TOPIC: VENTILATION

Ventilation: Boyle's Law

◆ Ventilation works by altering the _____ gradient.

Boyle's law:

- $P_1 \times V_1 = P_2 \times V_2$
- Change in volume _____ a change in the pressure.

- ____ in volume causes ____ in pressure.

- ____ in volume causes ____ in pressure.

◆ Changing the volume of the thoracic cavity alters the _____ pressure.

- Atmospheric pressure = 760 mmHg

Inspiration:

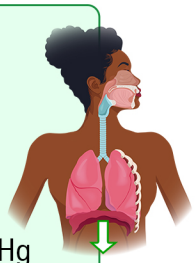
Diaphragm: _____

Thoracic cavity volume: ____

Pressure: ____

Pressure in lungs __ 760 mm Hg

Air flows: ____ lungs.



Expiration:

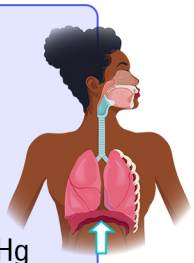
Diaphragm: _____

Thoracic cavity volume: ____

Pressure: ____

Pressure in lungs __ 760 mm Hg

Air flows: ____ ___ lungs.



EXAMPLE

During the 1940s and 1950s, iron lungs were a common intervention for patients whose diaphragms were paralyzed due to polio. The patient would be positioned with their body inside a sealed chamber with only their head sticking out. One way iron lungs were designed was to have the foot end of the chamber move in and out, changing the volume inside the chamber. Use your knowledge of Boyle's law to circle the words in bold that make each statement correct.

Volume in the chamber decreases:

a) Pressure in the chamber: **(greater than / less than /equal to)** 760 mm Hg.
b) Atmospheric pressure: **(greater than / less than / equal to)** 760 mm Hg.
c) Pressure in the chamber would force air **(into / out of)** lungs.

Volume in the chamber increases:

a) Pressure in the chamber: **(greater than / less than / equal to)** to 760 mm Hg.
b) Atmospheric pressure: **(greater than / less than / equal to)** to 760 mm Hg.
c) Pressure in the chamber would force air **(into / out of)** lungs.

TOPIC: VENTILATION

PRACTICE

Why does air rush into the lungs during an inhale or inspiration?

a) Increase in atmospheric pressure.

b) Diaphragm moves upward.

c) Decrease in air pressure in the lungs.

d) Contraction of abdominal muscles.

PRACTICE

During expiration, which action contributes to the movement of air out of the lungs during eupnea, or quiet breathing?

a) Contraction of intercostal muscles.

b) Relaxation of the diaphragm.

c) Contraction of the abdominal muscles.

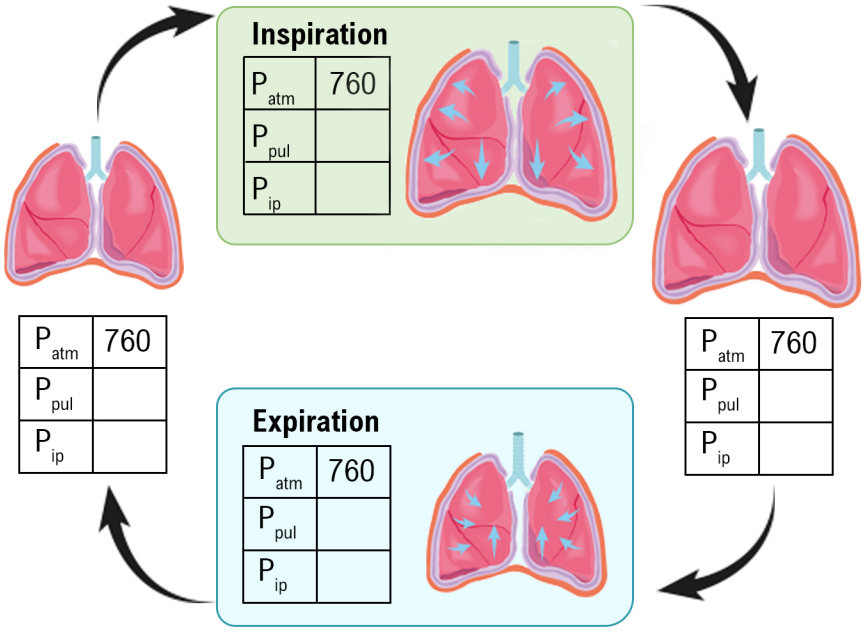
d) Expansion of the ribcage.

TOPIC: VENTILATION

Pressure Changes During Ventilation

◆ Ventilation alters pressure gradients with respect to _____ pressure (P_{atm}).

- Intrapulmonary Pressure (P_{pul}): open system → _____ to P_{atm}.
- Intrapleural Pressure (P_{ip}): closed vacuum → _____ equalize to P_{atm}.

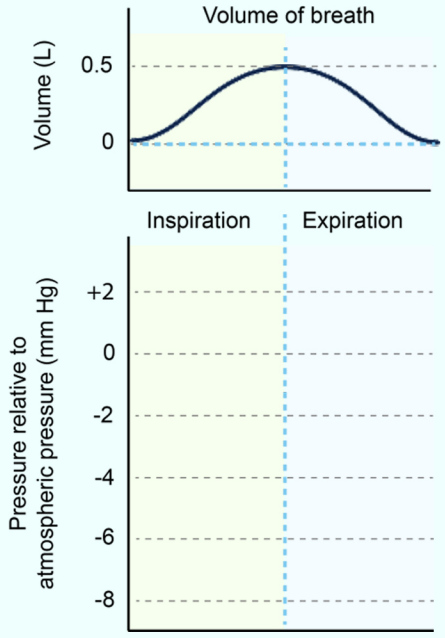


EXAMPLE

Two graphs are shown below. The top graph, titled "Volume of breath", shows the volume of air inspired and expired during ventilation. The bottom shows pressure relative to atmospheric pressure in mm Hg and has not been filled in.

a. Draw a line that represents the approximate change in *intrapulmonary pressure* during inspiration and expiration. Label the line "P_{pul}".

b. Draw a line that represents the approximate change in *intrapleural pressure* during inspiration and expiration. Label the line "P_{ip}".



TOPIC: VENTILATION

PRACTICE

At the end of inspiration, the intrapulmonary pressure is equal to _____.

a) Atmospheric pressure.

b) Transpulmonary pressure.

c) Intrapleural pressure.

d) Both A & C are correct.

PRACTICE

When the volume of air in the lungs is the greatest:

a) The intrapulmonary pressure is equal to the atmospheric pressure.

b) The intrapulmonary pressure is at its maximum.

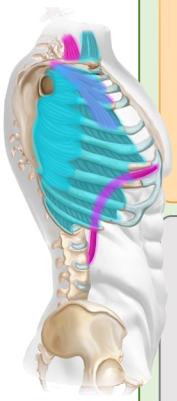
c) The intrapulmonary pressure is at its minimum.

d) The intrapulmonary pressure is equal to the intrapleural pressure.

TOPIC: VENTILATION

Muscles of Ventilation

- Primary Respiratory Muscles: used during _____ breathing (eupnea).
- Accessory Respiratory Muscles: recruited during _____ breathing.



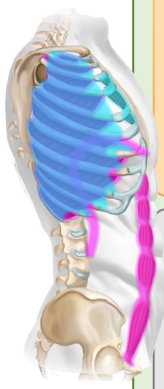
Inspiration

Primary Respiratory Muscles

- Diaphragm: contracts; moves _____.
- External intercostals: contract; ribs move ___ and ____.

Accessory Respiratory Muscles

- Sternocleidomastoid; Scalenes; Pectoralis minor; Serratus anterior.



Expiration

Primary Respiratory Muscles

- Diaphragm: relaxes; moves _____.
- External intercostals: relax; ribs move _____ and ___.

Accessory Respiratory Muscles

- Internal intercostal muscles; Transversus thoracis; Rectus abdnominis.

EXAMPLE

Fill in the table below indicating which muscles you would expect to contract or relax during inspiration and expiration for both eupnea (quiet breathing) and forced breathing. In each cell, write a "C" if you expect that muscle to be contracting and write an "R" if you expect that muscle to be relaxed.

	Eupnea		Forced Breathing	
	Inspiration	Expiration	Inspiration	Expiration
Diaphragm				
External Intercostals				
Sternocleidomastoid				
Scalenes				
Pectoralis Minor				
Serratus Anterior				
Transversus Thoracis				
Internal Intercostals				
Rectus Abdominus				

TOPIC: VENTILATION

PRACTICE

Which muscle is used for inspiration during both eupnea and forced breathing?

a) Rectus abdnominis.

b) Sternocleidomastoid.

c) Serratus anterior.

d) External intercostal muscles.

PRACTICE

Which muscle is likely to be contracting while blowing up a balloon?

a) Rectus abdominis.

b) Sternocleidomastoid.

c) Diaphragm.

d) Scalenes.