BIOLOGY 12 - RESPIRATION - CHAPTER NOTES

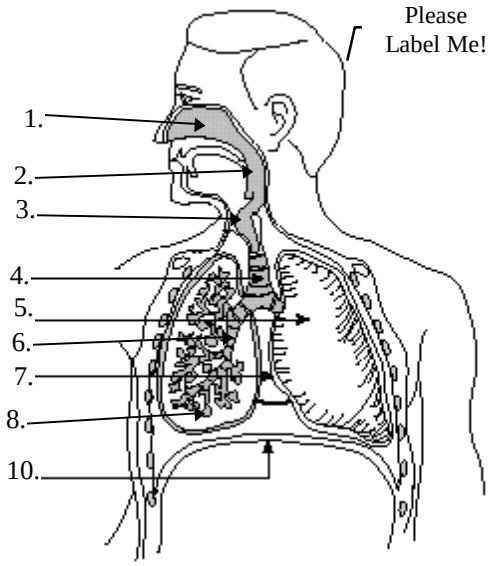
- *We often think of respiration as just **breathing**. In fact, breathing is just one part of this physiological process. As biologists, we divide respiration up into **four areas**:*

	the movement of air into and out of the lungs
	the exchange of O_2 and CO_2 between **AIR** and **BLOOD**.
	the exchange of O_2 and CO_2 between **BLOOD** and **TISSUE FLUID**
	the process which produces **ATP** in mitochondria --> requires O_2 and releases CO_2

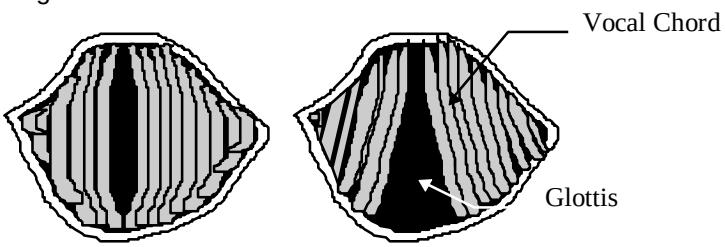
BREATHING: BRINGING AIR TO THE LUNGS

- "_____" - breathing air in
- "_____ - breathing air out

1. Air enters the nasal passages.
   - **hairs** and _____ trap dust and debris
   - the air is _____ and _____
2. The warmed and moistened air passes through the _____ (a common passage for food and air).
   - the nose itself contains two nasal cavities (narrow canals with convoluted lateral walls that are separated from one another by a _____). The nasal cavities are connected by tubes to the tear ducts (which is why you get a runny nose when you cry), and to the ears via the _____.
   - Special ciliated cells at the top recesses of the nasal cavities are _____.



- When we breathe, the _____ (the opening to the _____ ("voice box")) is open, and when we swallow, the _____ covers the glottis.
3. The air enters the_____. It is like a triangular box with the _____ _____at the front corner.
- Elastic ligaments called _____stretch from the back to the front of the larynx just at the sides of the glottis.



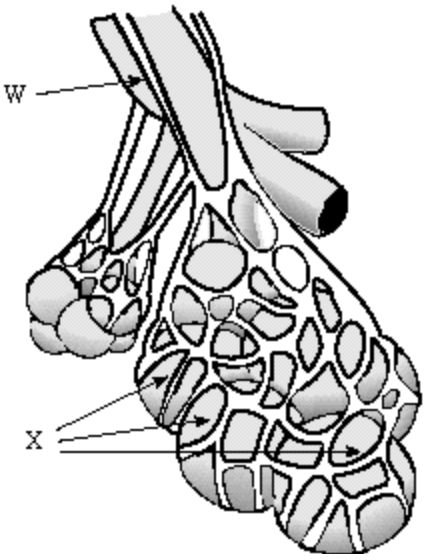
Narrow Glottis
High Pitch

Wide Glottis
Low Pitch

- These cords _____ when air is expelled past them through the glottis. This vibrations produce sound.
- The_____of the voice depends on the length, thickness, and degree of elasticity of the vocal cords and the tension at which they are held.
- _____ adjust the tension of the chords to produce different sounds.

4. The air enters the _____ (windpipe). The trachea is held open by cartilaginous rings, and is _____ _____ _____ _____The cilia beat upward to move up mucus and any dust or particles that were inhaled or accidentally swallowed. _____ **can destroy cilia**.
- **Tracheostomy**: an operation in which an incision is made into the trachea below a blockage (and a tube is then inserted).

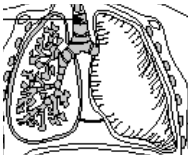
5. The trachea divides into two _____ which branch into many smaller passages called **bronchioles** that extend into the lungs.
6. The bronchioles continue to branch out, and as they do, their walls get thinner and diameter smaller. Each bronchiole ends in sacs called _____**l**, which fill up much of the lungs.
- There are approximately _____ _____ _____**per**



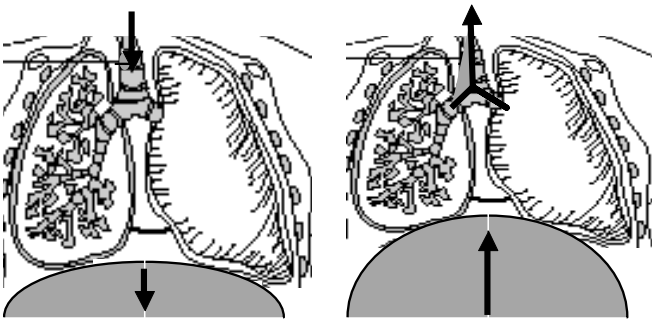
Capillary network around alveoli

lung, for a total of 150 m^2 of alveolar area (at least 40 time the area of the skin).

- Each alveolar sac is enclosed by a single layer of _____ _____ _____ _____, which is surrounded by _____carrying _____ _____. _____ _____ occurs between blood and air in alveoli.
- The alveoli are lined with a film of_____to prevent them from collapsing when air leaves them.



  - The lungs themselves are _____ _____that lie on both sides of the heart in the thoracic cavity. The branches of the pulmonary arteries follow the bronchial tubes and form a mass of capillaries around the alveoli. The right lung has 3 lobes and the left lung has 2 lobes. A lobe is divided into lobules, each of which has a bronchiole serving many alveoli.
  - Because so lungs contain so much air space, they are very light, and would **<u>float</u>** in water.
- Breathing is powered by the_____, a thick, dome-shaped muscle on the floor of the thoracic cavity (chest cavity).
- Lungs are enclosed by two _____ _____. One pleural membrane lines the chest walls, and an inner membrane lines the lung. In between is fluid. This makes for an **<u>air-tight</u>** seal.
- What powers breathing? Creating "_____ _____" powers breathing. Negative pressure is air pressure that is **less** (756 mm Hg) than the pressure of the surrounding air (760 mm Hg). This negative pressure is created by _____ _____ _____inside the _____ **cavity**. Air will naturally move in to fill this partial vacuum. The space in the thoracic cavity is made bigger by the _____ of the _____ _____ (this makes it move downward and become less dome shaped). When the diaphragm contracts, the space within lungs _____.



- The muscles attached to the ribs, called _____ _____, will also _____ when you breathe in. This contraction pulls the _____ _____ _____, further increasing the space within the thoracic cavity.
- The air pressure in the lungs becomes less than the atmospheric pressure. Air naturally rushes **into** the lungs to fill this natural vacuum.
- When the _____ _____, it _____ _____and when the _____ _____ _____the _____ _____ _____ _____ _____. This **decreases** the volume in the thoracic cavity, and **air is forced out** of the lungs (_____).

CONTROL OF BREATHING

- _____ _____ _____ _____ _____ _____ **<u>control the</u>** _____ _____**.**

1. CO_2 levels in the blood will increase as cells continue to produce it. The concentration of CO_2 will increase until they reach a _____ _____.
2. _____ in arteries detect the increased CO_2 and H^+ levels.
3. The chemoreceptors send a signal to a _____ _____in the _____ _____of the brain. It detects the rising levels of CO_2 and H^+. This center is not affected by low oxygen levels. There are also chemoreceptors in the **carotid bodies**, located in the carotid arteries, and in the **aortic bodies**, located in the aorta, that respond primarily to H^+ concentration, but also the level of carbon dioxide in the blood. These bodies communicate with the respiratory center.
4. The _____ _____ _____ _____ _____to the _____ **and** _____ **in the** _____ _____.
5. The diaphragm contracts and lowers, while the rib cage moves up.
6. Air flows into alveoli, and the _____ _____ _____ _____ _____ .
7. _____ _____in the **alveoli walls** detect this stretching.
8. _____ in **alveoli** send signal to brain to_____the _____ _____from sending its message to the diaphragm and rib muscles to contract. They therefore stop contracting.

9. The diaphragm _____, and moves _____, resuming its original shape. The rib cage _____ and moves _____and _____.
10. Air is forced out the lungs.

- Thus, carbon dioxide levels in blood regulate breathing rate. Therefore, it is better to **not** give pure oxygen to a patient to get breathing going (should be a mixture of oxygen and carbon dioxide).
- The breathing rate is also subject to _____ _____ _____. *Why do you suppose that is?*
- Average human breathes in, on average, **500 ml** of air per breath (this is called the _____ _____). The **vital capacity** is the **maximum** that can be breathed in per breath, and averages as much as **6000 ml**.)
- Only about **350 cc** of the 500 cc normally breathed in actually gets down deep enough to reach the Alveoli. The other part of this air is stuck in bronchioles and doesn't get to the alveoli. This area is called the "Dead Air Space". Breathing through a long tube increases the amount of dead space beyond maximum inspiratory capacity. Thereafter, death will occur because the air inhaled never reaches the alveoli. This is why you can't breathe for very long through, for example, a garden hose.
- Also, some air (called _____ _____") remains in lungs after expiration (about 1000 ml).

EXTERNAL RESPIRATION: EXCHANGE OF GASES IN THE LUNGS

- External Respiration _____ _____ _____ _____ **(at alveoli) and blood (in _____ _____).**
- Both alveoli walls and capillary walls are _____ **cell layer thick**.
- This exchange of gases is by _____ **alone**. (recall that _____ _____ _____states that material will flow from area of high concentration to area of low concentration).

	$[O_2]$	$[CO_2]$
capillaries	low ↑	high ↓
alveoli	high	low

- Deoxygenated blood is high in CO_2, which is carried as **bicarbonate ion (HCO_3^-)**.

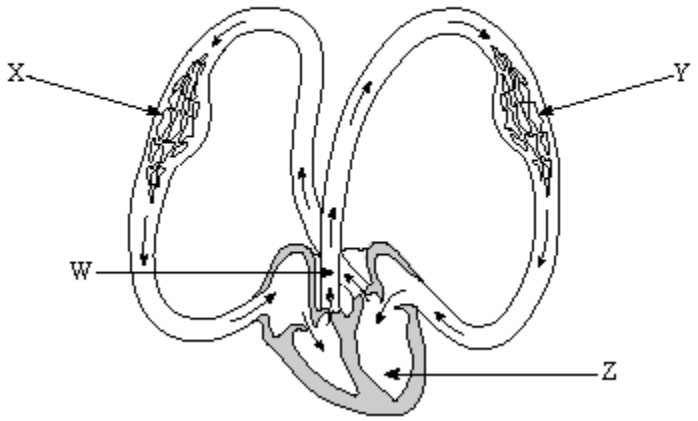
carb**onic anhydrase** in RBC

$H^+ + HCO_3^-$ ----------> $H_2O + CO_2$

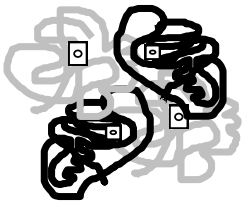
in blood <---- to alveoli

- The above reaction is driven **to the right** as CO_2 leaves the blood, and is sped up by the enzyme **carbonic anhydrase** in red blood cells.

The reaction $CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$ occurs in which area of the diagram below?



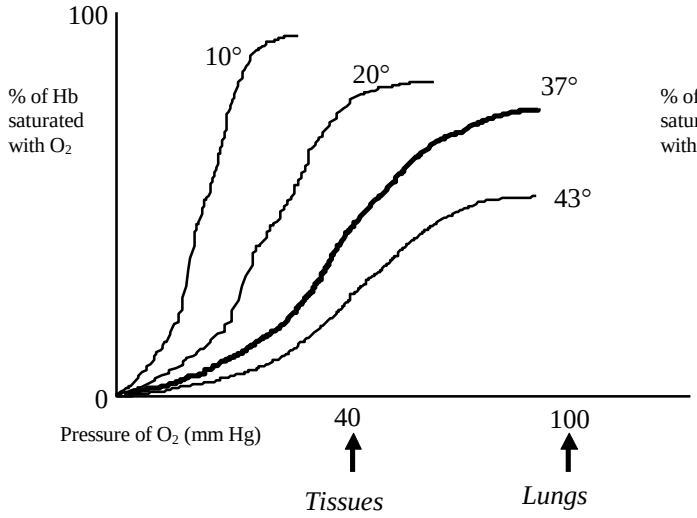
- _____ is an iron-containing respiratory pigment found within red blood cells.
- There are about ____ _____ hemoglobin molecules per RBC.
- Hemoglobin increases the _____ _____ _____of blood by _____**X**.
- Hemoglobin is composed of **4 polypeptide chains** (a _____") connected to 4 **heme** groups (contain **iron**).
- The iron portion forms a **loose association with O_2**. Four O_2 bind per hemoglobin molecule.
- **How** does hemoglobin work? It is **more attracted** to oxygen in _____ _____ _____ _____, and **less attracted** to oxygen in the more _____ _____ _____. Hb will bind O_2 in the lungs, and release it in tissues.



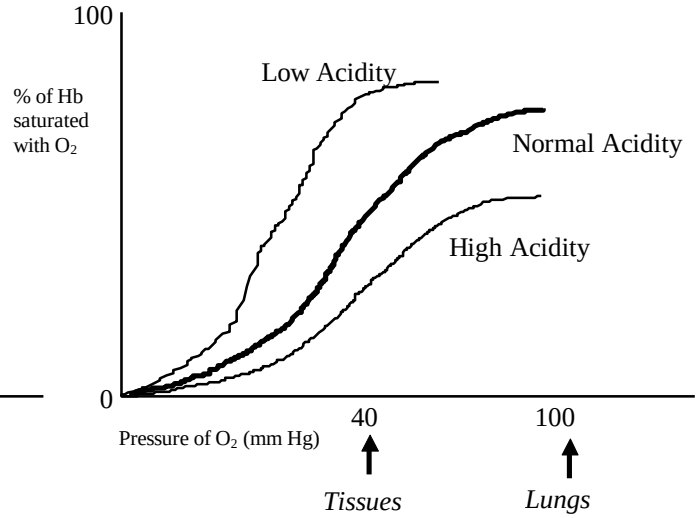
_____ _____ _____	LUNGS ----------> <---------- TISSUES	_____
reduced Hemoglobin *dark purple*		*oxyhemoglobin* *bright red*

- Hemoglobin takes up O_2 in increasing amounts as Pressure of O_2 increases until about 100 mm Hg.
- **Temperature Effects**: Hb takes up O_2 more readily in low temperatures (lungs), gives up O_2 more readily at higher temperature.
- **pH Effects**: Hb takes up O_2 more readily in the more basic or neutral lungs, and gives it up more readily in the more acidic tissues.

Affect of Temperature on Hb Saturation



Affect of Acidity on Hb Saturation



INTERNAL RESPIRATION: EXCHANGE OF GASES IN THE TISSUES

- Internal respiration is the **exchange of O_2 and CO_2 between** _____ **and** _____ _____.
- Oxygen diffuses from the systemic capillaries (blood) into _____ _____. HbO_2 -----> Hb + O_2
- Tissue fluid is low in O_2, high in CO_2, due to constant cellular respiration. CO_2 therefore diffuses into the blood.

The Fate of CO_2

- A **small amount** of CO_2 is taken up by hemoglobin.

Hb + CO_2	TISSUES ----------> <---------- LUNGS	$HbCO_2$ *CARBAMINOHEMOGLOBIN*

- **Most** CO_2 combines with H_2O to form **carbonic acid**, which then dissociates to H^+ and HCO_3^-.

$CO_2 + H_2O$ ----> H_2CO_3 ----> H^+ + HCO_3^-
to Hb *to Plasma*

⇒ ***Note***: ***Hemoglobin combines with the excess H^+*** *that this reaction produces. That way,* _____ _____*remains* _____. *You could say that Hemoglobin acts like a* _____

CELLULAR RESPIRATION: PROCESS THAT PRODUCES ATP IN CELLS

occurs in the mitochondria inside cells:

$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O +$ **ENERGY** (i.e. 38 ATP)
glucose

Cellular Respiration converts **glucose** (and **fatty acids)** to **ATP**, the cell's primary energy molecule, as well as lesser amounts of other energy rich molecules. (i.e. if you run out of glucose & fatty acids, then your body will start "burning" protein to make energy)

RESPIRATORY DISORDERS

1. **Common Cold**: Caused by **viral infection**. About 150 viruses known to cause colds.
- Mild symptoms: sore throat, watery mucusy nasal discharge.
- No Cure -- treat symptoms. Antihistamines, decongestants, ASA, rest.
2. **Influenza**: a more severe viral infection.
- Symptoms include fevers, aches, cold symptoms. **Vaccines** have been developed, but the virus is constantly **mutating** into new forms. Over 20,000,000 people died in a flu epidemic in 1919-20.
3. **Bronchitis**: usually caused by viral infection of nasal cavities that spreads to bronchi and causes a **secondary bacterial infection**.
- In **acute bronchitis**, there is heavy mucoid discharge, coughing.
- **Chronic bronchitis** is not usually due to bacterial infection, but rather to **chronic irritation of bronchial lining** (leads to degeneration of lining, loss of cilia). Chronic bronchitis is usually due to **smoking**.
- Treatment for acute bronchitis is antibiotics and rest.
4. **Pneumonia**: caused by bacteria or viruses which infect lungs. The lobes of the lungs fill up with mucus and pus.
- Many AIDS patients die of ***Pneumocystis carinii*** infection.
- Treatment is antibiotics (if bacterial), hospitalization.
5. **Emphysema**: most often caused by smoking.
- Deteriorating bronchioles ----> alveoli cut off. This leads to ballooning of lungs due to trapped air. The trapped air causes the alveoli to rupture.
- Symptoms include coughing, sluggishness, heart racing. The heart and brain starve for oxygen. May lead to a heart condition.
- Hard to treat: often surgical removal of some lung tissue helps.
6. **Tuberculosis**: caused by tubercle bacteria. Can detect with a skin test, X-Rays.
- If the bacilli invade lungs, cells the invaders with capsule called **tubercles** (a defense mechanism). This may kill sufferer.
- Treatment: quarantine, antibiotics, other drugs.
7. **Lung Cancer**: Smoking is the #1 cause! (see text).
- Lung cancer is a progressive disease --> early detection is important.

Progress of disease:

1. Lungs exposed to **carcinogenic irritants**.
2. Bronchial cells **thicken**, callus, cilia die.
3. "**Atypical**" cells start appearing in thickened lining ("in situ" cancer).
4. Some of these cells break loose and penetrate other tissues (= **metastasis**). This is the point where true cancer begins.
5. **Tumor**(s) grow, tubes become blocked, lung collapses, secondary infections can occur.

- **Treatment**: chemotherapy, surgery, pneumonectomy (remove lung).

*Smoking Risks (a **partial** list):*

• lung cancer	• bronchitis/emphysema
• larynx cancer	• peptic ulcers
• bladder cancer	• reduced lifespan
• pancreas cancer	• weak immune system