Teaching "**BECOMING WHALES**": an Outline

GOALS:

1. Discover fossils of early whales, showing how, where, and when they evolved from 4-legged mammals.
2. Experience how historical science works: not with lab experiments, but by predicting and testing.

ENGAGE:

1. Has anyone seen a real whale? Where? What kind?
   Display whale scale models (about 1/100th actual size)
2. How big are these whales? As big as this room? Bigger? How much bigger?
   Display Whale Strip (50 foot length of bulletin board boarder, or rope, or....):
   size of Humpback or Gray whale; Blue whale about twice as long.
3. What kind of animal is a Whale? [a Mammal]..... some of their features?:
   Big, swim in oceans, nurse their young, hair, ...
   OVERHEAD: Chart and outline (based on the Kiosk)
   Hind limb buds on whale embryo
   Hip bones in adult whales
4. How long have they been around? (Whales in time) **Cenozoic Time Line** (front or side wall)

EXPLORE: "How did they get here?"
"WE'RE GOING ON A DIG.... A WHALE DIG!"
Each fossil we find, we're going to DATE it and PLACE it in its proper place on a TIME LINE
Eocene Time Lines: hand out to teams (pairs); [Optional: hand out the **narrative** (2 pages)]
Envelopes of Whales: hand out to teams..... "DON'T OPEN YET, WAIT 'TILL I SAY SO"

NARRATIVE (teacher reads first 2-3, then allow teams to finish on their own, if they have the narrative):

Strip #1:	36 mya	*Dorudon*, etc.			
Strip #2:	55 mya	Mesonychids	OH: Ancient whale tooth		tiny hoof on each toe!
Strip #3:	50 mya	*Pakicetus*	OH	**Pakistan**	Gingerich
			OH	Continental Drift - Tethys Sea	
Strip #4:	37 mya	*Basilosaurus*	Hind legs	Egypt (& Georgia, Louisiana, Br. Columbia)	Gingerich
Strip #5:	46 mya	*Rodhocetus*		**Pakistan**	Gingerich
			OH	Nostril shift (*Pakicetus* - *Rhodocetus* - modern)	
			OH	New fossils (Science cover)	

Note critical gap between #3 and #5 (46 and 50 mya): legs to flippers and flukes
DISCUSS WITH TEAM MATES WHAT TRAITS ARE EXPECTED IN AN INTERMEDIATE FORM BETWEEN *PAKICETUS* AND *RODHOCETUS*
IN YOUR NOTEBOOK, SKETCH WHAT YOU THINK THAT INTERMEDIATE MIGHT LOOK LIKE
PREDICTIONS: Circulate around, looking for sketches. As sketches begin to appear, start handing out strip #6
Ask: In what country would you look if you wanted to find the fossils of this intermediate form?

Strip #6:	48 mya	*Ambulocetus*	**Pakistan**	Thewissen	tiny hooves on toes!

EXPLAIN: (Discussion Questions) Let students discuss within teams, record, finish at home? Go over the questions in class next day. Contact the Webmaster for preferred answers to Discussion Questions.

ELABORATE (Extensions):
Disc. Q. #5: *Pakicetus* Reconstructions - including latest post cranial skeleton, and *Rodhocetus* Reconstructions
Disc. Q. #9: show Family Tree of Whales
Ankle Bones Newer Whale Family Tree
Whale Phylogeny Based on DNA Analysis and Osmoregulation data
Combined Trees: Morphological Features on the left, Molecular Features on the right
Do the KIOSK on whale evolution....use the Worksheet.
Power of MILEs: Multiple Independent Lines of Evidence: Read Ray Sutera's article: "Origin of Whales..."
Tutorial for doing Molecular Analysis to answer Phylogenetic Questions .... on our site
VIDEO (WGBH/PBS-Evolution series): Whale Evolution Segment (#2, first 15 min.);

EVALUATE: Ask a few sample questions (reflecting the goals); also "what did you learn?" and "what questions do you have?".