LESSON 1 Where did the Whales Come From?

Lesson at a Glance
Students investigate information about the development of today’s whales during the last 60 million years. The readings take students from the whale’s early terrestrial ancestors to the aquatic mammals of today.

Lesson Duration
Two 60-minute periods

Essential Question(s)
What is a fossil?
How did whales evolve from land to sea animals?

Key Concepts
• Fossils are preserved remains of plants and animals that lived thousands to millions of years ago.
• Fossil remains indicate that whales evolved from hoofed land animals.

Instructional Objectives
• I can differentiate between an observation and an inference.
• I can compare fossil evidence and living things to identify similarities and differences.
• I can find clues to chronological order to access and understand information.
• I can use information to build a timeline.

Related HCPSIII Benchmark(s):
Science SC.4.1.2
Differentiate between an observation and an inference

Science SC.4.5.1
Compare fossils and living things

Language Arts LA.4.2.2
Use organizational patterns (e.g., sequential, cause and effect) to access and understand information.
Assessment Tools

Benchmark Rubric:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Scientific Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark SC.4.1.2</td>
<td>Differentiate between an observation and an inference</td>
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<table>
<thead>
<tr>
<th>Topic</th>
<th>Biological Evolution</th>
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</thead>
<tbody>
<tr>
<td>Benchmark SC.4.5.1</td>
<td>Compare fossils and living things</td>
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<table>
<thead>
<tr>
<th>Topic</th>
<th>Understanding Text Structures</th>
</tr>
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<tbody>
<tr>
<td>Benchmark LA.4.2.2</td>
<td>Use organizational patterns (e.g., sequential, cause and effect) to access and understand information</td>
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<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
<td>Benchmark LA.4.2.2</td>
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Assessment/Evidence Pieces

Lesson

- Student Worksheet: Compare and Contrast
- Student Assessment Where Did Whales Come From?

Materials Needed

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Class</th>
<th>Group (optional)</th>
<th>Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method to project PowerPoint</td>
<td>None</td>
<td>Whale Evolution Timeline Worksheets (5 per group or 1 per group depending on instructional methods)</td>
<td>Student Reading: Fossil Clues to the Humpback Whale</td>
</tr>
<tr>
<td>PowerPoint: Whale Evolution</td>
<td></td>
<td>Glue</td>
<td></td>
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<tr>
<td>PowerPoint Whale Picture</td>
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SAFETY: Please remind the students about safety and using caution when using scissors.

- Scissors
Instructional Resources

Student Reading: *Fossil Clues to the Humpback Whale*
Student Worksheet: *Compare and Contrast*
Student Worksheet: *Where Did Whales Come From?*
Teacher Answer Key: *Where Did Whales Come From?*
Student Worksheet: *Where Did Whales Come From?-Assessment*
Teacher Answer Key: *Where Did Whales Come From?-Assessment*
PowerPoint Presentations: *Whale Evolution* and *Whale Picture*
Supplemental Resource: *Life and Times of the Humpback Whale Interactive Game*

Student Vocabulary Words

**aquatic:** an animal or plant living and/or growing in water.
**fossil:** any remains, impression, or trace of a living thing of a past geologic age, such as a skeleton, footprint, etc.
**organism:** a form of life composed of many parts that work together; plant, animal, etc.
**terrestrial:** an animal that lives on land.

Lesson Plan

**Lesson Preparation**

- Review the Science Background provided in the Unit’s Overview.
- Prepare copies of the Student Reading *Fossil Clues to the Humpback Whale*.
- Prepare copies of the Student Worksheets *Compare and Contrast, Where Did Whales Come From?*, and *Where Did the Whales Come From?-Assessment*.
- Preview PowerPoint presentations *Whale Picture* and the *Whale Evolution* and make arrangements to project it.
- Preview the interactive piece *Life and Time of the Humpback Whale* to be completed at the end of Step III.

I. **Observations vs. Inferences**

A. Show students the PowerPoint *Whale Picture*, or print out the images and pass them out.
B. Ask students to describe everything they see regarding the whale images.
C. Record all responses on chart paper or chalkboard.
D. Define observation to students.
E. Have the students examine the list of words they used to describe everything they see regarding the whale images.
F. With the students, determine which words are observations and which are inferences. Circle the observation words.

II. **Student Reading – Fossil Clues to the Humpback Whale**

*NOTE to Teacher: If this reading is too difficult for your students, you can discuss the concepts with them before they do the compare and contrast worksheet. Another strategy would be to have your students do the reading in small groups and list the key concepts after they have read each paragraph.*

A. Write *fossil* on the board. Facilitate a discussion of what students already know about fossils. Ask them how they think a mammal, such as the humpback whale, came to live in the ocean when the majority of mammals live on land.
B. Then distribute the *Fossil Clues to the Humpback Whale* student reading. Have students read it and discuss it with the students.
Optional: You may present the Student Reading to the class as a whole using an overhead projector; do the reading together; provide students with a copy of the Student Worksheet only. This will significantly reduce the number of copies required. The next two steps may also be done in groups. Break the students into four groups and assign one worksheet per group. Then have student groups discuss their work.

C. Have students complete their worksheet Comparing and Contrasting.
D. Have students discuss the answers for completeness, and to hear about how others compare and contrast the fossil animals to today’s animals.

III. Whale Evolution Timeline

A. Explain to students that a timeline is a way to show, or map something that has happened, whether in recent times or in the past.
B. Show PowerPoint – Whale Evolution.
C. Demonstrate how a timeline measures time from the present to past or from the present to the future. Show how a timeline reads, TODAY or PRESENT and to the left the numbers indicate the dates which increase. For example, 60 MYA…50 MYA…40 MYA…30 MYA…PRESENT.
D. Divide the students into groups of two or more if your class is large, and distribute the Where Did Whales Come From? worksheets. If making lots of copies is not feasible, consider making larger groups of 4 or more to reduce the number of copies needed.

SAFETY: Please remind the students about safety and using caution when using scissors.

E. Go over the directions with the students, and instruct them not to glue down the pictures until they have carefully read and evaluated their answers.

F. In order to reinforce the student learning have the class work in pairs on the computer using the Life and Times of the Humpback Whale Interactive Game.

G. Once that is completed discuss as a class by having the groups share their answers. Then hand out Where Did Whales Come From?-Assessment.

Extended Activities
Compare Ambuloculus, Basilosaurus and a Dorudon whale with a Humpback from today.
LESSON 1  Fossil Clues to the Humpback Whale

Fossils are preserved remains of plants and animals that lived thousands to millions of years ago. The oldest fossils are approximately 3.5 – 4 billion years old. The vast majority of dead organisms are broken down by living organisms and decay until there is nothing left. Only under certain conditions will fossils be formed. Aquatic organisms with hard parts like teeth, bony skeletons, or shells are the most likely organisms to be preserved as fossils.

For a fossil to form once the organism dies, thick layers of silt need to cover it before it decomposes. This provides a shield around the skeleton which greatly slows down the decay process. Over time (thousands to millions of years) water carrying dissolved minerals passes through the skeleton and replaces the chemicals in the skeleton with rock-like minerals. The minerals take the shape of the original skeleton and will last millions of years. In time erosion may wear away some of the sediment, exposing part of the fossil which helps it to be found and studied. Many fossils are found when large amounts of Earth are moved, as in building roads or quarry mining.

The Hawaiian Islands are too young to find many fossils. Still forming, the Big Island is only 400,000 years old while Kauai is around 5 million years old. However scientists, rock hounds, and others do bring fossils to Hawai‘i for us to be able to see the similarities and differences of plants and animals alive today.

Scientists have learned much about the humpback whale through fossils found on land and in the ocean. The humpback whale is a mammal. Mammals first lived on land, not in the sea. Animals that live on land are called terrestrial animals. Some whale body parts are more characteristic of land mammals than aquatic ones that live in the ocean. Whales have lungs for breathing instead of gills, like fish. The bones in their fins look like huge jointed hands, and the movement of the spine is more like one of a running mammal than that of a fish.

Research suggested that the whale’s oldest ancestor, Sinonyx, was a four-legged hyena-like animal that lived on land more than 60- million-years ago (MYA). But a recent discovery by Professor Hans Thewissen, PhD, of the Department of Anatomy, Northeastern Ohio Universities Colleges of Medicine and Pharmacy (NEOUCOM), pegs the missing link between whales and their four-footed ancestors to be Indohyus, a 12 to 15 pound mammal that looked like a miniature deer.  

How did they link this animal that lived about 48 million years ago with today’s whales that weigh tons? Dr. Thewissen and his team had been given a box of sedimentary rocks that had hundreds of fossilized bones of Indohyus. While cleaning rock particles from a fossilized skull, the skull accidentally broke. The fracture revealed an unusual bone structure around the animal’s ear. It was a little bowl-shaped structure. The inside of that bone was very thick; the outside of the bone was very thin. Whales are the only mammals with this unique bone structure. The fossilized bone of the Indohyus and the whale’s bone were the same shape.

(Cell phone in picture below is for size comparison)

Closer inspection of other fossil parts showed similarities between Indohyus front teeth and those seen in whales. That discovery overturned the previous assumption that whales were already carnivores before they left land. The Indohyus teeth showed that it was an herbivore which means that whales later developed into carnivores.

http://www.windows.ucar.edu/tour/link=/headline_universe/olpa/whales_20dec07.html&edu=elem
Fossils also showed the Indohyus bones had a thick outside layer, much thicker than in other mammals of this size. Heavy bones make it slow on land and easier prey for predators. However, in the water the same structural feature would help it stay on the bottom, where it could forage and hide.

The discoveries from the fossils of the Indohyus have helped scientists to have a better understanding of how whale’s ancestors moved from land animals to this near-shore-dwelling, shallow-water animal to today’s ocean dwelling whales.

Fossils are also used to help understand the evolution of whales. Comparisons of fossils from Indohyus to Ambulocetus to Basilosaurus to Dorudon show parts that are the same and parts that have evolved or changed, making today’s whale a marine mammal. Notice over time how the fossilized skeletons become more and more like today’s whales.

50 MYA - Ambulocetus

45 MYA - Basilosaurus

40 MYA - Dorudon

Today’s Sperm Whale
LESSON 1  Compare and Contrast

For each set of pictures, the first is a fossil skeleton of an extinct animal. The other is a living animal you could see today.

1. For each set of pictures, you will complete a T-Chart or Venn Diagram.
2. For the last set of pictures, you will also write 4 to 5 sentences to compare and contrast the animals.

Set 1

Dorudon Whale 40 MYA

Humpback Whale Today
1. Write a list of characteristics and facts for each of the animals in the first 2 boxes. Then write the similarities and differences in the boxes below. This is called a T-chart.

<table>
<thead>
<tr>
<th>Dorudon Whale 40 MYA</th>
<th>Humpback Whale Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex: Extinct</td>
<td>Ex: Exists now</td>
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<td></td>
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</table>

**Similarities:**

**Differences:**
Sab er T ooth C at exist ed for a bout 3 5 mill ion ye ars. It per i s hed only 12 ,000 ye ars ago .

Bali T i ger today
2. Fill in the Venn Diagram:

Unique Features of the Saber Toothed Tiger

Unique Features of the Bali Tiger today

Similar Features of the 2 animals.
Page 5 - Compare and Contrast

Set 3

(2a) Jurassic bird 100MYA

(2b) Jurassic bird 100MYA

Albatross birds today
Page 6 - Compare and Contrast

3. Fill in the T-Chart below with features, characteristics and facts about each animal. Then, list the similarities and differences.

<table>
<thead>
<tr>
<th>Jurassic bird 100MYA</th>
<th>Albatross birds today</th>
</tr>
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<tbody>
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</table>

List the Similarities

List the Differences
4. Fill in the Venn Diagram below with features, characteristics and facts about each animal. Then, use the information to write your paragraph in step 5:

Unique features of the Mammoth 400TYA

Similarities of the 2 animals.

Unique features of the African Elephant today

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Mammoth 400TYA

African Elephant today
LESSON 1  Where Did Whales Come From?

Directions:  
- Read the description of each mammal, and find the matching picture.  
- Cut out the picture, and glue it to the correct description.  
- Cut out the completed descriptions with the pictures, and connect them to make a timeline showing possible evolution of the whale.
The *Sinonyx* was a shore-dwelling mammal that looked something like the hyena. Around 60 MYA, it started to enter the sea for the rich food sources of the ocean. The *Sinonyx* has dental and facial characteristics like living whales and dolphins. This included an elongated muzzle (jaw, mouth), nostrils had moved back to a point above the canine teeth – the first exam. The nostrils had moved back along the snout to be useful than those of *Ambulocetus*. It still appeared to have legs strong enough to mainly use its tail to move rather than its legs.

- **Rodhocetus**: This is the earliest known mammal to swim.
- **Sinonyx**: was a shore-dwelling mammal. It lived about 60 MYA. It had hooves, like a goat or cow, and nose, like many fish-hunting whales and dolphins. This included an elongated muzzle (jaw, mouth), tusks, like living whales and dolphins. The *Sinonyx* has dental and facial characters.
- *Sinonyx* was the first to enter the sea for the rich food that looked something like the hyena. Around 60 MYA, it started to enter the sea for the rich food sources of the ocean.
Dorudon - The Dorudon lived approximately 40 MYA, at the same time as Basilosaurus, and it is the most likely ancestor to the modern whales. - Dorudon was fully aquatic and had a long, sinuous body. - It did not have the ability to use underwater sounds to locate objects (echolocation) as some modern whales can.

Indohyus - The Indohyus was a small mammal that looked like a miniature deer. - It lived about 49 MYA. - It had an unusual bone structure around the neck, which made it easy for predators to break off its neck. - The inside of its bone is very thin, whereas the outside is very thick. - The inside of that bone is very thick, the outside is not. - It lived on the bottom, where it could forage and hide. - The same structural feature would help it stay for a long time. - The Indohyus had heavy bones making it slow. - The Indohyus was about 12 to 15 pounds. - The Indohyus could locate objects underwater (echolocation) as some modern whales can.

Ambolocetus - Ambolocetus is one of the best examples of an animal between whales and terrestrial (land) animals. - It lived about 47 MYA. - It lacked a blowhole, but its skull and tooth structure were very similar to modern whales. - Its spine moved up and down, allowing it to walk on land in the same way sea lions do today. - This amphibious animal lived about 47 MYA.

Basilosaurus - Basilosaurus was a very large, serpentine animal that was first thought to be the remains of a sea serpent. It was approximately 50-ft. long and lived approximately 35 – 45 MYA. - It was very small around the hips, and had hind limb bones that were too small to bear its weight on land. - The vertebral column shares characteristics of whales with tail flukes. - The nostrils had fused into a large single blowhole that had moved further back on the head from that of Rodhocetus.

Dorudon - The Dorudon lived approximately 40 MYA, at the same time as Basilosaurus, and it is the most likely ancestor to the modern whales. - Dorudon was fully aquatic and had a long, sinuous body. - It did not have the ability to use underwater sounds to locate objects (echolocation) as some modern whales can.
Basilosaurus

- Basilosaurus was a very large, serpentine animal that was first thought to be the remains of a sea serpent. It was approximately 50 ft. long and lived approximately 35–45 MYA. It was very small around the hips, and had hind limb bones that were too small to bear its weight on land. The vertebral column shares characteristics of whales with tail flukes. The nostrils had fused into a large single blowhole that had moved further back on the head from that of Rodhocetus.

Ambolocetus

- Ambolocetus is one of the best examples of an animal between whales and terrestrial (land) animals. It lacked a blowhole, but its skull and tooth structure were very similar to modern whales. Its spine moved up and down for swimming, like the modern whales do, but its four legs were still functional enough that it was probably able to walk on land in the same way sea lions do today. This amphibious animal lived about 47 MYA.
**Sinonyx** - The Sinonyx was a shore-dwelling mammal that looked something like the hyena. Around 60 MYA, it started to enter the sea for the rich food sources of the ocean. - The Sinonyx has dental and facial characteristics like living whales and dolphins. This included an elongated muzzle (jaws, mouth, and nose), like many fish-hunting whales and dolphins. - It had hooves, like a goat or cow. - Rodhocetus was the earliest known mammal to swim mainly using its tail. - The Rodhocetus had a powerful tail for swimming. - Its body moved like many fish-hunting whales and dolphins. - Rodhocetus had more flexible spine for tail movement. - It lived about 60 MYA.

**Indohyus** - The Indohyus was about a 12 to 15 pound mammal that looked like a miniature deer. - The Indohyus had heavy bones making it slow on land and easier prey for predators. In the water, the same structural feature would help it stay on the bottom, where it could forage and hide. - It has an unusual bone structure on the outside of the bone. Whales are the only mammal with this unique bone structure. - It lived about 49 MYA.

**Where Did Whales Come From?** - Teacher Answer Key
Where Did Whales Come From? - Teacher Answer Key

**Dorudon**
- The Dorudon lived approximately 40 MYA, at the same time as Basilosaurus, and it is the most likely ancestor to the modern whales.
- Dorudon was fully aquatic and did not walk on land.
- Dorudon was about 20 feet long and weighed approximately 15 to 20 tons.

**Indohyus**
- The Indohyus was a mammal that looked like a miniature deer, about a 12 to 15 pound mammal.
- It lived about 49 MYA.
- It had an unusual bone structure around the ears, which helped it stay submerged and forage underwater.
- The indohyus had heavy bones making it slow on land, but its same structural feature would help it stay in the water and avoid predators.

Modern whales can produce sounds to locate objects (echolocation) as some mammals do. Dorudon was fully aquatic and lacked large, J-shaped teeth, likely ancestor to the modern whales. Indohyus lived about the same time as Basilosaurus, and it is the most likely ancestor to the modern whales.
Basilosaurus - Basilosaurus was a very large, serpentine animal that was first thought to be the remains of a sea serpent. It was approximately 50-ft. long and lived approximately 34 – 45 MYA. It was very small around the hips, and had hind limb bones that were too small to bear its weight on land.

- The vertebral column shares characteristics of whales with tail flukes.
- The nostrils had fused into a large single blowhole that had moved further back on the head from that of Rodhocetus.

Ambolocetus - Ambolocetus is one of the best examples of an animal between whales and terrestrial animals. It lacked a functional lung, and its four legs were still able to move up and down for swimming. Its spine moved up and down like the modern whales do, but its teeth were similar to modern whales.

- Ambolocetus is one of the best examples of an amphibious animal that lived about 47 MYA.
- It was small enough to walk on land in the same way sea lions do today.

The humpback whale evolved over time. It used to live on land, not in the sea. Some whale body parts are more characteristic of land mammals than aquatic ones that live in the ocean. Whales have lungs for breathing instead of gills, like fish. The bones in their fins look like huge jointed hands, and the movement of the spine is more like one of a running mammal than that of a fish. Research suggested that the whale's oldest ancestor, Sinonyx, was a four-legged hyena-like animal that lived on land more than 60- million-years ago (MYA).

- The nostrils had fused into a large single blowhole that had moved further back on the head from that of Rodhocetus.
- The vertebral column shares characteristics of whales with land mammals.
- It was small enough to walk on land.
- The ancient whale that was first thought to be the remains of a sea serpent was a very large, serpentine animal.
Where Did Whales Come From? - Teacher Answer Key

Name: __________________________  Date ________________

1. What is the difference between an observation and an inference?

An observation is something that you can see with your eyes. An inference is a guess based on your observations.

2. Why is it important to study fossils?

Fossils can tell us a variety of things depending on what kind of organism they are from, and how they were preserved. For example the anatomy of an organism.

3. How has the humpback whale evolved over time?

The humpback is a mammal and it used to live on land, not in the sea. Some whale body parts are more characteristic of land mammals than aquatic ones that live in the ocean. Whales have lungs for breathing instead of gills, like fish. The bones in their fins look like huge jointed hands, and the movement of the spine is more like one of a running mammal than that of a fish. Research suggested that the whale’s oldest ancestor, Sinonyx, was a four-legged hyena-like animal that lived on land more than 60- million-years ago (MYA).
Where Did Whales Come From? - Assessment

Name: ________________________  Date ______________

1. What is the difference between an observation and an inference?

2. Why is it important to study fossils?

3. How has the humpback whale evolved over time?