

The Respiratory system-II

Regulation of respiration

Breathing is controlled by the central neuronal network to meet the metabolic demands of the body

- Neural regulation
- Chemical regulation

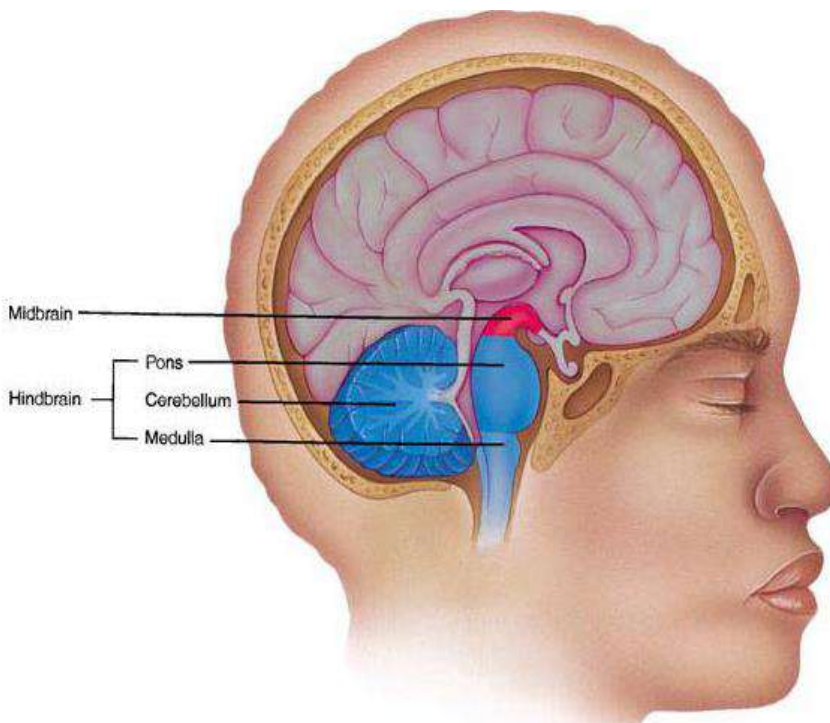
Respiratory center Definition:

A collection of functionally similar neurons that help to regulate the respiratory movement

- Medulla Basic respiratory center; Pons: produce and control the respiratory rhythm
- Higher respiratory center: cerebral cortex, hypothalamus & limbic system
- Spinal cord: motor neurons

Neural regulation of respiration

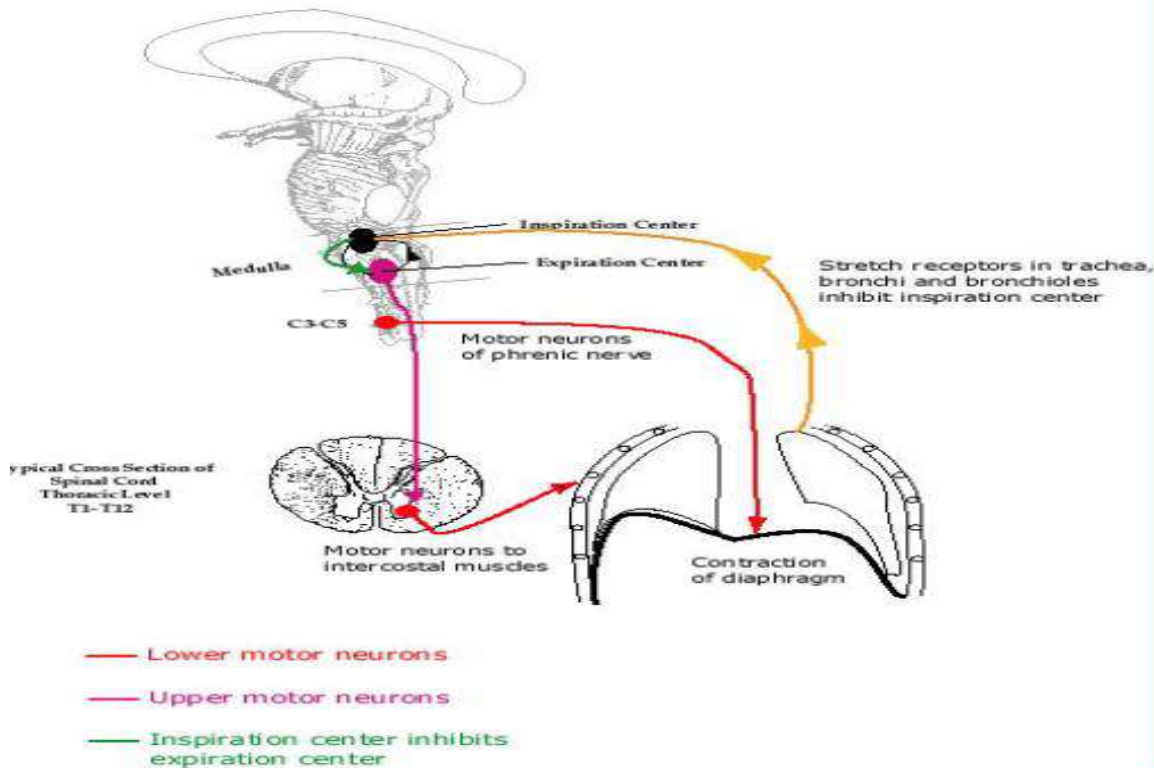
- Voluntary breathing center
 - Cerebral cortex
- Automatic (involuntary) breathing center
 - Medulla
 - Pons



Neural generation of rhythmical breathing

The discharge of medullary inspiratory neurons provides rhythmic input to the motor neurons innervating the inspiratory muscles. Then the action potential ceases, the inspiratory muscles relax, and expiration occurs as the elastic lungs recoil.

THE MEDULLA'S CONTROL OF THE RESPIRATORY CYCLE



Respiratory center

- Dorsal respiratory group (medulla) – mainly causes inspiration
- Ventral respiratory group (medulla) – causes either expiration or inspiration
- Pneumotaxic center (upper pons) – inhibits apneustic center & inhibits inspiration, helps control the rate and pattern of breathing
- Apneustic center (lower pons) – to promote inspiration

Pulmonary stretch reflex

The reflex is originated in the lungs and mediated by the fibers of the vagus nerve:

- Pulmonary inflation reflex: inflation of the lungs, eliciting expiration.
- Pulmonary deflation reflex: deflation, stimulating inspiration.

Pulmonary inflation reflex

Inflation of the lungs → +pulmonary stretch receptor → +vagus nerve → - medullary inspiratory neurons → +eliciting expiration

Chemical control of respiration

Chemoreceptors

– Central chemoreceptors: medulla Stimulated by $[H^+] \uparrow$ in the CSF

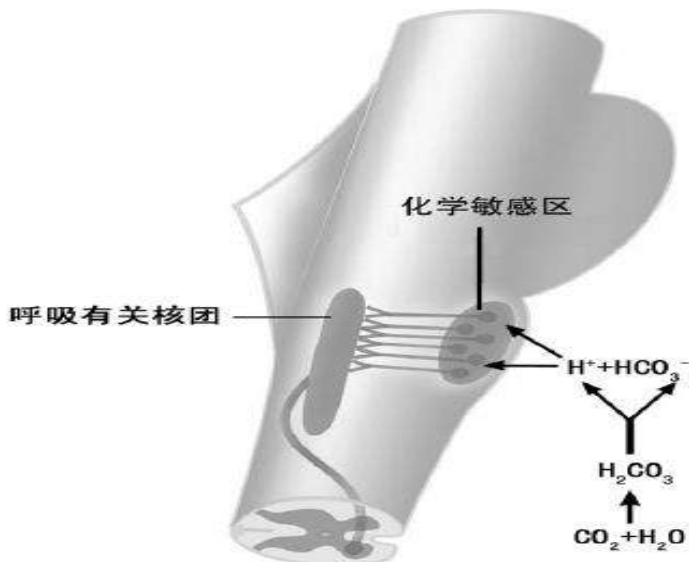
Peripheral chemoreceptors

Carotid body

– Stimulated by arterial $PO_2 \downarrow$ or $[H^+] \uparrow$

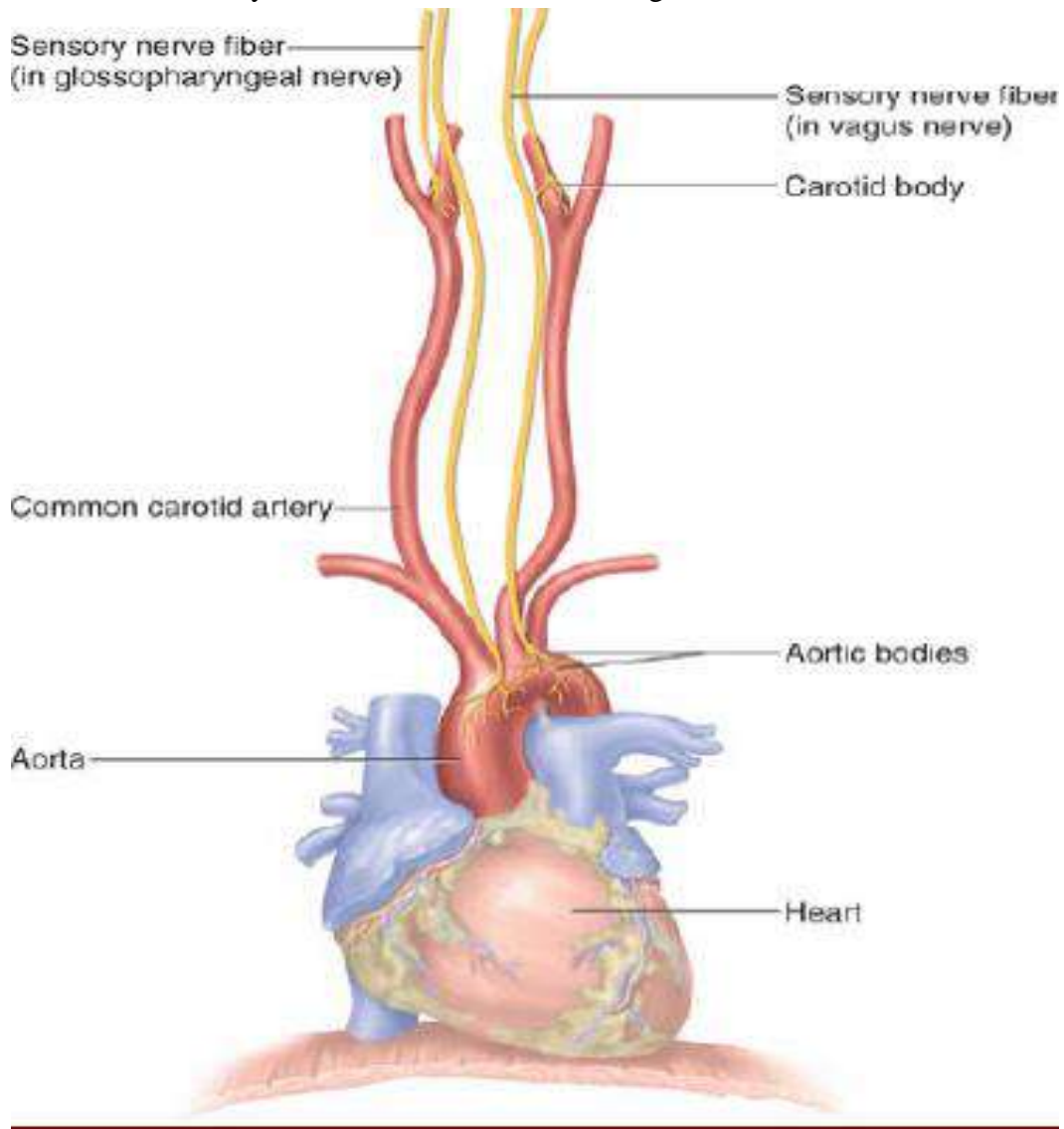
Aortic body

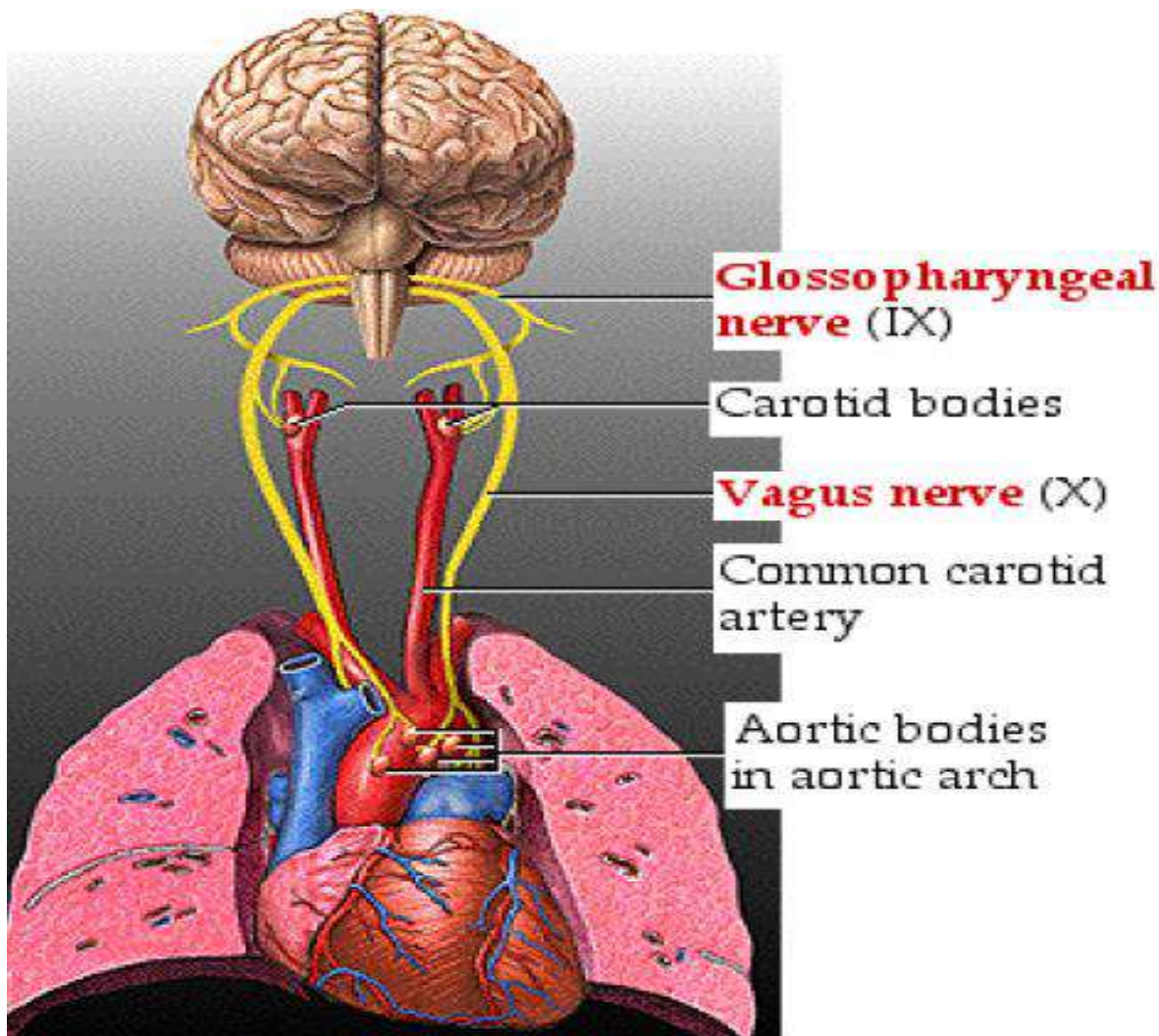
Central chemoreceptors



Peripheral chemoreceptors

Chemosensory neurons that respond to changes in blood pH and gas content are located in the aorta and in the carotid sinuses; these sensory afferent neurons alter CNS regulation of the rate of ventilation.





Major Stimuli for the Central and Peripheral Chemoreceptors

Peripheral chemoreceptors—that is, carotid bodies and aortic bodies—respond to changes in the *arterial blood*. They are stimulated by:

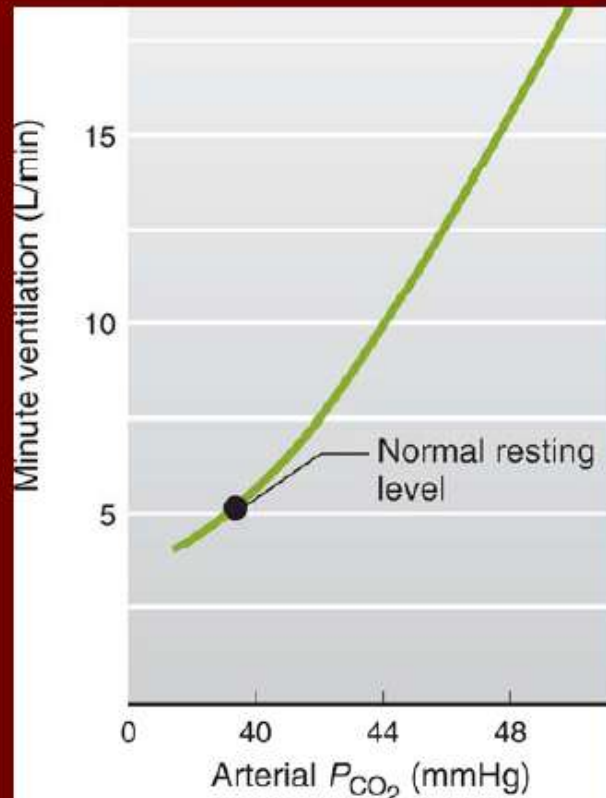
1. Decreased P_{O_2} (hypoxia)
2. Increased hydrogen ion concentration (metabolic acidosis)
3. Increased P_{CO_2} (respiratory acidosis)

Central chemoreceptors—that is, located in the medulla oblongata—respond to changes in the *brain extracellular fluid*. They are stimulated by increased P_{CO_2} via associated changes in hydrogen ion concentration. (See Equation 13–11.)

Effect of carbon dioxide on pulmonary ventilation

Small changes in the carbon dioxide content of the blood quickly trigger changes in ventilation rate.

$\text{CO}_2 \uparrow \rightarrow \uparrow$ respiratory activity

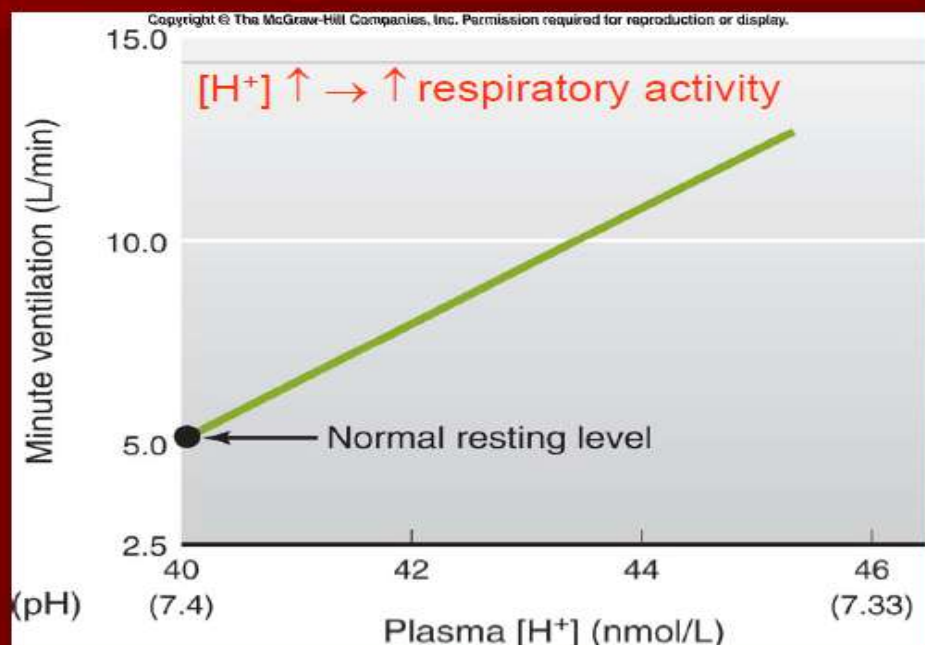


Central and peripheral chemosensory neurons that respond to increased carbon dioxide levels in the blood are also stimulated by the acidity from carbonic acid, so they “inform” the ventilation control center in the medulla to increase the rate of ventilation.



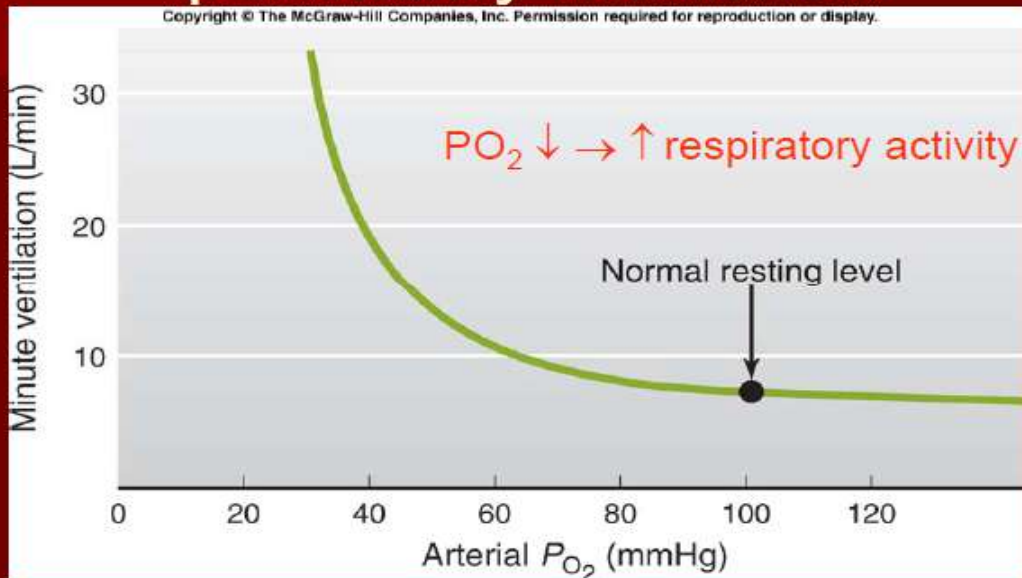
Effect of hydrogen ion on pulmonary ventilation

Regardless of the source, increases in the acidity of the blood cause hyperventilation.



Regardless of the source, increases in the acidity of the blood cause hyperventilation, even if carbon dioxide levels are driven to abnormally low levels.

Effect of low arterial P_{O_2} on pulmonary ventilation



A severe reduction in the arterial concentration of oxygen in the blood can stimulate hyperventilation.

Chemosensory neurons that respond to decreased oxygen levels in the blood “inform” the ventilation control center in the medulla to increase the rate of ventilation.

