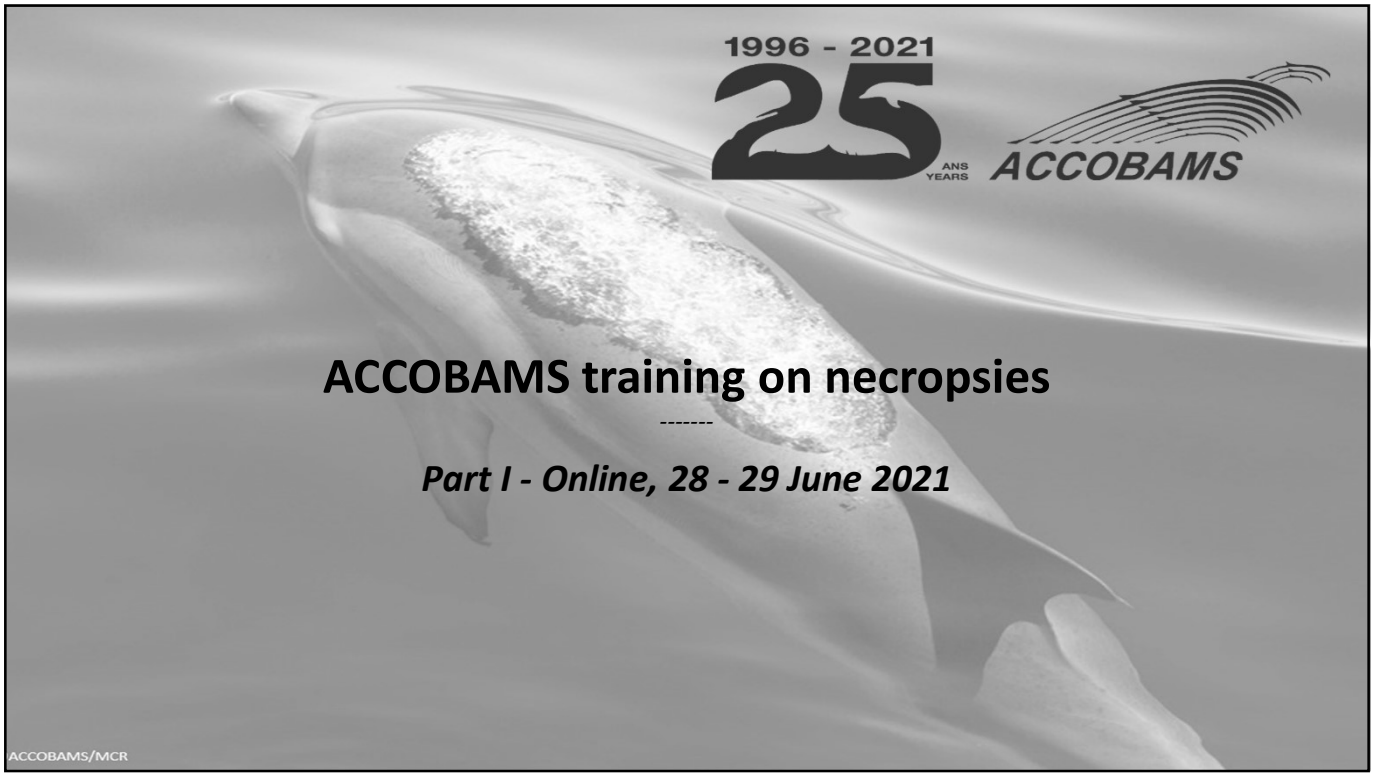


ACCOBAMS training on necropsies

Part I - Online, 28 - 29 June 2021

1996 - 2021 25 ANS YEARS ACCOBAMS

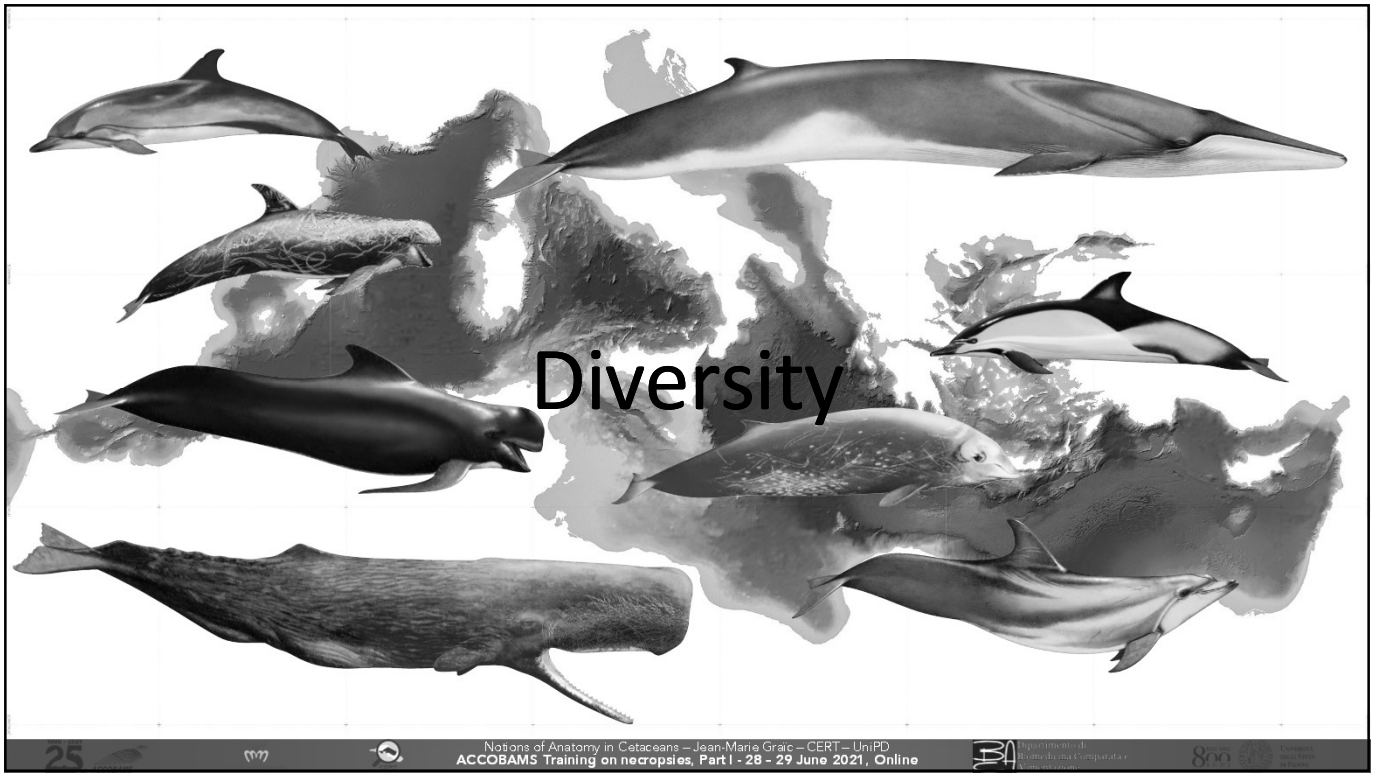
Basic Anatomy and Physiology

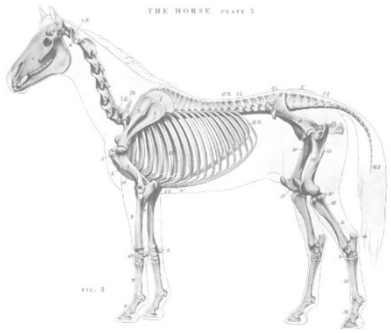
Jean-Marie Graïc, DVM, PhD
CERT
University of Padova, Italy

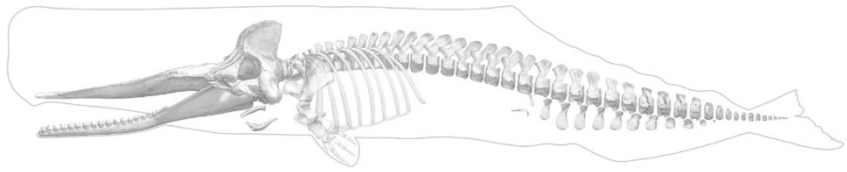
CERT 800 1222·2022 ANNI UNIVERSITÀ DEGLI STUDI DI PADOVA

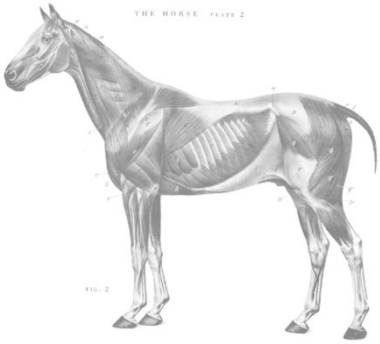
Notions of Anatomy in Cetaceans

what you need to know

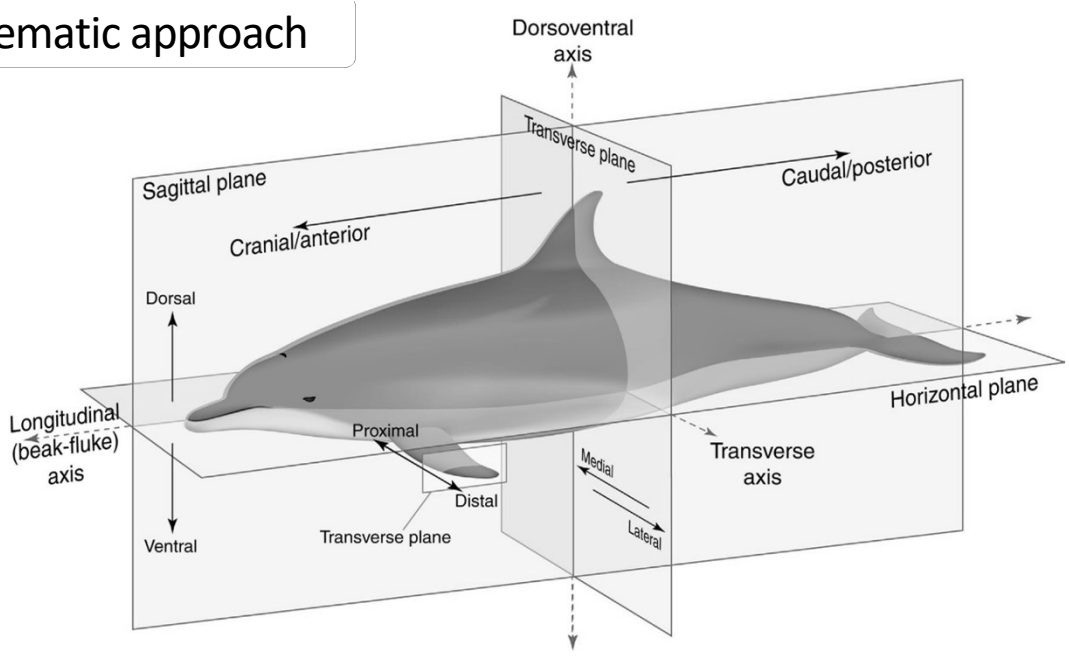








Systematic approach



Main Anatomical Aspects by system

Main differences to expect in stranded cetaceans

- The integumentary system and senses
- The locomotor system (skeleton and muscles)
- The circulatory system (+thymus and spleen)
- The respiratory system
- The digestive system
- The urinary system
- The reproductive system
- The endocrine system
- The nervous system

The integumentary system

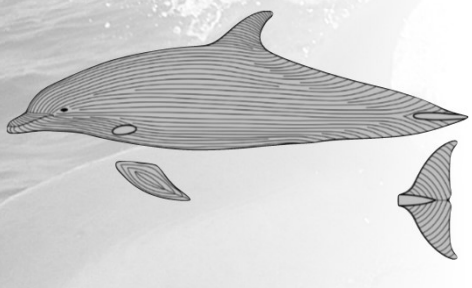
and senses

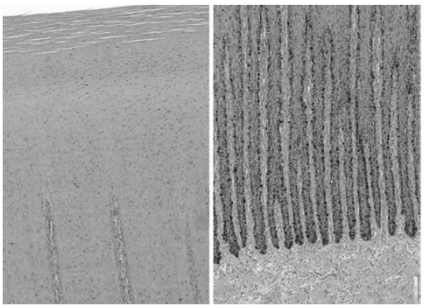
Skin

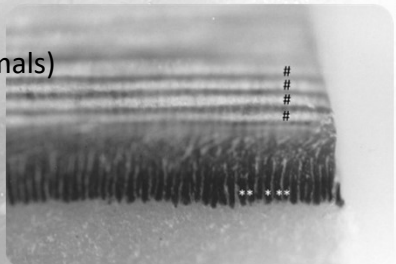
- Thermal insulation
- Energy storage
- Hydrodynamic:
  least resistance to flow (drag)
- barrier to hyperosmotic environment
- barrier to intrusions
  (like other mammals and animals)

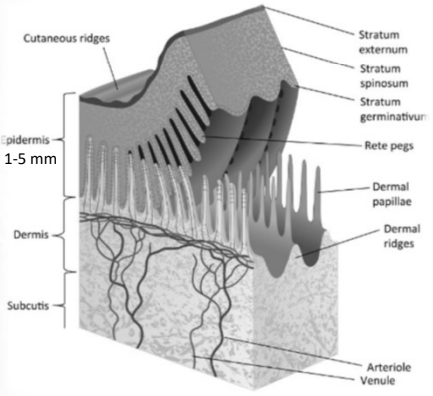
Skin

- Thermal insulation
- Energy storage
- Hydrodynamic:
  least resistance to flow (drag)
- barrier to hyperosmotic environment
- barrier to intrusions
  (like other mammals and animals)





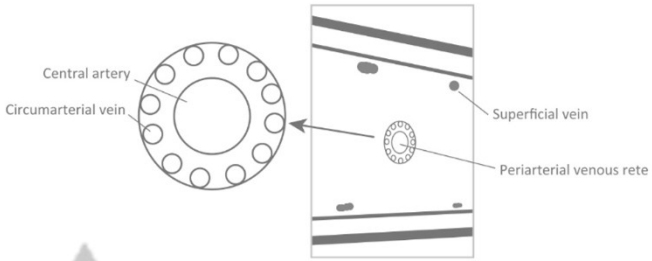


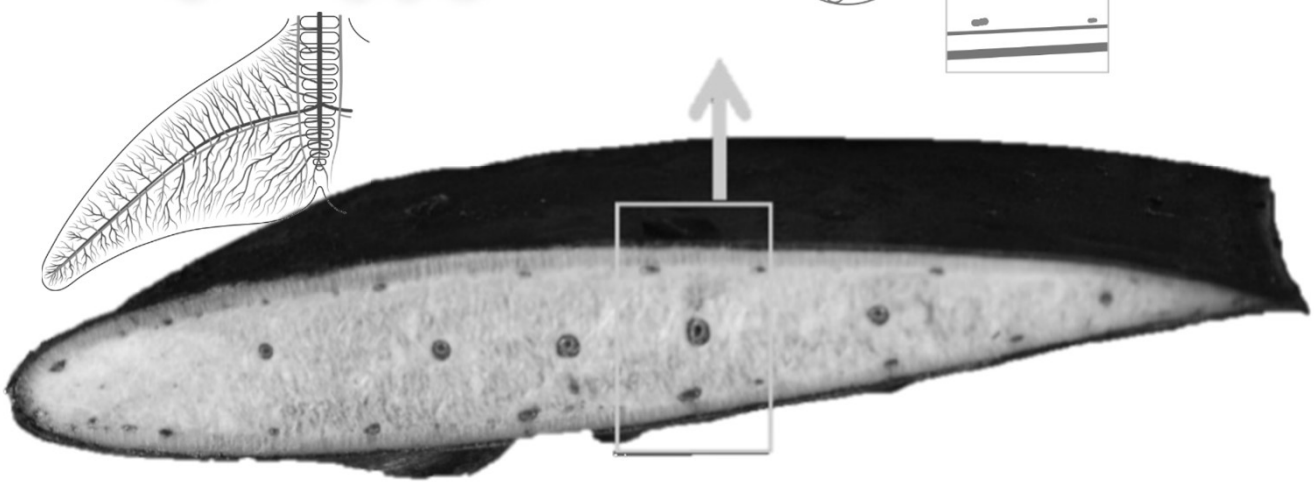


Burne, 1952

cation on the body, species, health and time of the year

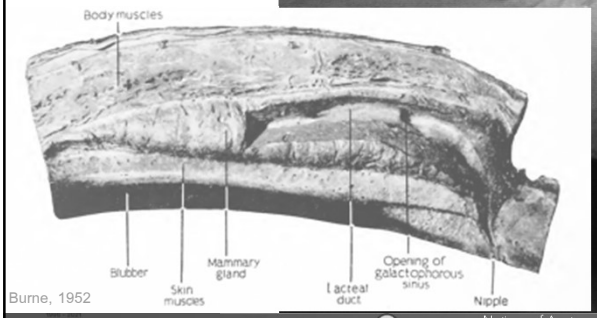
heat management is tightly regulated





Mammary glands

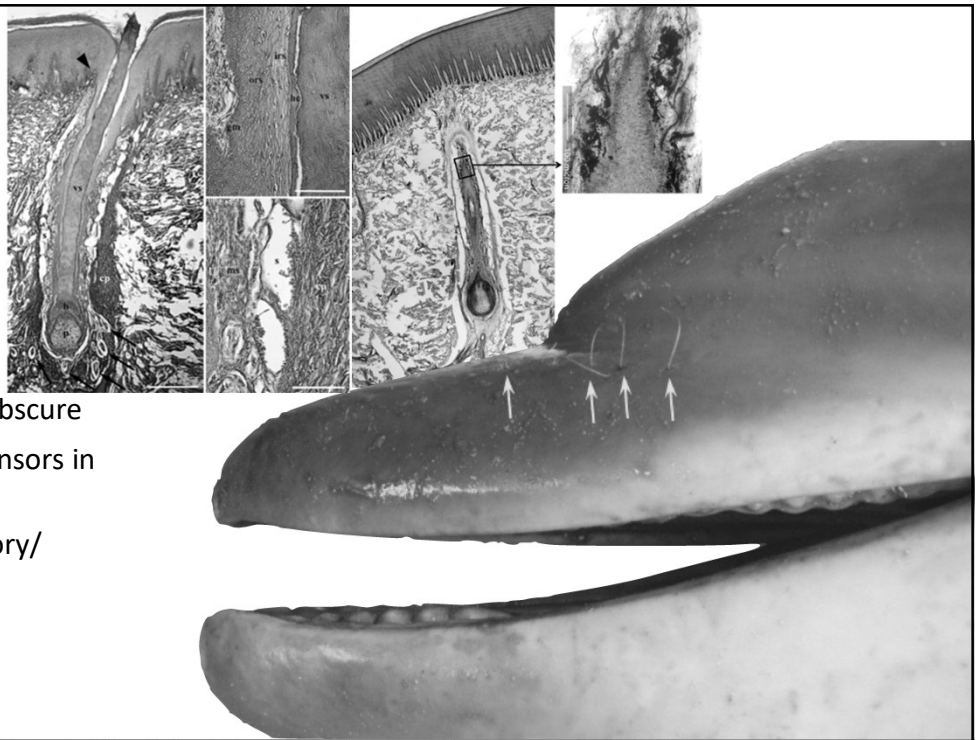
- Hidden behind slits



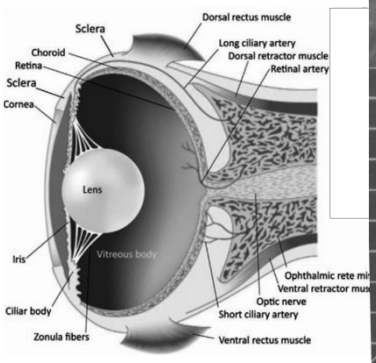
Burne, 1952

Whiskers

- whiskers do exist
  - not all ages
  - not all species
- function is currently obscure
  - probably motion sensors in early life
  - maybe electrosensory/ magnetic field

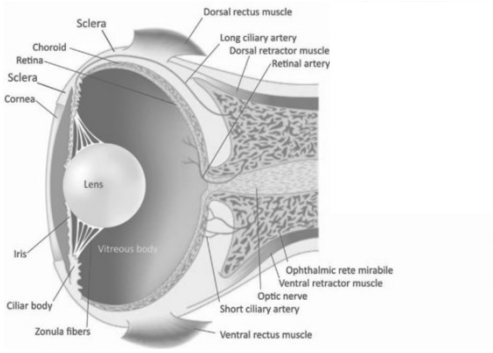


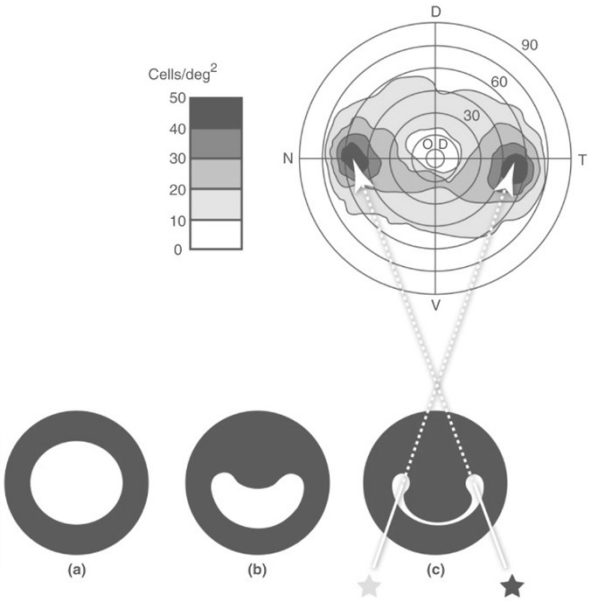
Eye



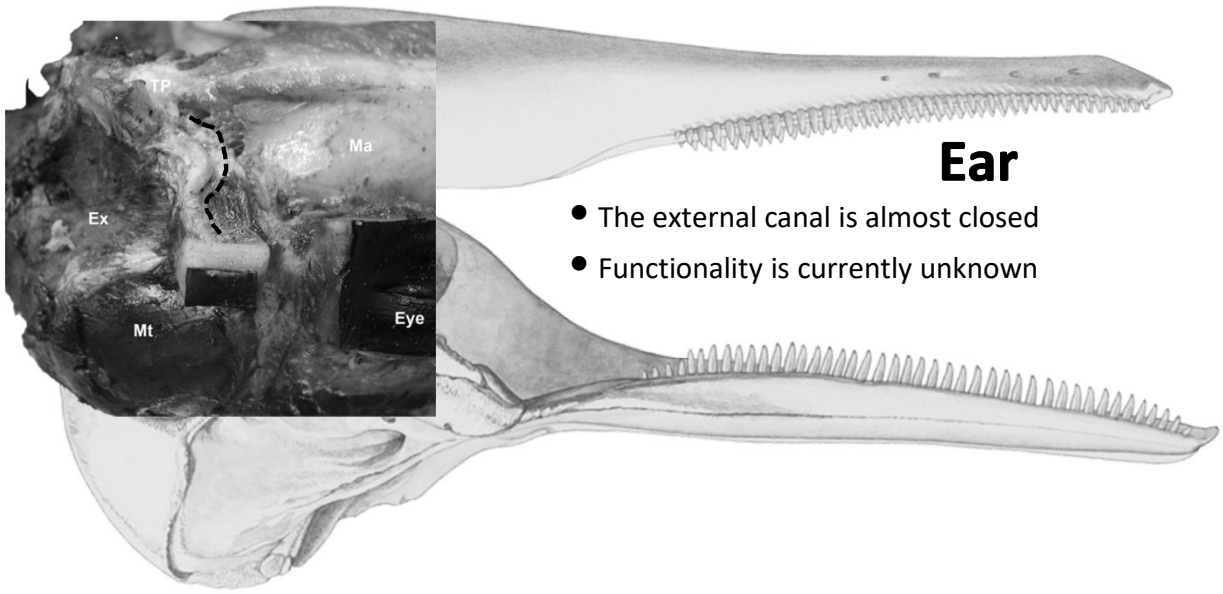
Eye

- Very peculiar eye morphology





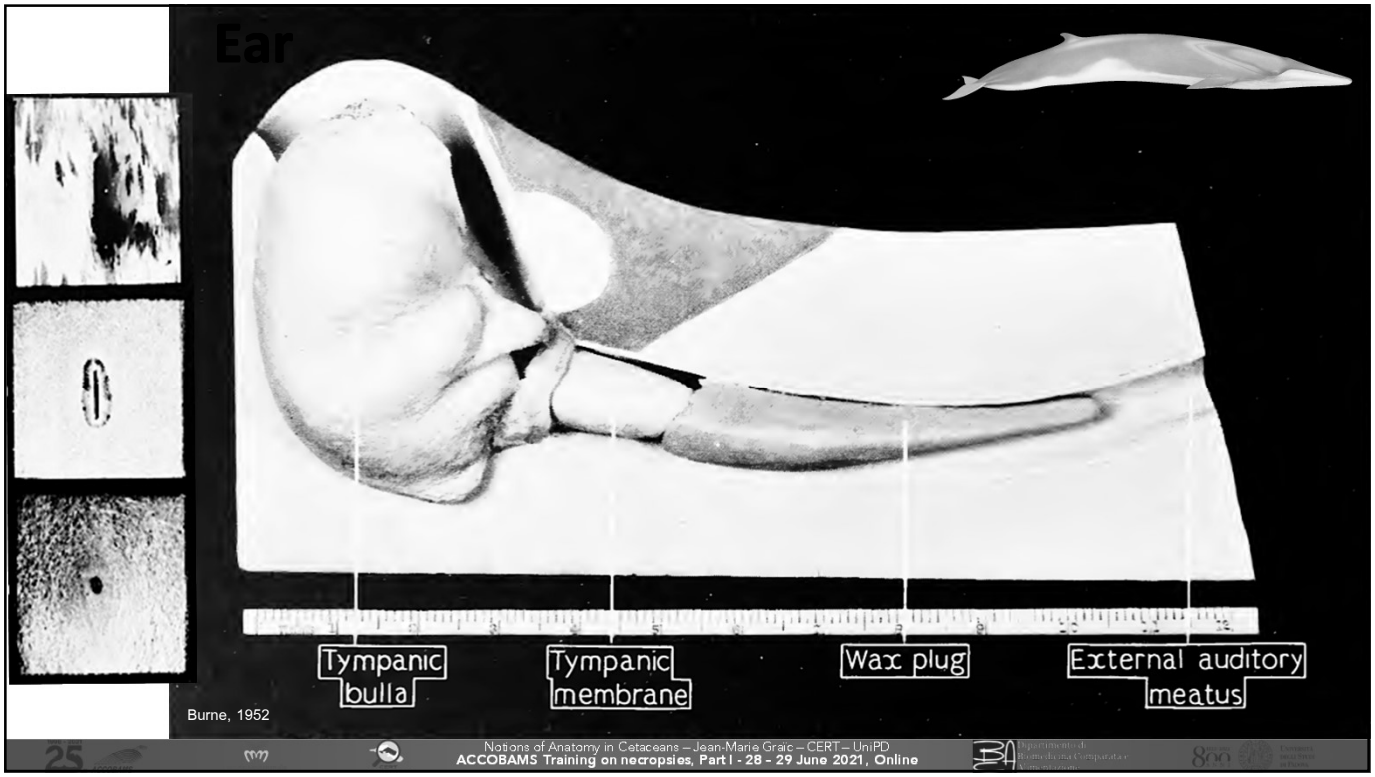
De Vreese et al., 2020



Ear

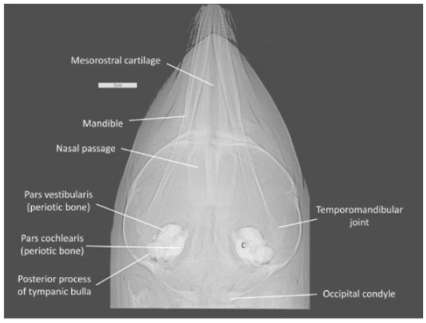
- The external canal is almost closed
- Functionality is currently unknown

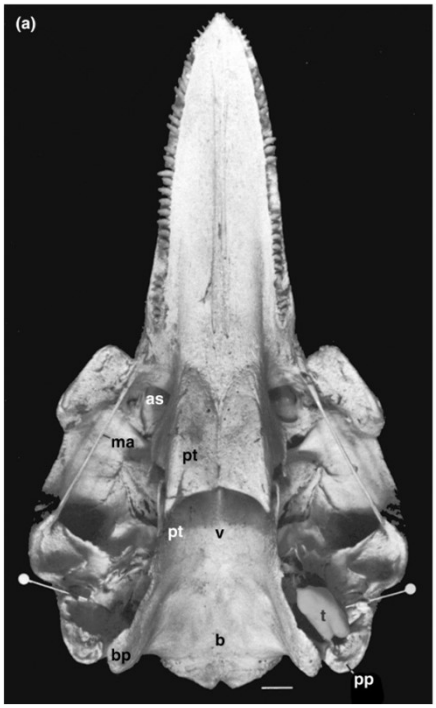
De Vreese et al., 2020

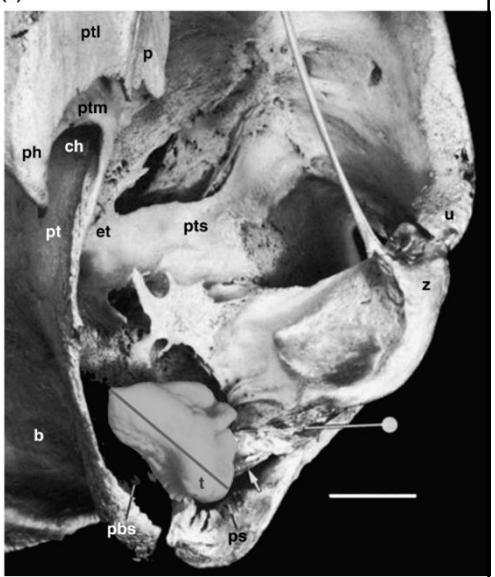


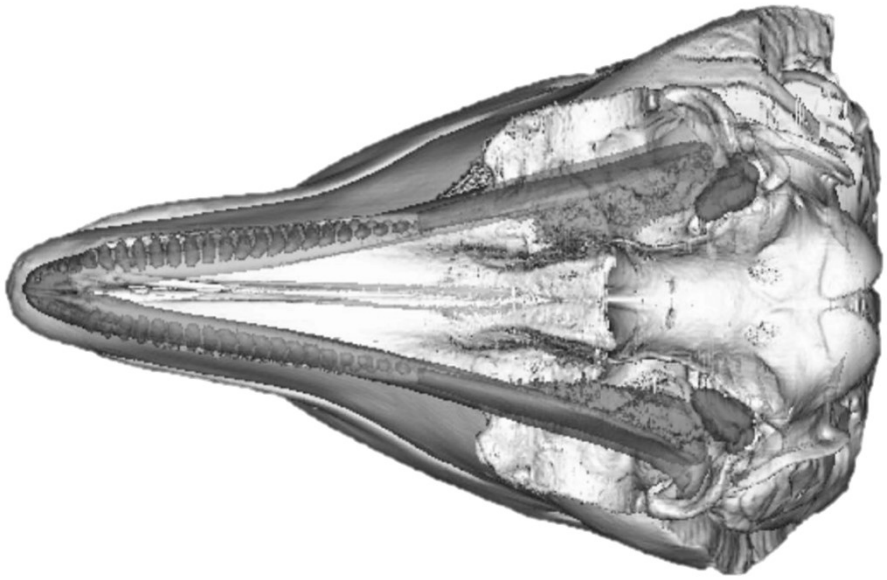
Ear

- The tympanic bulla contains the inner ear



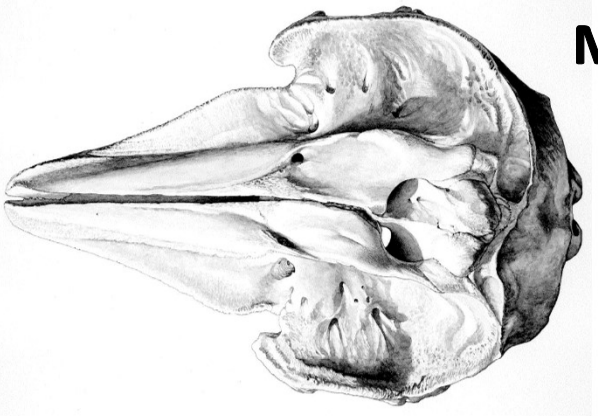


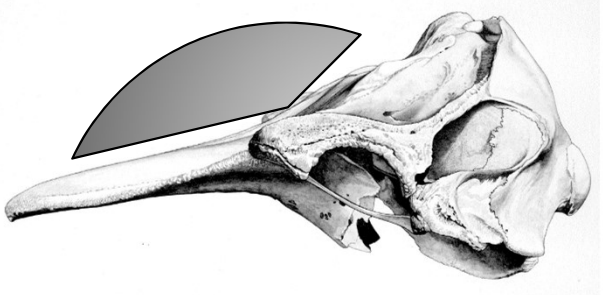


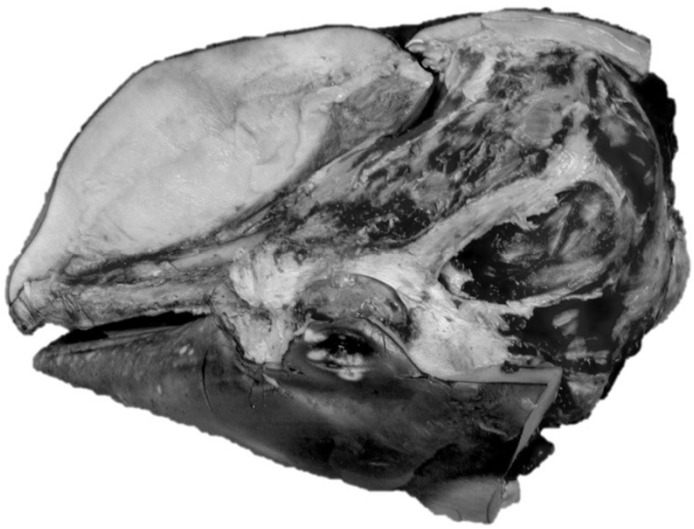


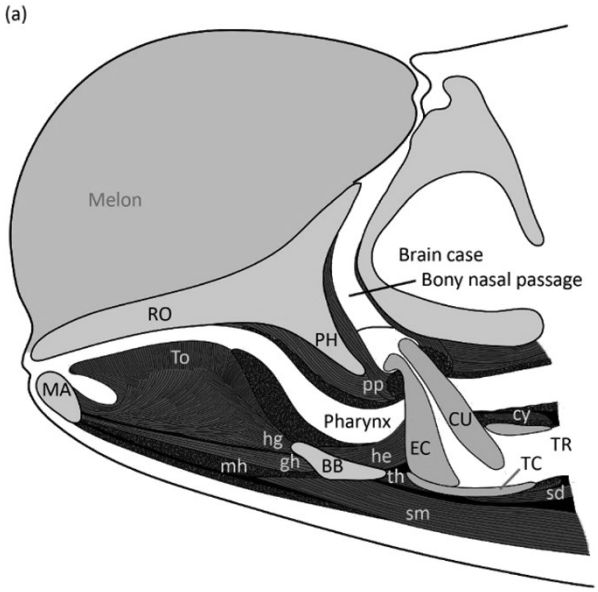
Cranford et al., 2010

Melon

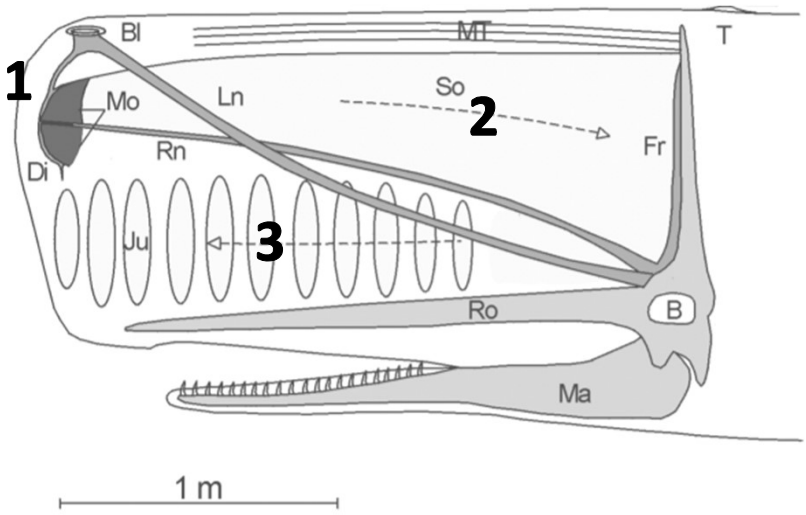


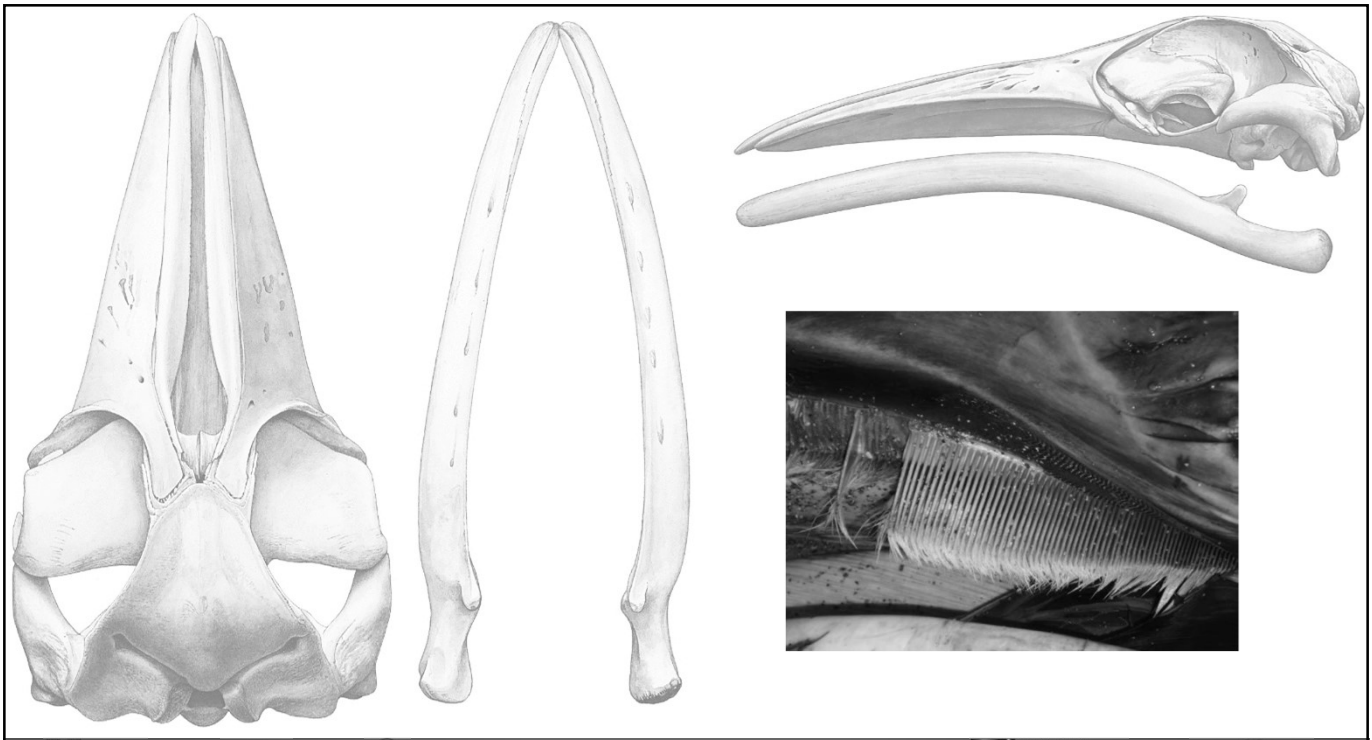






Notions of Anatomy in Cetaceans – Jean-Marie Graïc – CERT – UniPD
ACCOBAMS Training on necropsies, Part I - 28 - 29 June 2021, Online



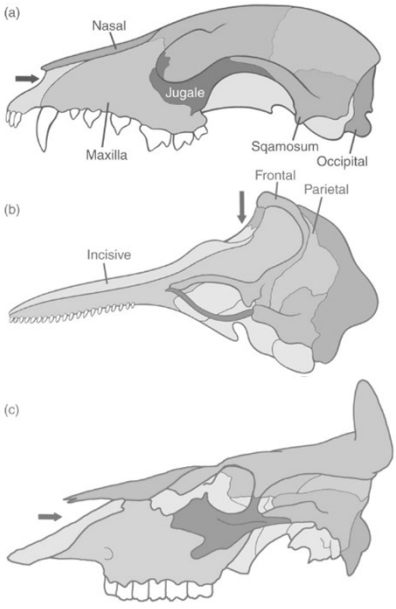


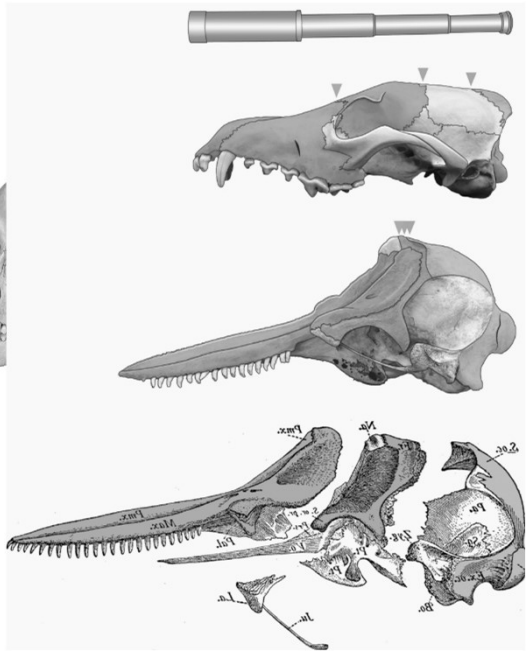
Notions of Anatomy in Cetaceans – Jean-Marie Graïc – CERT – UniPD
ACCOBAMS Training on necropsies, Part I - 28 - 29 June 2021, Online

The locomotor system

(skeleton and muscles)

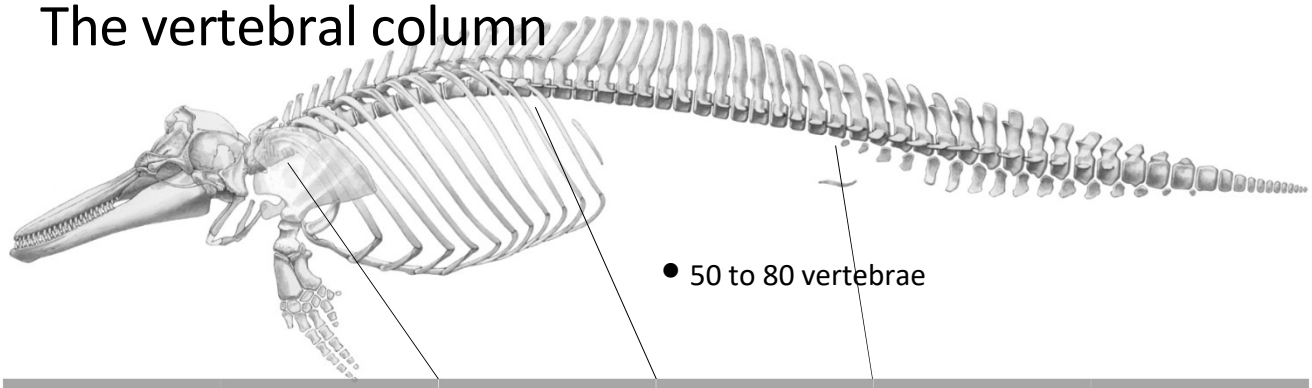
The skull





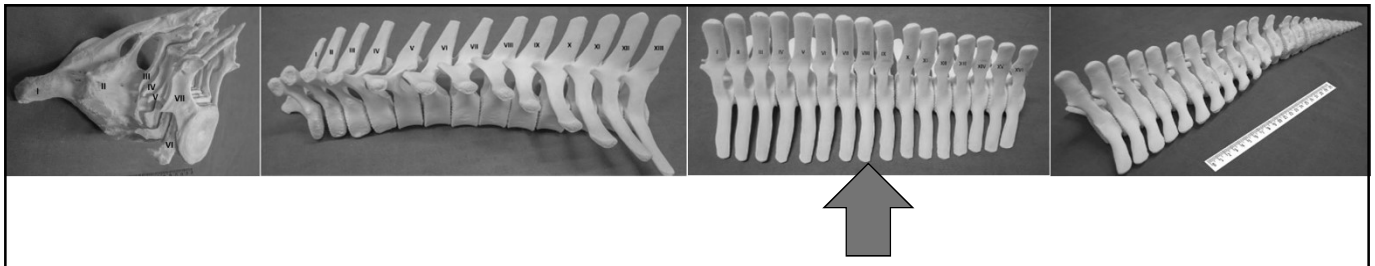
Notions of Anatomy in Cetaceans – Jean-Marie Graïc – CERT – UniPD
ACCOBAMS Training on necropsies, Part I - 28 - 29 June 2021, Online

The vertebral column



- 50 to 80 vertebrae

Species	C	T	L	Cau	Total
T. truncatus	7	12–14	16–19	24–27	62–65
S. coeruleoalba	7	15	18–22	32–35	74–79
D. delphis	7	14	21	31–35	73 (70–75)
G. griseus	7	12–13	18–19	30–31	68–69
G. melas	7	11	12–14	28–29	58–59
O. orca	7	11–13	9–12	21–25	50–54
P. crassidens	7	10–11	9–11	20–23	47–52

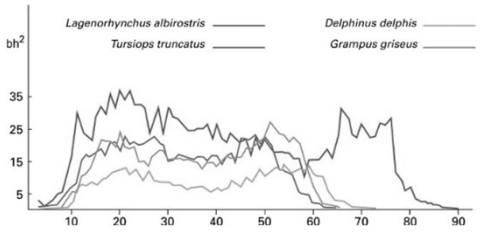


The vertebral column

Moment of resistance

➔The lumbar vertebras are subject to the most stress in large species

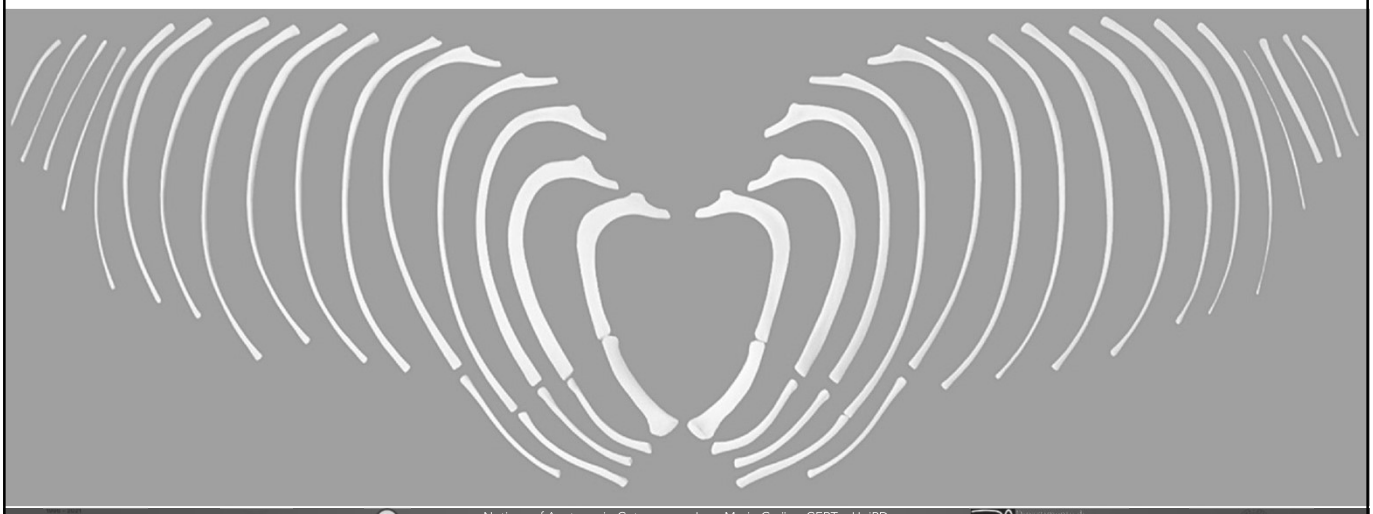
➔ Injuries frequent

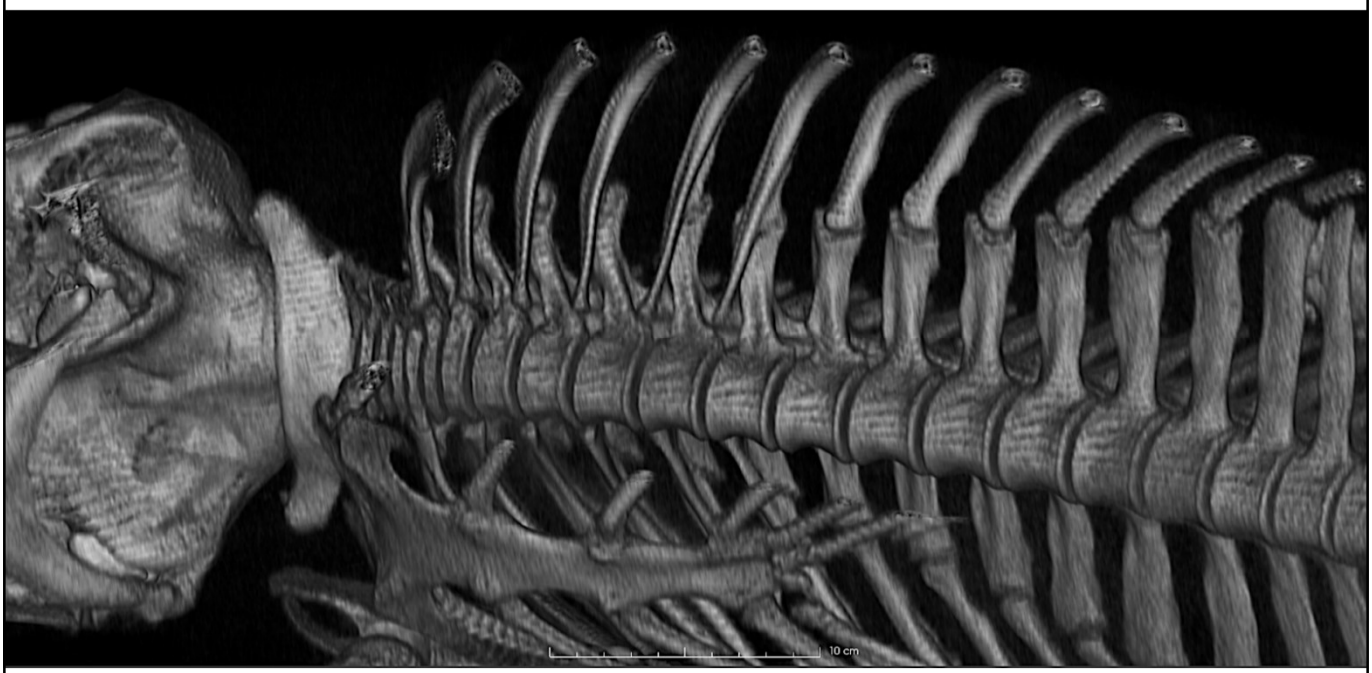


$W = bh^2$; Slijper (1936, 1946)

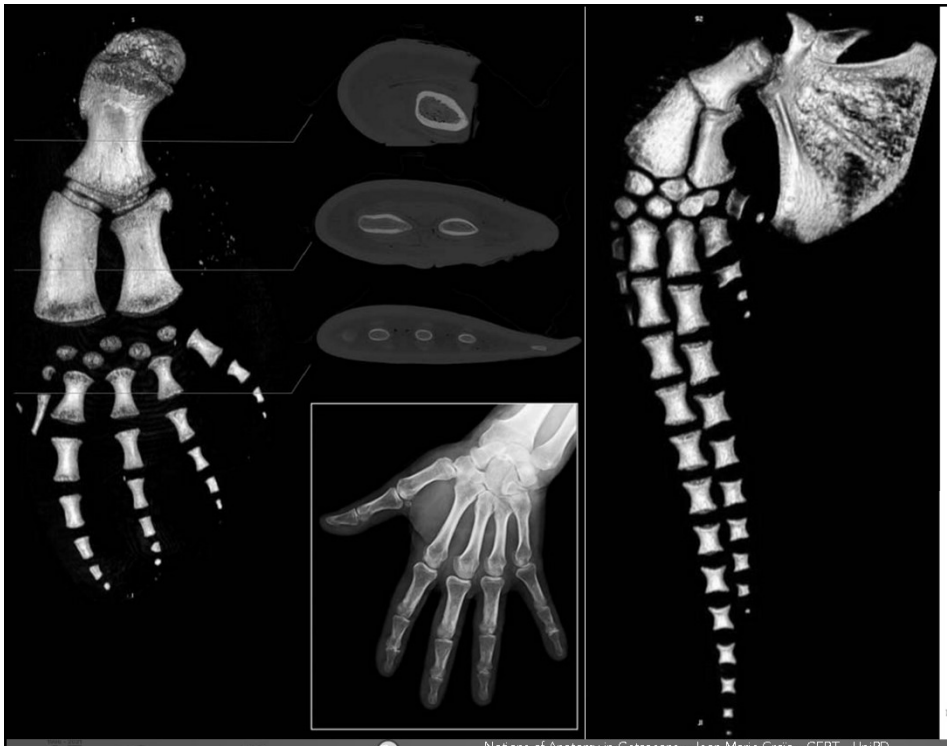
Ribs

Normal to find 4 to 6 first ribs with two parts





Sternum



The pectoral fin

- ➔ is a complete mammalian limb
- ➔ Epiphysis fusion and bone density can help determine age

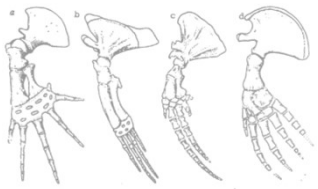
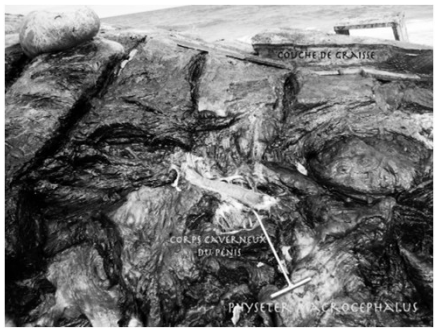


Figure 37. Skeleton of the pectoral limb of some cetaceans (Howell, 1930)
Legend:
a) Eubalaena b) Balaenoptera c) Globicephala d) Platanista

The pelvic limb

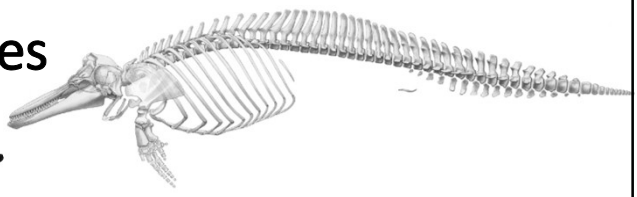
vestigial

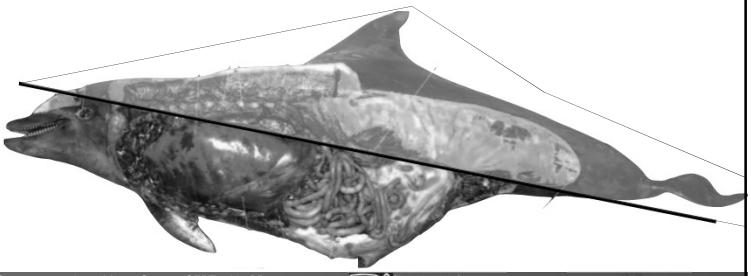
- Remnants of the coxal bone
- Found above the genial slit
  - Slightly deeper in males

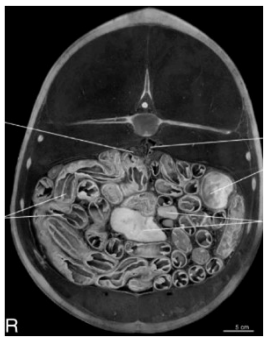


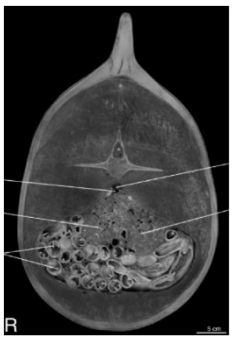
© Pierre Henri Fontaine

Muscles

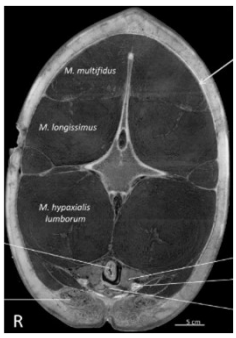


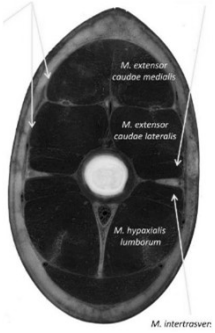


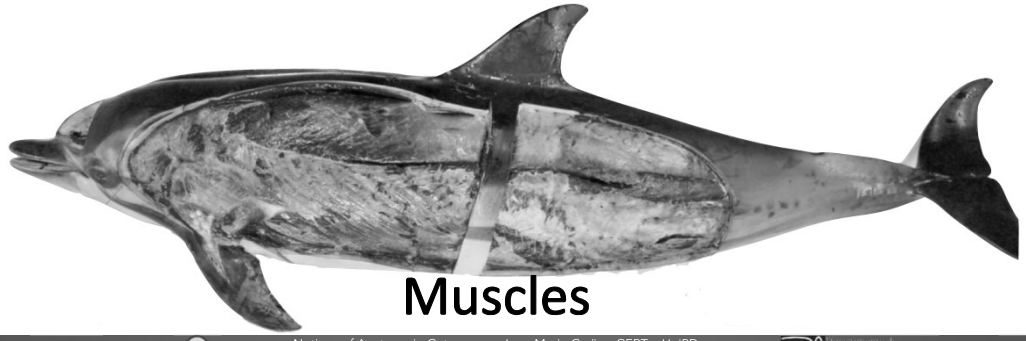

R


R

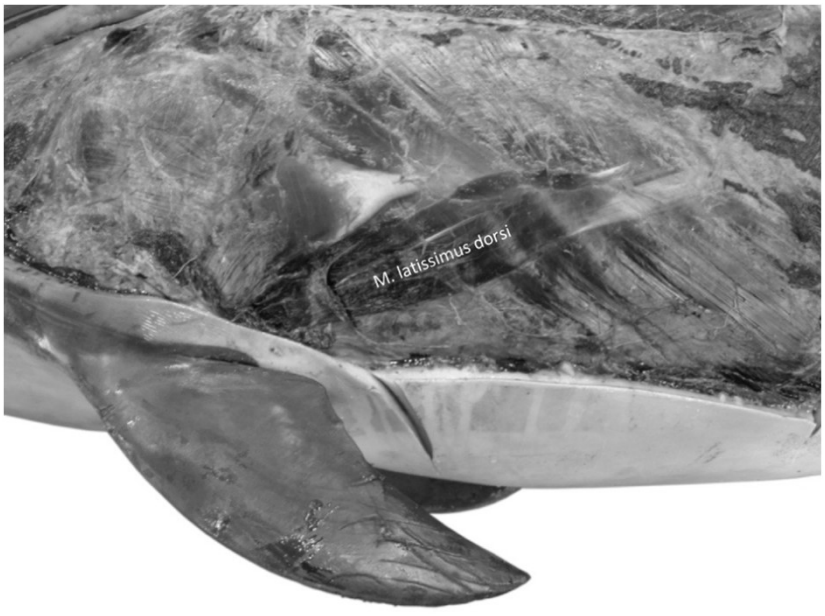

R


M. multifidus
M. longissimus
M. hypaxialis lumborum
R


M. extensor caudae medialis
M. extensor caudae lateralis
M. hypaxialis lumborum
M. intertrasver



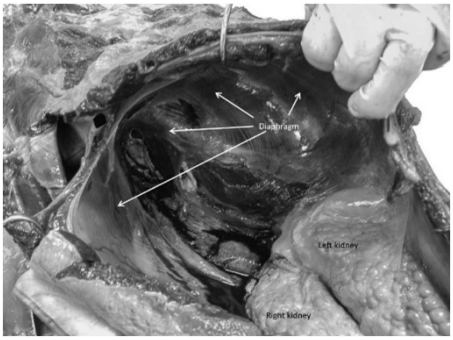
Muscles


M. latissimus dorsi

Muscles

Diaphragm

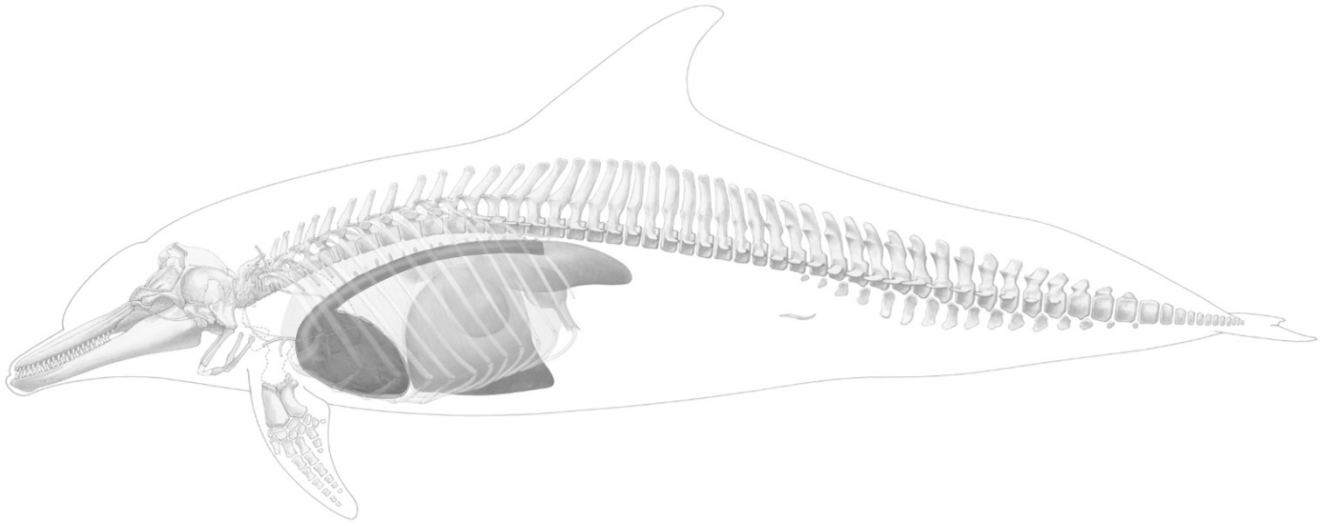
- Extremely deep and curved
- Strong, could participate in blood flow management

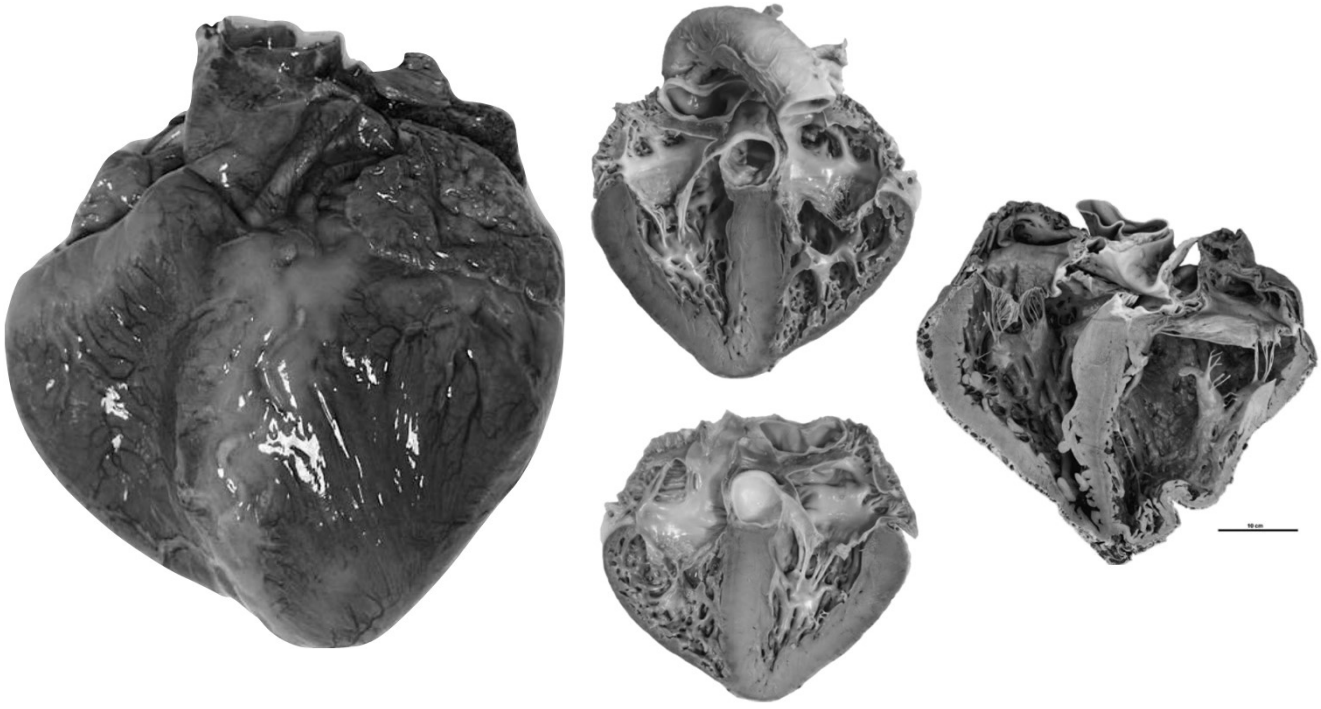


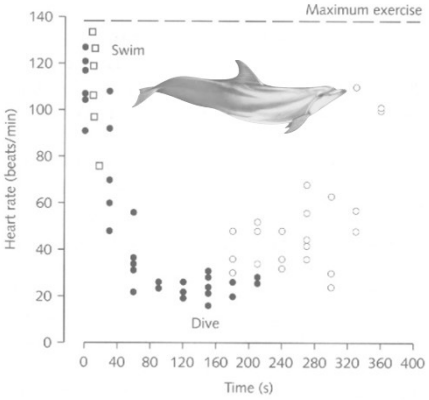
Lillie et al., 2017

The circulatory system

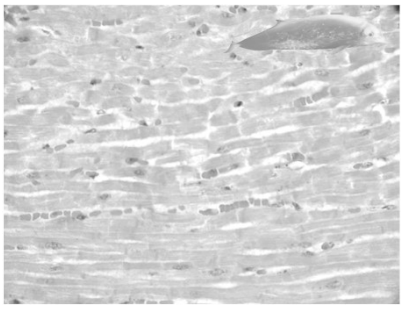
(+ thymus and spleen)

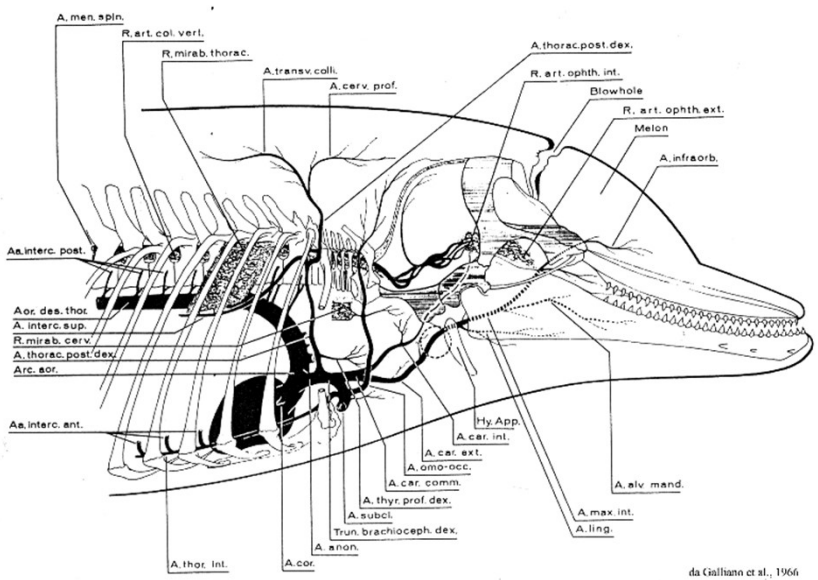




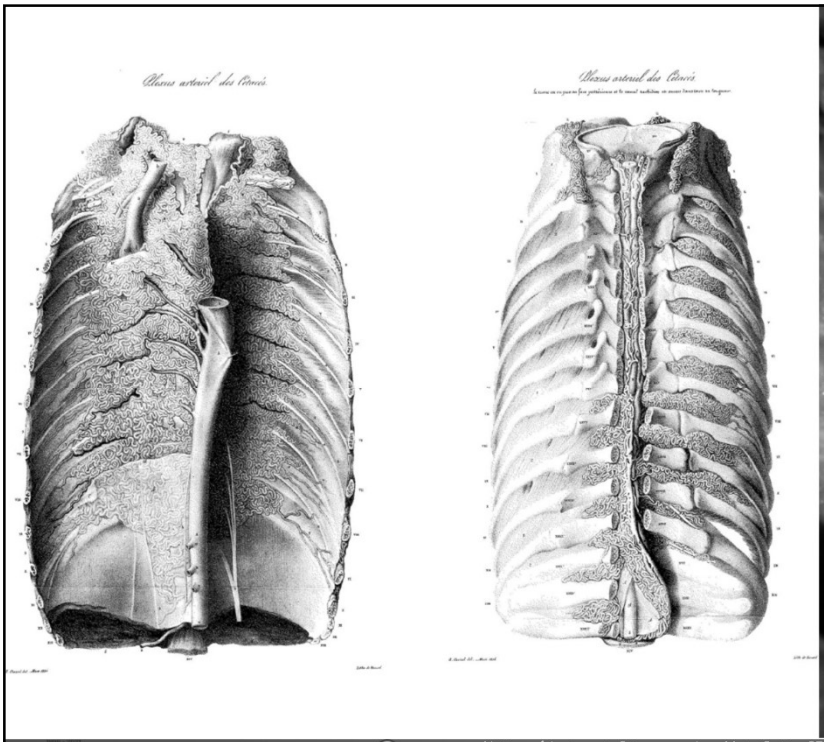


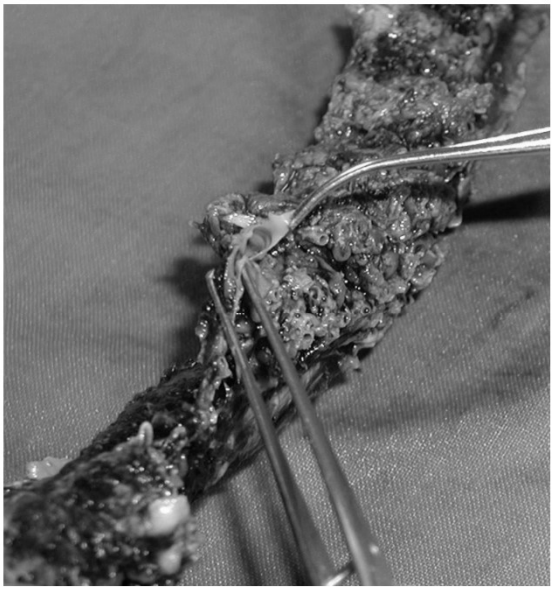
Heart rate in relation to dive duration for bottlenose dolphins freely diving to 210 m. Each point represents the average heart rate for 10 s intervals during the dive. Solid circles are values for heart rate during the descent; open circles are for the ascent phase. Average heart rates for dolphins swimming on the water surface are shown by the squares. The upper dashed line illustrates the maximum heart rates for bottlenose dolphins pushing on a load cell.

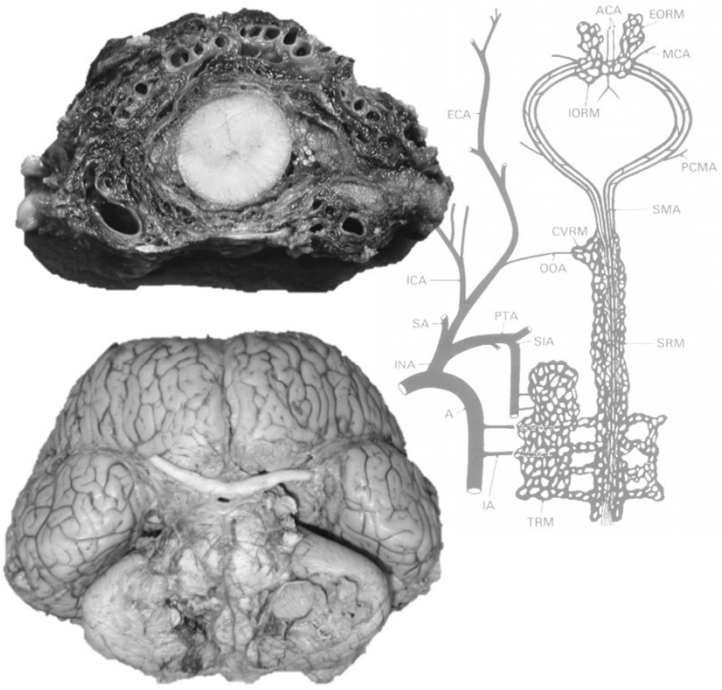


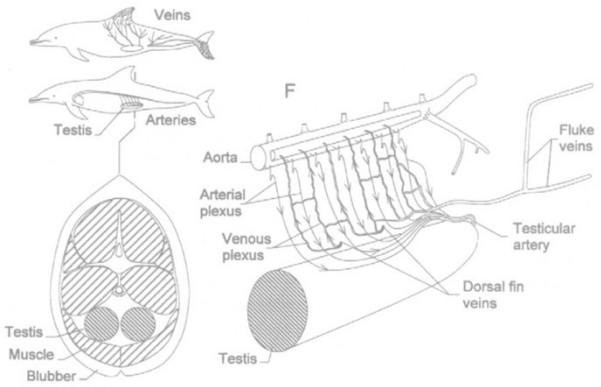


da Gallisano et al., 1966

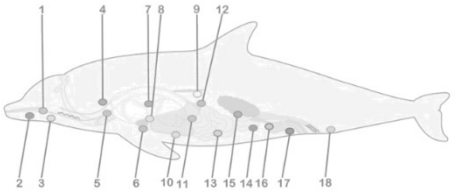

Plexus arteriel des Cetacés.
Plexus arteriel des Cetacés.



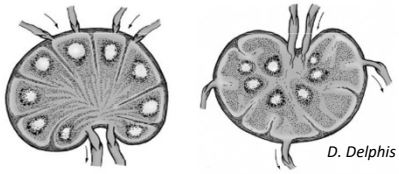

ACA
EORM
MCA
ECA
IORM
PCMA
SMA
CVRM
OOA
ICA
SA
PTA
SIA
SRM
INA
A
IA
TRM



Lymphatic system

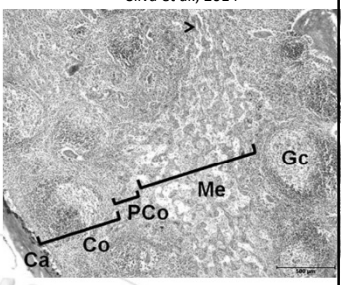


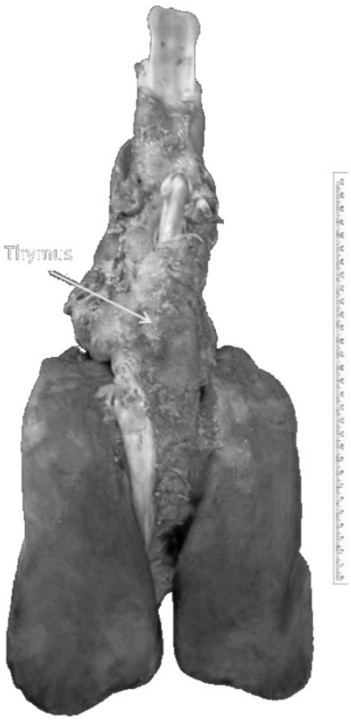
Several lymph nodes are easily accessible



D. Delphis

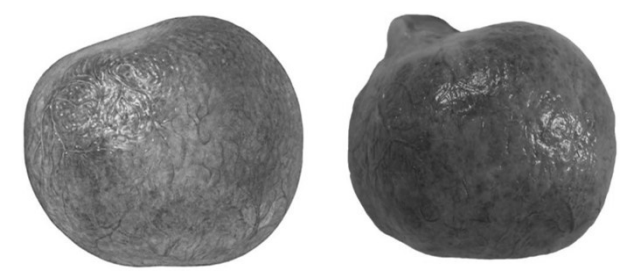
Silva et al., 2014

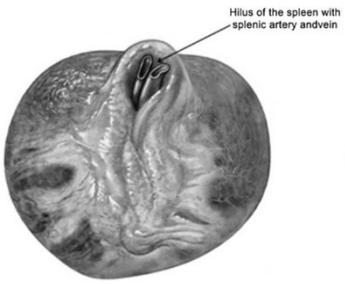


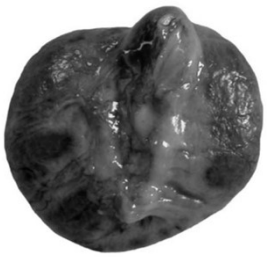


Thymus

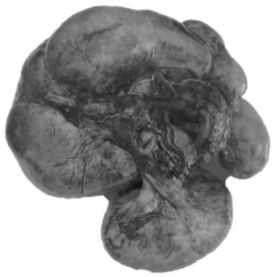
- Placed similarly to other mammals
- Degenerates in adults like in most mammals



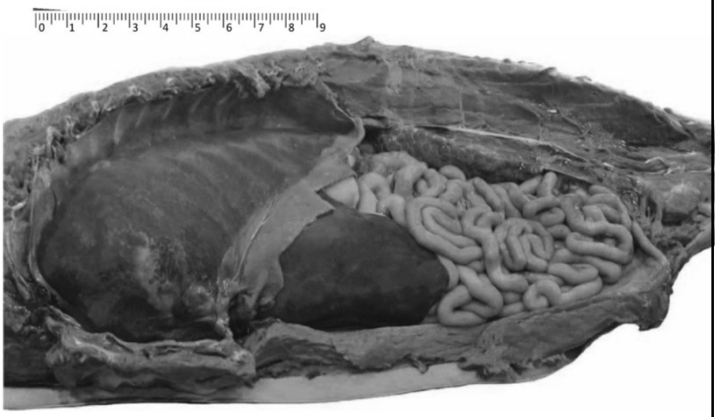




Spleen

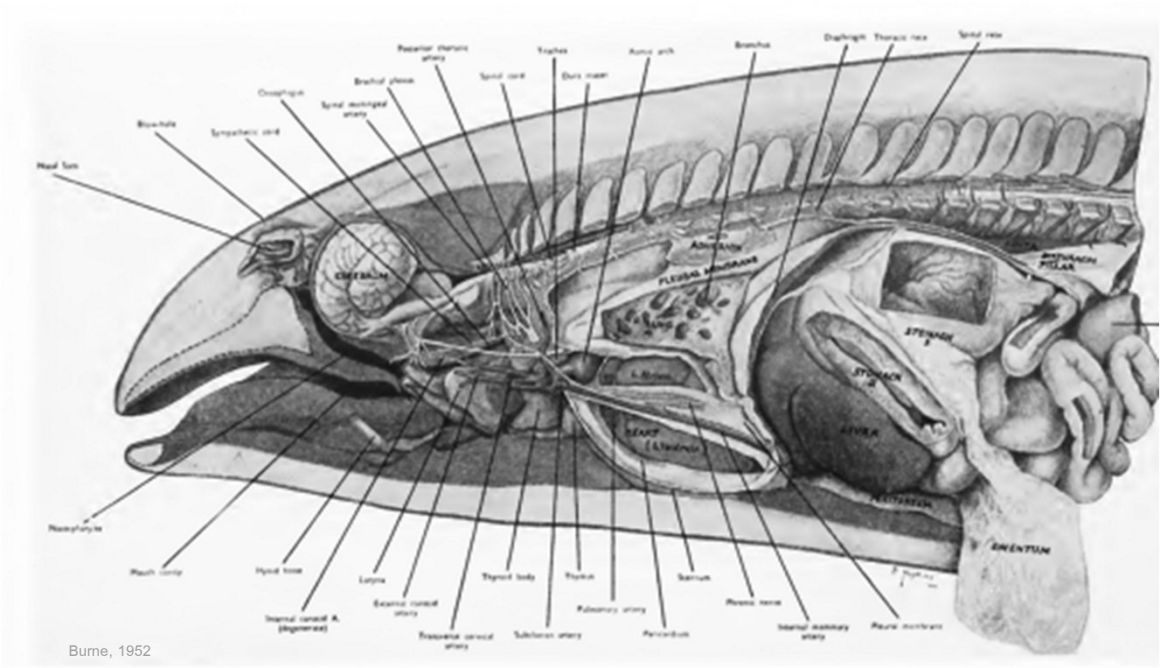


- Small (0,2% of body weight)
- Ectopic ones are frequent

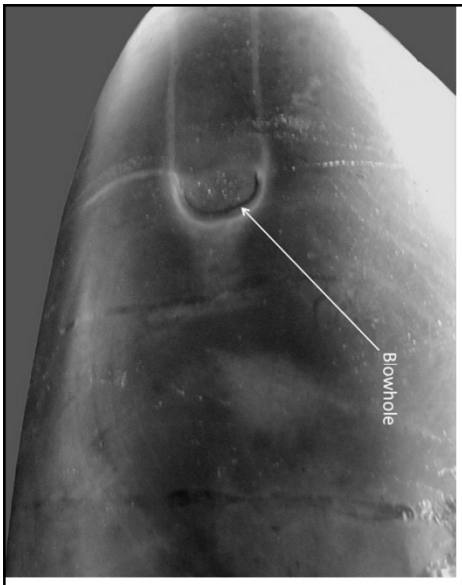


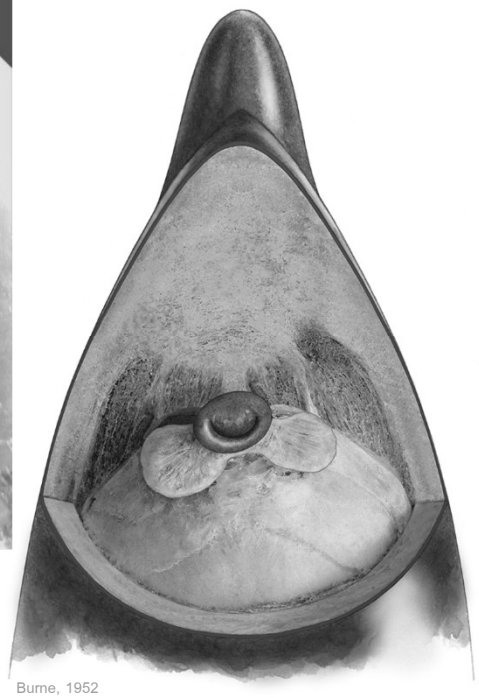
The respiratory system

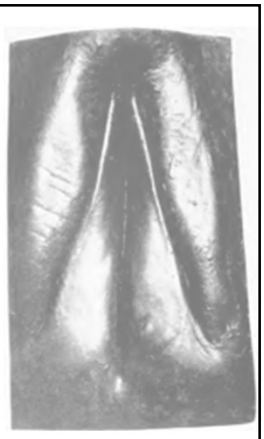
Notions of Anatomy in Cetaceans – Jean-Marie Graïc – CERT – UniPD
ACCOBAMS Training on necropsies, Part I - 28 - 29 June 2021, Online



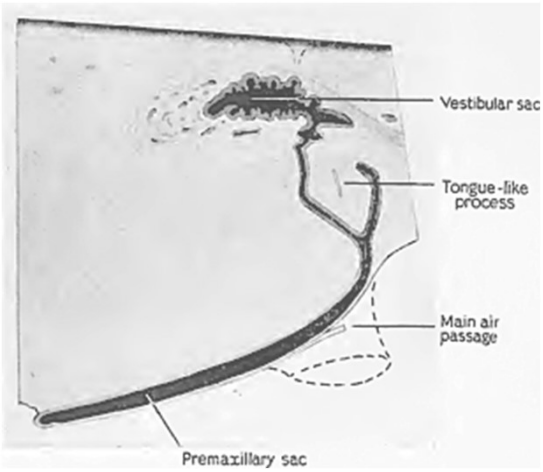
Burne, 1952

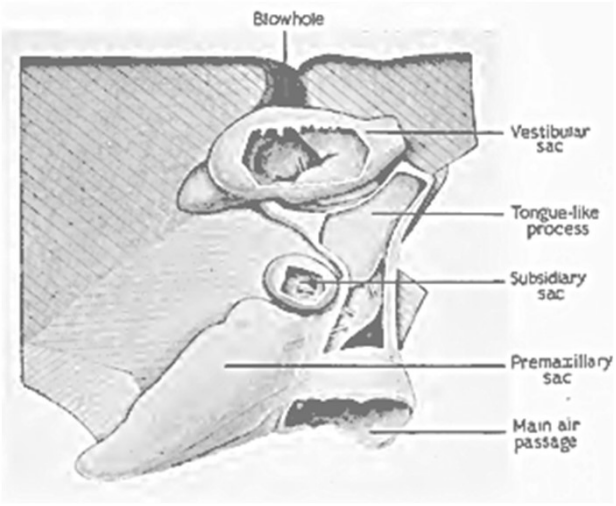




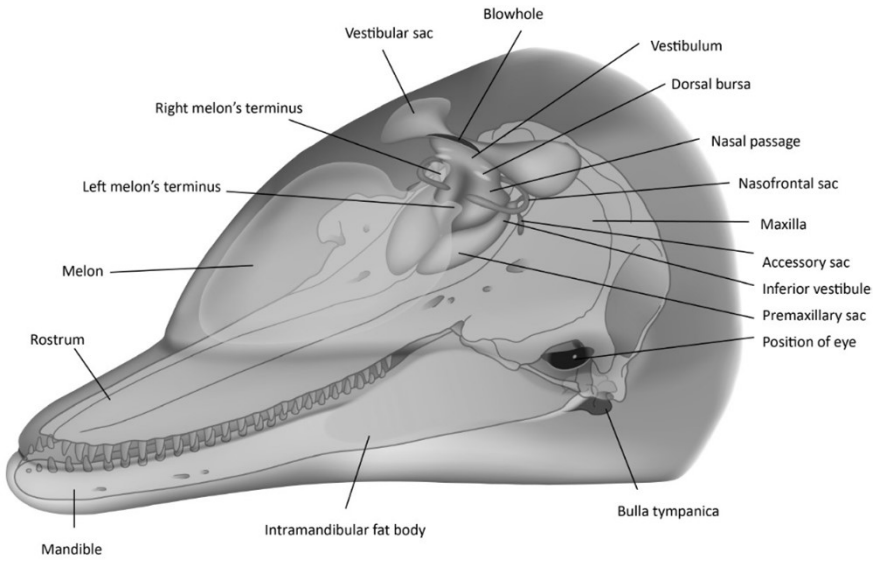


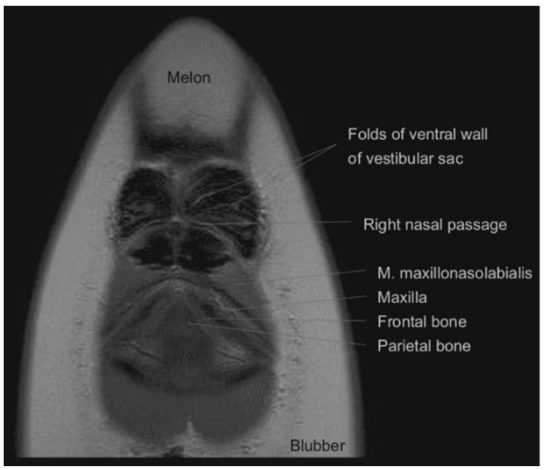
Burne, 1952


Vestibular sac
Tongue-like process
Main air passage
Premaxillary sac

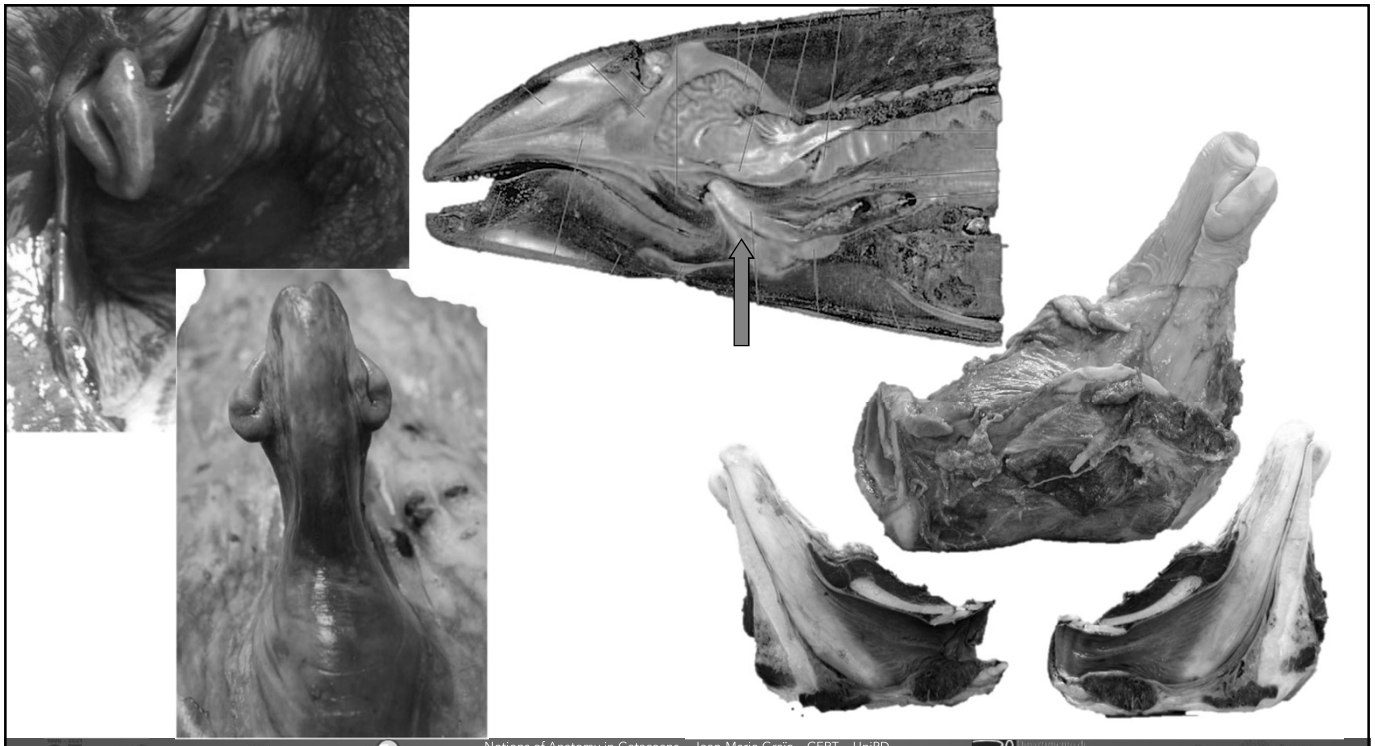

Blowhole
Vestibular sac
Tongue-like process
Subsidiary sac
Premaxillary sac
Main air passage

Burne, 1952

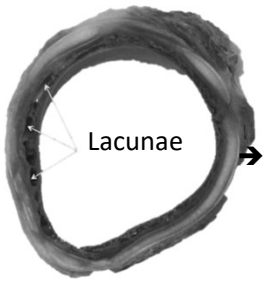

Blowhole
Vestibular sac
Vestibulum
Dorsal bursa
Right melon's terminus
Nasal passage
Left melon's terminus
Nasofrontal sac
Maxilla
Accessory sac
Melon
Inferior vestibule
Premaxillary sac
Rostrum
Position of eye
Bulla tympanica
Intramandibular fat body
Mandible



© Karen Stokin



Trachea

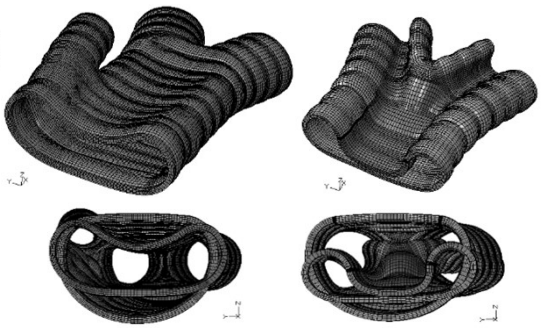


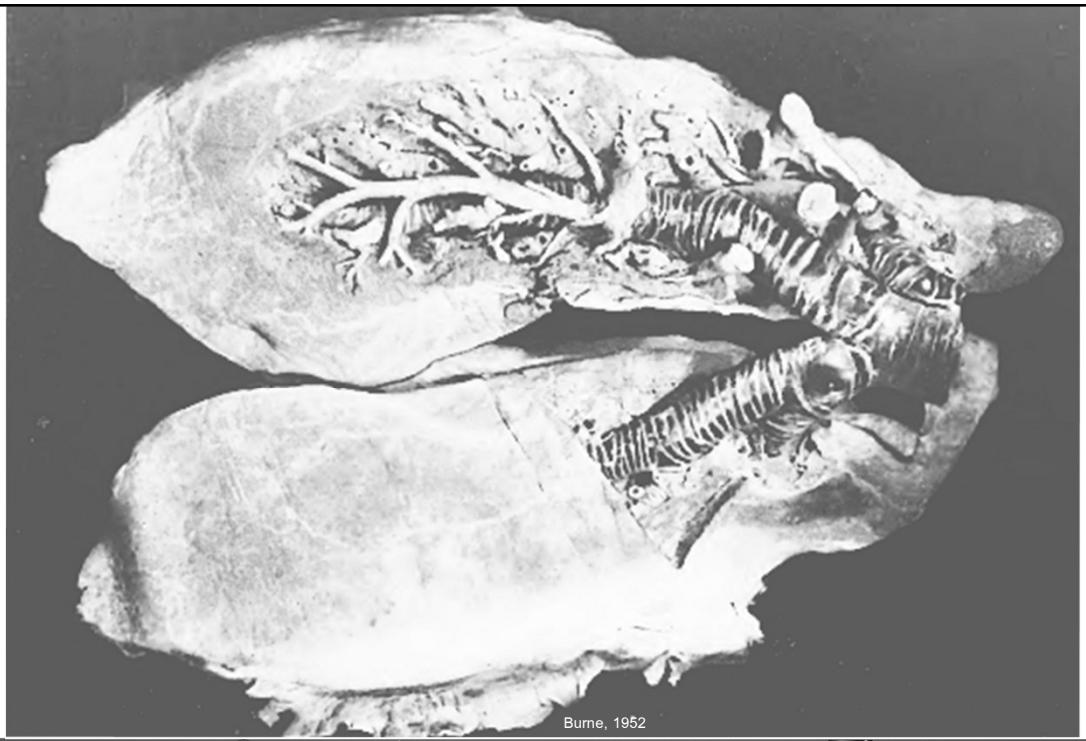
➔ The structure of the dolphin trachea is less collapsible

➔ higher rigidity

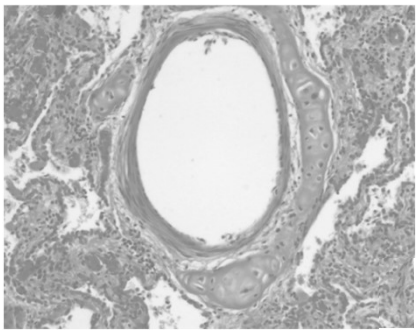
➔ lack of tracheal muscle

➔ shape of the tracheal rings



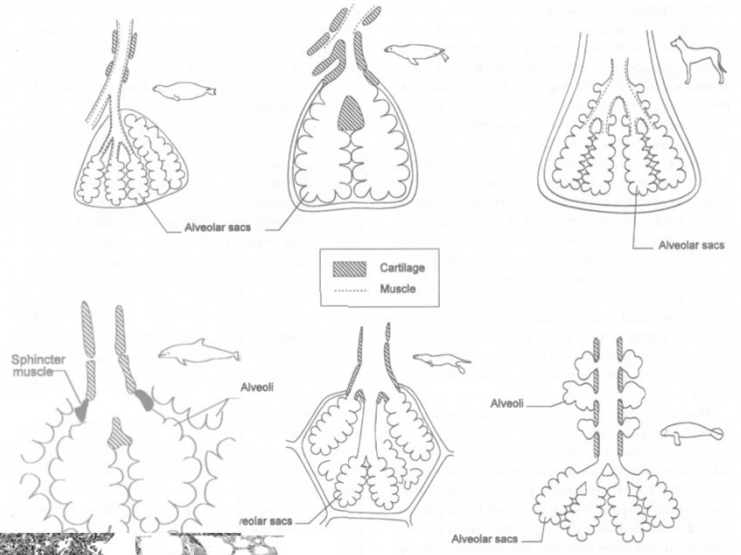


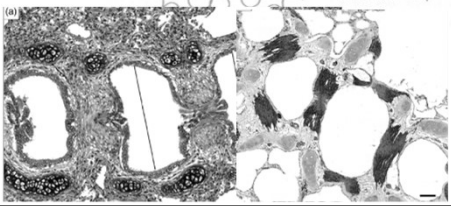
Burne, 1952



During a dive

- Air is present inly in rigid spaces of the lungs
- Alveoli collapse

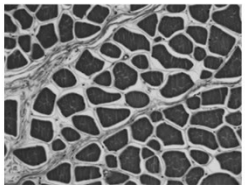


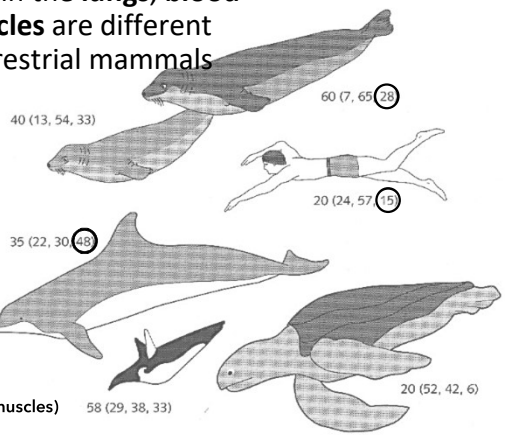


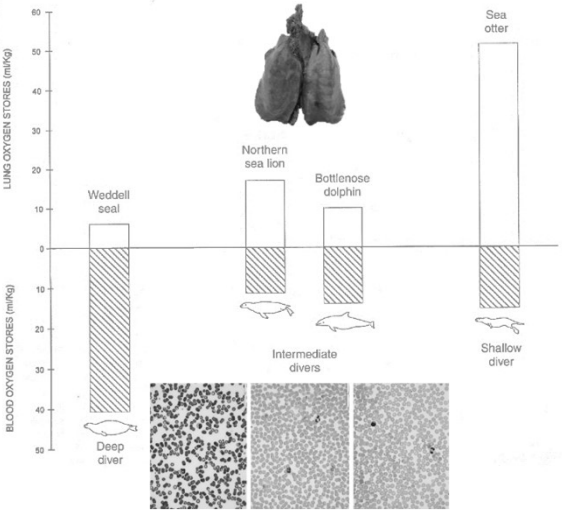
Oxygen storage

Adaptations to diving

- The respective oxygen storages in the **lungs**, **blood** and **muscles** are different from terrestrial mammals

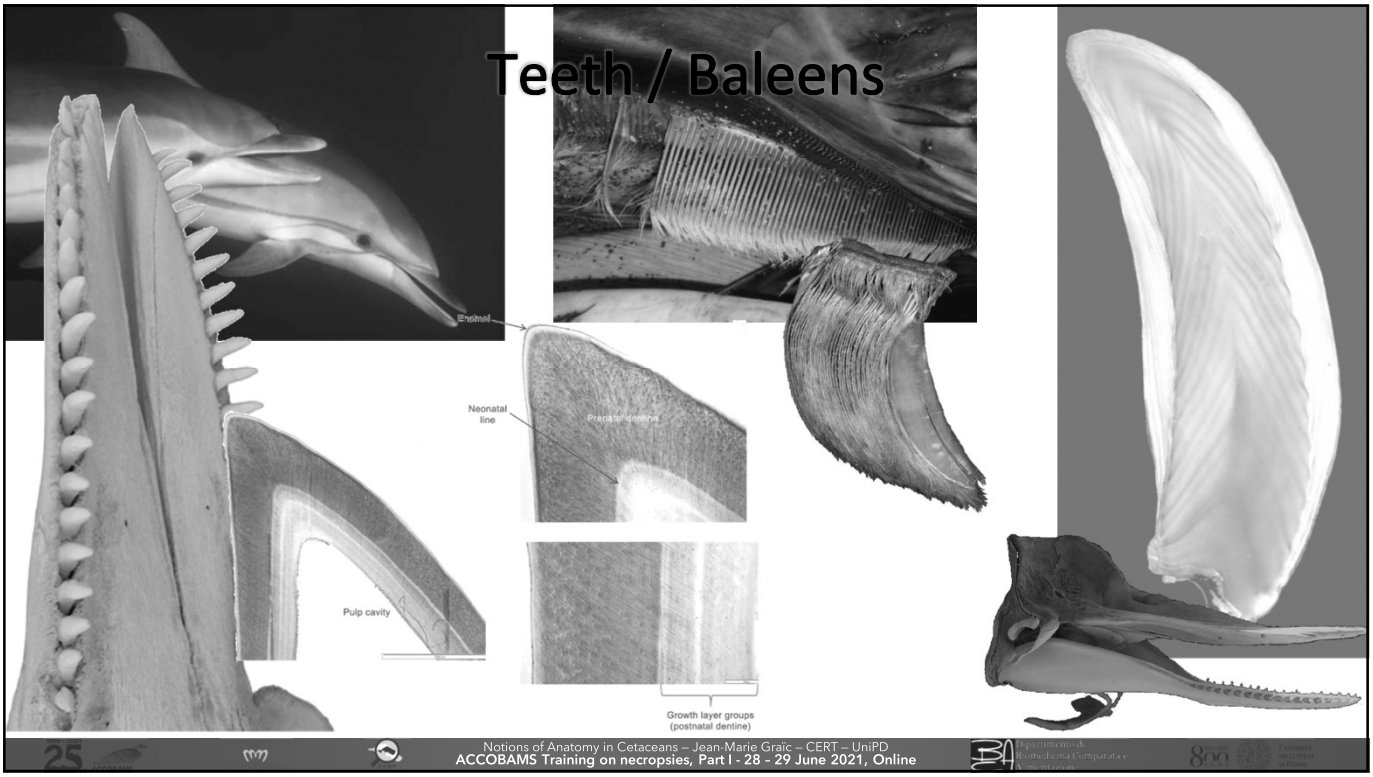






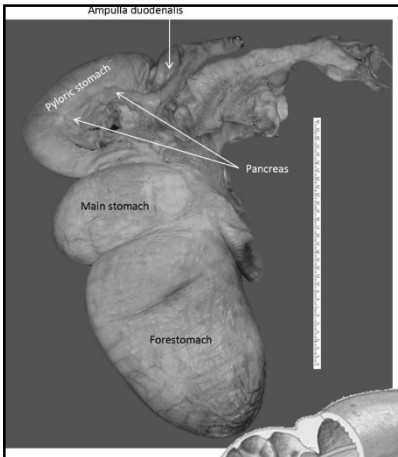
The digestive system

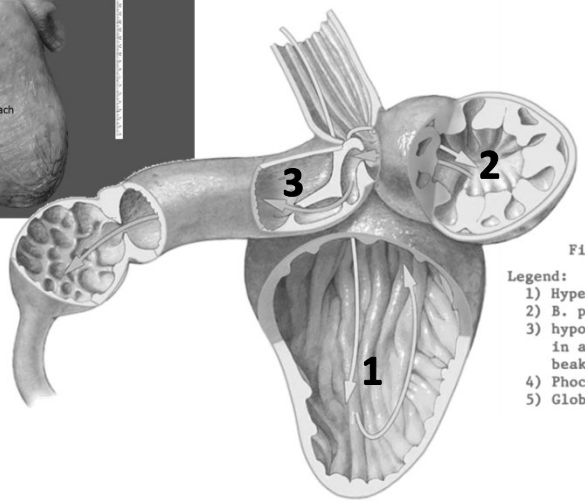
Teeth / Baleens



Tongue

Stomach





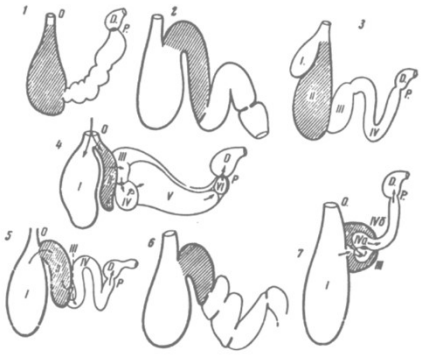
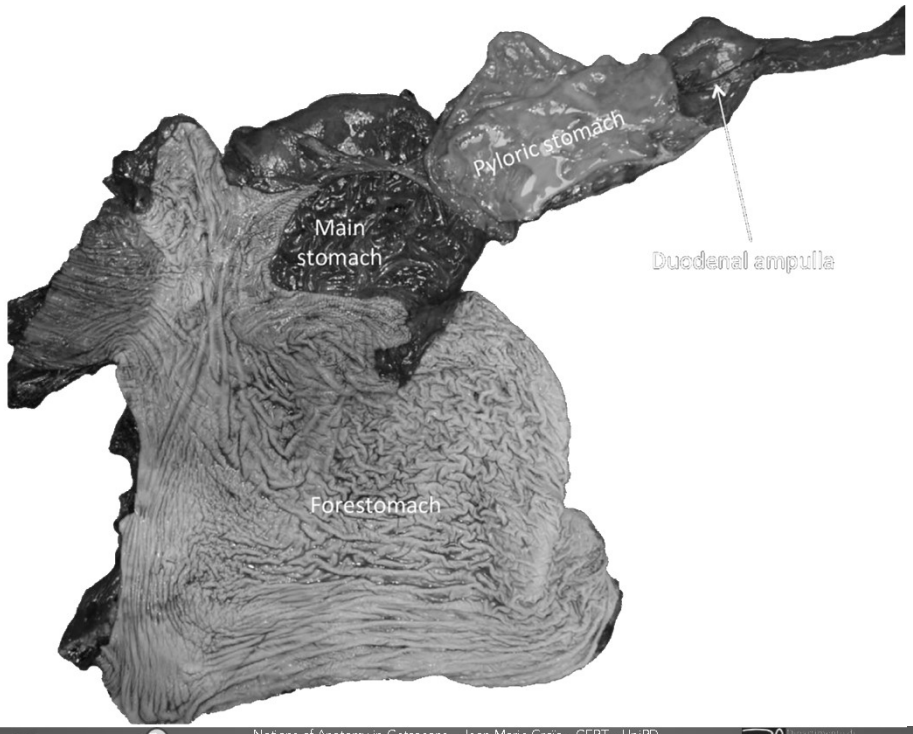


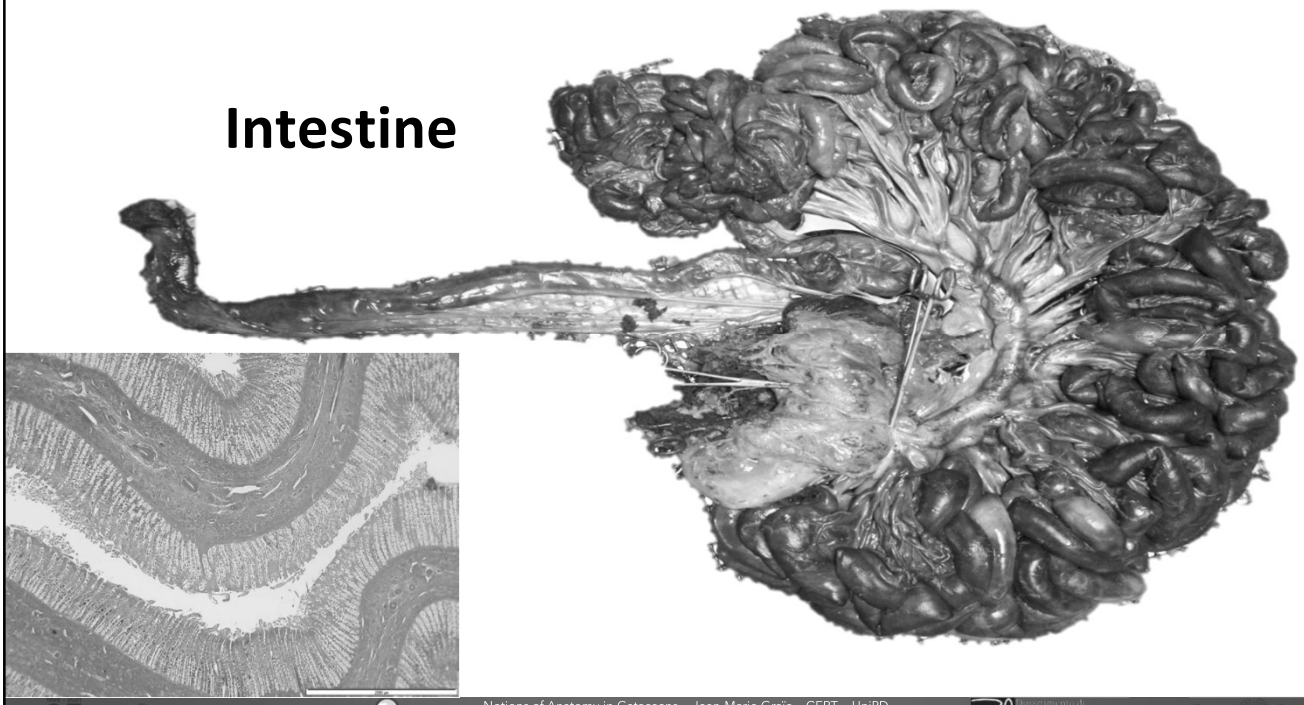
Figure 68. Diagram of stomach structure in some cetacean species (according to Jungklaus, 1898, with additions)

Legend:
1) Hyperoodon
2) B. physalus
3) hypothetical structure of stomach in ancestors of contemporary beaked whales
4) Phocoena
5) Globicephala
6) Delphinapterus
7) Lagenorhynchus
o) esophagus
P) pylorus
D) duodenum
The gastric fundus is hashmarked

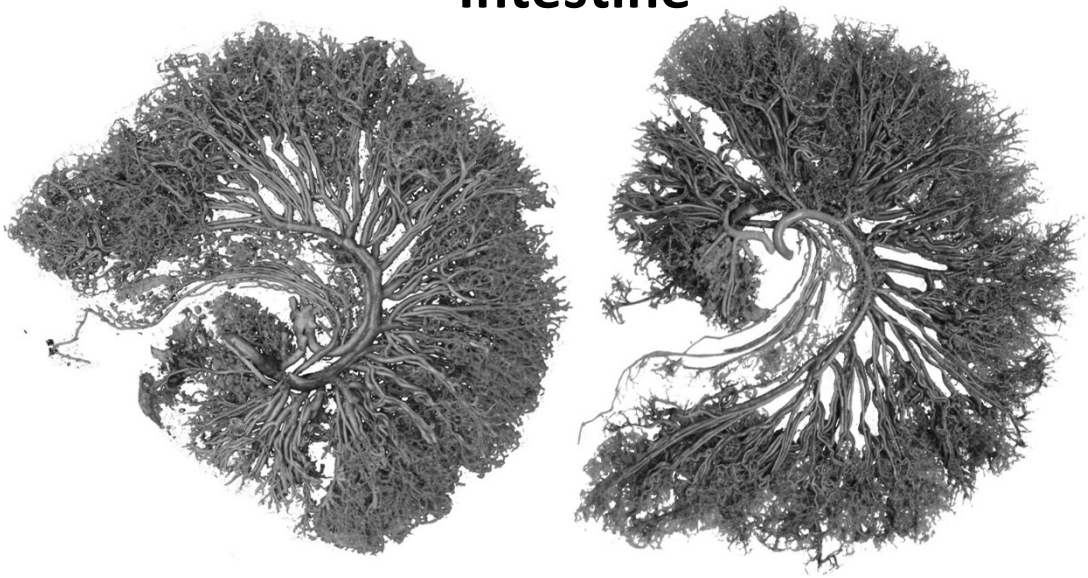
Yablokov, 1972

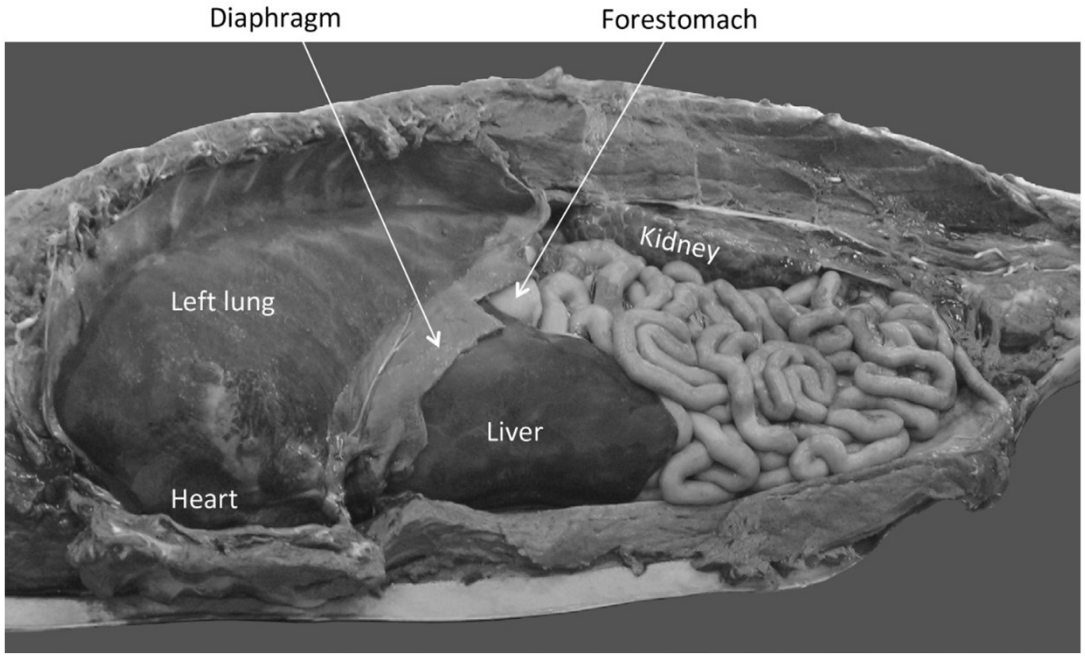


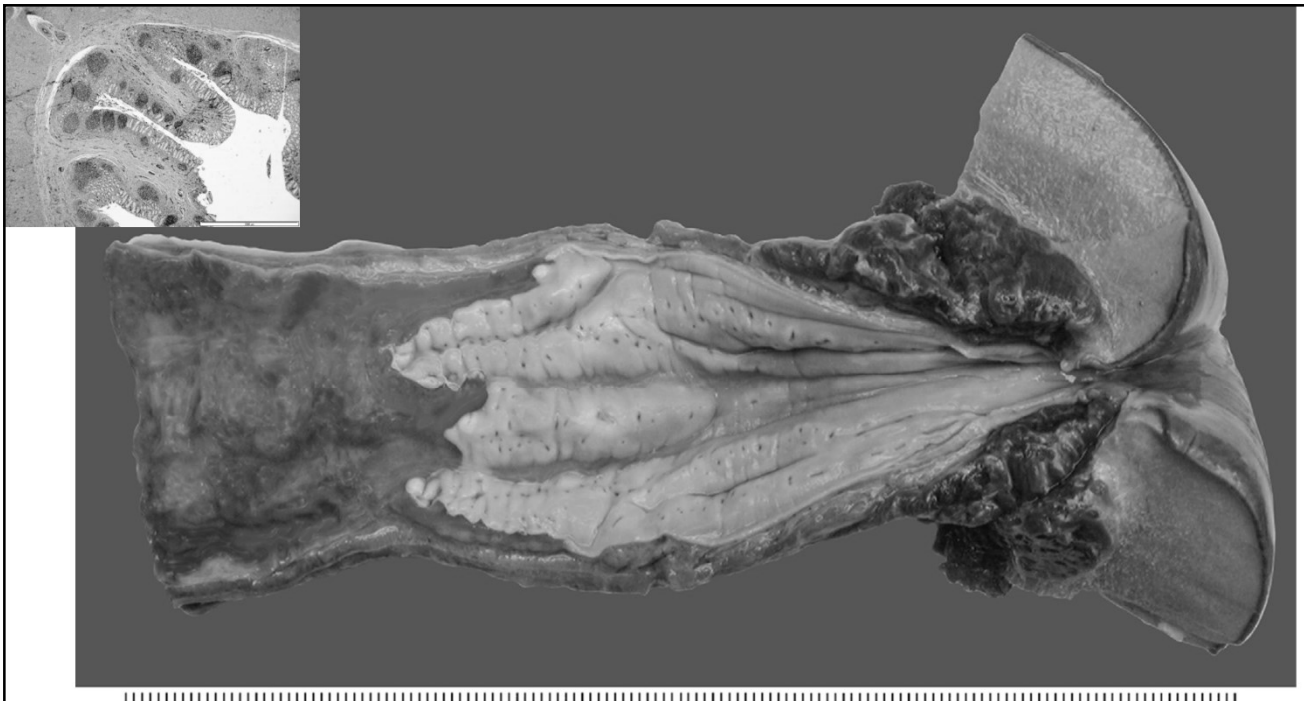
Intestine



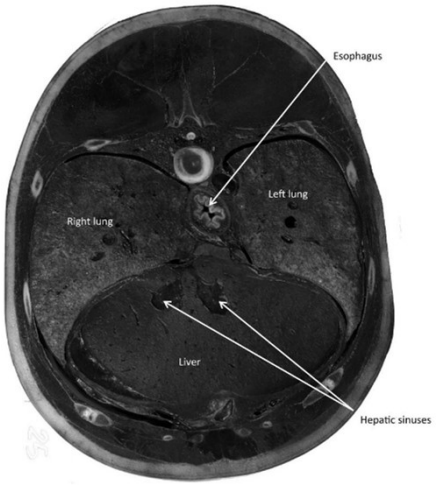
Intestine

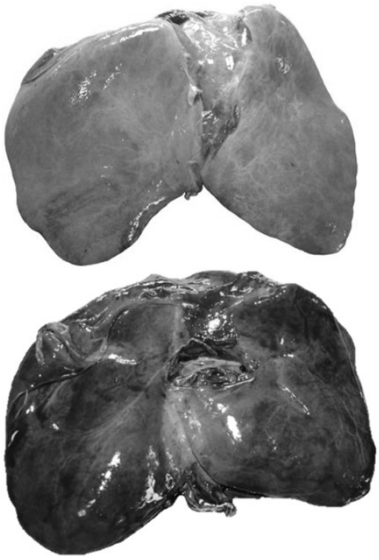


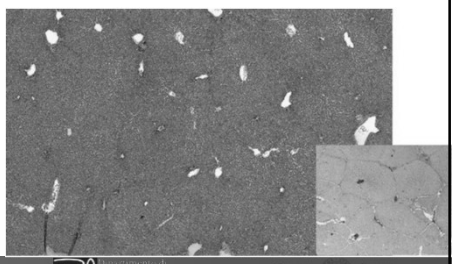

Diaphragm
Forestomach
Kidney
Left lung
Liver
Heart


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

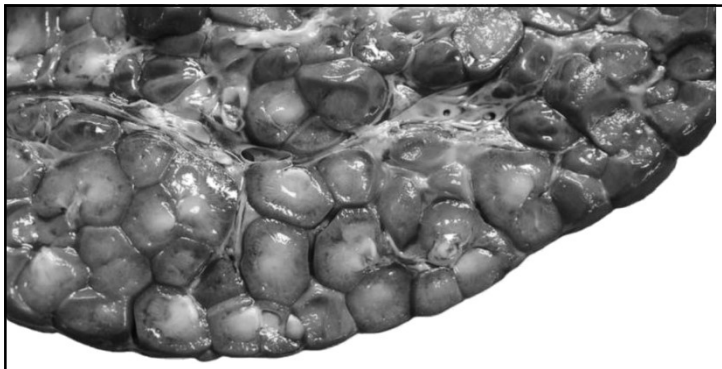
Liver

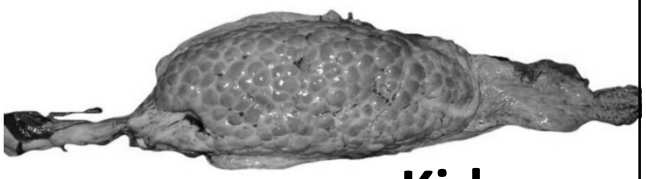




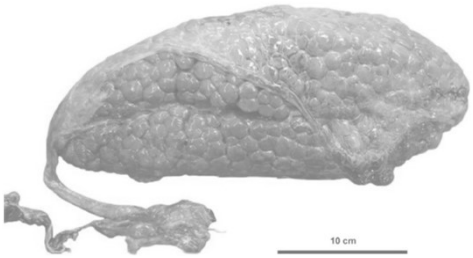


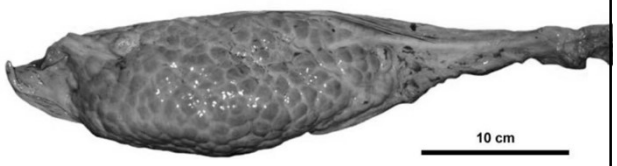
The urinary system

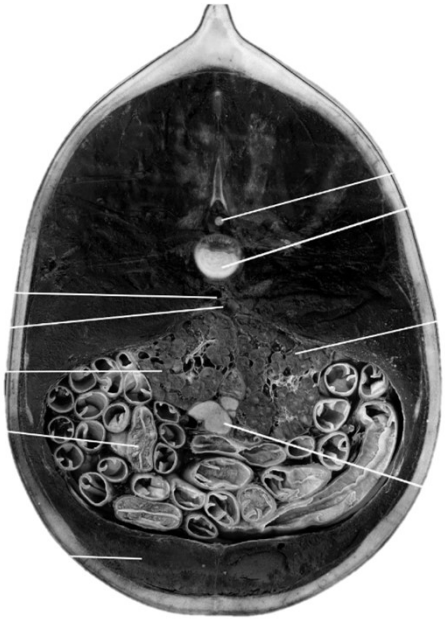


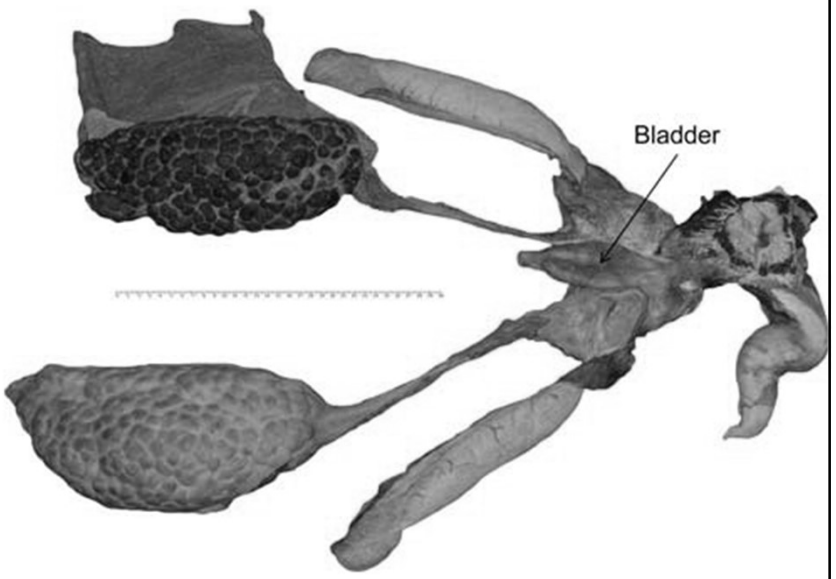


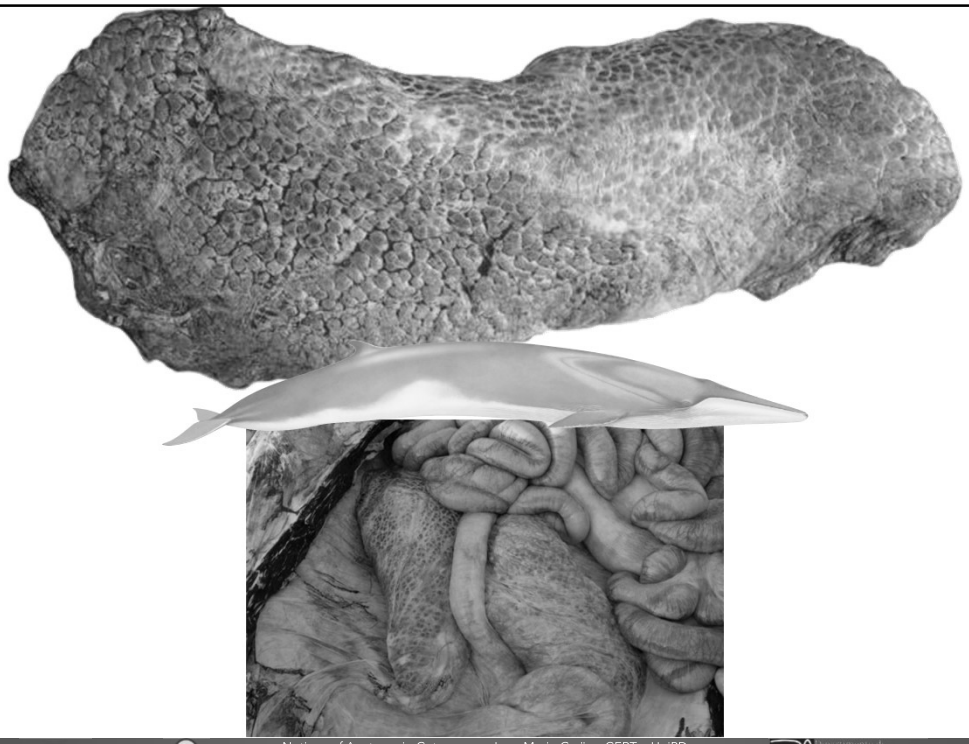
Kidneys





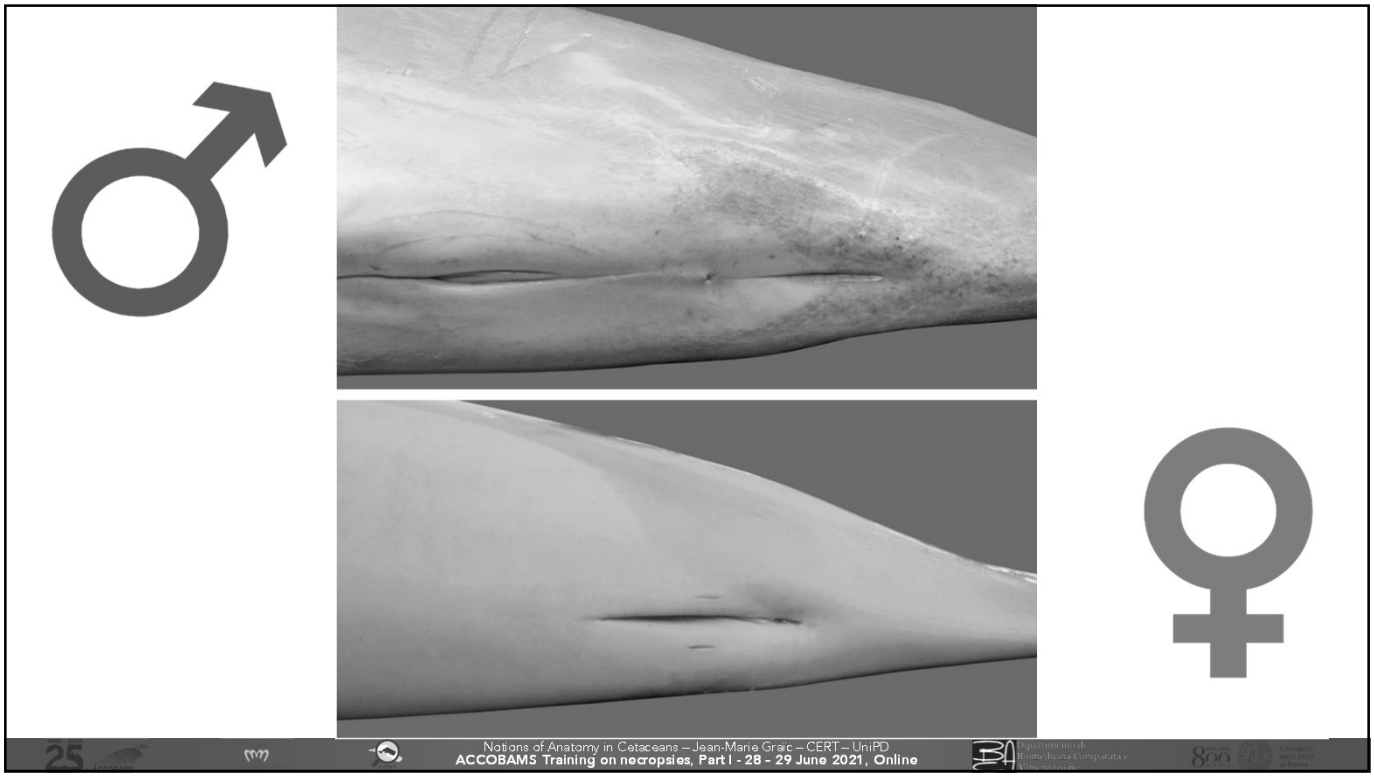


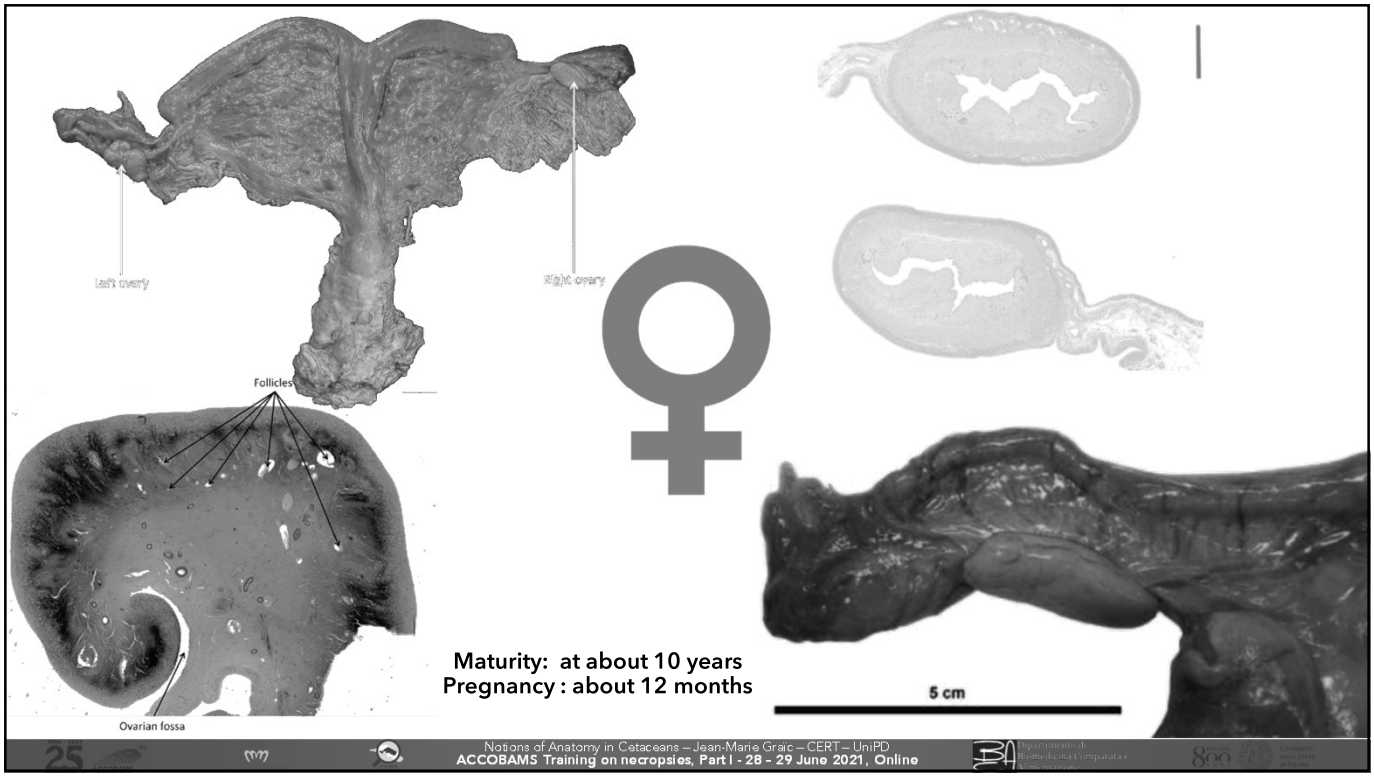


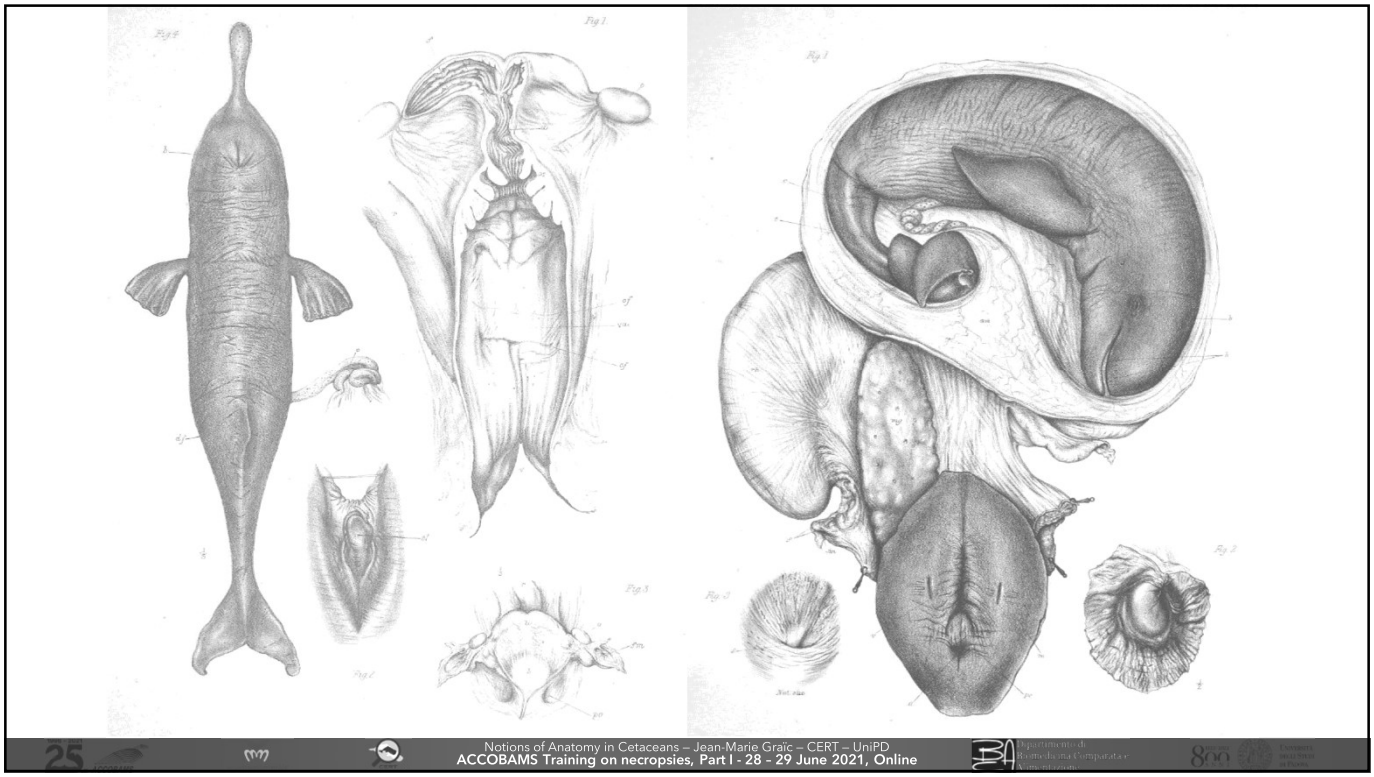


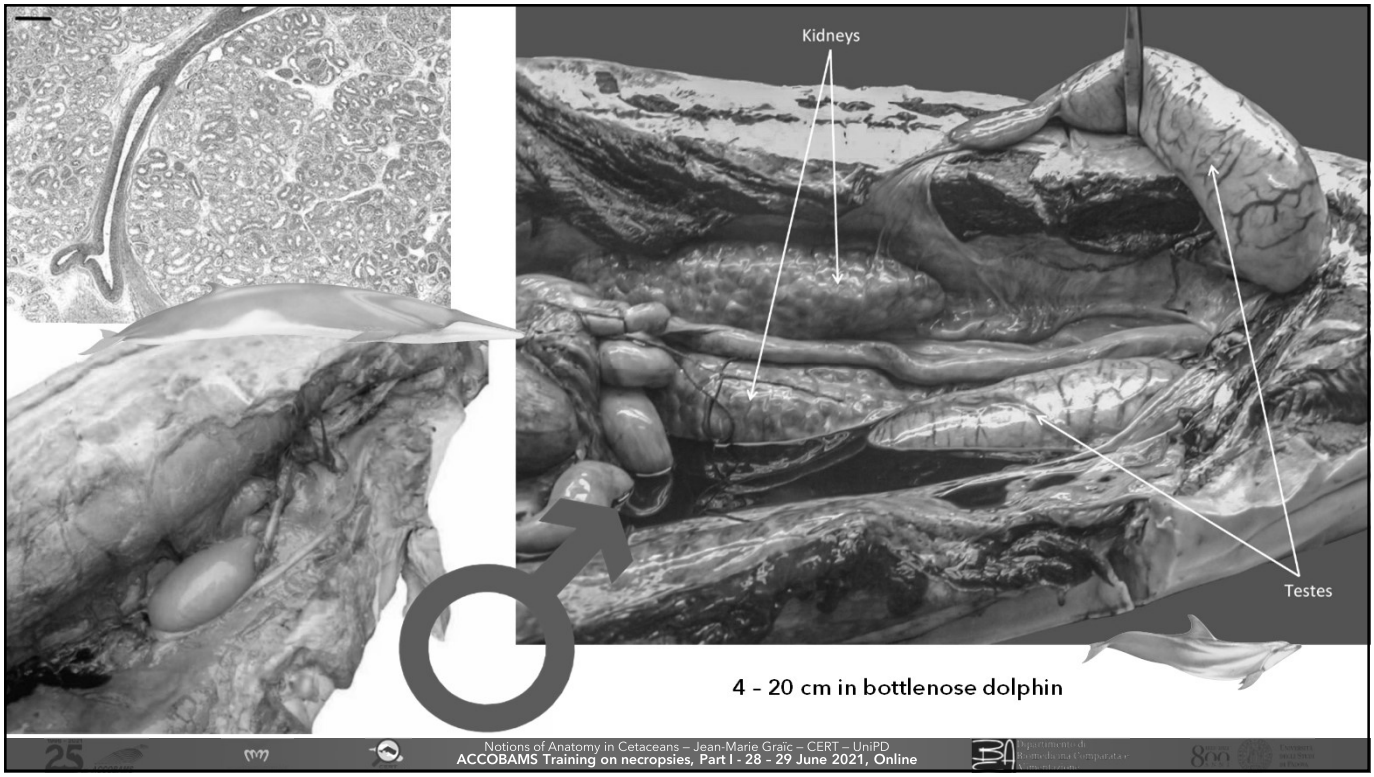
The reproductive system

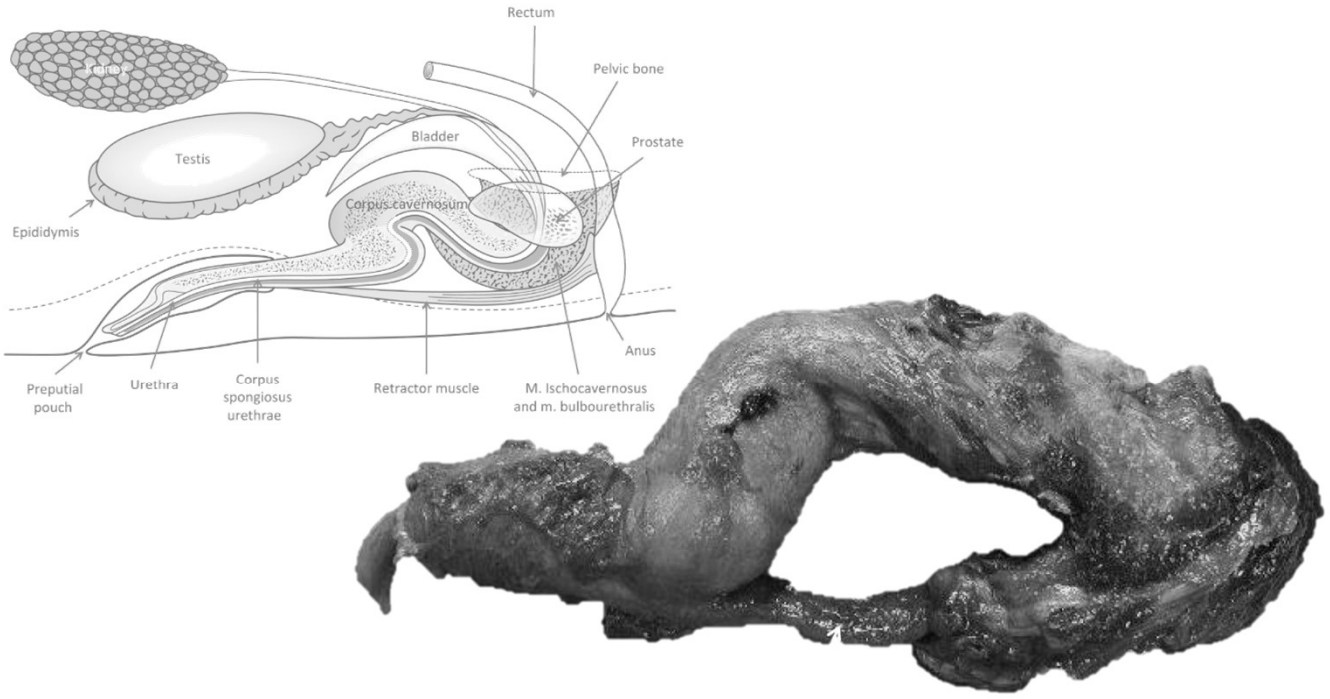
Notions of Anatomy in Cetaceans – Jean-Marie Graïc – CERT – UniPD
ACCOBAMS Training on necropsies, Part I - 28 - 29 June 2021, Online


Notions of Anatomy in Cetaceans – Jean-Marie Graïc – CERT – UniPD
ACCOBAMS Training on necropsies, Part I - 28 - 29 June 2021, Online


Left ovary
Right ovary
Follicles
Ovarian fossa
Maturity: at about 10 years
Pregnancy : about 12 months
5 cm
Notions of Anatomy in Cetaceans – Jean-Marie Graïc – CERT – UniPD
ACCOBAMS Training on necropsies, Part I - 28 - 29 June 2021, Online



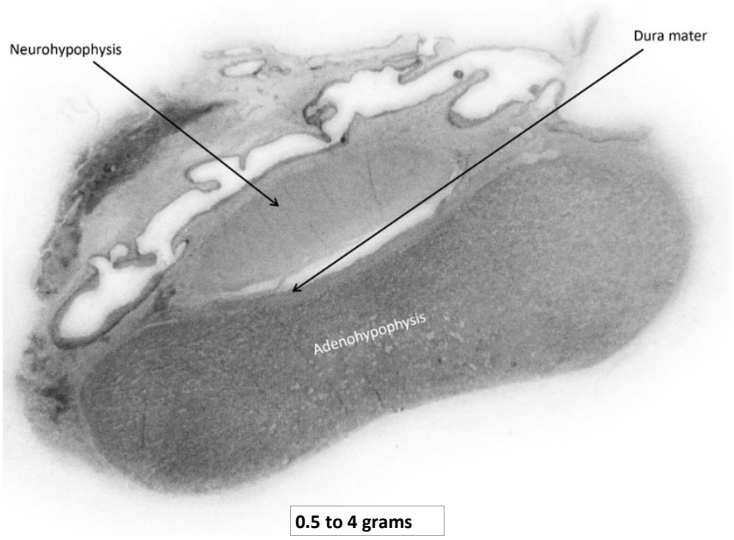

Kidneys
Testes
4 - 20 cm in bottlenose dolphin



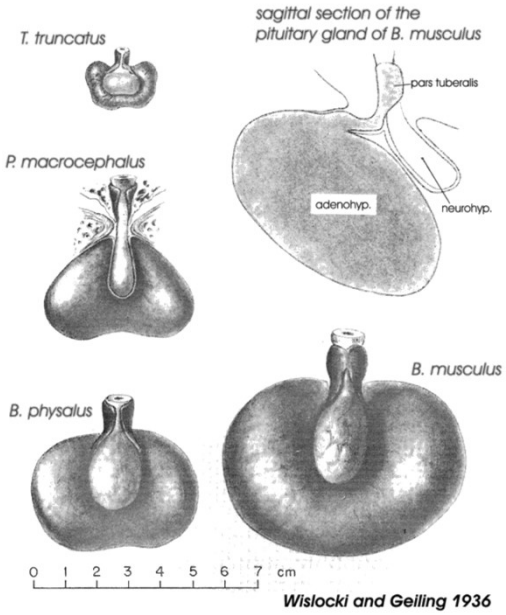
The endocrine system

Notions of Anatomy in Cetaceans – Jean-Marie Graïc – CERT – UniPD
ACCOBAMS Training on necropsies, Part I - 28 - 29 June 2021, Online

Hypophysis



0.5 to 4 grams



Wislocki and Geiling 1936

Epiphysis (pineal gland)

Absent, rare or very difficult to find?

- It depends on the species

Neuroscience and Biobehavioral Reviews 32 (2008) 1451–1484

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

Review

Cetacean sleep: An unusual form of mammalian sleep

Oleg I. Lyamin [a,b], Paul R. Manger [c,*], Sam H. Ridgway [d], Lev M. Mukhametov [b], Jerome M. Siegel [a]

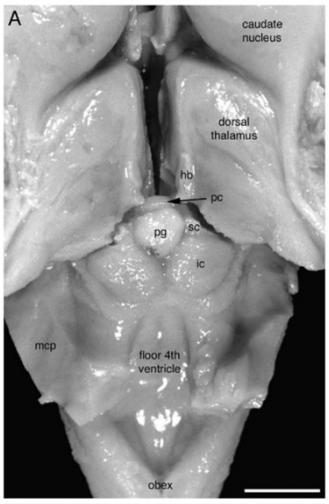
[a] Department of Psychiatry, University of California, Los Angeles, Neurobiology Research 151A3, Sepulveda VAMC, 16111 Plummer Street, North Hills, CA 91343, USA
[b] Utrish Dolphinarium Ltd., 33 Leninsky Prospect, 119071 Moscow, Russia
[c] School of Anatomical Sciences, Faculty of Health Sciences, University of the Witwatersrand, 7 York Road, Parktown, 2193 Johannesburg, South Africa
[d] Department of Pathology, School of Medicine, University of California, La Jolla, CA 92093, USA

ARTICLE INFO

Keywords:
Evolution

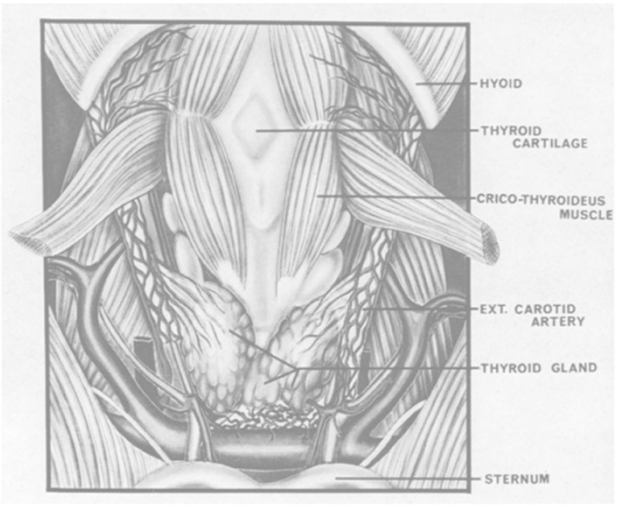
ABSTRACT

Our knowledge of the form of lateralized sleep behavior, known as unihemispheric slow wave sleep (USWS), seen in all members of the order Cetacea examined to date, is described. We trace the discovery

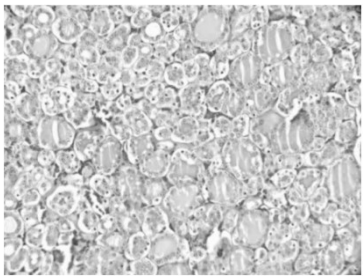


Thyroid

Normal position



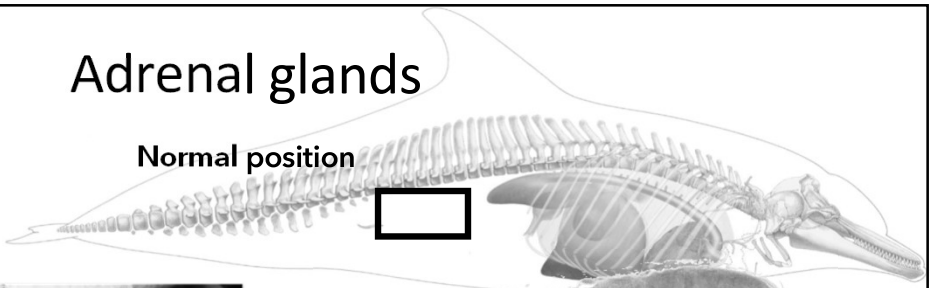
Ridgway, 1971

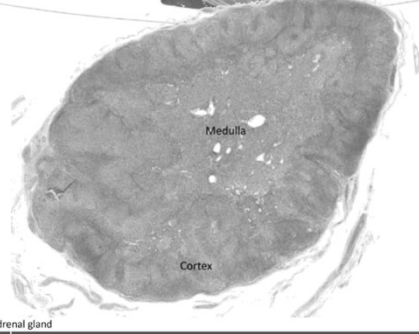


Thyroid gland

Adrenal glands

Normal position

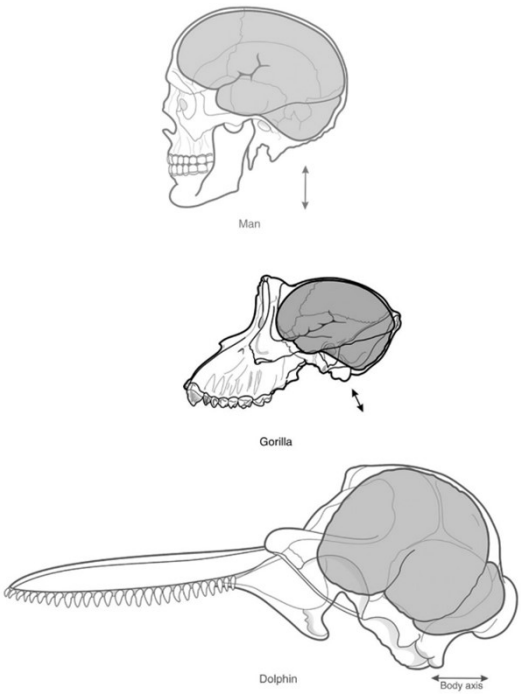


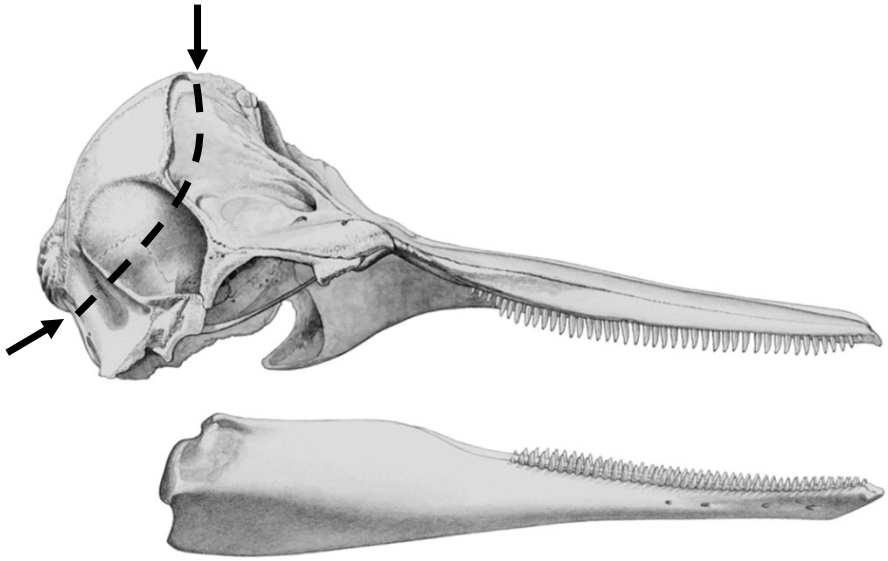


Adrenal gland

The nervous system

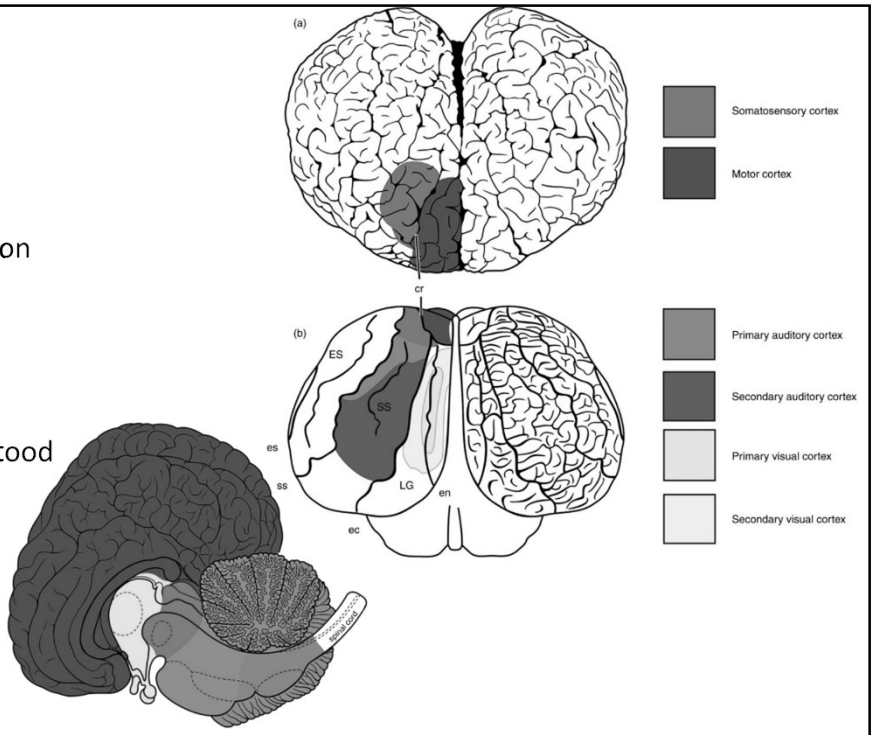
- The brain is located far back in the head






ID
496

- General mammalian organization
- Very specialized
- Still functionally poorly understood



1996 - 2021 25 ANS YEARS ACCOBAMS

CERT marinemammals

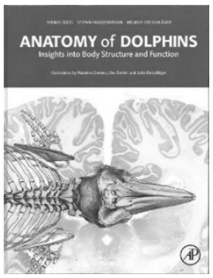
Dipartimento di Biomedicina Comparata e Alimentazione

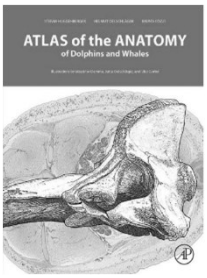
1222 · 2022 800 ANNI

Università degli Studi di Padova

CERT
CETACEAN STRANDINGS EMERGENCY RESPONSE TEAM

ACCOBAMS Training on necropsies, Part I - 28 – 29 June 2021, Online





Authors: Bruno Cozzi, Stefan Huggenberger and Helmut Œlschläger
Most illustrations © Massimo Demma

Sandro Mazzariol
Cinzia Centelleghe
Giorgia Carrazzola
Davide Pedrotti
Guido Pietroluongo
Giuseppe Sciancalepore
Tommaso Gerussi
...