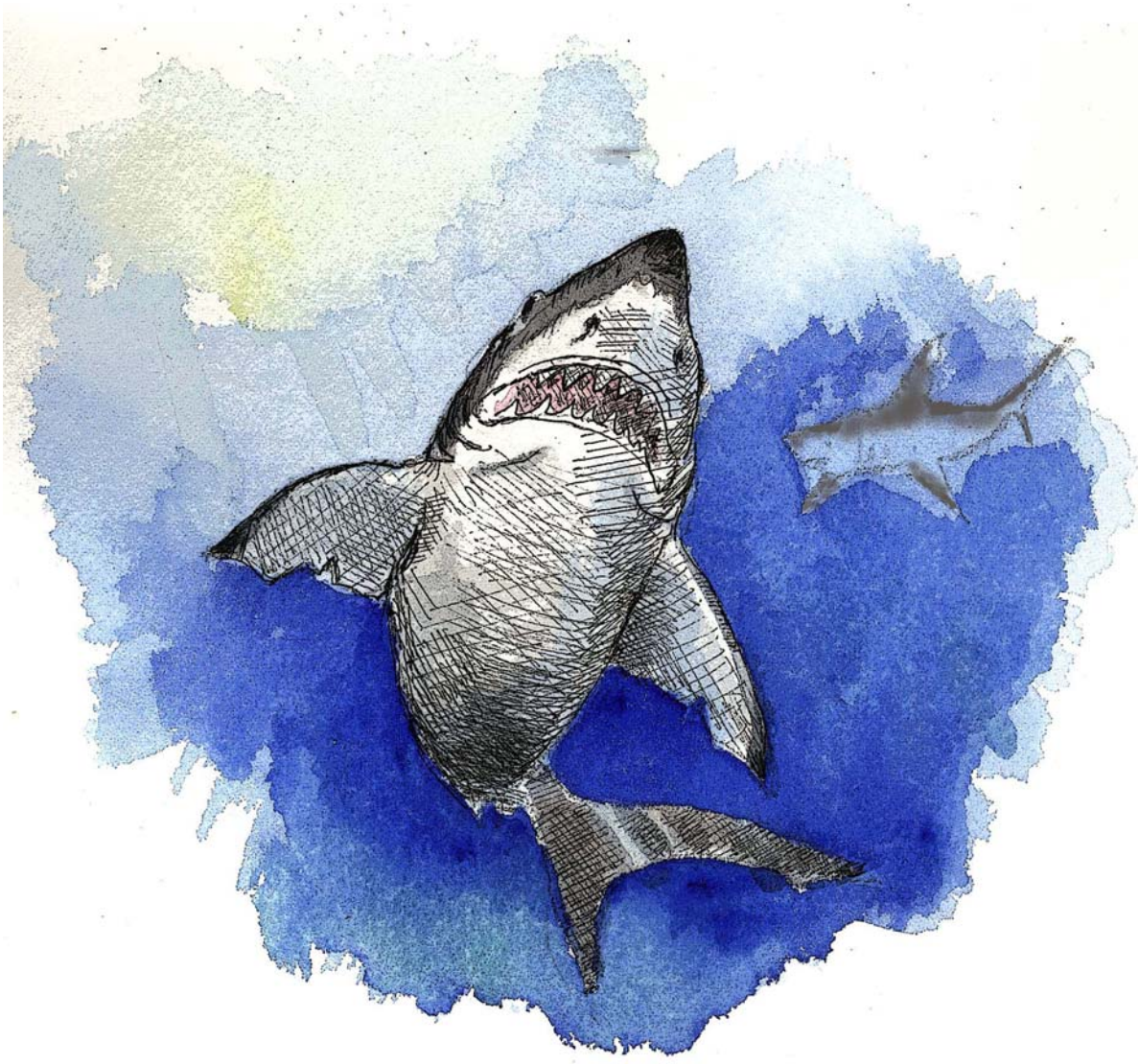
Sharks
Past and Present



A compilation of shark and ray information

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Drawings by Takashi Ito

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Introduction

Fossil Shark Teeth

The most common vertebrate fossils found in Florida Neogene deposits are shark teeth. These fossilized marine animals are the focus of this book.

We have photographed and classified over 200 of their remains. We will discuss their geology, their scientific classification and the methods used to preserve, catalog and study them. We hope that this book will give it's readers a better understanding of the sharks that inhabited the shallow sea that covered Florida a million years before the seas receded and man engulfed the land.

About This Guide

The principal objective of this guide is to help fossil collectors identify teeth they find and to classify them as to both their scientific and common name. To this end we have photographed 100's of specimens of shark teeth found in fossil shell beds, outcroppings, gravel bars in the rivers and specimens collected worldwide.

Compare the specimen you find with those illustrated in this guide. If you match your tooth with one pictured here, you are on your way to identifying the species of shark.

We have included a discussion of the method (the binominal system) used by taxonomists to assign fossil animals into scientific categories, i.e.: family, genus, species, etc. There is a faunal list, which places each animal in this guide into its proper scientific category.

One of the most important responsibilities required of you for your collection is that you catalog your finds. Otherwise it will have little scientific value. Record every item of information you can accumulate about your fossil and the site where it was found. Assign a number to each fossil you find and paint that number on the specimen with white paint and India ink.

There is a discussion of the recurring glacial and interglacial periods that were the primary cause of the variations of the Florida shoreline during the Neogene. These eustatic changes had a profound effect on all vertebrate life in Florida during the Miocene, Pliocene, and Pleistocene Epochs.

Modern Sharks

Sharks are among the most successful predators in the sea, with few known enemies and an evolutionary history dating back more then 400 million years. They exhibit extreme diversity in form, behavior, and the habitats they occupy. One of the oldest living creatures in the sea, sharks are among the world's most successful and diverse groups of animals. The earliest evidence of sharks is isolated pieces of spines, teeth and dermal denticles that appeared about 430 million years ago in the Silurian Period, known as the "Age of Fishes." Sharks appear to have changed very little since prehistoric times, and the only important visible change is their size. Like dinosaurs and other creatures living at that time, early sharks were gigantic. One of the ancestors of the shark reached lengths of more than 60 feet (24.4m). Over millions of years, sharks have adapted to their environment and the largest predator shark now reaches lengths of only about 25 feet (7.62m). By studying shark fossils and comparing them to the sharks of today, scientists now predict that the shark is as developed as it is going to become for many years.

This is still saying a great deal. Some people have described sharks as “swimming computers” because they are so successful in adapting to their environment. Not only can they smell, see, feel, hear, and taste, but sharks have at least six different sensory systems active at any one time in order to find food, be aware of the surrounding environment, and even navigate over great distances. Some sharks can sense a mammal from a distance of nine feet, using two unique, highly sensitive monitoring systems called vibration detection and electro-reception. Shark's eyes, which can distinguish colors, employ a lens up to seven times more powerful than a human's. In addition, sharks have a highly developed sense of smell, they grow new teeth as the old ones wear out, and they are not prone to get certain diseases such as cancer.

Some sharks have been named after other creatures, such as the crocodile, zebra, bull, tiger, cow, cat and dogfish sharks. Some are named for their colors, the Great White, Blue, Blacktip, Whitetip, Copper, Silvertip, Grey Reef and Lemon. The Angel, Goblin, Carpet, Spinner, Hammerhead, Thresher, Basking, Megamouth, nurse and cookie cutter shark are named for their appearance or for their behavior. Thresher sharks have extremely long elegant tails, which they use to thresh or stun their prey, rounding them up into groups that can be fed upon more easily. Angel sharks have small triangle-shaped wings which look fancifully like angel wings swimming through the water.

The deep sea holds many startling species of sharks about which relatively little is known. One shark, the dwarf shark, is fully grown at only six inches, and another dubbed the "cookie cutter," has a round mouth with large wedge-shaped teeth which it uses to carve out plugs of meat from large fish. The eyes in these deep-water sharks are often emerald green and adapted to see the luminescence of other animals that also dwell where sunlight never reaches. Almost all sharks can be considered flesh eaters, although a few, like whale sharks, feed by filtering the water for plankton and small fish using gill rakers. The degree of specialization in feeding is indicated by the shape and size of a shark's teeth. Thin, pointed teeth, as in the Shortfin Mako shark, are for grabbing and holding prey; serrated, wedge-shaped teeth for cutting out big mouthfuls are found in the great white shark; small conical teeth help the nurse shark crush prey such as crabs and mollusks.

Shark's teeth form in several parallel rows, one behind the other in the shark's mouth. As teeth are lost, new ones replace them throughout a shark's life, the average shark will grow 30,000 teeth in a life time. Studies by Mote Marine Laboratory (Mote) scientists have shown that, on average, small nurse sharks will, one tooth at a time, replace an entire front row of teeth every 9-21 days or so in summer. In winter when they are feeding less and their metabolism slows down, they replace an entire row every 1-2 month. Altogether, there are more than 350 species of sharks. All have certain anatomy in common, most notably the fact that their skeletons are made entirely of lightweight cartilage, as contrasted to the bony fishes, whose skeletons contain true bone. Unlike most bony fishes, sharks do not have a swim bladder, and will sink to the bottom if they stop swimming. Typically, sharks pull water in through their mouths and spiracles (small holes on top of the head in some species) as they swim, and pass it through five to seven gill slits on each side of the head. As water passes over the gills, oxygen is extracted.

Unlike humans, or most other animals, sharks can reproduce in various ways. Some female sharks carry their babies inside the body while they develop, sometimes for more than a year, until they give birth to live young. Other sharks develop inside an egg case, which the young must break open. This egg case may be laid or may remain inside the pregnant female. Once they are born, juvenile sharks spend the early portion of their lives in nursery grounds, which are protected, shallow areas in bays and estuaries. Although sharks are some of the most fascinating and fearsome creatures of contemporary fact and fiction, we still know very little about them. These fast-moving predators roam, silent and unseen, throughout the world's oceans. Observation in captivity teaches us very little about their actual behavior, and our ability to follow them on their travels is very primitive. Fins, scuba gear, shark cages and even ships are quickly left behind with one flick of a powerful tail. Even now in the 20th and 21st centuries, we are just beginning to uncover the mysteries of these magnificent, prehistoric fishes.

Only one serious predator threatens the shark's survival, which goes backs 400 million years,: humans. Commercial and sport fishermen take more than 1,000,000 sharks a year from the Gulf of Mexico alone. Each year fewer than 75 shark attacks on people are reported, most of which are not deadly. Clearly, we are much more dangerous to sharks than they are to us.

Fossil Shark Teeth

About Fossils

Fossils represent the remains of once living creatures and plants, or those representations formed by the actions of once living organisms. For example, the bones of a dinosaur are fossils and so does a dinosaur make the footprints in wet sand or mud. There are a number of ways organisms can fossilize and be preserved for vast periods of time. These include freezing, mineralization, recrystallation and replacement. Most of the vertebrate fossils found in Florida are the result of mineralization, a form of fossilization that turns bone into stone. Water percolating through the bones removes the organic hard part and substitutes a different mineral for the original mineral matter of the bone. The resulting fossil has the outward appearance of the original bone but have a substantially different chemical composition. The most common minerals are silica and iron compounds.

Cleaning & Preserving

Most of the bones found in south Florida can be cleaned with warm water and a stiff brush. If the specimen has a calcareous matrix adhering to the bone it can be dissolved with a solution of 15% acidic acid or by vinegar. Then rinse thoroughly with warm water. When the bones are completely dry they should be impregnated with a preservative. The most useful
Preservatives are solvable plastics. Butvar dissolved in acetone is the preservative most widely used by Florida paleontologist. For use in gluing together broken bones use a thick solution of Butvar and acetone to glue the breaks. If the breaks are glued badly, acetone can be used to loosen them and they can be repositioned properly. Other alternatives are 527 glue, DUCO cement dissolved in acetone or water solvable white glue such as Elmer's Glue dissolved in a small amount of water**.**

Where to Hunt

Almost any excavation in south Florida will bring fossils of some kind to light. The more extensive the excavation of a site the better chance you have of finding fossils. There are a number of marl pits in south Florida that continually produce thousands of magnificent fossil shells. Vertebrate fossils are relatively scarce but any dig may uncover a good deposit of bones. One note of WARNING, the owner of these pits will not tolerate trespassing.

DO NOT ENTER PRIVATE PROPERTYWITHOUT THE OWNERS PERMISSION

In the state of Florida it is a Felony to trespass on a construction site. Seek permission from the proper authority before venturing onto any property. Another approach to fossil collecting that is rapidly gaining popularity is scuba diving and snorkeling in the rivers, creeks, lakes, and just off shore in the Gulf of Mexico. There are even organized fossil dives available from Venice area dive shops. This is a very productive way to collect vertebrate bones and teeth. Most waterways are on public property, and collectors are required to obtain a permit to collect there.

LIFE IN FLORIDA'S NEOGENE SEAS

This book describes and illustrates the fossilized remains of the Sharks that inhabited the shallow seas covering much of Florida during the times of warmer temperatures when glacial ice retreated from great areas of North America. These shallow seas were an inviting home to a rich variety of marine life both vertebrate and invertebrate that lived there during warmer parts of the Neogene. The Neogene is the time span from the Miocene to the Pleistocene Epochs 25 million to 2 million years ago.

There is much evidence that large scale variations of the water level of these seas occurred as the continental ice masses waxed and waned. Sea levels during the last 15 million years fluctuated between 30 meters (90 feet) above and 100 meters below modern levels. Because of this predominant influence of the sea throughout the geologic history of Florida, it is not surprising that the great majority of sediments found in this state are Marine in origin. These marine sediments document a fairly complete record of the marine life homesteading Florida for the last 45 million years of geologic time. The most abundantly fossilized marine vertebrates are the sharks, rays and dugongs (extinct mammals related to the modern manatee). Not as common are the cetacean (Whales), porpoises, walrus, and a great variety of bony fishes. Most genera of the sea animals survive today although many of their species have become extinct. It is apparent that they were not as effected by the same climatic deterioration that decimated the land mammal fauna of Neogene Florida and its "here again gone again" eustatic sea.

GLACIAL & INTERGLACIAL PERIODS OF THE FLORIDA NEOGENE

EPOCHS	GLACIAL & INTERGLACIAL STAGES	SEA LEVEL
RECENT PLEISTOCENE	POST INTERGLACIAL STAGES WISCONSINAN	HIGH LOW
	SANGAMONIAN INTERGLACIAL	HIGH
FT. THOMPSON	ILLINOIAN GLACIER	LOW
BERMONT CALOOSAHATCHEE	YARMOUTHIAN INTERGLACIAL	HIGH
	KANSAN GLACIER	LOW
AGE: 10,000 - 2 MILLION	AFTONIAN INTERGLACIAL	HIGH
	NEBRASKAN GLACIER	LOW
PLIO MIOCENE	PRE-NEBRASKAN INTERGLACIAL	

HIERARCHIES OF CLASSIFICATION

Some method of distinguishing one particular animal from among the millions of diverse life forms is necessary; this is done by a system that names and classifies all animals. It is called the binomial system. In this system each, which is considered a different type, is given a name consisting of two parts, a specific name and a generic name. The specific name denotes the species and
is always written with a small letter.

The generic name denotes the genus to which the species belongs and is always written with a capital letter. A genus is a group of species, which has similar features that are closely related. There are other categories used in the higher classification of animals. Just as related species comprise a genus, so related genera make up family related families, an order, order a class, and class a phylum.
Here is an example to illustrate the classification of animals. The great white shark is classified as follows:

Phylum: Chordata
Subphylum: Vertebrata
Class: Chondrichthyes
Order: Selachii
Family: Lamnidae
Genus: Carcharodon
Species: carcharias

For the paleontologist the binomial system has a serious flaw. Although the species is the basic unit in this system on classification, science has no satisfactory definition of species that can be applied to fossil animals.

As a result taxonomists arbitrarily create new species or subdivide existing ones. They can and do change the names already assigned to many fossil animals. These names are called "synonyms" and they are a serious problem for paleontologists. An example of this is giant sloth named
Eremmitherium mirabile by Leidy in 1855 and it has been given thirty names changes since that time. This synonymy problem has plagued systematizes from the very beginning and will do so until the very end-------when ever that is.

There are a number of valid reasons why some revising of generic and specific names is necessary. The taxonomist who believes he is the first to name the fossil may be unaware it has been previously described under a different name by an earlier work. Since the first name proposed has priority, secondary names are invalid and become a synonym. On occasion a fossil is given a name, which unknown to the author, is already in use. When this type of error is discovered a new name must be chosen. Changing the name of a fossil usually represents a refinement of scientific knowledge, but sometime it is just an arbitrary decision made by a single over ambitious worker.

The Evolution of Sharks

Most of our planet is ocean...

Earth is the pelagic planet and the principle apex predators of that realm for the last few hundred million years have been sharks.

The ancient relatives of modern sharks appeared in the seas about 400 million years ago. The oldest of these sharks are known only from isolated teeth embedded in rocks of the Late Middle Devonian period (about 380 million years ago). The most impressive evidence of the earliest sharks is from the Cleveland Shale's of the Late Devonian (about 360 Million years ago) and related formations in Kentucky and Tennessee. Teeth, vertebrae, and rare impressions of skin, kidneys, and muscles discovered in the shale's from along the shores of Lake Erie provide an excellent picture of the primitive shark known as Cladoselache.

As it is presently understood, sharks go back through the fossil record some 400 million years. As far as the fossil record shows, sharks represent the earth's first fully jawed vertebrates. Sharks have survived at least four global mass extinctions that knocked 80% of the planets mega-- fauna into extinction. Sharks live today in essentially the same structure, form and function as in the times preceding the rise and fall of the dinosaurs. Sharks in very similar forms to shark of today actually predate trees.

Having survived the last 400+ million years, sharks have acquired many remarkable features. While often described as "primitive" sharks are and always have been on the cutting edge of the biotic arms race. Sharks are a cosmopolitan species, with many makes and models. The endothermy, electro-sensory apparatus, and the optics of several species are all better than top of the line, they are superlative. Indeed a 1200 lbs Mako shark slow cruising the open seas at 6 knots certainly represents an apex predator at the top of the food chain, but sharks can also be found at all levels of that vast chain. Whether the setting is benthic, pelagic, sub-tidal, or estuarine, there is a specialized shark for that environment. From the tiny cigar shark to the massive whale shark, sharks are a formidable biotic mode.

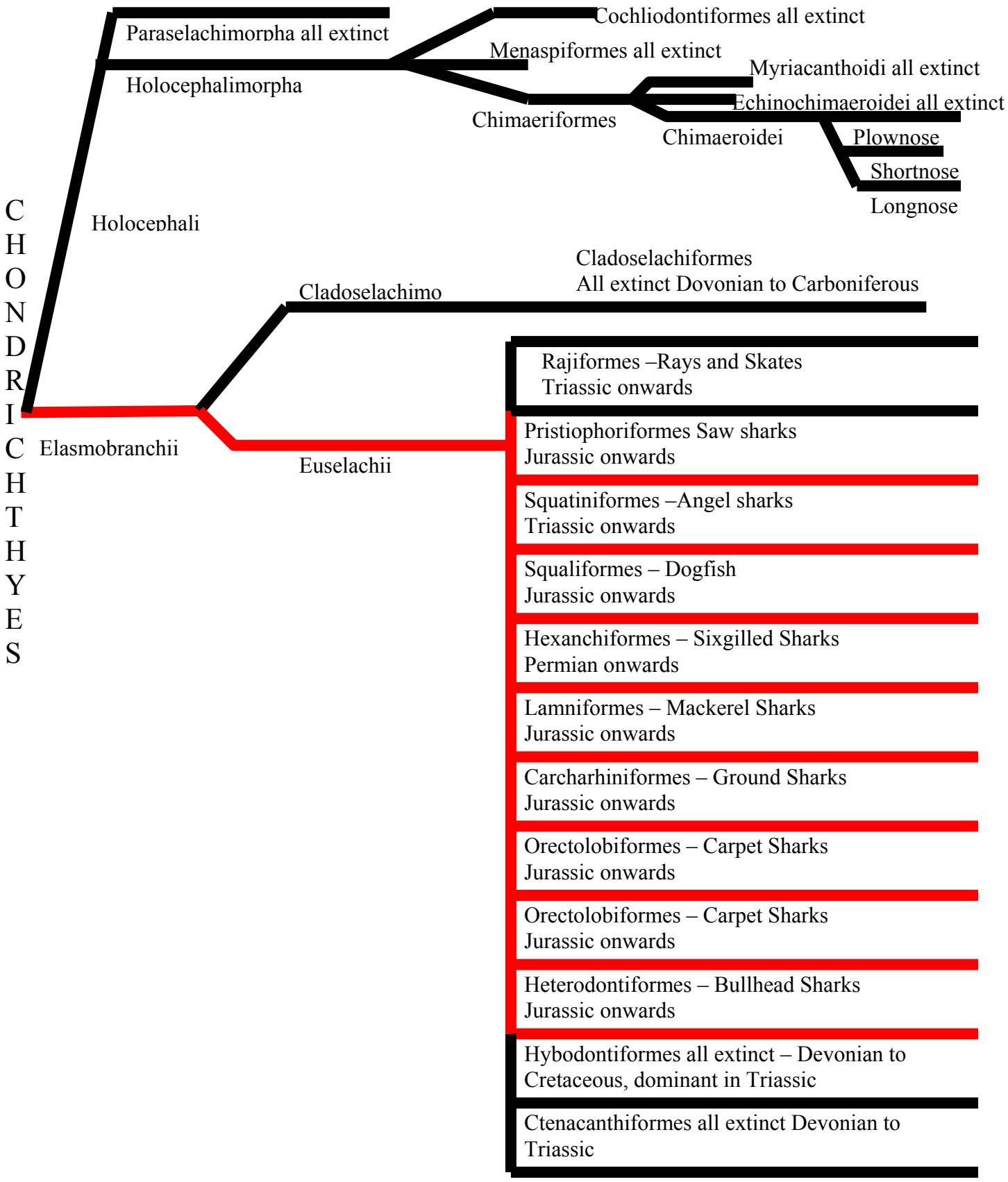
Sharks are nearly impervious to infections, cancers and circulatory diseases and have shown the ability to heal and recover from severe injuries while healing rapidly. It is believed that these are features that sharks have acquired through surviving all the mass upheavals of the last 400+ million years of natural selective chaos. The down side of this mode is long life and slow rate of maturation and reproductive turnover, quality over quantity.

Compared to other fishes like salmonids or tuna that may lay millions of eggs, sharks typically have litters of a dozen or so, but some species can have as many as 136 pups or as few as 2. Sharks have been able to get away with this because of the quality of the product but when bi-pedal primates (humans) introduce huge artificial pressures (gill-nets, long-lines) the curve is ruined and sharks are at a sudden and decisive disadvantage.

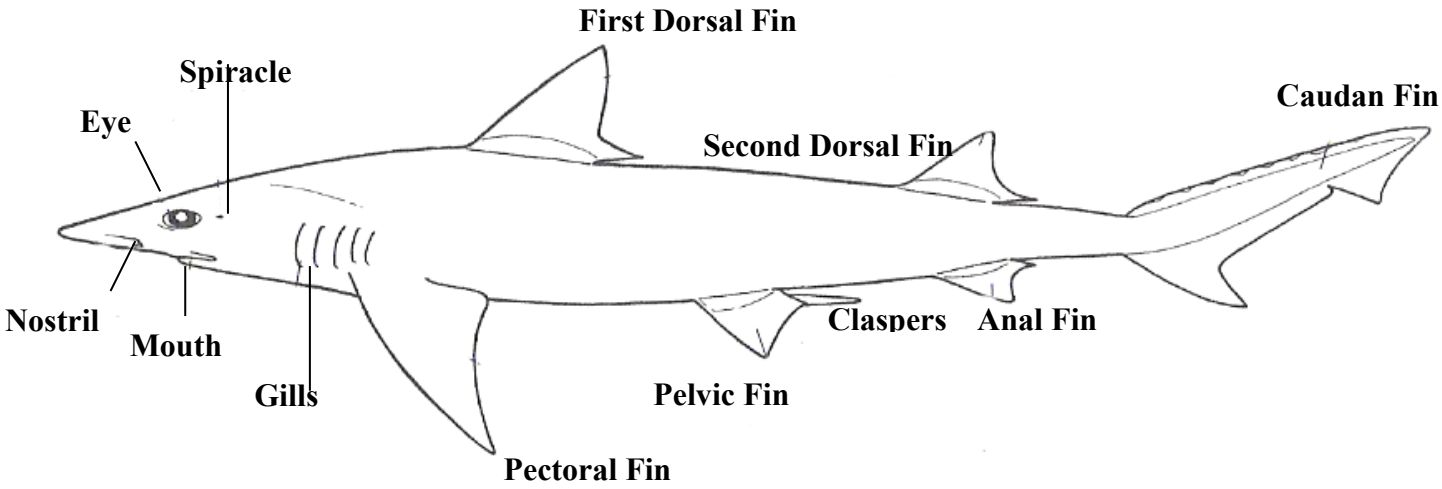
Most species of sharks give birth to live young whose eggs were hatched internally. Some species drop egg cases of various designs. A few species practice various forms of intra-uteral cannibalism, some consuming developing embryos, and some consuming siblings as well. These sharks are born ready to go, no quarter asked nor given.

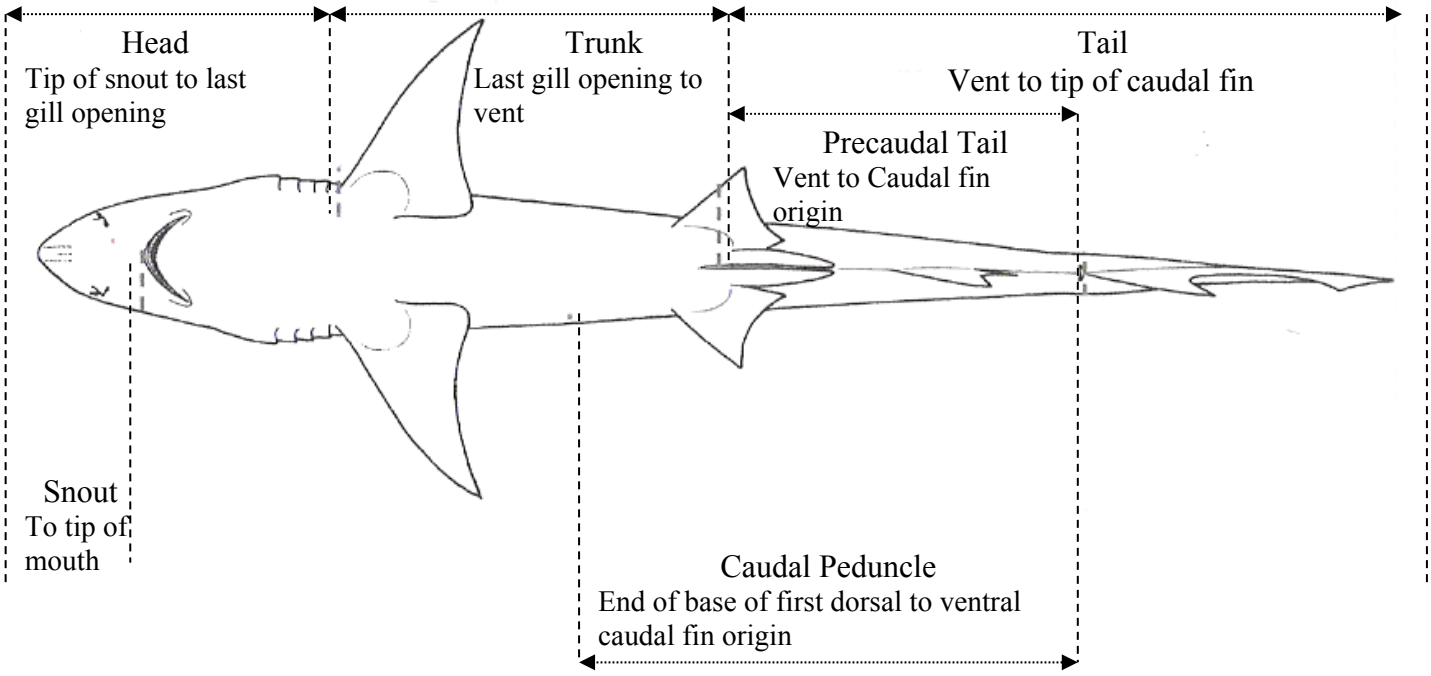
Gestation can take as long as 14 months, but many species of sharks simply aren't well understood by science. Movements, migrations and breeding habits of most sharks are blank spots. Many of the best know species of sharks are not well studied and every new season turns up new revelations and insights, even new species. For all the questions answered more questions are raised. In many respects humanity still exhibits vast deserts of ignorance when it comes to the natural world and sharks are still on the frontiers of that desert.

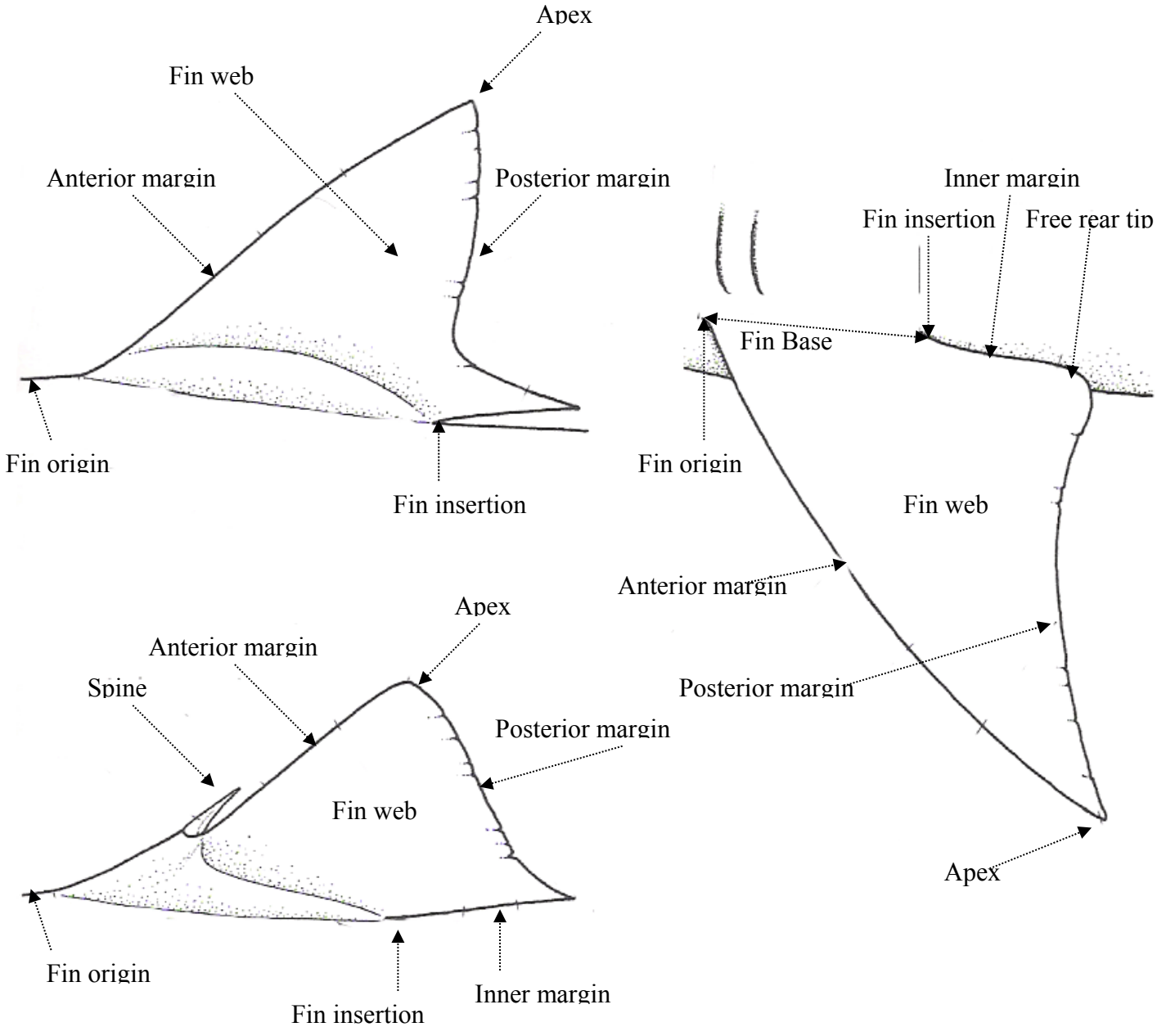
Shark Family Tree

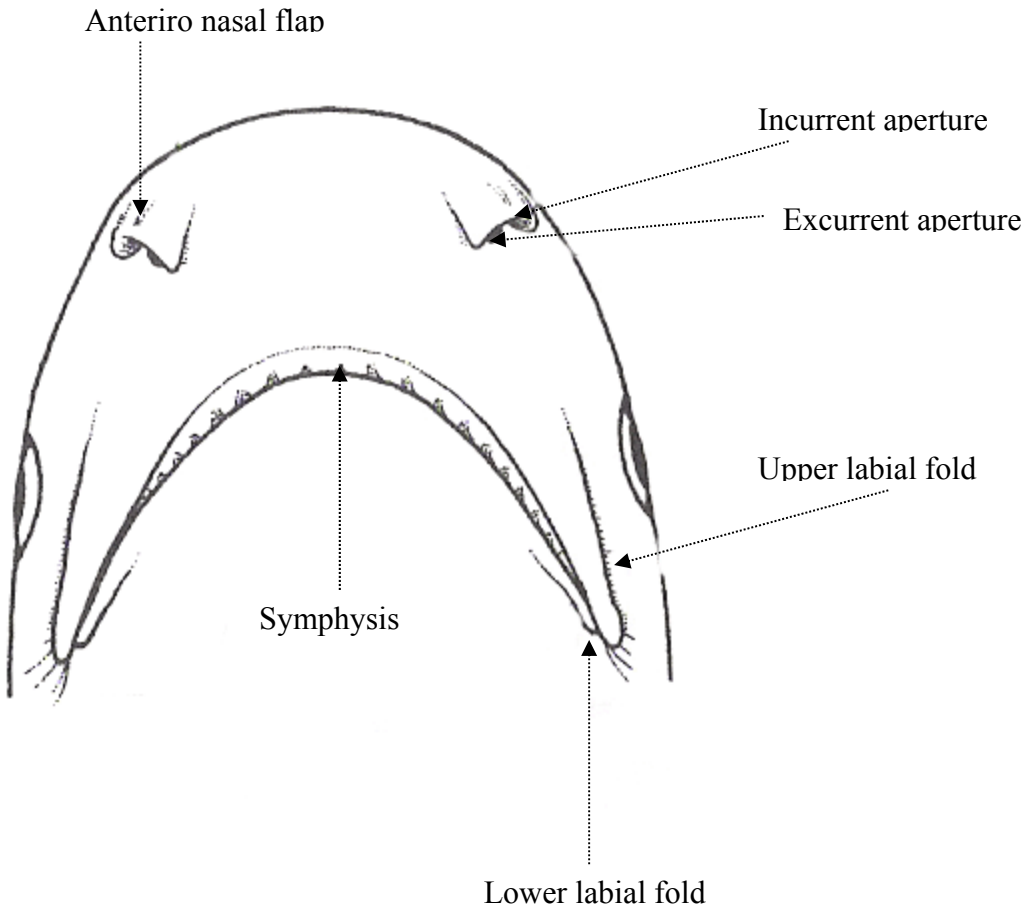


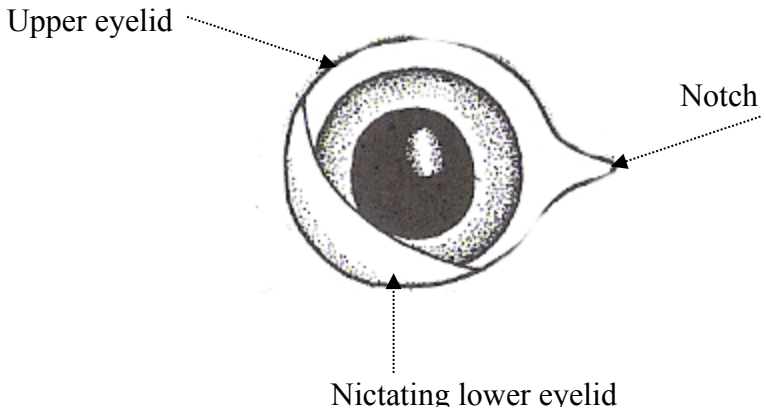
Shark Parts











Basic Shark Physiology

Sharks arose about 350 million years ago and have remained virtually unchanged for the past 70 million years and still comprise a dominant group. Although they live in an environment that is fairly resistant to change and have not been majorly affected by humans until now, but to survive for this long on a geological time scale they must be doing something right. Their success is largely to the original genetic traits they inherited from their more primitive ancestors. This gives sharks some amazing adaptations allowing them to occupy some varied ecological riches.

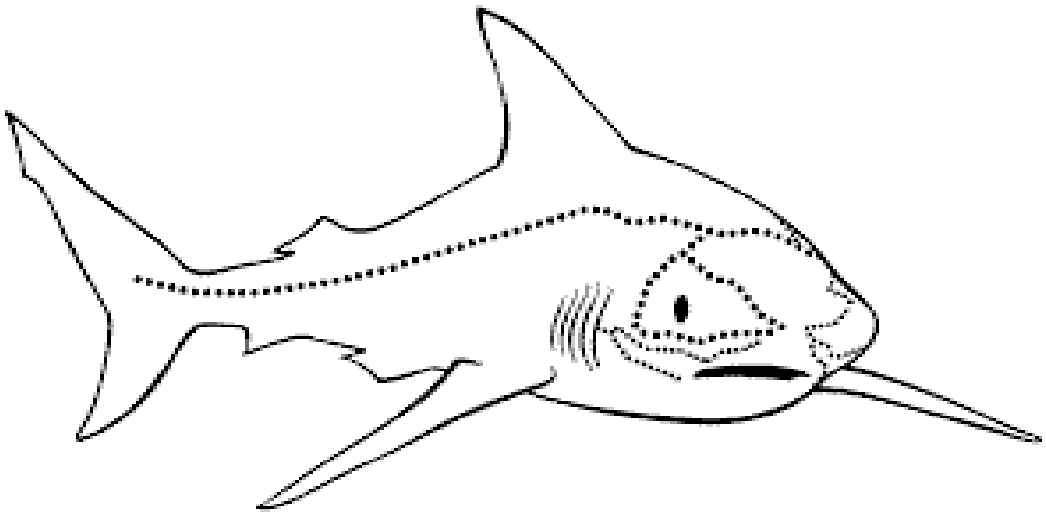
Acoustic Senses:

Hearing:

Sharks hear with its ear (and other organs), although the only external manifestation of the ear is a small duct, not easily visible. The inner ear of a shark consists of three chambers, the utriculus, the sacculus, and the lagena, and in each one there is a calcified ear stone that is connected to a series of hair like sensory cells.

Lateral line:

The lateral line is a series of fluid-filled canals just below the skin of the head and sides of the body. It is connected to the outside through small pores. The lateral line contains a number of small sensory cells, which detects current and turbulence caused by water. The lateral line senses low frequency sounds and functions mainly distance perception and detecting water flow.



The lateral line system with its canals

Eyesight:

Sharks have a laterally compressed eye with a large and spherical lens. Its eyes are particularly sensitive to movement in dim light. Sharks may have some color vision since they have cone cells in their eyes. At the back of the eyes there is a reflecting layer of cells, called the tapetum lucidum, which reflects the light back again to help it see more effectively. A shark's pupil can dilate and contract and in clear water the shark can see up to 15 m.

Taste:

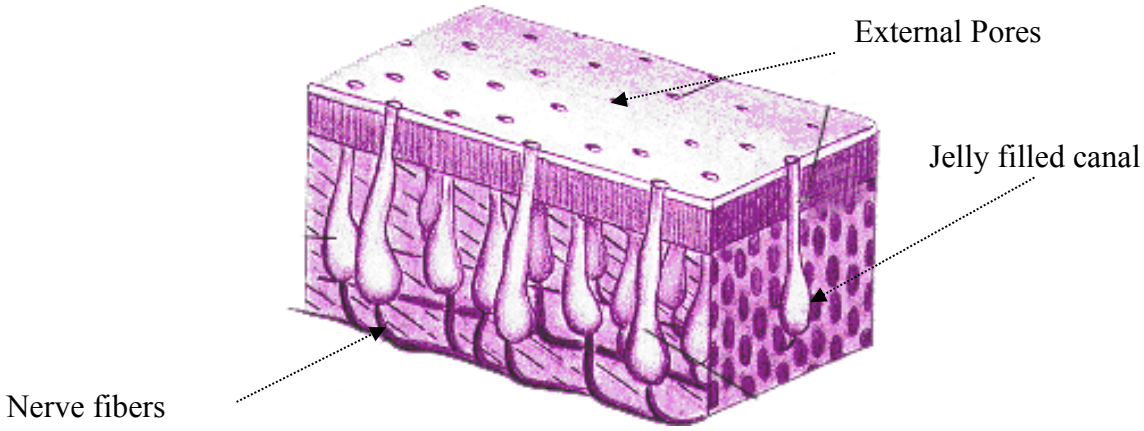
Sharks and Batoid have taste buds in their mouths but these have not been studied extensively. It may help in the final acceptance or rejection of the prey items.

Smell:

The shark has paired external nostrils, which leads to the olfactory organs. They have an acute sense of smell and can detect some chemicals in such dilutions as one part in a billion and up to 100 m away.

Ampullae's of Lorenzini:

The ampullae's of Lorenzini form a complex and extensive sensory network around the shark's head. External pores cover the surface of the shark's head and each leads to an jelly filled canal connected to a membranous sac called an ampulla's. These sacs have sensory cells, which detects weak electrical fields over short ranges. They are only effective within a few centimeters, as they sense bioelectrical fields in the final stage of prey capture. The ampullae's may also detect temperature, salinity, mechanical stimuli and magnetic fields.



The ampullae's of Lorenzini

Sensory Pits:

A sensory pit is a small depression in the skin, which is formed by the overlapping of two enlarged scales. At the bottom of the pit there is a small cluster of sensory cells that resemble a taste bud. The precise function of the sensory pits has not been determined but they may be sense organs. They occur on the backsides and lower jaw of the shark.

Physiology and Anatomy

Skeleton:

The skeleton of sharks is made of cartilage. This is a fibrous tissue that can actually be quite hard, your nose and ears are made up of cartilage. Because of this fact it is quite rare to find fossil skeletons of sharks.

The shark's cranium is a single cartilages block, which encloses the brain, olfactory system and auditory capsules. The jaws are loosely attached to the cranium.

This is a shark skeleton. It has no ribs since the water supports its weight.

Muscles:

There are two types of muscle cells: red muscles for slow muscle action like cruising, and white muscles for fast, sudden bursts of speed.

Digestive Tract:

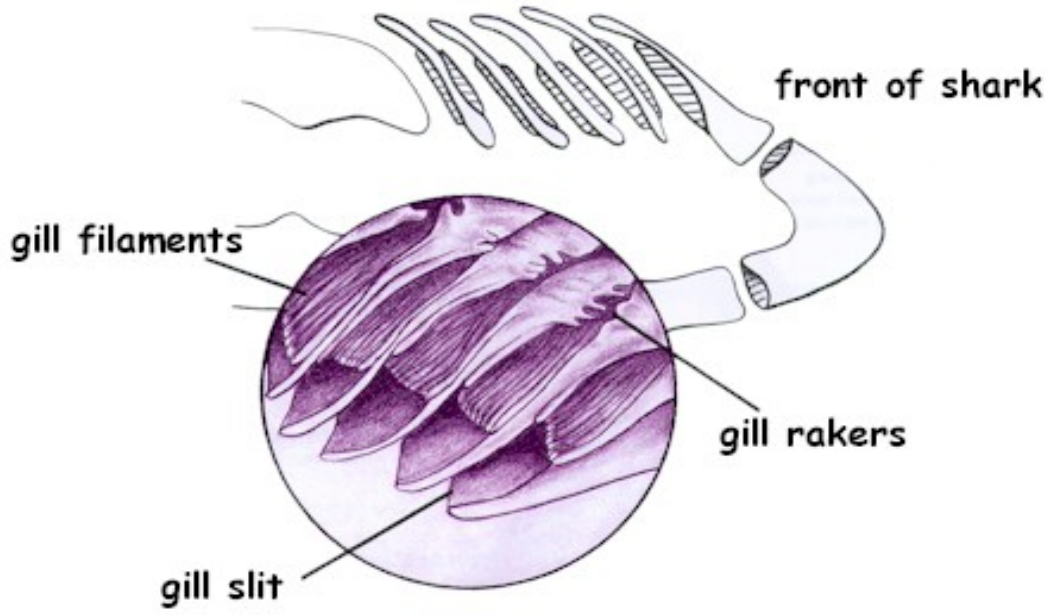
The shark short and wide esophagus ending in u-shaped stomach, in may species this leads to a spiral valve which is twisted and turned to increase absorption area. After the valve the digestive tract leads to the rectum and the cloacae. The cloacae are a common opening for the urinary, digestive and reproductive system.

Circulatory System:

A shark has a two-chambered s-shaped heart and the blood flows from the heart to the gills and then to the rest of the body. Fast swimming sharks have body temperature slightly higher than the surrounding water. This is due to increased muscle activity. Sharks also have low blood pressure and to maintain blood flow the shark must move its muscles to circulate the blood.

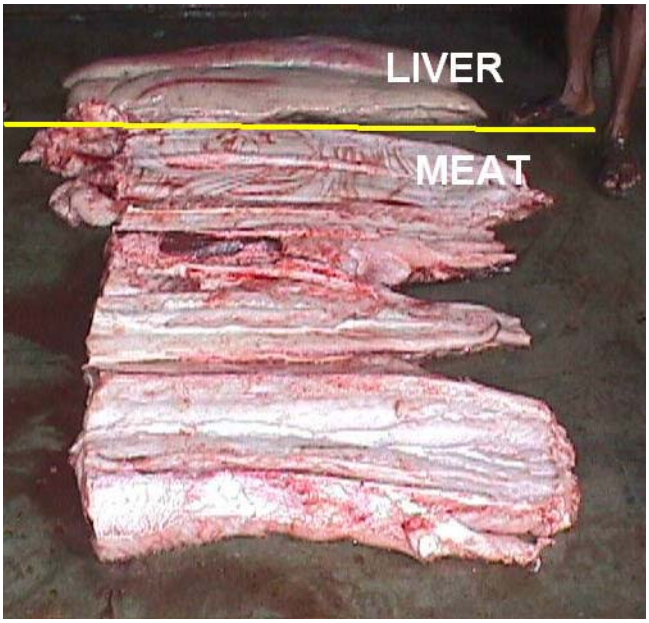
Gill slits:

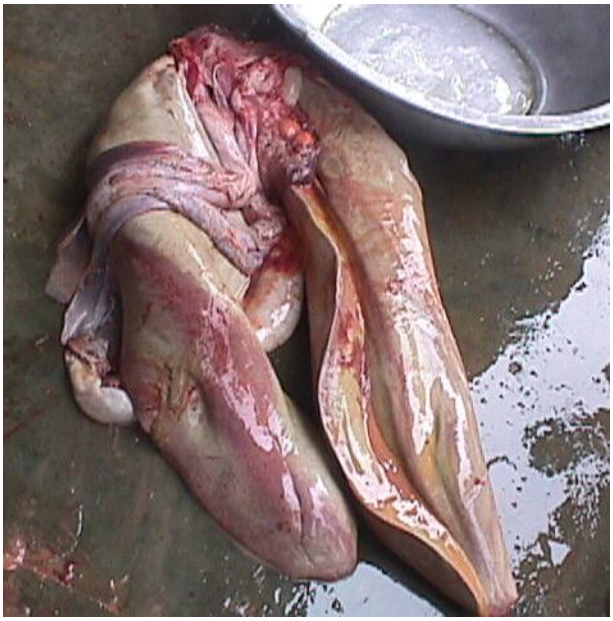
Water enters the gill chambers through the mouth or spiracles in order for the shark to breathe. Previously it was thought that sharks had to move to keep breathing, but know we know that they can pump water over their gills by opening and closing their mouth. Due to low blood pressure the sharks rely on muscular movement to circulate their blood. Blood in the gill filaments absorb oxygen from the water and water then exits through the gill slits.



Liver:

A shark's liver may weigh 5% to 25% of its total body weight. This is due to storing oils and fatty acids for energy as well as for buoyancy.





Stomach:

Sharks are cold blooded and thus have a lower metabolism than warm-blooded animals. This gives it the advantage of having to eat less than similarly sized mammals. A shark eats 1% to 10% of its body weight per week and some sharks go for several weeks without food.

Nostrils:

Sharks have paired nostrils with an incurrent and an excurrent opening leading to olfactory organs. These organs can detect tiny traces of chemical substances up to one part per billion. Some sharks have sensory projections, called barbells, extending from near the nostrils.

Size:

Sharks and Batoid (rays) show great diversity in size. The largest shark is the Whale shark (Rhincodon typus) at 13+m. Among the smallest are the Midwater shark (Squaliolus latidicaudus) and the Pygmy ribbon tail Catshark (Eridacnis radcliffei) which measures in at 22 -25cm. The largest Batoid is the Manta ray (Manta birostris) with a disc width of over 6.7m and a weight of more than 2 tons.

Body Shape:

Sharks typically have a fusiform body (rounded and tapering at both ends). This type of body shape reduces drag and minimizes swimming effort. The Great white shark is a good example of this although it has more of a spindle shaped body. Batoid are flattened, with a ventral (underneath) mouth and gill openings.

Coloration:

Sharks and rays usually have different colors on the ventral and the dorsal (top) side. Counter shading is when the dorsal side is darker than the ventral side. This darker coloration on top makes it more difficult to be seen from above while the lighter color underneath blends in with the lighter surface of the sea when viewed from below.

Some coastal sharks and Batoid have other markings on them like stripes, which disappear with age. In contrast the whale sharks keep its spots throughout its life.

Fins:

Fins are composed of cartilaginous (cartilage) rods (for support) covered by a thin layer of flesh and skin. There are five types of fins:(a) Paired pectoral fins lift the shark as it swims as, (b) paired pelvic fins stabilize the shark, (c) One or two dorsal fins, with or without spikes, to stabilize the shark, (d) A single anal fin (if present) provides extra stability and (e) The caudal fin which propels the shark.

Batoid show various amounts of fin fusion and reduction especially the greatly expanded pectoral fins, which are used for propulsion.

Head:

Eyes are lateral (side) on the shark and dorsal on the Batoid. Some sharks may have an eye lid like membrane, called a nicitating membrane, to protect its eyes while it is feeding. In general deep-water sharks have larger eyes than shallow water sharks. In clear water a shark can see up to 15 m.

Sharks and Batoid have ventral external nostrils, which may have appendages, called barbers, near the nostril e.g. Hound sharks.

The shark's mouth is usually on the underside with the exception of the whale shark, Megamouth shark (Megachasma pelagios), frilled sharks and some carpet sharks. Teeth are modified, enlarged scales