Respiratory control

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MD 5/6

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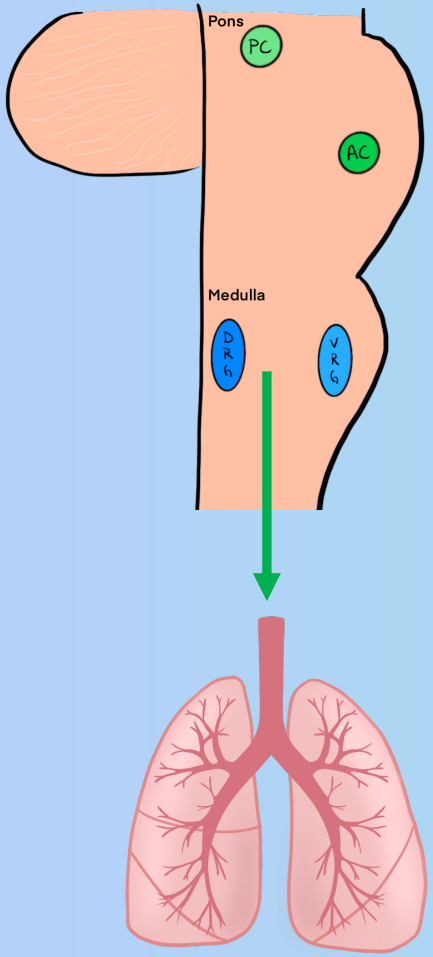
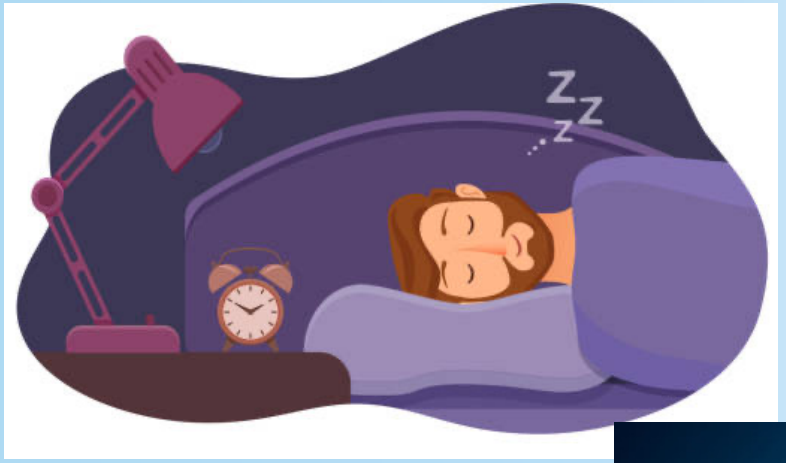
Let’s get control of that breathing

- Involuntary breathing
  - Active inspiration and passive expiration
  - The respiratory control center
  - Central chemoreceptors
  - Peripheral chemoreceptors
- Voluntary breathing
  - Active inspiration and expiration
- Exercise
  - Ventilation and perfusion
  - Changes due to exercise

Involuntary breathing
= unconscious breathing





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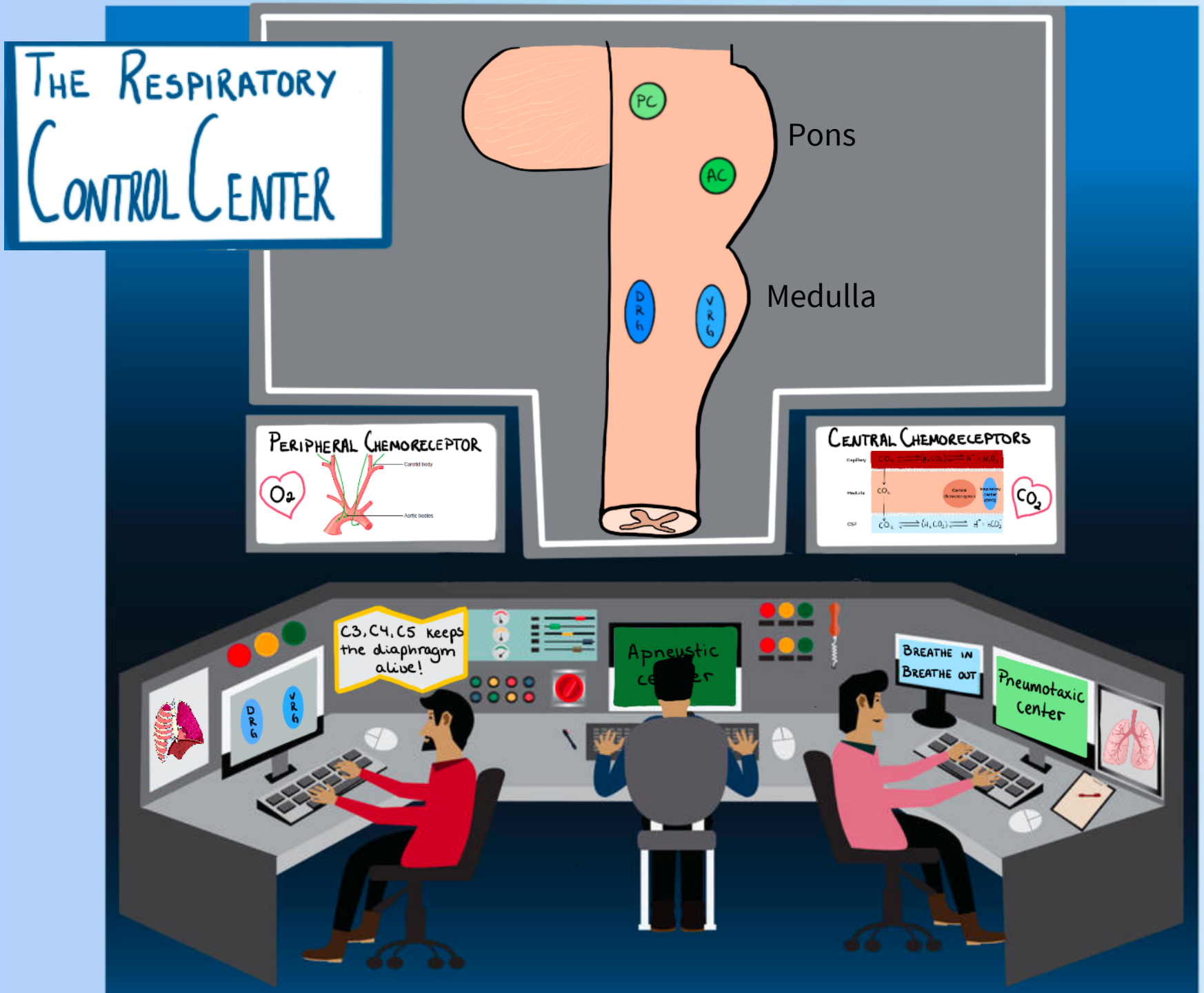
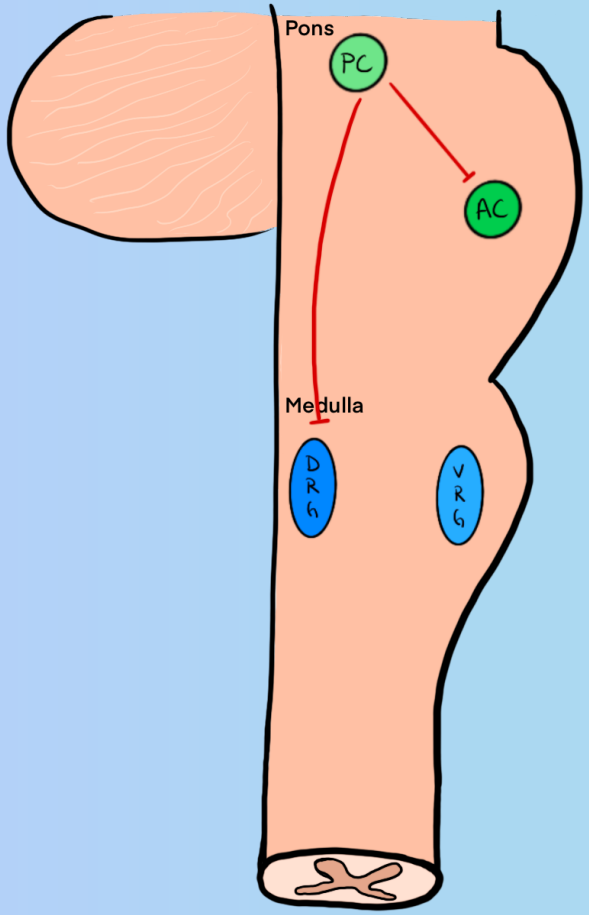
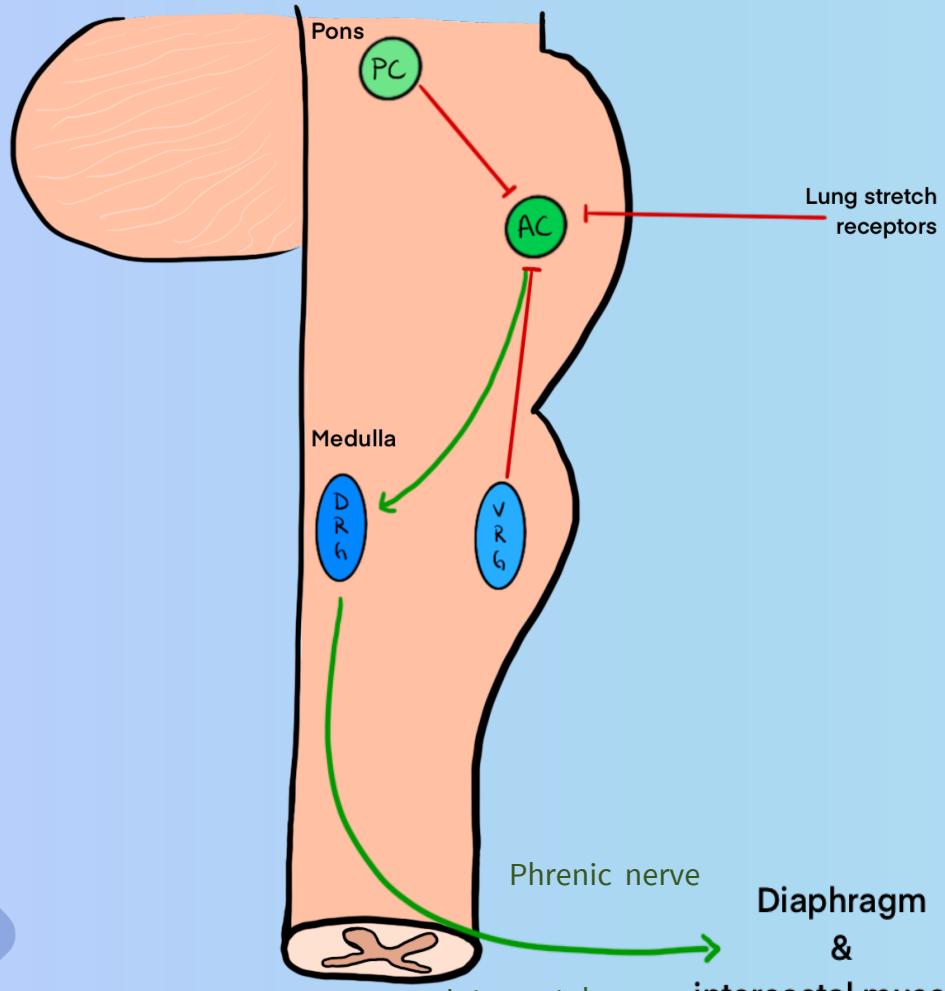

THE RESPIRATORY CONTROL CENTER
PC
AC
DRG
VRG
Pons
Medulla
PERIPHERAL CHEMORECEPTOR
O2
Carotid body
Aortic bodies
CENTRAL CHEMORECEPTORS
CO2
C3, C4, C5 keeps the diaphragm alive!
Apneustic ce
BREATHE IN
BREATHE OUT
Pneumotaxic center

Pons: pneumotaxic center

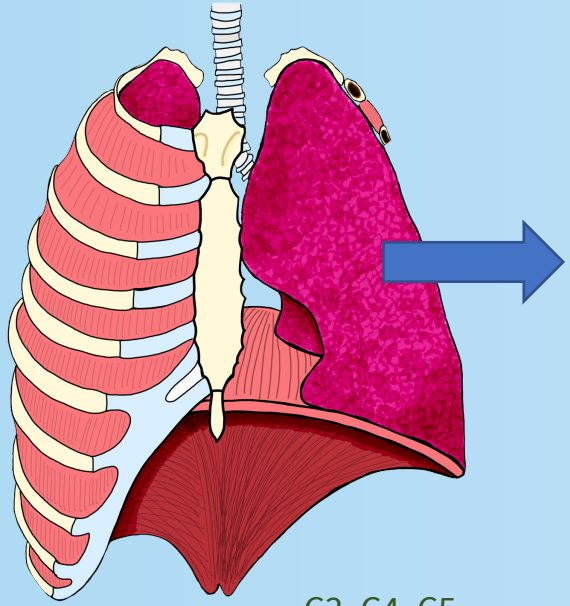


- Smooth transition from inspiration → expiration
- Inhibits:
  - Apneustic center
  - Inspiratory center (DRG)

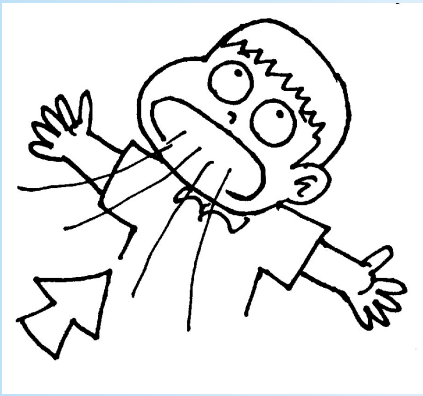
Pons: apneustic center



- Apneusis = prolonged inspiration
- Triggers prolonged inspiration
- Inhibited by:
  - Pneumotaxic center
  - Ventral respiratory group
  - Lung stretch receptors

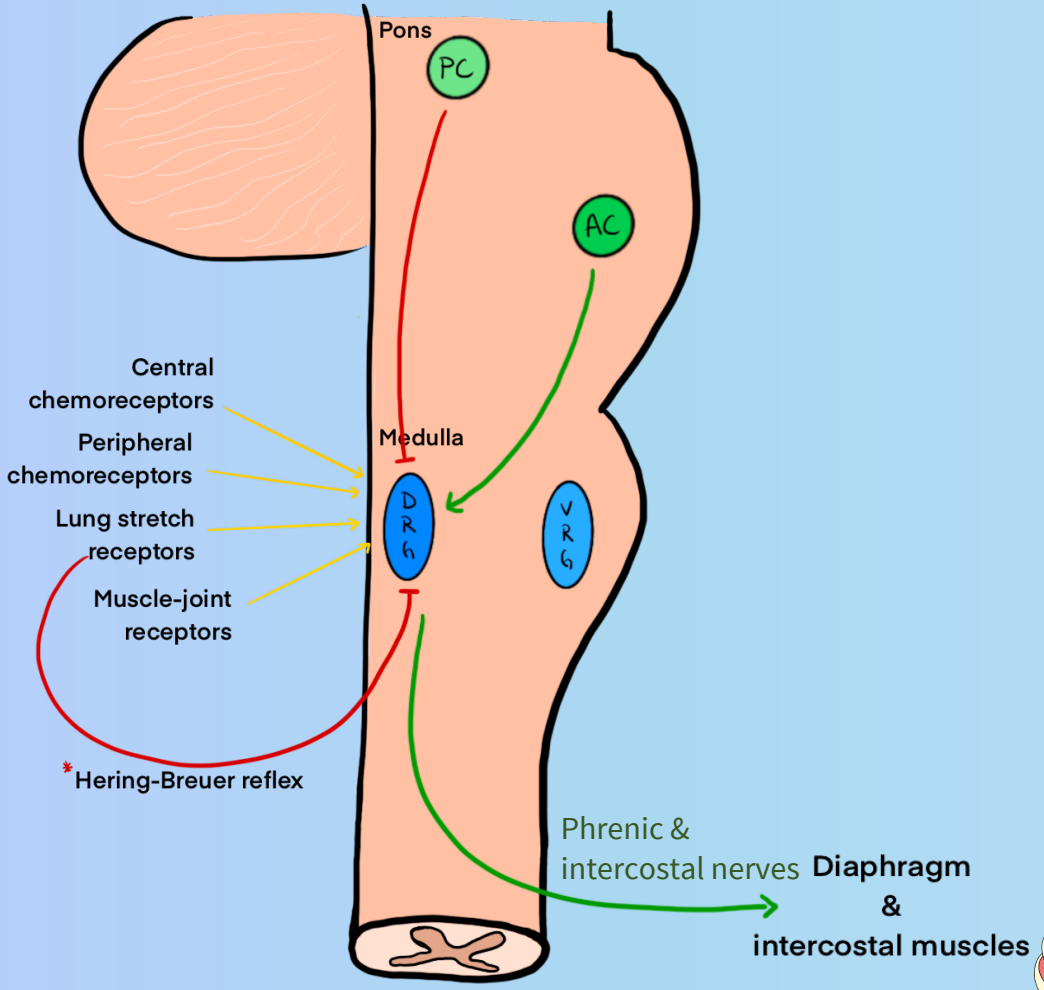


C3, C4, C5
keeps the diaphragm alive

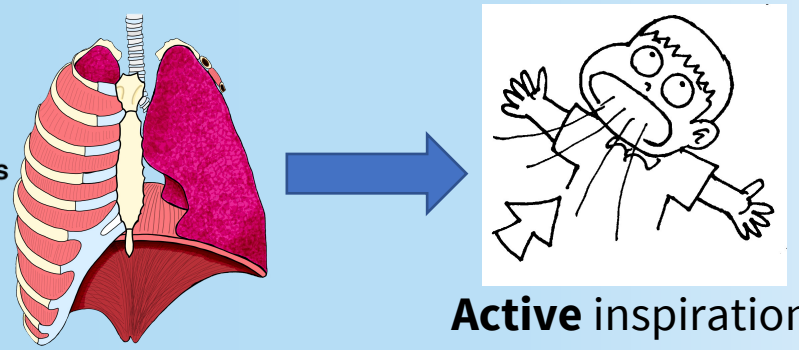


Prolonged inspiration

Medulla: Inspiratory center



- Location: Dorsal respiratory group
- Active during inspiration
- Sensory input
- Motor output via intercostal and phrenic nerves
- Inhibited by:
  - The Hering-Breuer reflex
  - The pneumotaxic center



Active inspiration

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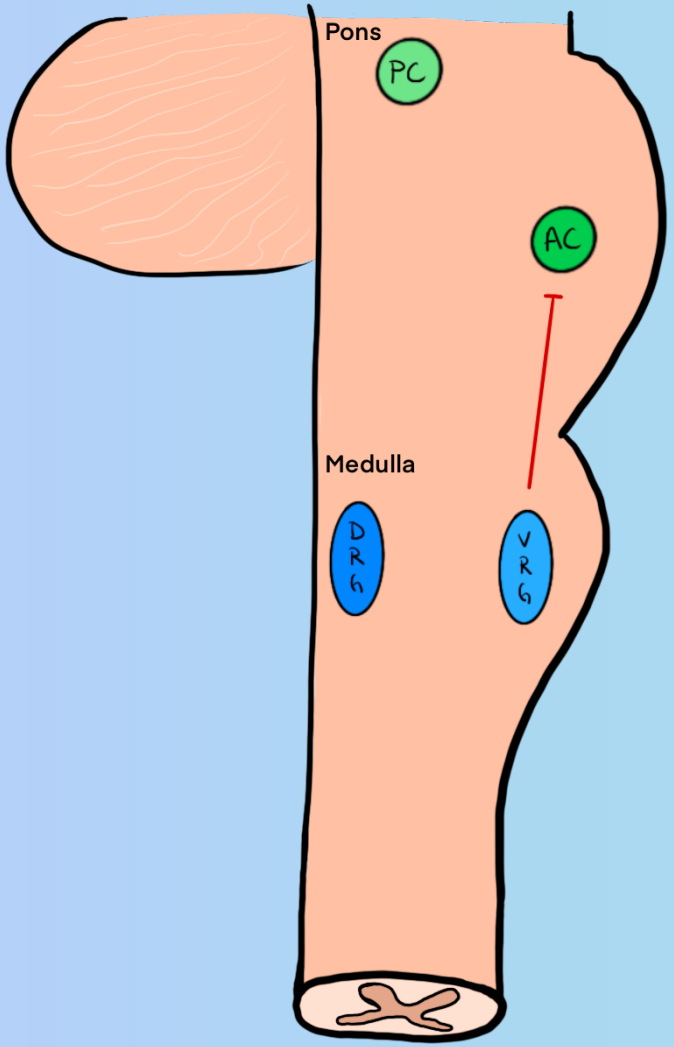
Medulla: Expiratory center



- Location: Ventral respiratory group
- Active during forceful expiration, like exercise - *motor output*
- Inactive during normal, quiet breathing
- Inhibits:
  - The apneustic center

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Let's review

	Brain stem center	Inspiration	Expiration	Main action
pons	**Apneustic center**	X		Trigger inspiration
pons	**Pneumotaxic center**		X *passive*	Control of respiratory rate and pattern
medulla	**Dorsal respiratory group**	X		Receive sensory input Send inspiratory signals to the intercostal muscles and diaphragm
medulla	**Ventral respiratory group**		X *active*	Active expiration *Active during exercise*

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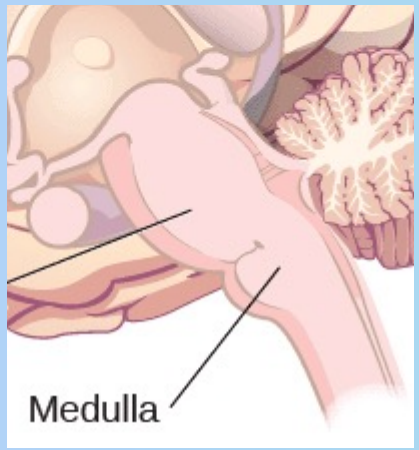
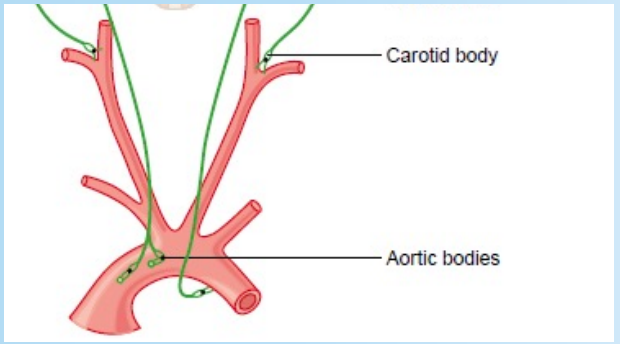
Chemo-receptors

- Central
  - Medulla
- Peripheral
  - Carotid sinus
  - Aortic arch





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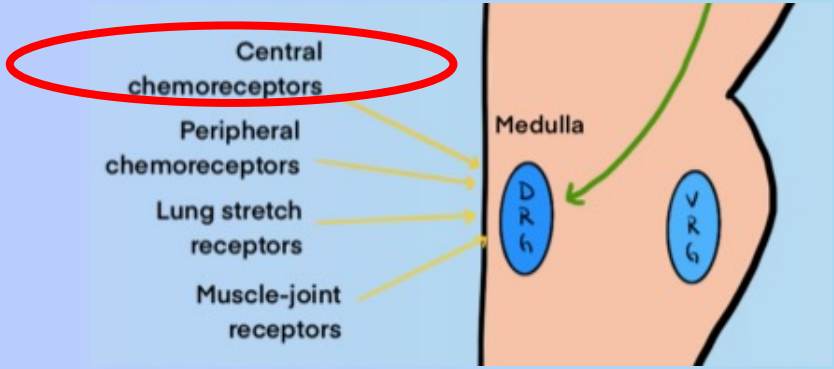
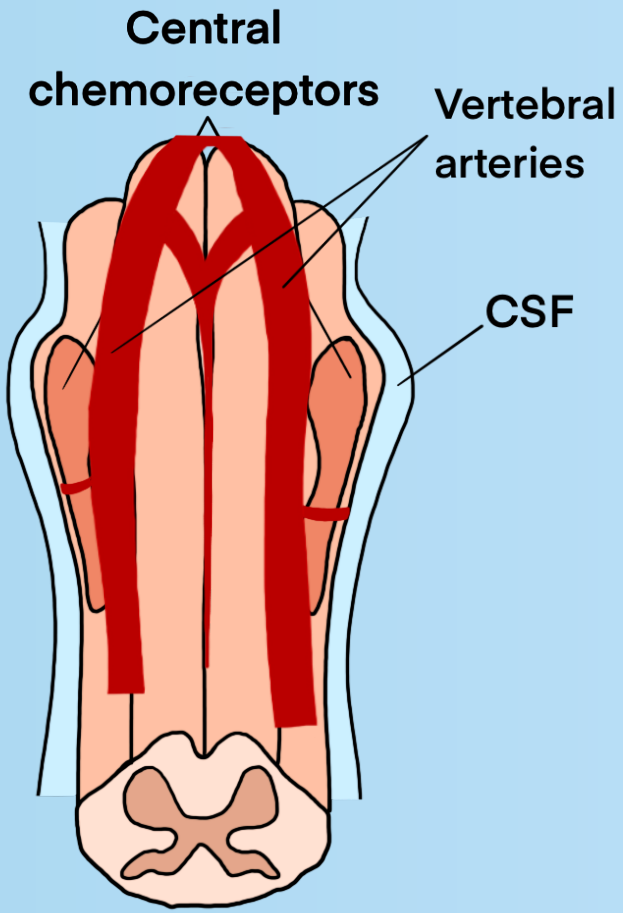
Central chemo-receptors





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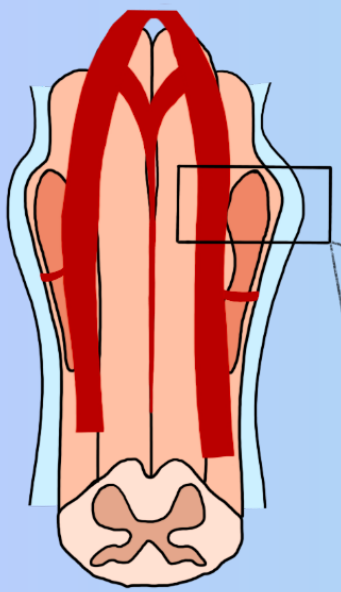

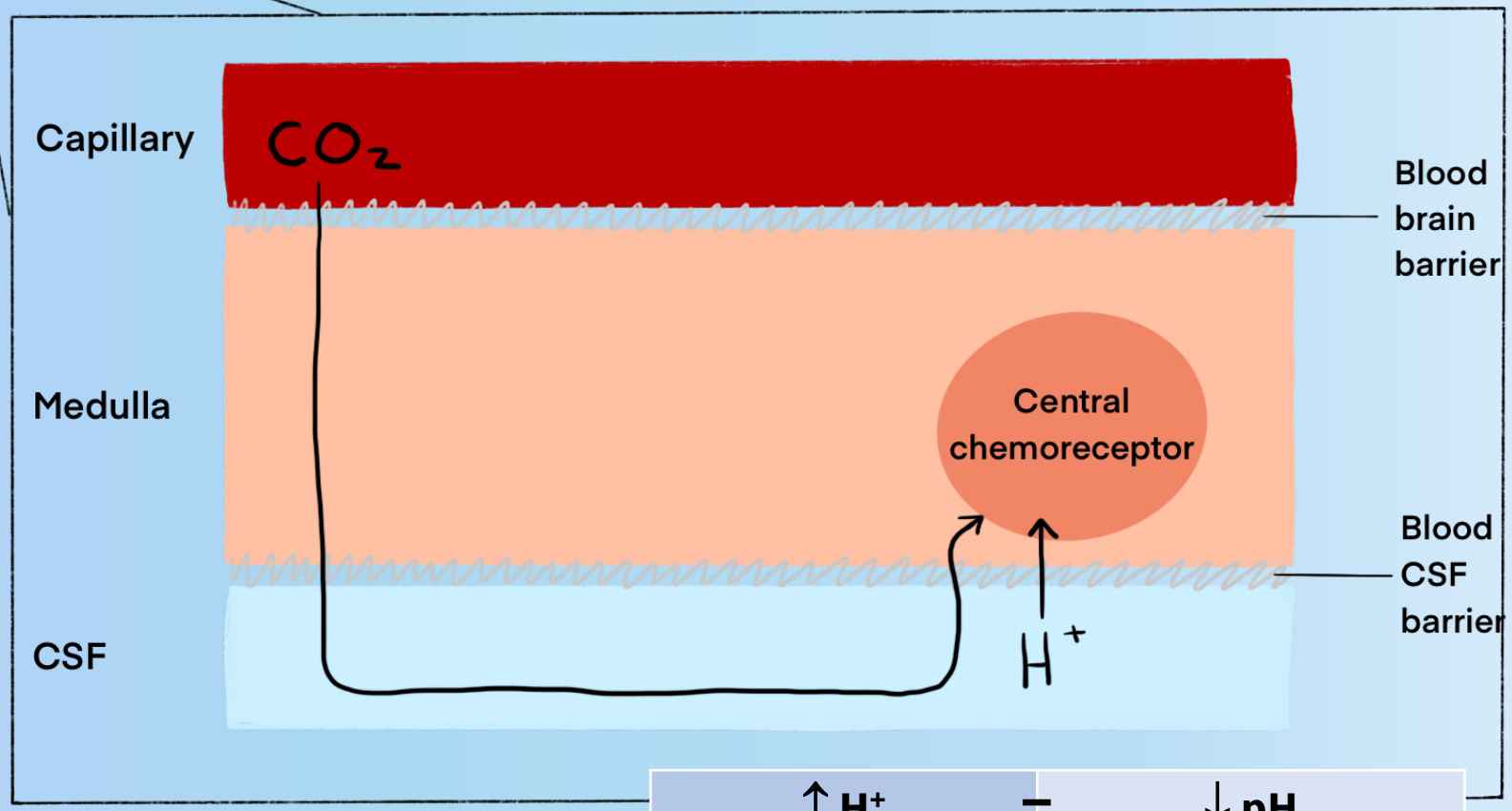

↑ H^+	=	↓ pH
↓ H^+	=	↑ pH

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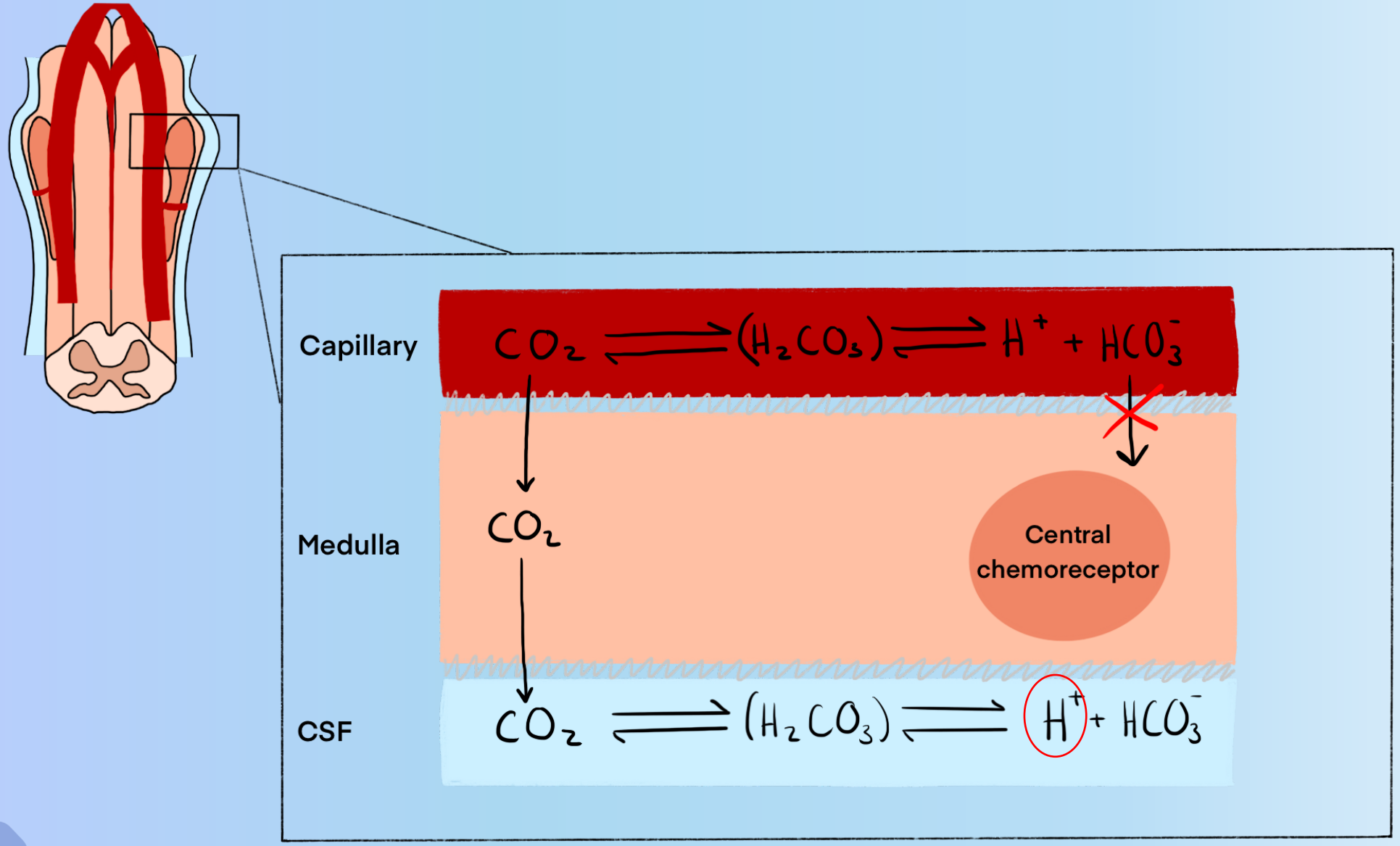
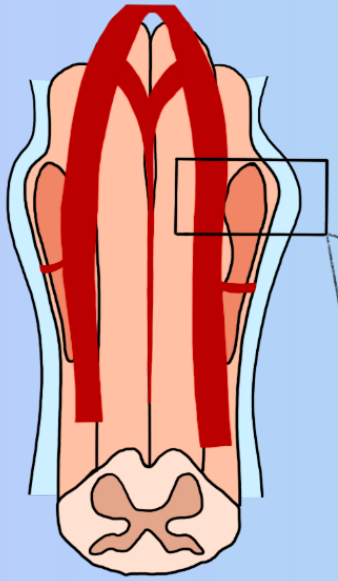
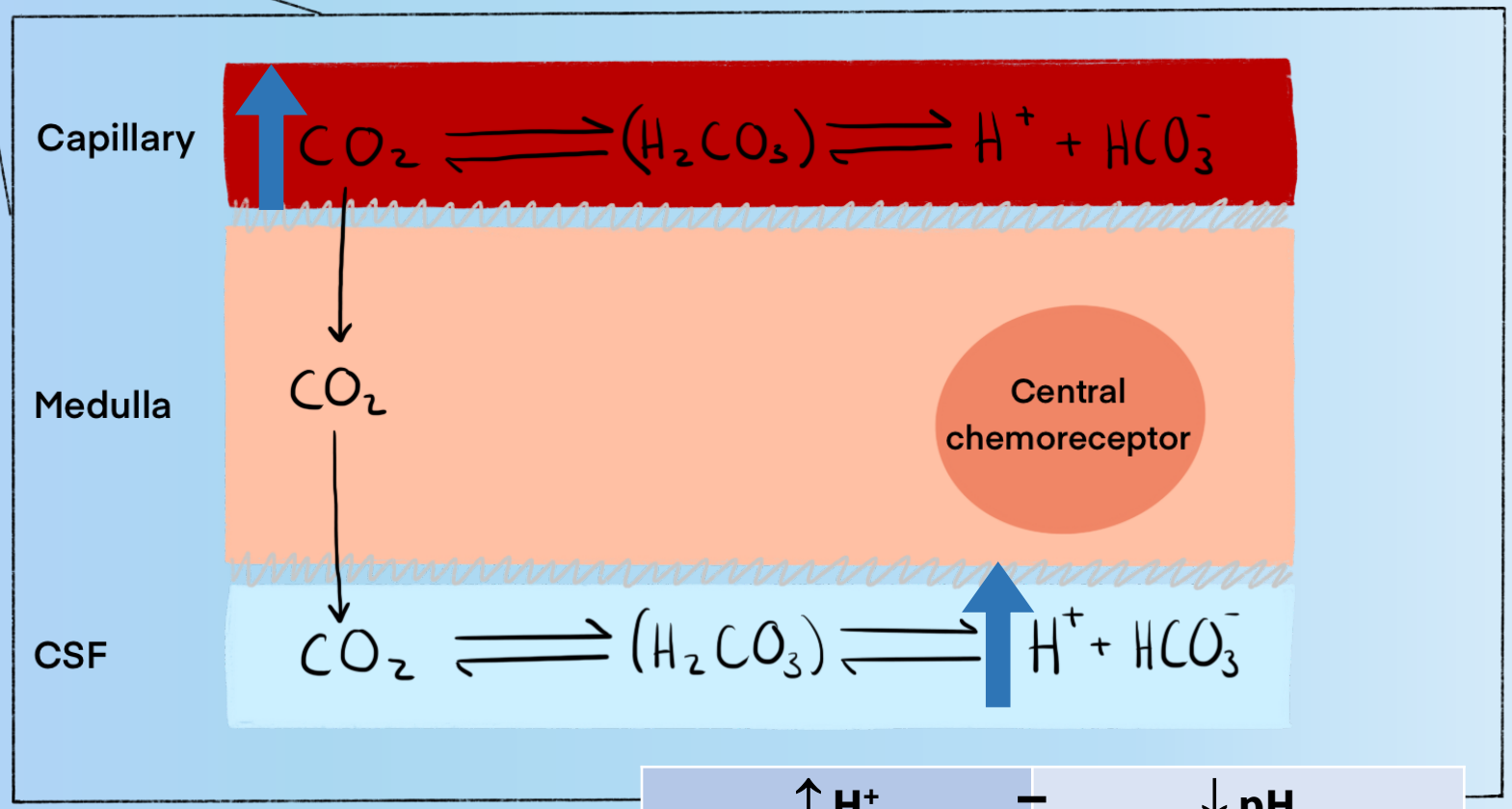

Capillary
$CO_2 \rightleftharpoons (H_2CO_3) \rightleftharpoons H^+ + HCO_3^-$
Medulla
CO_2
Central chemoreceptor
CSF
$CO_2 \rightleftharpoons (H_2CO_3) \rightleftharpoons H^+ + HCO_3^-$





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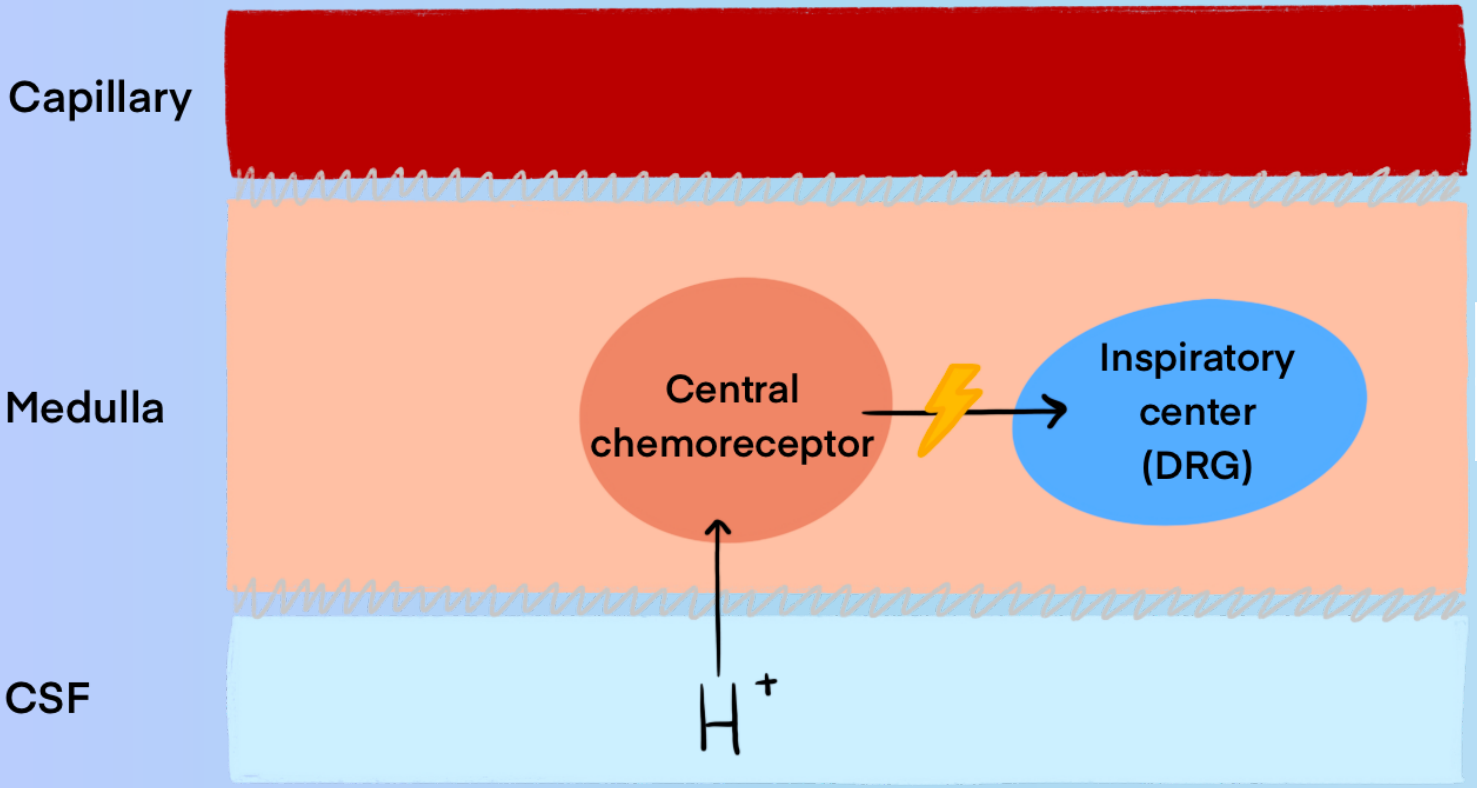

↑ H^+	=	↓ pH	→	↑ Breathing rate
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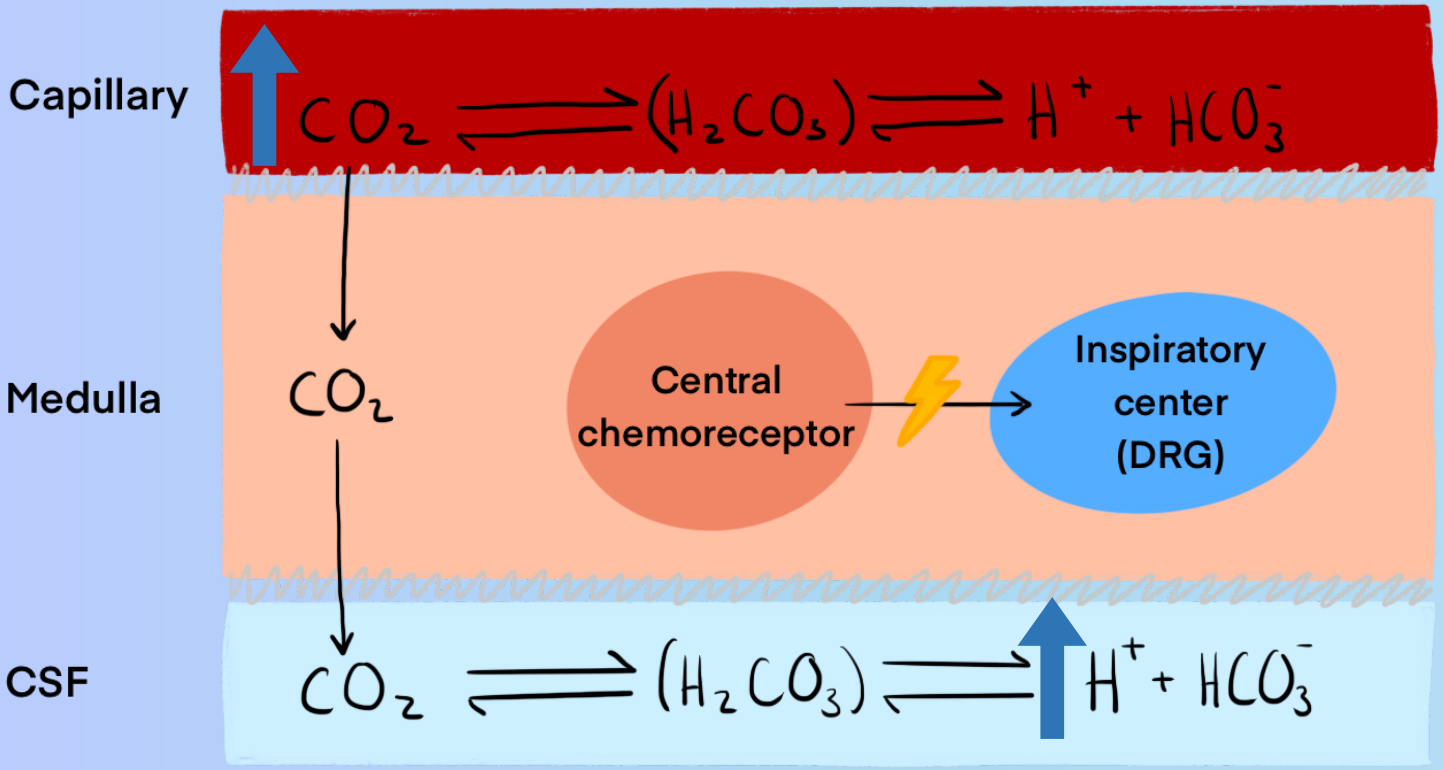
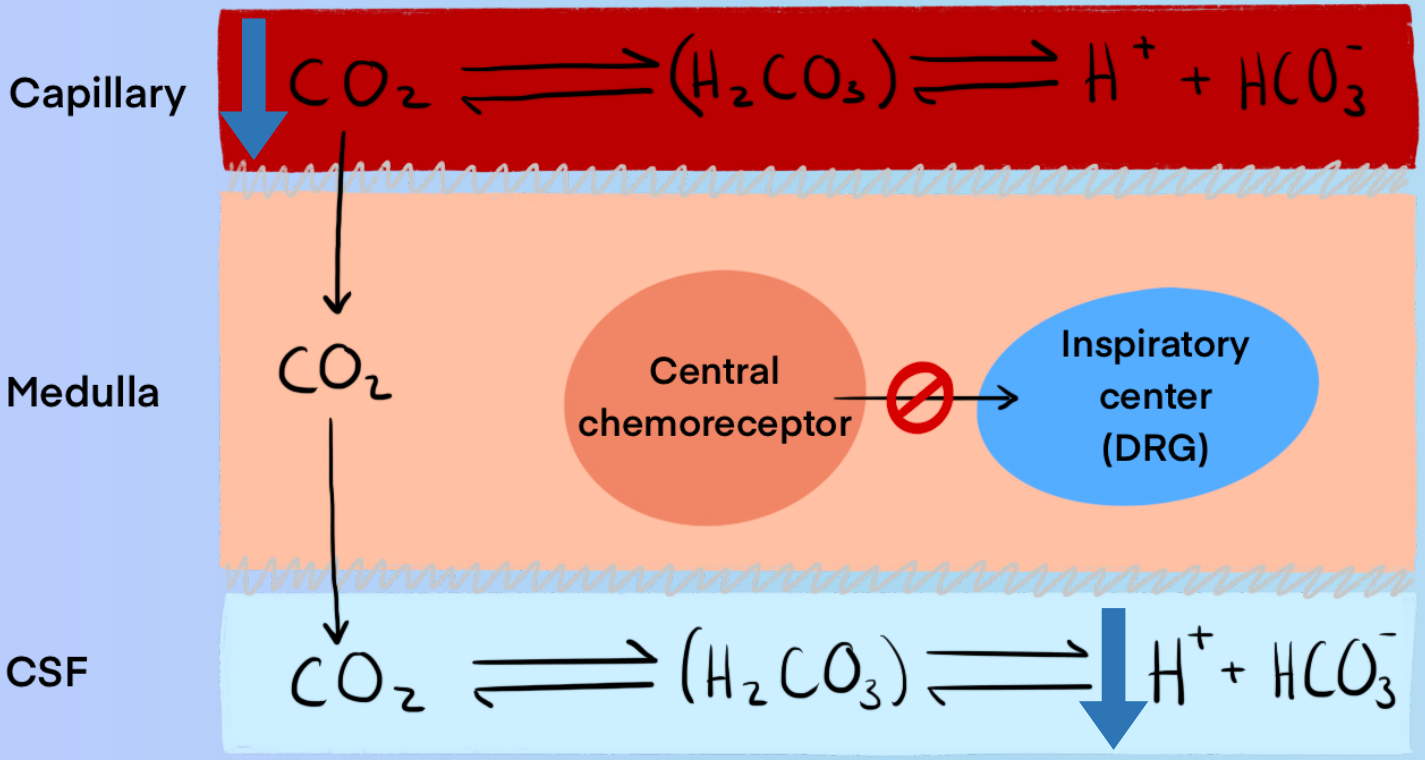


↑ H^+ = ↓ pH → ↑ Breathing rate

May lead to

Hyperventilation

↓ Pa_{CO2}



↓ H^+ = ↑ pH → ↓ Breathing rate

May lead to

Hypoventilation

↑ Pa_{CO2}

↓ Pa_{O2}

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Peripheral chemo-receptors

Pa_{O2} ↓

Pa_{CO2} ↑

pH ↓

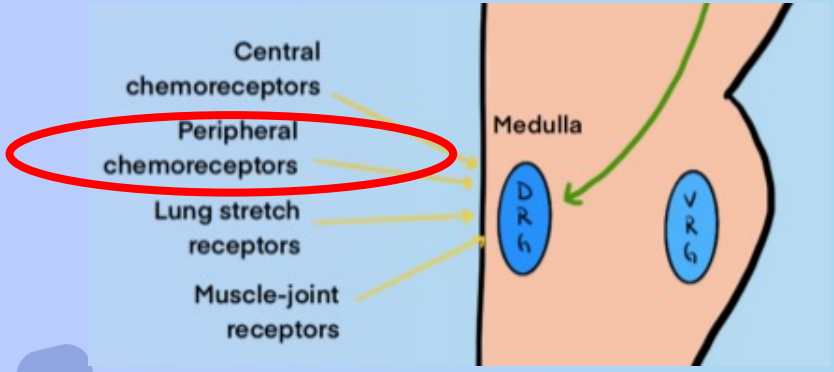
Pa_{O2} ↓

Pa_{CO2} ↑

PaO_2 has to drop below 60 mmHg !

Carotid bodies

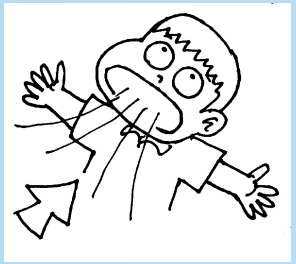
Aortic bodies



CN IX

Inspiratory center (DRG)

CN X



Increased respiratory rate

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Overview of other receptors

	Lung stretch receptors	Muscle-joint receptors	Irritant receptors	Juxtacapillary receptors
Type	Mechanoreceptor	Mechanoreceptor	Rapidly adapting receptors	Sensory nerve endings
Location	Airway smooth muscle	Joints and muscles	Between airway epithelial cells	Alveolar walls
Stimulation	Distension of the lungs	Movement of limbs during **exercise**	Noxious chemicals and particles	↑ blood volume ↑ interstitial fluid volume
Effect on respiratory rate	↓	↑	↑	↑
Reflexes	Hering-Breuer reflex*		Coughing reflex	

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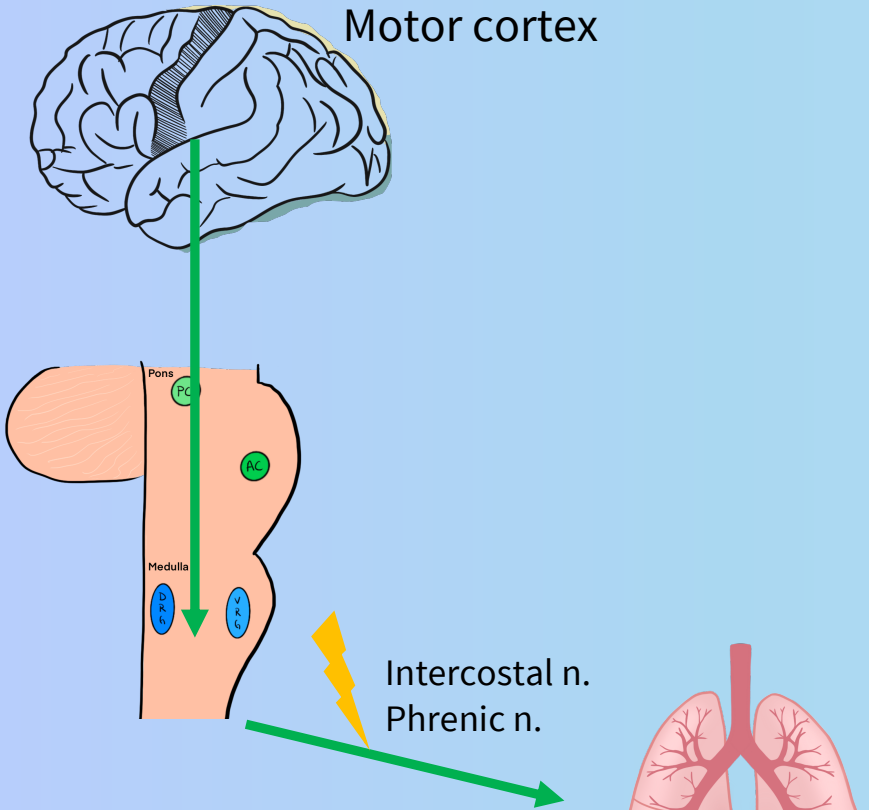
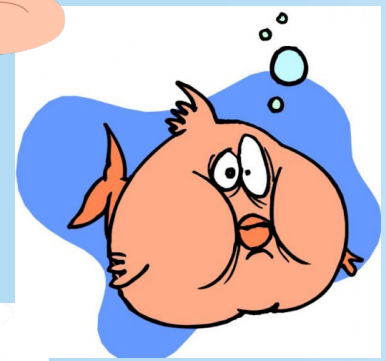
Let’ take a deep breath

Voluntary breathing
= breathing under conscious control



- Hypoventilation



- Breath holding

- Hyperventilation

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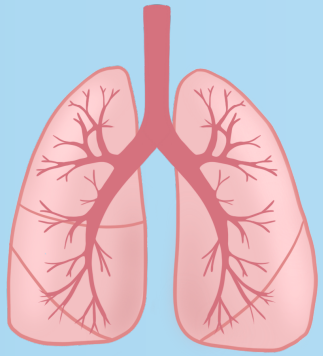
Clinical correlation

Mr. Stress is been under a lot of pressure at work lately. One late evening, 1 hour before the deadline of handing in the annual work report he starts sweating, his heart is racing and his breathing rate increases.

He is hyperventilating and he starts to feel dizzy. His co-worker, Ms. Namaste, hands him a paper bag and tells him to breathe into it.

He slowly starts to feel better.

Why does the paper bag help Mr. Stress?



Hyperventilation

$\downarrow Pa_{CO_2}$

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You`re at the gym

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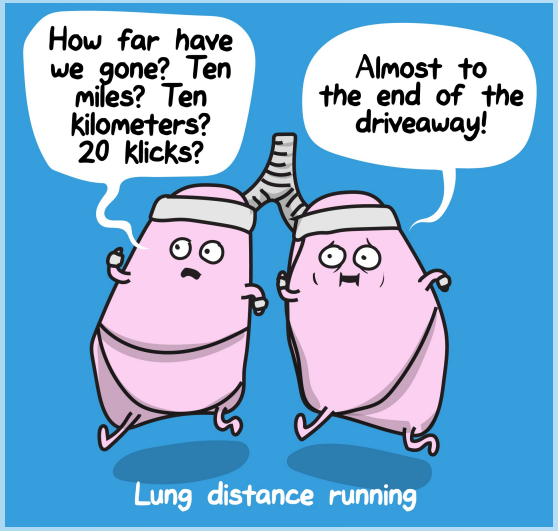
Increased cardiac output

Increased CO_2 production

Increased respiratory rate

What is happening to your respiratory system?

Increased ventilation



Increased O_2 consumption

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Ventilation and perfusion

Definition

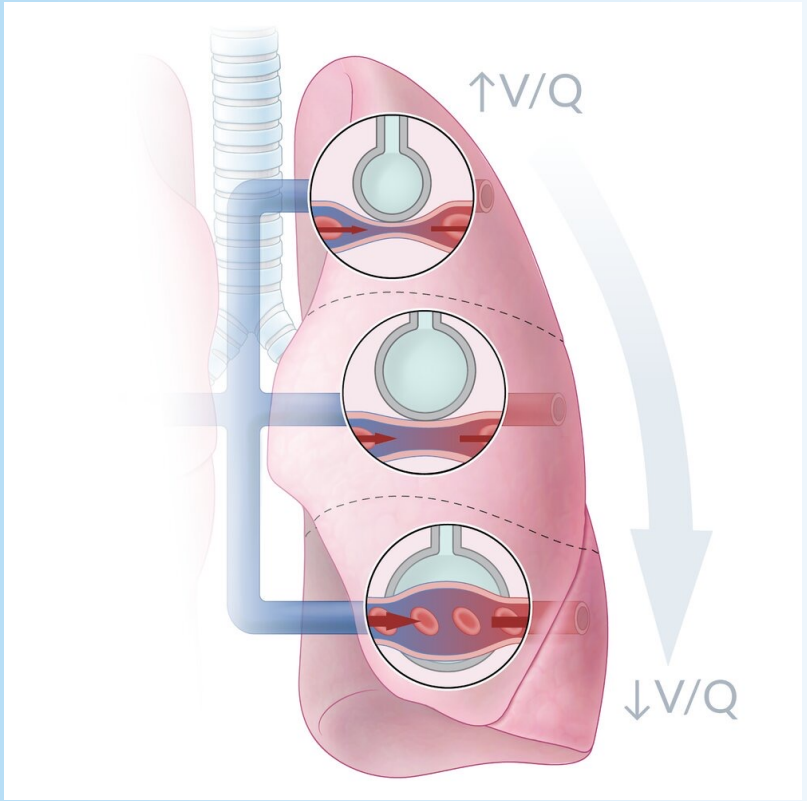
Ventilation (V)
The movement of air between the atmosphere and the lungs

Perfusion (Q)
The delivery of blood to the alveoli

V/Q ratio

Diffusion

- Gas exchange



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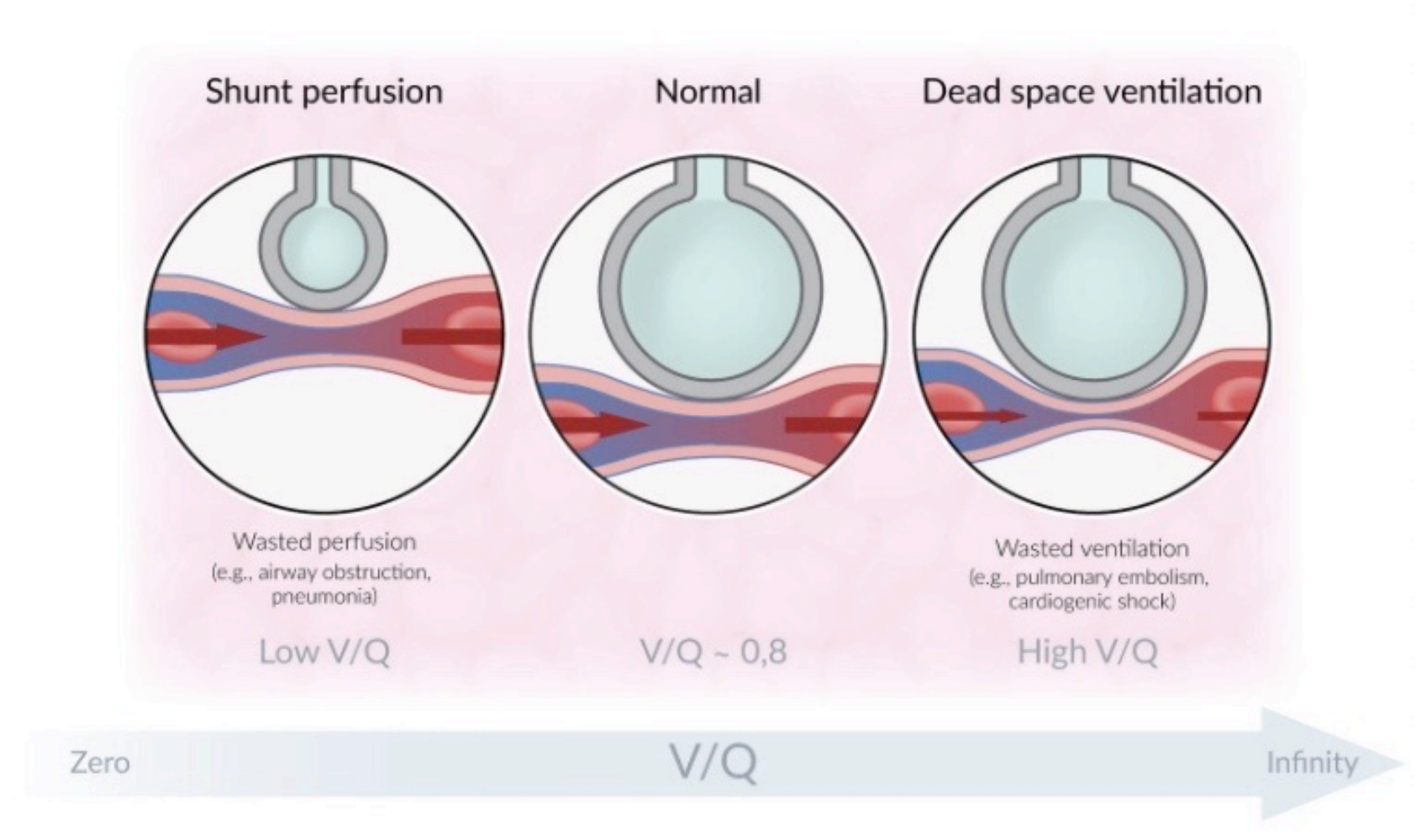
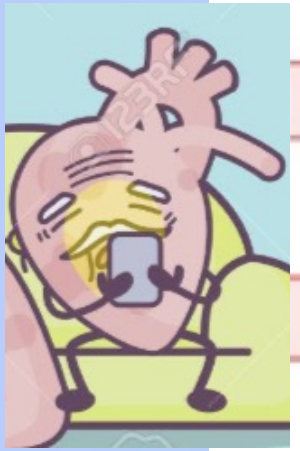
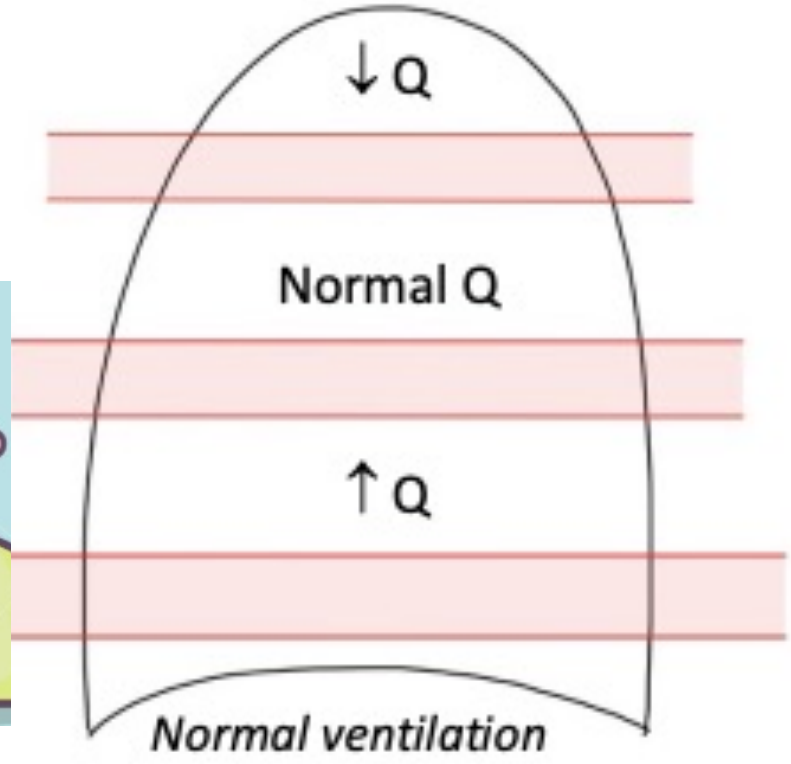
Ventilation/perfusion mismatch

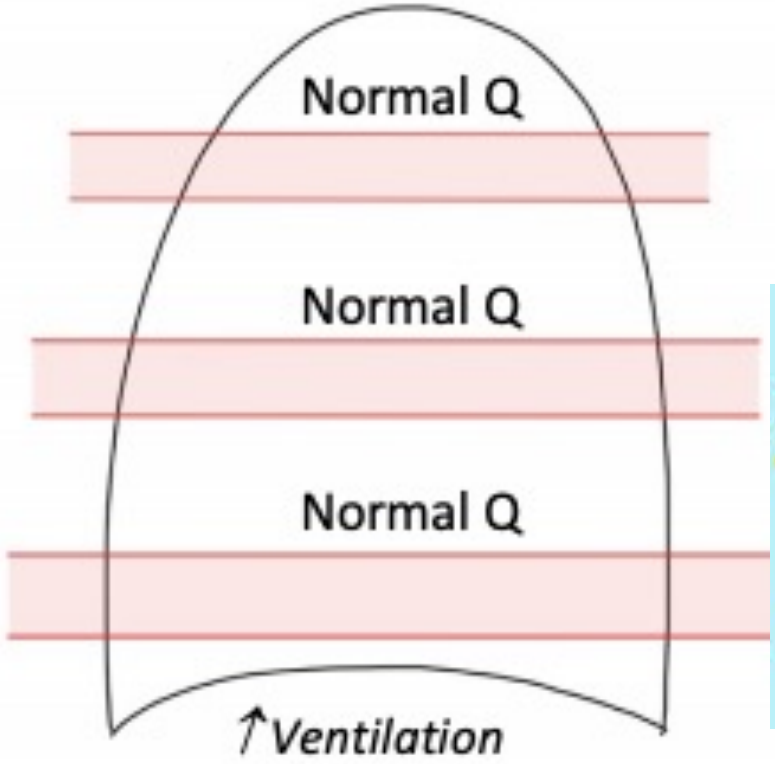


↑ ventilation + ↑ perfusion = ↑ gas exchange





V/Q ratio ~ 0.8

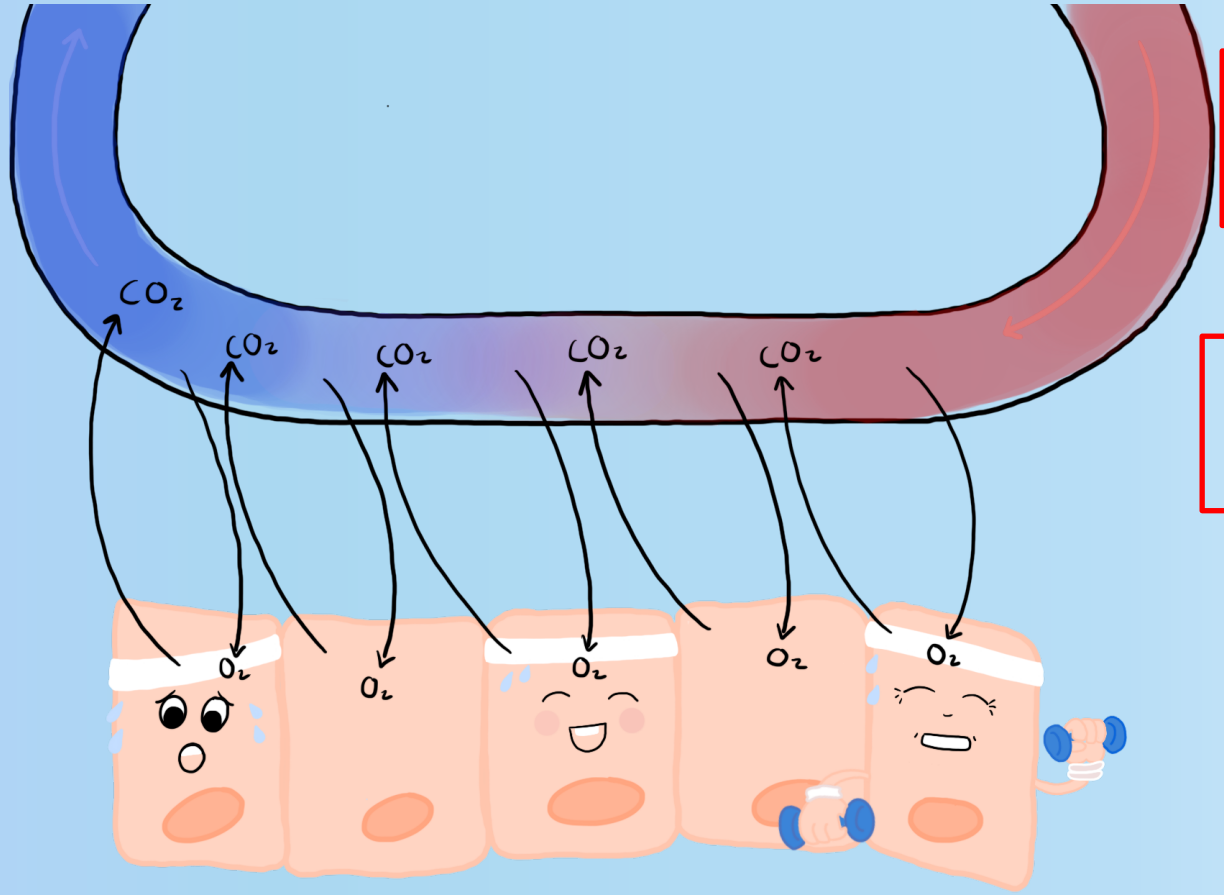


V/Q ratio = 1

Gas exchange at tissue site

During exercise
↓ PvO_2: 20 mmHg
↑ $PvCO_2$: 60 mmHg

Normal values
PvO_2: 40 mmHg
$PvCO_2$: 45 mmHg



During exercise
PaO_2: 100 mmHg
$PaCO_2$: 40 mmHg

No change!

Normal values
PaO_2: 100 mmHg
$PaCO_2$: 40 mmHg

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A little summary

↑ O_2 consumption
↑ CO_2 production → ↑ venous PCO_2

↑ Ventilation
↑ Cardiac output → ↑ perfusion
↑ Gas exchange

V/Q ratio = 1

↓ Physiologic dead space
↓ Affinity of hemoglobin to O_2

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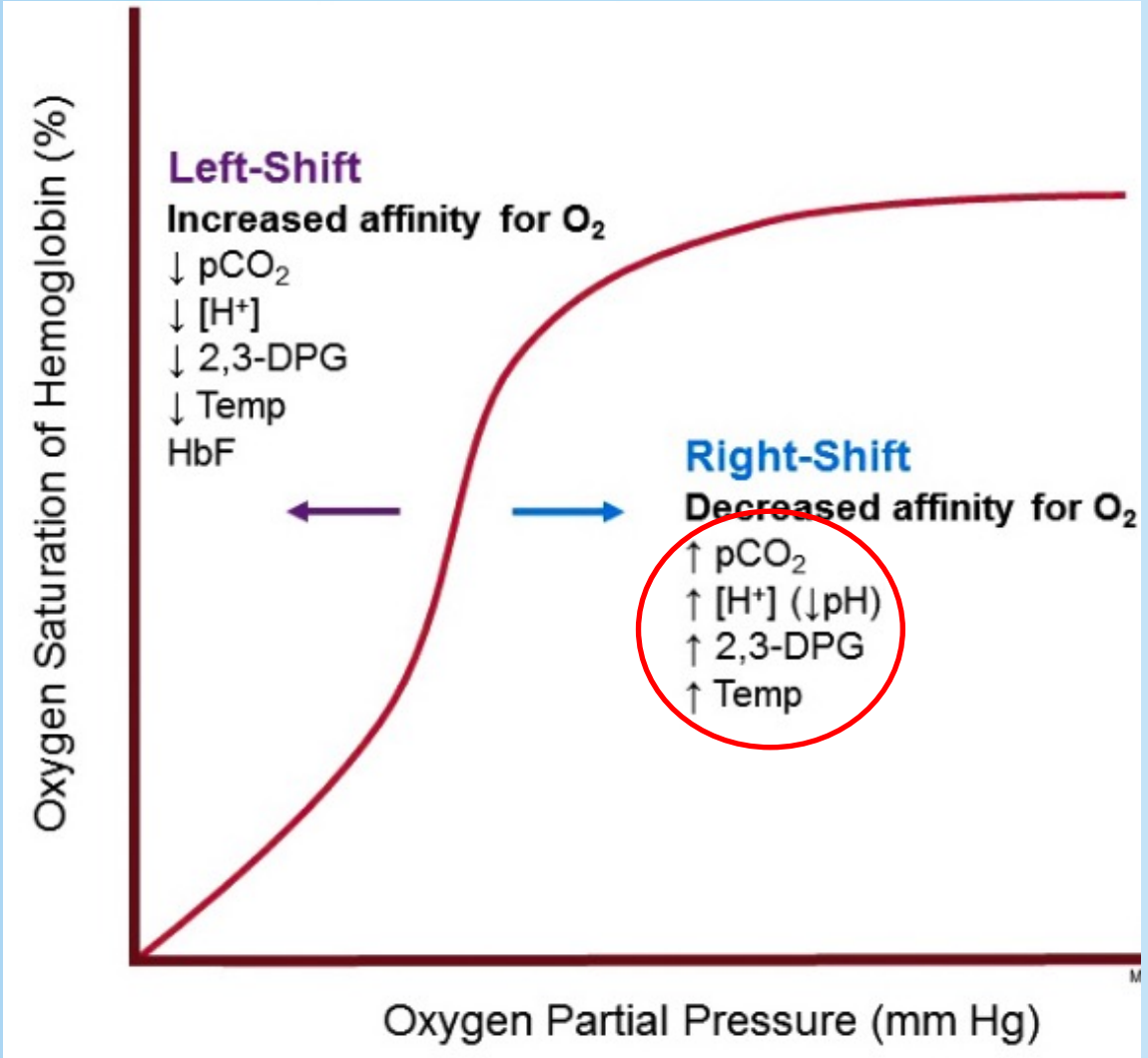
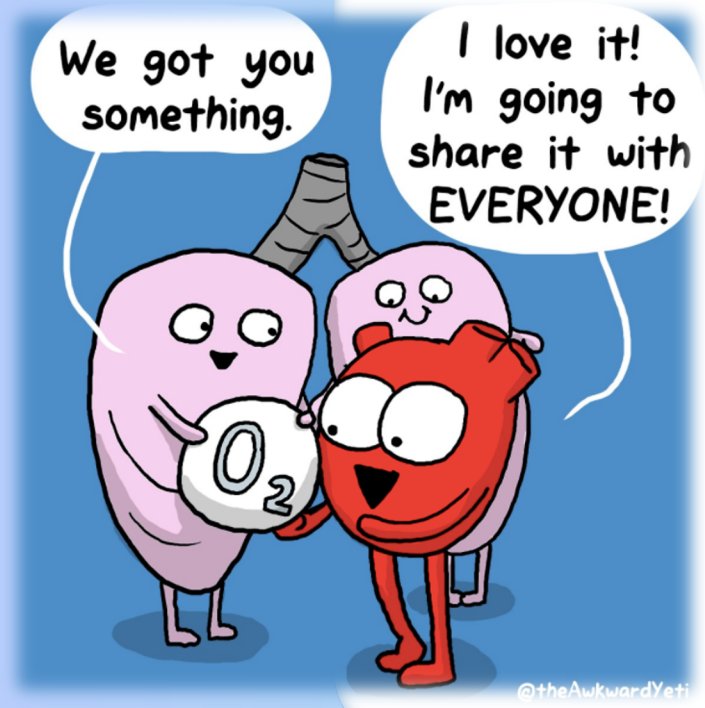
The Bohr effect





Best of luck!

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