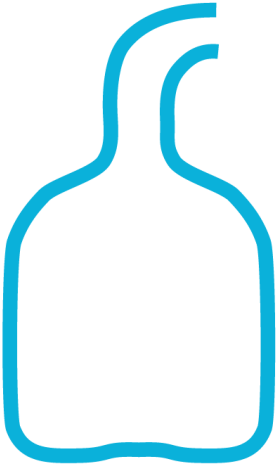
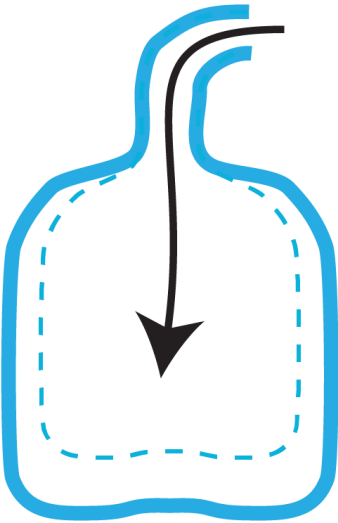
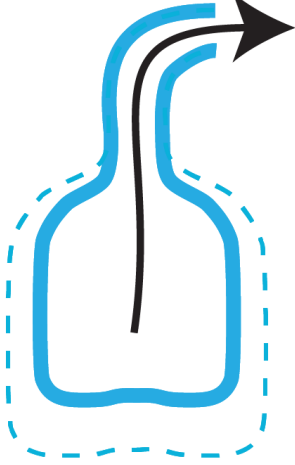


C.4.2. The Pleura.

A. How do the lungs really Inspire and Expire?

<p>1. How does air go in and out of the lungs? There are many ways to tell this story but I have chosen to start with a flexible bottle ... like a balloon.</p>	<p>2. In the diagram below, you see, left, a sketch of a normal open bottle. For the fun, I have rendered the neck of the bottle into something that is similar to the respiratory upper ways.</p>
<p>3. As this bottle is open, the air inside is at equilibrium (= same pressure) with the air outside and air will not flow in or out of the bottle.</p>	<p>4. To get air to flow into the bottle, the size of the bottle has to increase (middle sketch). This is the inspiration.</p>
<div style="display: flex; justify-content: space-around; text-align: center;"> <div data-bbox="288 837 564 1384"> <p>normal</p>  </div> <div data-bbox="628 837 967 1442"> <p>inspiration</p>  </div> <div data-bbox="1031 837 1326 1384"> <p>expiration</p>  </div> </div> <p style="text-align: right; font-size: small;"><i>BasicPhysiology.org</i></p>	
<p>5. To get air to flow out of the bottle, the size of the bottle has to decrease (right sketch). This will increase the pressure inside and therefore push the air out. Simple!</p>	<p>6. As we have seen in the previous page, the movements of the diaphragm and of the rib cage make the size of the “bottle” (i.e., the lungs!) increase and decrease.</p>

B. Air Pressures:

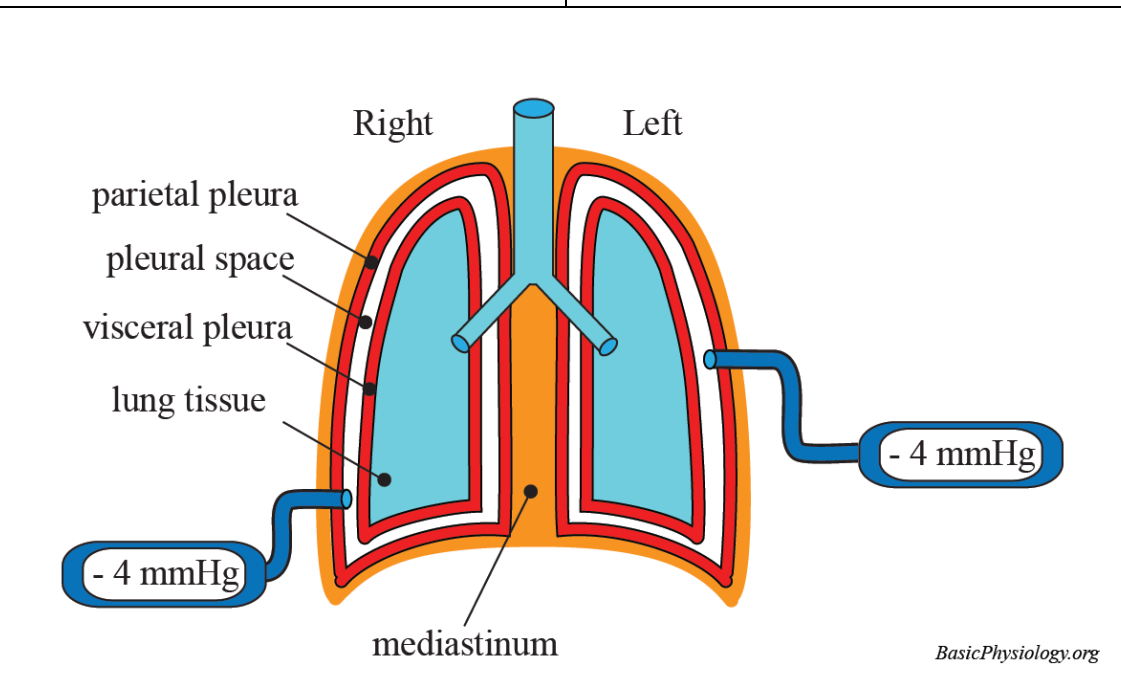
<p>1. As discussed above, the flow of air in or out of the lungs is totally determined by the pressures inside and outside of the lungs.</p>	<p>2. If the pressure inside the lungs is lower than outside, then air will flow into the lungs (inspiration). If the pressure inside is higher, air will flow out of the lungs (expiration).</p>
<p>3. What is the pressure actually outside? In reality, this pressure is the atmospheric pressure; the column of air that weighs down upon us.</p>	<p>4. This pressure amounts, at sea level, to about 760 mmHg. This varies a bit according to the weather etc.</p>
<p>5. So, the pressure outside is (about) 760 mmHg. The pressure inside the lungs, normal size, is obviously the same (at least, when your mouth and nose are open!).</p>	<p>6. If the lungs increase in size (larger volume), then the pressure will (slightly) decrease, and this will create an inflow of air. The opposite occurs when the lung volume is reduced; then the pressure is increased and air is squeezed out.</p>
<p>7. This is how the lungs work; by increasing its size, air is inspired. And when the lungs are squeezed, air is expired.</p>	<p>8. The principle is similar to that used in bellows. <i>(see diagram in the first page of the Respiratory System).</i></p>

C. Complication!

<p>1. The lung is actually a very delicate and fragile organ.</p>	<p>2. If the surface of the lung were simply fixed to the inside of the chest wall, then the pushing and the pulling, the constant stretching and compressing by the ribs will bruise and damage the lung surface.</p>
<p>3. Therefore, a special system has been built between the lungs and the rib cage to protect the delicate lungs and, at the same time, to “fasten” or to fix the lungs to the rib cage.</p>	<p>4. This special system consists of:</p> <ol style="list-style-type: none"> 1. two pleura's 2. the pleural space 3. the pleural fluid 4. the pleural pressure.

D. The two pleura's:

<p>1. The lungs are covered with a special membrane called a 'pleura'. Because it is fixed to the lungs, this membrane is called the visceral pleura (viscera = internal organ).</p>	<p>2. There is a second pleura, that covers the inside of the chest wall. This is called the parietal pleura (parietal = partition).</p>
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------



<p>3. Between the two pleurae's, there is a fluid (= pleural fluid) to lubricate the two surfaces. This lubrication is necessary because when one breathes, as the lungs expands or deflate, the two pleura will rub against each other. <i>Try this at home!</i></p>	<p>4. The space between the two pleura's is called the pleural space. Note that the right and the left lungs each have their own parietal and visceral pleura and therefore their own pleural space.</p>
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

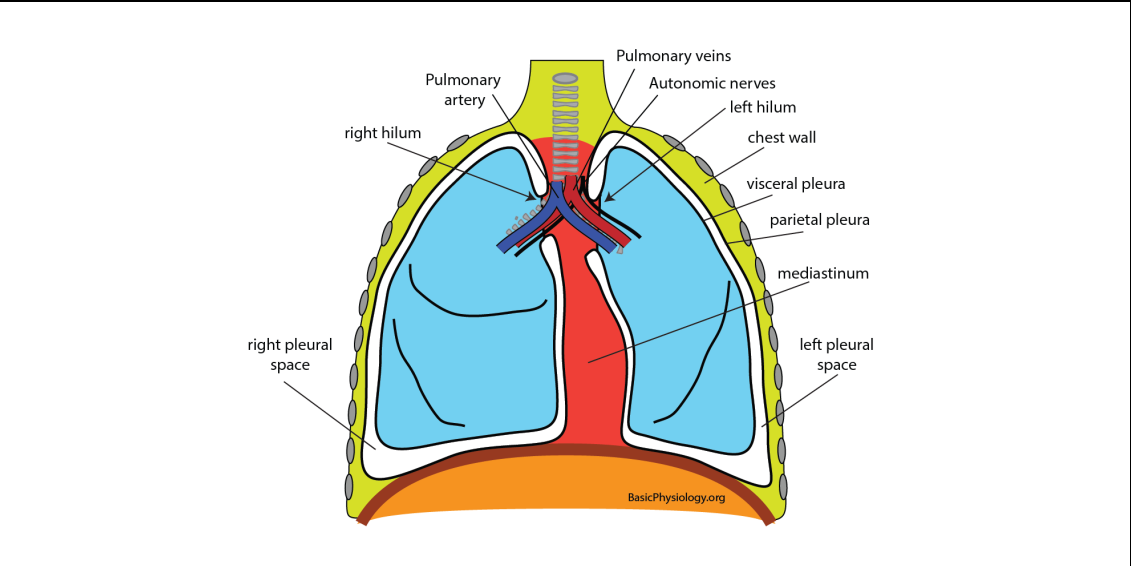
<p>5. This makes that the two pleural spaces are NOT connected to each other. In fact, this divides the chest into a right lung cavity and a left lung cavity.</p>	<p>6. Note that the pleural space space is actually quite small, about 100 ml (50 ml each).</p>
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------

Try this at home!: Take two hard but flat surfaces. Two glass plates are ideal but you can also try this with two flat plastic surfaces. Place them on top of each other and rub one on top of the other. Notice how rough this actually is. Now place some water between the two plates and rub again: Aaah! This is much smoother! If the pleural space is dry, as in **pleuritis** (= infection of the pleura), then the two pleurae will rub against each other without the lubrication of the pleural fluid and this is painful!

E. The Hilum

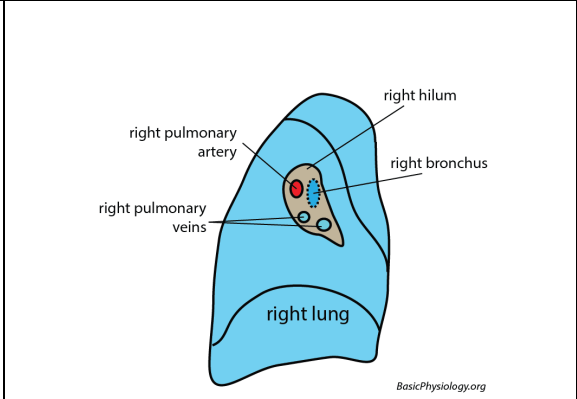
1. Ok, we now have two separate spaces or sacks inside the chest; the right and the left pleural space (=lungs). But how do air and blood get in and out of these pleural sacks?

2. That is the task of the lung **hilum** (=lung roots, pleural ‘hili’).



3. These are like a fold or a root, one for the right and one for the left lung where the blood can go in and out and where the left and right bronchia connect to the lungs.

Note that the artery here is colored blue and the veins red! *Why did I do that?*



4. In the second diagram, we see the right hilum with the entry and exit sites for the right bronchus, the right pulmonary artery, the two right pulmonary veins and the lymph vessels (not shown) and the nerves (also not shown) and the bronchial circulation (also not shown). The left hilum looks very much the same.

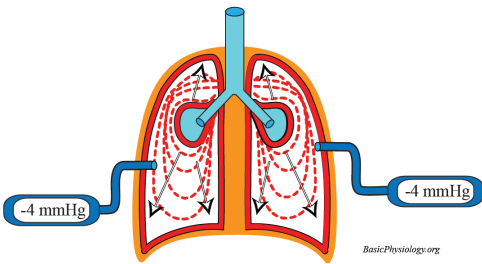
5. Remember that there is a third ‘space’ inside the chest; the **mediastinum**. This space, located between the two lungs, contains the heart, all the major blood vessels, the trachea and the esophagus. It is the central ‘shaft’ inside the chest.

Because the arterial blood from the right heart is oxygen-poor while the venous blood, having been oxygenated in the lungs, is now oxygen-rich.

F. The Pleural Space

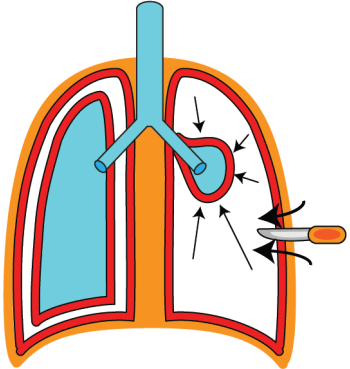
1. The pleural space is crucial to a proper functioning of the lungs!	2. The point is that the pressure inside the pleural space is lower than that in the lungs itself or outside the chest. Not much, by about 4 mmHg, but that is enough.
3. What do you think will happen when the air pressure in the pleural space is lower than the atmospheric pressure?	4. If the pressure in the airspace is lower than the atmospheric pressure, then the two pleurae's will be "sucked" against each other.
5. You can compare this with the situation when you inflate a balloon. If you inflate a balloon (put higher pressure in it), the balloon will expand.	6. But if you suck the air out of the balloon, then the balloon will shrink and the walls of the balloon will "stick to each other".
7. There are, in daily life, many examples where a slightly lower pressure is put to good use.	8. Here are a few examples: <ul style="list-style-type: none"> a. sucking a fluid through a drinking straw b. drawing a fluid into a syringe c. inspiration!

G. The Lung expansion

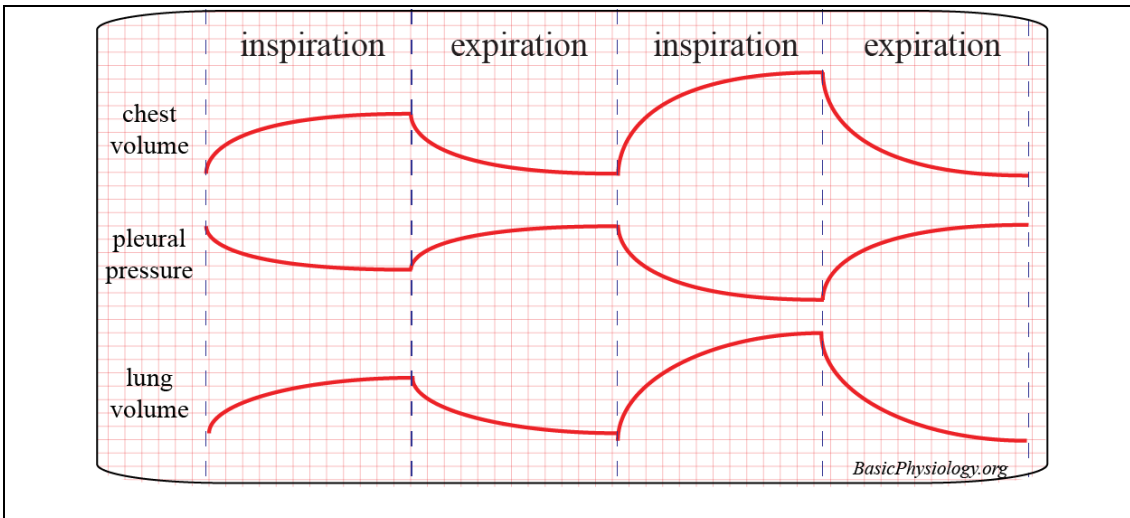
1. The lungs themselves are very elastic . If you would take them out of the chest, they would collapse into a small ball.	2. But, inside the chest, the pleural pressure is less than the pressure outside.
 <p>The diagram shows a cross-section of the lungs within the chest cavity. The lungs are depicted in orange and red, with a blue trachea and bronchi. The pleural space is shown as a thin layer between the lungs and the chest wall. Two blue tubes are connected to the pleural space, each labeled '-4 mmHg', indicating the negative pressure. Arrows point from the tubes towards the pleural space. The text 'BasicPhysiology.org' is visible at the bottom right of the diagram.</p>	3. The ribs, if they were not strong, would collapse under this negative pressure like the balloon when you suck the air out.
<p><i>animation?</i></p>	4. But because the ribs and its cage are strong, the visceral pleura, with the lungs attached to it, is now pulled towards the parietal pleura as shown in the diagram .
5. Therefore, this negative pleural pressure will make the visceral pleura 'stick' to the parietal pleura.	6. The beauty of this arrangement is that the pleurae are 'stuck' to each other but not 'fixed' so they can still slide along each other.

<p>7. This sliding is made easier because of the pleural fluid to lubricate this friction.</p>	<p>8. This is exactly what constantly happens during our inspiration and expiration.</p>
----------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------

H. Pneumothorax.

<p>1. But there is a risk!! The risk is what happens if you get a hole to the pleural space.</p>	<p>2. If for some reason there is a hole in the pleura, then air will flow into the pleural space, the pleural pressure will immediately become equal to the outside pressure and, <i>pfhee...</i>, the lungs will collapse!</p>
<p>3. This condition is called a pneumothorax (pneumo = air in the chest (=thorax)).</p>	 <p><i>animation?</i></p>
<p>4. The hole can be located either through the parietal pleura or through the visceral pleura.</p>	
<p>5. A hole through the parietal pleura is most often caused by a trauma, a knife, a bullet, a car accident etc. Something sharp has punched a hole through the rib cage.</p>	
<p>6. A hole through the visceral pleura is often caused by the bursting of one or more alveoli to the pleural space. Often because of wear and tear, too much coughing, smoking etc.</p>	<p>7. In most cases, the pneumothorax is one sided; either the left or the right lung collapses.</p>
<p>8. If by accident, both lungs collapse, meaning that there are two holes occurring simultaneously (both pleural spaces are not connected remember?), then you are really unlucky. Both lungs will collapse and you die immediately!</p>	<p>9. With one lung collapsed however, you don't die, as the other normal lung is enough to keep you alive! But a collapsed lung is painful and you need help.</p>

I. Pleural Curves:



<p>1. The three curves drawn above shows the changes in volumes and pressures during the breathing of the lungs.</p>	<p>2. When the chest expands (by flattening the diaphragm and raising the ribs), then the volume in the chest increases.</p>
<p>3. This increase in chest volume will, by itself, lower the pleural pressure.</p>	<p>4. This decrease in pleural pressure will “stretch” the lungs towards the chest wall thereby increasing the lung volume.</p>
<p>5. Since there is an opening between the lungs and the outside world (through the respiratory airways), air will then flow into the lungs: inspiration!</p>	<p>6. The same chain of events occurs during expiration, only in the opposite direction! (decrease in chest volume > decrease in pleural pressure > decrease in lung volume > expiration).</p>