

**FROM LAND TO WATER: WHALE EVOLUTION INTERNET ACTIVITY      WS Sample Responses**

**A. WHALE ANATOMY**

1. What does the Latin word “cetuss” mean? Whale
2. How would you pronounce the word “cetaceans”>? Su- tay- shuns
3. What three groups of organisms are considered cetaceans? Whales, dolphins and porpoises
4. What are the two subgroups of cetaceans? Odontoceti and Mysticeti
5. What characterizes the subgroup Odontoceti? Whales, dolphins and porpoises with teeth
6. What characterizes the subgroup Mysticeti? Filter feeding baleen whales

**Follow the instructions given to compare anatomical parts.**

Click on the labels to compare the whale’s anatomy with that of a fish and a cat. Fill out the chart below with **your answers** to each structure, by placing an “X” under the organism whose structure is more similar to the whale’s.

Structure	FISH	CAT
Ears		X
Eyes		X
Lungs		X
Forelimb		X
Jaw		X
Mammary gland		X

7. According to the anatomical evidence, which organism is more closely related to a whale? Cat
8. Draw and label the cladogram that you created for the whale, fish and cat below.
9. What is the relationship between whales and cats? They are both mammals.

**B. FOSSIL RECORD**

1. What is a fossil?  
Signs of life that has become preserved in the geological record.
2. What are the most likely parts to become fossilized?  
Hardest parts of the animals like bones and teeth.
3. What are trace fossils? List some examples.  
Indirect signs of past life; tracks, burrows, nests and coprolites.
4. What is a coprolite? Fossil poop
5. What fossilized anatomical structure can be useful to anatomists? Teeth
6. Compare the fossil teeth of whales to the other organisms on the website. What sort of organism has fossil teeth most similar to whale teeth?  
Mesonychid
7. What is a mesonychid? What is an ungulate? What is an ungal?  
Mesonychids are omnivorous or scavenging ungulates that lived millions of years ago.  
Ungulates are mammals with hooves (ungals) instead of claws.

8. What are some modern day ungulates?  
The odd toed horse, rhino and tapir group (perissodactyls) and the even toed cow, camel, pig, hippo, giraffe and deer group (artiodactyls).
9. To what group did the other skull belong? The seal group (Order Carnivora)
10. Which are more closely related to whales.. seals or horses? Horses
11. What other organisms belong in the Order Carnivora? Dogs, cats and raccoons.
12. Check out the anklebones. List some examples of modern day Artiodactyls.  
Camels, deer, cows, pigs, hippos, girafes
13. Which anklebone looks more similar to the fossil whalebone? Artiodactyls
14. What does this mean for whale's closest relatives?  
Whales are more closely related to cows, pigs, hippos and deer (not perissodactyls).
15. Before we look at molecular evidence, check out more in the fossil record. What environmental shift was responsible for the process of natural selection that led to whales?  
Movement from the land to water.
16. How is the water different from the air? What does that really mean?  
Water is more dense than air. A cup of water has more molecules bouncing around in it than a cup of air.
17. What doesn't light travel as straight or far in water as in air?  
There are more things for the light waves to bounce off of in water, so light can not travel in a straight line or as far.
18. Why don't we have directional hearing under water (click on HUH)?  
Water has the same density as your head, so there is no time lag for the sound to travel to your other ear.
19. What happens each time a molecule bounces into you? It takes away some heat, which cools you down.
20. What four parts of the whale have changed over time?  
Migrating nostrils, arms to flippers, tail (change in locomotion) and the incredible shrinking whale leg.
21. Click on the whale forelimb (arm). What is the earliest whale that investigators have found? What does it look like?  
*Pakicetus*, a dog?
22. What were the forelimbs good for in the earliest whale? Running
23. Compare it to a human arm. How is your arm different from this whale's arm?  
slender, elongated, suitable for brachiation.....; whale arm is wide and flat, suitable for swimming.
24. Which early whale could walk on land and swim in the water? What does it look like? How do its forelimbs compare to the whale's arm?  
*Ambulocetus*, an alligator, long fingers for paddling like a river otter
25. What was the first fully aquatic whale? How does its arm compare to *Ambulocetus* and a modern whale?  
*Dorudon* An intermediate, it had flattened bones like a modern whale, but still had some muscular control of joints.
26. How are modern whale's arm bones different?  
Its arms have flattened bones but there is no muscular control at the joints. And some bones turned into cartilage.

27. Click on games and try “morph a limb”. Click on a bone, then use the buttons to change its size or rotate it. How do you think the differences in bone shape relate to how the two animals moved in their environment?
28. Go back and try the game “be a paleontologist”. How long did it take you to get the bones in their proper position?

### C. THE MOLECULAR PICTURE

1. When finished, click the whale in the bottom left hand corner and return to “Molecules Home”. Which molecules help to show how animals are related? DNA
2. What are chromosomes made of? What is DNA made of?  
Tightly coiled DNA; A twisted ladder of nucleotides
3. What are the steps of the DNA ladder made of? Molecular compounds called nucleotide base pairs
4. What are the four flavors of nucleotide base pairs? What do they stand for? How do they pair together? What do they do?  
A = adenine, T = thymine, C = cytosine, G = guanine A to T and C to G  
They encode each organism’s unique genetic blueprint.
5. Compare the patterns of a nucleotide sequence between a whale, a horse, a cow and a seal. Complete this chart:
 

Number of differences in a --->	Horse	Cow	Seal
Sequence #1	3	2	4
Sequence #2	2	1	3
Sequence #3	2	3	4
Sequence #4	2	1	3
Sequence #5	1	1	4
Sequence # 6	3	2	3
Sequence # 7	4	1	5
Sequence # 8	3	2	5
Total Number of Matches	1	7	0
6. Draw your cladogram of the whale, horse, cow and seal below.
7. To which group does the molecular evidence suggest is most closely related to whales? Cows
8. Click “Find out how DNA changes”. When was the common ancestor to cows and whales?  
Millions of years ago.
9. What is a part of the editing process of DNA? Mutations
10. What are mutations? Changes in the pattern of nucleotide bases in a particular spot.
11. What is a point mutation? Record an example. Change in one nucleotide base pair, e.g. T to C.
12. What is a neutral mutation? One that has no effect
13. What are the three other possible changes?  
A change in meaning; nonsense; or a change back to the original pattern
14. How can a change in meaning be helpful? What happens to that mutation in the population?  
A change in meaning can make an organism more fit, making it able to have more offspring than its neighbors. Becomes more common.
15. What if the mutation hurts the organism or its chance of having offspring?  
That mutation will get edited out of the population