

L-7 Respiratory System

Functional Anatomy and Respiratory Volume

Dr Than Kyaw

26 March 2012

Topics (general outline)

- Introduction
- Functional anatomy
- Pulmonary ventilation
- Exchange of gases through pulmonary membrane
- V/Q ratio
- Regulation of respiration
- Factors affecting respiration rate
- Hypoxia, dyspnea, and cyanosis

Introduction

- O_2 - Vital requirement of animal
- Animals may live - for **days** without water or
 - for **weeks** without food
- Without O_2 - live for a **few minutes** only!
- This vital function -- done by **respiratory system**

Functions of respiratory system

Primary functions

- delivery of O₂ on tissues
- removal of CO₂ (product of cellular respiration)
- related function – ventilation

Secondary functions (non-respiratory functions)

- regulation of pH of body fluid (how)
- thermoregulation (how)
- phonation (making sounds)
- defends against microbes (how)
- **removes** some chemicals as well as producing others (how)
- **trap** and dissolve blood clots (how)
- **smelling** (olfactory epithelium – at the caudal portion of nasal cavities)

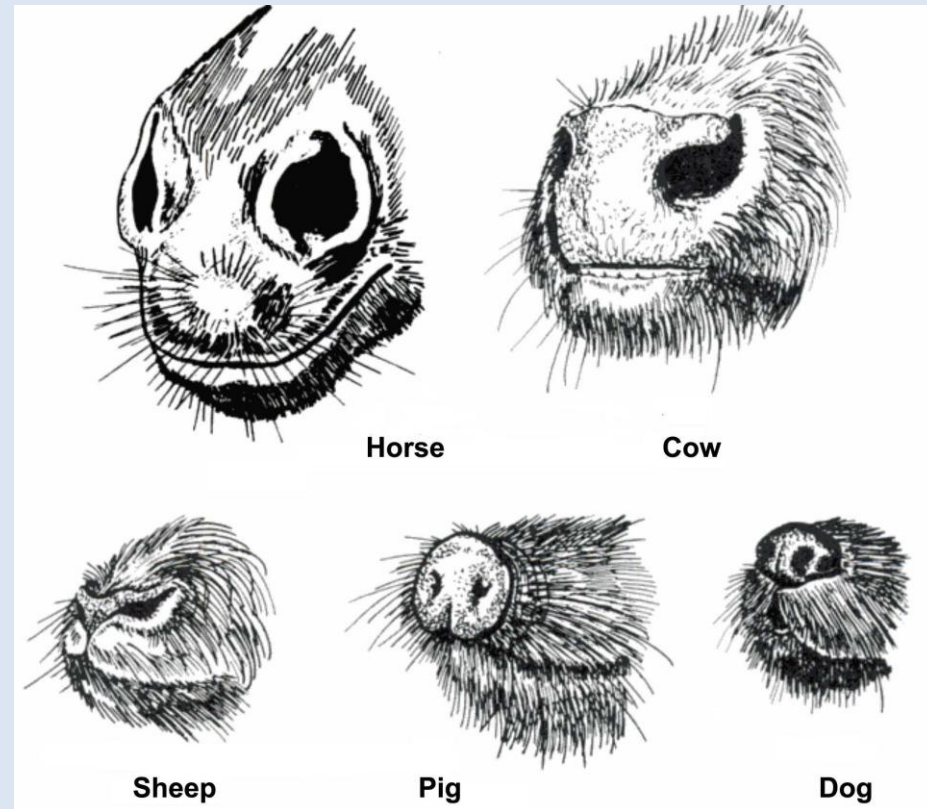
Respiratory apparatus

- **Air passages to lungs**
 - nostrils
 - nasal cavities,
 - pharynx
 - larynx
 - trachea
 - bronchi
 - bronchioles
 - alveoli
- **Lungs**
- **Pleura**

Air passages to lungs

– nostrils (nares)

- external openings to the air passage
- **Horse** – most **pliable** (easily bends) and **dilatable**
- **Pig** – most rigid
- dilatability – advantageous when more air is required
- especially for horse (runner)



Air passages to lungs

– nasal cavities

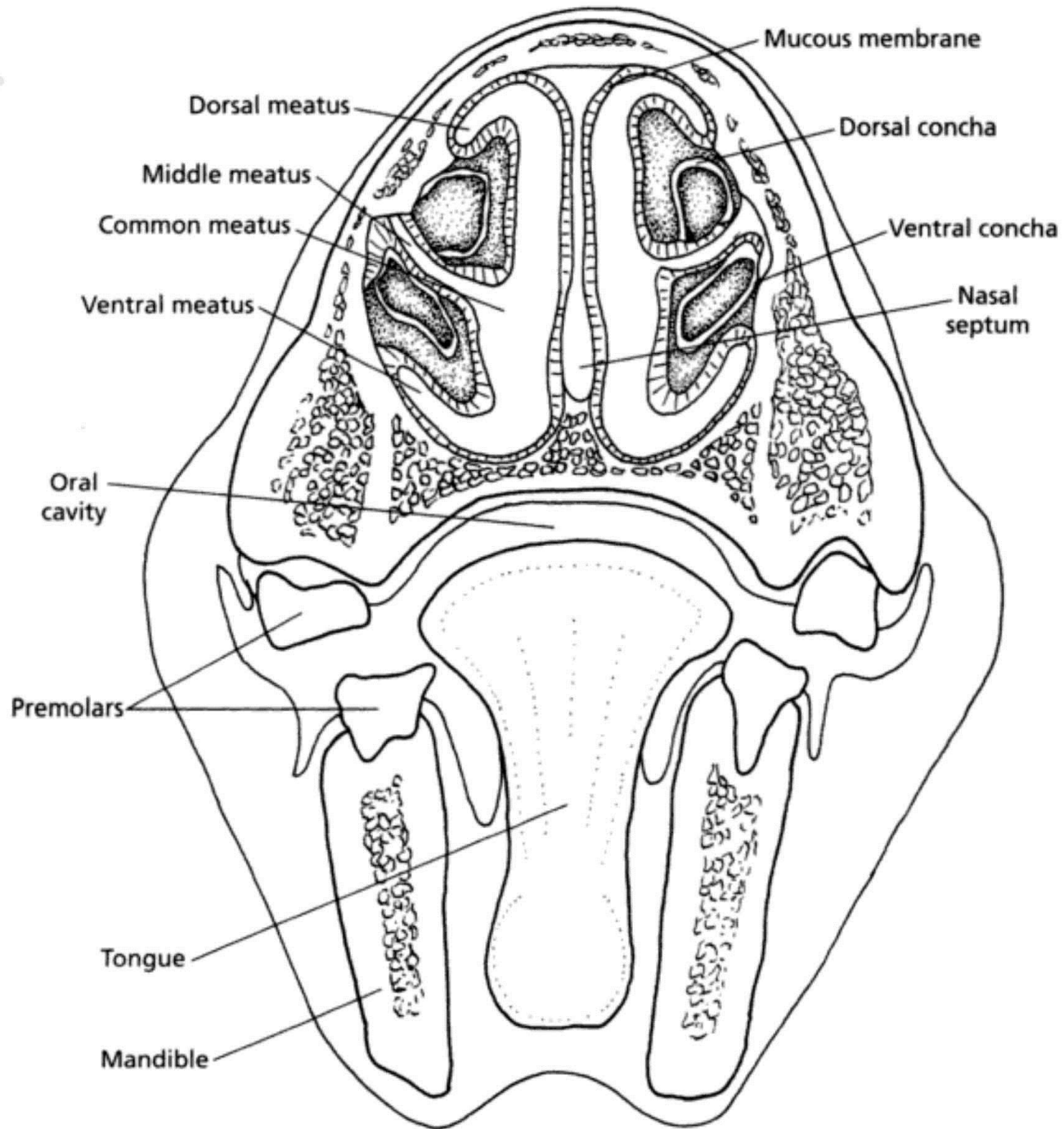
- paired and separated by nasal septum
- each consists of mucosa-covered turbinate bones (**conchae**); separating the nasal cavity into

dorsal, middle and ventral meatus

- cooling effect to blood supplying the brain

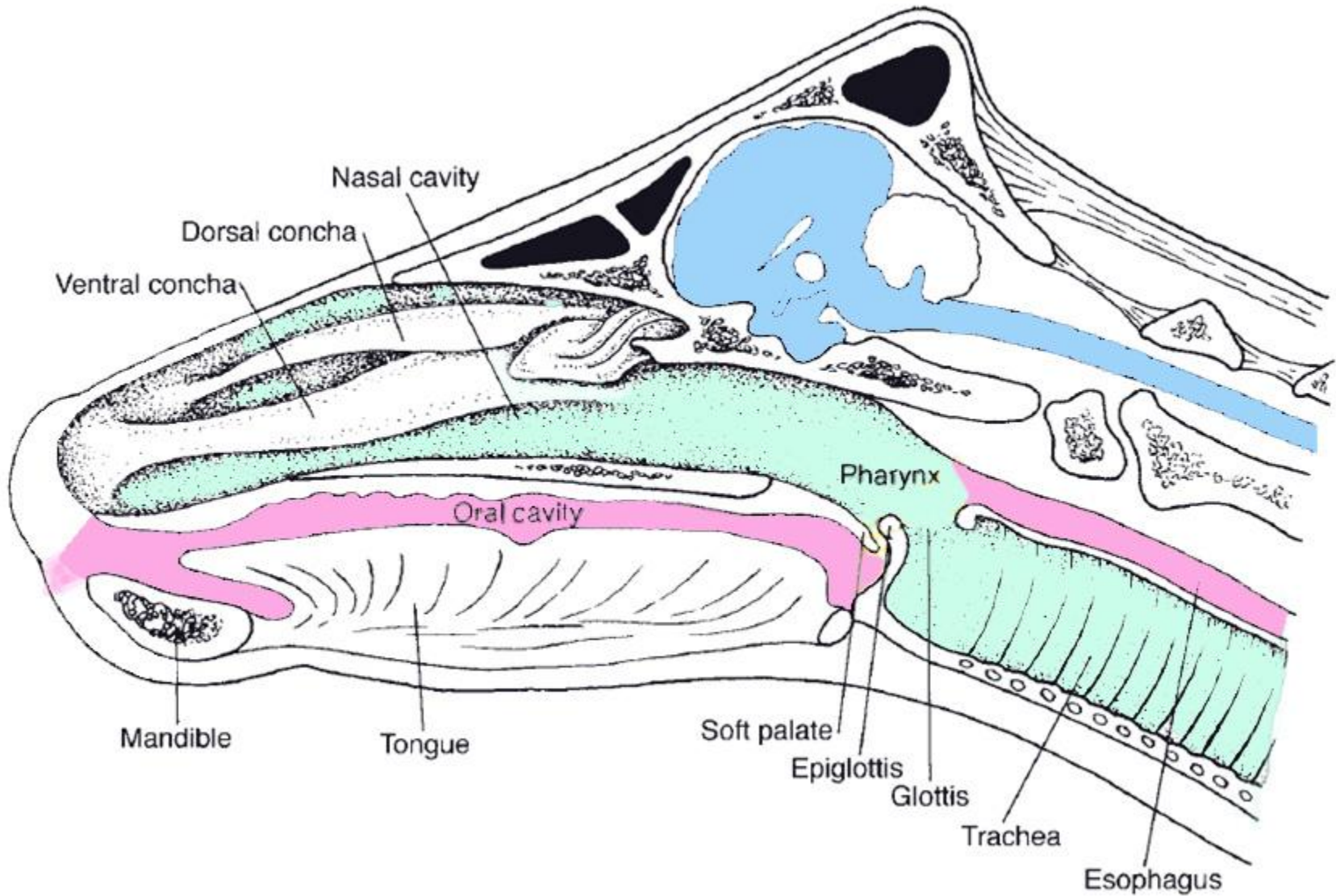
(in the conchae - arteries supplying the brains divide many smaller arteries and rejoin before entering the brain; as a result brain temperature: **2 – 3°C lower than core body temperature.)**

- mucosa - well vascularized
 - serve to warm and humidify inhaled air when more air is required
- especially for horse (runner)



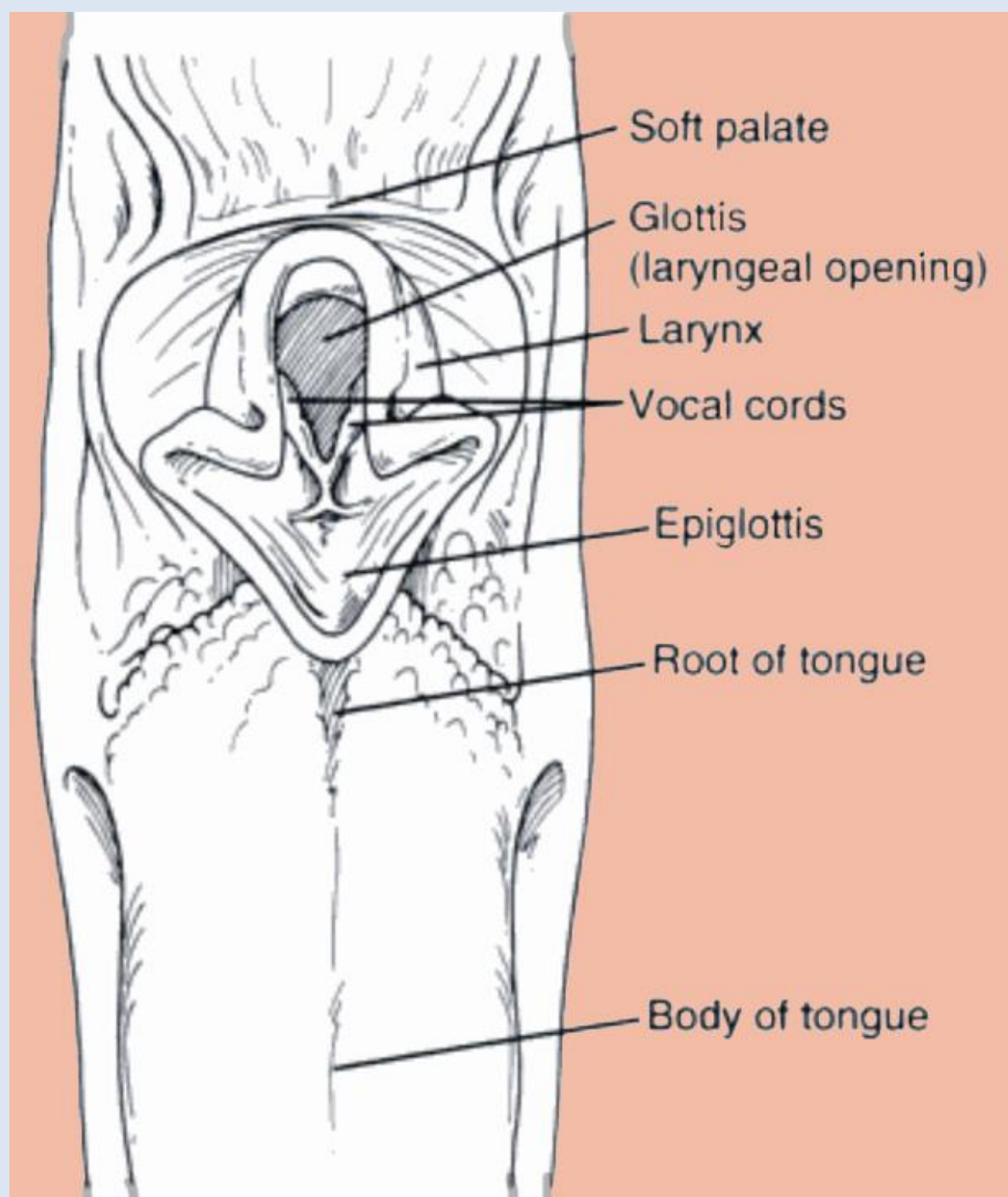
Pharynx

- Common passage way for air & food
- Openings to the pharynx
 - 2 posterior nares
 - 2 eustachian tubes
 - oral cavity
 - glottis
 - esophagus
- Larynx – organ of sound production in **mammals**
 - Syrinx** -- organ of sound in **birds**
- Glottis -- slit-like opening (site for endotracheal tubing)
- Epiglottis – leaf-like extension from larynx, at the root of the tongue
 - passively bend over larynx during the act of swallowing
 - prevent bolus from entering the trachea



Upper respiratory tract of cow, midsagittal section.

Cranial view of
canine glottis,
opening to the
larynx between
vocal cords and
epiglottis.

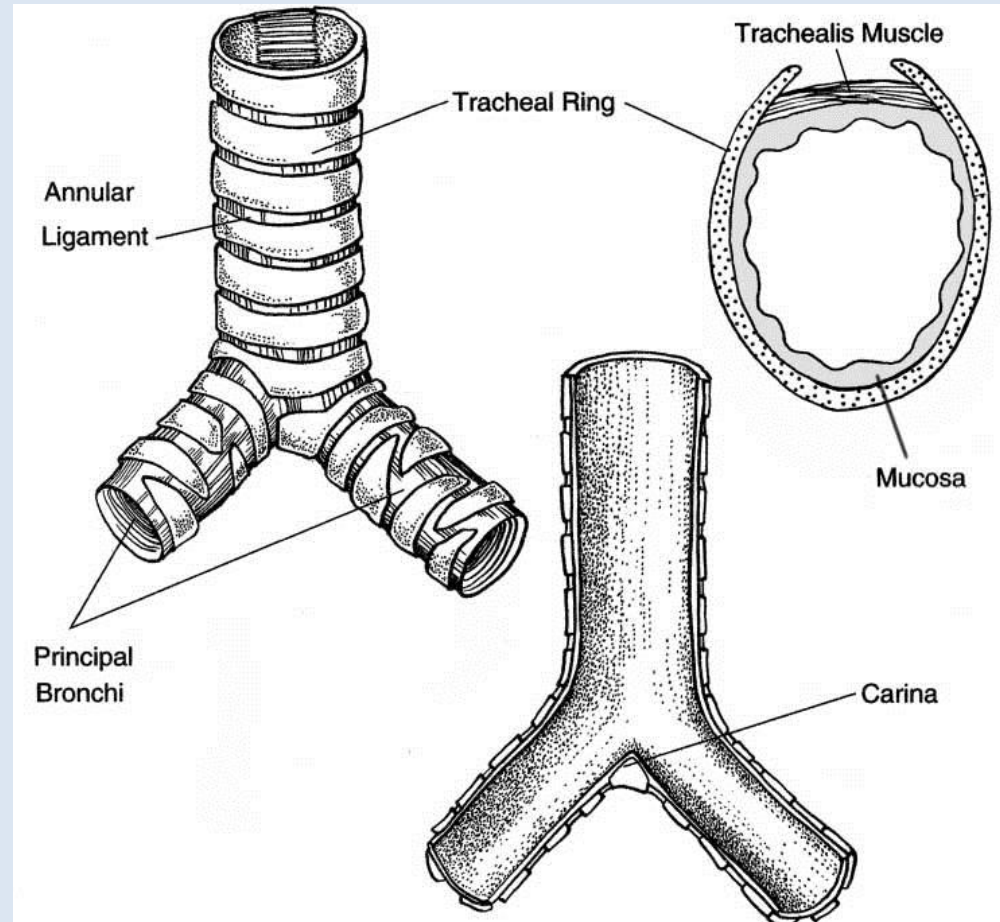


Trachea

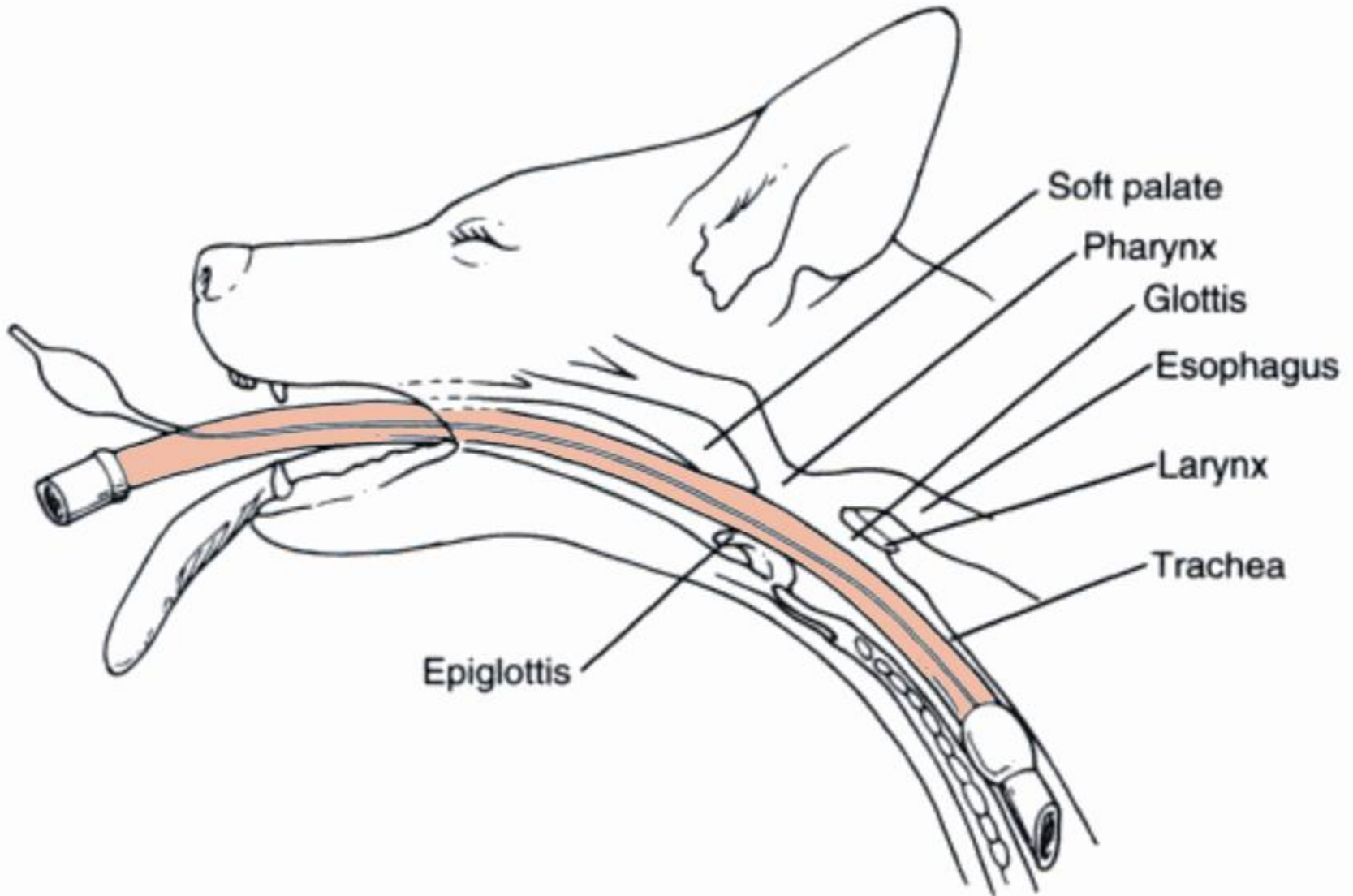
- Continuation **from** the larynx
- tracheal rings -- incomplete -- permits variation in diameter regulated by tracheal smooth m/s
- diameter can increase during times of greater ventilatory requirements

Bronchi

- Right and left
 - Bronchioles
 - Terminal bronchioles
 - Respiratory bronchioles
 - Alveolar duct
 - Alveolar sac
 - Alveoli

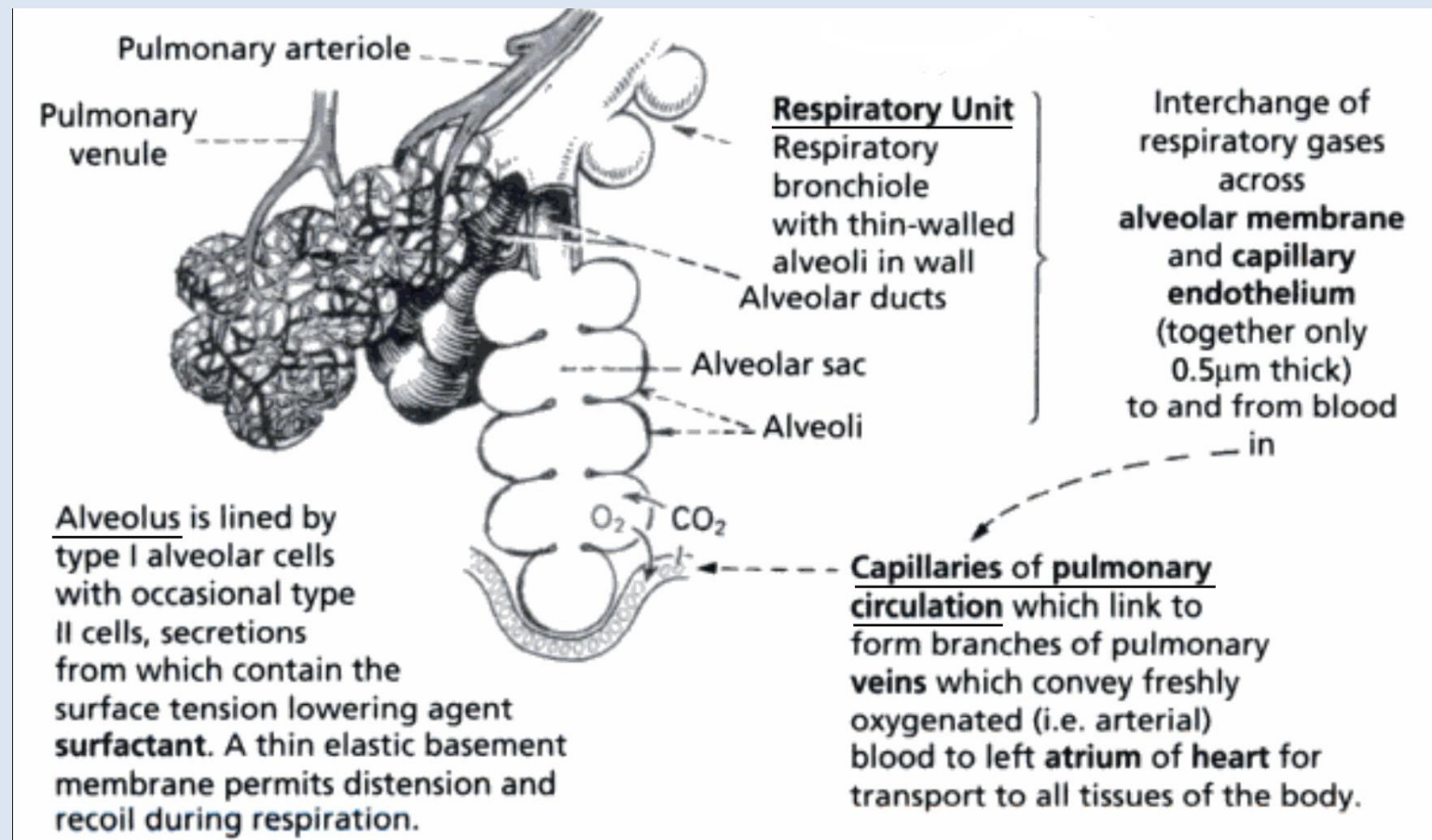


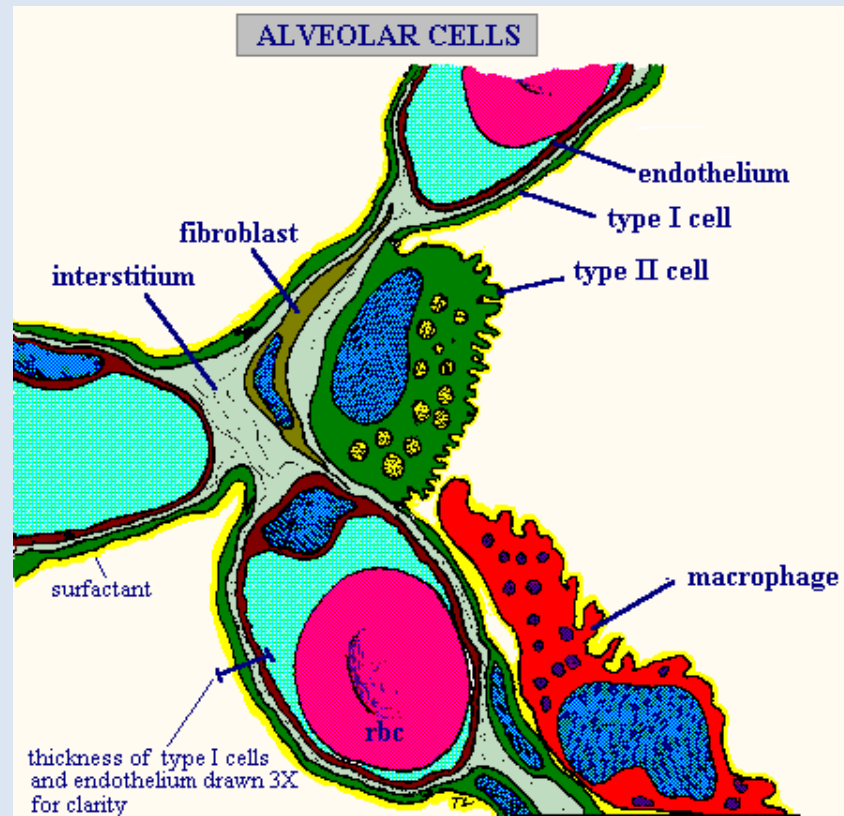
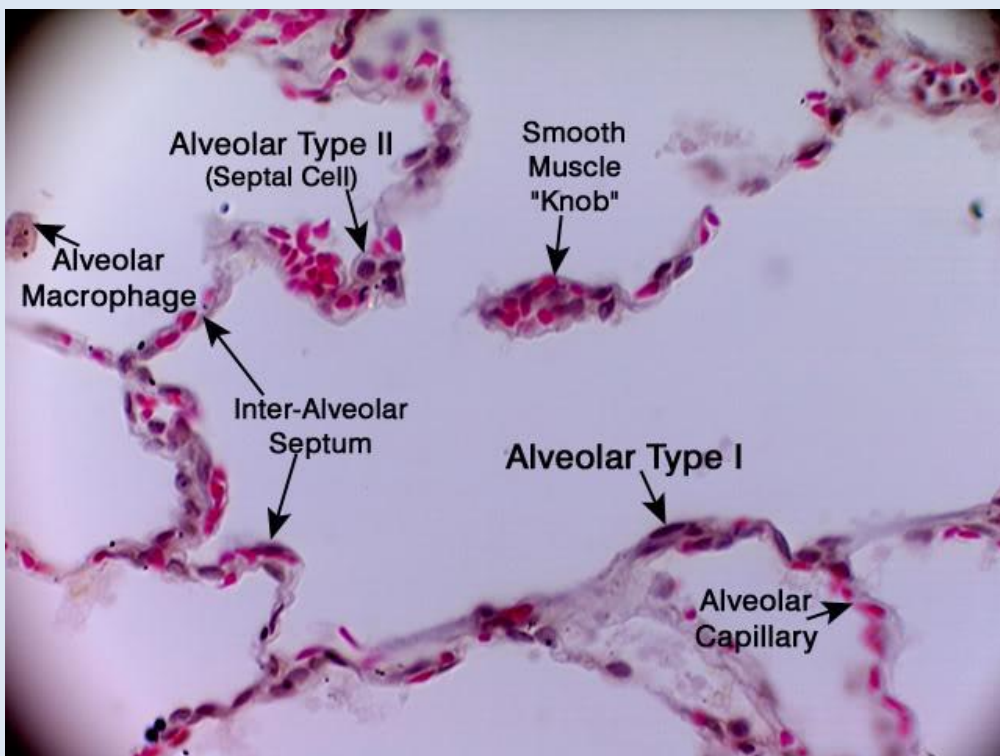
Tracheal intubation



Pulmonary alveoli

- Principle sites of gas exchange between the air and blood
- Diffusion distance is minimal at alveolar level
- Alveolar epithelium and capillary epithelium are intimately associated.





Alveolar cell types

Alveolar cell types

Alveolar **type I** cells.

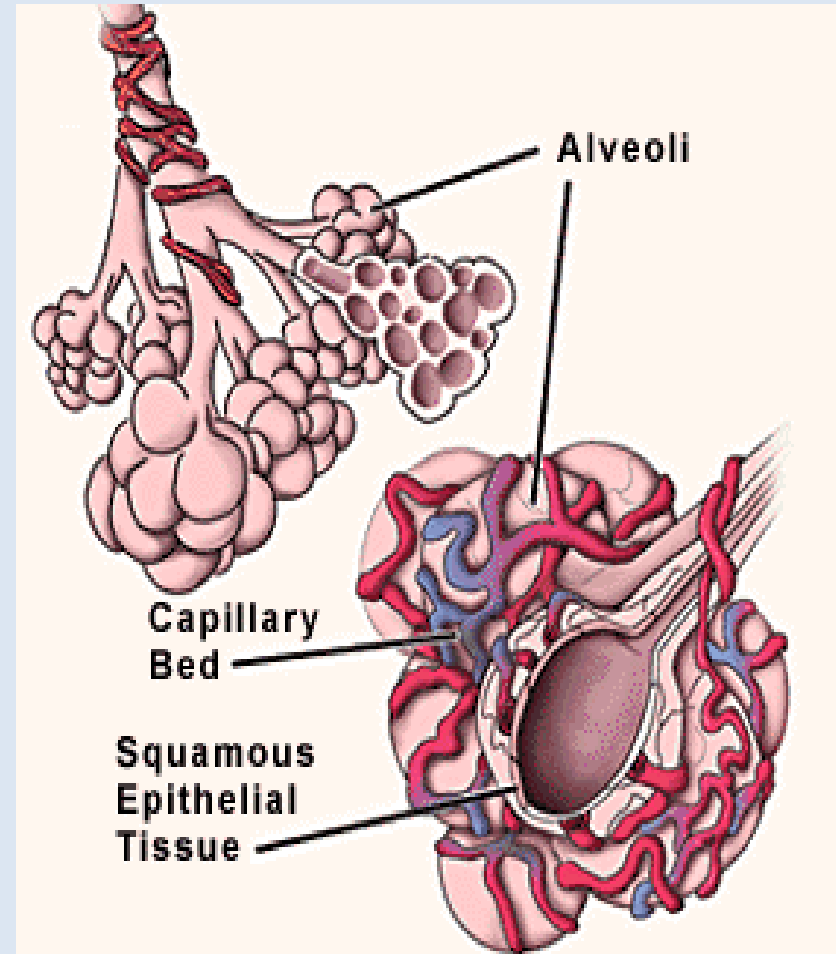
- **Squamous** cells, as thin as $0.05\ \mu\text{m}$; 95% of the alveolar epithelial surface.

Alveolar **type II** cells.

- Irregular, **cuboidal** shaped; cytoplasm
- **Cytosomes** granules secrete pulmonary **surfactant**
- Surfactant -- protein-phospholipid mixture
 - reduce the **surface tension** of the alveoli
 - prevent **collapse** of alveoli during exhalation, and
 - act as a **bactericide**

Features of Alveoli for efficient gas exchange

- large surface area to absorb oxygen (about 70 Sq. meters in man).
- moist surface to allow oxygen to dissolve.
- thin lining to allow easy diffusion of gases ($>1 \mu$)
- diameter - 7μ
- dense network of blood capillaries for easy gas exchange.



Features of capillaries for efficient gas exchange

- dense network -- to carry CO₂ and O₂
- Large surface area to transport gases
- Lining is **one cell thick** so gases can pass through quickly and easily.
- Carbondioxide diffuses 20 times faster than oxygen

Change in thickness

- Fibrosis

– affect gas exchange

Lungs and Pleura

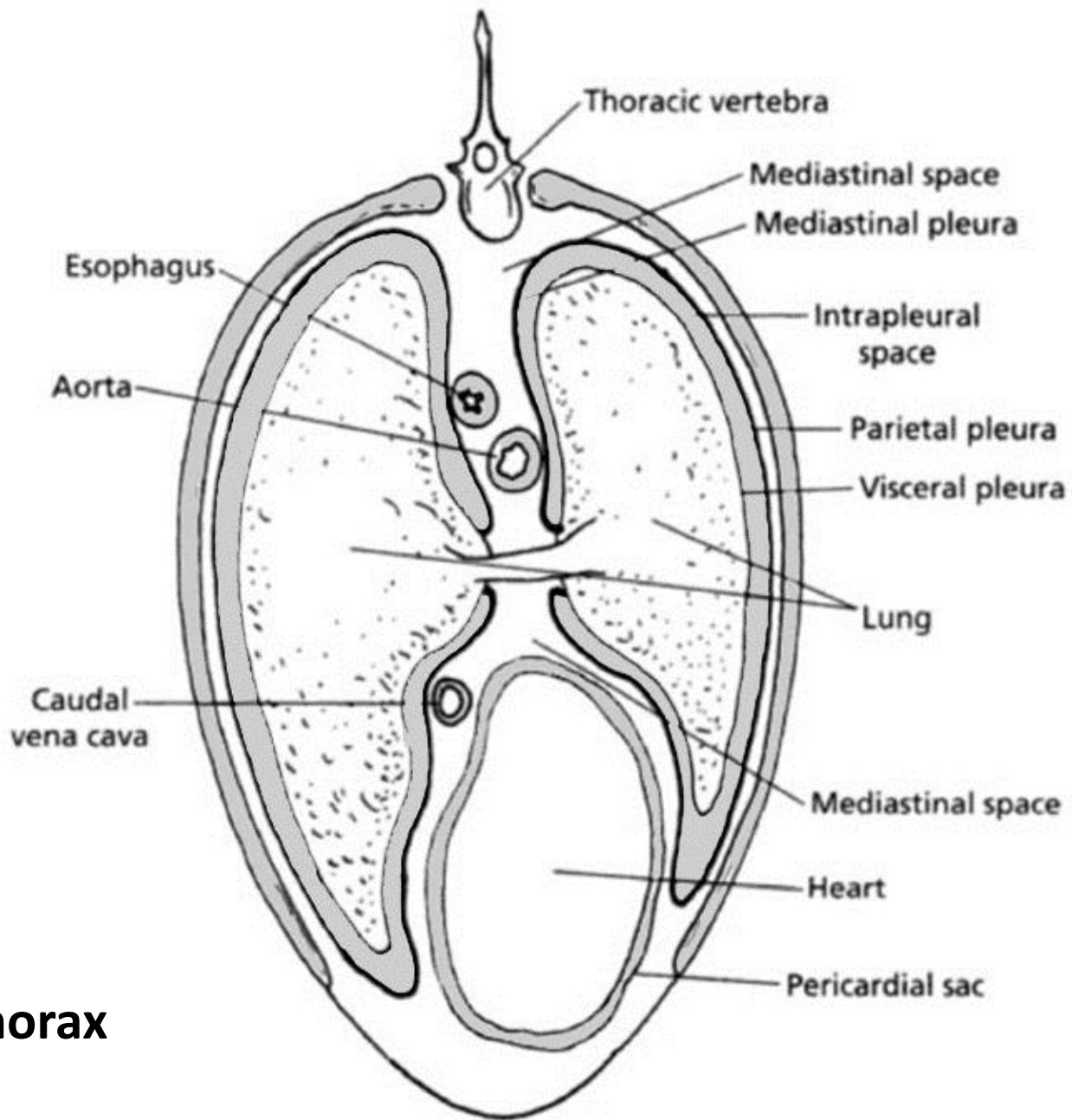
Lungs

- pair; occupy all space in the thorax
- Expansion of thorax → provide air inflow into the lungs
↓
lungs expand
- Air – **radiolucent** (penetrable by X-ray)
 - air-filled lungs provide good contrast for thoracic structures that are radio-opaque
- Blood – relatively **radiopaque**, can be seen in the X-ray

Lungs and Pleura

Pleura

- Serous membrane, **friction-free movement** of lungs
- 2 layers – **visceral** (covering the lung)
 - **parietal** (also k/s **costal**; attached to the thoracic wall)
- Intrapleural space – filled with fluid
- Mediasternal space -- the junction of 2 pleural sacs near the midline of the thorax in which are found heart, vena cava, esophagus, thoracic lymph duct.
- **Pleuritis, pleurisy** -- friction, difficult breathing, severe sharp pain



Equine thorax

Respiration/Respiratory cycle

2 phases

1. Inspiration -- involves enlargement of thorax and lungs accompanied by air inflow

Enlargement of thorax by contraction of **diaphragm** and appropriate intercostal muscles.

Inspiration need greater effort than expiration

2. Expiration – passive

-- appropriate intercostal contraction

-- abdominal m/s contraction

-- force abdominal viscera forward to press on the diaphragm → decrease thoracic vol.

2 types of breathing

1. Abdominal Breathing

- predominate in **normal** condition
- visible abdominal contraction
- protrude during inspiration and recoil during expiration

2. Intercostal Breathing

- characterized by pronounced rib movements
- painful condition of abdominal (e.g peritonitis)

Muscles involved in Inhalation

1. Diaphragm:

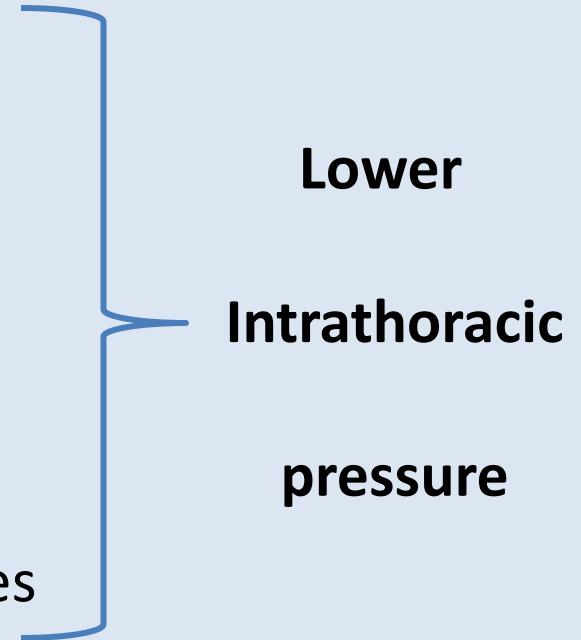
- contraction draws air into lungs
- 75% of normal air movement

2. External intercostal muscles:

- assist inhalation by raising rib cage
- 25% of normal air movement

3. Accessory muscles assist in elevating ribs:

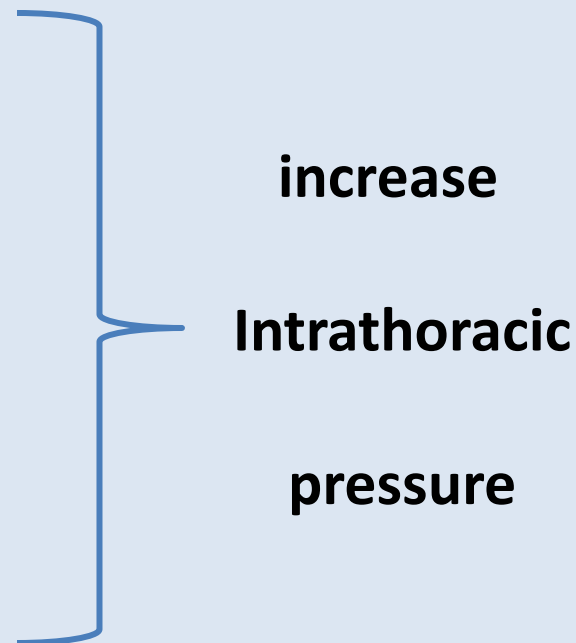
- E.g. serratus , pectoralis, scalene muscles



**Lower
Intrathoracic
pressure**

Muscles involved in exhalation

1. Internal intercostal and transversus thoracis muscles:
 - depress the ribs
2. Abdominal muscles:
 - compress the abdomen
 - force diaphragm upward



Terminology for States of breathing

-- variations:

- frequency of respiratory cycle
- depth of inspiration
- both

Eupnea -- normal quiet breathing

Dyspnea -- difficulty breathing

Hyperpnea -- ↑ depth & frequency – notable after physical exertion

Polypnea -- rapid shallow breathing (panting)

- similar to hyperpnea in regard to frequency but not in depth

Apnea -- transient cessation of breathing

Tachypnea – excessive rapidity of breathing

Bradypnea -- abnormal slowness of breathing

Pulmonary volumes and capacities

Tidal volume

- amount of air breathed in or out during a respiratory cycle
- can increase or decrease from normal depending on ventilation requirement

Inspiratory reserve vol.

- amount of air that can still be inspired after inhaling the tidal volume

Expiratory reserve vol.

- amount of air that can still be expired after exhaling the tidal volume

Pulmonary volumes and capacities

Residual vol

- the amount of air remaining in the lungs after the most forceful expiration

Total lung capacity

- the sum of all volumes

Vital capacity

- the difference between total volume and residual volume
- it is also the maximum amount of air that can be breathed in after the most forceful expiration

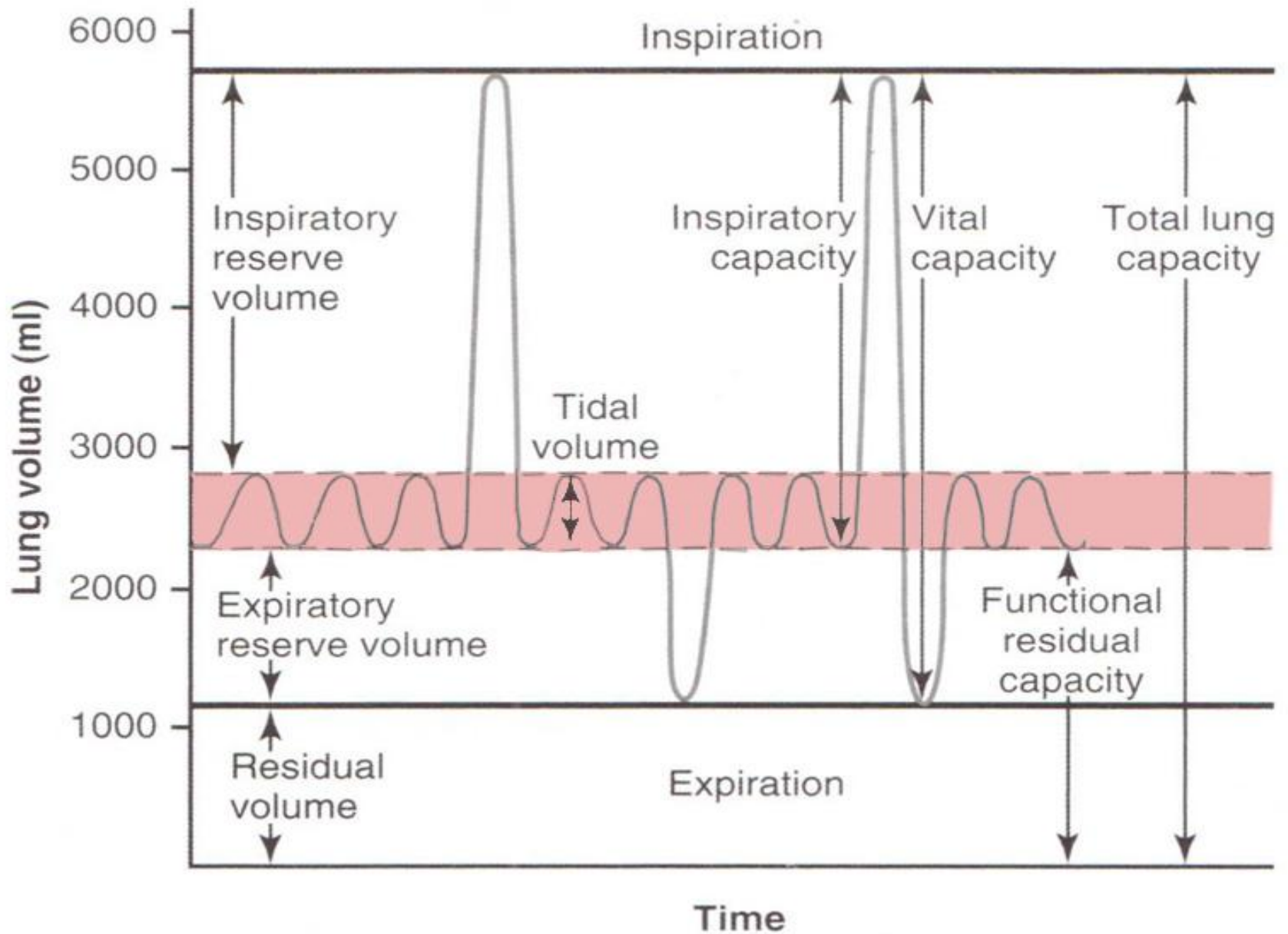
Pulmonary volumes and capacities

Inspiratory capacity

- the sum of tidal and inspiratory reserve volume

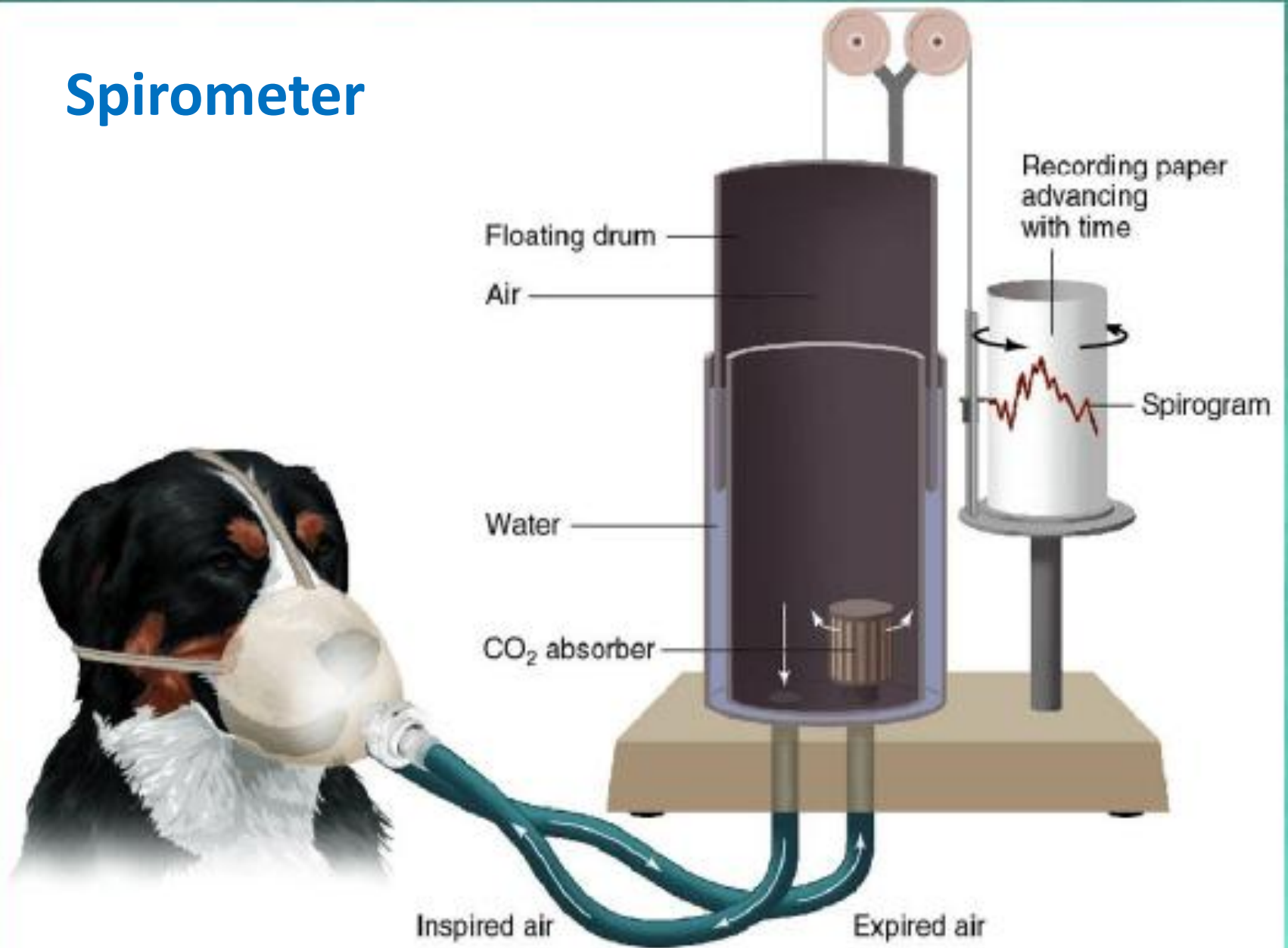
Functional Residual vol

- the sum of expiratory reserve volume and residual volume
- serve as reservoir for air and help to provide constancy to the blood concentration of the respired gas



Spirometer tracing showing the relationship between lung capacity and respiratory volume.

Spirometer



Lung volumes of man and horse

	<u>Human</u>	<u>Horse</u>
Tidal volume	500 mL	6,000 mL
Inspiratory reserve volume	3,000 mL	12,000 mL
Inspiratory capacity	3,500 mL	18,000 mL
Expiratory reserve volume	1,000 mL	12,000 mL
Residual volume	1,200 mL	12,000 mL
Functional residual capacity	2,200 mL	24,000 mL
Vital capacity	4,500 mL	30,000 mL
Total lung capacity	5,700 mL	42,000 mL

NOTE: Floating property of the lung

Lungs of dead animals

- Because of remains of residual volume in the lung , excised lung sections of dead animal or slaughtered animals **float** in water

Fetal lungs

- consistency – like liver, no air, **sink** in water
 - after birth and even one breath – **residual air** left
 - the lung float in water due to residual air
 - **Determine whether newborn animal was born dead?**

Pneumonic lungs

- due to consolidation – lung tissue sinks in water

End of Lecture