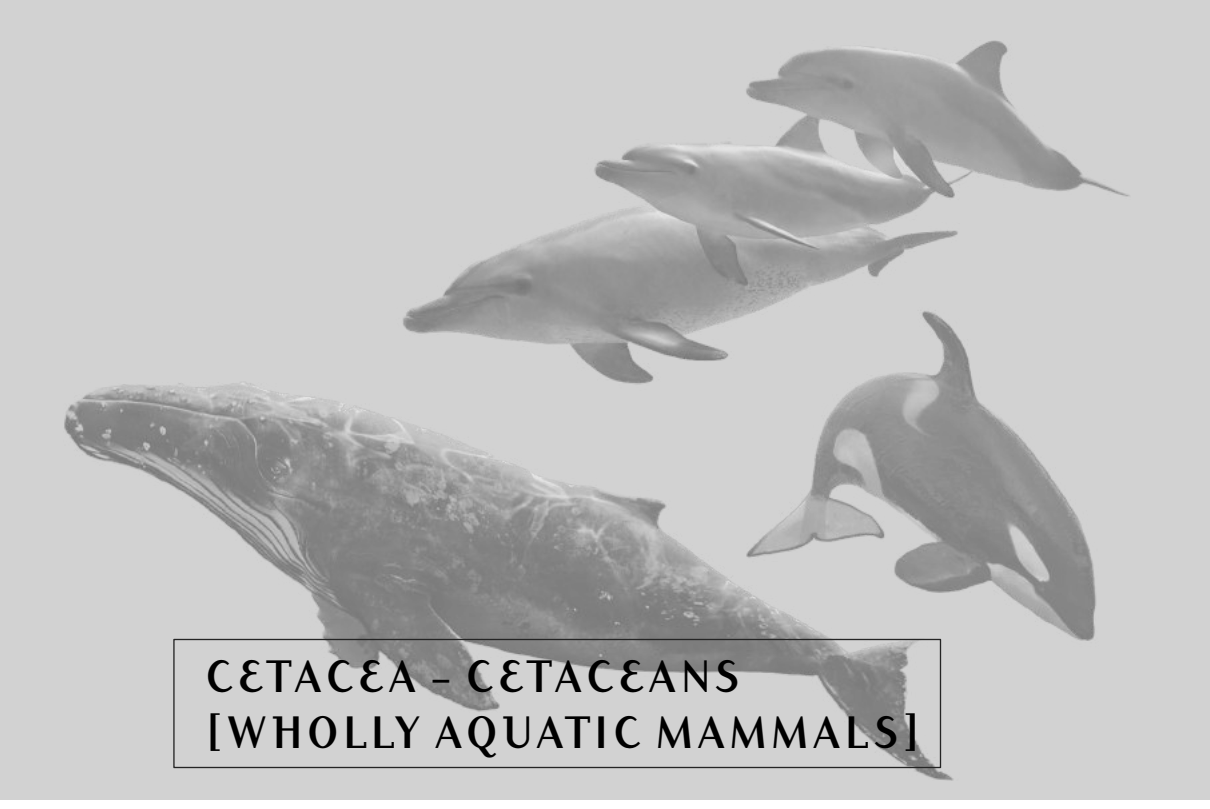

CETACEA – CETACEANS [WHOLLY AQUATIC MAMMALS]

Biological Profile

- Cetaceans are wholly aquatic mammals; they cannot survive on land.
- Cetaceans occur in all the oceans and adjoining seas of the world, as well as in certain lakes and river systems.
- Because cetaceans live in an exclusively aquatic environment and need *not support their own weight,* they can attain great size.
- There are approximately 89 living species, with 46 genera in 14 families, divided into 2 suborders: Odontoceti or toothed whales [containing porpoises, dolphins, other predatory whales like the beluga and the sperm whale, and the poorly understood beaked whales] and the filter feeding Mysticeti or baleen whales [incl. species like the blue whale, the humpback whale and the bowhead whale].
- Odontocetes have an asymmetrical skull with a single blowhole, whereas mysticetes have a symmetrical skull with double blowhole.
- Odontocetes generally feed on fish, cephalopods [squid, octopus], and crustaceans. The conical teeth seize slippery prey but are not adapted for chewing. The killer whale [Orcinus] regularly takes warm-blooded prey such as penguins, pinnipeds, and other cetaceans.
- Key characteristics are their fully aquatic lifestyle, streamlined body shape, often large size and exclusively carnivorous diet.
- Most species are dark above, light below, camouflaged from below against sky, from above against depths

- They propel themselves through the water with powerful up-and-down movement of their tail which ends in a paddle-like fluke, using their flipper-shaped forelimbs to manoeuvre.
- Lack sweat glands and sebaceous glands.
- All have a fibrous layer [blubber] filled with fat and oil just beneath the skin, which assists in heat regulation.
- The bones are spongy in texture, with the cavities being filled with oil.
- Cetaceans are the swiftest animals in the sea; some dolphins can maintain a sustained speed of 26–33 km/hr.
- Most cetaceans can see well both underwater and above water. A greasy secretion of the tear glands protects the eyes against the irritation of salt water.
- Most cetaceans are gregarious to some extent, and most have a relatively long period of parental care and maturation. The gestation period ranges from 9.5 to 17 months. There is almost always a single offspring.
- The rapid growth rate of most cetaceans is at least partly related to the milk's high calcium and phosphorus content.
- Unlike sea birds and marine reptiles, marine mammals lack specialised glands to excrete salts. All salt excretion is through the kidney, and marine mammals possess a specialised kidney to handle the large volume of electrolytes and water they process.

The Sea
The sea! the sea! the open sea!
The blue, the fresh, the ever free!
Without a mark, without a bound,
It runneth the earth's wide regions round;
It plays with the clouds; it mocks the skies;
Or like a cradled creature lies.

I never was on the dull, tame shore,
But I loved the great sea more and more,
And backwards flew to her billowy breast,
Like a bird that seeketh its mother's nest;
And a mother she *was*, and *is*, to me;
For I was born on the open sea!

The waves were white, and red the morn,
In the noisy hour when I was born;
And the whale it whistled, the porpoise rolled,
And the dolphins bared their backs of gold;
And never was heard such an outcry wild
As welcomed to life the ocean-child!
[Bryan Waller Procter, 1787–1874]

Suborder Odontoceti

- Odontocetes use echolocation to detect, track, and discriminate their prey, as well as negotiate their environment. Their hearing abilities match the frequency of greatest sensitivity to the higher frequencies used for foraging and navigation. Hearing and echolocation together provide odontocetes with a highly developed biosonar system.
- Odontocetes tend to be social and live in groups.
- Odontocetes rely on peripheral vasoconstriction along with bradycardia, for supply of oxygen to the heart and brain during deep dives. After submersion, there is a reduced distribution of blood to organs and tissue, making them anaerobic. The oxygenated blood is redistributed to the heart and brain, which are essential organs when the whale is faced with asphyxia.

Suborder Mysticeti

- These are the 'moustached' or baleen whales, one of the 2 extant branches of the cetacean group. There are 16 species in 4 families in this group, rather less than the toothed whales, the other major cetacean branch. What the suborder Mysticeti lacks in variety it makes up in size, being the largest animals of all time on earth.

  All baleen whales filter relatively small living things from the water with baleen. Baleen, which used to be called whalebone, is a flexible substance made of keratin. It forms a series of vertical plates. These plates, with a fringed edge, hang in the mouth of the whale from the upper jaw. Baleen plates strain out large amounts of tiny animals from the water at a time. They are not modified teeth. The teeth themselves are vestigial in baleen whales.

  Zooplankton, consisting of small animals such as shrimplike krill and other crustaceans, fish such as mackerel and herring, and bottom fish such as cod are all eaten by baleen whales. They use various feeding techniques to harvest their food. [marinemammals.in]
- Baleen whales are all essentially filter feeders, but their feeding techniques vary; the humpback and blue whale are gulpers – they open their mouths wide and gulp enormous mouthfuls of seawater, their prey gets caught amongst the baleen plates as the seawater is pushed back out through them. Bowhead and right whales are skim feeders, they swim along with their mouths half open, allowing sea water to flow through their baleen and trap plankton. Grey whales swim on their sides along the bottom of the ocean floor and suck up mud and water; they use their baleen to filter out tiny crustaceans from this sludge. [uk.whales.org]
- Mysticetes seem to employ only a crude form of echolocation but do produce a variety of moans and squeals, which are sometimes combined into elaborate 'songs' and are primarily for communication.

King of the Deep

Oh! the whale is free of the boundless sea,
He lives for a thousand years;
He sinks to rest in the billow's breast,
Nor the roughest tempest fears:
The howling blast as it hurries past,
Is music to lull him to sleep,
And he scatters the spray in his boisterous play,
As he dashes the king of the deep.
Oh! the rare old whale, 'mid storm and gale,
In his ocean home shall be,
A giant in might, where might is right,
And king of the boundless sea!
[Joseph Edwards Carpenter, 1813–1885]

Performing Under Pressure

- The body structure and physiology of cetaceans is designed for performing under pressure, similar to that of the pinnipeds.

  Before diving, a cetacean expels the air from its lungs. The following are some of the adaptations that make long dives possible:

  1. The oxygen combined with the haemoglobin of the blood and with the myoglobin of the muscles accounts for 80–90% of the oxygen supply utilised during prolonged diving.

  Deep-diving cetaceans have mass specific blood volumes that are 3 to 4 times those found in terrestrial mammals [i.e., 200 to 250 ml of blood per kilogram body mass, in contrast to a human value of 70 ml blood per kilogram]. The concentration of haemoglobin is also elevated to a level about twice that found in humans, and the concentration of myoglobin, the oxygen storage protein in muscle, is extremely elevated, measuring about 10 times that in human muscle.

  2. Arterial networks act as shunts, maintaining the normal blood supply to the brain but effecting a reduced supply to the muscles and an oxygen debt that the animal can repay when it surfaces.

  3. A decreased heartbeat further economises the available oxygen.

  4. The respiratory centre in the brain is relatively insensitive to an accumulation of carbon dioxide in the blood and tissues.

  The hydrostatic pressures encountered at great depths are alleviated by not breathing air under pressure and by the permeation of the body tissues with noncompressible fluids. [Adapted from Nowak, 1999]

- Lung size is not the secret to the deep-diving whale's success. The most important way to get oxygen for these animals is not through taking large breaths of air, but how they store oxygen molecules within their bodies.

  Ambient air contains 21% oxygen. When inhaled, the lungs absorb a portion into the blood stream. Exhaled air contains about 14–16% oxygen, which indicates that about only one third of the oxygen present in inhaled air is utilised

by the lungs. Of that absorbed oxygen, the lungs in man contain about 34% of the oxygen reserve; 41% of the oxygen is found in the blood in haemoglobin; 13% is distributed in the muscles, and 12% can be found in the remaining body tissues. In deep-diving whales, on the other hand, the lungs carry only 9% of the oxygen, whereas 41% is found in the muscles, another 41% in the blood, and 9% in the remaining body tissues. With each breath he takes, man exchanges only 10 to 15% of the air in his lungs; this is also the case with the terrestrial mammals.

Whales, however, exchange 85 to 90% of the air in their lungs with each breath. Thus man must breathe 16 times a minute, while a dolphin of similar size averages only 1 to 3 breaths a minute and large whales like the sperm and finback whale breathe, on the average, every 2 minutes. The whale's breathing organs in addition have a particularly firm and incompressible structure due to the pressure changes at different water levels and to the fact that these animals empty their lungs almost completely with every breath. [Adapted from Slijper, 1968]

Affiliative Signals & Tactile Sensitivity

- Social interaction and tactile contact are of significant importance to many cetacean species. With their skin being a highly refined sensory organ of touch, physical contact is necessary and frequent in multiple whale and dolphin species. When captured or placed in stressful situations, dolphins are said to respond well to human touch. Robson has commented that when touched and stroked and spoken to soothingly, stranded whales become calm and less stressed.
- Drone footage in 2019 of a pod of orcas off the coast of British Colombia, Canada, revealed how 'loving' killer whales make far more physical contact with each other than scientists thought. The most surprising thing caught by the footage was the extent of the playful and affectionate touch shared between the animals, something not visible from the boat. Andrew Trites, co-lead researcher and professor at the Marine Mammal Research Unit at the University of British Columbia in Vancouver said: "The same way we hug our kids and hug our friends, touch furthers those bonds. That's the power of touch, and here we have killer whales reminding us of that – who would have thought?"
- Touch – High tactile sensitivity. Affiliative behaviour often involves contact, with body & sound, similar to grooming in primates, calming, bonding, building trust.

  Reconciliation – After aggression, friendly contact increasingly likely between antagonists.

  Sex often involves prolonged 'foreplay' of rubbing, caressing, buzzing. 'Mounting' also occurs between males, presumably as a dominance behaviour.
- Touch is important for communication at short range in most cetacean species. The skin of cetaceans is well innervated and is very sensitive to touch. "Dolphins and whales may rub or caress one another with their flippers or other parts of the body. Gentle rubbing seems to play an important role in

maintaining affiliative relationships in some dolphin species. For many cetacean species, sexual contact appears to have a variety of social and communicative functions in addition to procreation. Sexual activity is often reported for all-male groups, and copulation is commonly observed between animals that are not sexually mature. Caldwell reports that infant male bottlenose dolphins in captivity attempt to mate with their mothers within a few weeks of birth." [Tyack, 2000]

- But not all contact behaviour is friendly. During aggressive encounters, dolphins can body slam each other, butt heads and ram each other with their rostrums. They also smack each other with their powerful flukes, and have even been observed leaping out of the water each other and slamming into each other while airborne. With sensitive skin, these kinds of aggressive contacts surely must hurt, and these are clearly aggressive signals. [dolphincommunicationproject.org]
- "Cetacean behaviour suggests sensitive tactual receptivity for a variety of functions incl. navigation, foraging, and social interactions. Various researchers have suggested that dolphins facilitate swimming efficiency by tactually monitoring water flow and adjusting their integument to reduce turbulence.… In the social domain, dolphins and other odontocetes contact each other with flippers, flukes, and trunk when they are engaged in social and sexual behaviour. Self-rubbing, variously attributed to pleasure, play, and hygiene [e.g., parasite control, removal of old epidural cells] suggest tactile sensitivity.… Cetaceans capture prey with their mouths suggesting rostral sensory involvement, of which the sense of touch appears to be prominent. Although vision may be used for tracking prey in clear water, turbid and lightless conditions are likely to minimise its importance." [Bauer, 2018]

Sound Over Sight

- The eyes of many cetaceans have specific design features for underwater vision. Deep-diving cetaceans enter a cold and dark environment in which blue-green light penetrates the best. The photopigments of cetaceans are shifted toward the blue end of the spectrum compared with those of terrestrial mammals, and they also have a tapetum lucidum that reflects light and increases the sensitivity of the retina at low light levels.
- Cetaceans rely heavily on their acoustic sensory system because a profound reliance on sound in the ocean for everything from communication to navigation is essential given the very limited light that penetrates more than 100 m or so. Sound travels much faster and further in water than air, allowing communication to occur over tens of kilometres and sometimes across an entire ocean basin.
- Dolphin brain stem transmission time is faster than that normally found in humans, and is approximately equivalent to the speed in rats. The dolphin's greater dependence on sound processing is evident in the structure of its brain: its neural area devoted to visual imaging is only about one-tenth that of the human brain, while the area devoted to acoustical imaging is about 10 times as large.

- Most terrestrial animals appear *unable* to modify their vocal repertoire based on what they hear, in sharp contrast to several groups of marine mammals, incl. seals, whales and dolphins, that have highly developed skills for vocal learning. Dolphins in particular display remarkable imitative abilities, they are exceptional vocal mimics. These unusual imitative abilities form the basis of the popular stories that dolphins have a 'language'.
- Odontocetes have inner ears that are specialised for high frequencies rather than very low frequencies. Odontocetes produce 3 classes of vocalisations: clicks, burst pulses, & whistles. Clicks are used for echolocation. They can 'eavesdrop' on one another's echoes, learn about environment and about echolocater's interests. Whistles have a social function. The function of burst pulses is uncertain.

  "There is strong evidence that some specific whistles, called signature whistles, are used by dolphins to identify and/or call each other; dolphins have been observed emitting both other specimens' signature whistles, and their own. A unique signature whistle develops quite early in a dolphin's life, and it appears to be created in imitation of the signature whistle of the dolphin's mother. Imitation of the signature whistle seems to occur only among the mother and its young, and among befriended adult males." [Wikipedia]

  Pregnant females hugely increase signature production in the last weeks of pregnancy. The infant born knows its mother's signature; aside from being used as a 'contact call' it aids in mother/infant reunions.

  Male coalitions can develop a 'coalition whistle' that replaces individual signatures. This kind of group signature whistle is also produced by animals forcibly isolated from the group, e.g. during capture or release. Other group-members may match the call. There is also some evidence of matching when groups meet.

  Orca calls are specific as to coalition, family, pod, kin group [even across pods], and community. Orcas are strongly family oriented. Stable groups of resident orcas possess group-specific call repertoires that are acoustically distinct from the repertoires of other groups. Vocal matching among orcas typically occurs within members of a matriline
- Many mysticetes sing, which can be simple, few-tone, repeated songs or extraordinarily complex ones. Baleen whales have inner ears that appear to be specialised for low-frequency hearing. Humpback whales sing complex series of sounds that may last tens of minutes before repeating. These song sound so musical to our human ears that recordings of them have become commercial bestsellers.

Big Brains

Spindle cells [neurons without extensive branching] have been discovered in the brains of the humpback whale, fin whale, sperm whale, orca, bottlenose dolphins, Risso's dolphins, and beluga whales. Humans, great apes, and elephants, species all well known for their high intelligence, are the only others known to have spindle cells. Spindle neurons appear to play a central role in the development of intelligent behaviour.

"Most people agree whales and dolphins are the 'brainiacs' of the sea.… Whales and dolphins behave in ways that suggest intelligence and a sophisticated mind. Not only do they learn as individuals, but as individuals that can pass their knowledge onto others.

"Whales and dolphins have large brains; brainy dolphins have a brain to body ratio second only to humans. Large-brained creatures generally have a few things in common: they live long lives; they are sociable; their behaviour is complicated; females give birth to only a few offspring throughout their lives and take extraordinary care of each baby while teaching them life skills; the youngsters take their time to grow up, become sexually mature and independent of their mothers.

"Whale and dolphin brains contain specialised brain cells called spindle neurons. These are associated with advanced abilities such as recognising, remembering, reasoning, communicating, perceiving, adapting to change, problem-solving and understanding. Perhaps the most obvious difference between our brains and that of dolphins and all toothed whales is that they have an entire area dedicated to echolocation." [us.whales.org]

Extended Mother-Young Bonds

"The young of many dolphins and other odontocete species are born into groups made up of many adult females with their young, and they rely upon an unusually extended mother-young bond. Bottlenose dolphin calves typically remain with their mothers for 3 to 6 years. Sperm whales and short-finned pilot whales suckle their young for up to 15 years. Dolphin calves are precocious in sensory and locomotor skills, and they swim out of sight of the mother within the first few weeks of life.

"Sperm whale calves may not be able to stay with their mother on deep foraging dives, and may remain separated from her nearer the surface for tens of minutes. Young calves often associate with animals other than the mother during these separations. The prevalence of alloparental care in these species may favour a more generalised caregiver-calf recognition system.

"Some baleen whales show a pattern different from this prolonged and highly social period of dependence in the young. In the seasonally migratory baleen whales, a young calf must migrate thousands of kilometres within months of birth, and the young of most species are weaned within one-half to one year. When an adult female humpback whale has a calf, she seems to avoid other mother-calf pairs.

"Very few groups of humpbacks with more than one calf are ever sighted on the breeding grounds. Some baleen whales may have an ecological setting in which a mother and calf may stay away from other mothers with young during most of the period of dependency. This reduces the potential for misallocation of parental care. In these cases, there may be reduced selection for parent-offspring recognition." [Tyack, 2000].

Fast Growth

"Cetaceans are fully adapted to an aquatic environment, and yet they must still breathe air and suckle their young as terrestrial mammals. The lack of physical maternal support to calves for transport and nursing means that neonate cetaceans must have sufficient motor skills to suckle, swim and breath-hold immediately after birth. To facilitate the critical transfer of energy during nursing, cetaceans produce milk with a *higher fat content* compared to that of terrestrial mammals, active nursing where milk is ejected into the mouth of the calf, and rapidly improving breath-holding capabilities, thereby enabling neonates to suckle for longer durations within hours of birth.

"Several species of large baleen whales undertake long annual migrations between high latitude feeding grounds and low latitude breeding grounds. It is likely they embark on this migration to reduce predation pressure and seek sheltered, warm and calm waters for the neonates. While travelling long distances might not pose large energetic costs for mothers, the cessation of foraging while lactating does impose a large energetic challenge for them, resulting in a significant decline in body condition. This creates a short critical time window on the breeding grounds to transfer sufficient energy to the calf for it to grow and survive the long migration back to the foraging grounds. Indeed, the growth rate of humpback whale calves is remarkably fast; studies have found a growth rate of 0.5–1 m per month in length, suggesting a need for substantial time investment in suckling.

"An increase in size gives the calf not only an energetic advantage during the subsequent migration, but it also increases its probability of surviving predation attempts. Rapid weight gain is optimised by having frequent access to the mother for nursing and by minimizing energy expended in travelling and diving. Humpback whale mothers modify their dive durations on foraging grounds corresponding to the dive capability of the calf, presumably to allow the calf to stay in close contact. By maintaining close proximity to its mother, the calf gains access to maternal provisioning and protection, while reducing the risk of separation.

"Close proximity also allows for hydrodynamic advantages by slipstreaming, thereby conserving energy during swimming. The use of acoustic cues between mother and calf could help maintain this close contact and facilitate the coordination of behavioural transitions such as initiating suckling." [Adapted from Videsen, 2017]

Playful Beings

"It has been said that play is a great expression of intelligence, and whales and dolphins are gold medallists in this field! Pods of dolphins leap, tumble, back flip and spin together; and there is often no explicable reason for their behaviour other than *pure social enjoyment*. Dolphins will race towards boats to surf in the bow wave or play in the wake performing amazing acrobatics. Why? Well, wouldn't you if you could? Some dolphins seek out big waves breaking close to shore and ride the waves alongside surfers, other dolphins prefer to play with plants or shells or other make-shift toys.