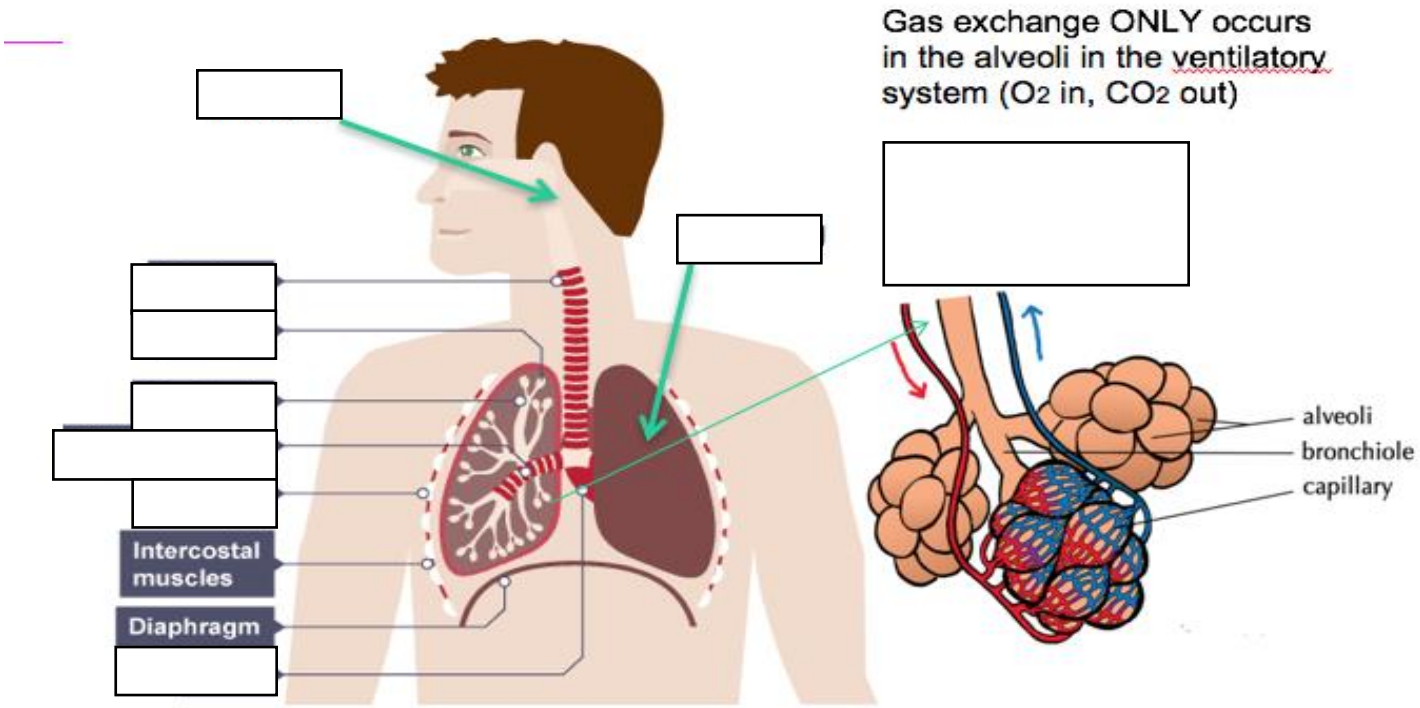
Exercise Physiology

2.1.1 List the principal structures of the ventilatory system

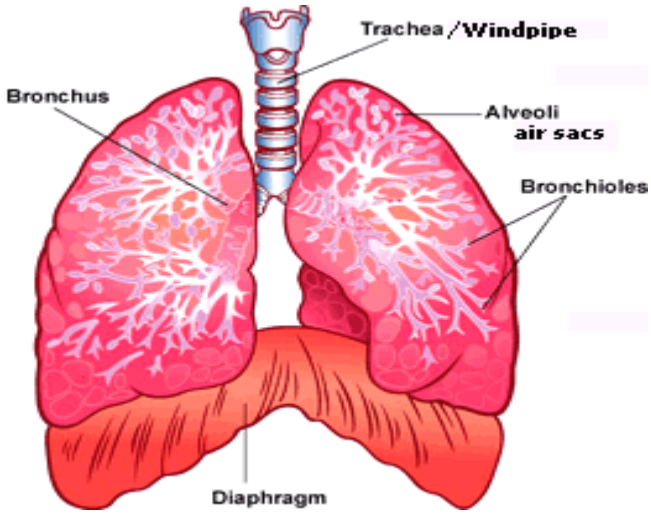
- The principle structures of the respiratory system are:
  - **Nose/Mouth –** used for inhalation of oxygen-rich air and expelling carbon dioxide rich air
  - **Pharynx -** passageway leading from the oral and nasal cavities in the head to the larynx
  - **Larynx (voice box) -** tubular structure connected to the top of the trachea
  - **Trachea (windpipe) -** conveys air from the larynx to the two main bronchi, with the lungs and their air sacs as the ultimate destination
  - **Bronchi (bronchus singular) -** airway in the respiratory tract that conducts air into the lungs. Bronchi will branch into smaller tubes that become bronchioles.
  - **Bronchioles -** any of the minute branches into which a bronchus divides.
  - **Lungs -** each of the pair of organs situated within the rib cage, consisting of elastic sacs with branching passages into which air is drawn, so that oxygen can pass into the blood and carbon dioxide be removed.
  - **Alveoli -** any of the many tiny air sacs in the lungs where the exchange of oxygen and carbon dioxide takes place.
  - **Diaphragm** - a dome-shaped, muscular partition separating the thorax from the abdomen in mammals. It plays a major role in breathing, as its contraction increases the volume of the thorax and so inflates the lungs.



(You don't need to know the tricks to preventing/getting rid of a side cramp. I'm just throwing it in there.

Tricks to preventing or getting rid of a side cramp (of the diaphragm)

- **Eat mindfully pre-run.** Foods that are higher in fat and fiber take longer to digest. That doesn't mean they are bad foods, but if you eat them within one to two hours before a run, they can cause havoc—creating stomach upset, stitches, and other problems.
- **Invest in a solid warmup.** Going from sitting to running speed can create irregular, rapid-fire breathing patterns, which can translate to you bending over in pain on the side of the road
- **Regulate your breathing.** Match your breathing to your strides—inhaling for two to four strides and exhaling for the same. The faster the pace, the shorter the sequence (fast pace = one or two strides per breath, slower = three or four strides per breath). This can not only prevent stitches, but also improve the efficiency of your oxygen transport.

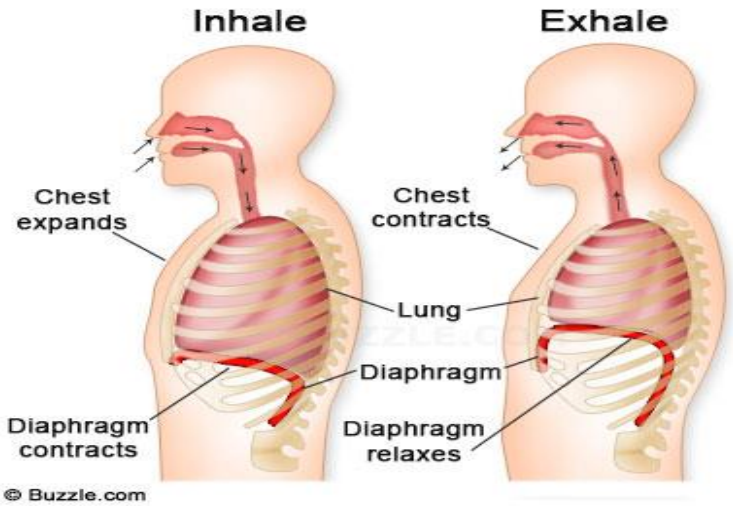


- **Slow down and exhale to release the stitch.** If you still get another side cramp, implement this strategy and it will go away in seconds (I promise). Slow your pace and exhale as the foot on the opposite side of the cramp strikes the ground. When you exhale, you relax the muscles of your diaphragm. When this happens in unison with your foot striking the ground, the impact forces travel up the body and through your core (your side too) and exacerbate (piss off) the muscles in spasm creating that stitch. When you change the side of the landing forces to the opposite side, the tension causing the stitch releases.

2.1.2 Outline the functions of the conducting airways (see 2.1.1 above too)

- Breathing based on physics
- Air flows from areas of high pressure to low pressure
- Inhalation occurs when the air pressure in the lungs is lower than in the atmosphere

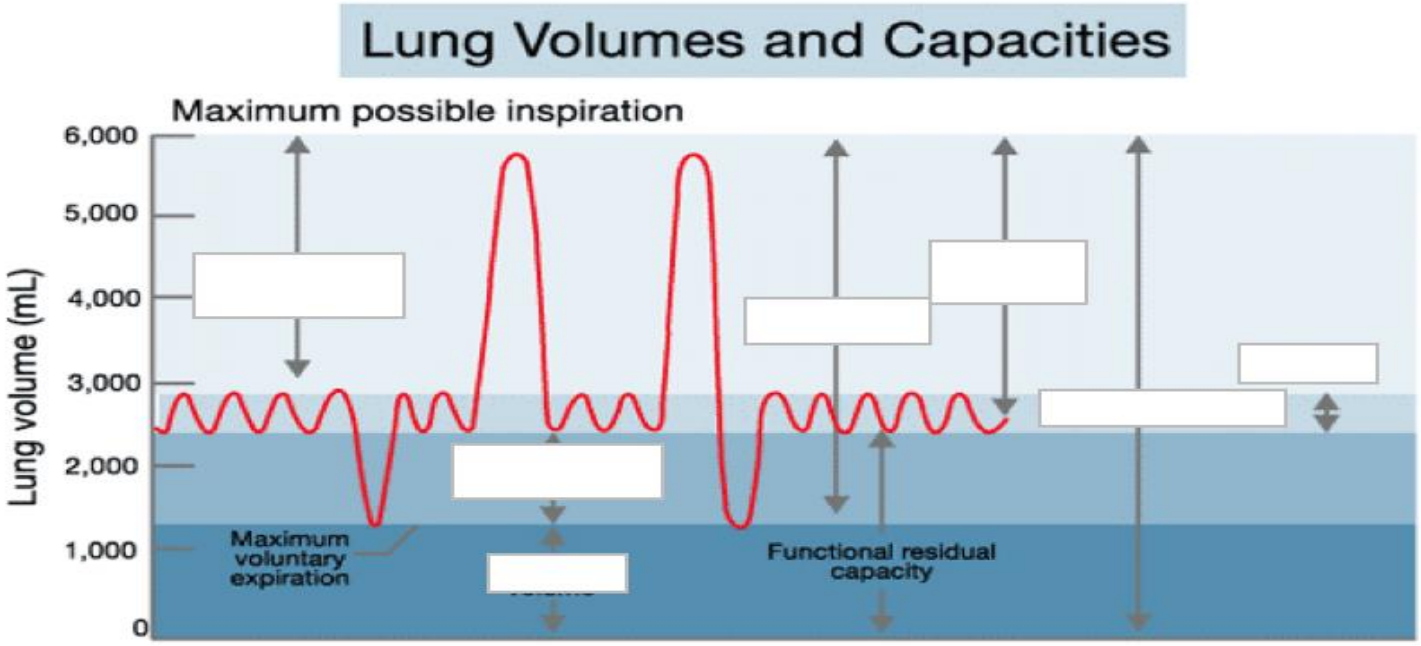
- At rest, inhalation caused by diaphragm contraction
- Diaphragm pulls downward (contracts) and creates a vacuum in the chest cavity by increasing lung volume.
- Draws air in due to pressure imbalance



- The exhalation process is passive (no energy required) because as the diaphragm relaxes it returns to original position, shrinking lung volume and creating greater pressure in the lungs compared to atmosphere.

- During exercise, more oxygen is needed in the active muscles and more carbon dioxide is being produced.
    - More air needs to be inhaled and exhaled at a faster rate
    - Additional muscles must be recruited to make this happen - external intercostal muscles (chest muscles), abdominals and even shoulders can assist in increasing lung volume
    - Compression also can use the contractions of these muscles to expel air faster thus increasing respiration rate.
    - Uses/needs an incredible amount of energy

2.1.3 Define respiratory terms

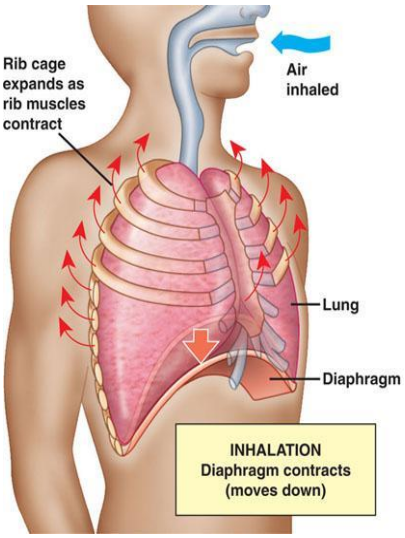


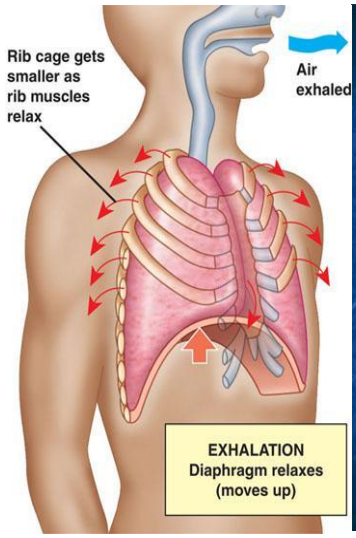
- **Atmospheric pressure –** pressure exerted by the weight of the atmosphere
- **Intra alveolar (intrapulmonary) pressure –** pressure of the lungs relative to the atmosphere
- **Pulmonary ventilation -** is commonly referred to as breathing. It is the process of air flowing into the lungs during inspiration (inhalation) and out of the lungs during expiration (exhalation).
- **Total Lung Capacity (TLC) –** the amount of gas contained in the lung at the end of a maximal inhalation
- **Tidal volume (VT) –** the amount of air moving into and out of the lungs while at rest.
- **Vital Capacity (VC) –** the greatest volume of gas that, following maximum inhalation, can be expelled during a complete, slow, forced exhalation
- **Expiratory reserve volume (ERV) –** the additional maximal volume of air that can be **expelled from the lungs** by forced exhalation after normal exhalation (after lowest tidal volume)

- **Inspiratory reserve volume (IRV)** - the additional maximal volume of air that can be **drawn into the lungs** by forced inhalation after normal inhalation (after highest tidal volume)
- **Residual Volume (RV) - volume** representing the amount of air left in the lungs after a forced exhalation; this **volume** cannot be measured, only calculated.

In other words…..

- **Total lung capacity** can be calculated by adding **vital capacity** to **residual volume** of the lungs.
  - During normal, quiet respiration, about 500mL of air is inspired. The same amount of air moves out with expiration. This volume of air is called the **tidal volume.**
  - When we forcibly take a deep breath, we can take in up to 3100mL above the tidal volume. This additional air is the **inspiratory reserve volume.**
- We can also forcibly exhale. This is termed the **expiratory reserve volume.**
  - Even after the expiratory reserve volume is expelled, some air is still trapped in the lungs because of pressure. This is called the **residual volume.**
  - This also allows for uninterrupted gaseous exchange during the breathing cycle.





Composition of Inhaled & Exhaled Air

Components of air	Inhaled air	Exhaled air
Oxygen	21%	16%
Carbon dioxide	0.03%	4%
Nitrogen	78%	78%
Water vapour	Varies (depends on the humidity of air)	More (usually saturated)
Dust particles	Varies	Usually none
Temperature (heat)	Varies (follows atmospheric temp.)	Body temperature

2.1.4 Explain the mechanics of ventilation in the human lungs (See 2.1.2 above above too)

- VE ($L.min^{-1}$) = VT ($L.Breath^{-1}$) x Bf ($breaths.min^{-1}$)

- VE = volume of air being exhaled per minute
- VT = tidal volume
- Bf = breathing frequency (breaths per minute)

TO DO

Complete the table below that presents some data collected during an exercise test.

	EXERCISE INTENSITY DURING RUNNING AT PROGRESSIVELY FASTER SPEEDS						
	Rest	8 $km.h^{-1}$	10 $km.h^{-1}$	12 $km.h^{-1}$	14 $km.h^{-1}$	16 $km.h^{-1}$	18 $km.h^{-1}$
V_T ($L.br^{-1}$)	0.67	2		3.3	3.6		4
B_f ($br.min^{-1}$)	12		22.3	24.2		30	38
$\dot{V}_E$ ($L.min^{-1}$)	8	40	58		98	115	

↑ Table 2.1: Comparison of $\dot{V}_E$, V_T and B_f values at rest and during incremental exercise

As exercise intensity increases, how is the increased ventilation achieved?