

# NOTES

## BREATHING REGULATION

# BREATHING CONTROL

[osms.it/breathing-control](https://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

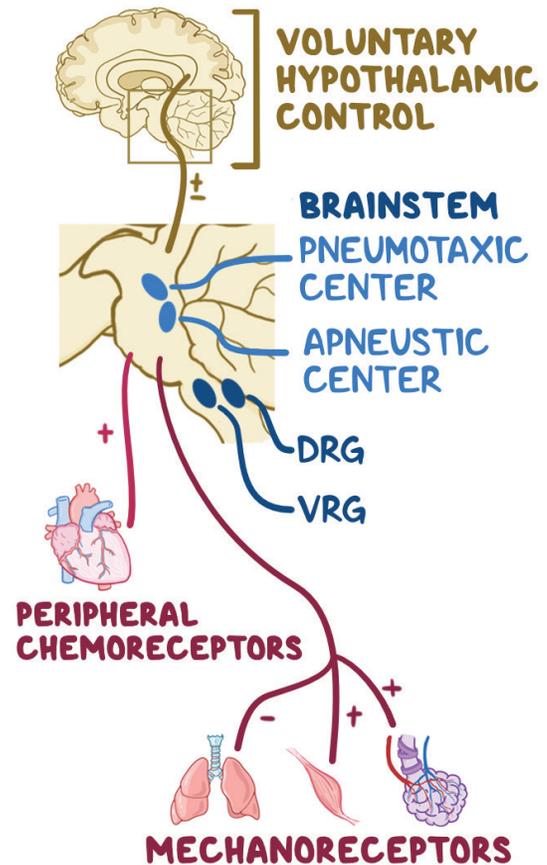
- Respond to bodily movement  $\rightarrow \uparrow$  respiratory rate

### 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.