REGULATION OF RESPIRATION

9- CHEMICAL REGULATION OF RESPIRATION

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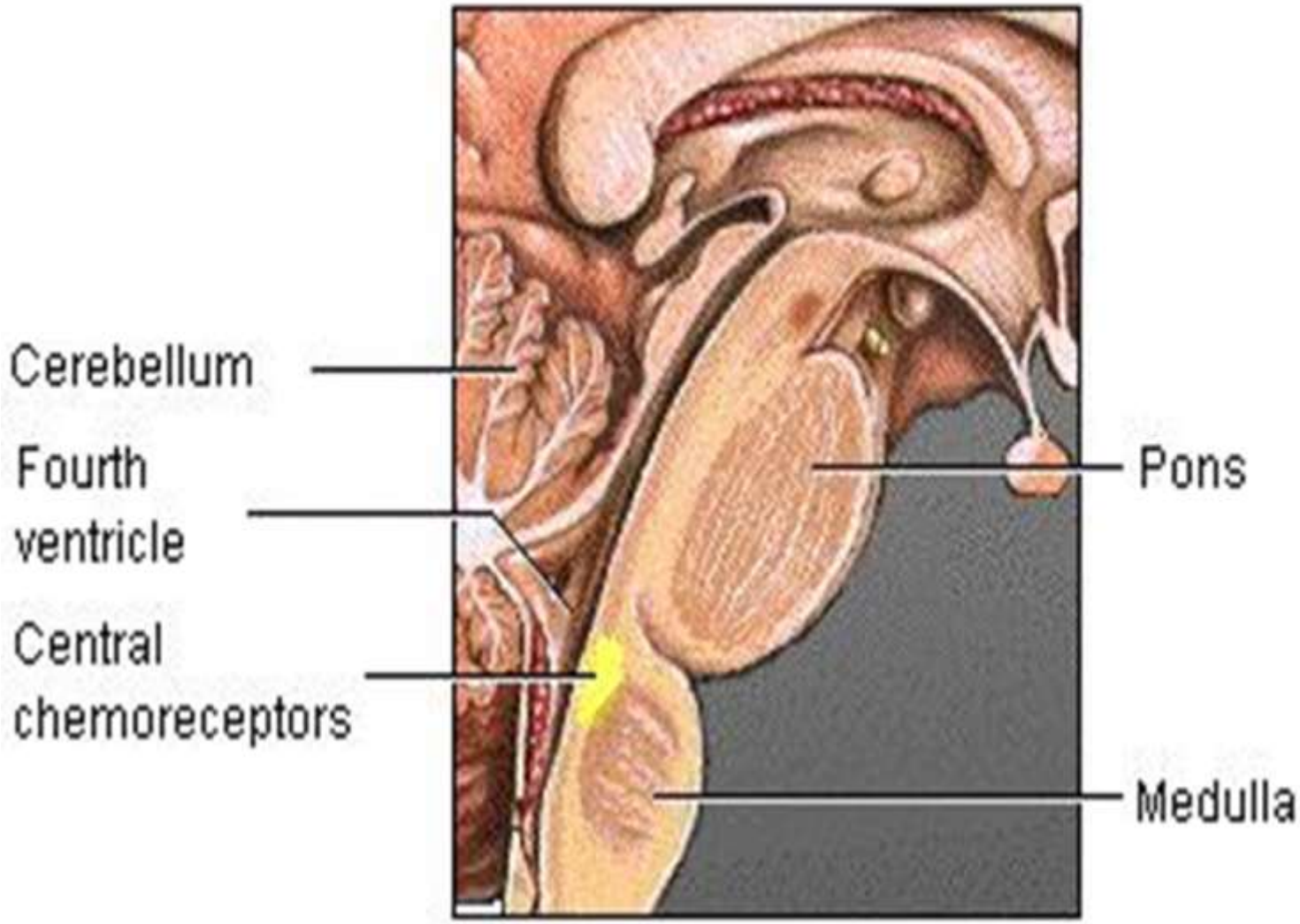
[B] Chemical regulation of respiration

-Respiration is stimulated by: ↑ Co2 tension , ↓ O2 tension and ↑ H+ ion concentration in the arterial blood.

- These changes are associated with increase the metabolic activity.

-This effect occurs via the peripheral and central chemo-receptors.

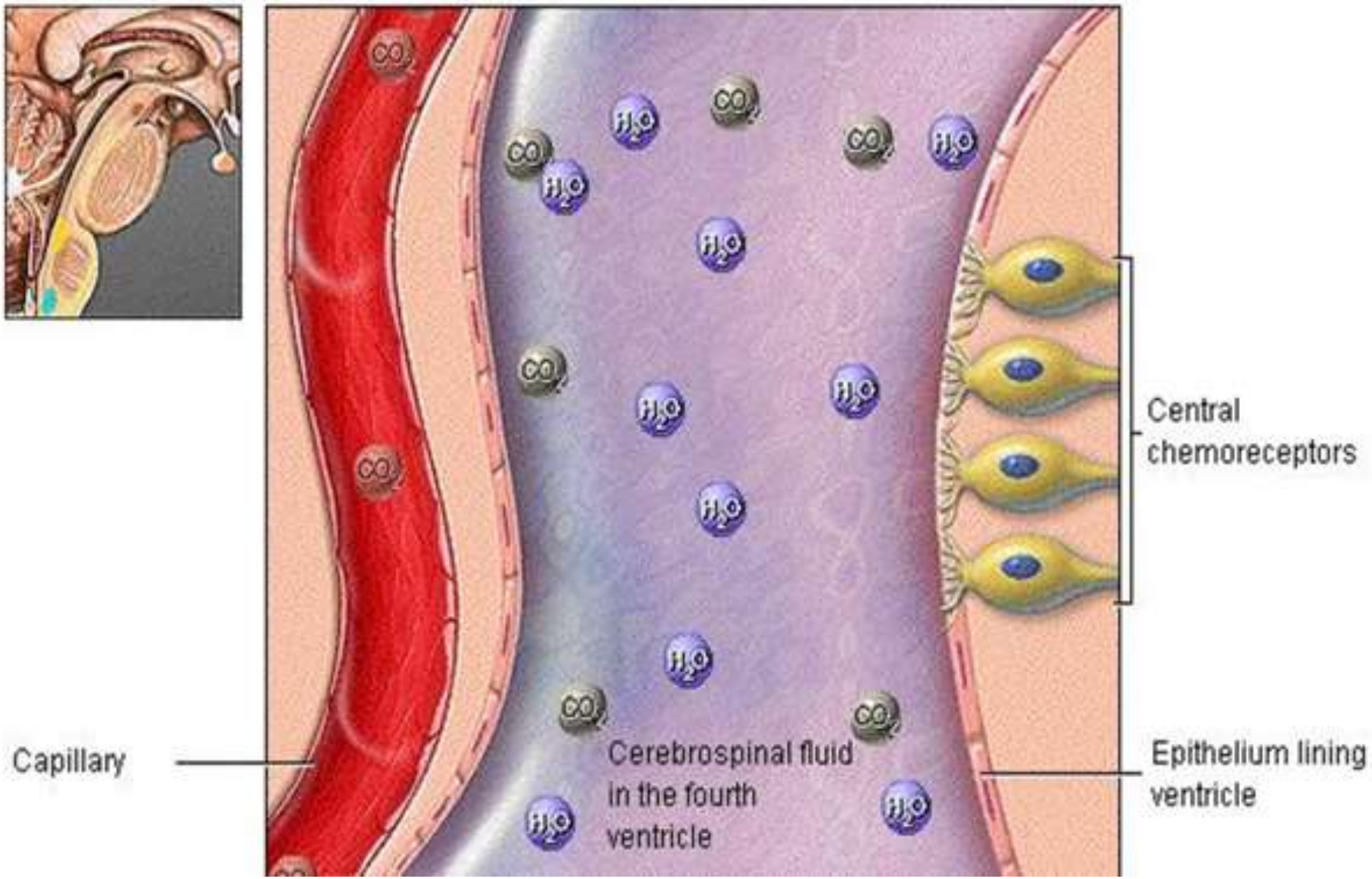
The central chemoreceptors in the medulla monitor the pH associated with CO_2 levels in the **CSF** in the fourth ventricle. The chemoreceptors synapse directly with the respiratory centers



Types of chemoreceptors

	Central chemoreceptors
Site	- Bilaterally in medulla - Near to respiratory center. **But**, separate from it.
Afferent	- Direct contact with (CSF) **But**, separated from the blood by the blood brain barrier (BBB).
Stimulus	- These receptors are **ONLY** stimulated by ⇧ PCO_2 in **arterial** blood. - CO_2 penetrate the BBB because CO_2 is lipid soluble. - **In CSF**: By carbonic anhydrase enzyme: - $CO_2 + H_2O \rightleftharpoons H_2CO_3$ $H_2CO_3 \rightleftharpoons H^+ + HCO_3$. H^+ in CSF stimulates the chemoreceptors which in turn stimulate the respiratory center. H^+ is not buffered by CSF as it has **low** protein content. ⇧ H^+ in arterial blood not stimulate these receptors as H^+ not penetrate the blood brain barrier.

Central Chemoreceptors: Effect of P_{CO_2}



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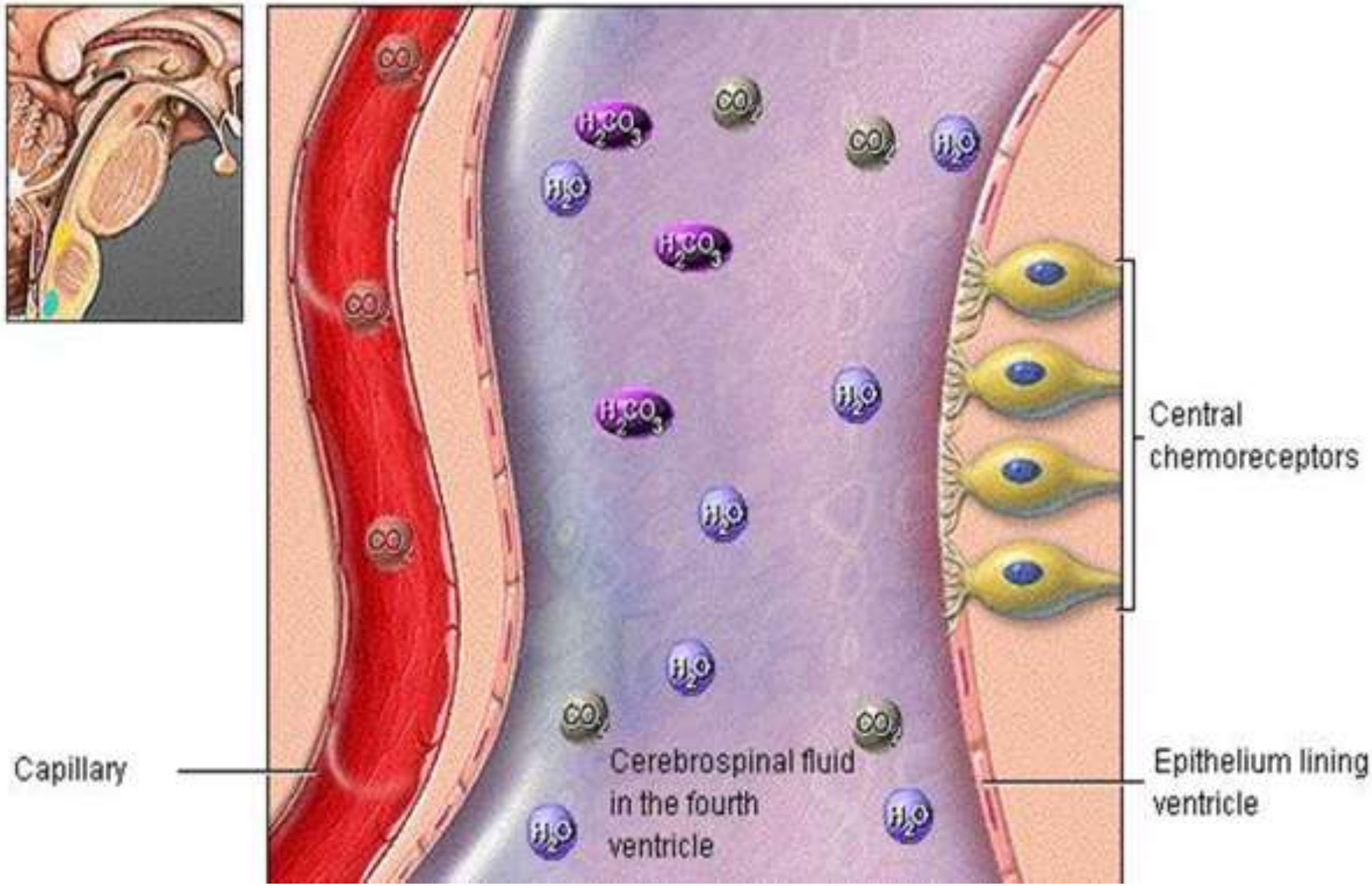
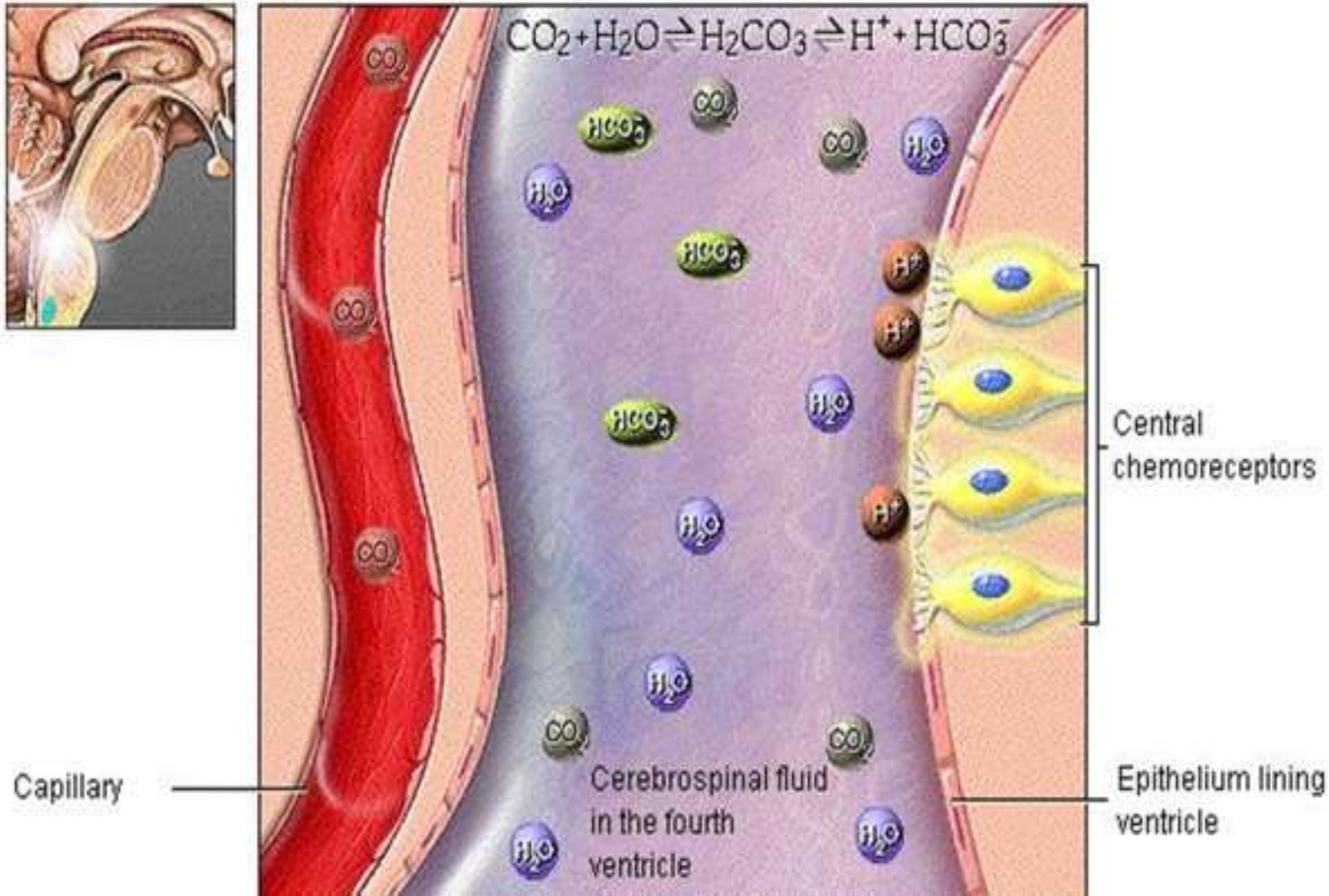
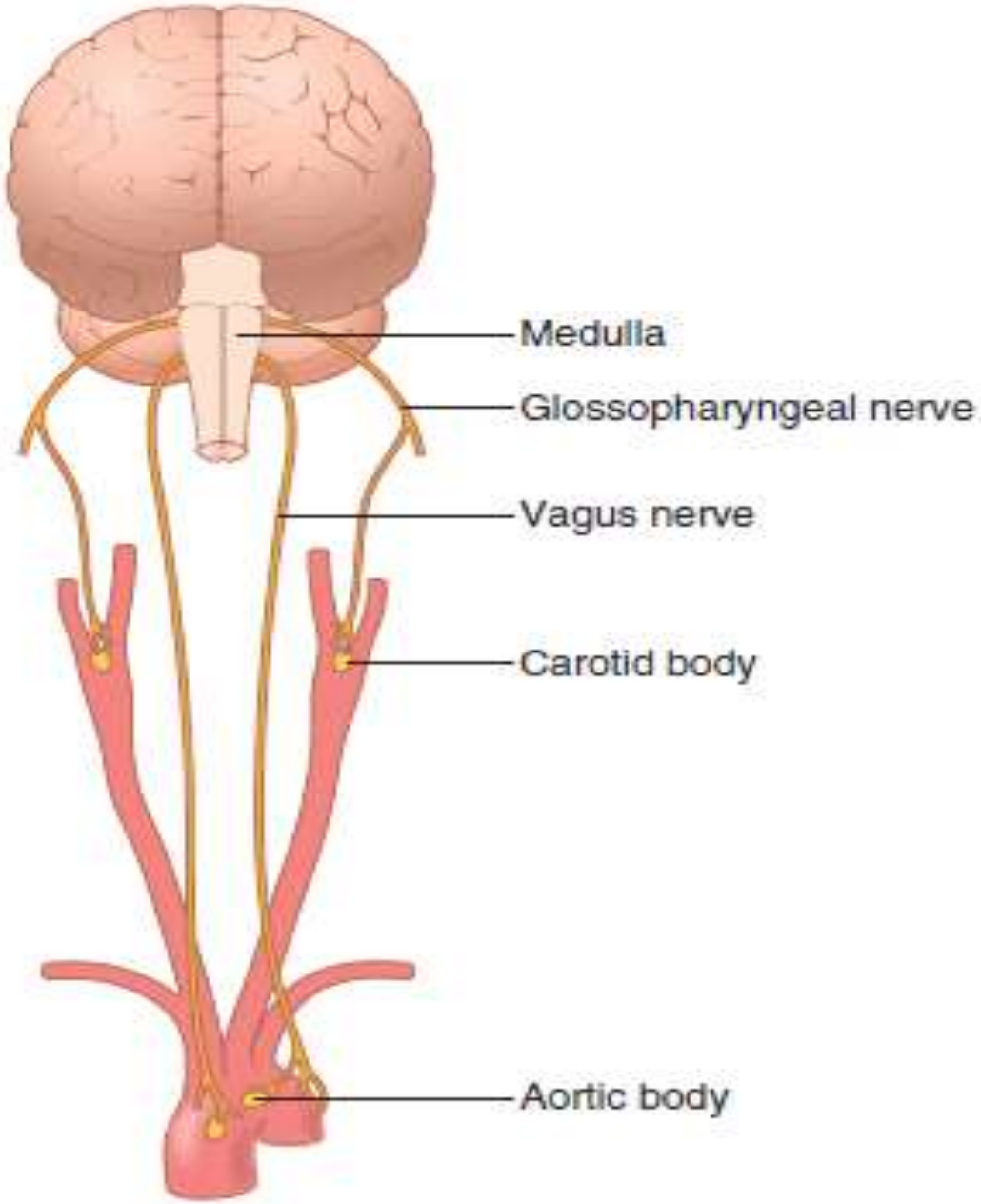


Central Chemoreceptors: Effect of P_{CO_2}

The hydrogen ions stimulate the central chemoreceptors, which send nerve impulses to the respiratory centers in the medulla.



Peripheral Chemoreceptors In Aortic & Carotid Bodies



Types of chemoreceptors

	Peripheral chemoreceptors
Site	1) Aortic body: in the aortic arch. 2) Carotid body: at bifurcation of common carotid artery.
Afferent	1) Aortic body via: Vagus nerve. (X) 2) Carotid body via: glossopharyngeal(IX) BOTH are called: the **buffer nerves**.
Stimulus	1. **Hypoxia** (⇩ O_2 tension to 60mmHg) the **main** stimulus. So, they are called **O_2 lack receptors**. 2. **Hypercapnia** (⇧ CO_2 tension) with less effect (30% of effect). 3. **Acidosis** (⇧ H^+ concentration). 4. **⇧ K^+ & ⇧ Nicotine**. These conditions occur by: **H**ypotension & **H**yperactive tissue **H**emorrhage & at **H**igh altitude. - The blood flow to these receptors is **very high** = 2000ml/100 gm tissue. - So, these receptors depend only on the dissolved O_2 and stimulated by very low PO_2. - **Not** stimulated by ⇩Oxyhemoglobin content as in anemia or CO poisoning. - **Histotoxic hypoxia** (⇩ O_2 utilization of tissue) is more powerful stimulant.

Ventilatory response to O2 lack

O2 lack is **a weaker stimulus** for the respiration than the *Co2 excess*, and **act only via** the **peripheral chemo-receptors .**

Respiration is markedly stimulated when the **PO2 in arterial blood** drops **below 60 mmHg** (normally about 95 mmHg).

This weak stimulatory effect **(2-4 folds only)** is **due to**:

1- Decrease O2 ⇨ more reduced hemoglobin, which is weak acid and buffer H+ leading to inhibition of respiration.

2- Decrease O2 ⇨ slight stimulation of respiration ⇨ wash of Co2 and H+ ⇨ decrease Co2 ⇨ strong inhibitory effect on respiration which oppose the stimulatory effect of decrease O2 leading to inhibition of respiration.

But **the O2 lack effect increased in cases of:**

Overdose of Anesthesia as it depresses the **central chemoreceptors** with no response to Co2 and respiration in these cases is maintained only by **O2 lack** ,So, 100% O2 during anesthesia ⇨ inhibit respiration and may be fatal.(Carbogen: Mixture of 5% CO2 + O2 is used to stimulate respiration)

⇧ PCO2 is **more** stimulants for respiration than O2 lack.

⇧ PCO2 acts on **both** central chemo-receptors (70%) & peripheral chemo-receptors (30%).

Effect of CO2 excess: The CO2 excess effect is augmented by the O2 decrease effect

Ventilatory response to CO2 excess

CO_2 excess	Effect
⇧ CO_2 in inspired air to **5%** ⇨ ⇧ PCO_2 in arterial blood.	**2 folds** increase in respiration To get rid of this excess CO_2.
⇧ CO_2 in inspired air to **10%** ⇨ ⇧ PCO_2 in arterial blood to 50mmHg	**10 folds** increase in respiration To get rid of this excess CO_2.
⇧ CO_2 in inspired air to **>10%**	**CO_2 narcosis:** Inhibition of respiratory center ⇨ more accumulation of CO_2 (hypercapnea) & headache & coma & death from CO_2 narcosis.

Ventilatory response to H+

Increased **H^+ concentration** in blood (acidosis) stimulates the respiratory center through stimulation of **peripheral chemo-receptors.**

Therefore, in diabetes mellitus with ketoacidosis → This led to hyperventilation (rapid and deep or **kussmaul`s breathing).**

On the other hand, an increase in **blood PH** or **alkalosis** inhibits the respiratory center e.g. after along period of hyperventilation.


Thank
You