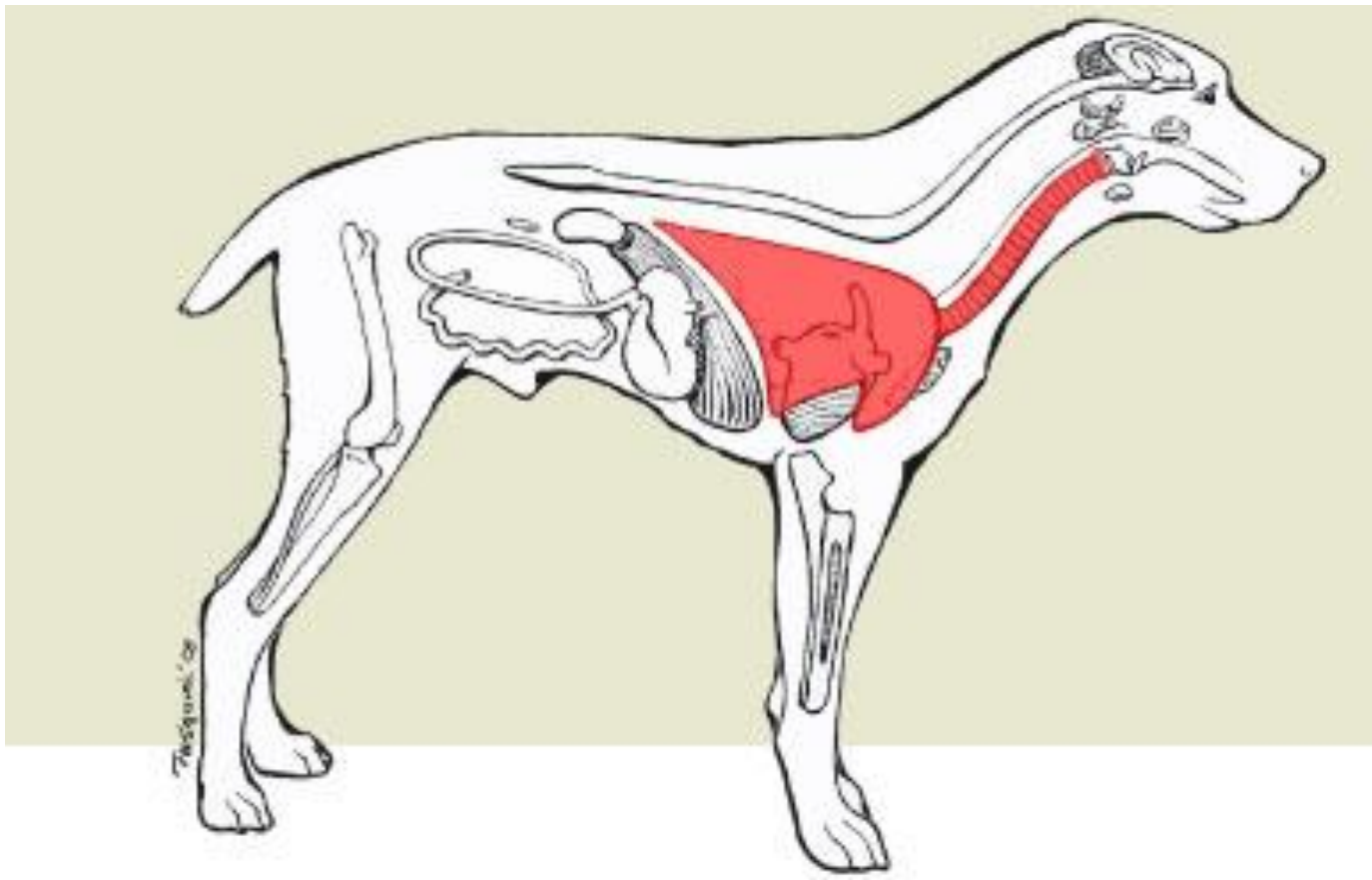


Lecture 9

The Respiratory System

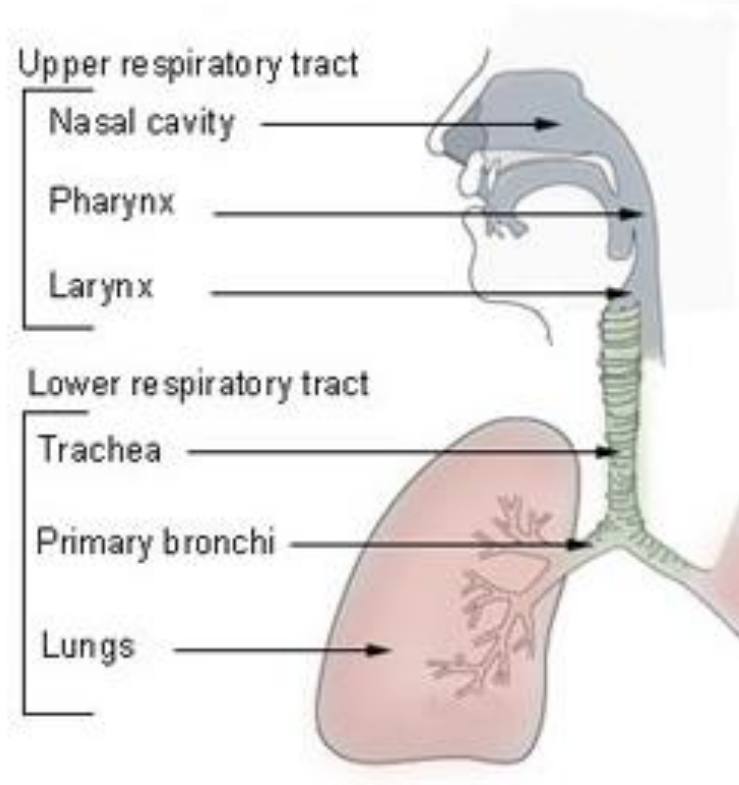


The Respiratory System

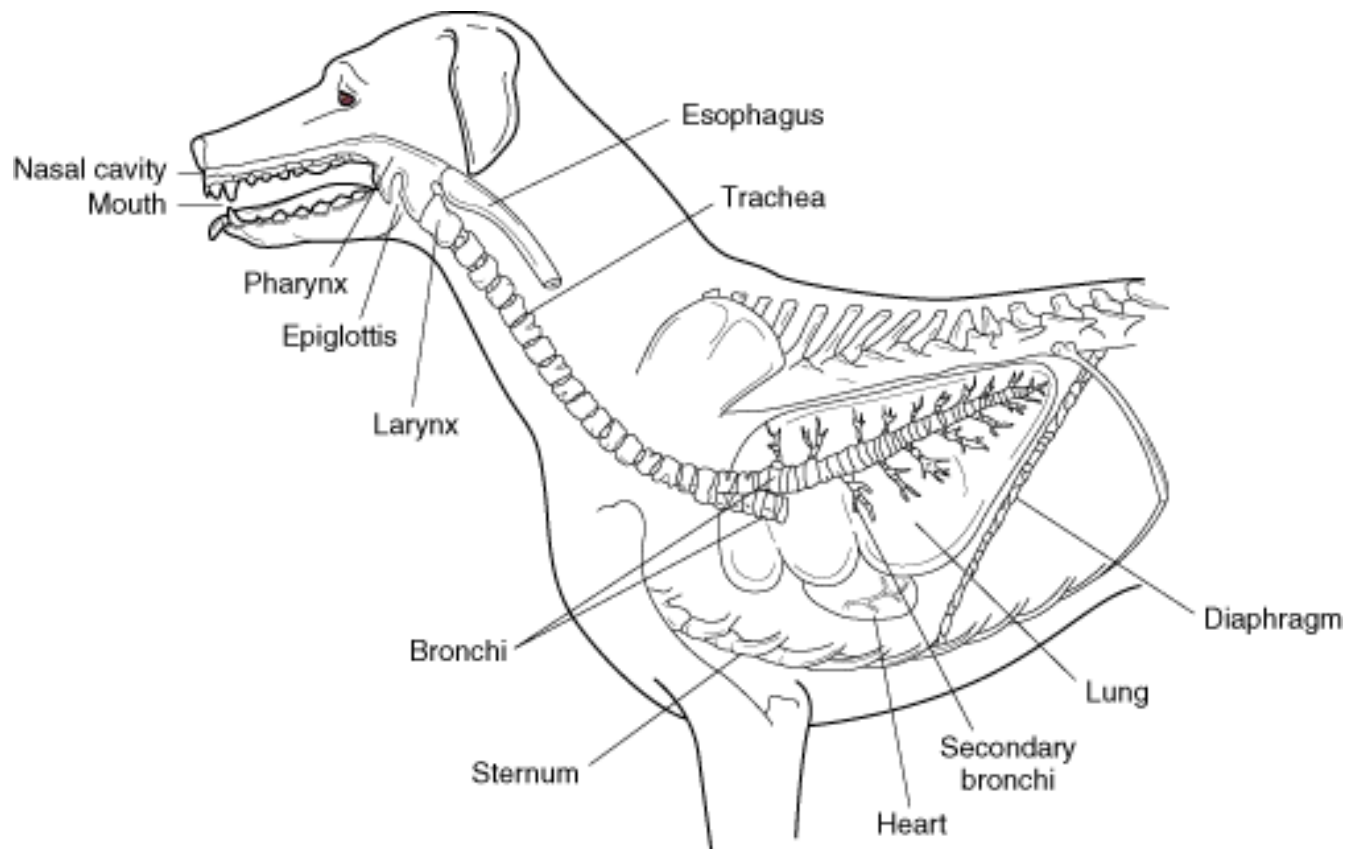
- The respiratory system is the body system that brings oxygen from the air into the body for delivery via the blood to the cells
- Respiration is the exchange of gases (oxygen and carbon dioxide) between the atmosphere and the body cells
- Ventilation means the bringing in of fresh air
 - Ventilation is also known as breathing

The Respiratory System

- The respiratory system is divided into upper and lower tracts
- The upper respiratory tract consists of the nose, mouth, pharynx, epiglottis, and larynx
- The lower respiratory tract consists of the trachea, bronchial tree, and lungs

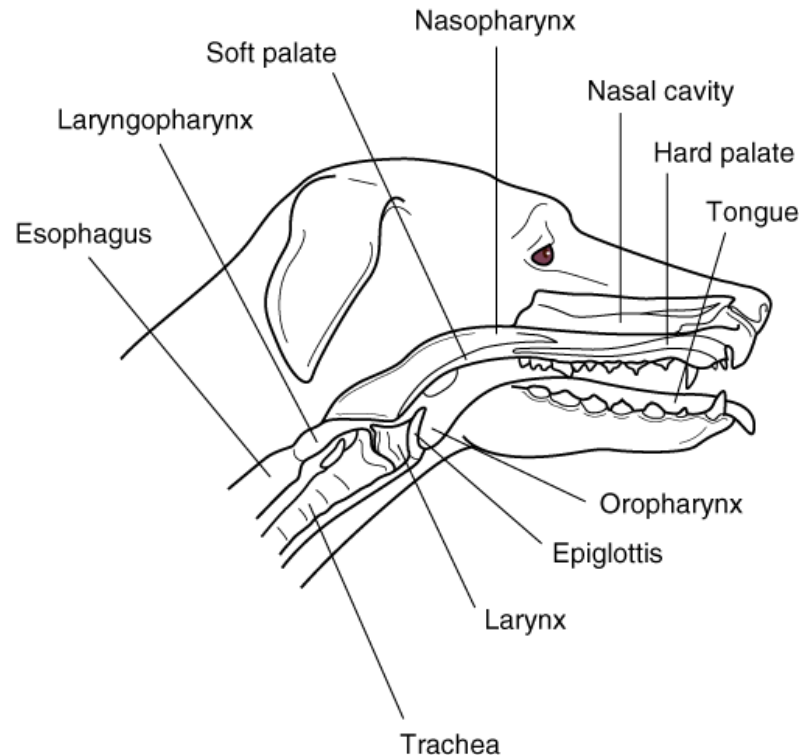


The Respiratory Tract



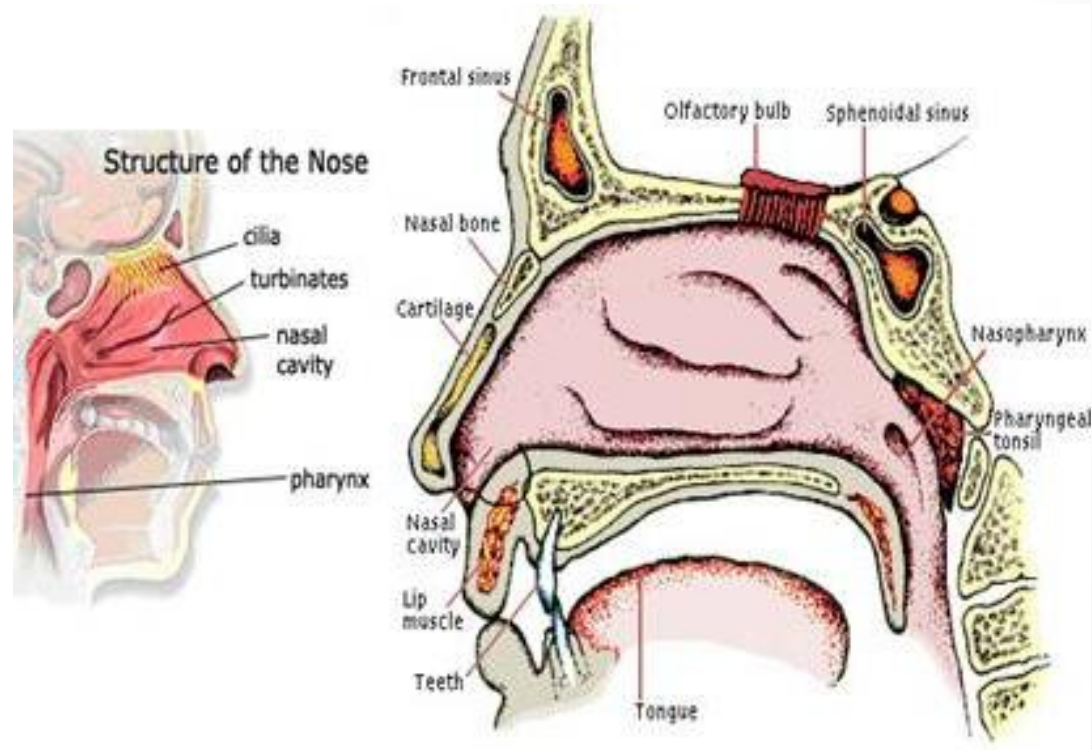
Upper Respiratory Tract

- Air enters and exits the body through the nose
 - nas/o and rhin/o are combining forms for nose
 - External openings of the nose area are called nares



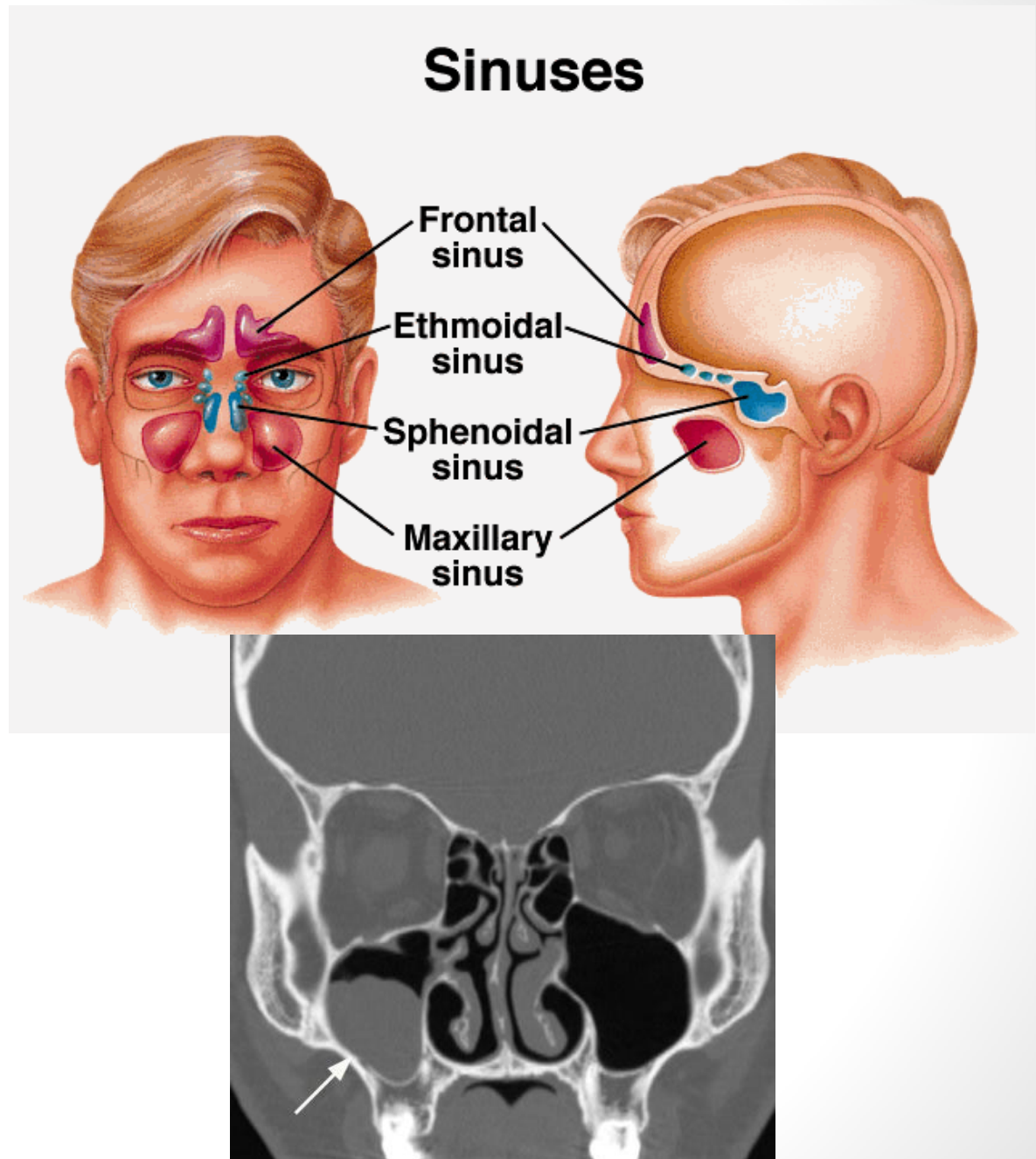
Nasal Structures

- Vestibule
- Nasal Turbinates
- Nasal Septum
- Olfactory receptors
- Mucous Membrane
- Cilia



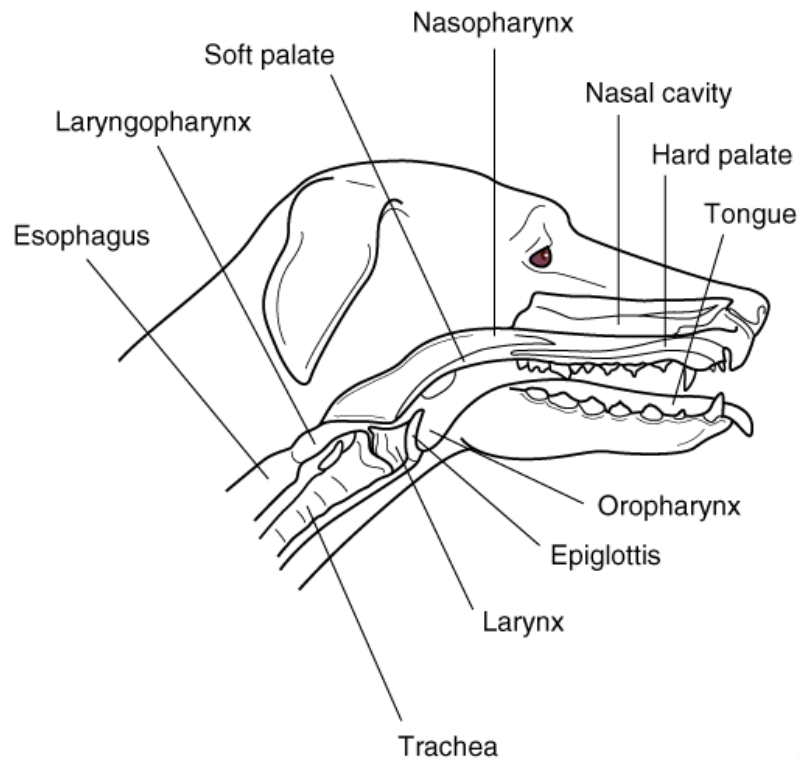
Sinuses

- Air or fluid filled spaces within the bone
- Sinuses have a mucus membrane lining
- The function of sinuses is to produce mucus, to make bone lighter and help produce sound
- Combining form is sinus/o



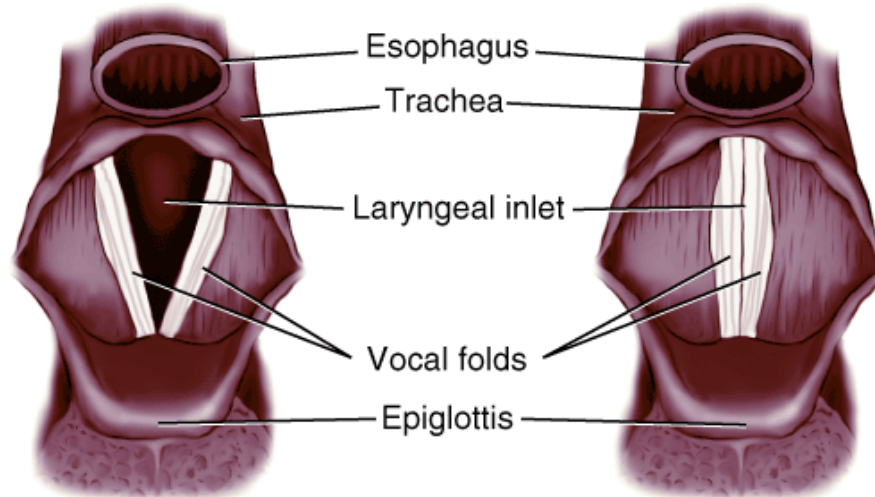
Upper Respiratory Tract

- The pharynx is the area from the back of the nasal cavity and mouth to the larynx
 - pharyng/o is the combining form for pharynx
 - Commonly called the throat



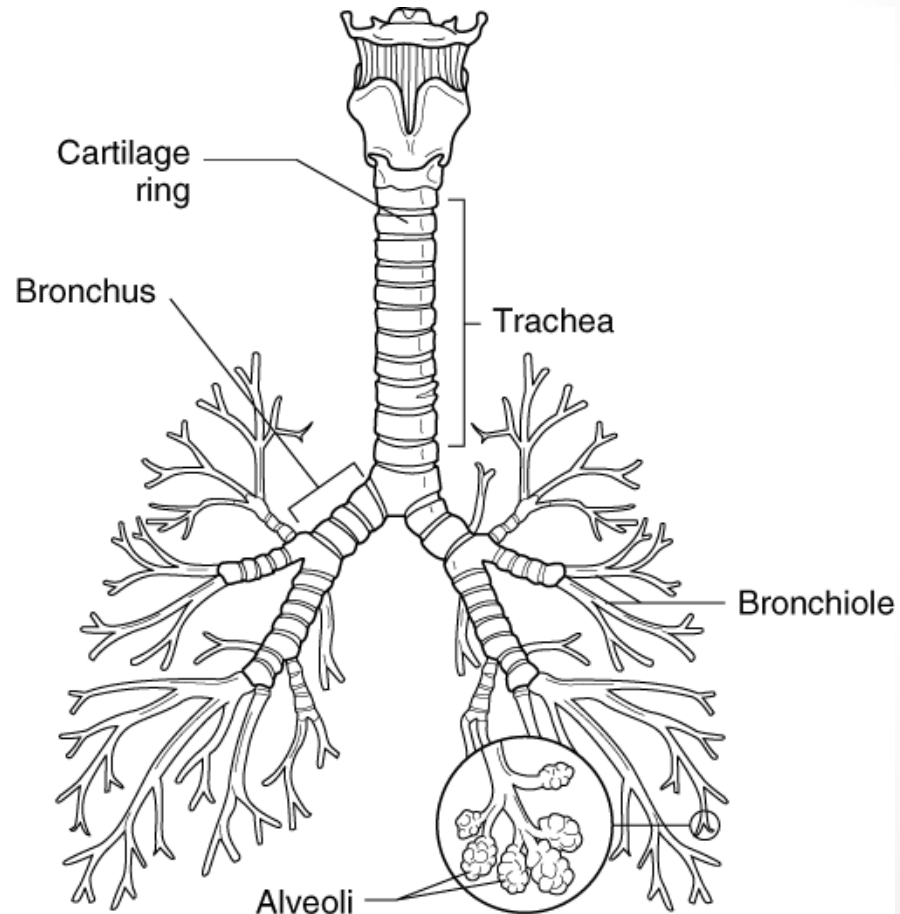
Upper Respiratory Tract

- The larynx is the area between the pharynx and the trachea
 - laryng/o is the combining form for the larynx
 - Commonly called the voice box
 - contains the vocal cords

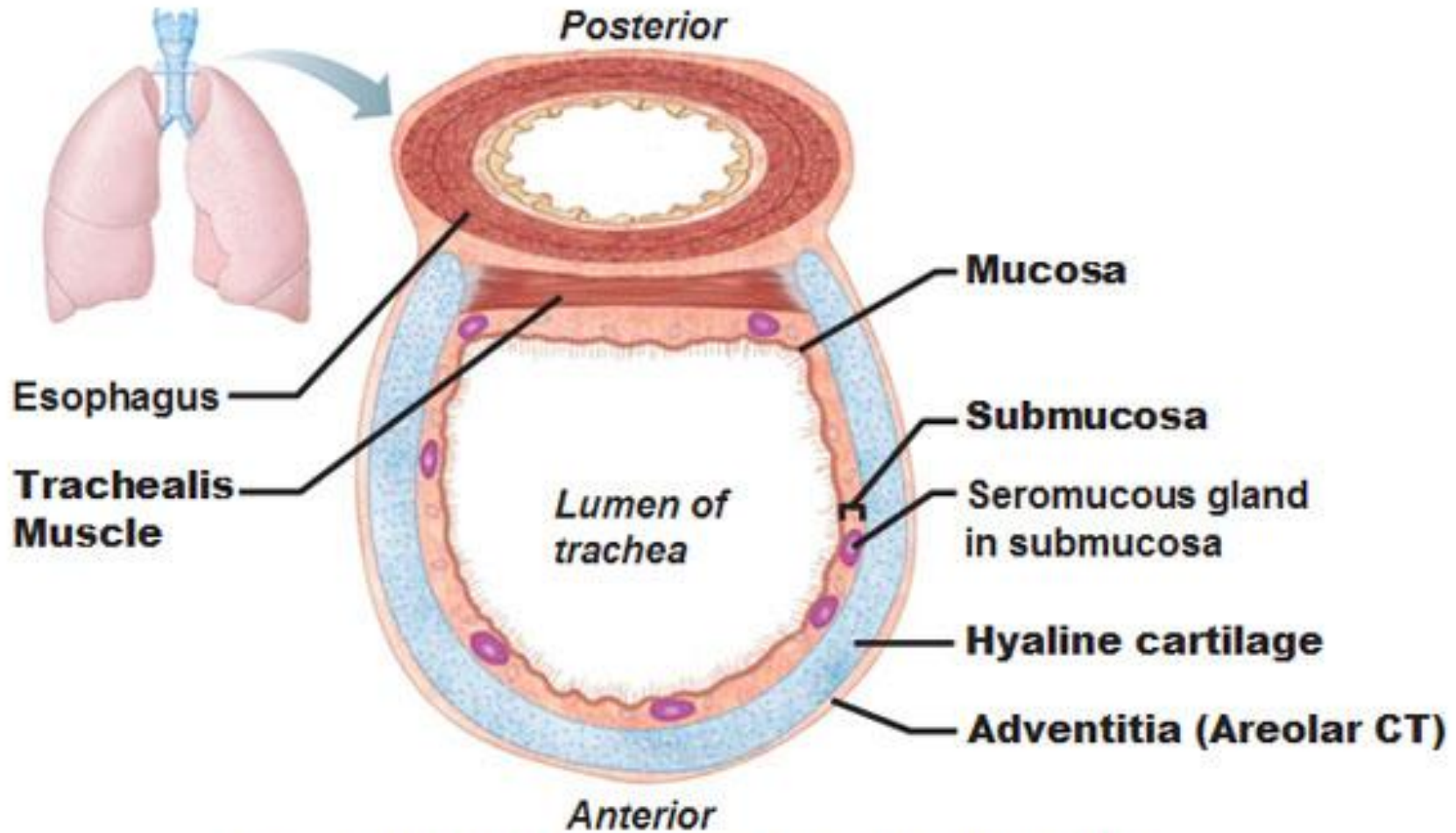


Lower Respiratory Tract

- The trachea extends from the neck to the chest and passes air from the larynx to the thoracic cavity
- Commonly called the windpipe
- Also lined with cilia
 - trache/o is the combining form for the trachea
 - Commonly called the windpipe
 - contains C-shaped cartilaginous rings



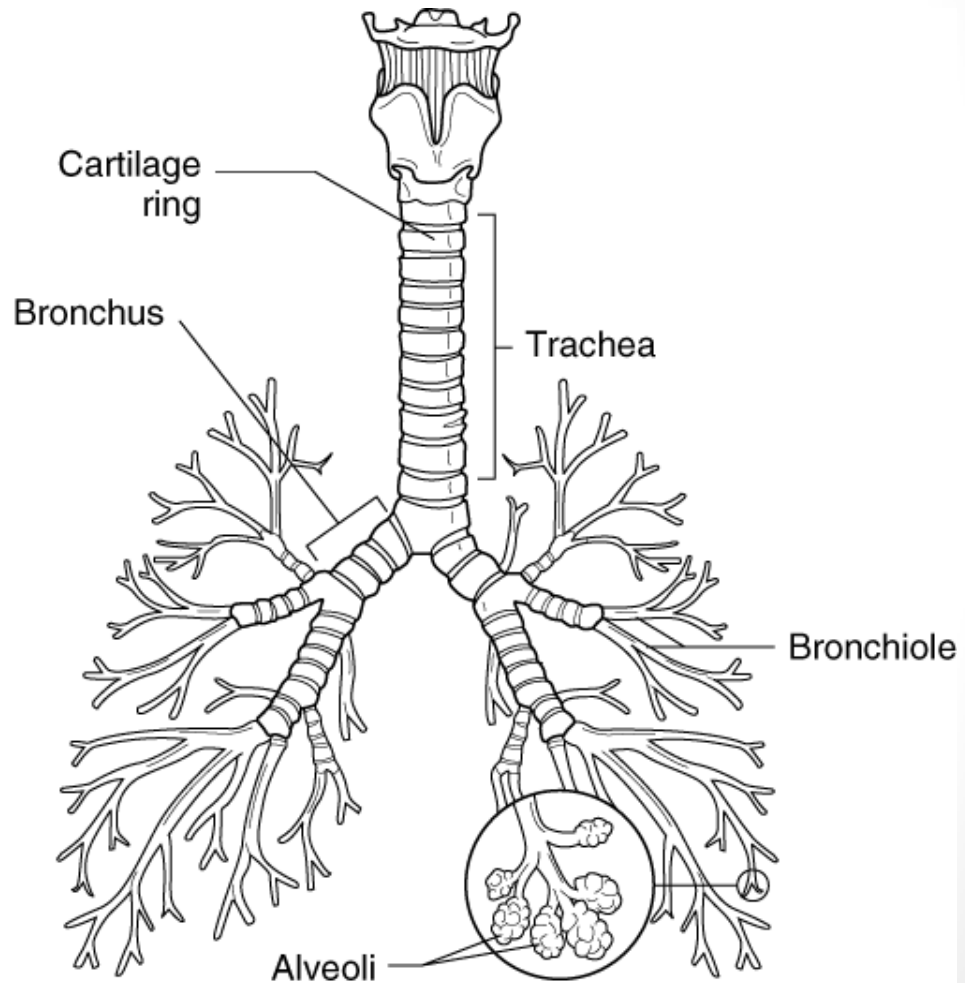
The Trachea



Cross section of the trachea and esophagus

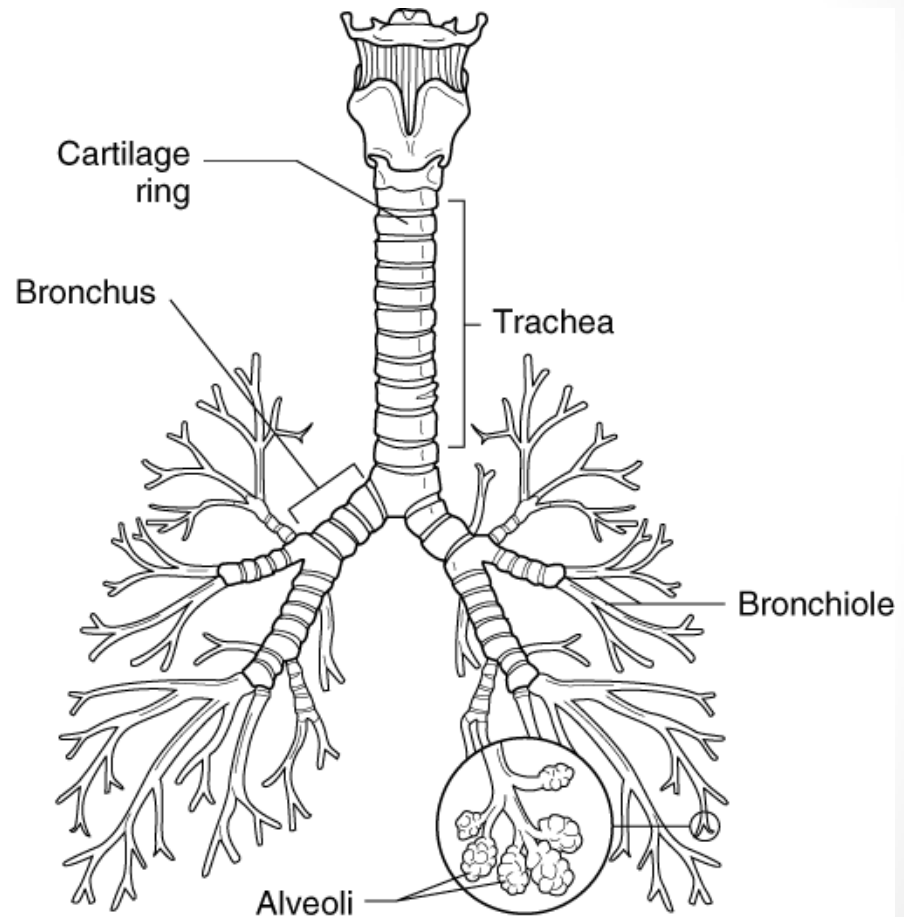
Lower Respiratory Tract

- The trachea divides into two branches at the tracheal bifurcation to form bronchi
 - bronch/o is the combining form for bronchi
 - Bronchus is the singular form of bronchi



Lower Respiratory Tract

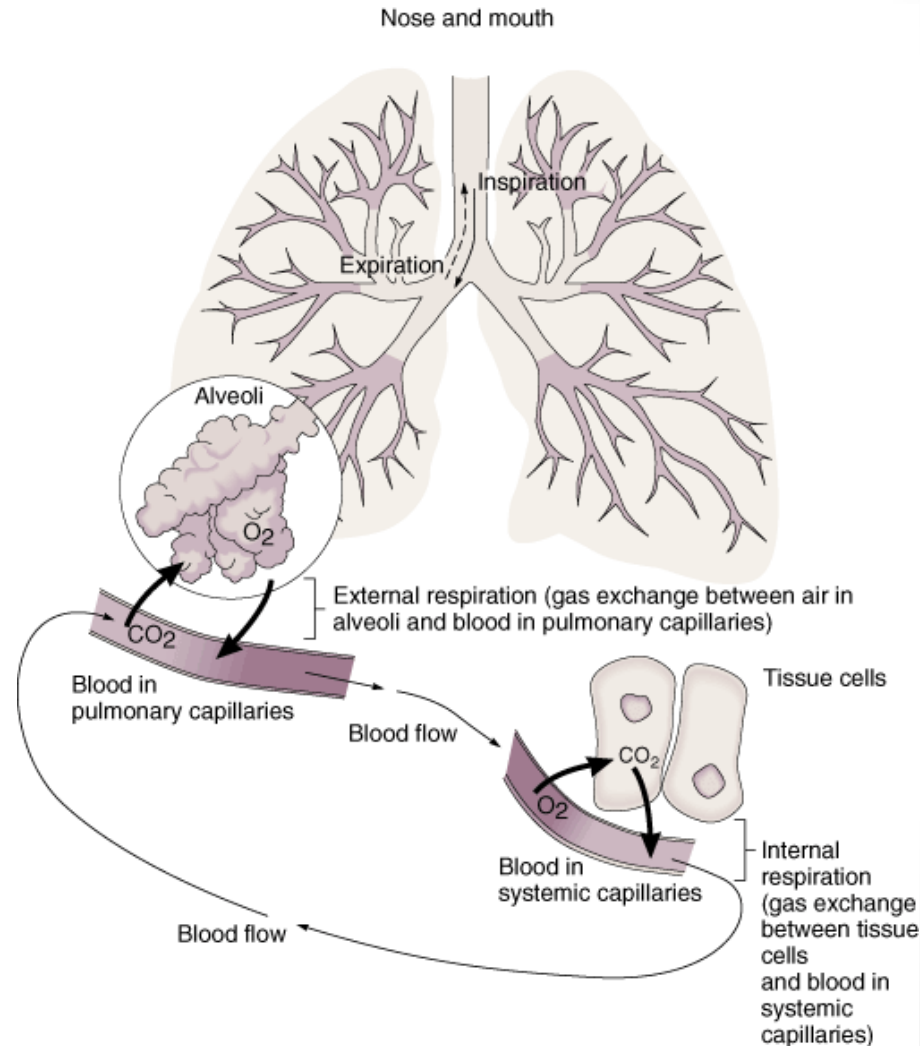
- The bronchi continue to get smaller as they divide in diameter until they become bronchioles
- Principle bronchus
- Secondary bronchus
- Tertiary bronchus (also known as bronchioles or bronchiolus, these contain no cartilage or glands
 - bronchiol/o is the combining form for bronchioles
 - -ole means small



Lower Respiratory Tract

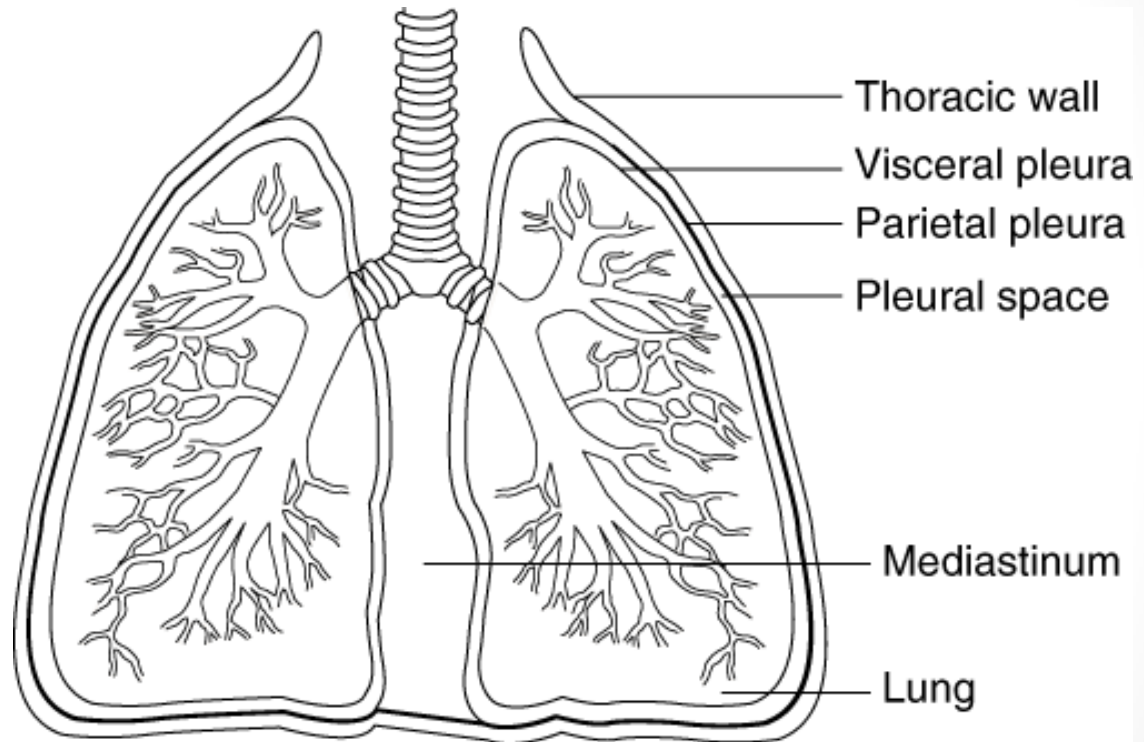
- Alveoli are air sacs where gas exchange occurs
- They have thin, flexible, membrane walls, surrounded by microscopic capillaries

- alveol/o is the combining form for alveoli (small sac)
- Oxygen diffuses and carbon dioxide diffuses across the alveolar wall



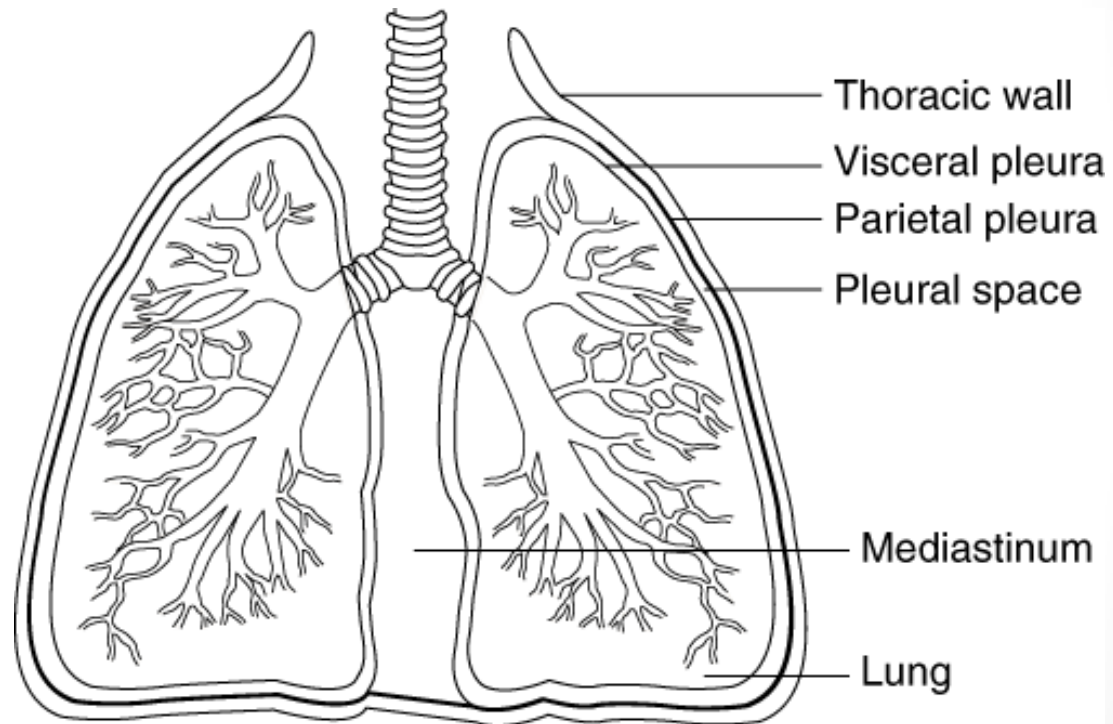
Supporting Structures

- The thoracic cavity is contained within the ribs
 - cost/o is the combining form for ribs
 - thorac/o and -thorax both mean chest cavity or chest

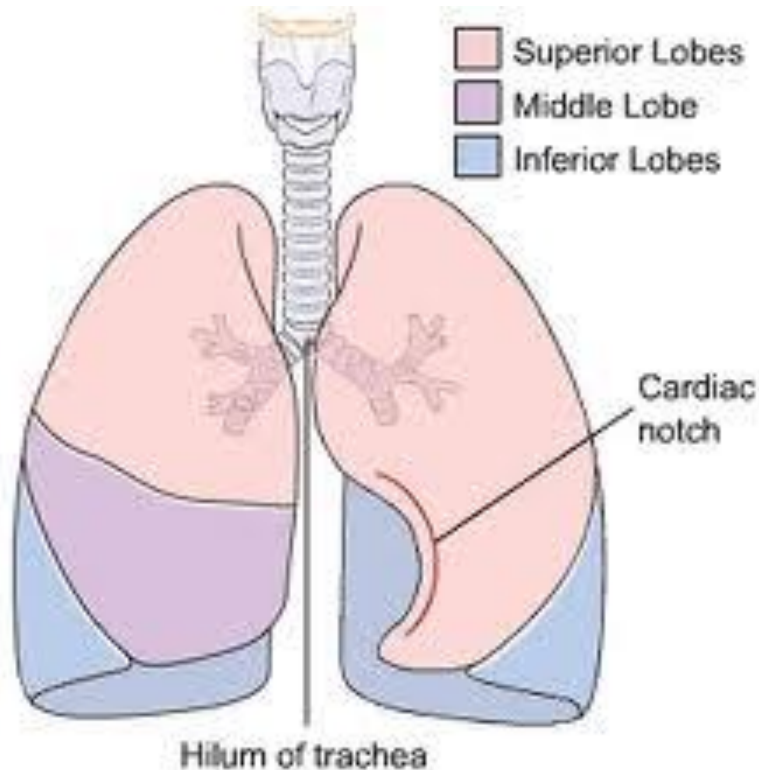


Supporting Structures

- The lung is the main organ of respiration
 - The lungs are divided into well-defined divisions called lobes
 - pneum/o, pneumon/o, and pneu all mean lungs or air
 - pulm/o and plumon/o mean lung



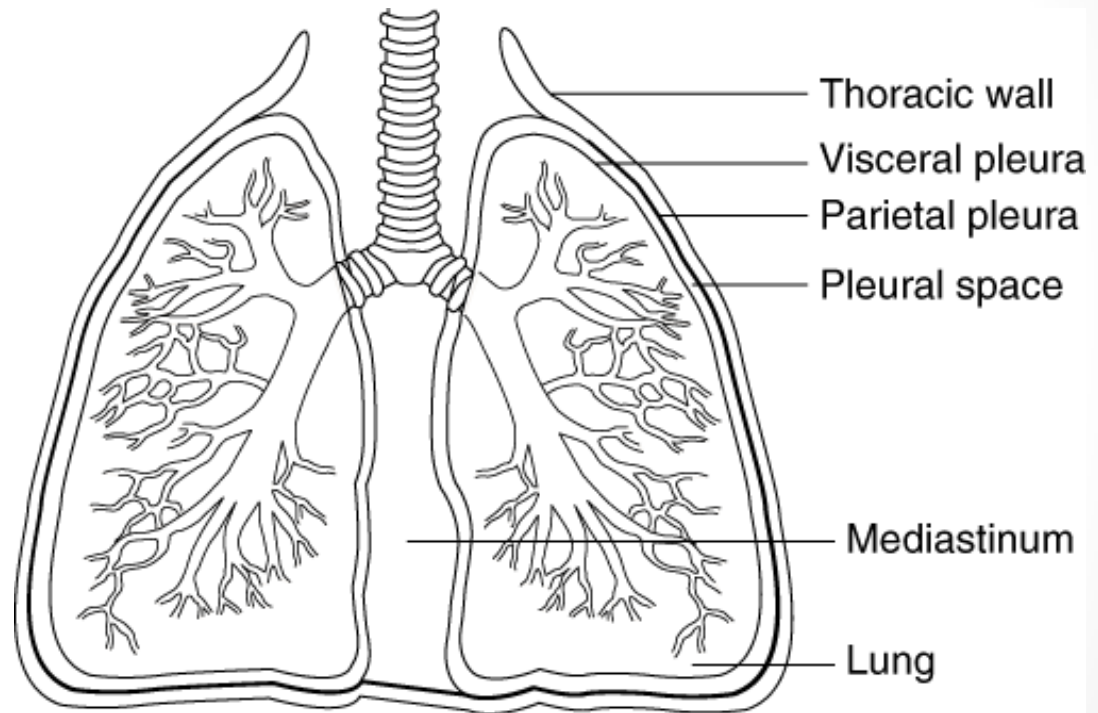
Lobes of the lung



- Species Differences
- The lungs of the **horse** show almost no lobation, and the right lung of the horse lacks a middle lobe.
- In comparison to this, the **ruminant lungs** and **pigs** are obviously lobed. The fissures between the lobes (*interlobar fissures*) are deeper in the **dog and cat** lung compared to other species.
- Avian respiration has many fundamental differences to mammalian respiration.
- The respiratory systems of non-homeotherms are also very different to that of mammals.

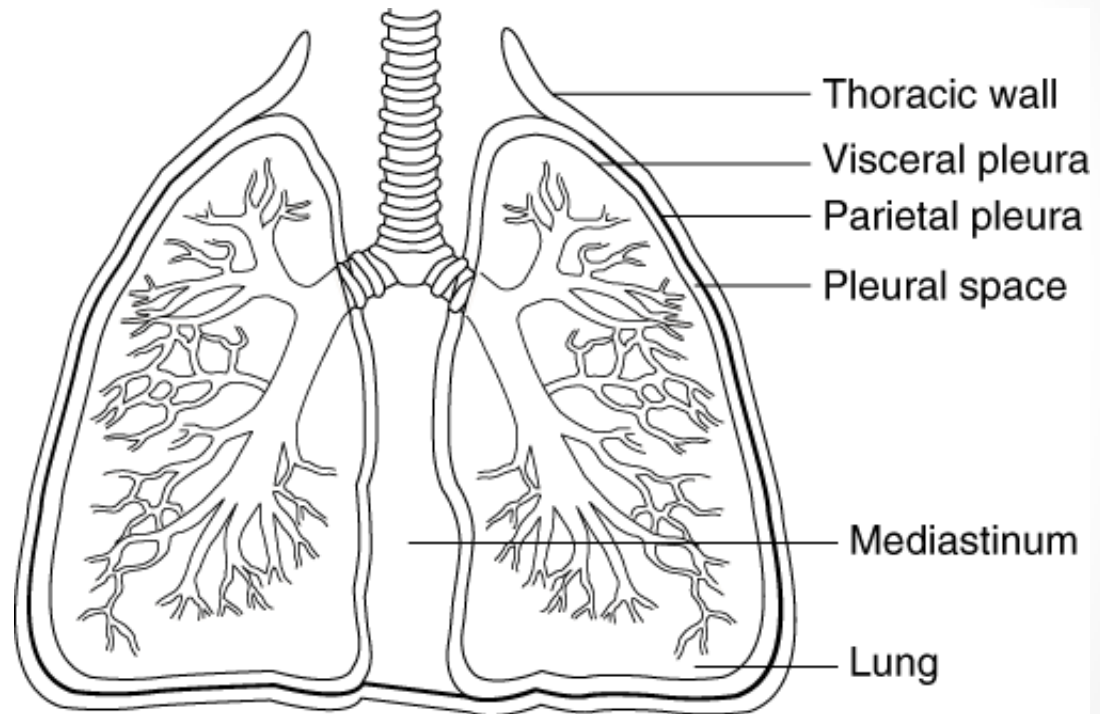
Supporting Structures

- The lung is encased in a membranous sac called the pleura
 - The pleura has two layers, and between these two layers is the pleural space which contains a little fluid to reduce friction between the two layer during breathing
 - pleur/o is the combining form for pleura



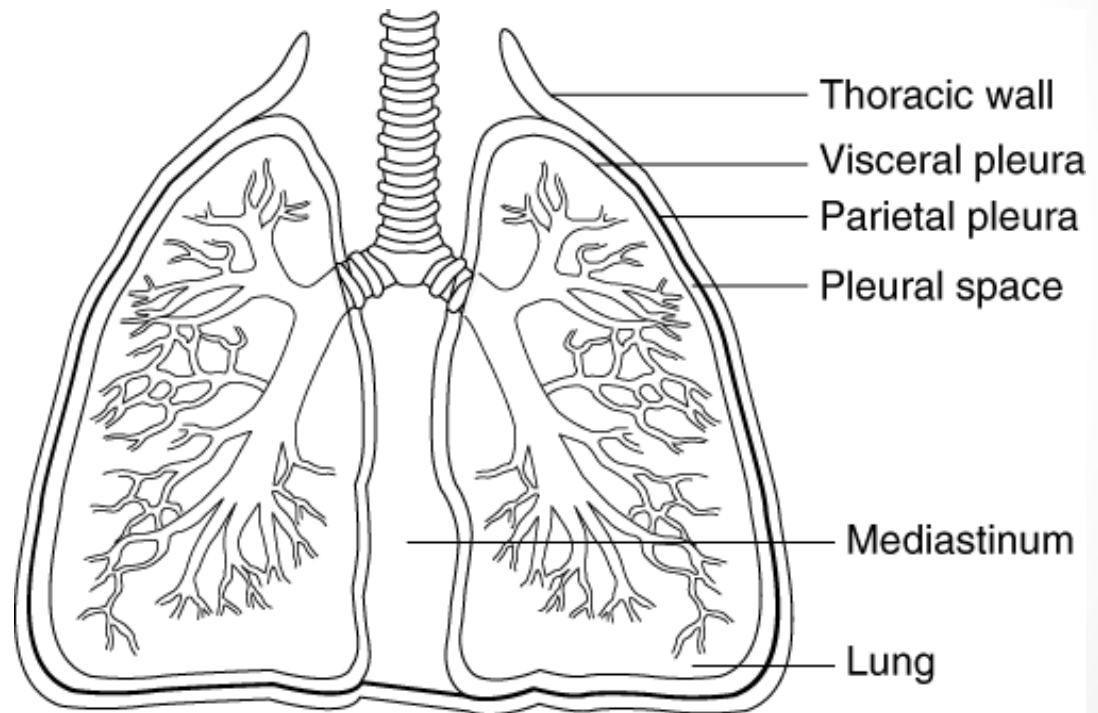
Supporting Structures

- The diaphragm is the muscle that separates the thoracic and peritoneal cavities
- Phrenic nerve innervates the diaphragm
 - dia- means across
 - phragm/o is the combining form for wall
 - diaphragmat/o and phren/o are combining forms for diaphragm



Supporting Structures

- Breathing is the inhalation and exhalation of air
 - Inhalation is the drawing in of a breath
 - Exhalation is the release of a breath
 - Inspiration and expiration can also be used
- Respiration is the exchange of oxygen and carbon dioxide



Terms Associated with Breathing

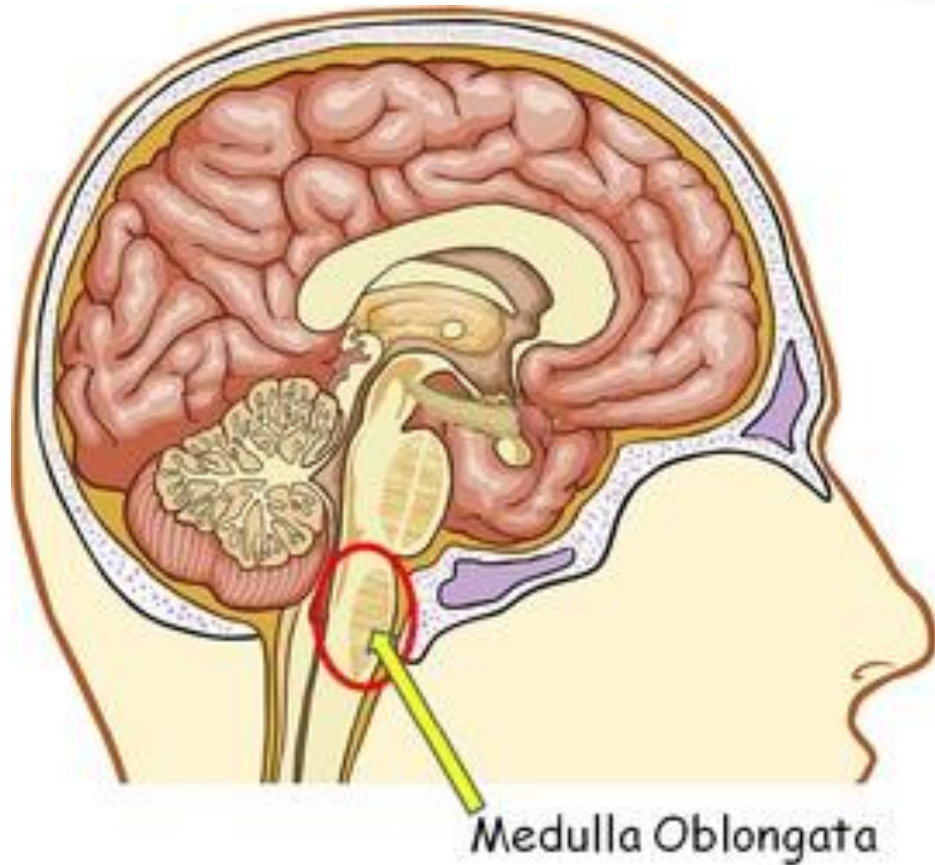
- The root pnea means breathing
- ox/i, ox/o, and ox/y refer to oxygen
- capn/o refers to carbon dioxide
- apnea
- dyspnea
- bradypnea
- tachypnea
- hyperpnea
- hypopnea
- hypoxia
- hypercapnia
- hypocapnia

Lung Volume Terminology

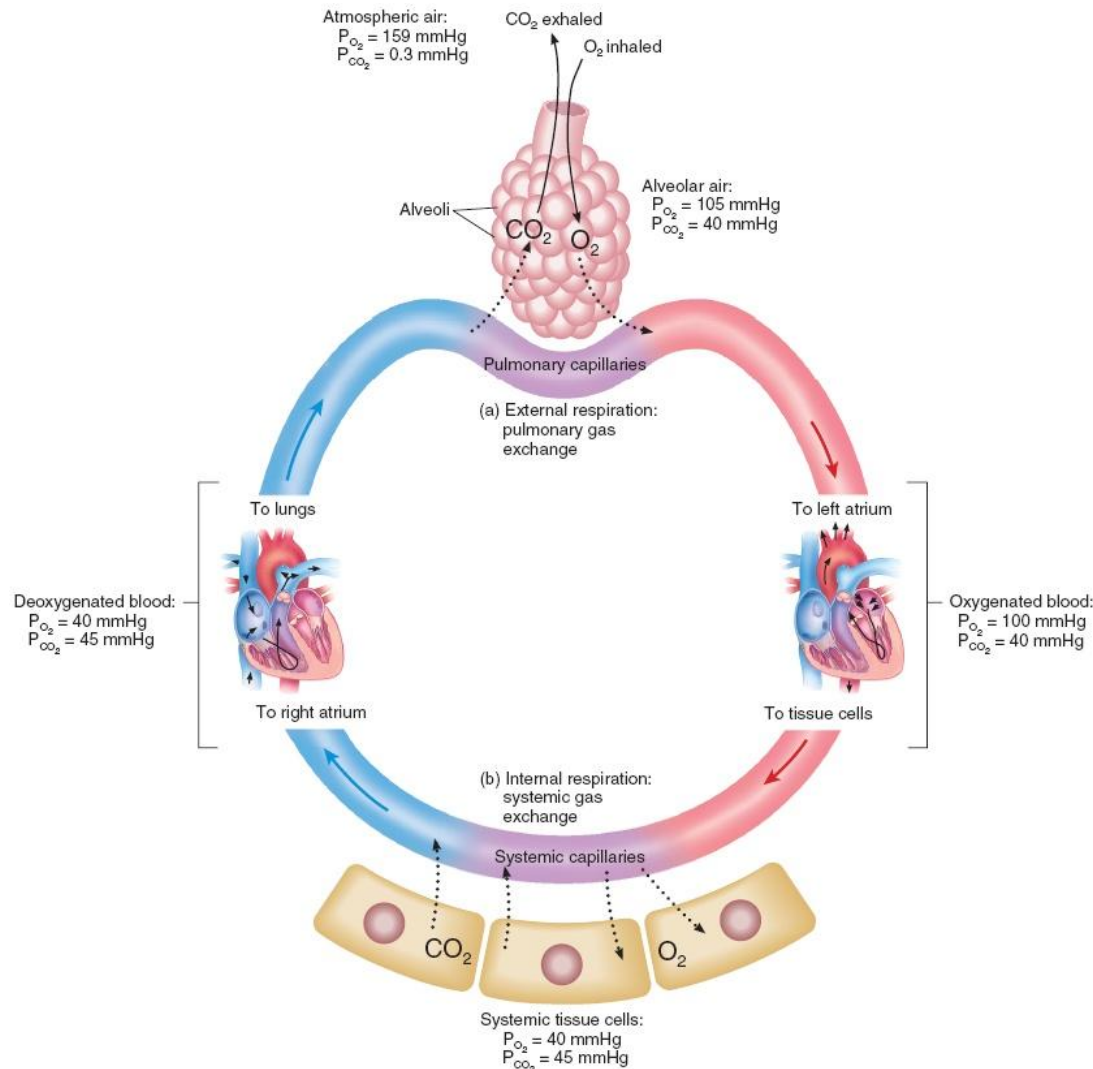
- Tidal volume – the amount of air exchanged in one breath
- Residual volume – air remaining in the lungs after a forced expiration
- Vital capacity – largest amount of air that can be moved in the lung

Respiratory control

- Respiration is an involuntary action controlled by the medulla oblongata
- However, this can be controlled by higher brain function – give an example



Internal & External Respiration



Aviary Respiratory System



Define the System

- Respiratory system delivers oxygen from the air to the tissue and removes carbon dioxide.
- Plays role in regulating body temperature
- Different from other vertebrates
- Cycles inspiration and expiration

Birds Breathe Better

- More efficient than mammals
- Transfer more oxygen with each breath
- Con - transfer toxins more effectively



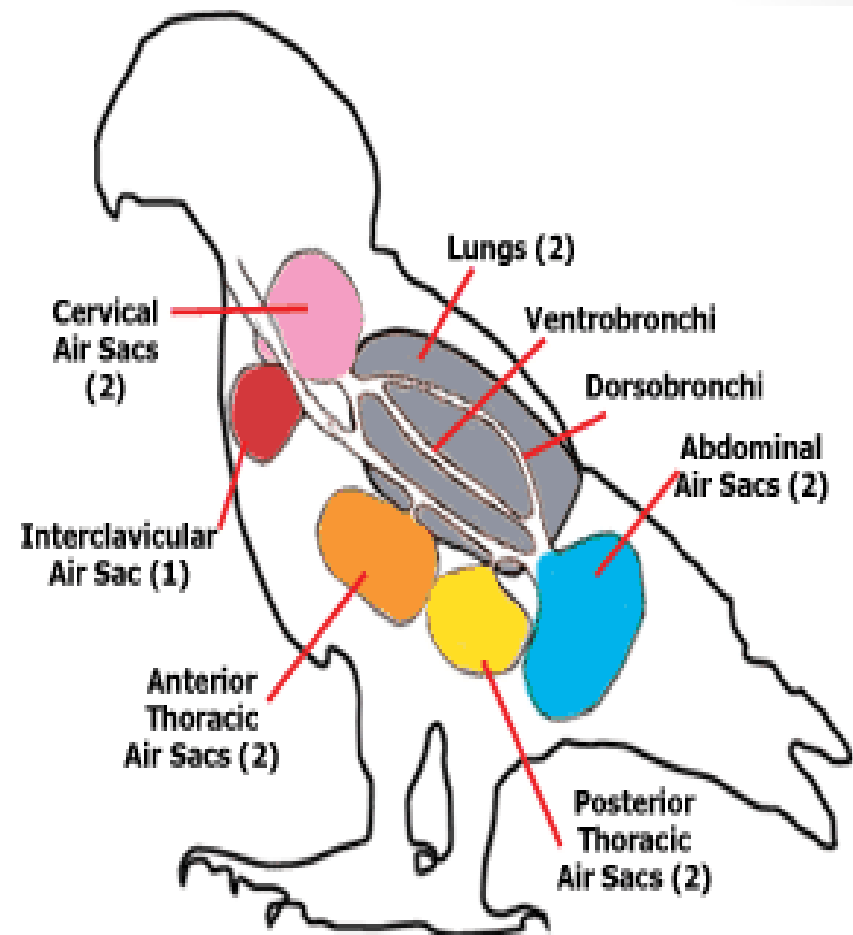
Basics



- Birds have lungs
- Air sacs
- Air sacs of birds extend into bone in shoulder and elbow, thigh bone, back bone, and skull

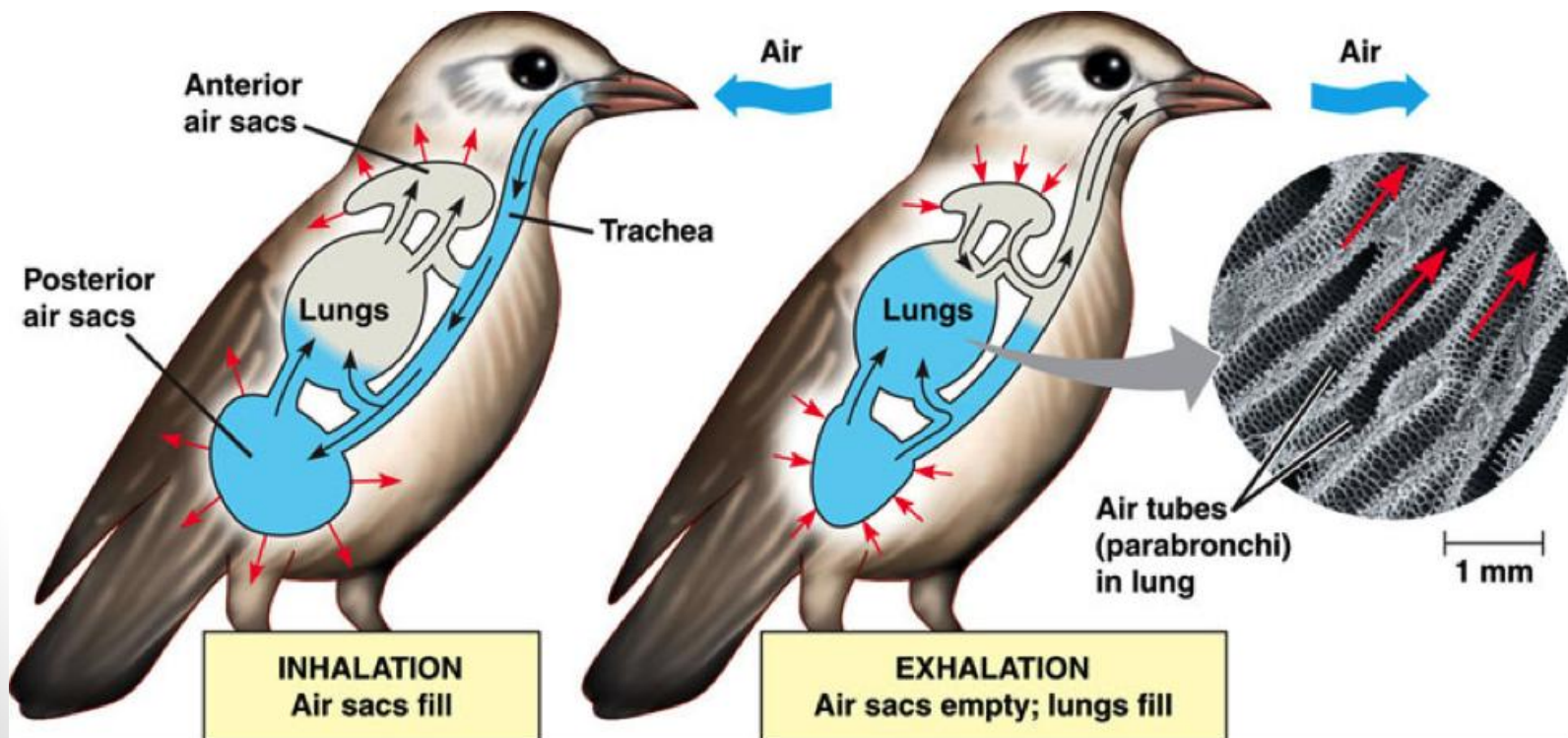
More

- Air is moved into and out of respiratory system with pressure changes in air sacs
- Muscles in chest cause sternum to push outward
- Causes air to enter air sacs
- Other muscles contract to push air out



Unidirectional Flow

- Most mammals have **BIDIRECTIONAL** flow - moving back and forth and into and out of the lungs
 - Air coming into mammals lungs is mixed with old air -
 - less oxygen
- Birds have **UNIDIRECTIONAL** flow
 - Fresh air and has high oxygen content



Diagnostic & Treatment Tools

- Stethoscope
- Naso-gastric tube
- Bronchoalveolar lavage – collection of fluid or mucus from the lower respiratory tract
- Bronchoscopy – examine bronchus using bronchoscope
- Phlegm – thick mucus secreted by the respiratory lining. Mucus from lower respiratory tract is called sputum
- Spirometer – measures lung volume
- Thoracocentesis – puncture of the chest wall to remove fluid from the plural cavity. Can also be used to drain a plural effusion or to expand a collapsed lung.

Pathology of the respiratory system

- Anoxia – absence of oxygen
- Asphyxiation – interruption of breathing (aka suffocation)
- Bronchitis – inflammation of the bronchi (can be acute or chronic)
- Cyanosis – blue discolouration of the skin
- Emphysema – chronic disease caused by enlarged alveoli or changes to the alveolar wall
- Hemothorax – accumulation of blood in the pleural cavity
- Pleural effusion – accumulation of fluid in the plural space
- Pneumothorax – accumulation of air or gas in the chest cavity
- Rhinitis – inflammation of the nasal mucous membranes

DIVING ADAPTATIONS

- High level of myoglobin (O₂ storage)
- Blood diverted to essential organs
- *Retae mirabila*: extra circulatory system → greater blood volume
- High anaerobic tolerance in tissues
- Blood storage in spleen – released in dives
- Reduced blood viscosity
- Bradycardia (25% in bottlenose dolphins) and decreased metabolic rate

DIVING ADAPTATIONS

- Brain and heart most vulnerable to lack of oxygen
- Cetacean brains operate at O₂ concentrations where a human would be unconscious
- High levels of anaerobic respiration in brain at end of dive
- Heart activity decreases (& O₂ demand)
- Blood flow fluctuates (high/none) to periodically flush out anaerobic by-products
- High levels of anaerobic respiration

AVOIDING THE BENDS

- ‘The Bends’ are caused by dissolved nitrogen being absorbed into the blood stream under high pressure.
- When pressure decreased the dissolved nitrogen come out of solution as tiny bubbles.
- These bubbles can block blood capillaries – causes pain, paralysis etc.

AVOIDING THE BENDS

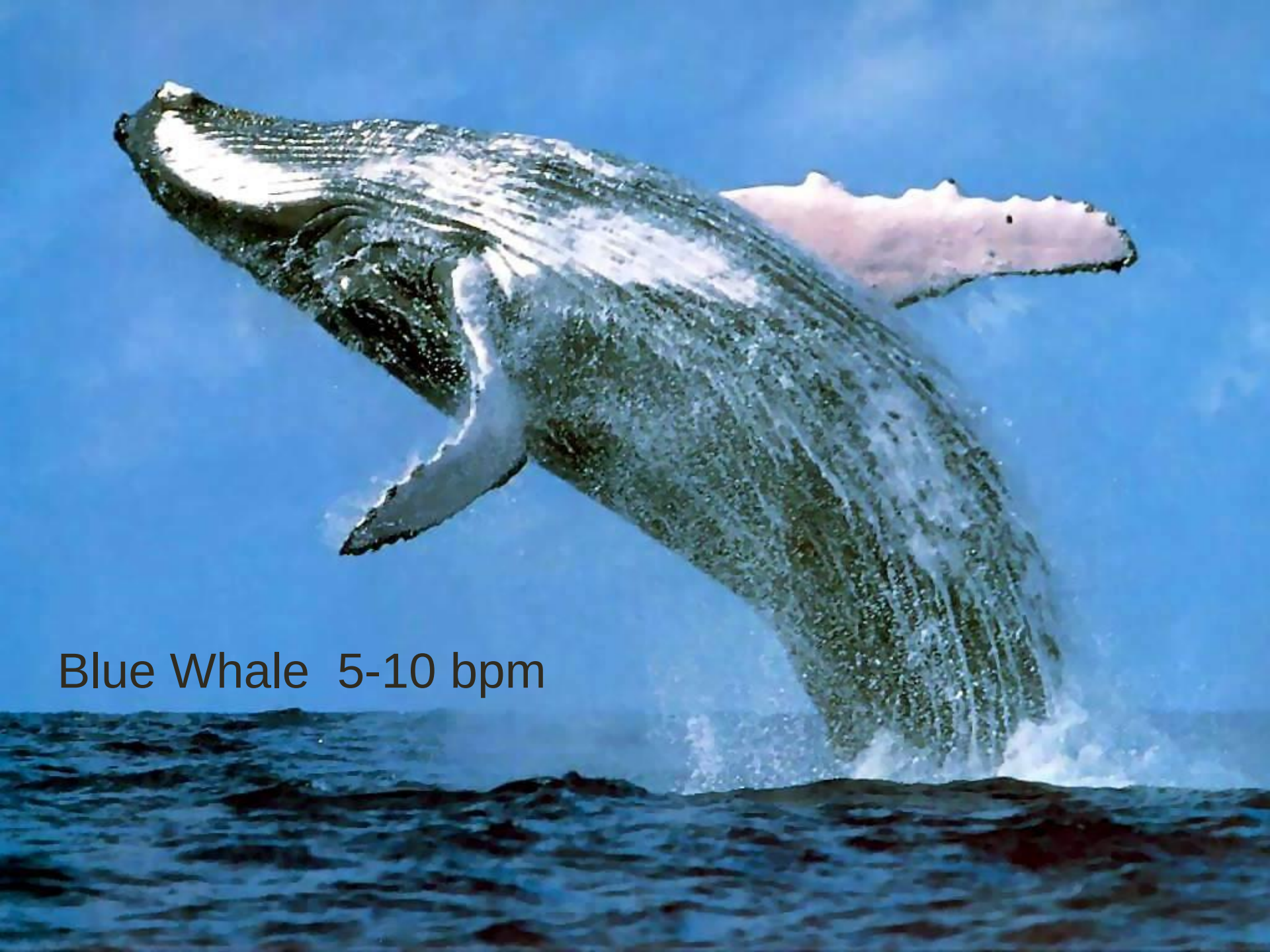
- Rib cage collapsible & lungs can compress.
- Air squeezed out of lungs and thorax into windpipe.
- Windpipe thickened, does not absorb air (or dissolved nitrogen).
- Rapid transfer of nitrogen from blood into lungs
- Some absorption of nitrogen in mucus
- Reduced circulation of blood to muscles – less risk of capillary block

Which vertebrate animal has
the fastest heart rate?



1260 bpm

Which vertebrate animal has
the slowest heart rate?



Blue Whale 5-10 bpm

Which animal has the largest
heart?



Blue Whale - size of a small car

Smallest Lungs

Why do animals at high
altitude have greater
concentration of RBC's?

The main physiological challenge of bar-headed geese is extracting oxygen from hypoxic air and transporting it to aerobic muscle fibres in order to sustain flight at high altitudes. Flight is very metabolically costly at high-altitudes because birds need to flap harder in thin air to generate lift. Studies have found that bar-headed geese breathe more deeply and efficiently under low oxygen conditions, which serves to increase oxygen uptake from the environment. The haemoglobin of their blood has a higher affinity for oxygen compared to low-altitude geese, which has been attributed to a single amino acid point mutation. This mutation causes a conformational shift in the haemoglobin molecule from the low oxygen affinity form to the high oxygen affinity form. The left-ventricle of the heart, has significantly more capillaries in bar-headed geese compared with lowland birds, maintaining oxygenation of cardiac muscle cells and thereby cardiac output. Compared to lowland birds, mitochondria (the main site of oxygen consumption) in the flight muscle of bar-headed geese are significantly closer to the sarcolemma, decreasing the intracellular diffusion distance of oxygen from the capillaries to the mitochondria. Bar-headed geese have a slightly larger wing area for their weight than other geese, which is believed to help them fly at high altitudes. While this decreases the power output required for flight in thin air, birds at high-altitude still need to flap harder than lowland birds