

CS 143 \* Animal Cognition  
**Lecture 2: THE CETACEANS**

**The Order of Cetaceans** (Again, Latin names *italicized*; Genus name capitalized, species not)

- Great variety of cetaceans! Over 80 species, w/varied habitats, foods, body sizes, social systems, etc.
  - Cognition studied in 1, behavior in ~10, so “the cetacean mind” is a great mis-representation...
- Key cognitive features that characterize the more studied species...
  - **Highly Social, Large brains, Acoustic, Few long-dependent young, Playful, Collaborative**

**Mammals** – Warm-blooded, breathe air (so must come to surface regularly – no gills), nurse young

- Completely aquatic (unlike other marine mammals like seals that sometimes come on land)
- Can see vestigial hairs (whiskers) in fetus and infants of some species

**Development** – Have only 1 offspring; Nurse for 2-5 years, depending on species

- **Long dependent** young, some species not reach sexual maturity until 10-12 years old
- Raised in school, much to learn!

**Brains** – Largest brains on planet, although significant variation across species

- Bottlenose dolphin = 1.5X vol of Human; Largest brain: 60ft **Sperm Whale** = 7.5X Human, 15lbs
- Huge cerebellum; Expansive convoluted cortex; Well developed social areas; Wired for sound!
- Buoyancy in aquatic environment supports gigantic body, and corresponding large brain size

**Evolution** – From land animals (?Two-toed, hoofed predators: **Artiodactyls?**), returned to sea ~55 MYA

- Earliest forms: **Archaeoceti**; Still had pelvis, hind limbs, poor acoustic sense;
  - Early forms: large teeth, small brains. Eventually large brains, small (or no) teeth, especially...
- **Odontocetes**: Complex sound system (social & echoloc) type beats out large teeth, small brain type
- **Mysticetes**: Probably branched off early from Odont’s (35MYA?), since Mysticete fetus has, then loses teeth

- **Mysticeti = Mysticetes, Baleen Whales**, filter feeders, 11 species

- **Baleen**, or “whale bone” = long keratinous plates with fringed edges
  - Hang down from upper palate (along elongated arched upper jaw) on both sides of mouth
  - Strain seawater, catch small crustaceans (e.g. krill, copepods), small fish, squid, etc.
- **Very large bodies** - Compare: Male Elephant: 6 tons; Female Blue Whale: 100 tons
  - Smallest (Pygmy Right Whale) = 6.4M (21ft) Largest (**Blue Whale**) = 30M (~100ft)
  - Blue Whale’s heart is the size of a Volkswagen bug!
- All **Marine**, various species found from tropics to poles
  - Some make epic global migrations; Others roam a particular zone
- Have two nares (nostrils) each with its own “nasal plug” which rapidly open/close when breathe
- Variable feeding strategies
  - e.g. **Roqualls** (e.g. Minke, Brydes, Sei, Fin, Blue, Humpback Whales) are “**Gulpers**”
    - i.e. Come up from below prey, gulp huge mouthful
    - Have expanding throat grooves
    - Some (e.g. Humpbacks) form bubble net around prey school, then engulf
  - e.g. **Right & Bowhead Whales** are “**Skimmers**”- Open mouth slightly as swim along, “grazing”
    - Have highly-arched upper jaw and very long baleen
  - e.g. **Grey Whale**, (often seen off our coast as migrate to southern mating/calving grounds)
    - “**Bottom feeders**”: Stir up bottom and sift out water & sand
- Do not have same specialized system for sound production/reception that Odontocetes have
  - Although do vocalize and may have rudimentary echolocation abilities
- Brains huge, but proportionally smaller than Odontocetes

\* We will be most interested in only one Mysticete: The **Humpback Whale** (*Megaptera novaenglia*)

- Produces elaborate “**songs**” that change each season, and all males learn new version

- **Odontoceti – Odontocetes, Toothed Whales**, ~70 species

- Generally smaller than Mysticetes; Vary from <2M (Vaquita) to >18M (Sperm Whale);
  - NOTE: Sperm Whale (“*Moby Dick*”) – the *only* gigantic Odontocete; Most are <6M
- Mostly **Marine** – Single blowhole (not doubled like Mysticetes); doubled nares inside head
  - Some **Riverine** (fresh water!) species (e.g. in India, SE Asia, China, Amazon) - Endangered!
    - Tend to be small, long-snout, “**primitive**”, relatively smaller brained than marine
    - Water often clouded so depend on echolocation, some have very poor eyesight
- All oceans, including Arctic - e.g. Belugas: Slow, blubbery “White Whale” AKA “Sea Canary”
  - e.g. Narwhals: Only tooth is elongated tusk in males, for sparring? sensing?
- All have evolved complex acoustic (vocalization and hearing) anatomy for **Echolocation** (see below)

- **Hunters:** Larger prey, capture one at a time, swallow whole, simple conical teeth for grabbing
  - Eat mainly fish, & squid, sometimes shrimp, reef creatures
  - Many **opportunistic feeders**; i.e. varied and idiosyncratic techniques
  - Some **hunt cooperatively**, herding school of fish & sharing access
  - Some (Bottlenose, Orca) will beach themselves to get prey (fish, seals respectively)
  - Some Orca also eat other marine mammals (large baleens, small dolphins, seals, sealions)

\* We will be most interested in the following Odontocetes:     - **Killer Whale (Orca): *Orcinus orca***  
 - **Bottlenose dolphin: *Tursiops truncatus*** (Atlantic) and ***T. aduncus*** (Indian Ocean)  
 - **Beluga Whale: *Delphinapterus leucas***                     - **Sperm Whale: *Physeter catodon***

## Perceptual & Motor Constraints on Cognition

- **AUDITION** = Primary sensory modality (i.e. Most refined reception, largest dedicated “wetware”)
  - **Hearing in Odontocetes**                                     - External ear opening vestigial
    - Elongated (telescoped) jaw bone, very thin at rear beside mammal-typical inner-ear
    - Sound enters throat & lower jaw, travels through fat channels to inner ear at rear of jaw
      - Fat is ~ same density as water = impedance match, so little sound energy lost
    - Exquisite discrimination abilities, brain a massive acoustic processor
      - e.g. Discriminate ball bearings differ ¼” @ 50 M !!
      - Odont’s hear up to 150KHz (Humans to 20kHz); Many most sensitive to “ultra-sonic”
  - NOTE: Mstycetes produce/are sensitive to lower frequencies, which travel farther in sea
- **Echolocation in Odontocetes**                                     - via Bilateral structures in forehead
  - Sound produced in nasal passages; Air recycled between air sacs, to phonate underwater
    - Vibrations of “**dorsal bursae**” (“monkey lips”, probably derived from nasal plugs)
    - Nasal sacs reflect sound (because of tissue/air impedance mis-match), direct it forward
    - Vibrations pass into fatty “**melon**” in forehead = lens to focus outgoing beam of sound
  - Produces series of clicks (bursts of broadband sound) that bounce back from targets in environment
    - Can produce slow to very rapid click-trains; faster for better focus & higher acuity
- So, perceive/represent world acoustically!
  - “X-Ray Vision” Get separate set of echos from bones, muscles, air sacs in other’s bodies
  - Tell shape, material, distance, size of targets                     - More detail on this to come!

Other perceptual/motor constraints include...

- **Somatosensory** (tactile) can be very **sensitive**, especially around genitals, also face in Odontocetes
  - Tactile sensitivity in face probably involved in sensing acoustic vibrations
- **Tacto-Acoustics:** Acoustic output can have tactile impact – from “tickle buzz” to “punch”
  - So note, “meaning” of at least some vocalizations may include their tactile qualities!
- **Vision quite good** (comparable to cat), esp. sensitive to **motion & high contrast**, no color (monochromat)
  - **No fovea**, but sufficient acuity to distinguish...
    - Human faces, although ID better if moving
    - Trained dolphins can leap and grab fish from trainer 20 feet above water
  - Many species “**spy hop**” (raise vertically out of water) to look around
  - Eyes placed laterally (prey-like); Vision mainly monocular, either side of head, totals up to 360°.
    - No visual access immediately above&ahead (echolocation site); Small binocular field below&ahead
    - Can “pooch” eyes out to look behind&above or behind&below; use e.g. during social interaction
- **Olfaction absent** (cannot smell, unlike many fish), no Olfactory Bulbs (see Brain lecture)
  - Do have minimal **Taste** receptors, but swallow food whole; Possibly taste pheromones in water??
- **No Hands**, limited manipulatory abilities, grab w/mouth only, can tow seaweed etc on flipper, tail
  - Fore limbs & hands contracted into paddle-like flippers, skeletal hands still pentadactyl (5 fingered!)
- **No malleable facial features:** Facial expression limited by hydrodynamic-streamlining, no pinna
  - Some **body language** (Gesture) - e.g. Can expose teeth/not; Can tilt exposing light underside
  - Dolphins can do aggressive “S-Posture” with body, jaw-snap - Most “wiggle” when play