



Chapter 22: Respiratory System

Mechanics of Breathing!

Pulmonary Ventilation

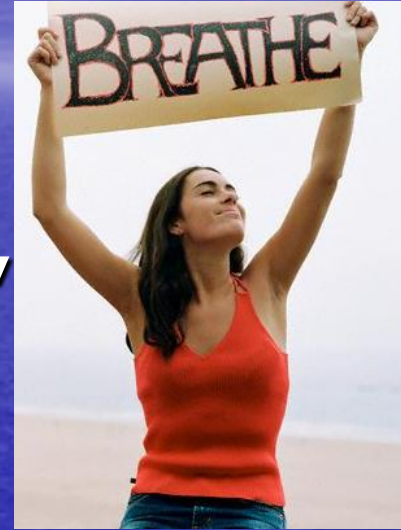
- Rule of thumb → *volume changes* lead to *pressure changes*, and pressure changes lead to the *flow of gases* to equalize the pressure
- **Boyle's Law: $P_1V_1 = P_2V_2$**
 - At constant temperature, the pressure of a gas varies inversely with its volume.
 - Gases always *fill* their container!
 - In a large container the molecules will be far apart and pressure will be low, decrease the volume and the molecules will be closer together and the pressure will be greater.

Pulmonary Ventilation

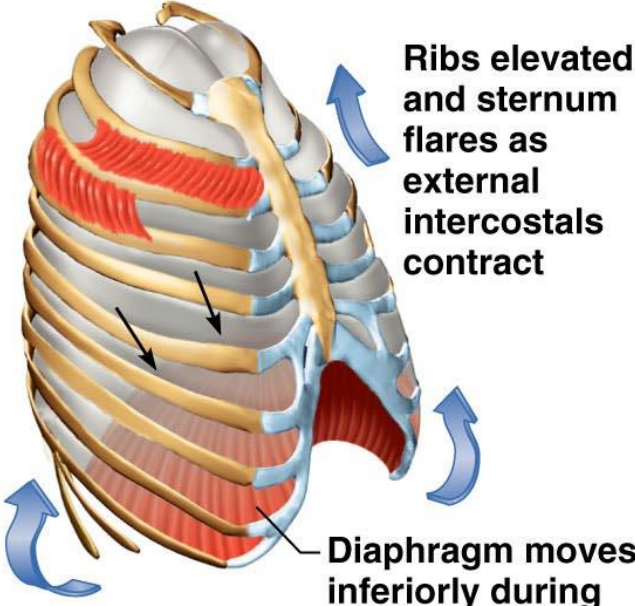
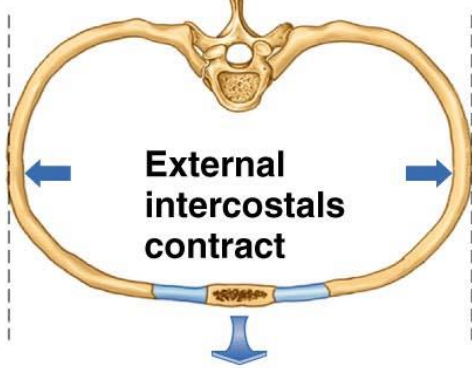
- Intrapulmonary Pressure (P_{pul})
 - Pressure in the alveoli
 - Rises and falls with the phases of breathing
 - Always equalizes with atmospheric pressure
- Intrapleural Pressure (P_{ip})
 - Pressure in the pleural cavity
 - Rises and falls with the phases of breathing
 - ***Always*** about 4mmHg less than P_{pul}

Inspiration (Inhalation)

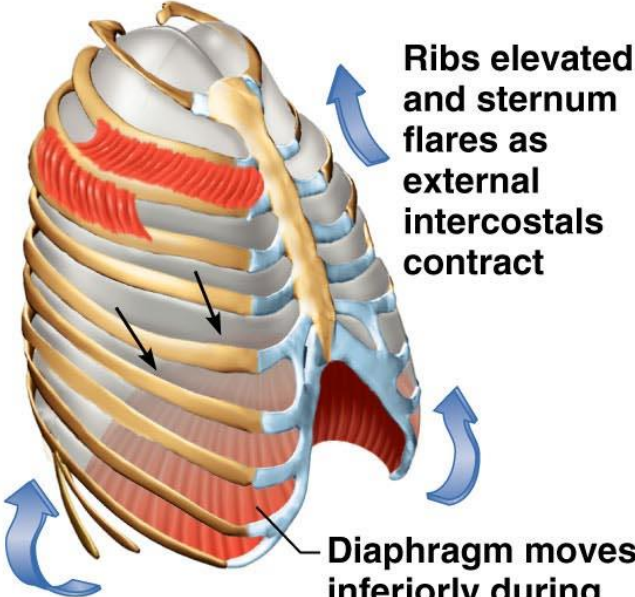
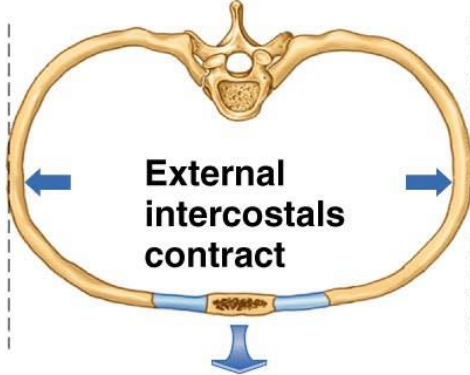
- Just before each inhalation, the air pressure in the lungs is equal to the pressure of the atmosphere ($\sim 1\text{atm}$, 760mmHg)
- For air to flow into the lungs, the pressure inside the alveoli must become lower than the atmospheric pressure
- Air will always flow from an area of high pressure to an area of low pressure.



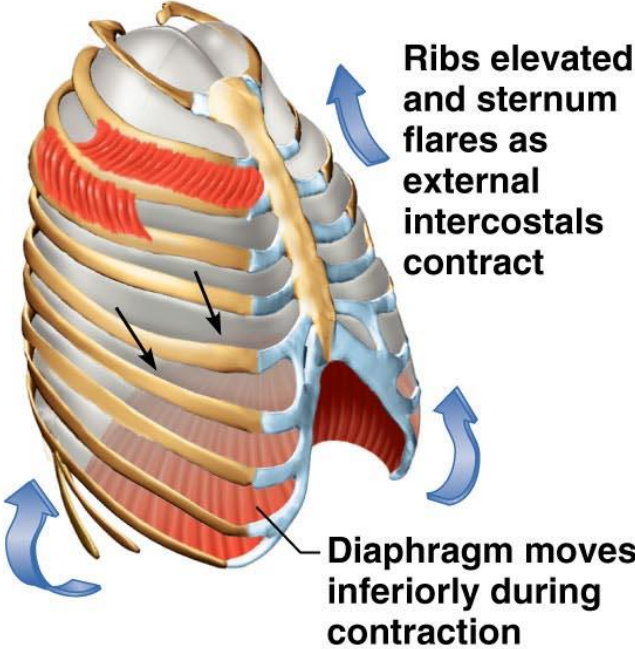
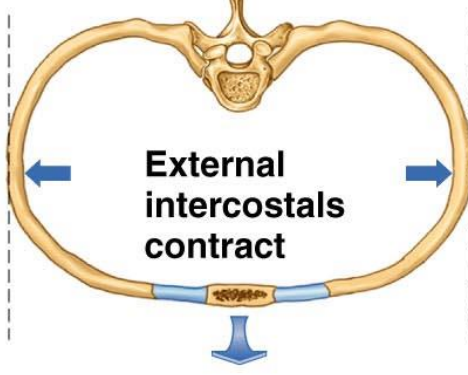
Inspiration (Inhalation)

	Sequence of events	Changes in anterior-posterior and superior-inferior dimensions	Changes in lateral dimensions
Inspiration	<p>① Inspiratory muscles contract (diaphragm descends; rib cage rises)</p>	 <p>Ribs elevated and sternum flares as external intercostals contract</p> <p>Diaphragm moves inferiorly during contraction</p>	 <p>External intercostals contract</p>

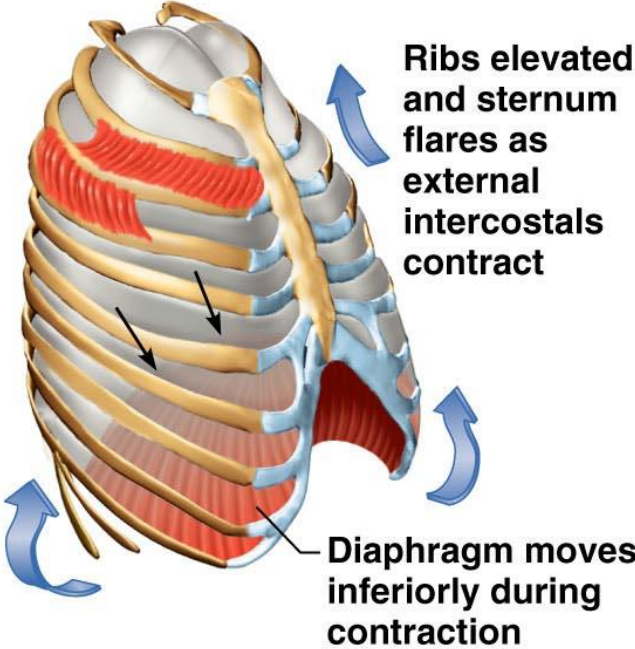
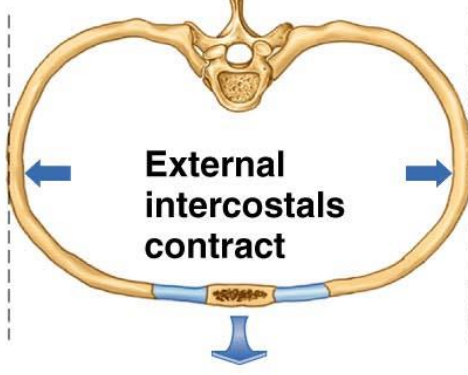
Inspiration (Inhalation)

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Inspiration	<p>① Inspiratory muscles contract (diaphragm descends; rib cage rises)</p> <p>↓</p> <p>② Thoracic cavity volume increases</p>	 <p>Ribs elevated and sternum flares as external intercostals contract</p> <p>Diaphragm moves inferiorly during contraction</p>	 <p>External intercostals contract</p>

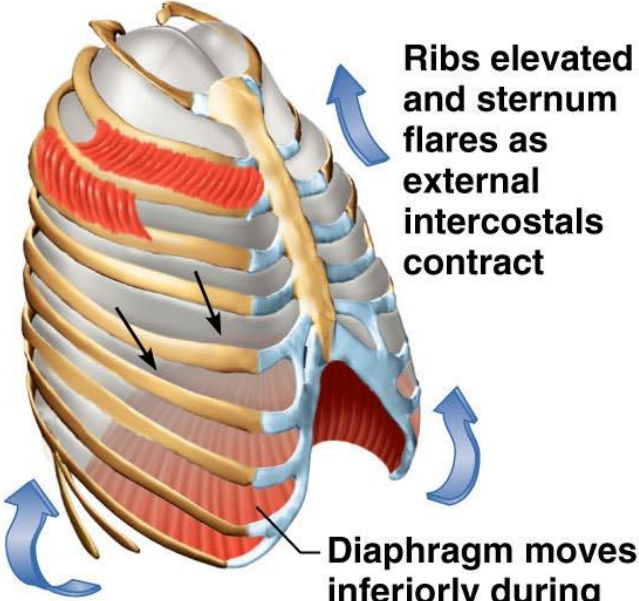
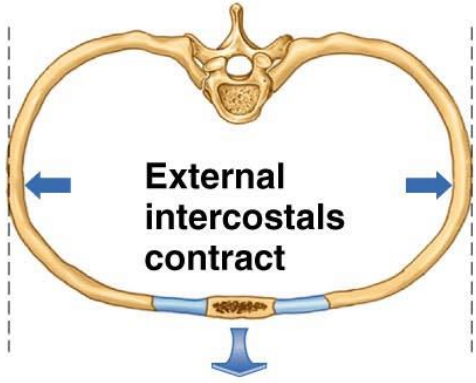
Inspiration (Inhalation)

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Inspiration	<ol style="list-style-type: none"> ① Inspiratory muscles contract (diaphragm descends; rib cage rises) <li style="text-align: center;">↓ ② Thoracic cavity volume increases <li style="text-align: center;">↓ ③ Lungs stretched; intrapulmonary volume increases 	 <p>Ribs elevated and sternum flares as external intercostals contract</p> <p>Diaphragm moves inferiorly during contraction</p>	 <p>External intercostals contract</p>

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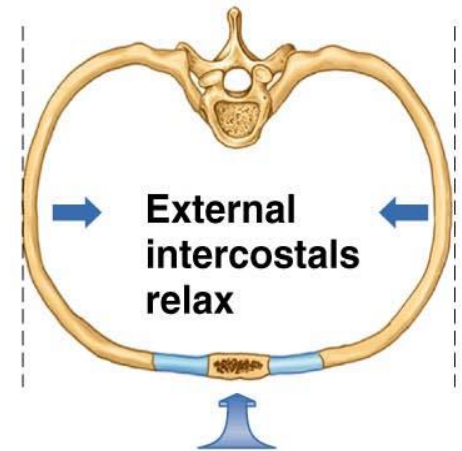
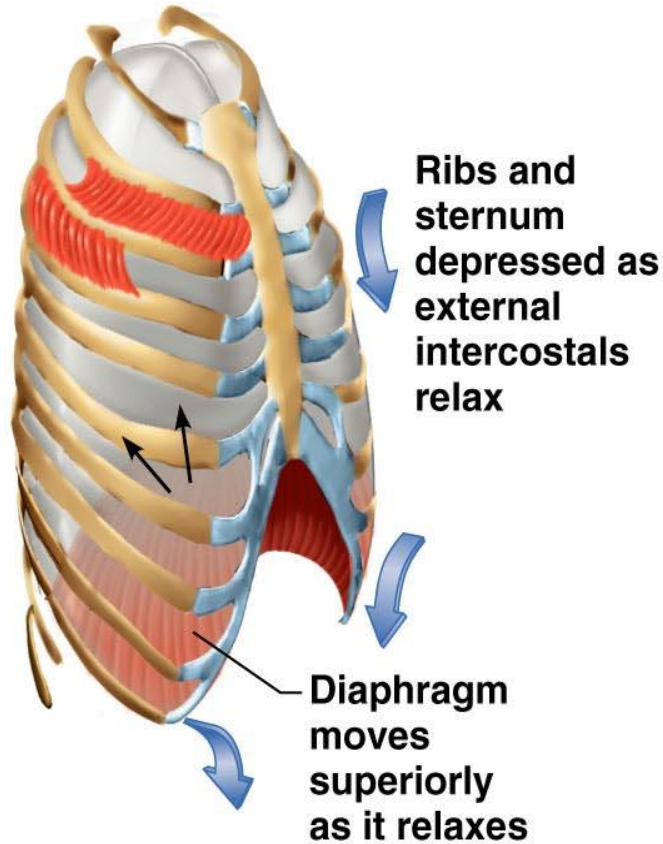
Expiration (Exhalation)

- Also due to the pressure gradient → exact opposite!
- Usually a passive process → inspiratory muscles relax and pressures increases
- Forced expiration – active process → contraction of the abdominal wall muscles (obliques and transversus abdominis)

Expiration (Exhalation)

Expiration

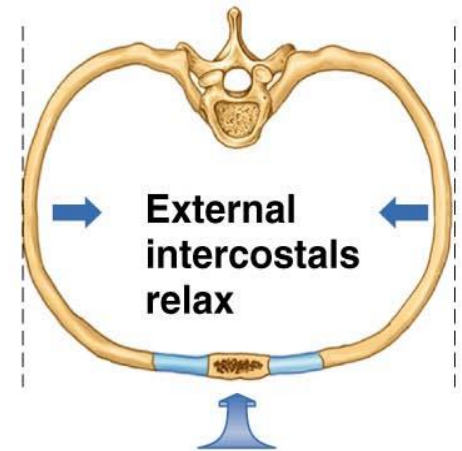
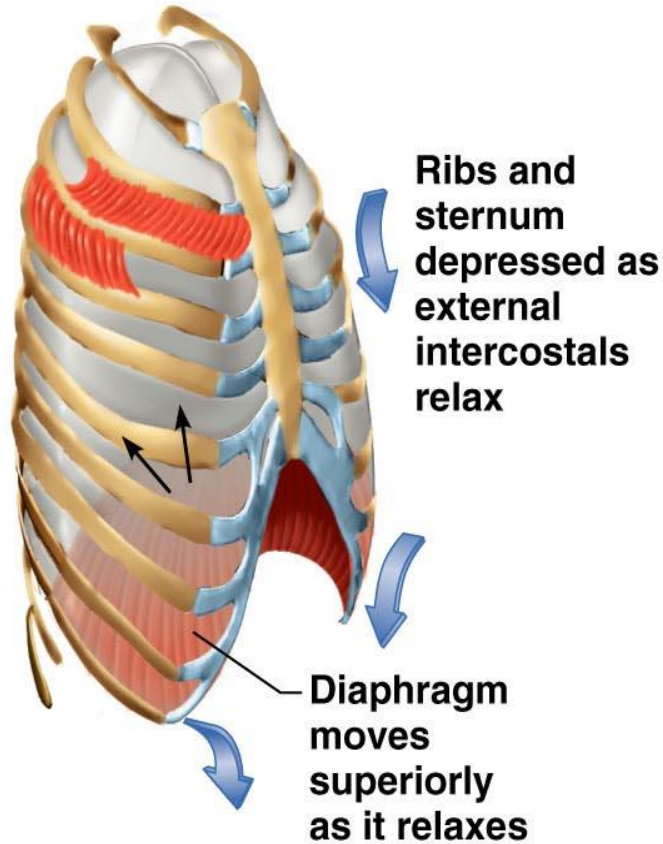
- ① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages)



Expiration (Exhalation)

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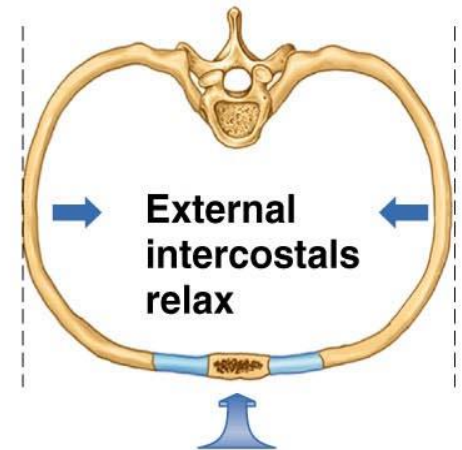
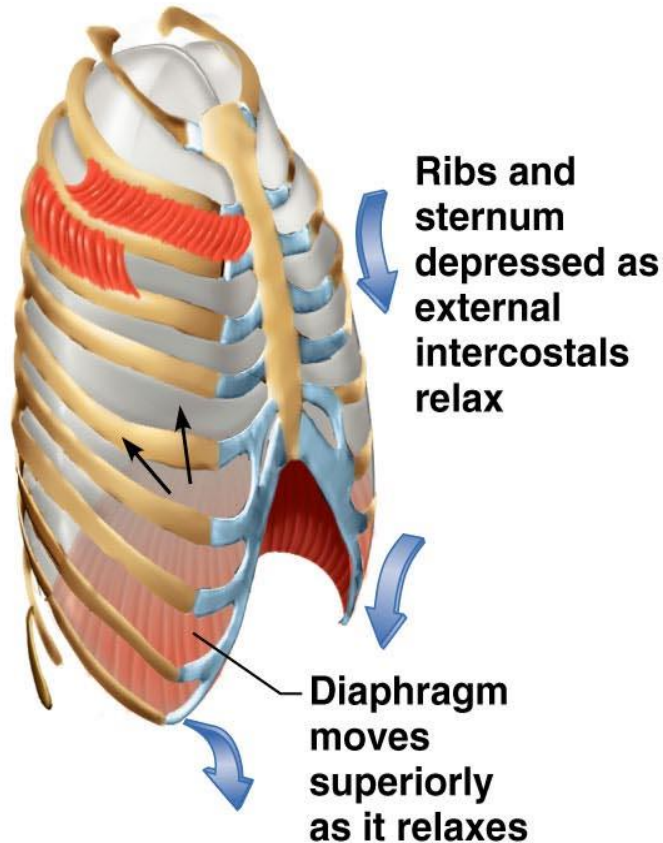
- ① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages)
- ② Thoracic cavity volume decreases



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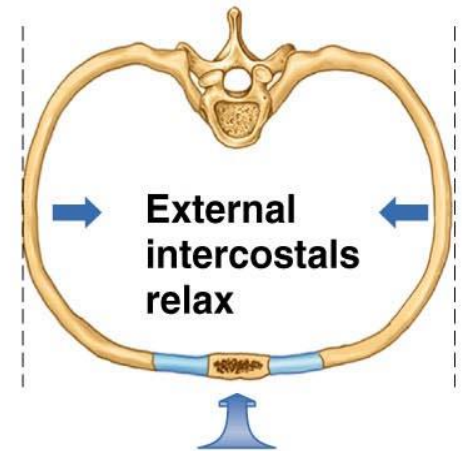
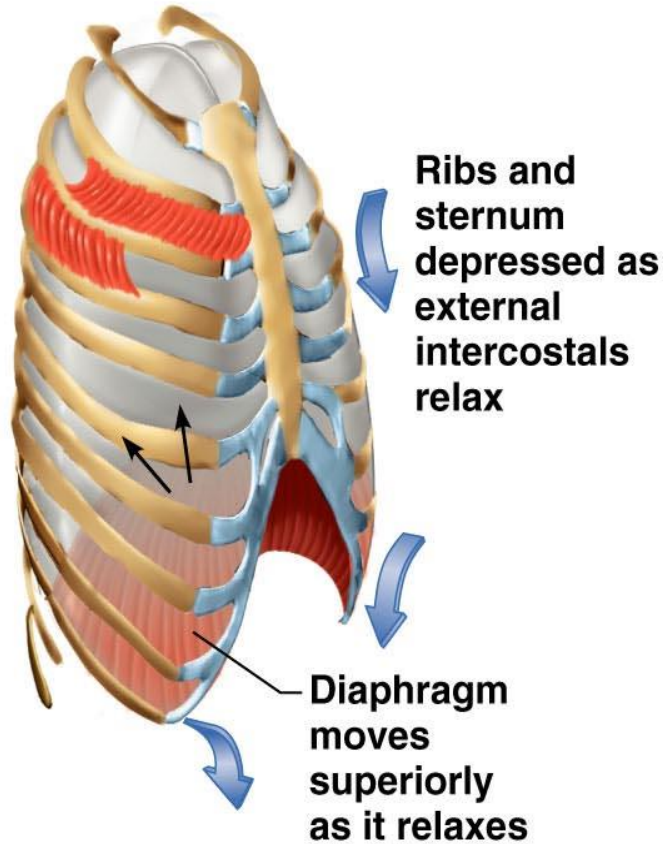
- ① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages)
- ② Thoracic cavity volume decreases
- ③ Elastic lungs recoil passively; intrapulmonary volume decreases



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Expiration

- ① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages)
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- ② Thoracic cavity volume decreases
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- ③ Elastic lungs recoil passively; intrapulmonary volume decreases
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- ④ Intrapulmonary pressure rises (to +1 mm Hg)



Expiration (Exhalation)

Expiration

- ① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages)
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- ② Thoracic cavity volume decreases
↓
- ③ Elastic lungs recoil passively; intrapulmonary volume decreases
↓
- ④ Intrapulmonary pressure rises (to +1 mm Hg)
↓
- ⑤ Air (gases) flows out of lungs down its pressure gradient until intrapulmonary pressure is 0

