Unit 4

Animal Systems: Respiration, Circulation and Immunity

Biology 30
Mr.Oosterom

Dynamic Equilibrium

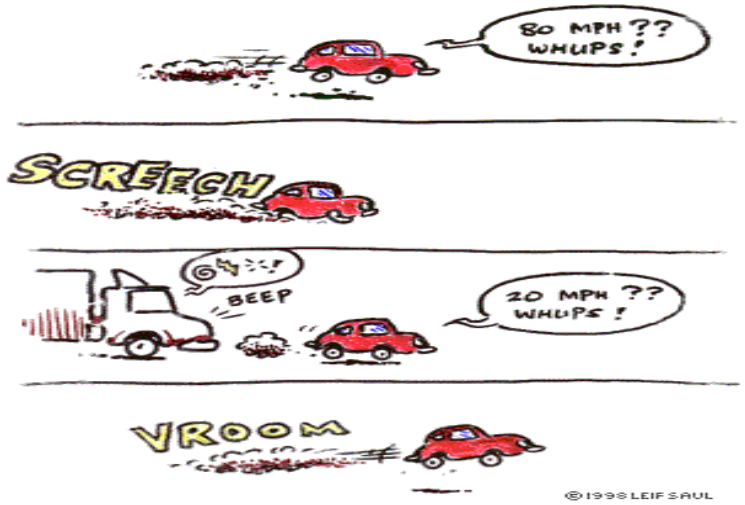
- A state of balance in an environment
- Achieved by internal control mechanisms that counteract outside forces that could change the inside environment (body)

Homeostasis

The steady state of conditions inside a living organism that allows it to function properly

Homeostasis is the dynamic equilibrium of the internal environment of the human body

Not too fast… Not too slow

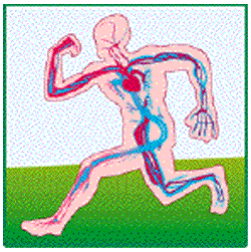


Examples of Homeostasis

- Temperature Regulation
- Food and Water Balance
- Regulation of blood sugar levels
- Regulation of blood calcium levels

Body Systems Involved in Homeostasis:

- Nervous System
- Endocrine System
- Circulatory System
- Digestive System **
- Excretory System **



** We will discuss these in limited detail. The others along with the reproductive system will be in great detail.

Temperature Regulation

- **Homeotherms**
  - Warm blooded - body temperature stays relatively constant (Endotherm)
  - birds and mammals

- **Poikilotherms**
  - Cold blooded animals - body temperature fluctuates depending on their environment (Ectotherm)
  - Lizards

How is temperature controlled?

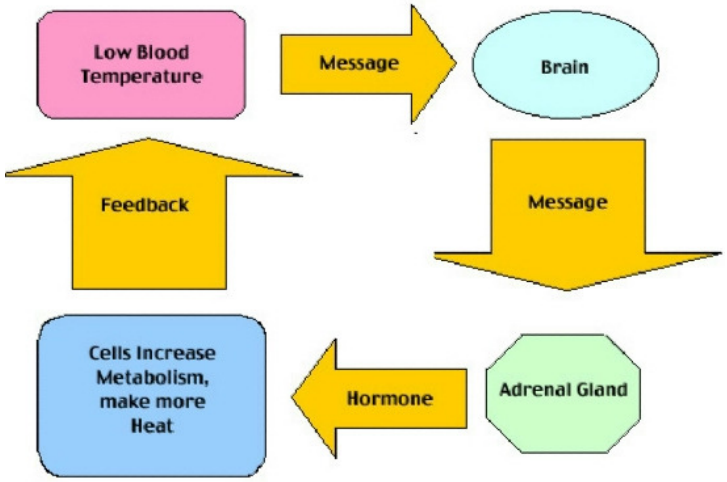
- Behaviourally
  - wearing more or less clothing
  - Excercising
- Physiological
  - Shivering
  - Vasoconstriction
  - Vasodilation
  - Sweat

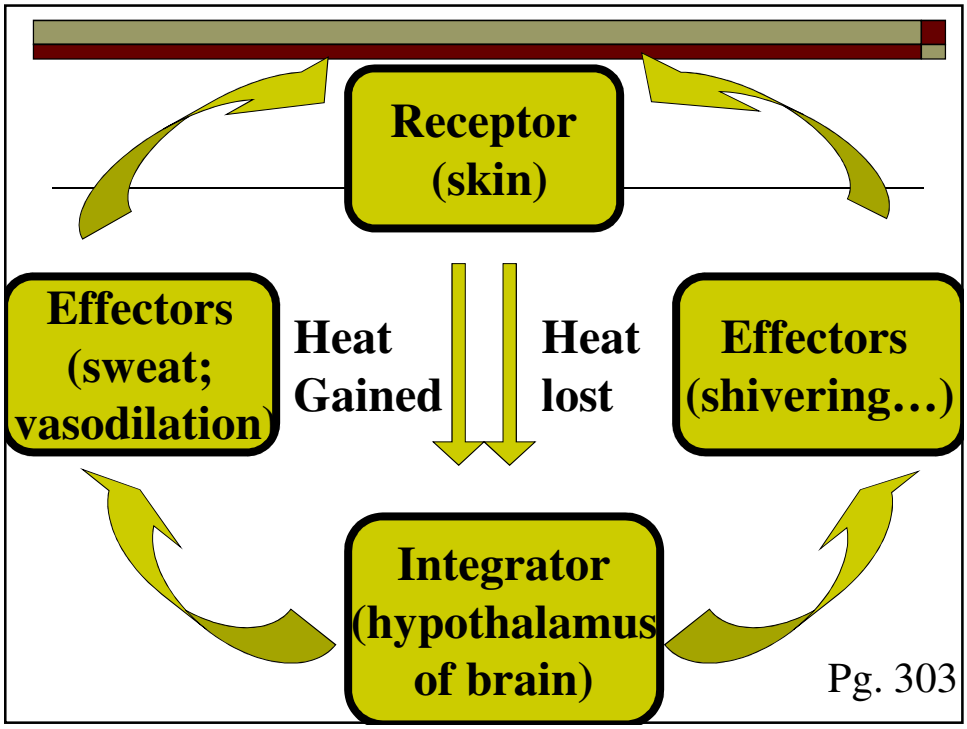
Physiologically - how does it work?

- Negative Feedback Loop
  - Receptor (Skin)
  - Integrator (Brain)
  - Effector (Sweat or shiver))

See Pg. 302-303 in textbook

Negative Feedback Loop Example





Negative Feedback Loop

- A process by which a receptor, an integrator and an effector detects, processes and produces a response to a change in a body constant (for example temperature) so that a reverse affect may take place, enabling the body to stay constant.

Receptors

- Found in every body organ and tissue.
- Send nerve impulses to the brain as a result of environmental stimulants.
- They are the first part involved in a negative feedback loop.

Integrator

- Sends messages to effectors.
- Acts as a messenger between the brain and muscles or organs
- An example is the hypothalamus of the brain.

Effectors

- **Causes a change in internal conditions based on external stimuli**
  - **Sweat glands are an example that enable the body to cool off when they produce sweat.**

Why do we breathe?

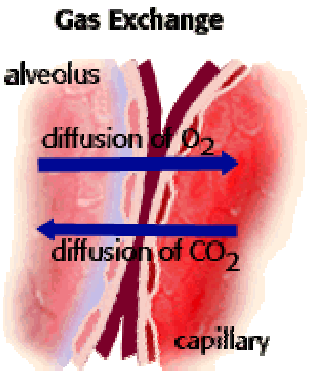
- Cells carry out the reactions of cellular respiration in order to ***produce ATP***. ATP is used by the cells for energy.
- All organisms need energy, therefore all organisms carry out cellular respiration.
- The energy needed to produce ATP comes from glucose. As we saw in the previous slides, glucose is produced by photosynthesis.
- The equation for cellular respiration is:

$$C_6H_{12}O_6 + \mathbf{6O_2} \rightarrow \mathbf{6CO_2} + 6H_2O + 36\ ATP$$

  - How do we get this oxygen, and get rid of the CO_2?

Function of the respiratory system

- **Gas exchange**
  - **CO_2 must be able to leave each cell**
  - **O_2 must be able to enter each cell**
- **Diffusion**
  - **What types of diffusion are involved?**
- **How are these gases transported to all the cells in the body?**



- **Simple diffusion**
- **Facilitated diffusion**

The Requirements

- Though different organisms have different respiratory systems, they function is the same
- There are TWO requirements for a respiratory system
  1. **Respiratory surface** – There must be a large surface area available for gas exchange to take place efficiently
  2. **Moist environment**

The Lung

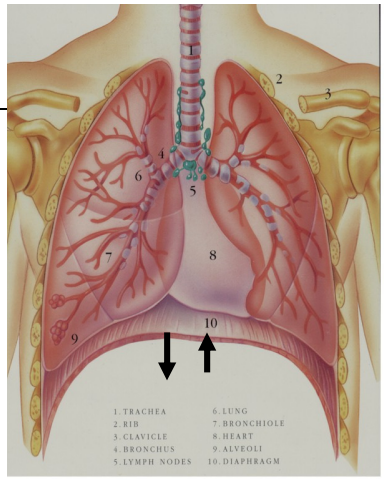
- The internal respiratory surface which is connected to the air by a series of passageways.
- Would you expect there to be differences in lungs between species?
  - Fig. 10.3

This tiger salamander, will lose its gills as it grows older, and will develop lungs to breathe air.

This is unlike most salamanders, which don't have lungs. Why do you think this is?

The Lung

- Three Basic Elements
  - Moist surface area
  - Means of forcing air to come in contact with lung surface
  - Circulatory system to carry the gases between lungs and other cells

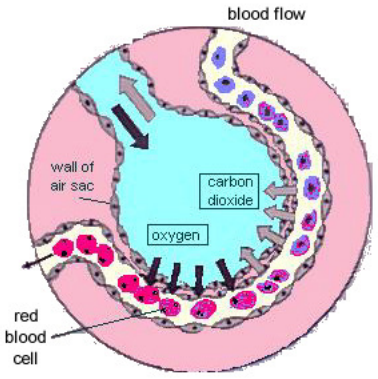


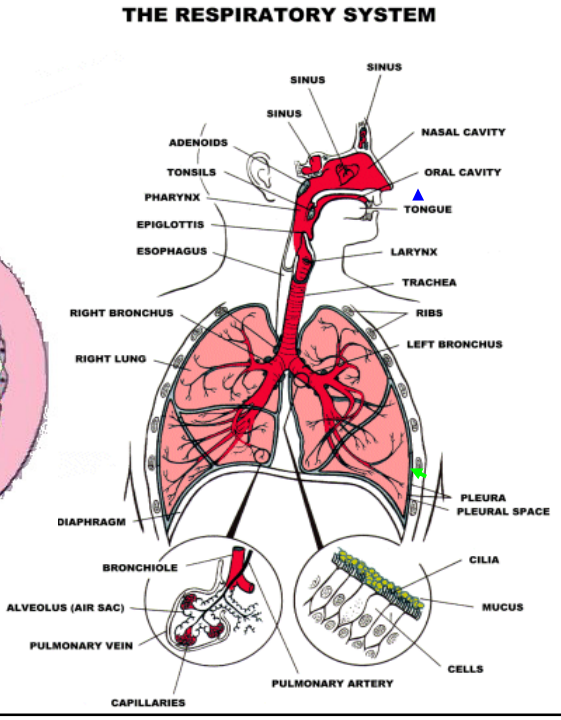
Levels of Respiration

- **At which locations does gas exchange occur?**

- **External** – Exchange of CO_2 for O_2 between the air and the blood
- **Internal** – Exchange of CO_2 for O_2 between the blood and the cells
- **Cellular –** Series of complex reactions that that take place in the mitochondria to make ATP

Respiratory Tract



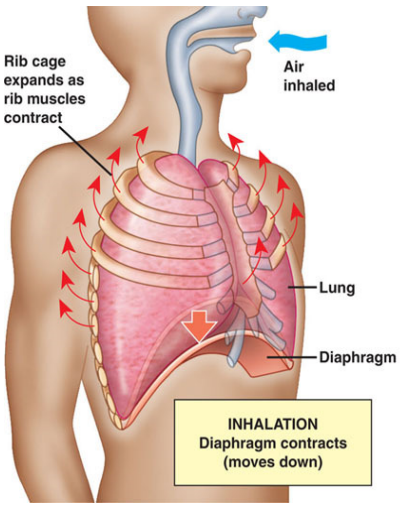


Pathway of a breath of air to the lungs (Page 335 & 337 in textbook)

1. Air enters via the **nostrils** or the **mouth**
   - Nostrils are preferred. Why?
2. **Nasal cavity** or **oral cavity**
   - Depending on the entrance of the air
   - Cilia in the nasal cavity help to filter out dust
   - Air is warmed and moistened
3. **Pharynx** (throat)
   - collects incoming air from the nose and mouth
4. **Glottis**
   - Opening to the trachea (windpipe)
   - Closed by the **epiglottis** when eating

5. **Larynx** (voice box)
   - Contains the vocal cords
6. **Trachea**
   - Carries air to the bronchi
   - Supported by semi-circular cartilage rings
   - **What would happen if these were not present?**
7. **Bronchi (sing. Bronchus)**
   - Carries are into each lung
   - Branches off into smaller **bronchioles**
8. **Alveoli**
   - Moist sacs – are the site of actual gas exchange
   - One cell thick and surrounded by a dense network of capillaries

Mechanics of Breathing - Inhaling



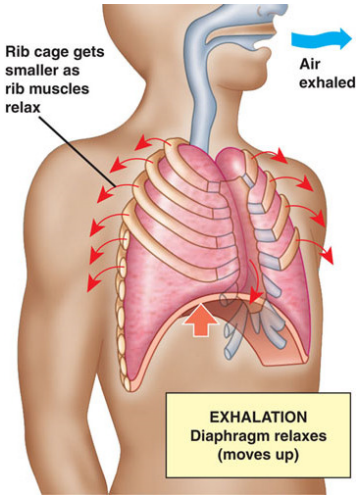
Inhalation

- The intercostal (rib) muscles contract, lifting the ribcage up and out
- The diaphragm contracts and pulls downward
- This negative pressure causes air flow into the lungs enabling them to inflate

Mechanics of Breathing - Exhaling

Exhalation

- The intercostal (rib) muscles relax, lifting the ribcage down and in
- The diaphragm relaxes and pushes downward
- This, now, positive pressure causes air flow out of the lungs enabling them to deflate



Exchange of Gases

Inhalation

- Oxygen must first dissolve in the fluids in the lungs
- Oxygen diffuses across the cell membranes into the capillaries (high concentration to low concentration)

Exhalation

- Carbon dioxide is dissolved in the fluids in the bloodstream
- It reaches the lungs where there is a concentration gradient allowing it to diffuse across the cell membranes and into the fluids in the lungs

Composition of inhaled and exhaled air

Constituent	Inhaled Air	Exhaled Air
Oxygen	20.9%	16%
Carbon dioxide	0.03%	4.0%
Water vapour	Variable	Variable but more than in inhaled air
Nitrogen	78.1%	78.1%
Noble gases	0.94%	0.94%

Some Lung Capacity Humour

Measuring Respiratory Volumes

- Tidal Volume (TV)
  - The volume of air inhaled and exhaled during normal breathing movement
- Inspiratory Reserve Volume (IV)
  - Additional volume of air that can be taken in over and above tidal inhalation (i.e. yawning)
- Expiratory Reserve Volume (EV)
  - Addition volume that can be forced out of the lungs over and above tidal exhalation

Measuring Respiratory Volumes

- Vital Capacity (VC)
  - Total volume of air that can be moved in and out of the lungs
  - Formula to calculate vital capacity

    VC = TV + IV + EV
- Residual Volume
  - The amount of air that remains in the lungs and respiratory system following a full exhalation
  - This **never** leaves the lungs, and the lungs would collapse if it did
- Respiratory Efficiency
  - The rate at which oxygen is transferred into the blood stream

Lung Capacity Graph

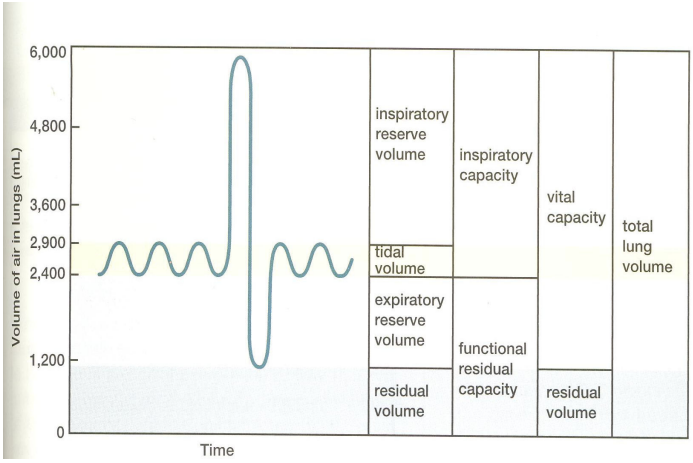


Figure 10.11 The graph shows the maximum volume of air that can be moved in and out of the lungs during a single breath: the vital capacity. The pattern shown in this graph is called a spirograph.

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Respiratory Health

- Pneumonia
  - Alveoli fill with fluid making gas exchange difficult or even impossible
- Bronchitis
  - Airways are inflamed due infection (acute) or due to an irritant (chronic). Coughing brings up mucus and pus
- Asthma
  - Airways are inflamed due to irritation, and branchioles constrict due to muscle spasms, making breathing difficult
- Emphysema
  - Alveoli burst and fuse into enlarged air spaces, reducing the surface area for gas exchange.

What Makes it all Possible?

- **The Circulatory System**
- Transporting…
  - Blood
  - Water
  - Nutrients
  - Hormones
  - Sugars
  - Toxins

Arteries

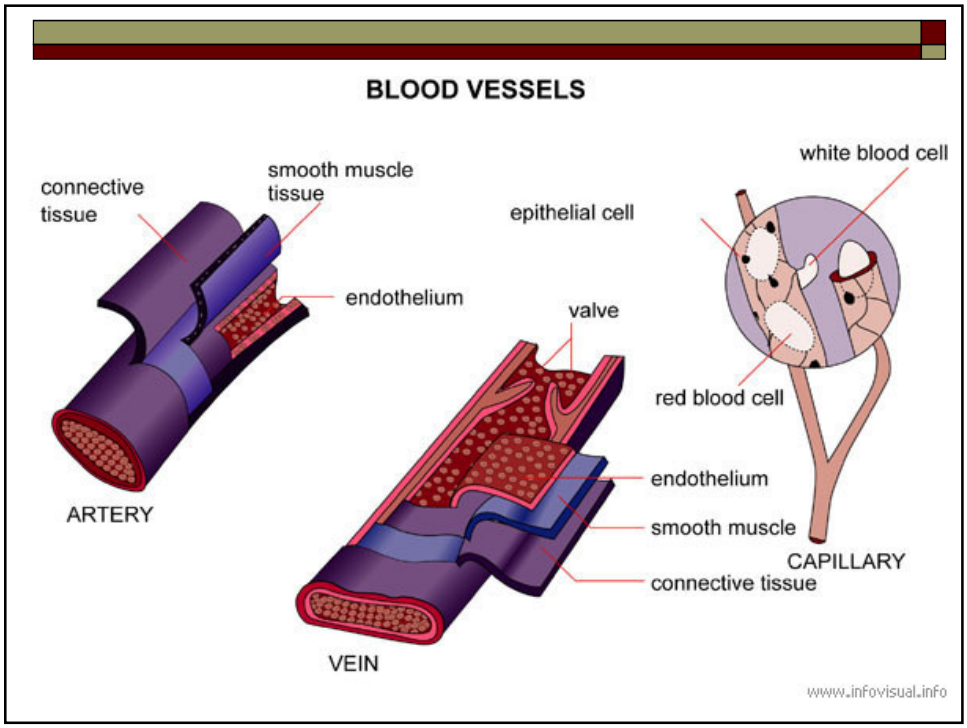
- Blood vessel that carries blood away from the heart
- Made up of elastic fibres and smooth muscle
- Thin layer of epithelial cells reduces friction
- In measuring your pulse you can feel the artery contracting and expanding

Veins

- Blood vessel that carries blood to the heart
- Has a thinner wall than arteries, but a larger circumference
- Is not elastic
- Gravity aide flow above the heart, one-way valves prevent back flow against gravity below the heart

Capillary

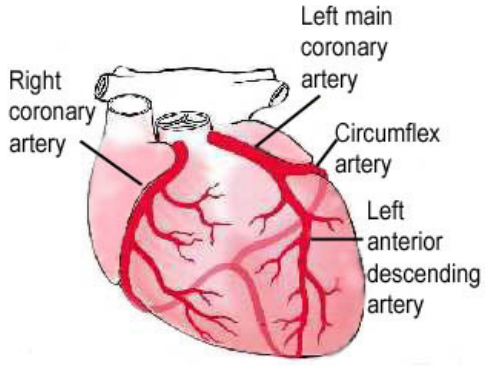
- The smallest blood vessel, only a single cell thick
- Allows for the exchange of oxygen and nutrients in the blood for carbon dioxide and wastes in the body cells.



Three Cycles of Blood Circulation

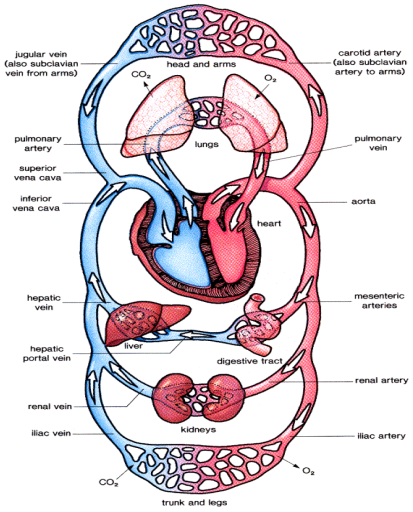
- Cardiac
  - Pathway blood takes in the heart
- Pulmonary
  - Pathway of blood from the heart to the lungs and back
- Systemic
  - Path through the rest of the body

Coronary/Cardiac Circulation

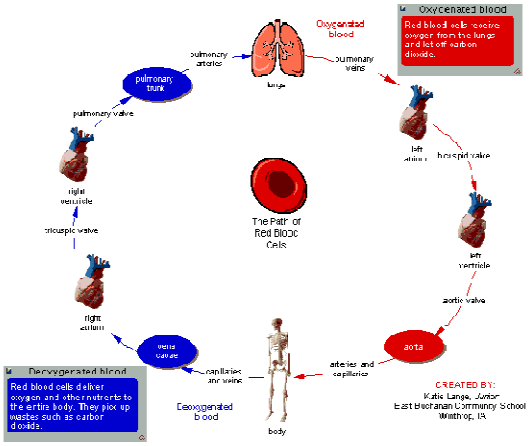


Circulation in and around the heart

Pulmonary and Systemic Circulation



Pathway of a Blood Cell

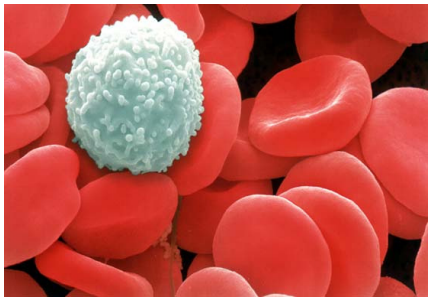


Components of blood

- Plasma - 55% of the blood
  - Water, proteins, dissolved gasses, sugars, vitamins, minerals and waste products
- Red Blood Cells - 44% of the blood
- White Blood Cells - 1% of the blood

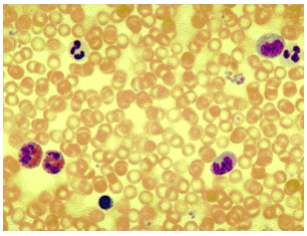
Erythrocytes (Red Blood Cells)

- **Cells in the blood of vertebrates**
- **Transport oxygen and carbon dioxide to and from the tissues.**
- **In mammals, these cells are disk-shaped and biconcave, contain hemoglobin, and lack a nucleus.**



Leukocytes (White Blood Cells)

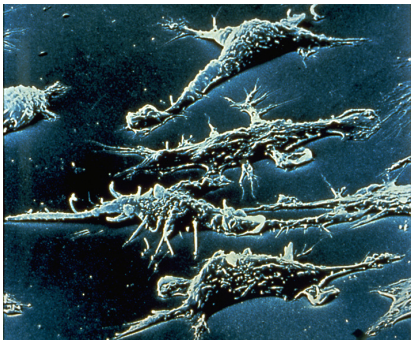
- **Blood cells that have a nucleus and cytoplasm and help protect the body from infection and disease.**

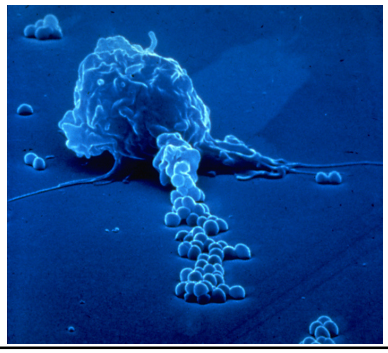


Lymphocytes and macrophages are good examples

Macrophages

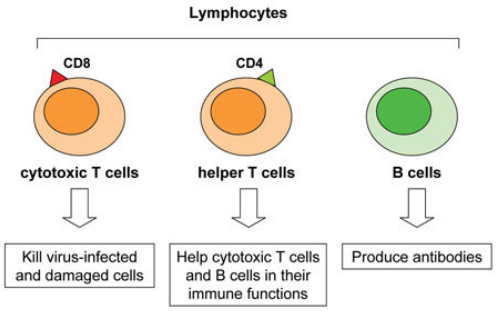
Four macrophages or "engulfing" cells. Macrophages are highly deformable cells. They are able to creep actively into the smallest gaps (and so also to penetrate the vascular walls, for example) and work their way into the most diverse tissue types. They form semi-liquid projections which are used for motility and also for trapping pathogens and other foreign bodies.





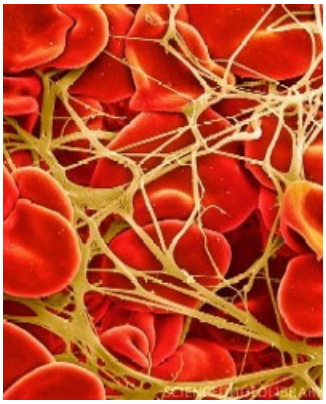
Lymphocytes

- Non-phagocytic cells that play a role in immunity by recognizing and fighting off specific pathogens.



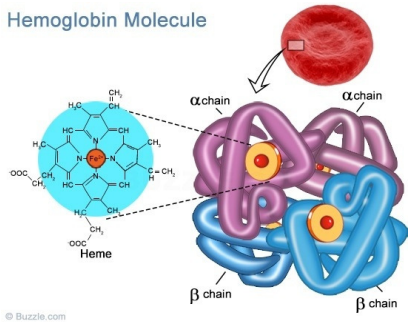
Platelets

- Fragments of cells that play an important role in clotting blood.



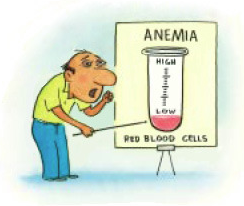
Hemoglobin

- **Red Blood Cells are packed with this iron containing molecule that binds with oxygen. It allows oxygen to be transported in the blood.**

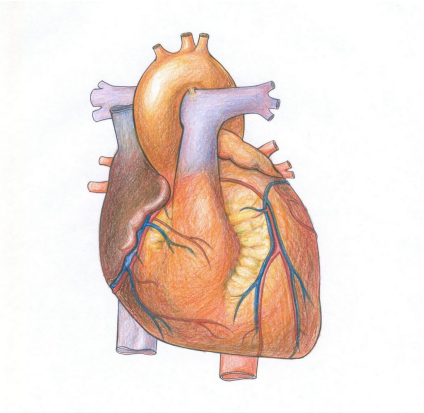


Anemia

- **This deficiency occurs when the number of healthy red blood cells decrease in the body which causes a shortage of hemoglobin (and thus low iron).**



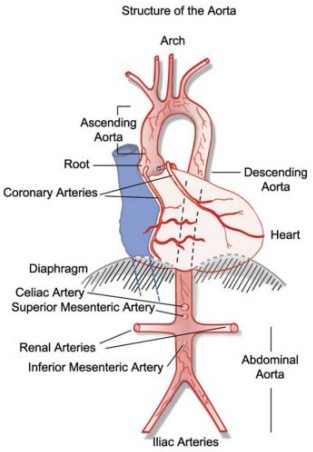
Blood Flow Through the Heart



1. RIGHT ATRIUM
   to
2. RIGHT VENTRICLE
   to
3. PULMONARY SYSTEM
   to
4. LEFT ATRIUM
   to
5. LEFT VENTRICLE
   to
6. AORTA (Rest of body)

Aorta

- **The largest artery**
- **Carries blood from the left side of the heart into systemic circulation.**

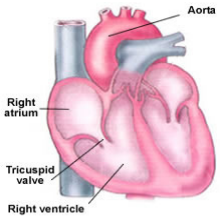


Bicuspid Valve

- A valve of the heart located between the left atrium and left ventricle that keeps blood in the left ventricle from flowing back into the left atrium.
  - Also known as the Mitral valve and is one of the two atrioventricular valves.

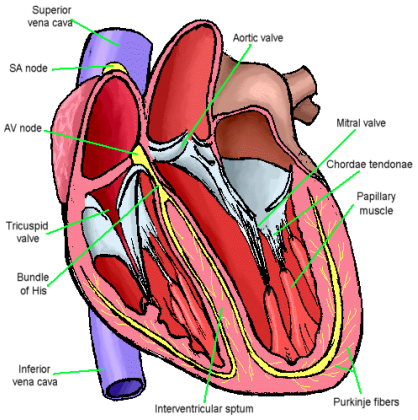
Tricuspid Valve

- A valve of the heart located between the right atrium and right ventricle that keeps blood in the right ventricle from flowing back into the right atrium.
  - It is one of the atrioventricular valves



Sinoatrial/ SA/ Sinus Node

- A small bundle of specialized cardiac muscle tissue located in the wall of the right atrium of the heart that acts as a pacemaker by generating electrical impulses that keep the heart beating.

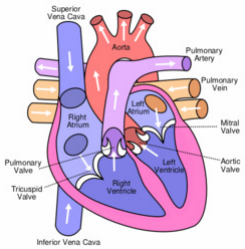


Atrioventricular Valves

- On both sides of the heart the atria and ventricles are separated from one another by this set of valves. (These are also called the bicuspid and tricuspid valves).

Atria

- The upper chambers of the heart that receives blood from the veins and forces it into a ventricle
  - Plural for atrium.



Left Ventricle

- The chamber on the left side of the heart that receives arterial blood from the left atrium and contracts to force it into the aorta.
- Septum → The wall that separates the right and left ventricles.

Right Ventricle

- The chamber on the right side of the heart that receives venous blood from the right atrium and forces it into the pulmonary artery.

Vena Cava

- Either of two large veins that drain blood from the upper body (superior vena cava) and from the lower body (inferior vena cava) and empty into the right atrium of the heart.

Pulmonary Artery

- A blood vessel that carries deoxygenated blood from the right ventricle of the heart to the lungs.

Pulmonary Vein

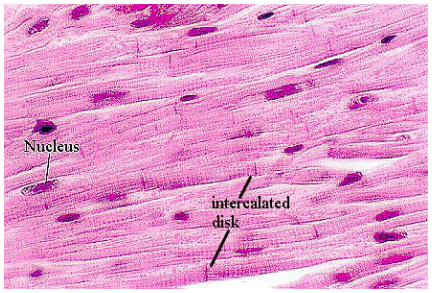
- A blood vessel that carries oxygenated blood from the lungs to the left atrium of the heart.

Electrocardiogram

- A device that measures the voltage of the electrical signals produced by the SA and AV nodes.

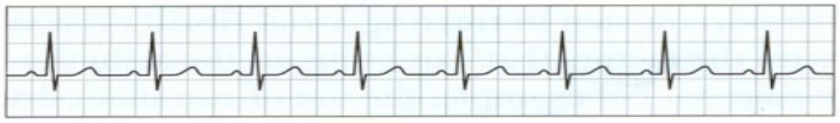
Cardiac Muscle

- This type of muscle consists of individual cells each with a single nucleus that form a branching interlocking network.

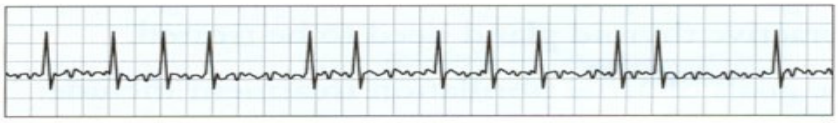


Electrocardiograph

- The tracing produced by an electrocardiogram.



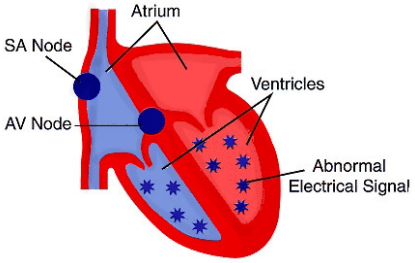
ECG tracing of a normal heart rhythm.



In atrial fibrillation, the tracing shows tiny, irregular "fibrillation" waves between heartbeats. The rhythm is irregular and erratic.

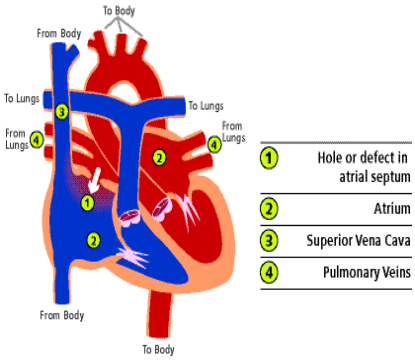
Ventricular Fibrillation

- This is a condition where the ventricles contract randomly causing the heart to quiver or twitch.

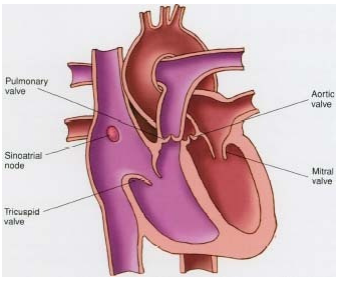


Septal Defect

- A hole in the septum that allows oxygenated and deoxygenated blood to mix.



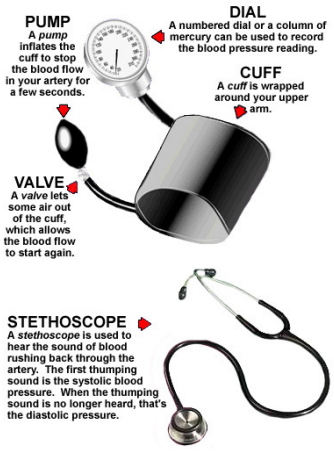
Heart Murmur



- A condition that occurs when one or more of the heart valves does not open or close properly

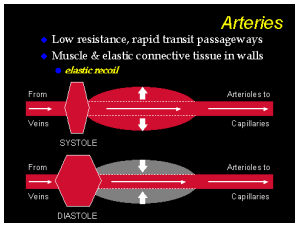
Sphygmomanometer

- An instrument for measuring blood pressure in the arteries.
- <u>Hypertension</u>
  - Condition where blood pressure is abnormally high



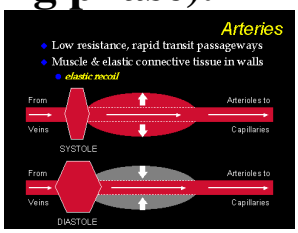
Systolic Pressure

- The blood pressure that is exerted on blood vessels only in short bursts following the ventricular contractions.



Diastolic Pressure

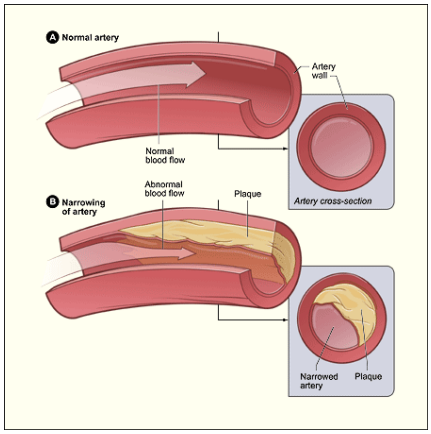
- The blood pressure that blood vessels are exposed to most of the time (pressure of the blood during the hearts resting phase).

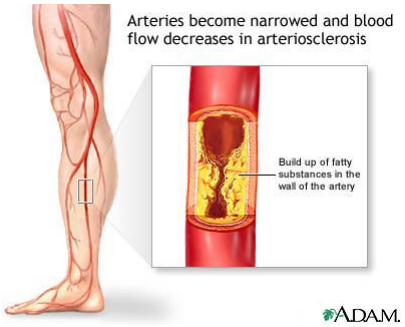


Atherosclerosis & Arteriosclerosis

- Atherosclerosis
  - A narrowing of the arteries caused by cholesterol or fatty tissue buildup called <u>plaques</u>, ON the inner lining of the artery wall.
- Arteriosclerosis
  - A condition where plaque material becomes deposited UNDER the inner lining of the arteries

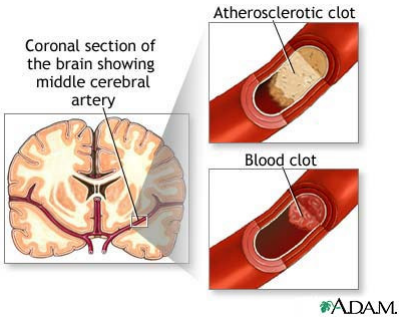
Atherosclerosis & Arteriosclerosis





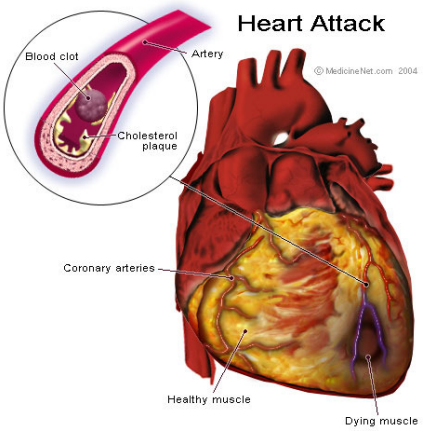
Stroke

- **A condition that occurs when a blood clot blocks an artery going to the brain and causes the brain to be starved of oxygen, killing the brain tissue**



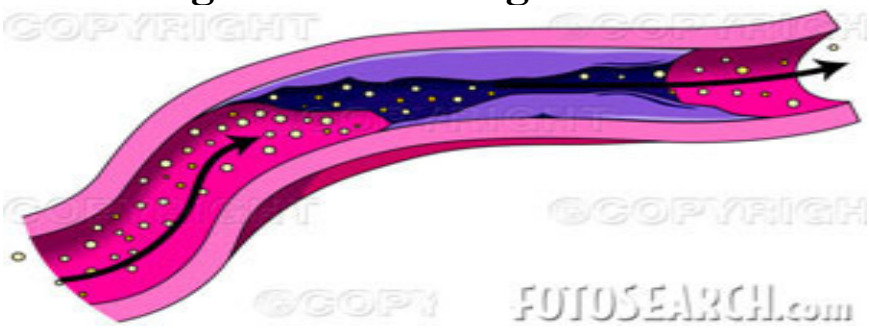
Heart Attack

- A condition that occurs when a blood clot blocks an artery going to the heart muscle and causes the heart to beat irregularly or stop altogether. A part of the heart actually dies when this happens.



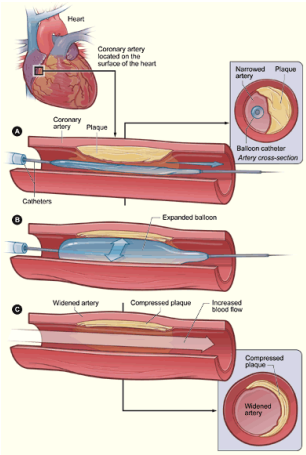
Clot Busting Drugs

- Medicines that help dissolve blood clots in arteries, allowing blood to once again flow through them.



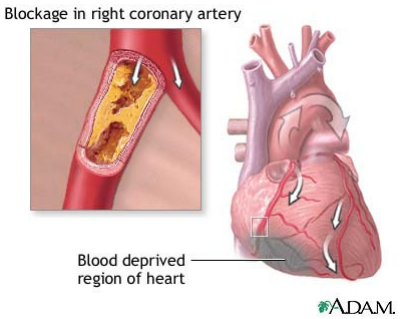
Angioplasty

- A procedure in which a fine plastic tube is inserted into a clogged artery, a tiny balloon is pushed out from the tip of the tube and forces the vessel to open allowing blood to flow through.



Coronary Bypass Surgery

- A common surgical procedure in which a segment of healthy blood vessel from another part of the body is used to create a new pathway around a blocked coronary artery.



ABO Blood-Typing and rH Factor

- The ABO system consists of A, B, AB, and O blood types.
- Type A
  - Have antibodies in the blood against type B.
- Type B
  - Have antibodies in the blood against type A.
- People with AB have no anti-A or anti-B antibodies.
- People with type O have both anti-A and anti-B antibodies.
- **Universal Recipients**
  - Have type AB blood
  - They can receive any of the ABO types.
- **Universal Donors**
  - Have type O blood
  - They can give to any of the ABO types
- **Rh system**
  - Classifies blood as Rh-positive or Rh-negative
  - Is based on the presence or absence of Rh antibodies in the blood

Short Research Assignment

Research the use of each technology or effects of each disorder:

- Artificial heart - Shandon
- Heart transplants - Taner
- Circulation machines - Derek
- Defibrillators – Wade
- Coronary Bipass – Tannis
- Heart attack / Stroke - Muskwa
- Angioplasty - Alvin

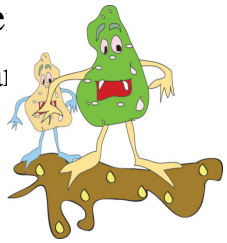
- Research your assigned topic
- Write ½ page about it's use or the effects it has on the circulatory system
- Present your findings in two minutes to the class. Fill in the hand-out with information from each classmate

Immune System

- The system responsible for keeping your body free from pathogens and preventing infection
- Your body has two defense systems
  - Non-specific defense
  - Specific defence

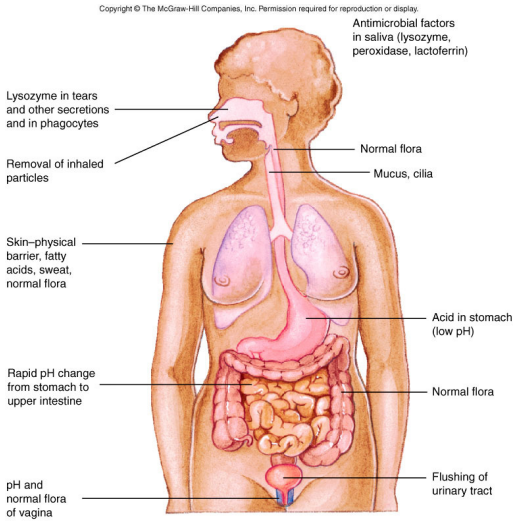
Non-specific Defenses

- These are your first line of defense against pathogens.
- They guard against all foreign organisms and not just any one specific organism.
- Two types of non-specific defe
  - Chemical barriers & physical ba
  - Inflammatory response



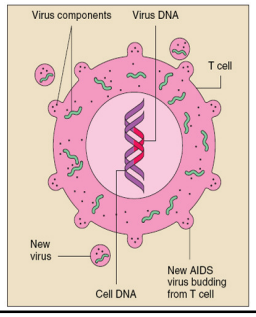
Physical and Chemical Barriers

- Physical Defenses
  - skin
  - membrane linings
  - Cilia
- Chemical Defenses
  - Sweat and oils
  - saliva
  - stomach acid
  - urine
  - tears
  - Mucus
  - Interferons *



AIDS – Acquired Immune Deficiency Syndrome

- The cause of AIDS is a virus called the <u>human immunodeficiency virus – HIV</u>
- The virus attacks the helper T cells of the immune system.
- The virus enters the T cell and remains within the cells for months or even years without producing symptoms



AIDS' Disturbing Properties

- It is able to mutate giving it the ability to produce different strains.
  - HIV-1;1981, HIV-2; 1985
  - Dozens of subtypes worldwide for each strain
- It causes change in the cell membrane of the T cell causing them to fuse together.
  - This allows the virus to pass from cell to cell without entering the bloodstream and becoming exposed to antibodies present in the blood

What's more?

- When HIV becomes active, the individual develops AIDS. The virus reproduces, spreads, and destroys helper T cells. The T cells become a HIV factory.
- Some possible triggers for HIV activation are:
  - other co-infections
  - contain a gene like a ticking time bomb

- The decrease in helper T cells weakens the immune system. The body loses its ability to fight disease and becomes susceptible to <u>opportunistic infections</u> and malignancies