Department of Veterinary Physiology

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B.V.Sc. & A.H.
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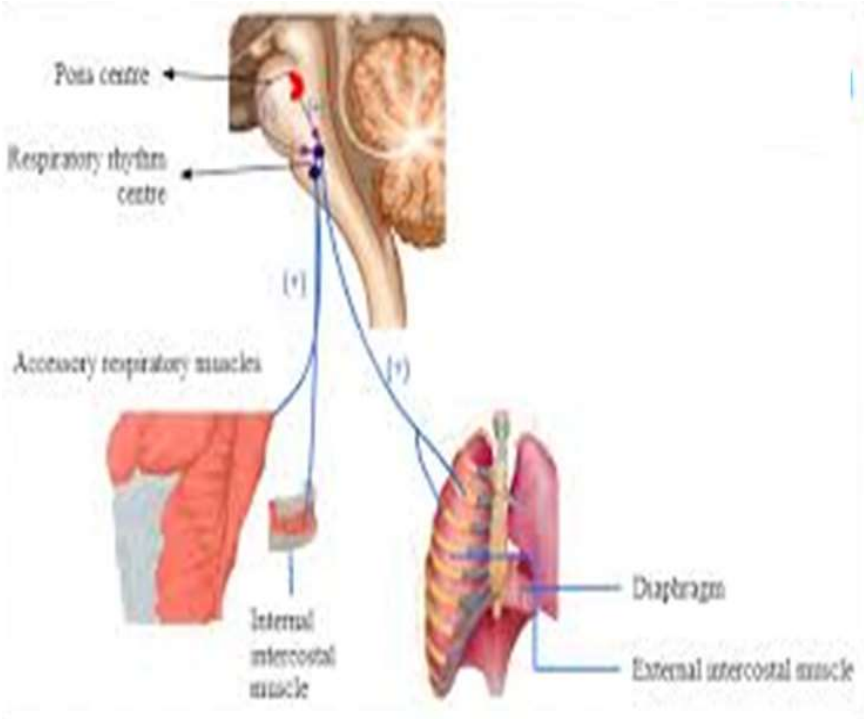
शुधनं नित्यं सर्वलोकोपकारकम्।

Regulation of respiration



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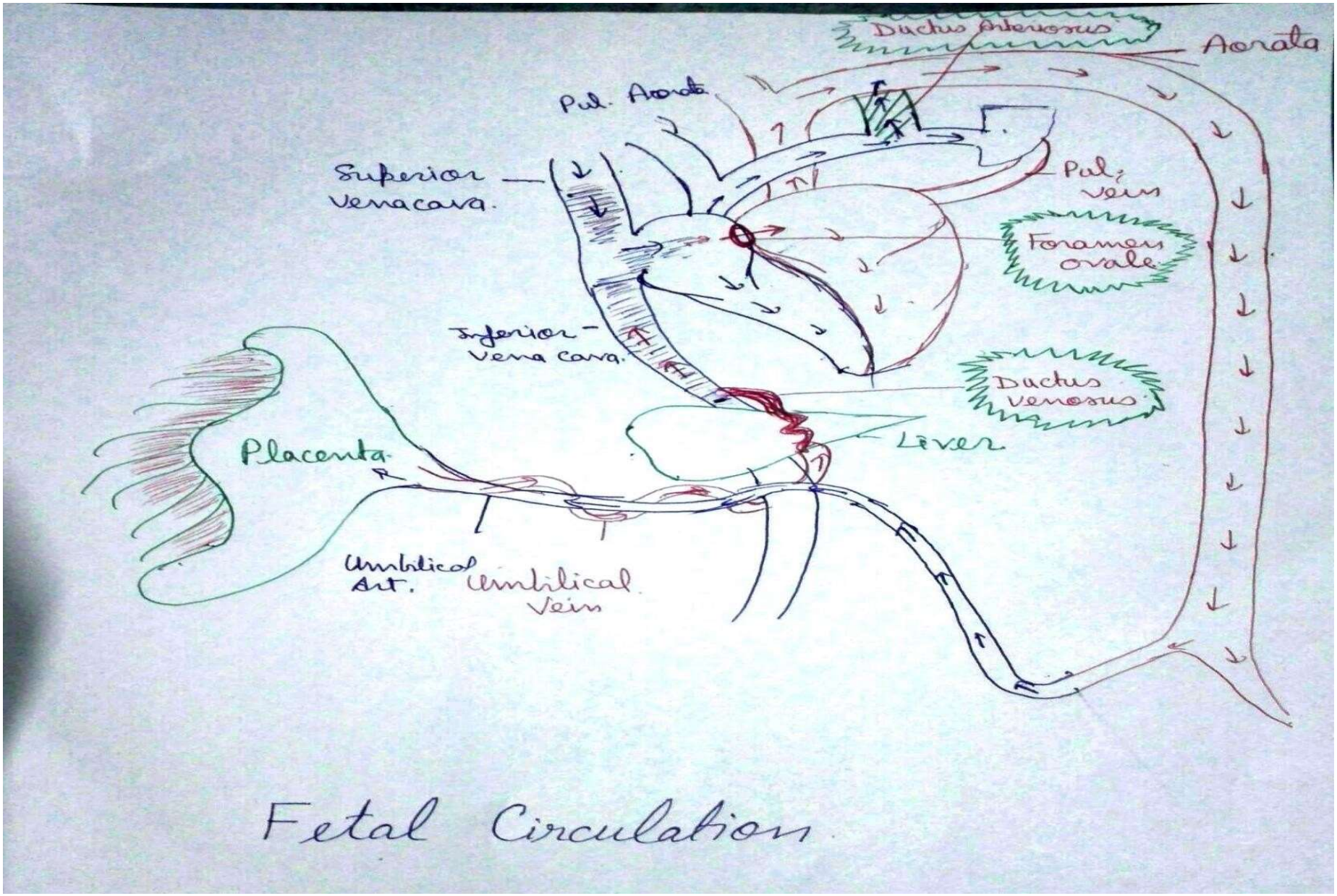
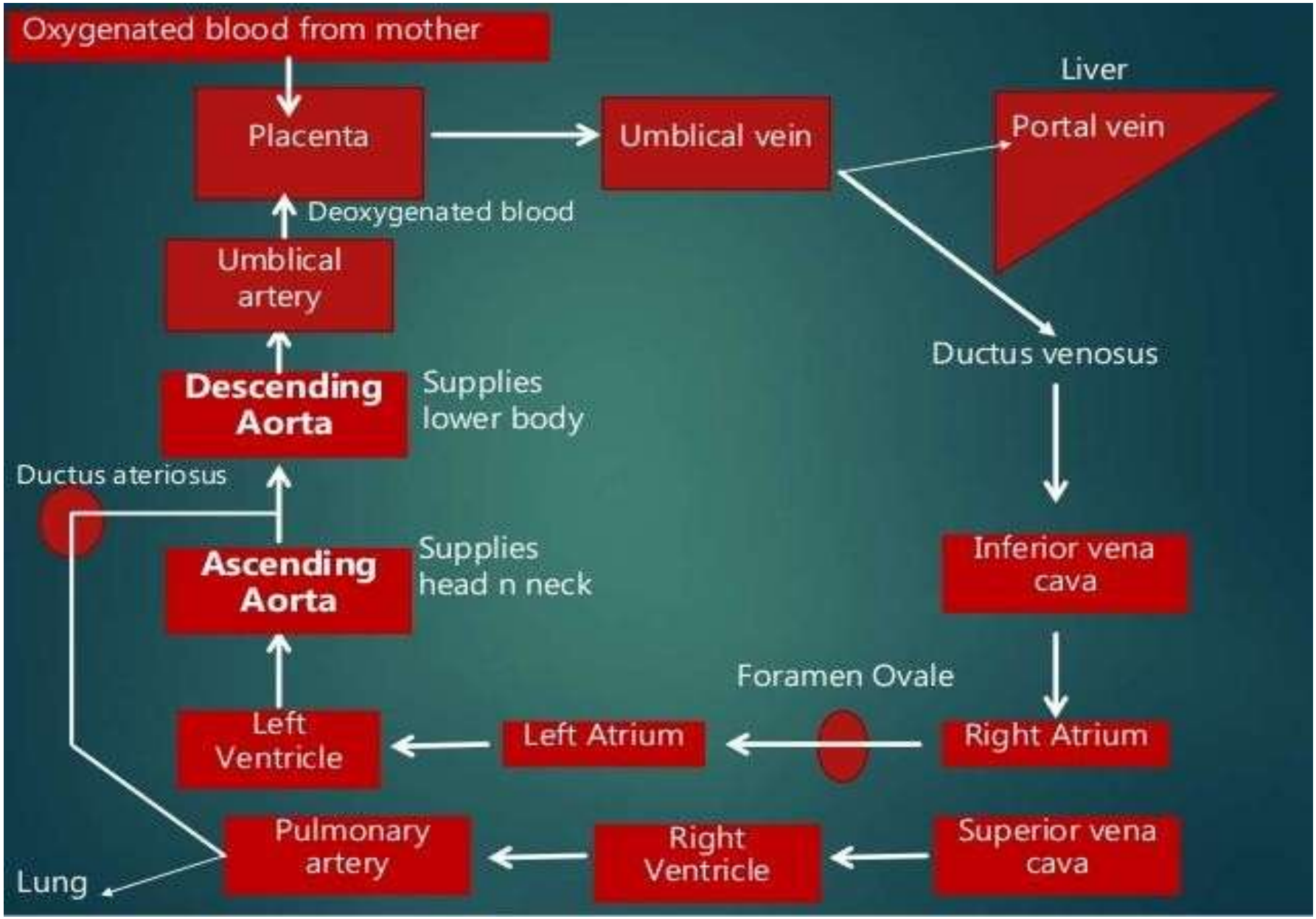
- **Foetal Respiration**
- **Regulation of respiration**
- **Respiratory reflexes**
- **Hypoxia**
- **Artificial Respiration**



Fetal Circulation.


Oxygenated blood from mother
Placenta
Umblical vein
Liver
Portal vein
Deoxygenated blood
Umblical artery
Ductus venosus
Descending Aorta
Supplies lower body
Ductus ateriosus
Ascending Aorta
Supplies head n neck
Inferior vena cava
Foramen Ovale
Left Ventricle
Left Atrium
Right Atrium
Pulmonary artery
Right Ventricle
Superior vena cava
Lung

Closing of Shunts

Shunt	Functional closure	Anatomical closure	Remnant
Ductus arteriosus	10 – 96 hrs after birth	2 – 3 wks after birth	Ligamentum arteriosum
Formamen ovale	Within several mins after birth	One year after birth	Fossa ovalis
Ductus venosus	Within several mins after birth	3 – 7 days after birth	Ligamentum venosum

Umbilical arteries → Umbilical ligaments

Umbilical vein → Ligamentum teres

- Foetal arterial blood has a low PO_2 since placenta is not an efficient gas exchanger and because oxygenated and venous blood mixes at several places in the foetal circulation; however, the foetus adapts to this **chronic hypoxia.**
- The mechanisms by which the fetus adapt to low PO_2 are
- The foetal haemoglobin has a very high affinity for O_2 than adult hemoglobin, oxy-hemoglobin curve is to the left of the adult hemoglobin curve that helps fetal hemoglobin to bind with greater amount of O_2 for a given PO_2 (this property of higher affinity of foetal haemoglobin to O_2 is due to different reasons in different species –
  - **In ruminants it is due to intrinsic property of hemoglobin molecule**
  - **In primates, foetal haemoglobin do not bind with 2-3 BPG, pigs and horse do not have foetal haemoglobin and foetal erythrocytes do not have 2-3 BPG but they hav adult Hb.)**
  - **In some species – foetal lambs, calves, foetus has more haemoglobin concentration**
  - **Cardiac output per unit weight is more in foetus than in adults**

Hence, fetus receives adequate amount of O_2 to support its requirement even with low PO_2

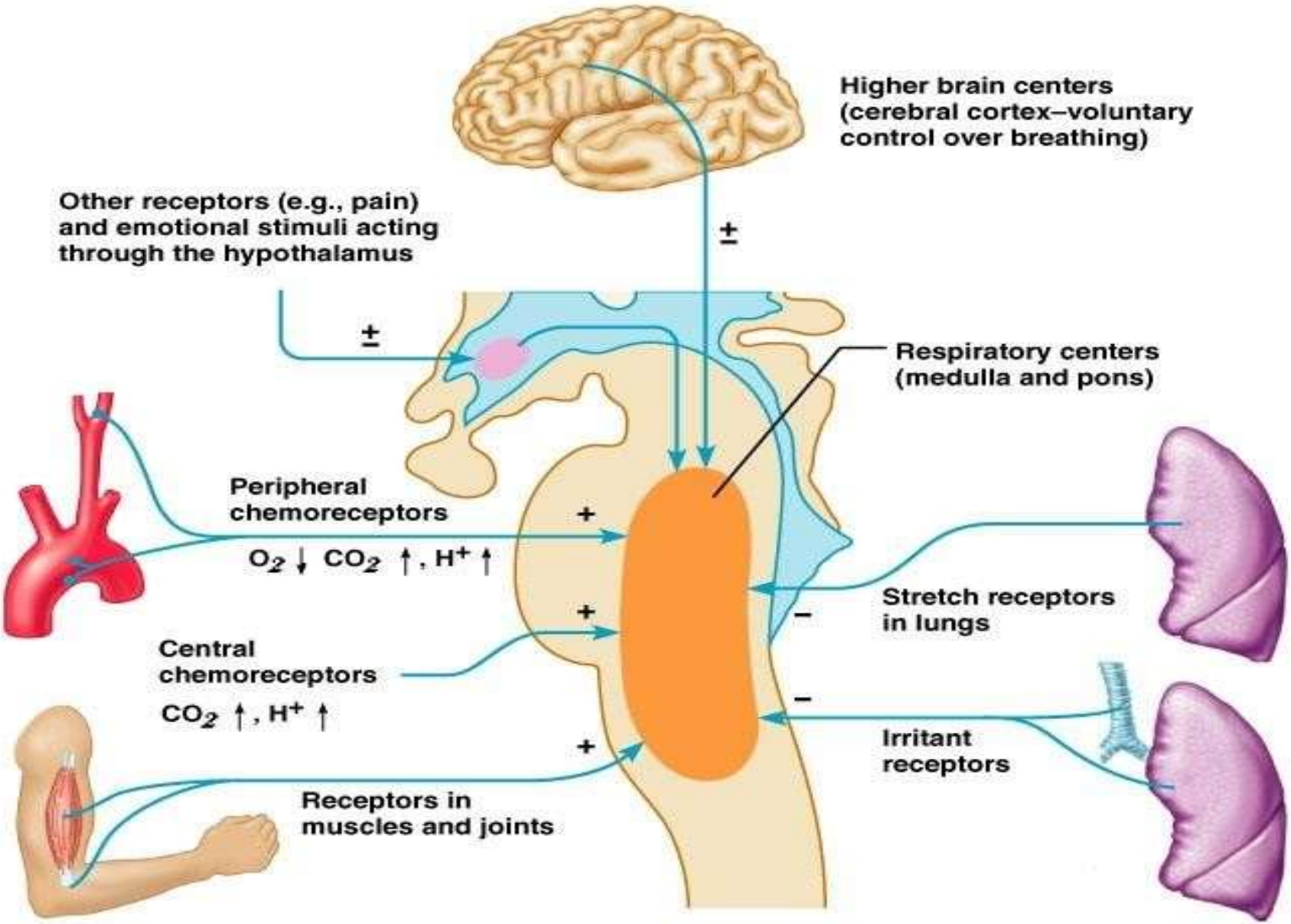
- Pulmonary surfactant is required to keep the lungs inflated after birth. This is secreted from about mid-gestation by **type II alveolar cells** and this secretion indicates stage of lung maturity which is associated with fetal serum cortisol level
- Immediately after delivery, the newborn takes the first breath which is stimulated by
- (1) hypoxia and hypercapnia in fetus due to loss of placental gas exchange
- (2) cooling of the fetus as fetus is delivered from the fluid surrounding
- (3) sensory input to fetus as it is licked by its dam
- Taking the first air into the lungs require a considerable effort as viscous fluid must be driven down the airways before air can enter the alveoli; as alveoli are inflated, the surfactant gets distributed over the alveolar surface and this prevents complete collapse of alveoli

REGULATION OF RESPIRATION

- The act of breathing originates with the rhythmic contraction of inspiratory muscles – the diaphragm which is innervated by
  - **phrenic nerves** originating in spinal nerves C_2, C_3 and C_4
  - **Intercostal muscles** which receive motor supply from Tl through T6
  - **Abdominal muscles** by the last few thoracic and lumbar spinal nerves.
- The cell bodies of the nerves innervating the respiratory muscles are located in the spinal cord
- These spinal motor neurons are directly influenced by neurons in the **medulla oblongata.**
- During forceful breathing, expiratory neurons of medulla stimulate spinal motor neurons that supply expiratory muscles to produce active expiration
- Under resting condition inspiratory activity far exceeds expirat**o**ry since **inspiration is active and expiration is passive**

The Respiratory Centers

- The rhythmic pattern of breathing and adjustments of respiration are regulated by a portion of brainstem known as respiratory centre.
- The respiratory centre is composed of several groups of neurons located bilaterally in the **medulla oblongata** and can be grouped into 4 major collections of neurons.
- A *dorsal respiratory group* **(DRG)** located in the dorsal part of medulla (inspiratory centre).
- A *ventral respiratory group* **(VRG)** located in ventrolateral part of medulla (expiratory centre)
- *Pneumotaxic centre* located in rostral pons.
- Another centre in the lower pons called *apneustic centre* also act as respiratory centre



Dorsal Respiratory Group

- DRG neurons are present in medulla in the nucleus tractus solitarius and the adjacent neurons in the reticular formation.
- This nucleus is also the sensory termination of both vagus and glossopharyngeal nerves which transmit sensory impulses to the respiratory centres from the peripheral chemorecceptors and several types of receptors from lungs.
- The DRG neurons project their fibres through phrenic motor nerves to diaphragm and to other inspiratory muscles.
- They are also connected to VRG neurons.
- **DRG neurons are associated with inspiration and stimulation causes inspiration.**
- The inspiratory neurons have the ability to generate impulses at regular intervals. This rhythmic generation of impulses from inspiratory neurons is in turn influenced by another group of neuronal network in brainstem called ***central pattern generator*** **(CPG)**
- The CPG is the pacemaker for the rhythmic generation of respiratory impulses.

Ventral Respiratory Group

- Located rostral and lateral to the DRG neurons, VRG are important during active breathing.
- The neurons are found in the **nucleus ambiguous and nucleus retro ambiugous.**
- VRG neurons are active both during inspiration and expiration.
- However, they do not participate in the regular rhythm generation.
- The VRG neurons project their fibres through spinal motor neurons to expiratory muscles and accessory inspiratory muscles.
- When there is need for increased pulmonary ventilation, signals pass over to VRG from the rhythm generator of DRG.
- **The VRG neurons contribute both for inspiration and expiration and are more important in providing expiratory force during expiration.**

Pneumotaxic Centre

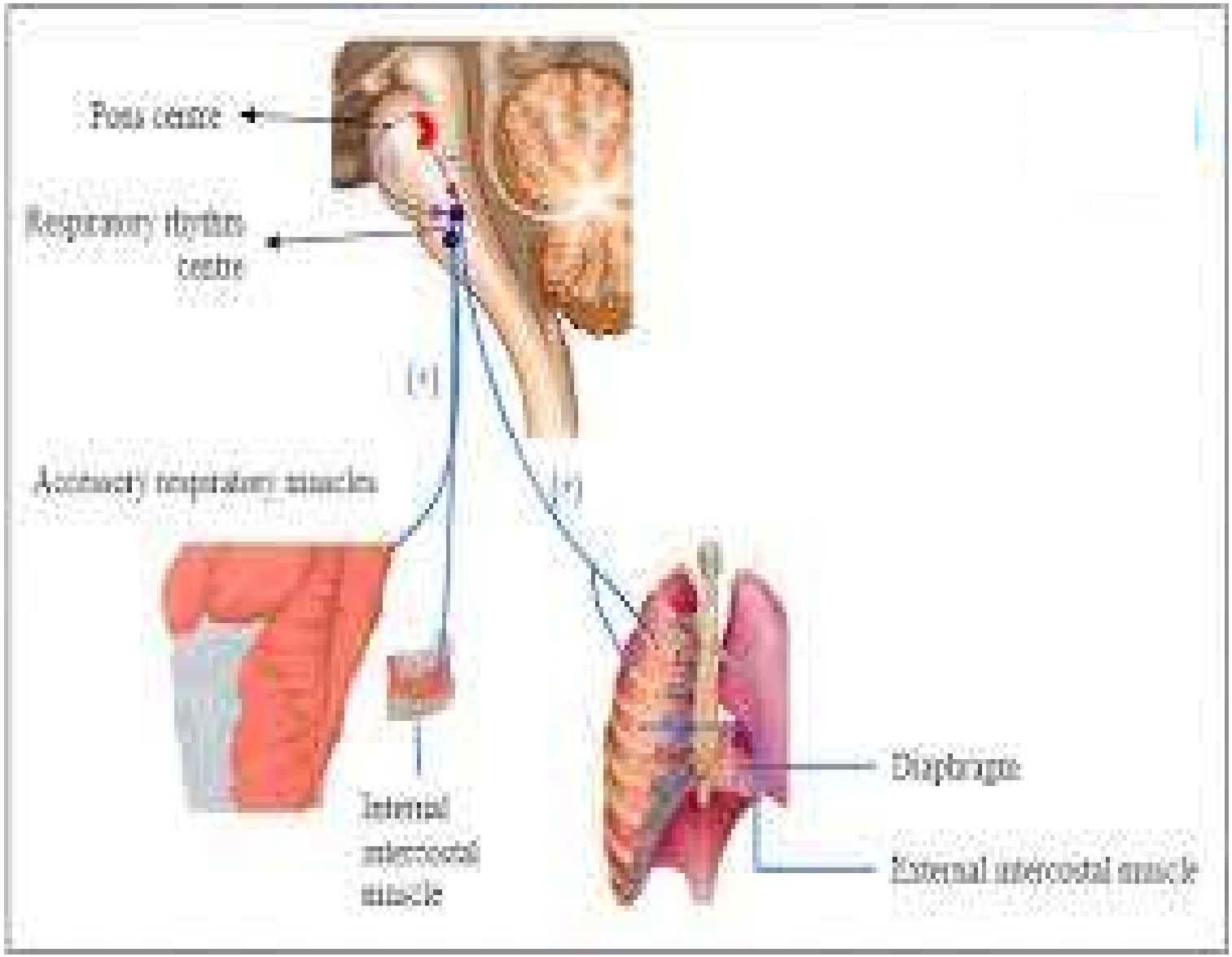
- Located dorsally in the **upper pons**, it transmits impulses continuously to the inspiratory area.
- The effect of this is to control the ***switch-off*** point of the inspiratory activity thus controlling the duration of the inspiratory phase.
- The pneumotaxic centre functions to limit the inspiration.

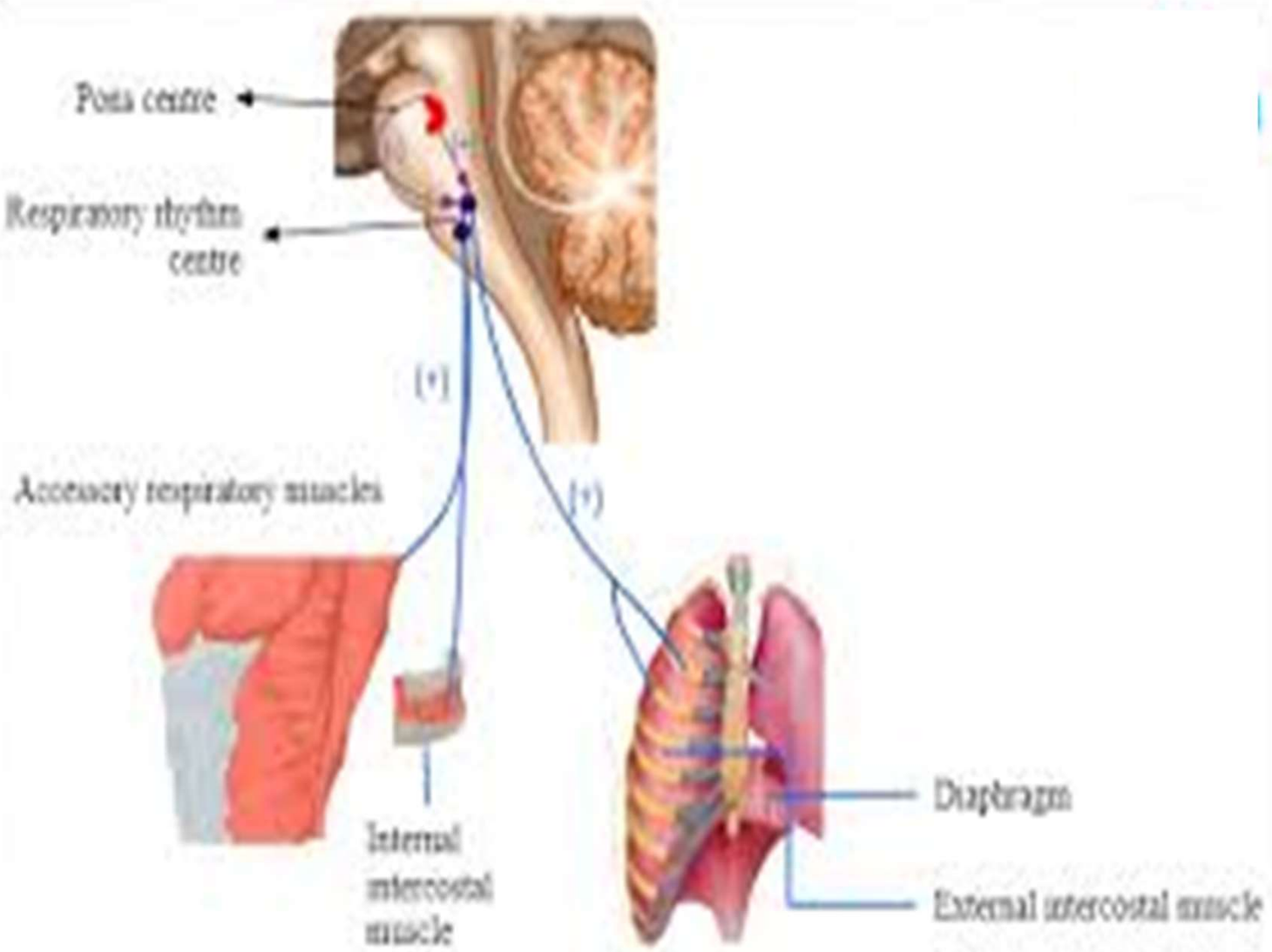
Apneustic Centre

- The apneustic centre of the lower pons send signals to the DRG and prevent switch off of the inspiratory neurons, thus inspiration is prolonged with very short expiratory gasps. This pattern of breathing is called **apneustic pattern.**
- Its function can be demonstrated by sectioning vagi nerves to medulla and transection of pons at the middle region to disconnect pneumotaxic centre. This results in ***apneustic pattern* of respiration.**
- The apneustic centre may provide extra drive to inspiration but the pneumotaxic centre and stretch signals from vagi over-ride the apneustic centre allowing normal respiration.

Respiratory reflexes

- **Neural Control**
- Respiratory activity is altered by **nerve impulses arriving at the respirat**ory centre from other parts of the nervous system. These respiratory reflexes influence the respiratory rhythm.
- ***Hering-Breuer Reflex (***Inflation Reflex*)*
- Lungs contain many slowly adapting receptors that detect stretch. These are located in **bronchi and bronchioles.**
- When lungs become stretched, the stretch receptors transmit impulses through vagus nerve to respiratory centre where they inhibit inspiration and prevent further inflation. The effect is called ***Hering- Breuer inflation reflex*.**
- This reflex prevents over distension of lungs.


Pons centre
Respiratory rhythm centre
(+)
Accessory respiratory muscles
(+)
Internal intercostal muscle
Diaphragm
External intercostal muscle


Pons centre
Respiratory rhythm centre
(+)
Accessory respiratory muscles
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Internal intercostal muscle
Diaphragm
External intercostal muscle

- During inspiration, impulses passing through vagi from lung stretch receptors inhibit the cardioinhibitory area of medulla and heart rate rises during inspiration.
- During expiration, this effect is removed and tonic vagal effect on heart decreases heart rate. This is called **sinus arrhythmia** and it is a normal phenomenon.
- **Deflation Reflex**
- As the stretch receptors become unstretched, it allows inspiration to begin again. In addition, compression receptors transmit impulses that inhibit expiration. Receptors of deflation reflex are located in bronchi and bronchioles and are distinct from the inflation reflex. Afferent nerve of this deflation reflex is vagus.
- This reflex reduces the degree of lung deflation.
- This reflex serves to prevent collapse of alveoli.

- ***Other Pulmonary Receptors***
- In addition to Hering-Breuer receptors, the lungs also contain rapidly adapting stretch or irritant receptors which are the nerve endings of unmyelinated nerves and they are **stimulated by bronchoconstriction, irritation by gases, dusts and histamine.** When stimulated, these receptors produce cough, broncho-constriction and mucus secretion and rapid shallow breathing.
- The lungs also contain **J receptors** which are situated at interstitial space close to the pulmonary capillaries. They may monitor blood composition during inflammation (like pneumonia) of lungs causing hyperpnea.

- **HYPOXIA**
- Inadequate supply of O_2 to tissues is known as ***hypoxia*.**
- Absence of O_2 supply to tissues is ***anoxia*.**
- The effects seen will be mostly cerebral; viz. confusion, excitement, hallucination, restlessness and unconsciousness.
- The anoxia can be classified into the following types.
- ***Anoxic Anoxia* (Ambient Anoxia)**
- In this anoxia the amount of alveolar ventilation is reduced. O_2 tension in blood is reduced. It may be caused due to obstruction of air passage, paralysis of respiratory muscle, pulmonary disease or congenital diseases of heart.
- Symptoms seen are dyspnoea, alkalemia, high cardiac output, increased pulse pressure, dilatation of peripheral vessels.
- Ambient anoxia is similar to anoxic anoxia and is caused by low PO_2 in environmental air; seen in high altitudes or closed space.

- ***Anaemic Anoxia***
- Decrease in O_2 carrying capacity of blood because of shortage of Hb. Partial pressure of O_2 is normal but insufficient amount of O_2 is delivered to tissue.
- Seen in haemorrhages, anaemia, CO poisoning; it causes increased cardiac output and rapid circulation time.
- ***Stagnant Hypoxia***
- It occurs during general or local failure of circulation. O_2 content of arterial blood is normal but tissues fail to receive enough O_2 because of diminished blood supply.
- ***Histotoxic Hypoxia***
- Seen in cyanide poisoning and in this condition, tissue oxidation is interfered. Paralysis of cytochrome oxidase system is responsible for this condition. The amount of O_2 and PO_2 are normal in arterial blood and above normal in venous blood.
- ***Other terms***:
- *Hypercapnea* and *hypocapnea* denote excess and reduced amount of CO_2 in blood respectively.
- *Cyanosis* is bluish or purplish colouration of skin and mucous membrane. It indicates degree of deoxygenation of Hb and relates to improper oxygenation of Hb.
- *Asphyxia*: hypoxia combined with hypercapnea. Breathing in closed areas causes this condition and results in suffocation.

Humoral Control

- The chemicals involved are CO_2, O_2 and H+ ions.
- The concentrations of these chemicals in the blood change the alveolar ventilation.
  - PCO_2 α alveolar ventilation
  - H^+ α alveolar ventilation
  - PO_2 α **1/** pH
  - PO_2 α **1/** alveolar ventilation

- ***Central Chemoreceptors***
- A chemosensitive area in the medulla is in contact with CSF through the brain interstitial fluid which bathes this area. This area is highly sensitive to changes in the H^+ ion concentration and this in turn is excitatory to the respiratory centre causing increase in tidal volume and frequency.
- ***Peripheral Chemoreceptors***
- Peripheral chemoreceptors are situated in the **carotid and aortic bodies.**
- The carotid bodies are located at the bifurcation of the internal and external carotid arteries and the aortic arch. They receive high amount of blood.

- **Hypoxia induced vasoconstriction of pulmonary blood vessels**
- At altitudes above 2,100 m, generalized pulmonary vasoconstriction is produced which raises the pulmonary arterial blood pressure (**pulmonary hypertension**) and work load of right ventricle is increased. If right heart fails, there is increase in systemic venous pressure and oedema develops.
- Cattle raised in high altitude develop ***brisket disease*** **(mountain sickness)** due to accumulation of oedematous fluid in brisket.
- In chicken oedematous fluid accumulates in the peritoneal cavity leading to formation of ***hypoxic ascites*****.**

ARTIFICIAL RESPIRATION

- **Artificial respiration** is a technique for providing air for an animal that is not breathing on its own but whose heart is still beating.
  - Artificial respiration is resorted to in cases of
  - cessation of respiration while under general anaesthesia;
  - drowning where the animal has been rescued from water –mainly applicable for small animals
  - poisoning by narcotics or paralytic substances
  - asphyxia from fumes, smoke, gases etc

Thank
You!!!