# ICHTHYOLOGY

## CHONDRICHTHYES
**(chimaera, sharks, rays, skates)**

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**CHONDR- (cartilage) + ICHTHYS (fish)**

## SHARK ATTACK IN NEWS



## HOW REAL IS THE RISK?!

- over 200 cases (50 lethal) unprovoked attack by great white shark…worldwide

In New York 10x more people is bitten by other people than sharks worldwide

Long term statistics:
*1 death by drown to 3,5 mil water activities*
*1 shark attack to 11,5 mil water activities*

**1995 - 2003** along costline of USA **1857** people killed by lightning.
In the same period **740** shark attacks – **22** lethal.
**http://www.flmnh.ufl.edu/fish/sharks/statistics/trends.htm**

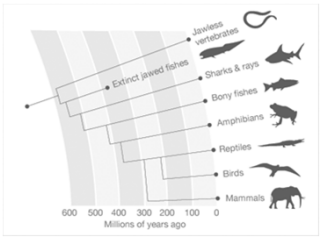
## SWIMMING SEASON IS COMING!

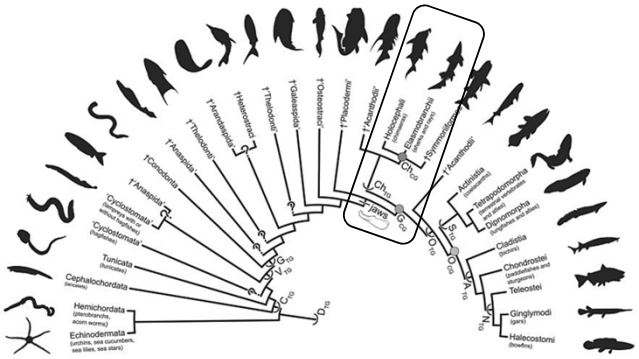
Hamish Jolly – designer of „anti-shark suit“
video at: **TED.com**

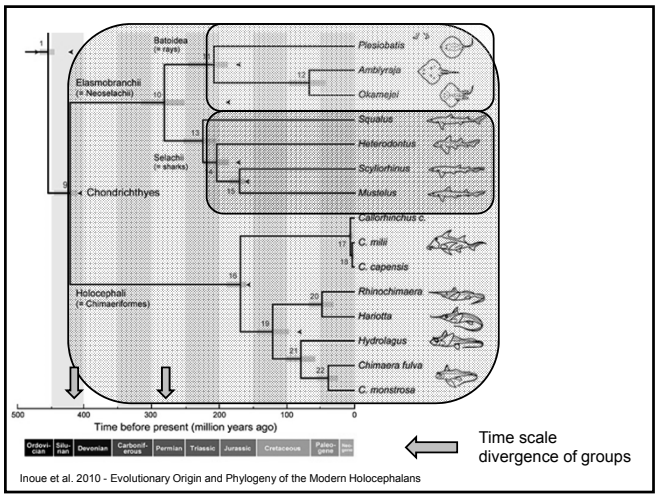
## RISK FOR THE SHARKS?!

- Overfishing (70-100.000.000 sharks/year)
- High demand for shark fin from Asian countries

# PHYLOGENY

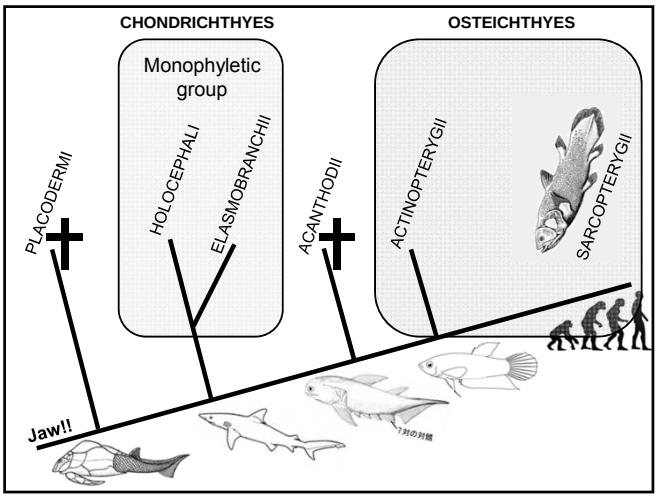



Time scale divergence of groups

Inoue et al. 2010 - Evolutionary Origin and Phylogeny of the Modern Holocephalans

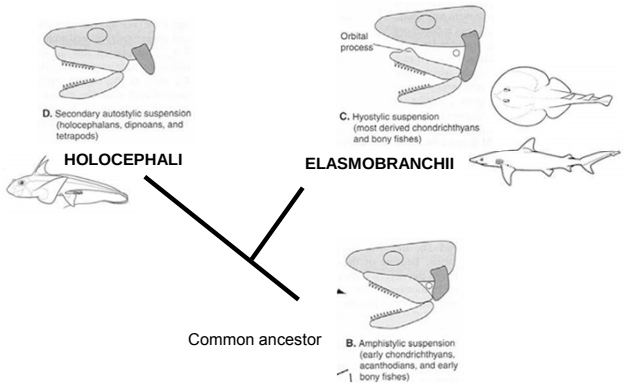



## EVOLUTION

- Over 450 milion year of evolution (200 mil. Before dinosaur
- Rare fissilization due to cartilage skeleton structure (except of teeth)

- Hammerhead sharks (Sphyrnidae) are most are most advnaced

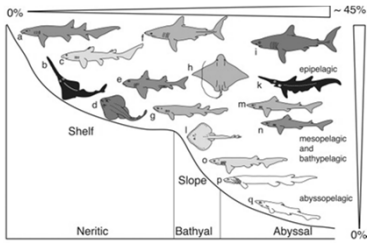
## CHONDRICHTHYES



## SPECIES RICHNESS WORLD DISTRIBUTION

**Chimaeras 30 sp.**
**Sharks 430 sp.**
**Skates, rays 540 sp.**

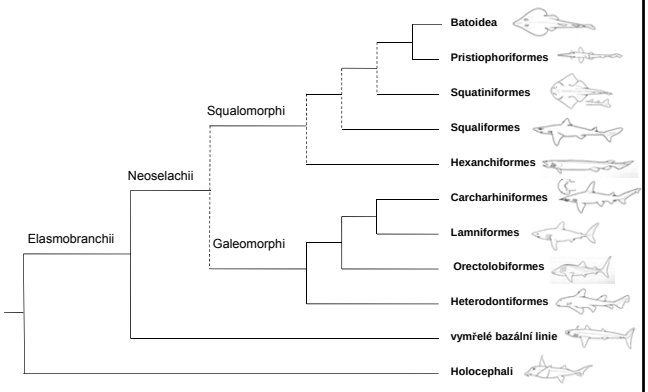
**(NELSON 2007)**



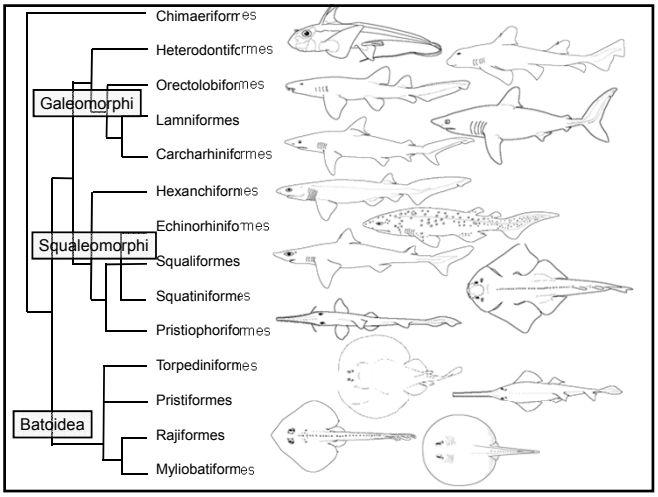

## COMMON CHARACTERISTICS

- Water (marine) organisms
- Cartilage (not real bones)
- Rare fissilization except teeth
- Hydrodynamic body, size range, 20 cm – 18 m
- Body covered with plakoid scales (homologic with teeth)
- Mostly 5 gill oponings (up to 7)
- Internal fertilization
- asymmetric „**heterocercal“** caudal fin (tail)

## PHYLOGENETIC TREE

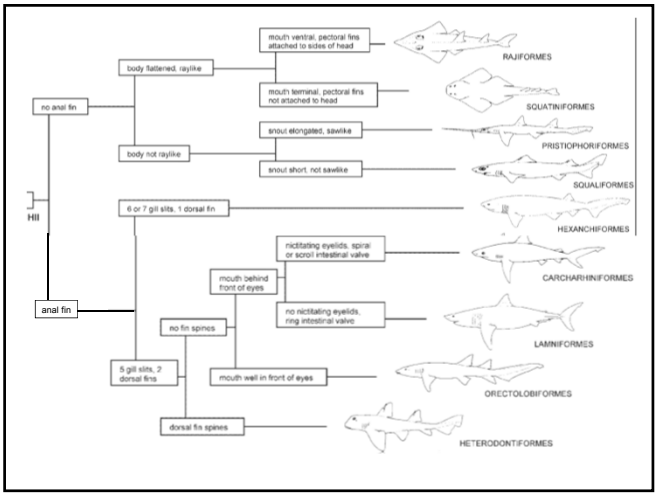



Stiassny et al. (1996) a Craft & Donoghue (2004)




## SPECIES DETERMINATION

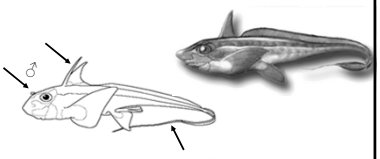
- Presence/absence of fin
- Shape and dimensions of fins
- Presence/absence of spines
- Presence/absence of spiracle
- Presence/absence of eye lid
- Size and position of jaws
- Number and size of gill openings



## a) HOLOCEPHALI
## CHIMAERIFORMES

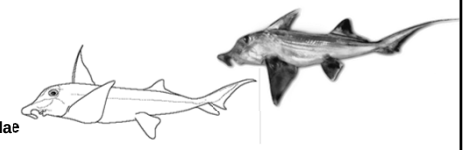
- Absence of ribs, stomach and spiracle
- Oviparious – egg similar to the shark egg
- „holocephali“ upper jaw joint firmly with the skull
- Sexual dimorfism (males: pterygopod, tentaculum)
- Plate-like teeth (whole-life)
- Skiny operculum
- Poisonous spine

family: **Chimaeridae**
2 - 20: *Chimaera, Hydrolagus*
Worldwide, ♂head clasper, toxic D spine





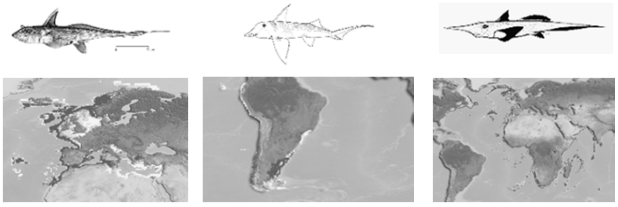
family: **Callorhynchidae**
**(chimérovkovití)**
1 - 4
South hemisphere



family: **Rhinochimaeridae**
**(pachimérovití)**
3 - 6: *Harriotta*, *Neoharriotta*, *Rhinochimaera* - worldwide

## DISTRIBUTION

- Pacific, Atlantic a Indian ocean
- Temperate zone – tropical zone
- Mostly below 200 m (depth)



*Chimaera monstrosa* *Callorhinchus callorynchus* *Rhinochimaera atlantica*

## Subclass - ELASMOBRANCHII

- Over 900 sp. **Chondrichthyes**
- **Carcharhiniformes** more than ½ of sharks, mostly sub-tropic and tropic
- Pelagic types live in open ocean **Lamniformes** (mako, great white, thresher shark, basking shark)
- **Squaliformes** deeper water of norhern hemisphere
- Rays of group **Rajoidei** mostly in deeper waters
- **Myliobatoidei** shallow water of tropics

## Selachii – modern sharks

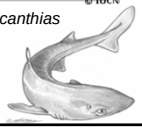
- Torpedo-lie body shape
- Elongated rostrum (head)
- Lower (inferior) mouth
- Mostly 5 gill openings

## WORLD DISTRIBUTION

- Continental shelf versus deep sea species

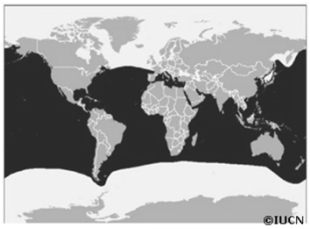
*Centroscyllium fabricii*

*Squalus acanthias*

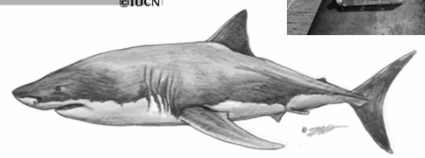


Zdroj: http://atlanticsharks.org

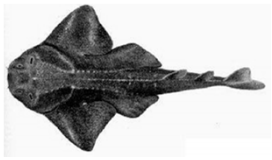
*Carcharodon carcharias* „***great white***“

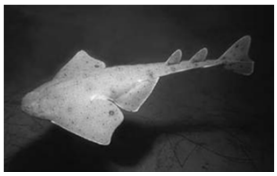



worldwide distribution
(except antarctic/arctic)

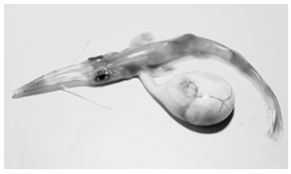


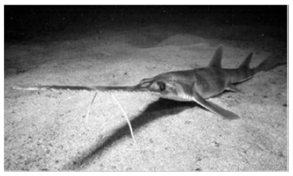
Angelshark
*Squatina squatina*





Longnose sawshark
*Pristiophorus cirratus*



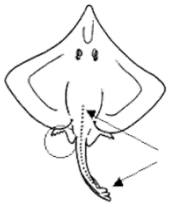


REYS - BATOIDEA

- Compressed, flattened body
- Mostly benthic
- Lower mouth
- Mostly 5 gill openings
- Bigger visible spiracle

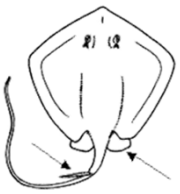
**order: Rajiformes - Skates (Rajidae)**

Two-parts pelvic fins
Robust tail without spine
Presence of bigger scales aligned along body in raws
Little caudal fin

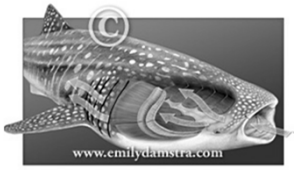


**order: Myliobatiformes - Rays and stingrays (Dasytidae + Potamotrigonidae)**

One-part pelvic fins
Narrow elongated tail with spine
Absence of bigger scales aligned along body in raws
Often bright colors on body



**ANATOMY - PHYSIOLOGY**




What is „FISH“

**JAWLESSS**

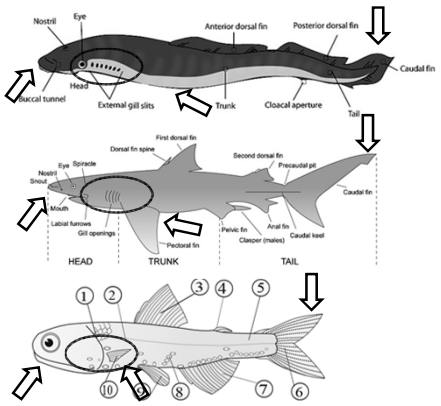
*Cartilaginous*

**JAWED**

Cartilaginous

Bony

## GENERAL ANATOMY OF FISHES

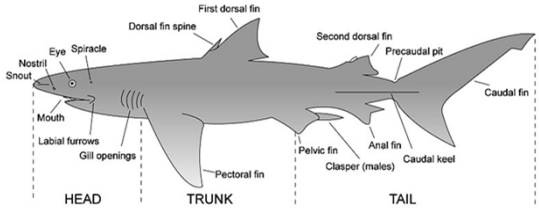



Lampreys

Elasmobranchs
Shark+skates

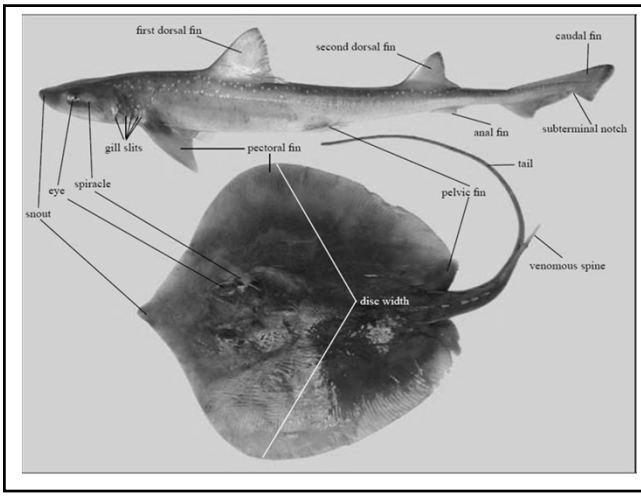
Bony fish

## GENERAL ANATOMY - shark

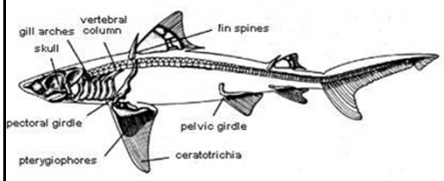


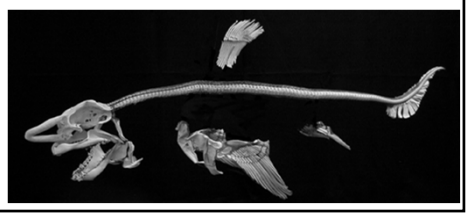

Cartilaginous skelet
Strong jaw
Scales - placoid
5-7 gill openings
One or two dorsal fins
Heterocercal caudal fin

Pelvic and pectoral fins are paired
Reproduction organ of male
Developed senses



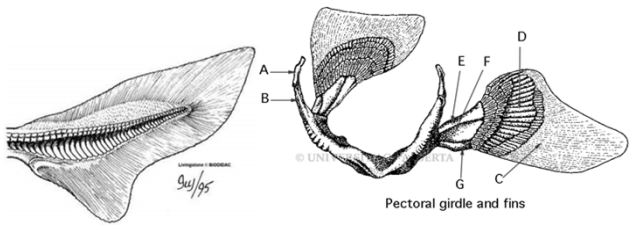

## CARTILAGINOUS SKELETON



## CARTILAGINOUS SKELETON

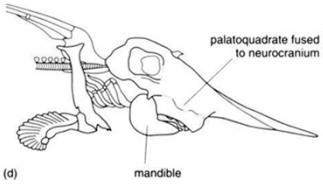
- heterocerkal tail (caudal fin)
- Caudal fin is the „engin“ for motion
- Pair limbs with inner skeleton

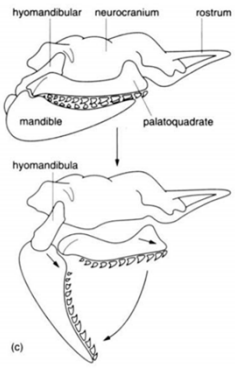



Pectoral girdle and fins

## CARTILAGINOUS SKULL

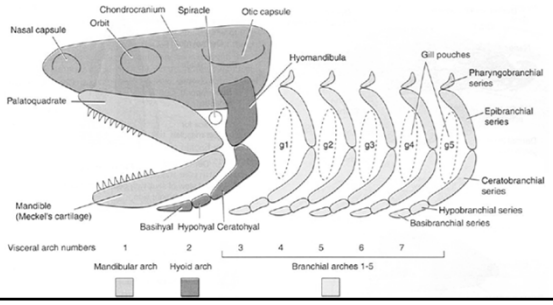
- neurocranium
- viscerocranium
- Jaws consits of pair cartilage
  upper=palatoquadratum
  lower=mandibulare



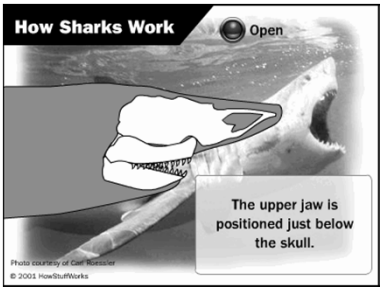
## Expected morpho-evolution of jaws from arches


Common ancestor with 9 gill arches - 3. a 4. become in shape of jaws

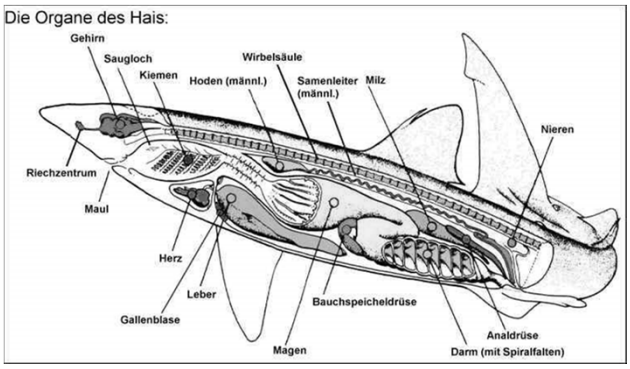



## SKULL - JAWS

- Shape of teeth – function for biting and cutting (chop)
- Robust heavy head – dynamic biting
- Hyostilic skull – protrusion of jaws from to skull




## INTERNAL ANATOMY




## INTERNAL ANATOMY

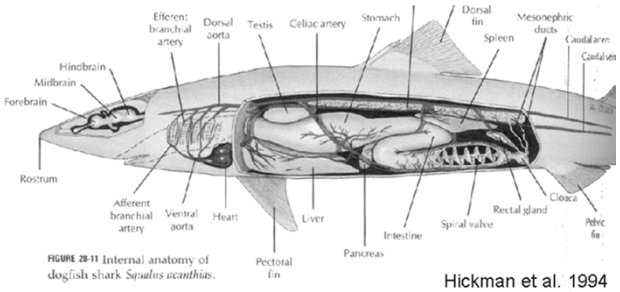
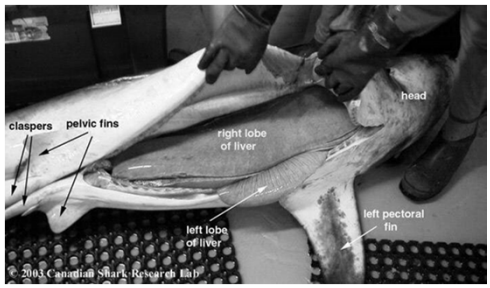



FIGURE 28-11 Internal anatomy of dogfish shark *Squalus acanthias*.

Hickman et al. 1994

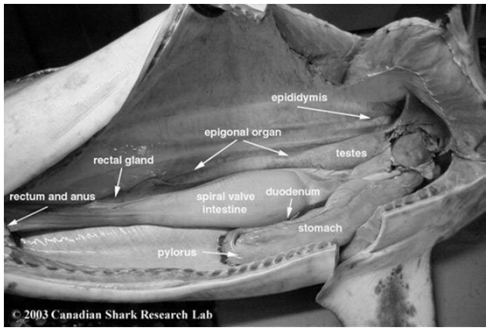
## INTERNAL ANATOMY

**MALE**



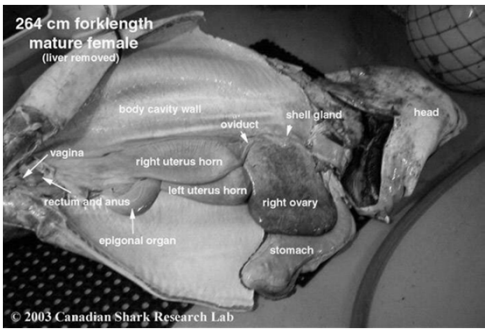

## INTERNAL ANATOMY

**MALE**



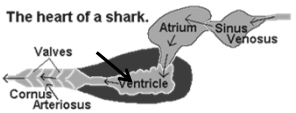
## INTERNAL ANATOMY

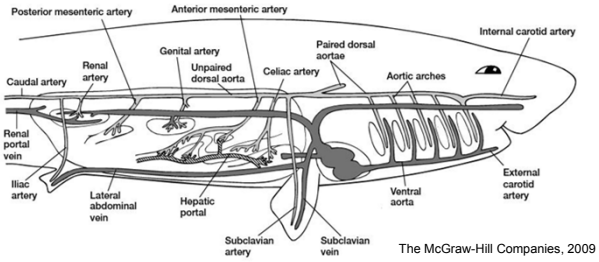
**FEMALE**




## BLOOD CIRCULATION

- Only one circuit (whole body)
- Four-part heart

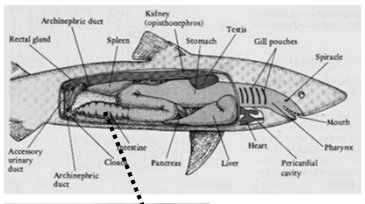


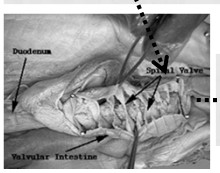

The McGraw-Hill Companies, 2009

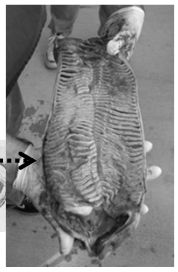
**FIGURE 12.11** **Basic vertebrate circulatory pattern illustrated in a shark.** The heart pumps blood to the ventral aorta, from which it is distributed to the paired aortic arches and then to the single dorsal aorta. From the dorsal aorta, blood flows forward to the head and posteriorly to the body where major branches carry it to visceral and somatic tissues.

## DIGESTIVE TRACT



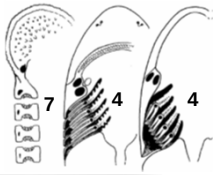

**„SPIRAL VALVE“**

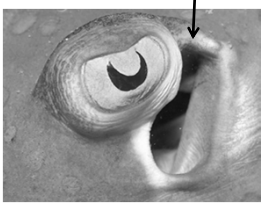


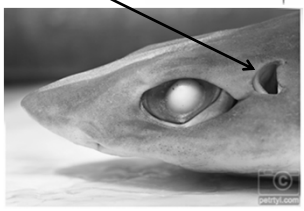



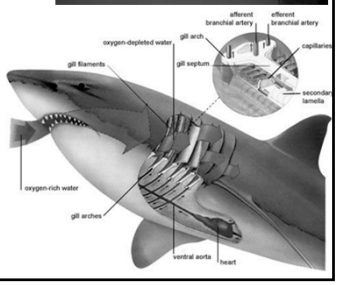
## RESPIRATION

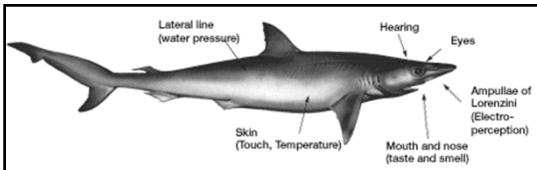
- Respiration and swimming
- Through the mouth (sharks)
- Through the spiracle (rays)



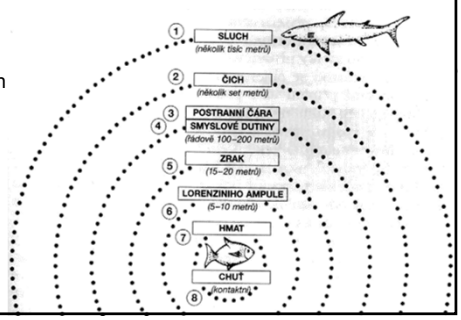





## SENSES

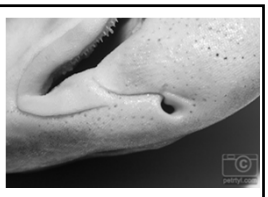
2/3 of brain capacity serves for perception



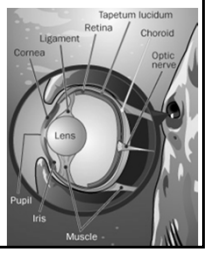
**smell** – drop of blood in the swimming pool „stereo-smell“

**Sight** – long-sighted

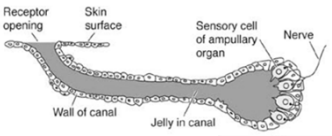
***tapetum lucidum*** improved night vision



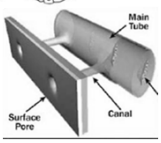
**Eye lens is spherical** – focusing by its movement
**Second lid** – for protection (predator, prey defense)

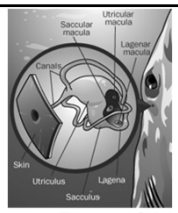



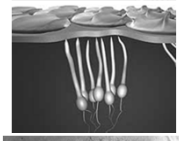

- **Hearing** 10 - 800 Hz (human 20-20.000 Hz).
- **Electroreceptors** – **Lorenzi ampule**, sense of bioelectric field of pray

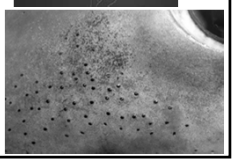



- lateral line



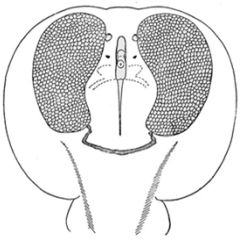



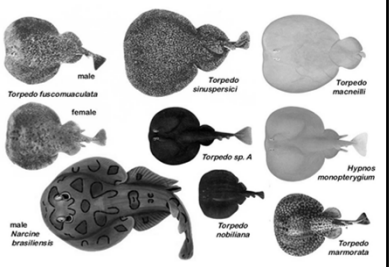





## ELECTRIC FIELD

**Torpediniformes** – 60 species
30 amper with 50 - 200 volts (eq. of hair dryer)
Adapted muscle tissue

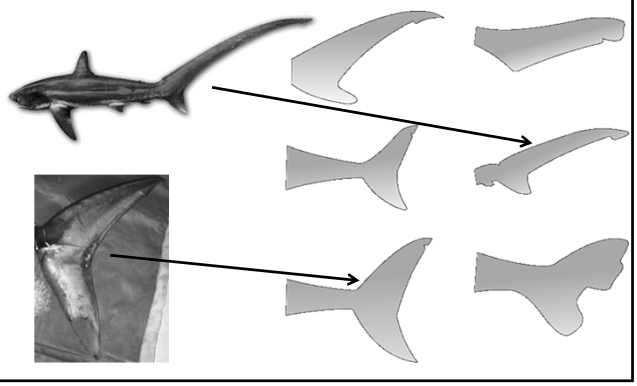





## LOCOMOTION – MOVEMENT - SHAPE

- Swimming muscles are attached to elastic skin – that makes effect of rubber band. It makes swimming easier (saving of energy).
- Asymmetric vs symmetric tail
- mako, great white) similar body shape as pelagic predátory fish (tuna) (55 km/h)
- Extrémní asymmetry in tresher shark
- Flat body of rays and skates – bentic species

## CAUDAL FIN - TAILS



## STRATEGIE „NULOVÉ HMOTNOSTI“

- Absence of gass bladder + enlarged liver filled with oil (squalen)
  - 25% of total body mass
  - 4 m shark has 80 litres of oil
  - 9 m shark has over 2000 litres
- Density (in comparison with water)
- Compressiblity – very low (like water)

## WHY TO EAT SHARK LIVER

- 90 tabs 30EUR


## METABOLISM

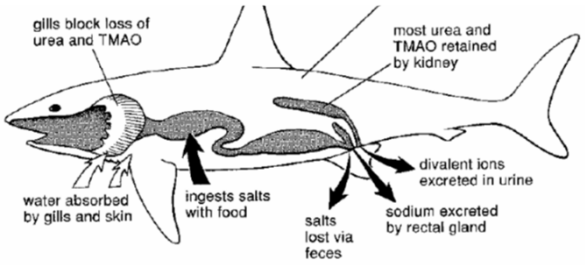
- Slow metabolism in comparison with teleost (bony fishes)
- Fish needs 2-3x more of oxygen and 4x more of food.
- „lazy“ benthic species – vs. termoregulation of pelagic sp.
- Slow growht vs life span (up to 60 years) hard to estimate the age when bone is absent

## OSMOREGULATION

- Hypoosmotic sea fish
- Isoosmotic sharks holds part of urine and TMAO (trimetylaminoxid) in body tissue (blood). They don‘t need to dring water!!

- Smell of dead shark ☺

## ISOOSMOTIC SHARKS




## ECOLOGY - ETHOLOGY


## ENVIRONMENT - HABITAT

- Mostly marine
- Some in freshwater **Potamotrygoninae** a ***Dasyatidae***.
- Bullshark (***Carcharhinus leucas***) and saw-fish (***Pristis perotteti***)

- Mostly up to 200m, some in deeper water (up to 4000m).
- In general in deeper water is lack of food. Resources are restricted.

## FOOD SPECIALISATION

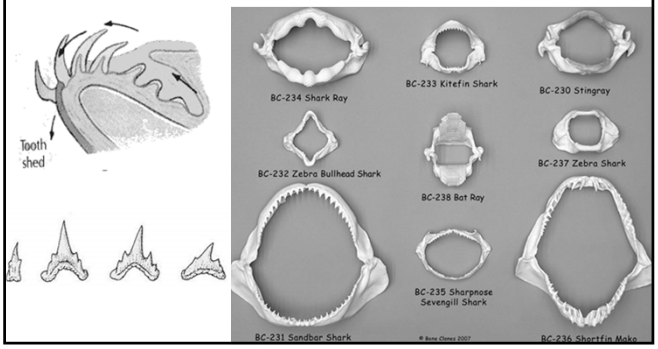
**1) OPEN-WATER HUNTER** (*Hexanchus, Isurus, Alpias, Squalus, Lamna, Carcharodon*)

**2) PLANKTON-FEEDER** (*Cetorhinus, Rhincodon, rejnoci-Myliobatidae*)

**3) BENTHIC PREDATOR** (*Heterodontus, Scyliorhinus, Pristiophorus, Squatina*, většina rejnoků)

## FOOD SPECIALISATION

- 4 types of teeth – regarding the food (pray)
- Some species up to 30 000 teeth during lifetime.




## FOOD SPECIALISATION

- Hunting technique
  - Saw-fish
  - Elektric ray
  - Thresher shark
  - Manta
  - Whale shark
  - Basking shark

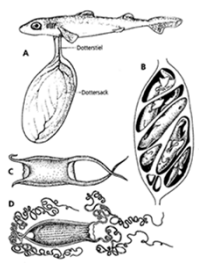
## REPRODUCTION

- Internal fertilization – vivparous or oviparous
- Male reproduction organ – **pterygopods = claspers**

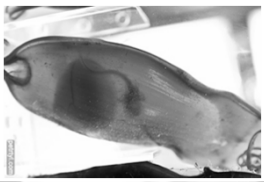
## REPRODUCTION

40% ovoparous – ancestral reproduction type

Pregnancy up to 24 m just a few offsprings = **K-strategy**

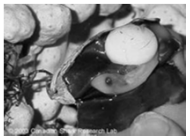


**Egg of chimaera**



**Eggs of sharks and rays**

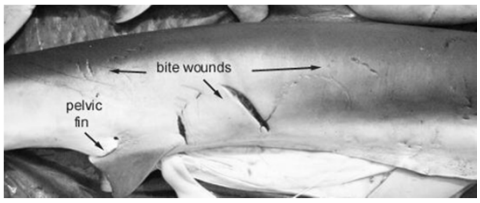
## REPRODUCTION



## REPRODUCTION

- **oophagye** – (thresher, mako, great-white)
- **embryophagye** – (sand shark)
- **Placental feeding -** *Carcharhinidae, Sphyrnidae* (mammal like!!)
- **Uterine fluid** *Myliobatoidae, manta* (milk-like substance)

- Females with 3x thicker skin than males




## REPRODUCTION

- **„Virgin birth“** – facultativve partenogenesis of sharks??

- *Sphyrna tiburo* in captivity

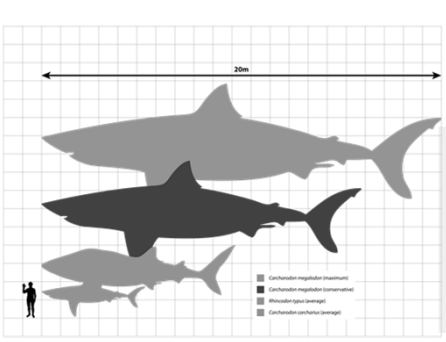
Chapman, D. D., Shivji, M. S., Louis, E., Sommer, J., Fletcher, H., & Prodöhl, P. A. (2007). Virgin birth in a hammerhead shark. *Biology letters*,*3*(4), 425-427.

- Saw-fish (*Pristis pectinata*)

Fields, A. T., Feldheim, K. A., Poulakis, G. R., & Chapman, D. D. (2015). Facultative parthenogenesis in a critically endangered wild vertebrate. *Current Biology*, *25*(11), R446-R447.

## SIZE – MYTH AND REALITY

- Extinct *Carcharodon megalodon?! (30/15m)*



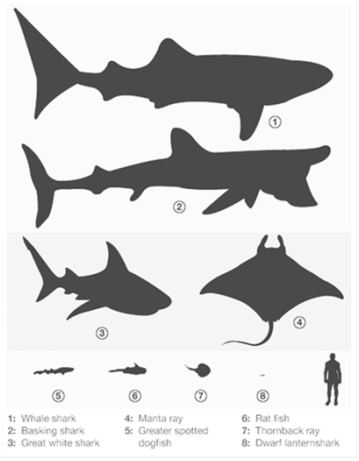

https://commons.wikimedia.org/w/index.php?curid=25031119

Reconstruction by Bashford Dean in 1909
https://commons.wikimedia.org/w/index.php?curid=4387521

## SIZE

*Etmopterus perryi* (20 cm, 150g) dwarf shark
*Rhincodon typus* (18 m, 12 t), biggest „fish“

Bigger body is safer (protection against predators)

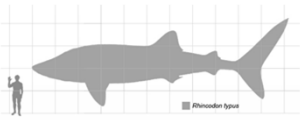


## SIZE

- Biggest white shark female: 6,4 m, 3312 kg
- Cuba, 1945

## PLANKTON FEEDER

- 12-16m/20 t




## RARITY

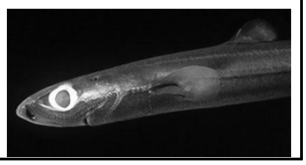
*Isistius brasiliensis*
Bioluminiscence, spoon-like bite

*Etmopterus* 15-19 cm
The smalliest one

Lamniformes „homoiothermy“

Life-span – 70+ *Squalus acanthias (*Spiny Dogfish)
Speed - *Isurus oxyrinchus 55km/h*

Bioluminiscence: *Etmopterus spinax, Megachasma pelagios*



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