Respiratory System

Oxygen is one of the most vital requirements of animals. An animal may survive for days without water or for weeks without food, but life without oxygen is measured in minutes. Respiratory system acts as supplying of O_2 to the blood & remaining CO_2 from the blood.

Respiratory apparatus:

- **Nostrils -** These are the external openings of the air passages, vary in size & shape from the soft, pliable, easily dilated (horse) to rigid openings (pig).
- **Nasal cavity -** It is separated from the mouth by the hard & soft palates & separated into 2 halves by a median cartilaginous septum.
- **Pharynx -** It is a common passage for food & air, but normally air cannot be inspired at the same time food is being swallowed.
- **Larynx (Voice box) -** It controls inspiration & expiration of air, prevents inhalation of foreign objects & is essential for voice production.

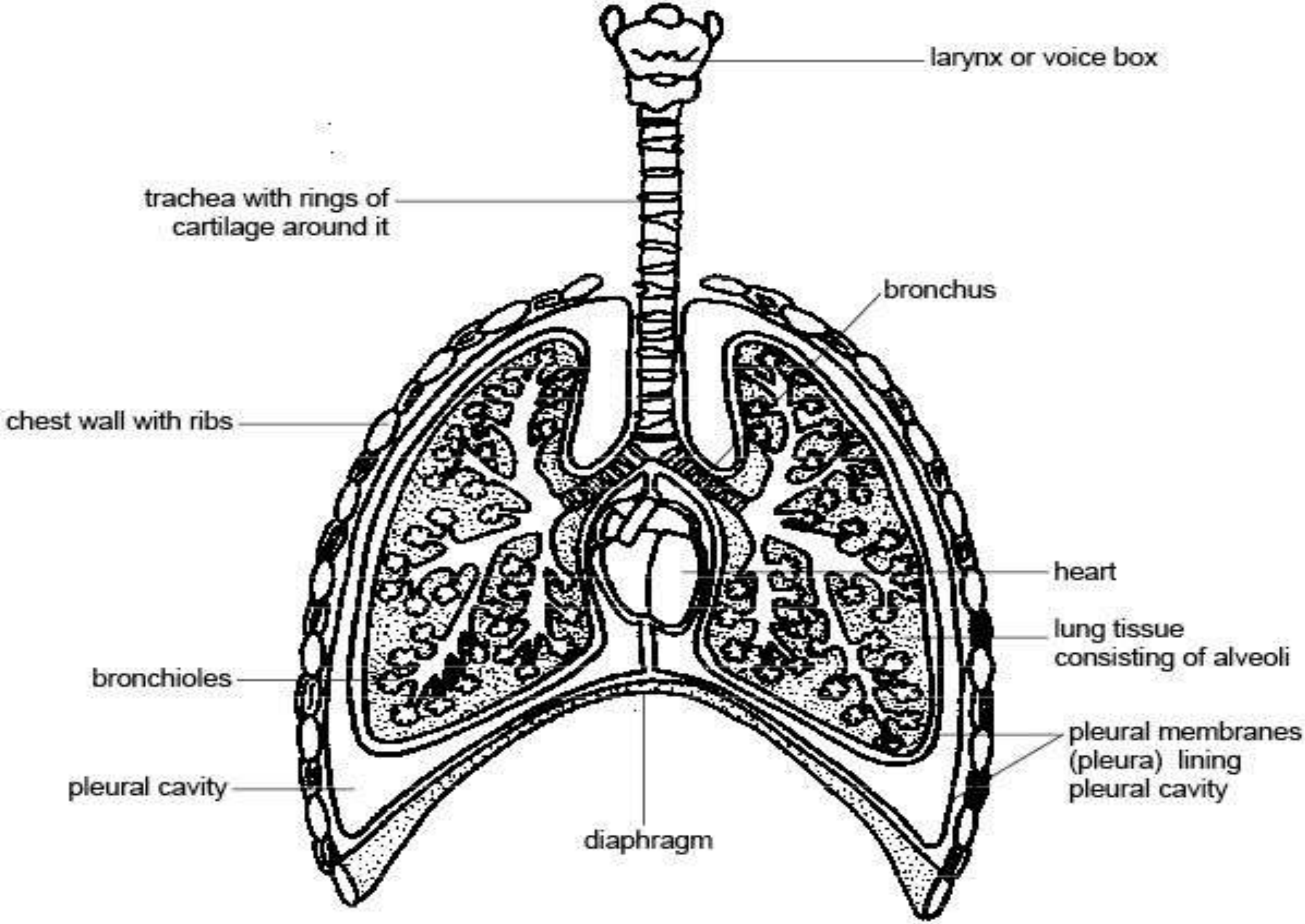
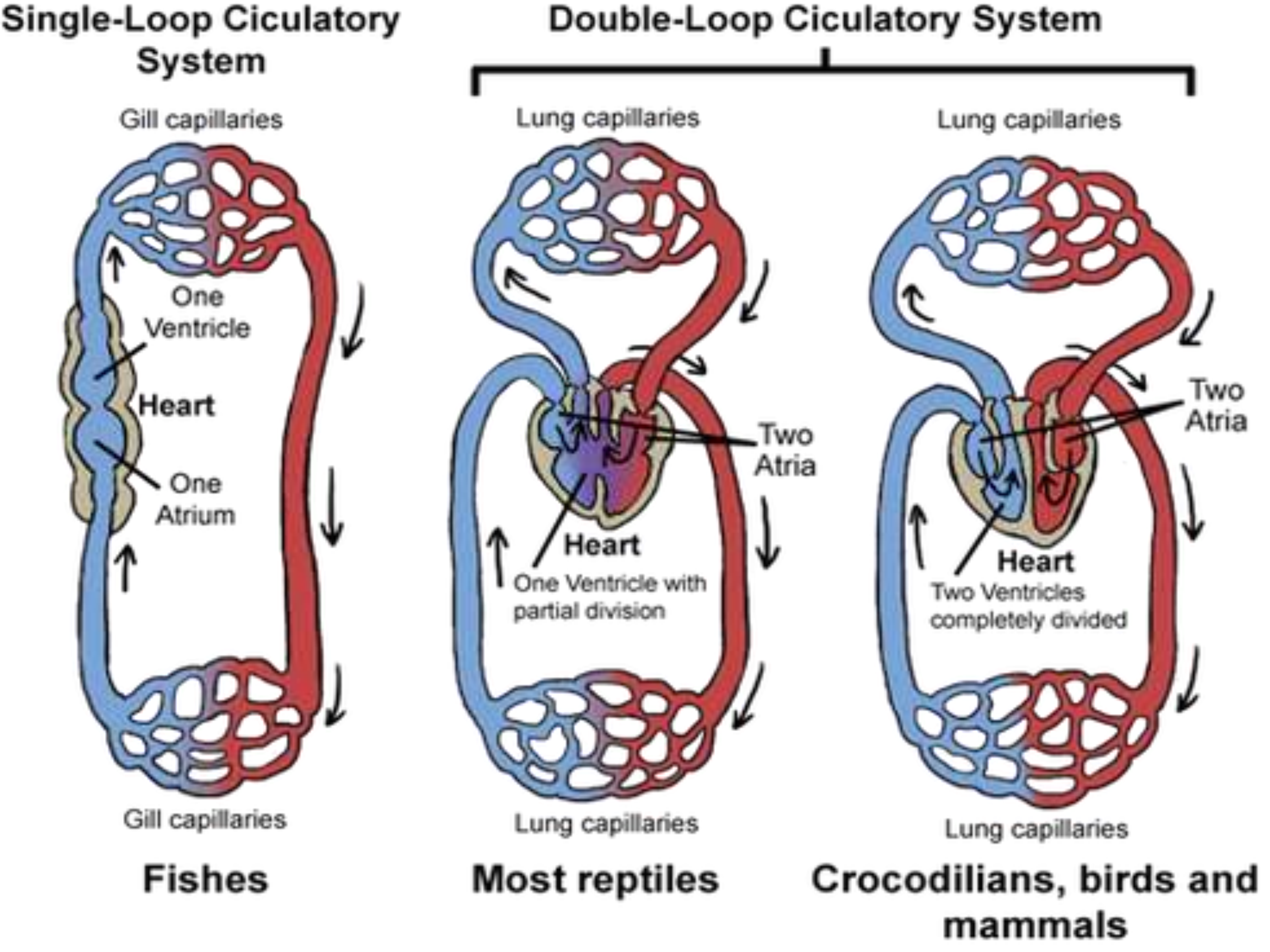


Diagram 9.3 - The respiratory system

- **Trachea:** Larynx continued by the trachea, divides into two chief bronchi, one for each lung. These bronchi branch into smaller bronchi & finally form smallest bronchioles. Each respiratory bronchiole branches into several alveolar ducts which terminates as alveolar sacs consisting of numerous alveoli. Blood capillaries are connected with alveolar walls so as that CO_2 in the blood may be exchanged for O_2 in the inspired air.

Lungs:

- ✓ It is a cone shaped structure with a base & apex.
- ✓ The hilus of each lung is located near the middle of the medial side, where the branches, pulmonary artery & nerves enter the lung & the pulmonary veins & lymphatic vessels leave the lung.
- ✓ It has 3 lobes in left & 4 in right i.e., cranial, middle, caudal & extra intermediate (rt. lung) lobules.


Single-Loop Ciculatory System
Double-Loop Ciculatory System
Gill capillaries
One Ventricle
Heart
One Atrium
Gill capillaries
Fishes
Lung capillaries
Two Atria
Heart
One Ventricle with partial division
Lung capillaries
Most reptiles
Lung capillaries
Two Atria
Heart
Two Ventricles completely divided
Lung capillaries
Crocodilians, birds and mammals

Pleura: It consists a single layer of mesothelial cells (smooth serous membrane simple squamous epithelium) of CT which acts as a lubricant to reduce friction between lungs & other substances of the thorax.

Mechanism of Respiration:

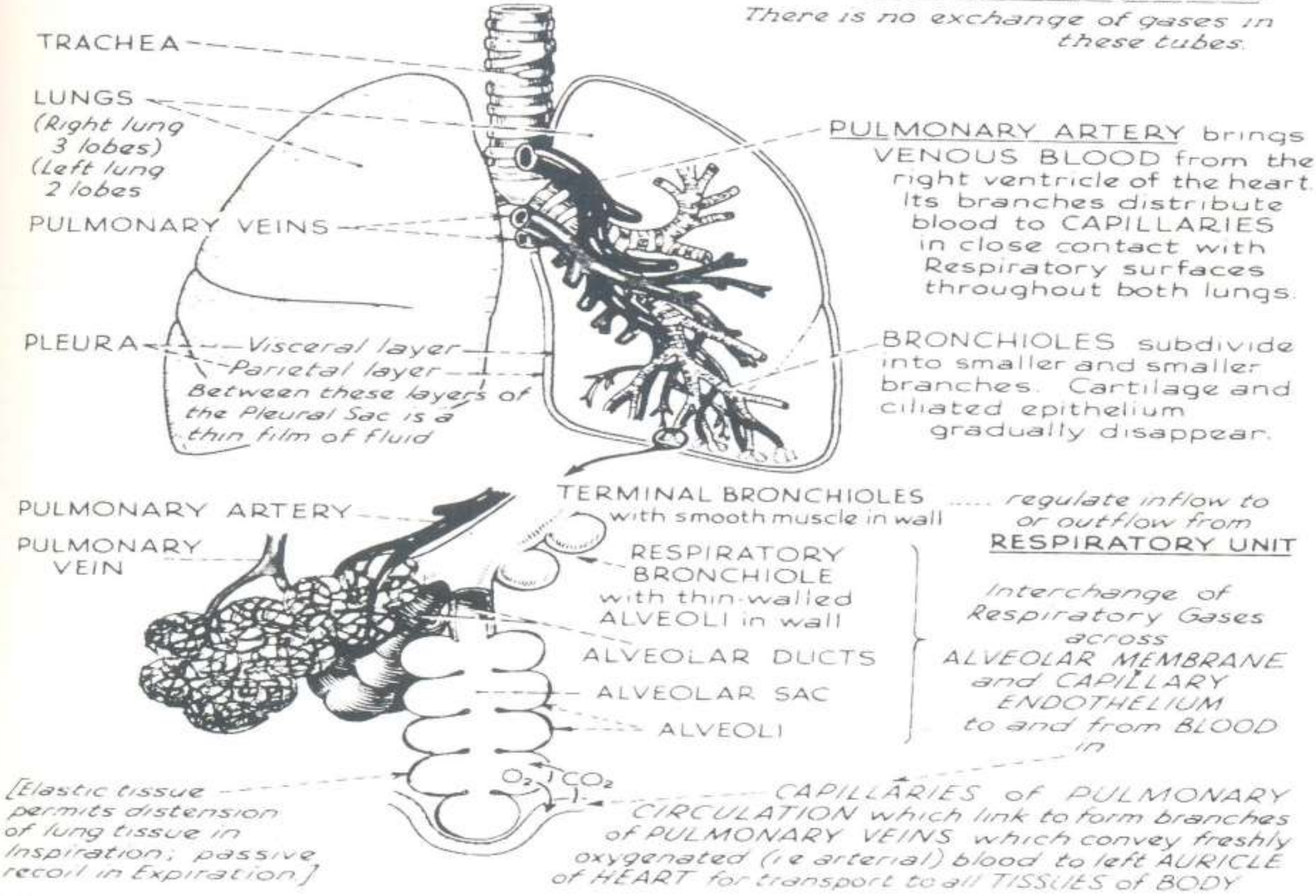
- The thin membranes of the alveolar wall & capillaries facilitate the movement of O_2 into the blood & movement of O_2 into the alveolar air.
- It constitutes external respiration while O_2 from blood is diffused to the tissues for cellular oxidation & the resulting CO_2 diffuses into the blood, consists of internal respiration.
- Enlargement of the thoracic cavity reduces the negative pressure of atmospheric pressure in the pleural cavity, causing the lungs to enlarge which results in an out flow of air into the lungs k/a inspiration.

- During respiration, contraction of the diaphragm emerges the thoracic sufficiently.
- Diaphragm is mainly consist of tendon but periphery constituents of striated muscle & rt. & lt. phrenic nerves.
- Contraction of muscular portion forces the abdominal contents caudad, thus $\uparrow^{ing}$ the length / volume of the thorax.
- Expiration is the movement of air out of the lungs & occurs when volume of the thorax is decreased.
- It may be because of tendency of elastic structures to return their normal shape.
- Elasticity of the costal cartilages, lungs & abdominal wall tends to return the thorax to its normal location without muscular effort.
- Forced expiration requires a considerable amount of muscular effort.
- The abdominal muscles press the viscera against the diaphragm.

LUNGS: RESPIRATORY SURFACES

The Trachea and the Bronchial 'Tree' conduct Air down to the RESPIRATORY SURFACES

There is no exchange of gases in these tubes.



- Other muscles may decrease the volume of the thorax by pulling the ribs caudad.

Intrathoracic pressure: This is the pressure within the chest, but outside the lung. It is normally negative i.e., little below to atmospheric pressure which reduced pressure exerted on the large veins & atria.

Pneumothorax: The lungs will never completely collapse also when the inspired air enters into the pleural cavity, this condition is k/a pneumothorax.

Artificial Respiration: It may be required during emergencies such as drowning, cardiac arrest, electric shock & CO poisoning. It may be applied by alternatively compressing & releasing the thorax. The rate should be approximate that of normal respiration.

Types of breathing:

- **Thoracic (costal) -** It involves movement of the ribs
- **Abdominal (Diaphragmatic) -** It involves during normal ordinary breathing
- **Eupnea -** Normal quiet respiration
- **Dyspnea -** Difficult breathing
- **Apnea -** Absence of respiration
- **Hyperpnea -** $\uparrow^{ed}$ rate & depth of breathing
- **Polypnea -** Rapid breathing

Atricular volumes & capacities:

- **Tidal volume -** the volume of air inspired or expired during normal respiration
- **Inspiratory reserve volume -** The amount of air that can be inspired during a normal quiet inspiration
- **Expiratory reserve volume -** The maximal amount of air that can be expired during a normal quiet expiration

- **Residual volume -** The remaining amount of air in the lung after maximal expiration
- **Vital capacity -** The maximal amount of air that can be expired after a maximal inspiration

Exchange of gases: The presence of Hb in erythrocyte increases the efficiency of O_2 transport & exchange in blood. The rate of gas exchange is influenced by some factors that are:

- Permeability of the membrane
- Surface area comes in contact
- Relative partial pressure of gases in blood & alveoli
- Volume of blood exposed to the alveoli

- The PO_2 is highest in the lung alveolar air having diffused across the respiratory membrane.
- When blood reaches the tissue capillaries O_2 diffuses out of the blood & combines with tissue level.

- So, the pressure differences favor the loading of O_2 at the lung alveoli & uploading of CO_2 where as at tissue level the opposite mechanism occurs.
- Mostly O_2 is combined with Hb of erythrocytes whereas CO_2 with the bicarbonate ion form (HCO_3^-) others as carbonic acid or combines with Hb as carbonic hemoglobin.
- Dissociation characteristics of HbO_2 saturates the Hb while the blood is in contact with alveoli, yet permit O_2 to be given up to tissues with a low PO_2.
- CO_2 produced by the tissues favors release of O_2 from HbO_2
- The presence of CO_2 makes the blood more acid & thus decrease the affinity of Hb for O_2. It is also k/a Bohr effect Therefore, the blood will hold less O_2 & favors unloading of O_2 at the tissue level.
- Metabolizing cells have higher temperature & need frequent O_2 to adjoin higher temperature also releases O_2 from HbO_2

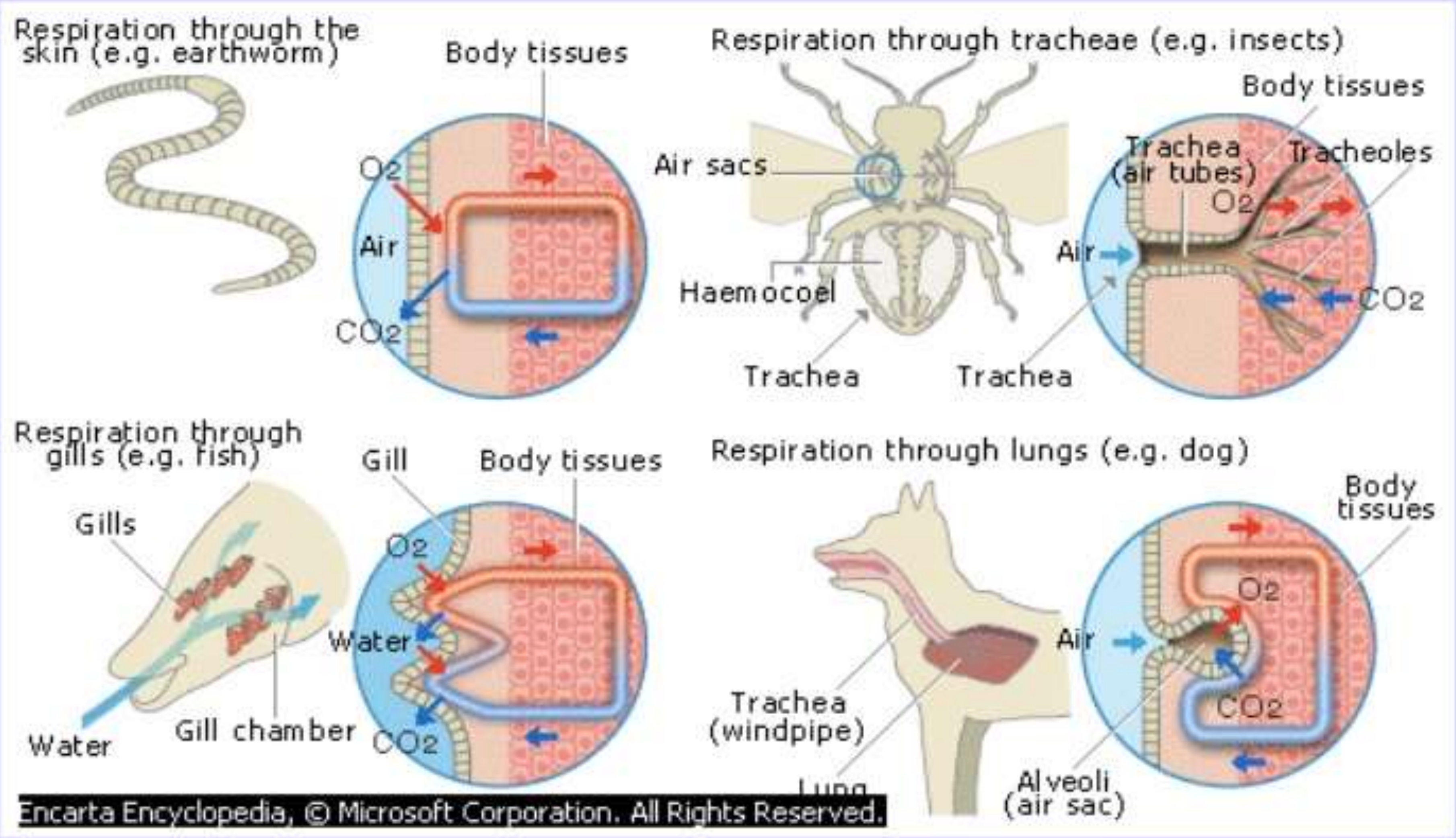
- CO_2 from the tissues enters the systemic capillaries because the PCO_2 of tissue fluid is higher than the PCO_2 of blood and also O_2 molecule differs across the capillary endothelium.

Respiratory Quotient: It is the ratio of the volume of CO_2 expired divided by O_2 inspired. The RQ of glucose is 1. The RQ of CH_2O>1 being converted to an O_2 poor material (fat).

Control & Humoro-chemical factors involve in respiration:

- The medullary rhythmicity area consists of an inspiratory center.
- Its stimulation leads to mechanical inspiration of air to the lung alveoli because the impulses are transmitted down to the spinal cord-cervical segments-phrenic nerves & intercostal nerves & intercostal muscle of the ribs to activate diaphragmatic inspiration.
- Expiratory neurons are also located in this area & are only activated when a forced expiration needed.

PHYSICAL RESPIRATION IN MORE COMPLEX ANIMALS



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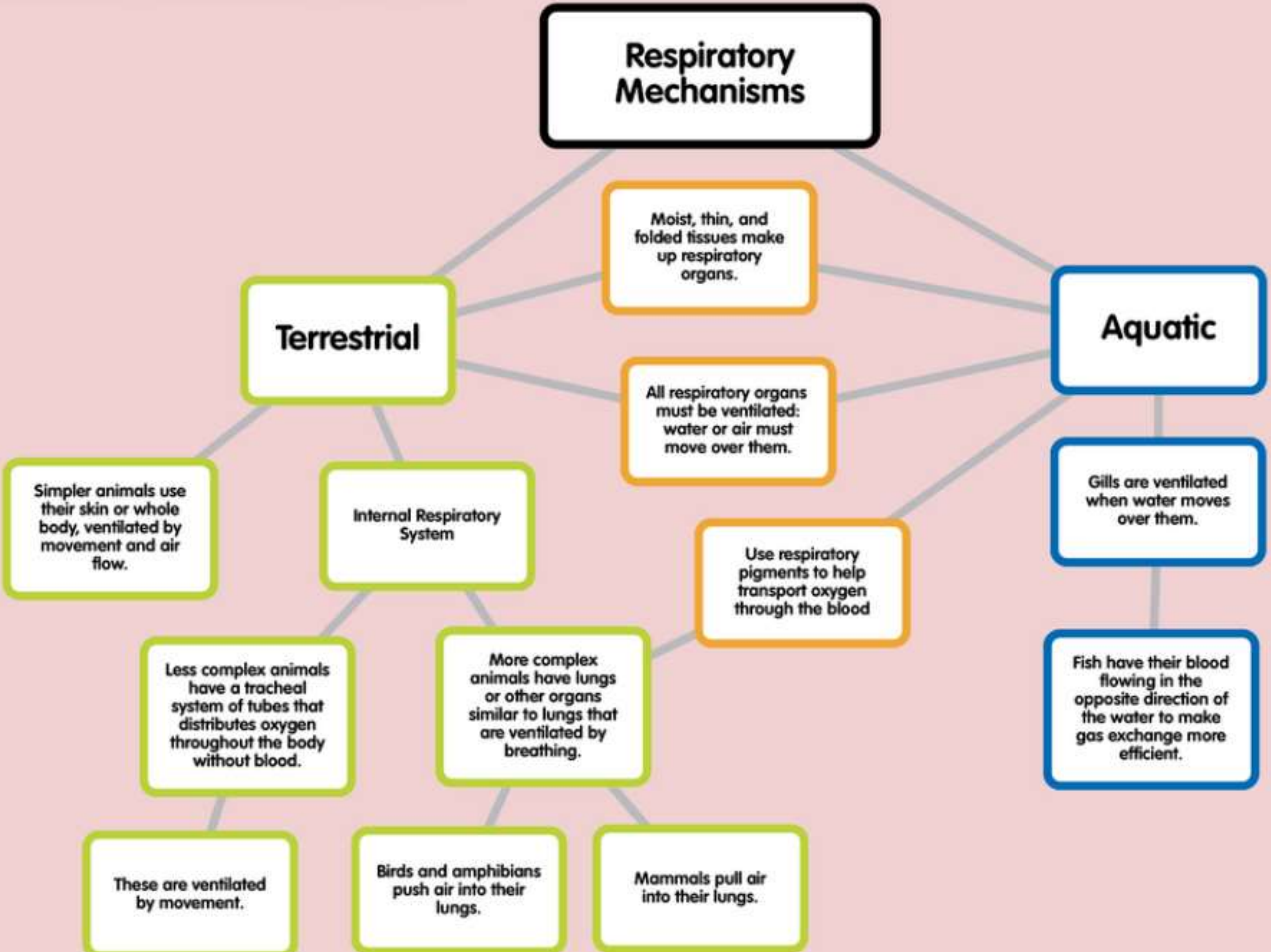
- During eupnea (normal breathing) a feedback circuit also prepare for regular intermittent rhythmic breathing rate for each species.
- This circuit forms between the inspiratory center pneumotaxic & apneustic area in the pons by way of a recurrent collateral branch of the phrenic nerves.
- Stimulation of the pneumotaxic center inhibits the inspiratory center & so the next inspiration cannot occur until this circuit is completed.
- The stretch receptors in the lung parenchyma, visceral pleura & bronchioles stimulated as the lung inflates during inspiration, causing the firing of impulses of different fibres of the vagus nerve into the brainstem & to inspiratory center to inhibit the center from firing.
- This is the hering breurer reflex, it reinforces the action of the pneumotaxic enter to stop inspiration & prevent over-distension of the lungs.
- Rapid deep breathing (hyperpnea) is due to simulation of respiratory center to $\uparrow^{ed}$ pulmonary ventilation & the exchange of gases across the respiratory membrane.

- The most humoro chemical factor influencing the activity of the respiratory centre is the level of CO_2 in the blood.
- An ↑ in PCO_2 of arterial blood will ↑ the activity of center & ↑^{ed} the ventilation rate.
- Medulla oblangata monitor the H^+ concentration of the CSF, since CO_2 easily crosses the blood brain barrier & ↑^{es} acidity.
- It gives an ↑^{ed} breathing rate from ↑^{ed} excitation of the respiratory enter.
- When PO_2 drops very much in arterial blood, it stimulates the chemoreceptors in the carotid & aortic bodies which send impulses up afferent nerves to stimulate the inspiratory center & thereby ↑ the rate of ventilation of the lungs until the major deficiency is made up.
- The rt. & lt. cardio-aortic nerves originates in the aortic body & travel to medulla in the respective vagus nerve.



Respiratory Mechanisms
Moist, thin, and folded tissues make up respiratory organs.
Terrestrial
Aquatic
All respiratory organs must be ventilated: water or air must move over them.
Simpler animals use their skin or whole body, ventilated by movement and air flow.
Internal Respiratory System
Gills are ventilated when water moves over them.
Use respiratory pigments to help transport oxygen through the blood
Less complex animals have a tracheal system of tubes that distributes oxygen throughout the body without blood.
More complex animals have lungs or other organs similar to lungs that are ventilated by breathing.
Fish have their blood flowing in the opposite direction of the water to make gas exchange more efficient.
These are ventilated by movement.
Birds and amphibians push air into their lungs.
Mammals pull air into their lungs.

- Therefore, reflex stimulation of respiration can be caused by ↑^{ed} PCO_2 and an ↑ in acidity of the blood, or a substantial ↓ PO_2.
- Paired carotid body is located near their perspective carotid artery.
- Fibres of the carotid sinus nerve originate among the epitheloid receptor cells of the paired carotid bodies.

Hypoxia: If the partial pressure of O_2 is below normal the animal is in the state of hypoxia.

Classification of Hypoxia:

- **Ambient-**It is characterized by environmental air low in PO_2
- **Anemic-** It results when O_2 carrying capacity of the blood ↓^{ed} because of a shortage of functioning Hb.
- **Stagnant-**It is caused by a general or local failure of the circulation. (short & narrower capillaries).

- ❖ **Histotonic -** It follows if the tissues are unable to utilize O_2 in the physiological oxidations.

Adaptation of respiration during muscle exercise:

- ✓ Exercise involves probably every process of ventilation
- ✓ Receptors in the joints & tendons of the leg, when stimulated reflex, excite ventilation, but they are weak
- ✓ The placement of chemoreceptor in arterial blood stream is adequate
- ✓ The chemoreceptor system provides maximum stability but needs to be oscillatory behavior although of low magnitude
- ✓ Chemoreceptor areas in the brain do not regulate ventilation during very acute formation of lactic acid, but in a residual manner & certainly for hours.