

NOTES

BREATHING REGULATION

BREATHING CONTROL

osms.it/breathing-control

WHAT IS BREATHING CONTROL?

- **Breathing (ventilation):** movement of gasses in, out of lungs
- Regulation maintains arterial partial pressures of O_2 , CO_2 (PaO_2 , $PaCO_2$)
- **Components:** brainstem respiratory centers; peripheral, central chemoreceptors; mechanoreceptors in lungs, muscles of respiration, joints

BRAINSTEM RESPIRATORY CENTERS

Dorsal respiratory group (DRG)

- Inspiratory center, located in dorsal medulla
- Sets basic rhythm of breathing
- Receives sensory input via cranial nerves (CN) IX, X from peripheral chemoreceptors, mechanoreceptors in lungs → sends motor output via phrenic nerve to stimulate contraction of diaphragm
 - DRG neurons generate repeating bursts of action potentials → period of quiescence
 - Bursts occur → action potential frequency “ramps up” → ↑ lung volume

Ventral respiratory group (VRG)

- Expiratory center, located in ventral medulla
- Inactive during basic, quiet breathing
- Provides high respiratory drive when ventilation needs to increase (e.g. exercise)

Pneumotaxic center

- Located in upper pons
- Limits inspiration by inhibiting DRG
- Limits tidal volume, increases respiratory rate

- Receives input from cerebral cortex

Apneustic center

- Located in lower pons
- Prolongs DRG inspiratory signal, diaphragm contraction → inspiratory gasps (apneusis)
- Associated with damage to pons/upper medulla

VOLUNTARY CONTROL

Cerebral cortex

- Sends commands to voluntarily override autonomic control of ventilation
- Hyperventilation
 - Voluntarily breathing at rate > that needed by metabolism
 - **Self-limiting:** hyperventilation → ↓ $PaCO_2$ (strongly inhibits autonomic respiratory centers, ventilation)
- Hypoventilation
 - Voluntarily breathing at rate insufficient for metabolism
 - **Self-limiting:** hypoventilation → ↓ PaO_2 , ↑ $PaCO_2$

HYPOTHALAMIC CONTROL

- **Strong emotions, pain:** act via hypothalamus, limbic system → signal respiratory centers → modify respiratory rate, depth
- Rise in body temperature → ↑ respiratory rate
- Drop in body temperature → ↓ respiratory rate

PULMONARY CHEMORECEPTORS & MECHANORECEPTORS

osms.it/pulmonary-central-peripheral-chemoreceptors

CENTRAL CHEMORECEPTORS

- Located in ventral surface of **medulla**
- Sensitive to changes in H^+ indirectly by sensing acute changes in $PaCO_2$ (unable to cross blood-brain barrier)
 - $\uparrow PaCO_2 \rightarrow$ conversion to carbonic acid (H_2CO_3) by enzyme carbonic anhydrase \rightarrow dissociation into H^+ , $HCO_3^- \rightarrow \downarrow$ CSF pH (\uparrow CSF $[H^+]$) \rightarrow stimulates central chemoreceptors \rightarrow stimulates DRG $\rightarrow \uparrow$ ventilation $\rightarrow \downarrow PaCO_2$ (40mmHg)
- Crucial minute-to-minute control
 - Match ventilation with metabolism by monitoring $PaCO_2$

PERIPHERAL CHEMORECEPTORS

- Located in **carotid bodies** at bifurcation (near aortic arch)
- Responds directly to changes in PaO_2 , $PaCO_2$
 - Strongly stimulated in linear fashion when $PaO_2 < 60$ mmHg
 - Weakly stimulated by $\uparrow PaCO_2$
 - Carotid bodies only: stimulated by \uparrow arterial $[H^+]$
- Afferents send information to DRG via **CN IX, X** \rightarrow directs ventilatory response to hypoxemia, acidemia, alkalemia

MECHANORECEPTORS

Lung stretch receptors

- Located in airway smooth muscle
- Respond to lung inflation \rightarrow termination of inspiration (Hering-Breuer inspiratory-inhibitory reflex)

Joint and muscle receptors

- Respond to bodily movement $\rightarrow \uparrow$ respiratory rate

Irritant receptors

- Respond to noxious gasses; particulates via **CN X** \rightarrow coughing, bronchoconstriction

Juxtacapillary (J) receptors

- Located in alveoli, near capillaries
- Respond to capillary engorgement $\rightarrow \uparrow$ respiratory rate

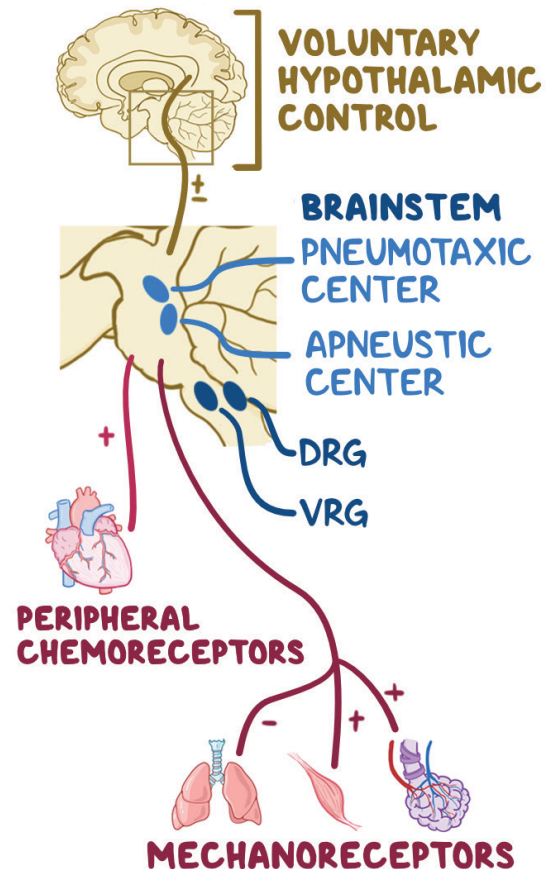


Figure 69.1 The brainstem is the respiratory center of the body. Many receptors throughout the body send signals to the brainstem so that it can regulate the breathing rate accordingly.