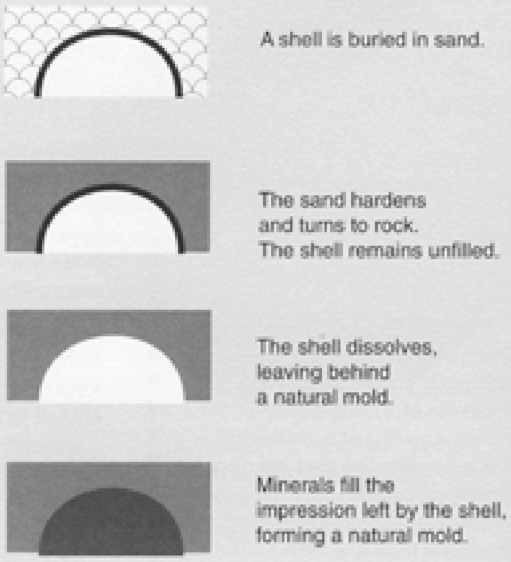
How Fossils are Preserved

Specific conditions must be present for the remains or signs of an organism to fossilize. Most dinosaur fossils found in western North America were preserved in sediments associated with water. High rates of sedimentation in rivers and streams would quickly cover an animal's bones and protect them from currents, scavengers and other things that scatter and break down bones.

Fossilization occurs when ground water minerals slowly fill tiny spaces in the animal's bones, or replace the specimen's original minerals. Or, an organism or object encased in rock may completely dissolve, leaving only an imprint of the original shape. These natural molds can fill with ground water minerals, becoming natural casts.

If initial burial happens quickly after an animal dies, impressions or molds of the animal's skin may be preserved. Fossilized footprints are molds of an animal's feet. Fossil footprints can fill with sediment and minerals, which can become casts of the prints.

Formations of Natural Casts and Molds



Ancient organisms may also be preserved by being frozen in polar or glacial ice, in tree sap, which fossilizes into amber or in tar pits.

Of all the plants and animals that have lived on our planet only a very, very small number have fossilized.

TEACHER'S NOTE

Fossilization in a Sponge

Review safe practices for doing lab experiments before beginning this experiment. Students must wear safety glasses.

(When bones are buried in sediment, ground water minerals slowly fill up the many, tiny holes and pores in the bone. After a period of time, the bone becomes filled with minerals. The sugar from the solution mimics fossilization by filling the holes in the sponge.)

Activities

Carbon Films

Collect several leaves. Place blank paper over the leaves and rub over it with the side of a pencil lead. Your carbon leaf rubbings are similar to many fossils that have been discovered. Plant fossils, in particular, are often nothing more than a film of carbon on rock.

Make an Impression

Try this activity to understand how fossil imprints are formed.

You will need: a paper plate, plaster of Paris, water, 4 large paper cups, stir sticks, petroleum jelly, fake fossils (leaves, sea shells, pine cones, twigs, etc.)

Fill two paper cups 1/2 full with plaster of Paris and two cups 1/4 full of water. Slowly add the plaster from one cup into one of the cups with water, and mix thoroughly with the stir stick. Pour the wet plaster into the paper plate and spread it evenly. Place your "fossils" on the wet plaster. Set the plates aside for the plaster to dry (about one hour). When the plaster is dry, spread the petroleum jelly over both the plaster and the "fossils." Mix the second batch of plaster and pour it on top of the dry plaster and "fossils." Allow the plaster to dry (about one hour). Pry the two layers apart carefully. Remove the fossils. Describe what you have made. (The two impressions of the fossil when placed together form a mold.)

Fossilization in a Sponge

Do this experiment to understand the chemical process that takes place on fossils buried in sediment.

Each pair will need: a large beaker, Bunsen burner, 2 cm cube sponge, a sugar solution

Dissolve 2 cups (500 mL) sugar and 1 cup (250 mL) water in a beaker over a Bunsen burner to make a sugar solution. Allow the solution to cool for 15 minutes. Drop the sponge into the solution. Place the beaker in a safe place where it will not be disturbed.

After one week, remove the sponge. Talk about what happened to the sponge. Compare what happened to the sponge to what happens to bones buried in sediment.

Dinosaur **Paleontology**

In a scene from T-REX: Back to the Cretaceous, *a paleontologist charts the exact location of the fossils found at a dig site.*

A Brief History of Paleontology

The first verifiable discoveries of dinosaur bones occurred in England. In 1822, Gideon Mantell described *Iguanodon* based on its teeth, and William Buckland discovered *Megalosaurus* in 1824.

The word *dinosaur* (terrible reptile) was coined by Richard Owen in 1842. As an anatomist working for London's Natural History Museum during the early 19th century, he reviewed many dinosaur fossil discoveries, and recognized these creatures as completely unlike other reptiles.

Othniel C. Marsh

Edward Drinker Cope

Othniel C. Marsh and Edward Drinker Cope were two famous dinosaur collectors. Their bitter rivalry was lampooned as *The Bone Wars* in newspapers across the United States during the 1890s. They accused each other of libel, plagiarism, and of spying

Paleontology Today

Since the mid-1960s, paleontology has seen greater activity and a new direction. Early paleontologists were concerned primarily with inventorying dinosaurs — finding out how many kinds there were, how they related to each other, and what they looked like.

Today's generation of dinosaur paleontologists is concerned also with interpreting dinosaur biology. They bring varied backgrounds to the science: biology, zoology, botany, geophysics, chemistry, astronomy, taxonomy and many other scientific disciplines, as well as geology and comparative anatomy.

The push is no longer to find the biggest and the best specimens, but to answer questions about how dinosaurs evolved, lived, died and interacted with their environments. The focus is no longer on dinosaurs, but on the world of dinosaurs. This new approach has provided many new answers, new theories, and new questions.

Royal Tyrrell Museum paleontologist, Dr. Philip Currie works at Barnum Browns' 1910 theropod bonebed.

Lost, Then Found

Theropods (beast foots) are the most diverse group of dinosaurs. There are more than 100 genera known, and another 50 in question. They are found on every continent — even in Antarctica.

They were slender, bipedal animals with long legs and sharp teeth that were used to catch and eat prey. Theropod evolution is thought to have been driven by the need to track, attack and feed more efficiently. The most celebrated theropod is *Tyrannosaurus rex*.

Although diverse, theropods are rare. Generally, less than 20 per cent of fossils at any site belong to meat-eating dinosaurs. One exception is Barnum Brown's legendary theropod bonebed on the Red Deer River in Alberta. In 1910, Brown excavated nine partial skeletons from this site. After that, the bonebed and its location were forgotten until 1997.

Using Brown's scant field notes and four archival photographs of the original camp and quarry, Royal Tyrrell Museum paleontologist Philip Currie searched the Red Deer River badlands for the site. "We were trying to match landscapes along the river with those in two of the photographs," says Currie. "We spent a day and a half looking, but were having no luck. Another photograph was of the camp, taken from across the river. I sent someone across in the boat with the photograph, and they found it right away — it was that obvious. Now, it makes sense that the quarry would be close to the camp..."

Three high, steep ridges and many hours later, Currie found the quarry. "All that was left of the original quarry was a sinkhole, but there were lots of fossils. Pieces of skulls, toe bones, bits of ribs.... It looks like Brown excavated only about 25 per cent of the site."

Because the quarry had yielded articulated leg bones from at least nine *Albertosaurs* and only two bones from another species, Currie thinks the animals were part of a social group.

THE LIFE OF A PALEONTOLOGIST

Prospecting

When dinosaur paleontologists do fieldwork, much of their time is spent prospecting — hiking and looking at the ground. They look for bones weathered out of the ground and follow trails of eroded bone fragments to their sources. They try to determine how many other bones are buried, if the bones belong to the same creature and if entire skeletons are preserved.

In a scene from T-REX: Back to the Cretaceous *a paleontology crew working at a dig site prepares to make molds of the fossil bones.*

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In a scene from T-REX: Back to the Cretaceous *a paleontology crew working at a dig site prepares to make molds of the fossil bones.*

Collecting

When a specimen is found, the first thing dinosaur paleontologists and their collection crews do is determine where the fossils are positioned in the rock. They dig down to the layer of the fossil using picks, shovels and jack-hammers. Small hand tools are used to uncover enough of the specimen to determine its outline. Most of the bone is left unexposed.

They then dig a trench around the specimen. To protect the fossils from damage, a jacket of burlap and plaster is wrapped around the top and sides of the specimen block and allowed to harden. A layer of tissue paper between the fossils and jacket keeps plaster from sticking to the bones.

Crews then undercut the fossils, adding more plaster and burlap. Eventually the block of rock, plaster, burlap and fossil sits on a small column of rock like a big mushroom, making it easy for crews to flip the block over. The bottom of the block is then jacketed.

Protected by up to 20 layers of plaster and burlap, the fossils are transported to the lab, where they are prepared and studied.

Very large specimens may be too heavy to move from the field intact. In these cases, parts of the skeleton are separated and taken out in smaller blocks.

Preparation

At the lab, the slow task of removing the rock from around the fossils begins. The amount of information obtained from a fossil depends largely on how carefully it is prepared.

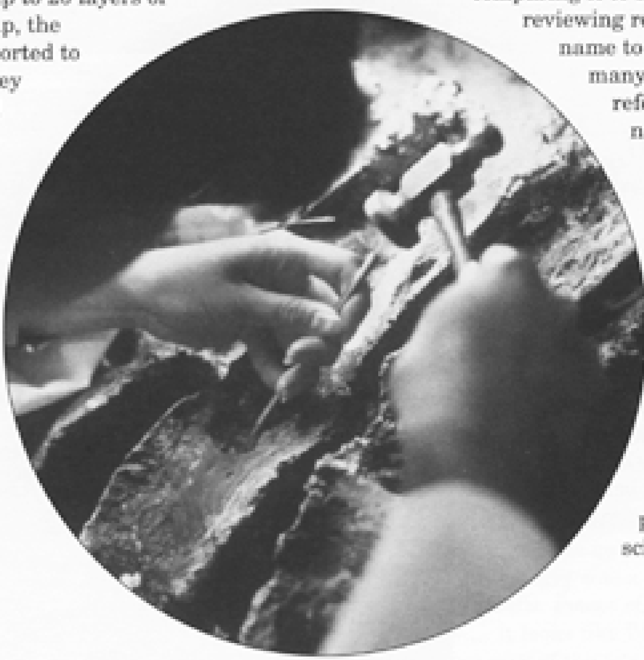
Technicians use fine tools to pick away at the rock surrounding the bones. Preservative is applied to cracks to strengthen brittle fossils. Gaps may be filled. Preparation around small or delicate bones is done using microscopes, giving technicians detailed images.

Once the specimen is prepared, molds of the fossils may be made by applying layers of liquid latex to the fossils. When the latex dries, the mold is removed and used to cast replicas of the fossil for study, exchange and exhibit.

Research

Years can be spent studying a single specimen, comparing it to similar fossils and reviewing research. Putting a name to a fossil can require many hours of research, reference to large numbers of publications and comparisons to other fossils in collections around the world.

If the specimen provides new information, the paleontologist writes a paper describing the research and conclusions and submits it for publication in a scientific journal.



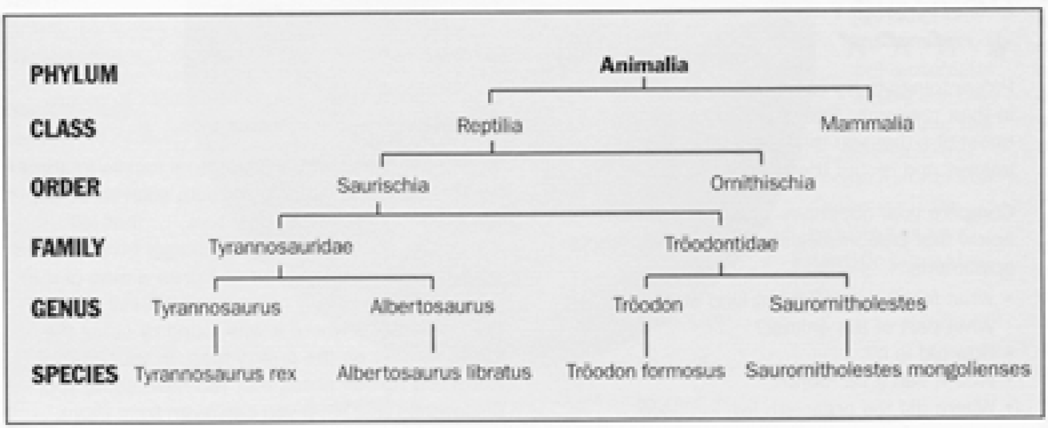
A lab technician carefully chips away rock that surrounds a fossil.

Classification *and* Pedigree

In a scene from T-REX: Back to the Cretaceous, *paleontologist Donald Hayden (Peter Horton) and Elizabeth Sample (Kari Coleman) discover a rare egg-shaped fossil.*

Biological Classification Systems

Biological classification systems group organisms together in a pattern that reflects their relationships with other organisms — for example, how apples are related to oranges, or how oranges are related to grapefruits and lemons.



Biological classification systems are hierarchical – each step in the hierarchy includes one or more groups in the next lower step. The higher groups contain organisms more distantly related to one another.

Dinosaur Cladistics

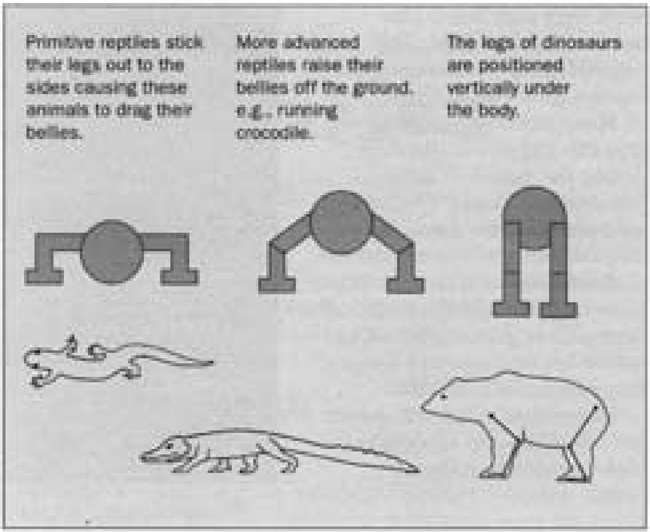
Early biological classification systems use overall similarity between organisms as an indication of how they are related. Cladistics introduced a different approach.

Cladistics groups organisms according to shared derived features — new, unique characteristics. A derived feature develops only once in the history of life. Therefore, animals that share a derived feature must inherit it from a common ancester.

Dinosaurs are animals that share a set of derived features found in their hind legs. The structure of dinosaur hips, knees and ankles differs from that of all other reptiles. It allows the hind legs to be positioned vertically under the body.

In Ornithischian (bird-hipped) herbivorous dinosaurs, one of the bones of the pelvis points backwards, as it does in modern birds. In Saurischian (lizard-hipped) dinosaurs, the pelvis points forwards, as it does in lizards. Saurischian dinosaurs can be either herbivorous or carnivorous.

Pterosaurs, the flying reptiles, and ichthyosaurs and plesiosaurs, swimming reptiles, lived during the time of the dinosaur. But, they are not dinosaurs.



The Bird-Dinosaur Connection

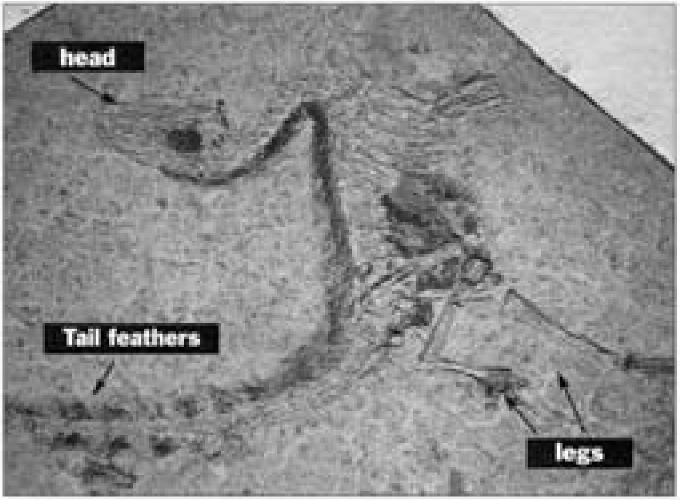
The terms lizard-hipped and bird-hipped are misleading. The hips of bird-hipped dinosaurs resemble the hips of true birds only superficially. In birds, the two bones are parallel. Adding to the confusion, starting in the Jurassic era, the hips of one group of saurischian theropods began changing. Millions of years later,

Feathers are a derived feature used to define birds. We assume all birds had a single ancestor because they all had feathers. Archaeopteryx *is called a bird because it had feathers. In other features,* Archaeopteryx *is like a small carnivorous dinosaur, so if we didn't know it had feathers and were grouping animals according to their overall similarity, we would call* Archaeopteryx *a dinosaur.*

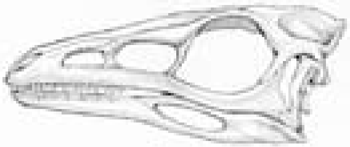
what were once lizard hips became true bird hips. This original group of dinosaurs, the *raptors*, gave rise to birds.

Many paleontologists believe that this happened sometime during the middle to early late Jurassic Period. Cladistic analysis indicates many shared derived features between modern birds and raptor dinosaurs. Many more features apply to birds and theropods in general, including hollow bones, three-toed feet and the presence of a wishbone.

Discoveries in the last decade provide additional support to the bird-theropod hypothesis.



Sinosauropteryx *(China reptile wing) is the latest in a series of bird-dinosaurs being found in China. The specimen is believed to have impressions of feathers or proto-feathers.*



Skull of a Troodon

In 1989, Philip Currie identified the skull of *Troödon* – ironically, one of the first dinosaurs to be discovered and described, but on the basis of only its teeth. Currie found the skull of the small theropod to be almost identical to that of an ostrich.

T– Rex: One of the Last of the Dinosaurs

Many people have a mixed-up picture of the world of the dinosaurs. A common misconception is that all dinosaurs existed at the same time – that herds of trumpeting *Parasaurolophus* grazed on the other side of the hill from long-necked *Apatosaurus*, while in the distance *Tyrannosaurus rex* chased *Stegosaurus*.

While many gaps exist in the fossil record, we do know that *Apatosaurus* and all other long-necked dinosaurs were at their height during the Jurassic Period, 145 to 208 million years ago. In many areas of the world, most had been replaced by more efficient herbivores, the duckbilled and horned dinosaurs, in the Cretaceous Period (64 to 145 million years ago). *Stegosaurus* was also at its height during the Jurassic.

Although the tyrannosaurs, which include *Albertosaurus* and *Tarbosaurus*, first developed 80 million years ago, *T.rex* was among the last of the dinosaurs to appear. This puts *T.rex* closer in time to humans than to *Stegosaurus* and *Apatosaurus*.

QUICK
FACTS

Dinosaurs are divided into two groups based on hip structure. The hip is made up of three separate bones. The position of two of these bones determines dinosaur groups.

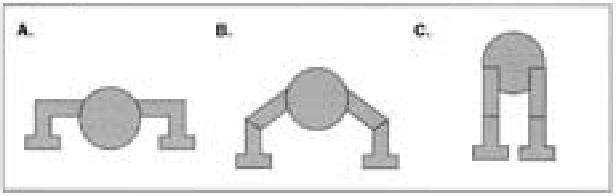
Activities

Dinosaur Families

Use reference books to create a picture chart to show dinosaurs that belonged to the lizard-hipped dinosaur family and the bird-hipped dinosaur family. Label each picture with the dinosaur's name.

The Dinosaur Walk

Working in a group of three, look at the diagrams showing reptile hip position and posture. Each group member chooses a position and practises walking. After each group member has tried all three positions, talk about which dinosaur walk is easier and which is faster. Find out in which way most dinosaurs moved and why.



Classifying Dinosaurs

Using the illustrations of *Archaeopteryx* and *Compsognathus*, classify the two dinosaurs under their physical characteristics. Compare likenesses and differences in the two creatures. See page 30 for illustrations.

The Geological Timeline Revisited

If the class made the geological timeline earlier, incorporate dinosaur groups and species into it. Some students may limit the dinosaurs to well-known ones such as *Apatosaurus* (formerly called *Brontosaurus*), *T.rex*, *Stegosaurus*, *Ankylosaurus*, *Triceratops* and *Velociraptor*.