

Model 3 – Evolution

Activity 1

WHALES IN TRANSITION - Fossils

1. For many years, we have been finding a number of fossils of various **primitive whales** between 25 and 45 million years old (for which time frame **no** fossils of strictly modern type whales have been found). Examples of these early whales would include ***Dorudon***, ***Prozeuglodon***, and ***Zygorhiza***. Place the **fossil picture strip #1** at about 36 mya on your timeline (actual range about 40-36 mya)
2. As more fossils have been discovered from the early Eocene epoch (55-33 mya), scientists searched for a land mammal from which whales would have most likely evolved. The group of animals that had the most features common to the earliest primitive whales found was called the **Mesonychids**. A typical example of these animals (e.g. *Pachyaena*, or *Sinonyx*) looked something like a wolf or hyena, with a large head, but with tiny **hooves** on all its toes! These are considered closely related to the even-toed hooved animals of today known as **artiodactyls**, with many branches evolving into modern deer, cattle, pigs, and hippos. **Place the mesonychid strip (#2)** at about the 55 mya level on your timeline (mesonychids lived from 60-35 mya). Whale specialists generally agreed that features such as **teeth** and various other skull features placed the now extinct mesonychids as the most likely group of land animals from which all whales of today evolved.
3. This picture of whale evolution was about all we had until **1983**, when the first of a series of discoveries began to fill the empty gap between land animals and whales. That first discovery (reported by whale specialist **Philip Gingerich** and others) was ***Pakicetus***. **Place the *Pakicetus* strip (#3)** on the timeline. It was a fragmented **skull**, with lots of teeth, found in Pakistan in sediments about 50 my old. Some of its teeth were very similar to those in mesonychids, while other teeth resembled those found in the later archaeocetes. Some of its other skull features (including its shape) were also similar to late Eocene whales like *Dorudon*. It was found in river sediments near what was once a shallow sea.
4. In **1990**, in Egypt, **Gingerich** and others reported the discovery of the fossilized **hind limbs** of a large, slender previously known primitive whale known as ***Basilosaurus***, around 37 my old (actually lived from 46 to 36 mya). Its hind limbs were proportionally very tiny (about 35 cm of foot and lower leg), and clearly unable to support any movement on land, but they were better developed than those found embedded in the hip region of some modern whales today. **Add *Basilosaurus* (#4)** to your timeline.
5. In early **1994**, **Gingerich** and others found the remains of ***Rodhocetus***, with well-developed hip bones, (and about 9 million years older than *Basilosaurus*). *Rodhocetus* is about 46 my old. From what we have of its skeleton, we conclude that its hind legs were at least somewhat functional. However, its vertebrae suggest powerful tail muscles, suggesting typical whale-like swimming, possibly with tail flukes. Its skull possessed certain whale-like features, including placement of nostrils further back on the head (toward the blowhole position), and enlarged ear capsule bones, typical of whales. **Place *Rodhocetus* (#5)** on the timeline.

Model 3 – Evolution

Activity 1

6. At this point, notice the critical **gap** between 50 and 46 mya. Although there are some apparently related fossils from those gaps, there are none showing clearly what the limbs or bodies were like for that period. Since *Rodhocetus* clearly had somewhat functional hind limbs (as indicated by the fairly robust pelvic bones), they were considerably reduced as compared with mesonychids. Discuss with your teammates what traits you would expect to find (in the **head, limbs, tail, and body**) in a fossil from that period which would be an **intermediate stage** of an animal evolving from a mesonychid into an animal like *Rodhocetus*. **Describe** those traits, then **illustrate** your predictions by making a sketch on the whiteboard. Predict what region of the world, and in rocks of what age, would you expect to find this intermediate stage?
7. Show your teacher what your team predicted, and you will be handed the next discovery.
8. In late 1994, **Hans Thewissen** (formerly one of Gingerich's students), and his team, reported the discovery in 48 million year old deposits in Pakistan of a nearly complete fossil with teeth similar to mesonychids and early whales. He called it ***Ambulocetus***. Place the ***Ambulocetus* strip (#6)** on the timeline. It was about the size of a large sea lion. Its tail was long and slender, with no evidence of use for swimming. However, it had rather short, strong hind limbs, with huge feet (each toe with a tiny mesonychid-type hoof!). The head had a long snout with no blowhole. It probably walked on land like a sea lion, and swam with an undulating up and down motion of its hindquarters (like a sea otter), getting most of its propulsion force from its large feet. It was clearly a 4-legged cetacean.

DISCUSSION QUESTIONS

(Discuss these with your team, record your answers, and be prepared to share with the class)

1. Which typical whale traits were the **earliest** to appear?
2. Which whale traits evolved much **later**?
3. What **age** sediments, and in what **region** of the world, would you search now to get the fossils which would shed more light on whale origins, and what specific **traits** would you expect to find?
4. How closely did your “predicted traits” (expected for an **intermediate** between mesonychids and *Rodhocetus*) match the *Ambulocetus* fossil found? Does *Ambulocetus* seem to fit fairly well into the sequence between mesonychids and *Rodhocetus*?
5. As each new “intermediate fossil” was found, filling a “gap”, how many new gaps were formed?
6. Several species of modern whales have well-developed rear limbs while embryos. As the embryo continues to mature, these limbs atrophy (shrink) and become nonfunctional. Why do you suppose this happens? (Why do the limbs form, and then why do they atrophy?)
7. What are some common traits of the earliest whale ancestors?