HKU Med LKS Faculty of Medicine
School of Chinese Medicine
香港大學中醫藥學院

Enrichment Course in Biology (2022-23)

Topic 13: Support and Movement

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Class Learning Objectives

1. **Describe the support system in human body**
2. **Explain the structures and functions of skeleton and bone**
3. **Understand the function and characteristics of muscles**
4. **Discover the mechanism of muscle contraction**

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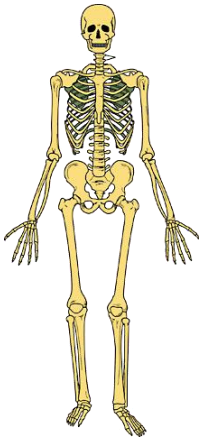
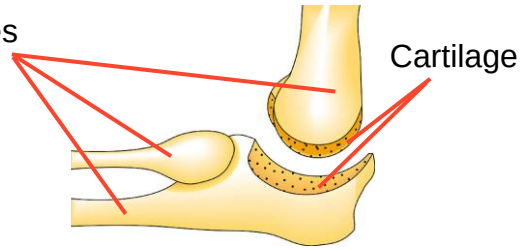
1.1 Human Skeletal System



Skeletal System

The human skeletal system consists of **206 bones**, which are connected by a network of tendons, ligaments and cartilage. The skeletal system is essential for support, movement, protection, blood cell production, calcium storage and endocrine regulation



Muscular System

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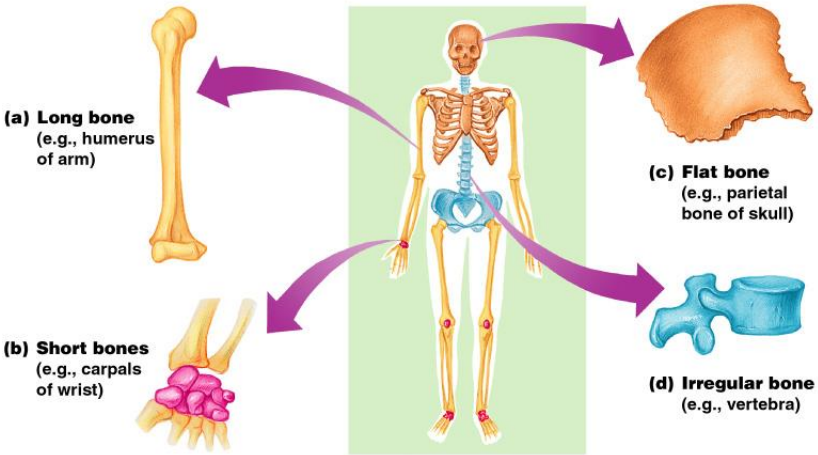
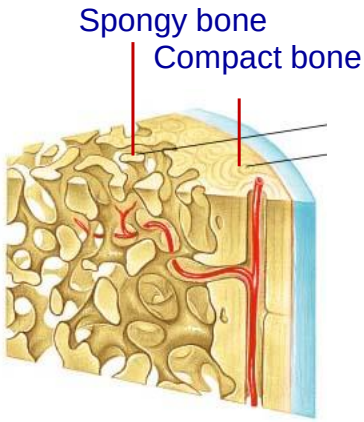
1.2 Shape and Structure of Bones

Bone Shape



Bone structure



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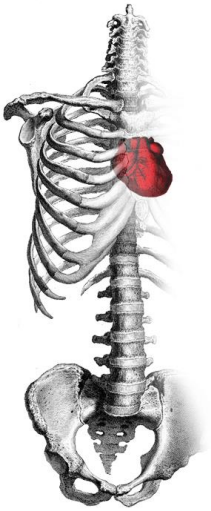
1.3 Functions of Bones



1. **Support of the body**
2. **Protection of soft organs**
3. **Control of movement together with skeletal muscles**
4. **Storage of minerals**
5. **Formation of blood cells (hematopoiesis)**

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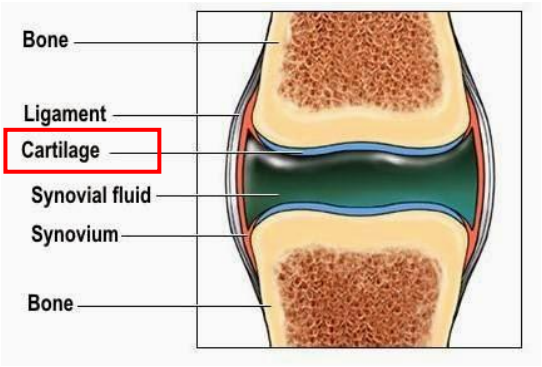
1.4 Cartilage and Its Functions

Location and types



- Hyaline cartilages
- Elastic cartilages
- Fibrocartilage

Characteristics

1) Mostly water; no blood vessels or nerves
2) Tough, resilient
3) Bends easily
4) Joint lubrication
5) Cushions against impact or pressure
6) Gives support while allowing motion
7) Heal poorly

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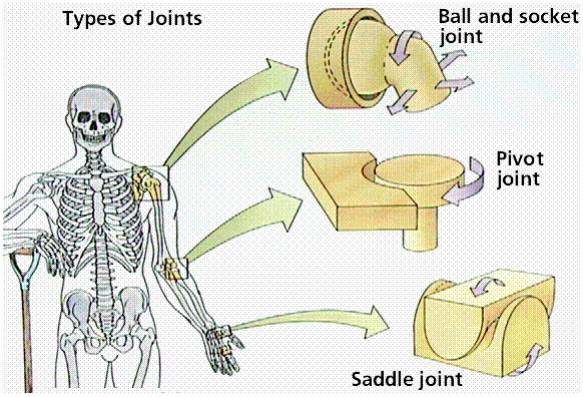
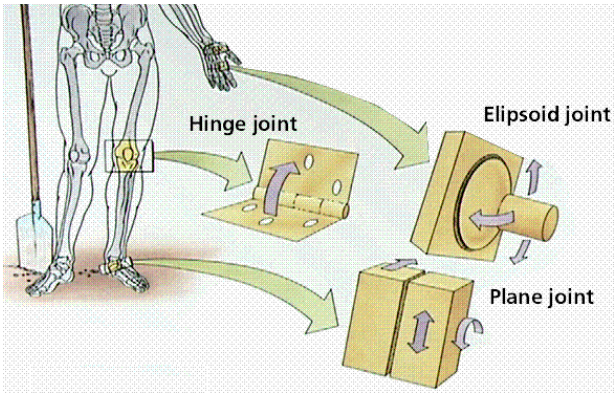
1.5 Joints and Its Functions

The joints perform different types of functions, which could be explained by using common mechanical devices





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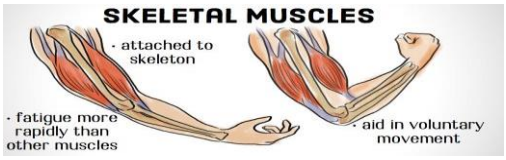
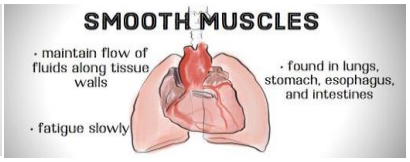
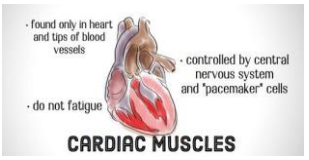
1.6 Types and Functions of Muscles







Location	Attached to bones	On hollow organs, glands and vessels	Heart
Function	Move the body	Compress tubes & ducts	Contract heart
Nucleus	Multiple, peripheral	Single, central	Single, central
Control	voluntary	involuntary	involuntary
Striations	Yes	No	No
Cell Shape	Cylindrical	Spindle-shaped	Branched

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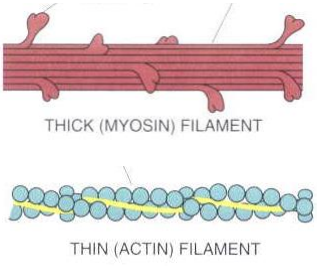
1.7 Components of Muscles

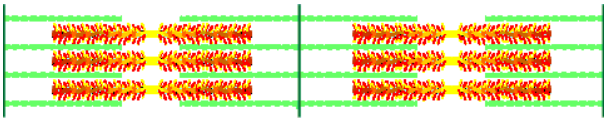
Muscle Fibers

- Are innervated by nerve impulse
- A motor unit is a nerve and the muscle fiber it stimulates
- Consist of myofibrils
  - **Myosin protein filaments** – thick filament (dark)
  - **Actin filament** – thin filament (light)



Sarcomere

- Contractile unit
- Many sarcomeres are in a myofibril
- Actin and myosin are in a sarcomere



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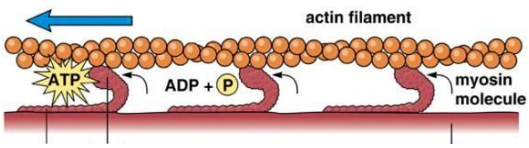
1.8 Contraction of Muscles

Video for muscle contraction

- Muscles pull when they contract
- Work in antagonistic pairs
  - Biceps ***flex*** the elbow
  - Triceps ***extend*** the elbow
- Muscle tone
  - When you are conscious, your muscles are never completely relaxed. Muscles are “ready”.
  - Responsible for posture

Sliding Filament Theory

- Muscle fibers shorten when actin slides over myosin
- Energy for sliding is by ATP



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Enrichment Course in Biology (2019-20)

Topic 14: Gut and Digestion

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Class Learning Objectives

1. **Describe the digestive system and its importance in human body**
2. **Explain the digestion process**
3. **Identify each organ in digestive system and its biological importance**

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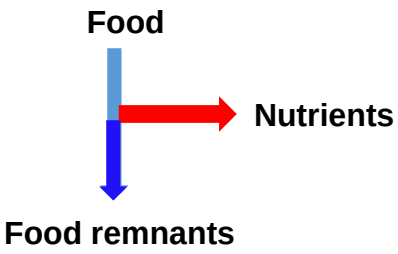
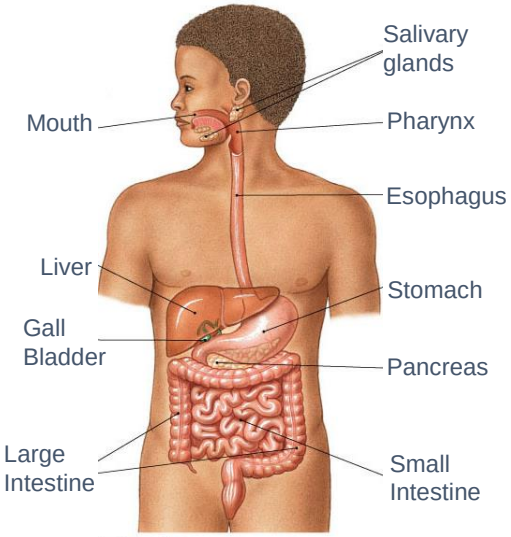
2.1 Human Digestive System

Digestive System

The digestive system involves a complex of organs (see right panel) to exhibit mechanical and chemical treatments to food, absorb the resulted nutrients, and excrete the undigested food remnants.





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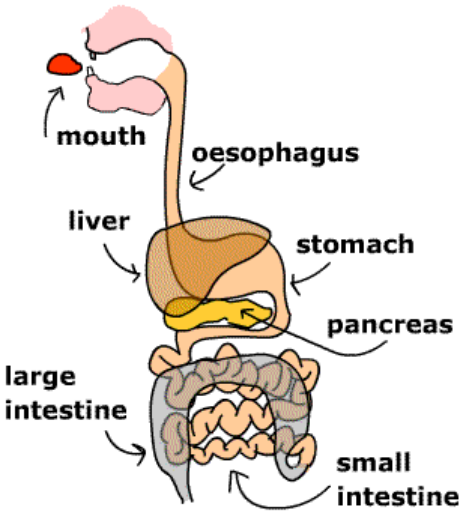
2.2 Digestion Process



Five Digestion Phases

1. Ingestion
2. Movement
3. Mechanical and Chemical Digestion
4. Absorption
5. Elimination

Two Types of Treatments

Mechanical (physical):
Chew, Tear, Grind, Mash, Mix

Chemical:
Enzymatic reactions to improve digestion of
Carbohydrates, Proteins, Lipids

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2.3 Organs for Physical Treatment

Mouth

Teeth mechanically break down food into small pieces. Tongue mixes food with saliva (contains amylase, which helps break down starch).

Esophagus

Secrete mucus, Moves food from the throat to the stomach using muscle movement called peristalsis

The rectum

The rectum is the last portion of the digestive tract, involves internal and external anal sphincters, and dictates the excretion of the food remnants.

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2.4 Organs for Chemical Treatment

Stomach

Stomack is a J-shaped muscular bag for storing and digesting food with digestive juices that contain enzymes and acid. Enzymes digest carbohydrates, proteins and lipids, whereas acid (HCl) in the stomach kills bacteria.

Small Intestine

Small intestine is rich in villi and microvilli for effective absorption of nutrients (80% ingested water, vitamins, minerals, carbohydrates, proteins and lipids). Small intestine also secretes digestive enzymes.

Large Intestine

Large intestine accepts what small intestine does not absorb and hold before feces before it is expelled through rectum. Large intestine also supports bacterial digestion, carbohydrate fermentation, water absorption and waste concentration

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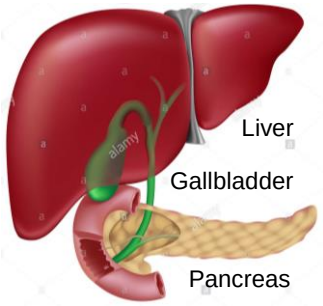
2.5 Accessory and Regulatory Organs

Effective digestion also requires the involvement of several accessory and regulatory organs such as liver, gallbladder and pancreas



Liver

Liver produces bile acids for mobilizing fat, filters out toxins and waste, such as drugs, alcohol and poisons.

Gallbladder

Gallbladder stores bile acids from the liver and releases it into small intestine upon activation .

Pancreas

Pancreas produces digestive enzymes to digest fat, carbohydrates and proteins, Pancreas is also an insulin-producing organ for regulating blood sugar.

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Enrichment Course in Biology (2019-20)

Topic 15: Energy and Metabolism

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Class Learning Objectives

1. Describe the relationship between energy and metabolism
2. Understand the importance of enzymes in metabolism
3. Describe the metabolism of carbohydrates, lipid and protein

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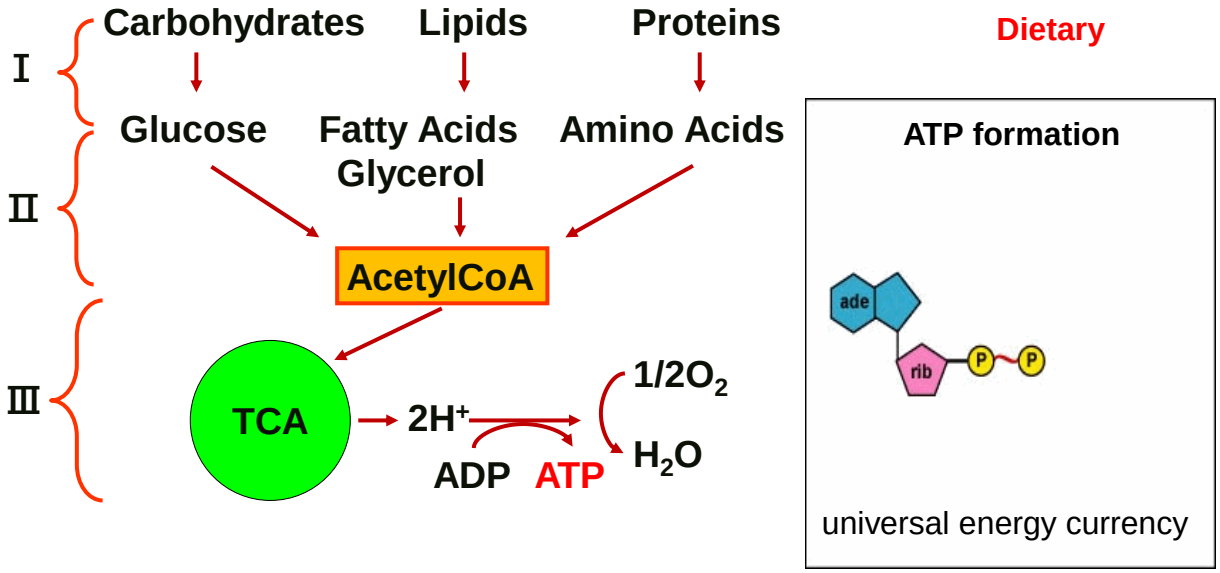
3.1 Bioenergetics and Metabolism



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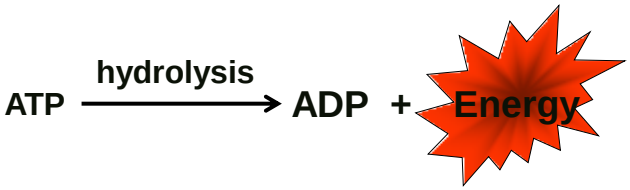
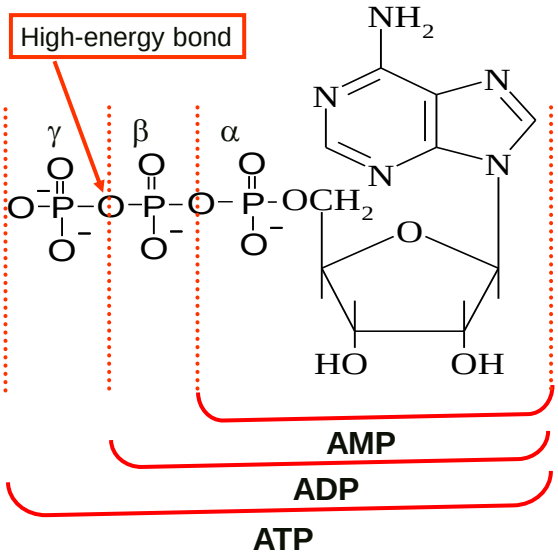
3.2 Bioenergy Molecule ATP

ATP consists of adenosine (adenine + ribose) and a triphosphate group. The bond between γ-phosphate and β-phosphate groups is the high energy bond. ATP is hydrolyzed to ADP while energy is released.





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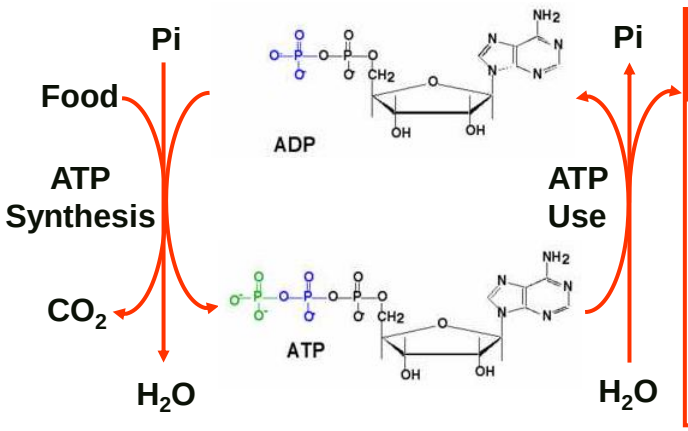
3.3 Power Transmission in Bioenergetics

Food metabolism produces energy molecule ATP. ATP is used in body to support mechanical, chemical, transport, electron potential and heat production. Power transmission by proton gradients represents a central motif of bioenergetics



Power transmission

1. Mechanical
2. Chemical
3. Active transport
4. Electron potentia
5. Heat production

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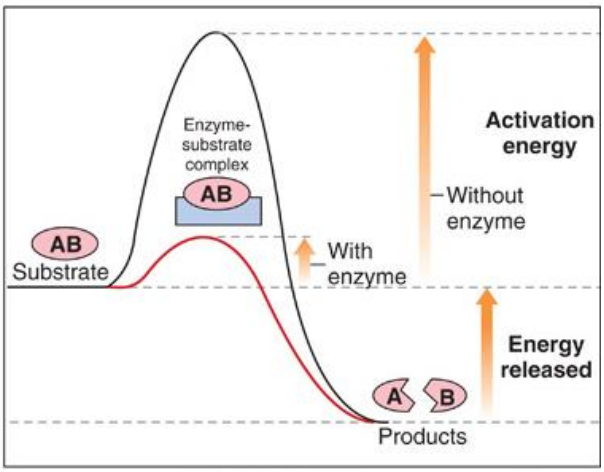
3.4 Enzymes in Bioenergetics

The formation and use of ATP are catalyzed by different **enzymes**.

Most of **Enzymes** are proteins.

Enzymes could reduce the amount of activation energy required for a reaction to proceed.

- Enzymes are not used up or altered.
- Products are not altered.
- Energy released is the same.



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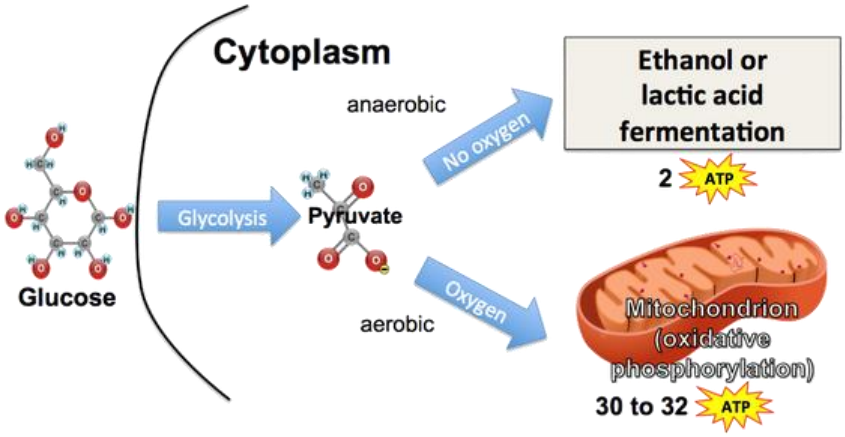
3.5 Glucose Metabolism

Dietary carbohydrates are converted to glucose in the digestive system. Glucose is transported into blood flow, and up-taken by cells.

In the cells, glucose undergoes glycolysis to release two ATP molecules under anaerobic condition, or further metabolized to generate 30-32 ATP molecules through oxidative phosphorylation in mitochondria.



http://www.sciencemusicvideos.com/ap-biology

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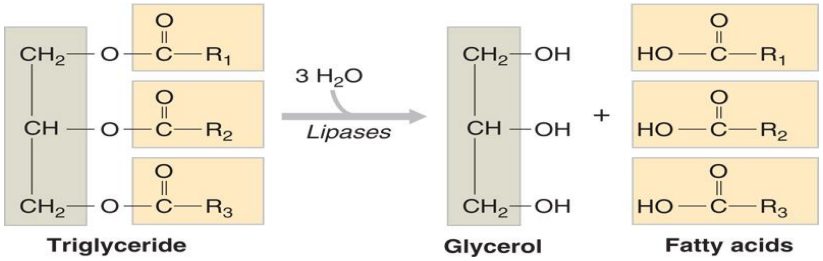
3.6 Lipid Metabolism

Triglycerides are broken down into glycerol and 3 fatty acid chains.



Glycerol enters glycolysis.
Fatty acids are oxidized and 2-C molecules break off as acetyl-CoA.
Oxidation of one 18-C stearic acid will net 146 ATP.
Oxidation of three glucose (18 Cs) nets 108 ATP.
Glycerol nets 22 ATP, so 1 triglyceride nets 462 ATP.

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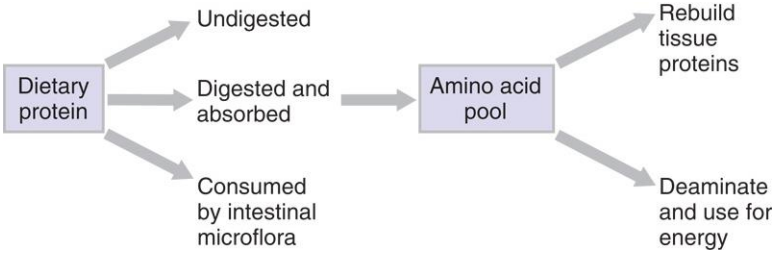
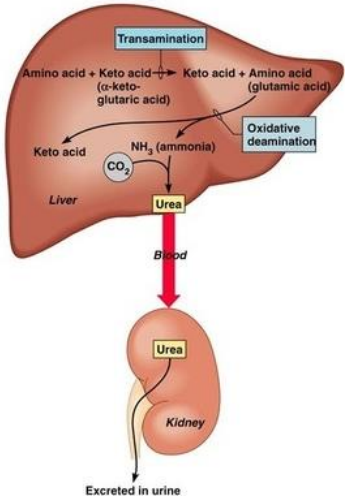
3.7 Protein Metabolism

Proteins are digested in the gut into amino acids which are then absorbed into blood and extracellular fluid.





Excessive proteins serve as fuel like carbohydrates and fats

- Nitrogen is converted to ammonia.
  - Carbon skeletons are oxidized.

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Enrichment Course in Biology (2019-20)

Topic 16: Fluid and Electrolyte Balance

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Class Learning Objectives

1. Identify the composition and compartments of body fluid
2. Describe the regulatory system of body fluid and electrolytes
3. Explain the contents and importance of major electrolytes

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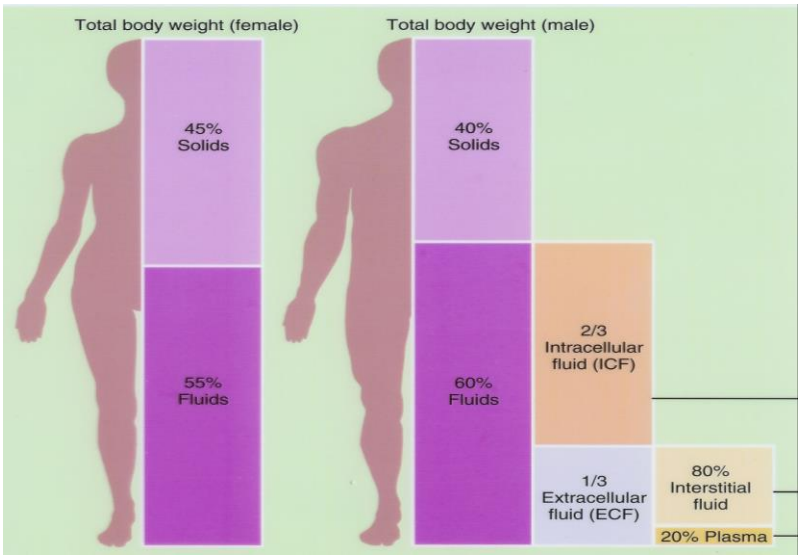
4.1 Body Fluid in Human Body

Quickfacts

- Body fluid takes 55-60% of body weight
- Males contain more body fluid than females
- Intracellular fluid takes 2/3 body fluid
- Extracellular fluid takes 1/3 body fluid
- Extracellular fluid exists as interstitial fluid by 80% and plasma by 20%.



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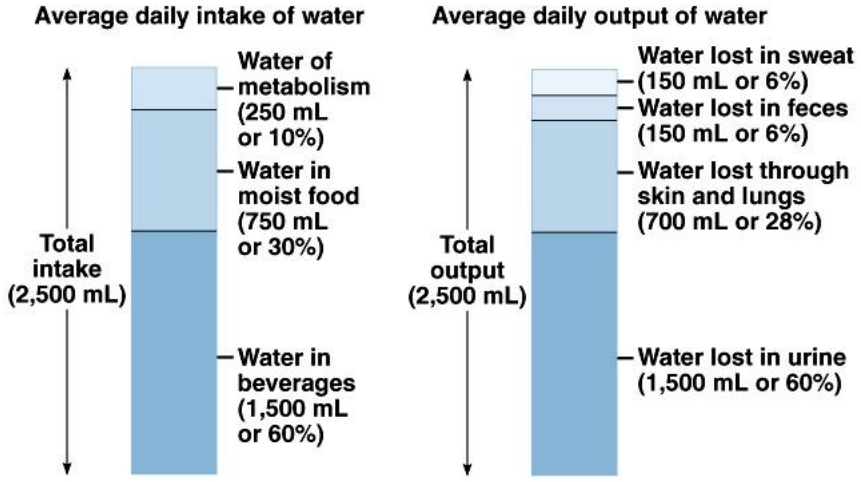
4.2 Balance of Body Fluid



Body fluid is well balanced via controlling daily intake and output of water

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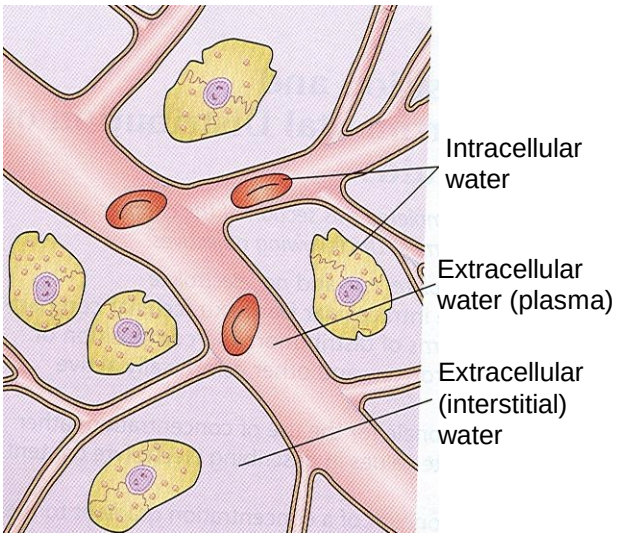
4.3 Fluid Compartments

1) Intracellular fluid (ICF)
-Located within cells
-42% of body weight

2) Extracellular fluid (ECF)
-found outside cell
- Intravascular (plasma)
- Interstitial
- lymph
- Transcellular

-30% of body weight



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4.4 Composition of Body Fluid

- Body fluid contains **water** and **solutes**
- Solutes are the dissolved substances and conduct electrical current.
- Concentration of solutes in solution = *osmolality or osmolarity.*
- Solutes may be electrolytes or non-electrolytes:

  -Electrolytes:

  - Cations($^{+}$): positively charged ions such as Na^{+}, K^{+} , Ca^{++}, H^{+}
  - Anions ($^{-}$): negatively charged ions such as Cl^{-}, HCO_3^{-} , PO_4^{3-}

  -Non-electrolytes: glucose, urea, creatinine, bilirubin

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4.5 Regulation of Body Fluid and Electrolytes

Body fluids are:

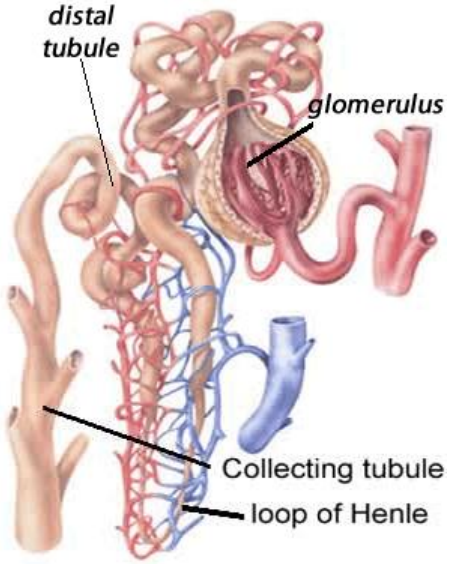
- Electrically neutral
- Osmotically maintained

Homeostasis is maintained by:

- Ion transport
- Water movement
- Kidney function

Renal tubule reabsorption is affected by hormones:

- Aldosterone
- Renin/angiotensin
- Atrial Natriuretic Peptide (ANP)



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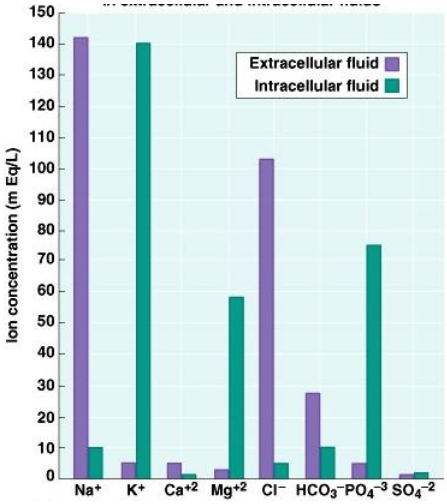
4.6 Major Electrolytes and its Importance

Major Electrolytes



Biological importance

Sodium (Na^+): takes 90 % of total ECF cations, pairs with Cl^- , HCO_3^- to neutralize charge, regulates water balance, and controls nerve and muscle function

Potassium (K^+): A major intracellular cation for resting membrane potential, regulating fluid, ion balance inside cell, and maintaining pH balance

Isotonic alterations in water balance may cause electrolyte imbalance, leading to hypernatremia and other disorders.

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Summary

1) **The basics of support and movement**
2) **The digestive system involving gut and digestion**
3) **The relationship between energy and metabolism**
4) **The body fluid and electrolyte balance**

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