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.
Examples of Homeostasis

- Temperature Regulation
- Food and Water Balance
- Regulation of blood sugar levels
- Regulation of blood calcium levels
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)
Body Systems Involved in Homeostasis:

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

- 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

- 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.
Integrator (hypothalamus of brain)

Effectors
(sweat; vasodilation)

Receptor (skin)

Effectors (shivering...)

Heat Gained

Heat lost
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.
Organization in Biology

- A complete organism is comprised of various parts, depending on the complexity of the organism. While some organisms are simple and composed of one cell, many organisms are very complex and their cells are organized into groups with specific functions.

- Cell → tissue → organ → organ system → whole organism
Organization in Biology (cont)

- **tissue**: a group of cells that have a specific function
  - ex. Muscle tissue, connective tissue
  - epithelial tissue (coverings)

- **organ**: a group of tissues that work together to perform a similar function
  - ex. Heart – made of muscle tissue
  - skin – made of epithelial tissue

- **organ system**: a group of organs that work together to perform a similar function
  - ex. Circulatory system – heart and blood vessels
  - digestive system – stomach, small intestine, large intestine, etc.
What does the circulatory system do?

- The Circulatory System
  - Transporting...
    - Blood
    - Water
    - Nutrients
    - Hormones
    - Sugars
    - Toxins
What does the circulatory system do? (cont)

- The human circulatory system is a closed, complete double system.

- Two main types of circulation:
  - Pulmonary — circulation that carries blood to and from the lungs. Important for picking up oxygen and dropping off carbon dioxide.
  - Systemic — circulation that carries blood to and from other parts of the body. Delivers oxygen and other materials to the body. There are various types:
    - Hepatic portal: delivers to and from the liver
    - Renal: delivers blood to and from the kidneys
    - Cardiac: delivers blood to and from the heart
Coronary/Cardiac Circulation

Circulation in and around the heart
Pulmonary and Systemic Circulation

jugular vein
(also subclavian vein from arms)

head and arms

CO₂

O₂

carotid artery
(also subclavian artery to arms)

pulmonary artery

lungs

pulmonary vein

superior vena cava

inferior vena cava

heart

aorta

trunk and legs

hepatic vein

liver

digestive tract

mesenteric arteries

renal artery

iliac vein

kidneys

iliac artery

CO₂

O₂

hepatic portal vein
Elements of a Circulatory System

- the average man has 5-6 L of blood (woman has 4-5 L)

- three main elements of any circulatory system:
  - transport vessels to carry fluid (arteries, veins, etc)
  - the transport medium (blood)
  - the pumping mechanism (heart)
Transport vessels - Arteries

- Blood vessel that carries blood away from the heart
- Most arteries carry oxygenated blood (except the pulmonary artery)
- 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
Aorta

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

- Blood vessel that carries blood to the heart
- Most veins carry deoxygenated blood (except pulmonary vein)
- 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
Transport vessels - Capillaries

- 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.
The Transport Medium - Components of blood

- Plasma - 55% of the blood
  - Water, proteins, dissolved gasses, sugars, vitamins, minerals and waste products
  - Helps transport carbon dioxide (55% of all CO$_2$ transport is by plasma)

- Red Blood Cells - 44% of the blood

- White Blood Cells - 1% of the blood
Erythrocytes (Red Blood Cells)

- 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.
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).
Platelets

- Fragments of cells that play an important role in clotting blood.
Leukocytes (White Blood Cells)

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

  ![Image of leukocytes](image)

  Lymphocytes and macrophages are good examples.
The Pumping Mechanism – The Heart

- the typical human heart is about the size of a fist
- has four chambers:
  1) right atria       3) left atria
  2) right ventricle  4) left ventricle
- both atria contract at one time, followed by both ventricles
- the atria serve as collecting areas for blood and they don’t produce a lot of force; the ventricles actually do the majority of the pumping of the blood
- the right ventricle pumps blood to the lungs while the left ventricle pumps blood to the rest of the body. Hence, the left ventricle is a lot more muscular
The Pumping Mechanism – The Heart

- between the atria and ventricles on each side of the heart are valves which prevent blood from flowing back into atria from ventricles
  - bicuspid valve (mitral valve): between left atrium and ventricle
  - tricuspid valve: between right atrium and ventricle
  - semilunar valves: between ventricles and arteries; prevent blood from flowing back into ventricles after contraction

- septum: a wall that separates the left and right sides of the heart. This wall prevents mixing of oxygenated and deoxygenated blood.
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.
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)
How the Heart Pumps

- The pumping action of the heart has 2 main periods:
  - (1) diastole: the period of relaxation of the heart
  - (2) systole: the period of contraction of the heart
How the Heart Pumps

- During diastole, the A-V valves (bicuspidxid and tricuspid) are open. Blood flows from the atria to the ventricles. By the end of diastole, the ventricles are about 70% filled. Systole begins with contraction of the atria. The contraction of the atria forces more blood into the ventricles, filling them. The ventricles then contract. While the ventricles contract, the atria relax.

- As the heart valves open and close, they make a “lub-dup” sound. The “lub” sound is caused by the closing of the A-V valves. The “dup” sound is made by the closing of the semilunar valves.
Control of Heartbeat

- Heart muscle has a built-in ability to contract without need from stimulus from the nervous system. These contractions are controlled by a structure called the sino-atrial node (S-A node), also called the pacemaker.

- When the heart receives electric impulses from the S-A node, the atria contract. Then, the impulse reaches another structure called the atrioventricular node (A-V node) which causes the ventricles to contract.

- The pacemaker itself can be regulated by certain nerves:
  - vagus nerves: slow down heartbeat
  - cardioaccelerator nerves: speed up heartbeat
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.
Electrocardiogram

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

- There can be several different specific problems with the heart itself, including:
  - Ventricular fibrillation
  - Sepal defects
  - Heart murmurs
Ventricular Fibrillation

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

- A hole in the septum that allows oxygenated and deoxygenated blood to mix.
- Can be treated by surgery
Heart Murmur

- A condition that occurs when one or more of the heart valves does not open or close properly
- Name comes from sound made by the blood escaping from the valve
- Some murmurs severe, others not as bad
Blood Pressure

- **Pulse**: the expansion and relaxation that can be felt in an artery each time the left ventricle of the heart contracts and relaxes.

- **Sphygmomanometer**: device used to measure blood pressure (blood pressure cuff).

- Blood pressure is measured in terms of height of mercury in a tube of a sphygmomanometer.
  - Average pressure in systole = 120 mmHg
  - Average pressure in diastole = 80 mmHg
  - Normal blood pressure = 120/80
Sphygmomanometer

- An instrument for measuring blood pressure in the arteries.

- Hypertension
  - 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).
Blood Pressure Risks

- High blood pressure can be caused by several things, such as a diet high in salt, a diet high in cholesterol, certain drugs like nicotine, heredity, age, lack of exercise, smoking and obesity
Atherosclerosis & Arteriosclerosis

- **Atherosclerosis**
  - A narrowing of the arteries caused by cholesterol or fatty tissue buildup called **plaques**, 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

[Image of normal and narrowed arteries with descriptions of normal and abnormal blood flow, plaque build-up, and 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.
Treatments for Circulatory System

- There are several treatments available for treating disorders of the circulatory system, including:
  - Drugs
  - Angioplasty
  - Coronary bypass surgery
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.
Cardiac Output and Fitness

- **Cardiac output**: amount of blood pumped by the heart, usually measured in ml/min
- **Stroke volume**: amount of blood forced out of the heart with each heartbeat
- **Cardiac output** = **stroke volume** × **heart rate**
- A higher stroke volume and a lower heart rate indicates the heart is very efficient since the heart is not working very hard to maintain a certain cardiac output
Cardiac Output and Fitness - example

<table>
<thead>
<tr>
<th>Individual</th>
<th>Cardiac output (mL/min)</th>
<th>Stroke Volume (mL/beat)</th>
<th>Heart Rate (beats/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4900</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>B</td>
<td>4900</td>
<td>50</td>
<td>98</td>
</tr>
<tr>
<td>C</td>
<td>4900</td>
<td>140</td>
<td>35</td>
</tr>
</tbody>
</table>
Cardiac Output and Fitness - example

- In this example, individual C is exceptionally fit. Individual C can deliver the same amount of blood (and oxygen) to the body per minute as A and B, but their heart is not working as hard to do it.

- Individual A represents an average person, with a stroke volume of 70 ml/beat and 70 beats/min
Heart Rate and Fitness

- maximum heart rate is not related to fitness
  - max heart rate = 220-age
- length of time it takes to return to resting heart rate is an indication of health. If it takes a long time for a person’s body to return to a resting heart rate after exercise, then that person is in poor shape
- a higher resting heart rate usually indicates poor health as well
Stroke Volume and Fitness

- two factors affect stroke volume:
  1. how easily the heart fills with blood (depends on the distendibility of ventricles and the amount of blood returned from the heart)
  2. how readily the heart empties (depends on strength of contraction and pressure on artery walls)

- regular cardiovascular exercise increases stroke volume by enlarging ventrical chambers, including distendibility (stretchiness) of ventricles, and strengthening ventricle walls.

- Strength training only may increase thickness of ventricle walls, but will reduce the elasticity of the ventricles.
The Lymphatic System

- lymphatic circulatory system – network of glands and vessels that carry lymph throughout the body

- lymph – colourless or pale yellow fluid that circulates throughout the lymphatic circulatory system. It is a lot like plasma in its composition
The Lymphatic System

- (see fig 9.24, p. 323)
  - the lymphatic system has no pump; movement of external muscles helps circulate fluid
  - lymph is made of fluid that escapes from blood in the capillaries. This fluid gets absorbed into the vessels of the lymphatic system and eventually rejoins the main circulatory system
  - the lymphatic system also works with white blood cells (leukocytes)