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ON

THE ORIGIN OF WHALES

BY

EINAR LÖNNBERG

LECTURE HELD AT THE ROYAL ACADEMY ON ITS CONMERORATION DAY

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ARISTOTLE already had a clear idea that whales are not fish, that they breathe with lungs, are viviparous, and that they suckle their offspring. In spite of this, and in spite of the good reputation ARISTOTLE had, which made him the highest of authorities in the scientific field for centuries, whales were categorized as fish for more than 2000 years by the general public, but also by the scientific writers after the great Greek researcher's death. The Englishman WILLUGHBY († 1672) did distinguish whales from fish in his work about the latter, but since this was not published until after his death by his friend and colleague RAY, he did not dare to pursue WILLUGHBY'S idea in this direction. RAY did not wish to digress too much from the general view and present any paradoxical opinions, he said, and therefore he considered the whales as belonging to the fish class. Thus it became the task of LINNÉ, in 1758, to definitely move the whales from the class of fish to the class of mammals.

The reason for this solid insistence on an erroneous perception of the nature of whales is to be found in their way of life and the shape of their bodies. All whales spend their entire life in water and in their whole organization carry out extensive adjustments that at a glance may appear as similar to the ones of the fish. In reality, this superficial resemblance is confined to the whale's spool-shape, its naked skin, the existence of a pair of pectoral fins, a tail fin, and in some cases also a dorsal fin. These similarities are, however, only illusory. The skin of the whales does not ever have has any scales of any kind and it is furthermore totally different in other ways in its structure to that of the fish. The whale fin is not skin supported by fin rays as in the fish, since the whale fins consist of a skeleton/ bone structure. The different parts of this bone structure have their exact counterparts in the forelegs of other mammals. The dorsal fin and the tail fin have no supporting element, it is made up of derma structure and fatty tissue; the dorsal fin is horizontal in the whales etc, in other words thoroughly fundamental differences. And when one begins to examine the whales' remaining anatomical structure, it can be observed that its fundamental structure corresponds to that of other mammals. Therefore, while there cannot be the slightest doubt that the whales are mammals; they have, however, as a result of their life in the water, changed to such a degree, that they hold a unique position within this class.

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Before we begin to in detail point out some of the more important differences between the whales and some of the more typical land mammals, it would be convenient to at least take a brief look at some of the of the most important current shapes of the former. Both regarding ways of life and body structure, the whales can be divided into two clearly defined and separate groups: toothed whale (odontocete) and whalebone whale. As the name implies, the former is equipped with teeth, to a smaller or larger extent, at least in the lower jaw (mandible), but lacks the baleen plate which is so characteristic for the other group, which will be addressed later. In connection with the different mouth armament it is clear that the lower jaw's halves of the toothed whale are firmly joined in a symphysis at the front, while in the whalebone whales, they are disconnected from one another.

The toothed whales are quick and lively animals, that are always on the move hunting their prey consisting of fish, octopus, and sometimes larger animals. Several kinds of organizational types are present in this group. The ones that subsist on fish normally have a large number of teeth, however, these teeth are uniform and of the simplest kind, usually one cusp and with one root. They are arranged in the upper jaw (maxilla) and lower jaw (mandible) in such a way so they interlock when the jaws are closed. The extended jaws with their sharp teeth in this way become an excellent catching tool for retaining even the most slippery of catches. In the whales that subsist on octopus, the dental system has often undergone a strong reduction and generally there are functioning teeth only in the lower jaw, and at times they may even be limited to just two.

Among the fish-eating toothed whales, the dolphins are the ones that are most known. The porpoise (*Phocaena phocaena*), common along our coasts, which yearly migrates into and than out of the Baltic again, also belongs to this group. In the past, during these migrations, it was exposed to getting caught at Middelfart. It is one of the smaller species, and it will not become longer than 180 cm, and it is easily distinguishable for its teeth that are pressed in from the sides. There are about 16 to 26 in each half of the jaw. Other species of the same family exist for example in the South Atlantic and the Pacific Ocean. One peculiarity in the porpoise is that, at times, in particular in the south Atlantic species, it has osseous lumps in the skin by and on the dorsal fin.[1] This is assumed to be the remains of an exterior armor, which would have existed in these toothed whales' ancestors.

The actual dolphins, which include many species distributed in a number of families, have regular, even, cone shaped teeth. In the perhaps best known and renowned of all, the common dolphin *(Delphinus delphis*) the number of teeth in each jaw half is up to 40-50, in other words it can have as many as 200 teeth.[2] The common dolphin is at home practically everywhere in the large oceans of the world, with the exception of its coldest parts. During a voyage at sea, one often sees flocks of these dolphins, who during repeated somersaults hurry towards the ship, speed past it, and upon reaching the stem,

[1] Similar lumps can be found along the back in a closely related genus, the *Neophocæna*, which exists in the Indian Ocean and the Pacific.
[2] Another species can have up to 246 teeth.

they will remain for a longer or shorter while, sometimes perhaps for hours, playing in front of it in all directions, as if the speed of the ship means nothing to them. This speed may, however, be quite significant, 6-8, even perhaps up to 12 knots or more.– If the ship is moving more slowly, for example at 3-4 knots, the common dolphin will usually abandon it quickly, after making their round. It really appears as if to them it is no fun when speed is slow. These dolphins have provided a change to the monotony on numerous occasions during long voyages, and for the seamen they might also be a welcome addition to the monotonous diet, when they have managed to harpoon some of these merry rakes. Many are the legends that seamen have about these dolphins on how they will predict the weather, announce a storm etc. This species, which is well known in the Mediterranean, was also the "delphinus" of the antique times, so frequently mentioned in the Greek and Roman mythology. This species is also where the heraldic dolphin descends from and from where it has obtained its curved shape, when it jumps out of the water. Thus it is this species, which provided the origin of the title of the French successor to the throne "dauphin". The common dolphin is not large, its length is only about 2 1/4 meters. It is black above and white below, and brown or gray patchy on the sides.

Several other kinds of dolphins of the genera *Prodelphinus* (approximately a dozen species in all oceans) and *Lagenorhynchus* live in a similar fashion. To the latter, whose 11 species mainly appear to thrive in tempered seas, some also belong to that we occasionally find along our coastlines like the White-nosed dolphin (*Lagenorhynchus albirostris*) and the white-sided one (*L. acutus*). These forms, which distinguish themselves through their white markings, as their names imply, live in large herds and gorge on fish. The family *Sotalia* includes a still indefinite number of species of dolphins, which distinguish themselves through their normally light color. These forms remain close to the coasts and often migrate high up in the large rivers. This is for example the case with the milk-white Chinese dolphin (*Sotalia chinensis*) as described by Linné's disciple Osbeck. In the upper parts of the Amazon River, there are two or perhaps more species of this family. The Indian speckled dolphin (*S. lentiginosa*) is light gray with small spots. These dolphins are usually fairly small from somewhat bigger than one to 2 ½ meters. It has been said about one species; found in Cameroon (*S. teuszii*), that it is a herbivore, which is surely a mistake, since no single whale variety is vegetarian.[3]

The *Steno* genus with two species in the South Atlantic and the Indian Ocean, is distinguished by its fairly thick and heavy teeth, 20-25 on each half mandible, whose enamel in a characteristic way is wrinkled or furrowed. One of these species is described as pitch black with white spots on top, and white on the bottom side. The Black Dolphin (*Tursiops tursio*) is one of the larger dolphin species, which quite frequently appears in the Baltic Sea and then often gives rise to the most vivid stories of strange marine animals. It is has a dark leaden gray to black color on top and, white under, and will become up to 3 ½ meters long. Last August some marine animals appeared outside Riga, that at first were taken for submarines. Once it had become clear that they really were animals and not submarines, they were shot at. The people shooting indicated that the

[3] The remains of vegetables, which have been found in the animal's stomach and which is the source of the perception quoted above, were probably swallowed by coincidence.

animals were 10-13 meter long, but shortly thereafter a *Tursiops*, hurt by gun bullets, came ashore at the mouth of the Adia River north of Riga. Their length had now shrunk to 12 feet and their weight was 458 kilos. There are *Tursiops* varieties in all seas, however, how many species there has not been determined. Some are smaller than *T. Tursio* and of another color. They are for example distinguished by their fairly thick teeth, although there are only about 20-26 in each lower and upper jaw respectively.

The *Cephalorhynchus* family includes 4-5 species in the southern hemisphere. They are usually not longer than a meter with a fairly wide, a nose section that is not very extended with small teeth(25 to 30 in each side of the lower and upper jaw respectively) and a triangular dorsal fin. Many times these dolphins have distinct white markings on the nose and on the sides.

In the Pacific there is a dolphin family *Lissodelphis*, which entirely lacks a dorsal fin.

The Pilot Whale (*Globicephalus melas*)[4] lives in the northern Atlantic and the Pacific all the way to New Zealand. It is a fairly large, 4-6 meter long black toothed whale with few teeth (7-11 in each lower and upper jaw respectively). The pilot whale usually appears in large groups and this social behavior facilitates the catch. At the Faeroe Islands in particular, the pilot whale is of economic importance. If a group of such animals, is noticed quite close to the shore, the people hurry to surround the whale on the outside with a line of boats, and by throwing stones and shouting at it, they try to push it towards land. When they have succeeded in bringing the whales close to the shore, preferably to a shallow bay, the harpooning will begin. The end of this will usually be that the wounded and frightened whales will rush towards land and get stranded there. The Faeroe islanders eat the meat and make use of almost the whole animal. They are so fond of this catching, or at least they used to be, that the saying goes that one Sunday when the priest was in the pulpit and news arrives about pilot whales, that in a blink of an eye the entire congregation was down by the boats leaving the church empty.

The largest toothed whales of the dolphin group are the killer whales (*Orcinus orca*). They are large and strong animals that will reach a length of up to 9 meters, but they are also gluttonous predatory animals and they are the only dolphins that will attack bigger and warm-blooded animals. There is an often quoted piece of information by ESCHRICHT that states that in the stomach of a killer whale, there are more than 13 porpoises and 15 other "*Phoca Hispida*". During the last years Antarctic expeditions have on numerous occasions observed how the killer whales have been following the "själhundar" and also found some that have managed to escape the jaws of their terrible enemy but whose awfully lacerated body bears witness of its teeth. On several occasions, people have seen how groups of killer whales have attacked big whalebone whales, which they have eventually overpowered and torn apart. Several observers have hereby stressed that the killer whales are particularly prone to attacking the defenseless Baleen whales from the front, bite its lips and try to tear out its tongue. The killer whale is easily identified through its broad rounded pectoral fins and in particular through its high dorsal fin which is often seen protruding above the water level. This is longer in the males; where it can be

[4] Several other forms have been described from different oceans.

up to a meter high. There are relatively few teeth, 10 – 13 in each side of the jaw but they are big and strong with somewhat flat roots. Their color is black on top and white on the bottom side with characteristic white spots on the sides. This marking varies which has led to the belief that there are several species. However, no conclusive evidence has been presented to the effect that there is more than one species living in the seas ranging from the Arctic to the Antarctic areas, and that also exists by our shores, even occasionally in the Baltic Sea. It is obvious that for such an animal with such habits as the killer whale, there will exist a large number of detailed myths about the sea monster etc., but no one has ever heard that the killer whale has ever attacked any ships or vessels.

The False Killer whale *(Pseudorca crassidens)* was first described as fossil in England, but has later been found alive both in the North Sea and elsewhere. It has also come ashore on the Swedish west coast. It is practically pitch black and approximately 5 meters long; the dorsal and pectoral fins are smaller than in the killer whale and the teeth have cylindrical roots. [5]

Related to the killer whales is an interesting form, which is often called Risso's Dolphin (*Grampeus griseus*) but since it has converted to only subsisting on octopus, it does not need strong teeth any more, instead it has reduced eliminated the teeth in the upper jaw, and has only 3-7 teeth on each side on the lower jaw. It will become about 3 – 3 ½ meter long and has quite a strange gray color, which at the bottom turns into a lighter yellow whitish color, while on and by the fins it changes into black. Furthermore, it has an uneven marking on the back with lighter streaks and spots, which makes it look as if the animal has scraped off some paint. The *Grampus* variety has been found in the most diverse seas from the North Sea to New Zealand and California. However, it is not common anywhere. It is very popular by New Zealand due to its habit of following the ships. There it is called "Pelorus-Jack" after the navigation instrument pelorus and it has come under protection. It is mainly or solely in arctic seas that the two forms of dolphins exist, which are different from the ones mentioned before, for example, since the neck section, as this has all the vertebrae "free", also from the outside is visible as a narrowing behind the rounded head, and the lack of dorsal fin. The white whale or the beluga (*Delphinapterus leucas*) was formerly very numerous in the Arctic Ocean and of great economic significance,[6] but there has been a significant decrease of its numbers during recent years, due to the most ruthless pursuit it has been exposed to from the whalers. Although marine animals by nature, the white whale will sometimes come far up into the rivers to go after the salmon. It has been found in the Yukon River 700 miles from its mouth. It will at times also go astray from its real habitat in the Arctic Ocean and has at times been observed in the Baltic Sea, predominantly on the Finish side. The white whale which is of solely of white color and reaches a length of approximately 4 meters, normally has 9 teeth in each side of the jaw, but its relative, the narwhal, only has two tusks in the upper jaw. Of these, the male usually only has the left tusk which is fully developed in horizontal shape, protruding long, straight but spirally twisted support teeth.

[5] The dwarf killer whale (*Orcella*) is a dolphin form, a little more than 2 meter long, that lives in Irawaddy and also by the coast of India. It has several teeth and a small dorsal fin and it is slate colored.

[6] This form distinguished itself through its, for a whale, unusually firm dermis. The epidermis of the white whale is widely eaten on Greenland and is said to have an almond taste.

The right tusk stops growing and will generally not be visible at all, which is also true of the female's both teeth. However, in exceptional cases, in the males both teeth or solely the one to the right may develop. The support tooth is twisted towards the left, even if it is the right one that is the developed one. The narwhals are grayish piebald and approximately 4 meter long. Little is known about the narwhal's way of life, since it stays up by the eternal polar ice. It is known in what way it uses its support tooth, which can become more than 2 meters long. Many hypothesis have been suggested regarding the narwhal using this support tooth for making holes in the ice, or for spearing its catch, just to mention a few of the more adventurous ones. However, it's most likely that it is mainly a weapon for the internal struggles of the males, since it is only them, and not the females that are equipped with this, indicating that is of a secondary male characteristic. One could perhaps compare the narwhal's tusks with the deer's antlers. There are many fables associated with the narwhal's tusks, such as for example the "sea-unicorn" and other monsters. In the past when the narwhal tusks were very hard to come by, they were viewed as articles of incredibly value and were paid for with fabulous sums. A few of these pieces were used as fortune bringing objects and even as medication.

Through their weak dental armament these whales somehow form a sort of transition between the octopus eating whales, which do however belong to a particular family. This does not include as many as many species as the dolphins, but can nevertheless demonstrate several different types that can in a natural way be divided into two groups; the Cachalot and the beaked whales. The former of the two, with its characteristic of numerous teeth in the lower jaw, includes the giant of the toothed whales, the Cachalot, or the Sperm whale *(Physeter catodon),* which among other things distinguishes itself through its enormous head, whose cranium is the most transformed one out of all the mammals, in that some of its bones are suppressed or missing while others are deformed in such a way that they are barely recognizable. Particularly striking is a high "comb", which is raised up behind and partly to the sides of the nose section, to a certain extent giving the head an appearance of a gigantic tray. Inside this is an enormous sac-like form, which contains the very valuable spermaceti oil, which in addition to the fat makes the Cachalot very desirable by the whalers. Another valuable product, which is obtained from this species, is the ambergris, a grayish substance, which is formed inside this animal's intestinal canal, but that does not exist in all the individuals and which is probably a sickly formation originated with aid of the gall.[7]

At first when the ambergris is obtained it is oily and nasty-smelling, but it hardens after being exposed to the air, instead obtaining a nice fragrance that later in the stores will be enhanced through various perfumes. Formerly ambergris was also used as medicine, but nowadays it is only used in the perfume industry. According to the information I have seen, a few years ago people would pay between 13.50 kronor and 22.50 kronor per ounce, and lumps with a value even up to 9,000 kronor have been found. It is quite natural that an animal that carries such valuable substances as spermaceti and ambergris will be highly sought after, but the Cachalot is definitely not a harmless adversary. In the past when the whale hunter only was equipped with a harpoon and a lance it was quite common that the boats would get crushed and human lives be lost during the wounded

[7] The amber often contains jaws of octopus and other undigested remains of cachalot food.

Cachalot's struggle for its life. Some whale hunters could actually tell stories about some old Cachalot males who did not even wait to be attacked before going on the offensive themselves. A full-grown Cachalot male can be up to approximately 18 meters, while the females are much smaller. These large animals' diet only consists of octopus, which they probably catch where the waters are quite deep. They can accordingly remain for a long time below the water surface; between 50 and 75 minutes. With its relatively narrow mandible with teeth they are able to very skillfully catch lots of octopus. Swallowing these octopuses is made easier by the two grooves or folds which make the throat extra expandable. The prince of Monaco, during one of his exploratory expeditions, had the occasion to observe the harpooning of a Cachalot and noticed how the Cachalot during its death struggle let out part of its stomach contents which consisted of a lot of octopus. The prince sent out a boat which succeeded in collecting a part of this before it sank, and when studying both this material and the 100-kilo remainder of the stomach contents, some very interesting octopus forms were found, some of them even new to science. Some of these were of quite a significant size and the Cachalot's lips bore profound marks from their sucking-discs.

The genus closest to the large Cachalot is the genus *Kogia*, possibly with three species that only reach a length of 3 for 4 meters. Unlike the Cachalot, the *Kogia*-species has a well developed dorsal fin and is therefore, and in many other aspects, more similar to the dolphins than its large relative. In one of the *Kogia*- species two teeth have been found in the upper-jaw as well, but it is not clear whether this should be seen as normal or not.

The beaked whales, whose name can be traced from the strong narrowing of the nose area in relation to the rest of the head, has a set of teeth which is reduced to 1 or 2 functioning pairs of teeth on the lower jaw. However, there is rudiment of teeth in a smaller or larger number. The now existing forms are distributed over four genera, with a few definite species. Since most of them are very rare and not very well known, the various discoveries on different occasions have often resulted in different names being given to them, believing that these were new unknown forms. The most common one is the Atlantic Beaked whale – the "Bottlenose" (*Hyperdoon rostratus*) as the whale-catching men have been calling it - which is exposed to a lot of whale catching in the northern Atlantic. In exceptional cases it even comes into the Baltic Sea, where two specimens became stranded in 1879. Their normal length is about 7 – 10 meters long. It is completely black when it is young, but over the years it becomes lighter and become lead-colored and yellowish-white. The cranium of the old male Beaked whale does show a certain similarity with that of the Cachalot, through its high sagittal crests formed by the rear upper jaw-bone. In front of these, in the Cachalot there is a reservoir with spermaceti that increases over the years, which is largest in the old males. This genus has both teeth in the apex of the lower jaw obliquely facing forward. The beaked whales live in small herds, which remain together, seldom abandoning a harpooned friend until he has breathed his last sigh. They are excellent divers and go very deep and are also able to remain under water for as long as 2 hours. It is really puzzling how a breathing animal is able to remain under water for that long.

By New Zealand, an almost entirely black beaked whale, called *Berardius,* has been found.

It is said that supposedly its teeth, two on each side close to the apex of the lower jaw, are movable, so they can be brought forth when needed – e.g. for catching octopus – and then be pulled back again. If this is true, it would be something unique for mammals. However, very little is known about this whale.

The genus *Mesoplodon* has a large compressed tooth on each side of the lower jaw slightly behind the apex. A species of the Sowerby's "small head" whale (*M. bidens*) also happened to get stranded on the Swedish shore. Of the other species of this genus, an onomatopoetic name that imitates this animal's snort when breathing can be noted a southern form, *M. layardi*, where the teeth mentioned begin growing in a band-like way and curve the upper jaw. This results in this whale only being able to partially open its mouth. No wonder this was first looked upon as a pathological phenomenon, although later it was determined as normal.

The fourth genus *Ziphius* has two functioning teeth in the lower jaw's apex. Many species' names have been given within this genus, but it is unclear whether this currently includes more than one species, *Z. cavirostris*, which also happened to get stranded in Bohuslän [Sweden], but however, appears to exist in all the oceans.

All that now remains of the toothed whales is a small group of flood dolphins, who are all quite different to one another, but who in their structure do show quite a few original characteristics that connect them with the extinct forms. However, they also show numerous characteristics that they have in common with the typical dolphins, while others suggest a connection with the Cachalots. Consequently, with all these deviations they do hold a fairly central position of a certain archaic kind.

One of these forms lives in the Ganges, namely "Susu"[8] (*Platanista gangetica*) as the natives call it. It does not have a real dorsal fin, but it is well-equipped with teeth and with its sensitive nose it pokes around in the mud searching for fish and crustaceans. The eyes are really minimal and most likely of little use. The cranium with its high ridges is somewhat similar to that of the Cachalot. The neck region is unusually well developed. In the Amazon River and in the Orinoco there is another genus with a species (*Inia geoffroyensis*), whose cranium, and other parts of its structure, is similar to the Cachalot. It has numerous teeth (26 to 32 in each jaw) with folded enamel. The back teeth also have a little protrusion, an extra cusp, which suggests that its ancestors had multi-pointed teeth. Another reminder from the ancestors is the bristle that *Inia* has on its nose. This form lacks the dorsal fin as well. Among the natives, *Inia* is viewed with a lot of fear and superstition.

The third hereto belonging genus is *Stenodelphis* (*l. Pontoporia*) which does indeed have a dorsal fin as a dolphin and is also in other aspects more similar to the real dolphins, while also showing a similarity with the other flood dolphins through its "free" cervical vertebras etc. It is South American as well, since its home is the La Plata River.

The other group within the system of whales, the Baleen whales, has gotten its name

[8] An onomatopoeic bane, which imitates the way this animal snorts when breathing.

from the baleen plates, i.e. the thin long triangular cornea plates that hang down from the palate into the mouth cavity. The short base is adhered to the palate, the exterior side is straight and smooth, and the interior side obliquely narrows towards the bottom and carries along its edge a dense fringe of a hair-like formation. Together these baleen plates form a strainer, through which the whales separate the small animals, which make up their diet, from the water. With the wide scoop-shaped lower jaw the whale takes in water with the small animals it contains. Then the mouth is closed and the water trickles out through the baleen plates whose hair fringes form a filtering device in which all the small animals get caught. Thereafter, the Baleen whale moves its tongue and these are licked off the baleen plates and sent down the whale's throat. By repeating this kind of movement the current largest animal alive is able to feed on small animals, each measuring no more than a few millimeters, but obviously consumed by the billions.

There is no trace of teeth in the adult Baleen whales, but it has been possible to point out the presence of numerous rudiments in the fetus stage that, although they never actually develop, do show that the Baleen whale has its origin in animals with teeth.

The Baleen whales form a more homogenous group than the Toothed whales; however, it is possible to distinguish two groups, the Right whales and the Finback whales.

The former group is characterized by the absence of a dorsal fin and of any grooves or folds in the throat. However, the whales belonging to this group have long baleen plates. Most noticeable in this group is the Greenland whale (*Balæna mysticetus*), now unfortunately almost extinct, thus only a few can now be caught every year in the polar ice on both sides of Greenland. As in so many other cases, it is women's fashion that is to blame for current annihilation of an interesting animal form. To the Greenland whale's misfortune it has the finest of all baleen plates, or "whale fishbone" as they are also known, which are used for corsets and other similar purposes. The value of the baleen plates in a moderately full-grown Greenland whale is up to approximately 25,000 to 30,000 kronor. Certainly, there are not many that carry such a precious mouth set. The length of the baleen plates can be up to 12-13 and seldom 15 English feet or approximately 360- 390 centimeters. The whole length of the animal is about 15-19 meters, seldom 21 meters. The head constitutes the third of the length. The usual color is black with a whitish color on the mandible parts. The Greenland whale is truly arctic in its existence.

The temperate part of the Atlantic is the home of the North caper (*B. glacialis)* or the Biscay whale as it is also called after its former numerous existence in the Bay of Biscay. From the early days it was being caught by the Basques and thereafter by an increasing number of populations, who would follow it further and further north across its whole area with such intensity that there was every reason to expect it to become extinct by the early 1800s. When, due to the lack of hunting objects of this variety, this branch of whale hunting stopped, only a very small strain remained. The strain increased somewhat and thus by the end of the last century, once again it started to become possible to observe the North caper in the North Atlantic. With the technical perfection that whale catching now has reached, there is little hope that the North caper's story will be a very long one, since in addition to the value of its blubber, it also carries the precious baleen plates. The North

caper is completely black and has a proportionally smaller head than the Greenland whale; it only makes up 25-28 percent of its body length, which is 14-17 meters. There are some closely related forms in the southern Atlantic and in the sea around Japan.

Neobalæna marginata is the name given to a small baleen whale which is only about 6 meters long and whose home is in the southern Pacific Ocean. It constitutes a transition between the Right whale and the Finback whale, since it does not have the throat grooves of the former, while it has a small dorsal fin just like the latter. This whale is said to be an unusually good diver and it has a larger number of ribs (17 pairs) than any other whale. The ribs are also comparatively large but loosely attached.

Among the Finback whales, these days, there are also a larger number of forms than among the Right whales. In the northern Atlantic there is no fewer than 5 good species divided into two genera. One of these (*Balænoptera),* includes 4 species, the Blue whale (*B. musculus*) the longest of all known species which becomes about 21 to 26 meters long, and is of a dark blue gray color, with completely black baleen plates; the Rorqual *(B. physalus),* 18-20 meters, gray-black above and white below, some baleen plates dark, others more or less of a light color, often striped with the bristle's color in accordance with the stripes from black to grayish white; the Sei whale, 12-15 meters, bluish black above, white below, black baleen plates with white bristle; the Lesser Rorqual *(B. acurostrata)* 7.5-9.5 meters, black above, white below, with a white band across the pectoral fin and white baleen plates. To at least a few of these there are parallel forms in other seas, but whether these are entirely separate species or not still remains uncertain. The Lesser Rorqual's parallel form in the Pacific Ocean has for example been described under the name of *B. davidson,* and the Blue whale's parallel as *B. sulphureus*. The latter can supposedly become even longer than its relative in the Atlantic; one was measured to be 95 English feet long.

The other Finback whale genus, which is spread out in most of the seas, and which can also be found in our area, is the Humpback whale (*Megaptera nodosa*). Its name reflects the large a number of nodular bumps on its head. Its pectoral fins are incredibly long (312 centimeters or more), longer than in any other whale species, while the whole animal is about 12-15 meters long. The Humpback whale's coloring varies quite a lot; black to gray or more or less white. Otherwise, the structure of the Humpback whale is fairly similar to that of the previous mentioned genus. In both, the nose party of the cranium is significantly shorter than it is in the Right whales, and not at all as curved. This results in a lesser height in the mouth cavity and thus the baleen plates not being very long. To compensate, in the Finback whales the lower jaw and throat sections are very expandable, thanks to the folds and grooves mentioned previously. The texture of the Finback whale's baleen plates is significantly thicker and therefore less valuable for industrial purposes. Moreover, these whales' layer of blubber is thinner that that of the Right whales and they sink when they are killed, which means that they have has less of a value for this as well for a long time they were able to live fairly undisturbed by humans, as long as the whale hunt was carried out in the old way with the harpoon and lance. But since a method has been invented to shoot the whales with canons and as projectile use a grenade carrying harpoon, their turn has come and their superior flexibility and mobility cannot save them

when they are being followed by high-speed steamboats. The number of Finback whales has also decreased alarmingly and perhaps the day will soon be here when the number of valuable animal species that become extinct will increase as a result of humans' greed and lack of common sense, instead of being subjected to a wise-economy-taxation, thus being preserved, so they in this way also can contribute to the wellbeing of future generations.

Apart from what we have learned from the history of the North caper, the fate of other whale species also shows that this unfortunate prediction probably very easily can come true. There is the Californian Grayback whale (*Rhachianectes glaucus*) that does not exist any more. This interesting form, which was an intermediate link between the Finback whales and the Right whales, was approximately 12 meters long or somewhat longer more, often of a gray color and speckled black with short light-colored baleen plates. It does not have a dorsal fin, but it has a couple of throat grooves. This whale used to live by North America's west coast. During the summer it would move north all the way up to the Arctic Ocean, but then it would go south during the winter, always staying close to the shore and it would often come into very shallow waters. Yes, it is said that at times it would actually remain close to shore at ebb tide and wait until the flood tide once again brought it along, which no other whale dares or even is able to do. The Grayback whale is described as ferocious, and that it even has the habit of attacking when it is being chased and it will try to trash the boat with its tail. There are also many emotional stories about how the Grayback mother tried to protect and defend its young one against the catchers' blood thirst. However, this did not help. The hunting if this animal species began in 1846. In approximately 30 years around 11,000 such animals were killed and now there is not even one left.

After this quick overview of the most important forms of today's whales, the ability of these animals to adapt to a way of life in the water ought to have become quite clear. First we can note that the elongated spool-shaped body, which in order to present as little resistance as possible against the water, has a completely smooth hairless surface. Under the epidermis layer, which can be up to 8 millimeters thick but only very slightly hardened, there is normally no firm or delimited derma. There is only a fat or blubber layer supported by connective tissue and elastic threads, which serves both as temperature protector and for reducing the animals' specific weight. This blubber layer also serves as an elastic coating, which protects the animal against the significant changes of pressure it is subjected to when it dives deep into the sea. Change of position has practically totally been taken over by the tailfin, which has come up as side lobes of the tail skin and perfected into a half-moon formed two-bladed propeller with an effect that supersedes anything that the human engineering sciences has ever been able to produce. As a result of this excellent motion device the two extremity pairs are no longer needed for position changes, and the one at the rear has also become completely reduced; now only existing as an inner rudiment. The front ones have once again been reformed into a pair of pectoral fins. These pectoral fins without nails or claws that would be unnecessary, however serves more as a balance organ and side rudder, than an organ for moving the body forward through the water. Thus, it is really only between the humerus and the shoulder blade where a real joint remains. The other connections between the different bones are with no function due to connective tissue bands. In addition, many

whales have developed a dorsal fin that functions as a balance organ, a kind of centerboard on their back. This dorsal fin is usually most developed in the best swimmers.

The less need the pulmonary breathing animals, which live in water, have to come up above the water surface to breathe, the better. The general rule is therefore that such nostrils have been moved to the upper side of the "nose". Examples of this can be found already among the reptiles; in the water snakes, crocodiles etc. In the whales this has gone even further. The nostrils have been moved upwards and backwards so they appear to be placed in the middle of the head. This obviously entails a shortening of the nasal bone, which can occur, since fortunately, as a result of the whale's way of life, these are no longer of any direct significance. In connection with this, what has occurred is a dislocation pf other bones, which can be noted through a close-up comparison. For the catching of its prey and its nutrition intake in the water, the facial or nasal part of the cranium has become substantially elongated in comparison with the brainpan. It is true that the structure and armament of the different whales is entirely different, as has already been stated, depending on from what type of catch they live. However, this elongation can always be noticed. In order to provide the cranium's link with the elongated nasal part with sufficient stability the upper jaw bone has been elongated towards the back as well, where it stretches out, so it covers most part of the frontal bone. In some of the tooth whale species, in which the elastic cushion of fat tissue on the nasal part, which constitutes a kind of breakwater in the quick swimming and diving movements, has developed into an unusual size, the upper jaw bones at the back and also on the sides are raised into high ridges, which provide support for this fat formation.

This is clearest in the Cachalot and the beaked whale. The intermediate jaw bone, even if not carrying any bones and the vomer are elongated to a degree corresponding with the upper jaw bone. The occipital bone is very large and it stretches up until the top side of the cranium where it partially covers, partially kind of presses the parietal bone to the side which then mainly or only (in the majority of tooth whales) become visible on the brainpan sides, while the occipital bone and frontal bone meet on the top of the tooth whale's head. As a result of these conditions, the brain pan becomes pressed together, short and wide to its form. Added to these oddities is an often very developed asymmetry, which means that the bones on one side are much more developed than those on the other side.

A long and weak neck would be an obstacle when swimming under water and therefore this has been significantly shortened and the seven vertebrae which normally form the neck in the mammals, whether long or short, have become very thin and often partially or completely grown together. A firm rib cage would run the risk of becoming compressed when the whale is diving into deep waters, and thus the sternum in the whales has become reduced and the ribs' connection with the sternum has become more loose and elastic. The back's vertebrae are very elastic but also tightly interconnected to enable the swimming movements with the tail fin. Going into additional details of the whales' adjustment would be to long.[9] Let it be enough to remind you of the fact that there is no

[9] An example of such an adaptation to life in the water is the circumstance that the young whales already

external ear, that the eyes are set for seeing in the water, and that the nasal opening, through an interesting mechanism can be shut completely, so no water can penetrate, etc.

Moreover, a very large amount of blood in relation to their body volume, and in connection therewith an incredibly rich – in parts formed as a net - ramification of the blood vessels, eliminates the inconvenience, which would otherwise occur when the whales are diving and are only able to breathe at long intervals. But from the physiological point of view there would be numerous problems that need to be solved within the whale animals' group, both regarding breathing, as well as some other life functions.

Now, with so many and such striking differences between the whales and the common mammals, one could also ask: is it possible that these divergences are of such importance that the whales could be deemed to have their origin in some other animal that would not be a mammal. To this an unqualified *no* can be given in response. The differences may appear to be big, but more than anything they come from transformation and displacement. For example, in the whales' cranium – although it looks entirely different – every bone of a normal mammal can be found; nothing new has been added and nothing is missing. In any case, the mere absence of an organ is not enough to warrant a unique origin, since if an animal changes it s way of living, an organ can become unnecessary, and thus become reduced until it finally may completely disappear. However, often after the organs have stopped functioning, stunted rests, rudiments, will remain for a long time span. These are of great evidentiary value when we wish to learn the real connections between the different animal forms. Such rudiments exist also in the whales, and from these we can draw the following conclusions. The following can be stated as an example. Although the whales, resulting from their adaptation to the water, have a smooth, hairless and gland-free skin, one can however say that they descend from mammals that are covered with hair, with skin glands. There are coat rudiments in most whale species, at least during the fetus stage, in the form of sparse hair on the lips and the nose, and several species preserve a smaller or larger amount of this hair in the named places also when fully developed. Since no other animals than the mammals have hair of such nature, this fact alone is evidence enough. There are glands of the skin gland type in the conjunctiva of the eye, which is only a continuation of the skin, and these, as well as the milk glands, are yet further proof of the link with the mammals just as above all the development of the fetus and everything connected therewith. It also easy to show that the ancestors of the whales were quadrupedal. I certain fetus stages you can see the rudiments of posterior extremities, although these never actually developed. A rudiment of a pelvis has however been found in all whales (except *Platanista?*). And quite often attached to this has been found an even more insignificant rudiment of femur and even of a tibia. As has already been mentioned, there are no external ears in the whales but it can be determined that their ancestors had such due to the rudiments of 3-4 muscles, which had the function of moving these ears.

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have come very long in heir development when come into his world. This can be noted already by the size proportions. A newborn Baleen whale is about ¼ , whereas a newborn Toothed whale is 2/3 as long as their respective mothers

Due to these and other reasons it is completely indisputable that the whales descend from quadruple, hairy mammals with exterior ears and skin glands etc. of a roughly normal type[10]. However, after coming this far, many difficulties still remain. It would also be meaningful to point out that the whales have nothing in common with neither of the groups of mammals, which exclusively or mainly live in the water, namely the Sirenia and the Phoca Hispida, although such thoughts have emerged from time to time. The exterior similarity that appears to exist between whales and sirenians is only due to a certain parallel development that has occurred as a result of a similar residence, and has no profound significance. The inner structure of both animal groups is entirely different and several newer discoveries appear to indicate a common origin for the Sirenia and the elephants. The Phoca Hispida once again shows a fundamental distinction to the whales consisting of that in the latter the tail with its fin is the dominating movement organ, while the hind legs have disappeared. In the Phoca Hispida, on the other hand, the latter has been much reduced while the hind legs have developed into functional swimming organs. It is inconceivable that there could be any direct transition between these two types of development. It is more than likely the case that the tail had already been diminished in the Phoca Hispida's earliest ancestors before they began living in the water, since it is not likely that it would become diminished by its way of living mentioned last, if we take into consideration the relationship within other various groups of mammals, that have representatives in the water[11]. However the tail will regularly become diminished in rummaging animals. Therefore, it is not inconceivable that some original predatory animals through these habits of living could have lost their tails and from these then develop on the one hand the bears, and on the hand the Phoca Hispidas. Of the latter no older remnants are known except for the Miocene, and they were fairly similar to the ones of today. The history of the whales, on the contrary, goes all the way back to the beginning of the Tertiary Era, the Eocene, and discoveries made during these last years have contributed to shed light on several extinct forms, that in a very particularly interesting manner filled out the gap between the strongly specialized whales of today and the more central mammal types. The series is not yet complete, but one can fairly easily imagine the paths that development has followed.

At the end of the Mesozoic Era and during the very earliest stages of the Tertiary Era there existed quite a large number of small primitive mammals, which were so primitive in their structure, that from there came the development of, on the one hand, the very first ancestor of the hoofed animals, *Condylarthra*, as well as the first ancestor of the predatory animals *Creodonta*. The latter continued differentiating itself in different directions and gave rise to the current various predatory animals. However, some Creodonts instead began to search for their feed in water among its animal life. In connection therewith they were adjusted to such way of living, and underwent some changes related thereto.

If one observes the cranium of a creodont, e.g. *Sinopa* (figure 1), which has been found as

[10] All the talk about the whales' direct descending from reptiles, e.g. such as the Marine Iguana, is thus completely foolish.

[11] Marsupial (*Chironectes*), insect eaters (*Potamogale*, *Myogale* and others) predatory animals (*Lutra* etc.), rodents (*Castor*, *Fiber* and others).

fossil in lower Eocene in North America and also in fluvio-marine layers of the Eocene era in Egypt, one can observe that in each jaw-half there is a set of teeth consisting of three front teeth, one cusp tooth, four intermediate teeth and three real molar teeth. The number is typical in the primitive mammals. The intermediate teeth have three cusps, and the real molar teeth have several cusps with three roots and they are all of a fairly similar size.[12] Otherwise, the cranium is quite similar to that of a predatory animal, such as a fox cranium. Both regarding the teeth and the structure of the cranium, such a creodont indeed differs very significantly from today's whales.

But several discoveries during these past years have greatly contributed to leveling out that breach. In the year 1904 the Professor FRAAS from Mokattam in Cairo described an animal that he called *Protocetus avatus*, which was obtained from the lowest layer of the intermediate Eocene era. The cranium of this animal (figure 2) is extraordinarily interesting. In regards to the brainpan part and the occiput, this cranium, which has been about 60 cm long, it is at approximately the same stage as in a creodont. The "joint buttons" (condylus??) in the neck, as well as the neck crest and temple cavity are well developed and the zygomatic arch is quite strong. This is an indication of well-developed neck muscles and a mobile head but also of good chewing muscles, which is not well developed in the whales of today. The frontal bones are amply spread out towards the sides above the eye sockets, which bears a similarity to the whales.

[figure 1]

[12] From such a set of teeth it is possible to distinguish the current predators through the differentiation of a predator tooth and through the diminishment of certain teeth, in particular the back teeth.

The face and nasal parts are very elongated. In connection herewith, the intermediate jaws are also prolonged towards the back, so the nose can gain firmness. The nasal bond forms a long roof over the nasal cavity and while it is true that the exterior nasal orifices have moved to the upper side of the nose, but one cannot really say that it has been pushed back to any considerable degree. However a look at the underside of the cranium, shows that the hard palate stretches much further back and (the choanas or) the posterior (inner) nasal openings are in connection herewith far back. This is also a clear adaptation to life in the water. The dental part is of great interest, since it does not show any significant deviations from those of the creodonts. The number is apparently the same as in the creodonts, 3 front teeth, 1 canine tooth, 4 intermediate teeth (premolars), and 3 real molars. The cuspid tooth is of the same size as in the predatory animals. Even the first, smallest middle tooth has two roots. The second middle tooth has two roots, and the third and the fourth ones have three. They have two distinct points and a prolongation of the enamel on the interior side indicates a previous inner heel. All genuine molars have three roots and three peaks, more or less developed. The simplification of the teeth of the *Protocetus* has not gotten very far and its creodont origin is clear, but the genuine molars are quite compressed towards the back and there are indications of a beginning of reduction. The cervical vertebrae are short but they are mobile/independent and suggest a strong and flexible neck. The second cervical vertebra (epistropheus) has approximately the same shape as in the ones in the creodonts and the predatory animals. The thoracic vertebrae have long spiky growths and are more similar to a land animal[13] than an animal living in the sea, and 10 ribs have a double connection of the joints. It is extremely interesting that a vertebra that has been found, which FRAAS has interpreted to be a sacral vertebra, which through its structure suggests that a bone of the pelvis was attached hereto. Unfortunately there are no remains of the actual pelvis or of the bones of the limbs. The tail is also missing, but FRAAS calculated the entire length of the animal from its nose to the root of the tail as approximately 1.60 centimeters. FRAAS also includes another species, the *P. zitteli,* which was originally described by STROMER, as part of the same genus. Of this latter one, a stone casting showed that this form had well developed nasal conchae and also most likely had a good olfactory organ, just as its ancestors living on land. From the same species caudal vertebrae have also been found, and it has been possible to establish that the tail was of a solid structure and functioned as a movement organ.

[figure 2]

While the *Protocetus,* as far as one can tell of the remnants known so far, has become a marine animal, it has not distanced itself very far from the creodont type otherwise. The next known link in the chain is what ANDREWS a couple of years later described as the *Prozeuglodon atrox*, which was found in layers above the *Protocetus*. The head of the *Prozeuglodon* (figure 3) is fairly similar to the head of the *Protocetus*. It is however significant that the nasal orifice has been moved further back, and that the nasal bones hereby have become shorter, while they still are relatively long. The neck arch is still

[13] Referring e.g. to the annual guide from the Swedish Science Academy called *Veteskaps-Akademiens Årsbok*, 8, 1910.

well developed and the zygomatic arch is quite strong. The frontal bone forms a roof over the eye sockets. However, the set-up of the teeth has changed somewhat. Behind the very sharp, cone shaped three incisors, and the somewhat larger canine tooth, there are four intermediate teeth and possibly two genuine molars. The first intermediate tooth has only a simple root. The other has two roots and a very compressed triangular crown, equipped with little spikes on the edges. These were missing in the *Protocetus,* but do exist, as we will see, in the next type. The third intermediate tooth has a similar crown, and also a small interior heel, supported by a third root. The fourth one has not yet transformed very much and it still bears a resemblance with the creodont tooth, and it also has three roots. This is also true of the following genuine tooth, which only has one front and two rear "bi-cusps". The teeth in the lower jaw correspond with those of the upper jaw but none of them has more than two roots. Unfortunately there is no remaining lower jaw left of the *Protocetus,* but that same bone from the *Prozeuglodon* is in good condition and shows a well developed, wide crown protuberance. The existence of this constitutes a correspondence with the creodonts unlike today's whales and proves that the *Prozeuglodon* was using masticatory muscles. The neck vertebrae of the *Prozeuglodon* have become strongly shortened in comparison with the corresponding ones in the *Protocetus*, and this is a development in direction towards the whales, and a departure from the creodont type.

[figure 3]

Yet another intermediate form has been described by FRAAS under the name of *Eocetus schweinfurthi.* This author points out that regarding the teeth, they are approximately in the stage as the *Protocetus* mentioned above, although the last molar has a prickly edge, while the body itself, judging by the look of the vertebrae, was more similar to that of the whales, just as the genus *Zeuglodon*, which was widely spread out among all the oceans during the intermediate Eocene era, as findings in Europe, America, and New Zealand have shown.

From the layers that are slightly above them, in which the *Prozeuglodon* remains were found and which thus are younger than these and pertain to the later part of the Eocene era, DAMES obtained remains of a prehistoric whale, which he in the year 1894 described under the name of *Zeuglodon osiris*. The same species later, on a better material, was described in more detail by STROMER in 1903. It has an elongated, low and evenly sloping cranium with a long nose section, formed by the intermediate bones and the bones of the upper jaw (fig 4). The nasal bones are short, so the nasal orifice is hereby moved far back, even behind the middle of the nose. The frontal bones have frontal wide protuberances, which cover the eye sockets as in today's whales. However, this was something that began to appear already in the *Protocetus*. The occipital crest and the parietal crest are still there, and the neck condylus are more perturbing than in the genuine whales, an indication of a more movable head. The zygomatic bone is a straight plank but thicker than the ones in the dolphins. The long lower jaw has a wide and emergent crown protuberance, which together with the parietal crest is an indication of the *Zeuglodon* having strong masticatory muscles. At the front there are 3 skittle-shaped incisors and a similar cusp tooth. The first intermediate tooth is also cone-shaped and has a root. The three following ones are compressed triangular-shaped with slightly prickled

edges and two roots. The two genuine molars in the upper jaw are also compressed with somewhat prickled edges, but may have a slightly different form.[14] The teeth of the lower jaw are similar, but there are 3 genuine molars. The vertebrae are in several aspects similar to those of the whales, but the spiky protuberances on the frontal thoracic vertebrae are, just as in the terrestrial mammals higher than the posterior ones, unlike the genuine whales. In an American species, *Basilosaurus cetoides* 14 vertebrae and 11 ribs with double connection of the joints have been counted. Several species that have been found, that have been given names based on findings in different countries, have been attributed to the same genus *Basilosaurus* or Zeu*glodon.* Closely related genera have also been lined up due to somewhat different teeth settings or due to a deviating form of the vertebrae etc. As a result of some of these findings we now know that the scapula of the *Zeuglodon* in its general form completely corresponds to that of the whales.

(FIGURE 4)

The brachium is more similar to the brachium of the whales than to that of any other animal, but it has not yet been simplified to such an extent as in today's whales and the joint plank against the underarm is more independent than in the whales, although it can only be used for bending and stretching. These deviations from the whale type constitute a heritage from the creodonts just as the existence in the *Zeuglodon* of a large flat elbow lump.

From the creodonts to these prehistoric whales, the Zueglodontidæ, the last years' paleontological discoveries has clearly shown this transition. There ought to be a complete agreement on this. However, there is some disagreement about whether there has existed a full direct genetic connection between the Zeuglodons and on the timescale immediately following Squalodontidae, which are now also extinct, but are considered to be directly original related forms for some of today's Toothed whales. The most specialized Zeuglodons were fairly large animals, and since we know that the size of animals increases as it develops further, it is quite evident that these large prehistoric whales became extinct already under the later part of the Eocene era without leaving any direct descendants. However, its history of development has been mentioned here, since it clearly shows how it has been possible for whale-type animals to come into being and to come from primitive predators.

However, besides the real Zeuglodons, during the Eocene era there were also other small primitive whale-type animals, which probably had a similar origin. From the Eocene layers in the Caucasus LYDEKKER has based on discoveries made by HJALMAR SJÖGREN, described such a small primitive Toothed whale, which was given the name *Microzeuglodon caucasius*. This form had already obtained triangular shaped teeth with serrated frontal and rear edges. However, even the teeth that were furthest back were separated by space, thus not as tightly pushed together as in the *Zeuglodon*. The number

[14] The decline in size toward the back, which is seen in the genuine molars already in the *Protocetus,* have thus here gone so far so the very rear molar in the upper jaw has disappeared.

of the teeth has however not increased beyond the original number. The brachium looked fairly simple (with a large *crista deltoidea*) and it has two joint surfaces in the lower part for the antebrachium bones, however, it is said that no real joint connection could take place and therefore the front extremities must have been finlike.

This *Microzeuglodon* is considered as a part of the original form of Squalodontidae.

In 1904, another similar primitive form was described from Miocene layers in Sicily by DAL PIAZ under the name of *Neosqualodon assenzæ* FORSYTH MAJOR. This one had between 10 and 11 two-rooted molars. The ones in the back were compressed, triangular shaped, 6-pointed, that is with three small peaks at the back edges and two at the front.

(Figure 5)

However, the frontal ones were 4-pointed with only two small peaks at the rear edge and one at the front edge.

This *Neosqualodon* could be said to be the most original representative of the Squalodontidæ known from Europe.

In 1893, LYDEKKER described an interesting Toothed whale from the Miocene layers at Chubut in Patagonia, which he called *Prosqualodon australis*. In 1899 he obtained more material and better knowledge about this, and last year TRUE was able to add more information to this topic. According to what is now known the *Prosqualodon* had a cranium, which to a large extent is consistent with a broad nosed Toothed whale. This can for example be observed by the strong development towards the rear that has occurred in the bones of the intermediate jaw, and even more so in the bones of the upper jaw, where the latter to a large extent covers the side parts of the frontal bone. However, the back part of the head did not have a round shape, like in today's whales, judging by LYDEKKER's, instead it was vertical, and with an occipital crest. The nasal orifices are quite far back, just like on an ordinary Toothed whale, but the nasal bones are still fairly well developed and protrude as a short triangularly shaped roof over the nasal orifice. The lower jaw has a fairly large and wide crown protuberance with a peak that points backwards. All these characteristics are primitive and point back to ancestors that look similar to the *Zeuglodon*-artadt. This is even more true for the teeth. The frontal teeth are simple and conical, just as the canine teeth. The intermediate teeth have a wrinkled enamel and small bumps. The genuine molars are compressed and triangular shaped with small peaks along the back and front edges as in the *Zueglodon*. They have double roots, which, however these have more or less grown together, which is also the case in certain intermediate teeth, but no complete preserved tooth series has been found. However, it can clearly be observed that the number of teeth as not that large in many later whale forms. LYDEKKER assumes that the *Prosqualodon* had four intermediate teeth and approximately six genuine molars. Apart from this interpretation it is however clear, that there has been an increase of the number of molars (= both the intermediate teeth and genuine molars together), so their number is 10 instead of the for the creodonts' typical number of 7 (4 intermediate+ 3 genuine molars).

The increase of number of teeth, which thus occurred early in the whales, has been the subject of many explanation intents. WEBER presented the theory that the milk dentition and the permanent ones entered into action at the same time, but this is not sufficient. KŰKENTHAL tried to interpret this as a partition of the teeth with double roots into single roots, thus doubling the amount. However, nothing like this has ever been seen, although two roots joining into one has been observed. This is almost really a general norm in the younger Squalodontidæ. Furthermore, one can note that the genuine molars already in the prehistoric whales showed a tendency of reduction and that this reduction continues clearly even among *Squalodon*-forms. Just as ABEL has emphasized, it is likely that the increase of teeth occurs in the region of the intermediate teeth in the upper jaw, and in the rear section of this, but behind the frontal teeth, and also through new formation[15].

During the Miocene era there were numerous examples in all the seas of the whale animal called *Squalodon*, whose teeth have a certain similarity to those of the shark. The *Squalodon* teeth are of varying shapes and forms and they undergo a significant transition during their development. They are pressed together from the sides, with smaller and larger prickles along the sides. Among the older types this prickling of the sides is more profound, and in all it is more pronounced in the back compared to the frontal edge. The frontal edge is at times smooth and in the younger ones, the prickliness will disappear, even by the back edge, although it will remain the longest at the crown's base. The general form of the teeth can vary very much; some may be short and sturdy, others tall and pointed, although all transitions between these extremes exist

The teeth, which correspond to frontal teeth (3) and cusp teeth (1), as well as the front intermediate teeth (4), have only one root. The rear intermediate teeth and the genuine molars, where these have not been reduced, have two roots. The two-rooted teeth's number is from 5 to 10 in each jaw, usually around 7. Of these, only the three furthest back can be counted as genuine molars. Thus, in some way, there has been an increase in the teeth count, as indicated above. Therefore, the teeth formula for the *Squalodon* is 3/3, cusp teeth 1/1, intermediate teeth 8/9 – 9/9, and genuine molars 3/2.

The skull of the *Squalodon* is flattened and rounded towards the back. The nasal bones are reduced, and the nasal cavities have been moved far back, just as in today's whales. These correspond very well, in general, with *Squalodon* regarding the general structure of the cranium. The cervical vertebrae are still free from one other (have not grown together); otherwise little is so far known about the vertebra in general.

[15] Such new formation of the teeth is not anything unique to the mammals. For example in the sea cows there are continuously new teeth being formed, although in another manner. They appear behind the molars and the whole row of teeth is pushed forward if necessary. The have also been some increase of teeth in some armadillos.

During the upper Miocene era the reformation of the Squalodontidae's teeth continued, thus several transitional forms have been obtained, which link them to the Toothed whales of today. It is in particularly the Austrian ABEL'S extensive research that has brought clarity on this, and the most and best material has therefore been found in Antwerp.

First of all, the form so typical serrated for the *Squalodon* of the frontal and back edge of the teeth disappears. At first it is reduced to a strip similar to a pearl necklace, and then it continues over into a sharp edge. The teeth crown becomes more and more cone-shaped, and the root becomes proportionately longer and thicker (both regarding the dentine and cement layers). The roots of the two-rooted teeth blend, so from the former separation in two, only a longitudinal groove can be noted on the interior and exterior sides, and eventually even this will disappear.[16] The number of teeth increases and the teeth from the upper and lower jaw connect with each other, thus forming an excellent catch apparatus. The genus *Scaldictus* provides examples of this transition. The older ones (e.g. *S. patagonicus*) of these species were not really larger than the *Squalodon*-forms, but the latter are believed to have been of approximately the same size as cachalots (e.g. *S. caretti*). Among the Miocene genus *Physeterula* (from Antwerp), in connection with the simplification of the teeth, the enamel disappears completely just as in the Cachalot. Already during the Miocene era, the development came so far that the *Prophyseter* (from Antwerp) completely lacks teeth in the intermediate jaw, and the ones in the upper jaw bones also appears to have had a propensity of falling out early. In the Miocene *Placoziphius* (from Belgium) the teeth had completely disappeared from the upper jaw, and it had practically reached the same stage as in today's *Kogia*. The development from *Squalodon* to cachalots began in the intermediate Miocene era and was finished before the upper Miocene era, as ABEL has pointed out.

The development of the beaked whale happened just as fast. After the Squalodontidae had transformed so far that their dental set, as already mentioned, consisted of simple single-rooted teeth, in some forms a reduction if the teeth took place in another manner and in connection therewith a very uneven reduction of certain teeth. This change was probably caused by the animals starting to live mostly or only of octopus, which did not require a sturdy set of teeth. In the Miocene whale *Palæœoziphius* (from Antwerp) one can find on each side of the lower jaw 12-13 simple and single-rooted teeth. Out of these teeth, the first and seventh pair are larger than the others. In an American form *Anoplonassa* from Savannah, Georgia, there are also two of the tooth pairs that have developed into a more significant size, while the teeth in between, if judging by the small size of alveoli, already have become rudimentary. The next stage can be seen in the *Mioziphius* from Belgium, of which ABEL investigated the remains of no less than approximately 50 craniums. Here the alveolar pair is bigger, and the rear pair has moved up closer to the tip of the lower jaw in comparison to the former ones. The alveolar grove between the two pairs of teeth is empty and open, just as a part behind the other pair. It's only behind these that there are some small alveolar for rudimentary teeth. In the

[16] According to KŰKENTHAL it still exists in the embryonic stage.

frontal alveolar, there is also a particular mechanism, which is very similar to the corresponding situation in today's genus *Beradius*.

The teeth in the upper jaw are overtime reduced without leaving any enlarged pair of teeth. In the *Mioziphius* there were still 48 small tooth alveolar in the upper jaw, in the *Choneziphius* in the upper Miocene era, a small amount of rudiments of such and already before the Miocene era had ended, the still existing genus *Mesoplodon* had already formed.

ABEL has shown that there are yet two other form series that develop from the Squalontids. The representatives of one of these are now extinct and therefore it will suffice to remember that it leads to a couple of groups of unparalleled long-beaked dolphins. The *Eurhinodelphis* for example had a "nose/beak" which was 9/11 of the whole head. It is in particular the toothless intermediate jaw, which is so enormously elongated, which indicates something particular in its way of living. The other of these last mentioned series begins with a small Squalodontid*, Microsqualodon,* from the Miocene layer of northern Italy, and then first transforms into the *Acrodelphius* type, which has only finely prickly teeth. The teeth then go through some additional changes in the Miocene *Delphinodon*, which still shows some weak remains of double tooth-roots, where the saw tooth form of the teeth edges have been replaced by some basal enamel folds. Through yet another intermediate form *Cyrtodelphis* we get to the *Inia* of today, which lives in the Amazon river and has single-rooted teeth. The rear ones have a basal bump on the inside, but not the frontal ones. The enamel is sort of folded alongside all *Inia*'s teeth. It is commonly reported that all the teeth of the closely related *Stenodelphis* in the La Plata River are similar, with a lump-formed thickening below the crown. Very recently (1909), TRUE has however pointed out that at least in the younger animals of this genus the teeth show several characteristics, which could only be interpreted as primitive features inherited from its ancestors. TRUE established that ten to twelve of the very rear tooth pairs, both in the upper and lower jaws, have crooked, somewhat spade like crowns with wrinkled enamel, which will raise more or less "linear denticles" on the inner surface. Each tooth in general has a small cusp in the middle and traces of another one on each side.

The American zoologist quoted above has observed, in the same way that the white whale (*Delphinapterus*) also have some teeth with two cusps. He says that at least four of the rear teeth in the lower jaw, on each side, and possibly also some from the lower jaw are in reality tritubercular when complete. The crowns of these teeth are somewhat flattened on the inside and bent inwards with the cusp. Both towards the front and also behind the middle point, there is a line-formed bicuspid, which does not reach the same level as the middle cusp. A study of the white whale material existing at the National Museum [Riksmuseum] sheds more light upon this and clarifies several important and interesting details regarding the white whale's teeth. If one looks closer at the unused teeth of a newborn white whale, one will find that it has about 9 teeth in each jaw half. Their positions indicate that no frontal teeth are part of this set, since there are no teeth in the intermediate jaw's bones, and none in the pointed part of the lower jaw either. Here are no cuspids either, at least not in the upper jaw, since the first teeth there sits quite far

behind the suture between the upper and intermediate bones, meaning that it is the most frontal intermediate tooth. Consequently, the 9 teeth that the white whale has can thus only consist of intermediate teeth (premolars) and possibly genuine molars (molars). However, since we have found above that the molars already in the original whale forms have a tendency of becoming reduced, it is most likely that these 9 teeth in the white whale all correspond to premolars, which as stated above, already in the *Squalodon* had increased to this specific number. But the similarity is not limited to the amount. A closer review of the white whale's tooth crowns – which are not at all worn out- as shown in by the picture (figure 5), which speaks clearer than words, that most of them bear an unmistakable correspondence with the *Squalodon* teeth, in the way there are compressed from the sides, and that the have a number of small cusps, more or less clearly developed. This correspondence becomes even more obvious, if we remember that the large reduction of the teeth that occurred in the white whale, with the tooth crown in the process of transforming into rudimentary organs. They are actually very small, usually only about 2 to 3 meters wide and not even the double in length. This crown sits as a wart on the much thickened root, which is still growing and becoming pushed forward, and then shortly, after the little crown has been worn out, by itself it forms the sole functioning tooth in the adult white whale. Consequently, there are no difficulties in deriving a set of teeth such as that of the white whale, from a Squalodontid, only by assuming that the former is a reduction of the latter, which is still ongoing. Several characteristics of the white whale, such as the free cervical vertebrae, the absence of a dorsal fin, the short and broad shape of the pectoral fins, etc. are indications of a more primitive form, whose direct tracing from one of the Miocene era's whale forms does not appear to signify any illogical straining of the material's evidentiary strength.

(Figure 6)

Among the now living dolphin animals, the porpoise and its genera hold quite an original position, which can be noted by the fact that its parietal bone is still slightly visible in the middle of the cranium, and also because of the compressed form of the teeth, and the remains of a carapace. A few years ago ABEL, on one occasion when working with a finding made by ANDRUSSOV in layers from the intermediate Miocene era on the peninsula of Taman (Black Sea), was able to show that the porpoise type goes all the way back to the time period of the tertiary era. The discoveries in question belonged to a genus that ABEL called *Palæphocæna*, which is closely related to today's *Neophocæna* and *Phocæna,* although as is expected, they give a somewhat more archaic impression. For example their parietal bones are more visible on the upper side of the cranium, and also less covered by scale bones on the sides etc. Just as what can be expected of a more original form, the *Palæphocæna* was smaller and its body length was only a meter.[17] Some older discoveries than these, which could be directly connected with the porpoise, have not been found. Unfortunately, there are no dental remains of neither the *Palæphocæna* nor the upper Miocene *Protophocæna* (from Antwerp) and therefore it is not known if their teeth were as in those of the porpoise of today, or more similar to those

[17] Another just as small prehistoric or original porpoise, the *Protophocæna minima*, has been described by ABEL from the upper Miocene layers at Antwerp regarding the frontal part of a cranium. From the upper Miocene JOH. MÜLLER described remains of a carapace-covered porpoise-like form, the *Delphinopsis freyeri* , which might also be part of this series.

of earlier forms of the Squalodont type. A porpoise that lives in the Black Sea and the Asowska Lake has recently been described by ABEL by the name of *Phocæna relicta*, since it is a relic form from the time when these waters constituted part of the large Tertiary Sarmatian Sea. The porpoise relic has according to ABEL a few teeth that are different to those of the usual porpoise. Only the most rear 5-6 teeth in the former have such a spade-shaped crown like that of the latter. In the others, the difference between the root and the chisel shaped crown is only marked by a shallow declivity. The same thing is sometimes also observed in the common porpoise; the widths of the tooth crowns vary quite a lot, just as the general appearance of the teeth. Sometimes they are simple, and sometimes more complicated, but the latter state is with no doubt the original one, and it leaves a connection to the condition of the ancestors of the tortoise. When the teeth are wide, their edge – in particular at the top – fairly clearly "crenulated" [? Swedish – "crenelerad"], just as some of the Squalodont teeth have been described. The inside of the tooth is not smooth either, instead it shows two longitudinal groves (figure 7), which is said to divide the tooth in three parts.[18] It is not unusual to see the same situation on the outside. Even if this is an indication of a more original situation, in particular when one finds in some of the back teeth that the middle section of the tooth crown protrudes more or less as a clear inner heel.[19] It is not unusual that the teeth all the way at the back, show an irregular somewhat bumpy crown (compare figure 8). However, all these characteristics vary, and cannot be found in every porpoise, and always vary when they are indeed there, which is natural since here we are looking at rudiments, which suggests that the porpoise's origin is from forms with multi-cusped teeth, and which at least in this part is similar to the Squalodontidae.

The paleontology has not yet provided any direct testimony on how more specialized forms of dolphins have developed. However, one could most likely assume that their development has occurred in manner analogue to the forms mentioned. But the differentiation their earliest ancestral form occurred earlier. In the dolphin genus *Steno* the enamel cover of the teeth is sort of wrinkled with furrows, similar to the condition of certain Squalodontidae. Moreover, in a young Pilot whale at the National Museum (Riksmuseum) some of the teeth, which were not yet worn out, were equipped with a pretty strongly wrinkled enamel. It is not unlikely that by studying the unworn teeth of young toothed whales, in particular the ones where the teeth have not multiplied, similar phenomena as the ones for the white whale mentioned above, might appear. Unfortunately, such material is very rare and difficult to obtain.

[figure 7]

[18] KŰKENTHAL has also observed a similar "division into three" in the porpoise's teeth.
[19] Occasionally, findings of teeth grown together in the Porpoise occur, just as KŰKENTHAL had exposed.

[Figure 8]

The origin of the Baleen whale is less clear. It is impossible to imagine that they could be derived from any type of toothed whale, since they have all gone further in their specialization, in some cases regarding the reduction of the nasal bone etc. The same is true for the Squalodontidae. However, on the other hand, the numerous tooth rudiments found in the Baleen whale's fetus prove that these whales descend from teeth bearing animals and from forms that for some reason have obtained the simplified structure of the teeth of the primitive animals (frontal 3/3, cuspid 1/1, premolar 4/4, molar 3/3), but to much higher number. These are conditions that often come hand-in-hand. One has to imagine a first original mammal; probably having the creodonts as a first starting point. There are so many similarities between the Toothed whales, in particular the Zeuglodons, and the Baleen whales, that this cannot only be caused by a parallel development, by adaptation to life in the water. While the Zeuglodons developed into fish eaters and predatory marine animals, one has to imagine that the earliest ancestor form of the Baleen whales – which undoubtedly were close to these - began feeding on smaller water animals,[20] such as small shrimp-type crayfish animals, such as *Mysis*, which are very frequent by the coastlines. Well-developed teeth were thereby of no use, and were consequently reduced. But when the animals ingested the smaller organisms into their mouths, it had to be taken in together with the water. Then the catch could best be retained by pressing the tongue against the palate, whose crosswise folds already from the beginning were of great use for this purpose. It is the case that the creodonts have had well-developed palatal folds; since such exist in all mammals, unless they for a secondary basis of particular reasons have been eliminated through reduction (such as specifically in the Toothed whales). But they do exist in the predatory as well as in the cloven-footed animals. Through the exterior stimuli that the palate fold was exposed to, through this kind of nutrient intake, it was spurred into further growth and further differentiation through natural selection. Once they had developed so far that they were able to function as a strainer, that is, having become baleens, the animals through this help received such abundant nutrition that their growth was strongly furthered. It was able to continue growing since the water is a load-bearing element, which does not present any impediment for the increase of body weight, and the Baleen whales thus reached the giant size they now have which widely exceeds all terrestrial animals.

Already during the Miocene era there were unmistakable Baleen whales. Thus, while the majority of the Toothed whales were still at the Squalodontidae stage or had only comparatively differentiated themselves from this stage, the type of organization of the baleen whales had already developed almost into what it still is today, although not yet as specialized. This fact proves that the Baleen whales cannot have been derived from the Squalodontidae, and the same thing can furthermore be seen by the fact that the latter in many aspects are more transformed and show more deviations from the central mammal type than the Baleen whales, e.g. regarding the development of the nasal bone etc. If we

[20] Certain analogy regarding the habits and the accompanying differences in mouth equipment can be made by referring to the ducks, and by looking at the fish-eating teeth-beaked Mergansers and the ducks with a strainer in the beak.

look at the well-preserved cranium of a Miocene Baleen whale from Argentina, *Cetotherium moreni* LYDEKKER, we shall find that a nasal bone in this animal has a substantial length and constitutes approximately 1/8 of the whole cranium's length. It is therefore longer than in the Baleen whales of today and its shape reminds us of the *Zeuglodon*'s nasal bones, just like the entire cranium with its flat elongated form, the extent of the frontal bone, etc., remind us of the corresponding parts in the first original last mentioned. Taking all this into consideration, this supports the hypothesis expressed earlier that the Baleen whale is derived from forms, which just as the Zeuglodons, and partially parallel with them came from the creodonts.

Now, all that remains is to very briefly touch upon two questions, which do not lack importance, namely the reason why the original whale suddenly appeared, and its fast development during the Eocene era, and then its disappearance and extinction, which was just as sudden while what we could call the side sprout remained and has developed in different directions. Regarding the first of these questions, the English paleontologist Dr. ANDREWS has no doubt correctly indicated the extremely important circumstance that at the end of the Mesozoic era and before the beginning of the Eocene era, the large number of all sorts of large marine reptiles (*Ichthyosaurs, Plesiosaurs, Mosasaurs* etc.), that during the secondary era swarmed in the seas, had become extinct, although the reasons for this are unknown. The only vertebrates living in the Eocene sea were really just fish, and a few Rhynchocephalian lizard forms. Consequently, it was clear that if any kind of terrestrial mammal were to adapt to life in the water, the opportunities were to be extremely favorable for development, not only due to the relative freedom from strong and dangerous enemies and competitors, brought about by the extinction of the maritime reptiles, but also due to the abundance of food, in the form of fish and lower animals, that were present readily available just like food on the table. It is also clear that this nutritious supply was going to have a power of attraction on the primitive predators of the creodont's group, which were looking for their food along the coastline. Naturally they were striving to become part of the richness of the water, probably first in the swamps and shallow waters around the mouths of rivers and similar places. But as their adaptation to life in the water improved and became more complete in the way that has been described above, they were able to go further into the oceans on their excursions. Eventually the water became more and more their new home, and finally they became completely independent of the land where their ancestors had lived. It even became so strange and dangerous to them, so they had to avoid every contact with it.

Once again, the reason why the first original whale, the Zeuglodon, became extinct as quickly as it had appeared is most likely due to its lacking ability of continued development and adaptation, after reaching a certain stage, and obtaining a more significant size. They pertained to a low type, which could not be further perfected. This can be noted from their insignificantly developed brain. Knowledge of this has been obtained by a natural casting of a *Zeuglodon*'s brain found in Fajum in Egypt, and also through another casting, which DR. ANDREWS has succeeded in making at the British Museum, with the assistance of a *Zeuglodon*'s cranium. Both these castings; the natural one and the artificial one, have been studied and reproduced by PROF. G. ELLIOT SMITH. In this way, we have now come to realize that the *Zeuglodon*, just as a large

number of now extinct mammals, had a very small and extremely low organized brain. With its relatively large cerebellum, but with a weak cerebrum without any convolutions or with stalked olfactory lobes, it is very similar to a reptile brain, and its weight has been calculated to be significantly less than 400 grams, perhaps even closer to 300 grams. As a comparison it is important to remember that the brain in today's whales has plenty of deep convolutions and has a significant weight. The brain of a fairly small Toothed whale, the *Tursiops*, weighs 1.886 grams. However, the head of the latter is somewhat smaller than the head of the *Zeuglodon.* It is not possible to carry out any other comparison, but the inferiority of the first original whales is clear in this regard. However, it is likely that also other circumstances have contributed to the extinction of the first original forms, although this is not known at this time.

In spite of the unfortunate incomplete data in the paleontologists' records, one can however, thanks to the last years important discoveries, say that one of the most specialized and transformed groups of mammals, the whales, have been linked, through clear intermediate forms, to the genealogical tree of the central mammal type, and evolutionism has hereby gained yet further support for its general applicability.