Lecture 2

FOOD COMPONENTS: FOOD CHEMISTRY AND NUTRITION

Chapters 3-4, pp.24-68.

2 FOOD COMPONENTS: FOOD CHEMISTRY AND NUTRITION

- Foods are made up mostly of biochemicals which are mainly derived from living sources such as plants and animals.

Nutrient Constituents in foods:

Macro-constituents	Micro-constituents
Carbohydrates	Minerals
Proteins	Vitamins
Fats	
Water	

2 FOOD COMPONENTS: FOOD CHEMISTRY AND NUTRITION

Functions of nutrients:

- Providing energy
- Promotion of growth, maintenance and repair of tissues
- Regulation and control of metabolic processes

CARBOHYDRATES

- Carbohydrates (from hydrates of carbon) are organic compounds with the basic structure $C_x(H_2O)_y$.
- Chemically, carbohydrates contain only the elements carbon, hydrogen and oxygen.
- The most important types of carbohydrates are:

Sugars, dextrins, starches, celluloses, hemicelluloses, pectins, and certain gums.

CARBOHYDRATES

Sugars: Mono-, di-saccharides

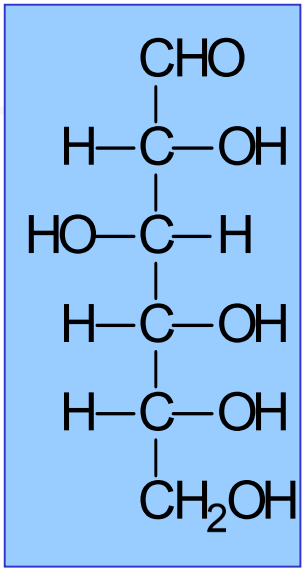
Sweet, water soluble, can be crystallized

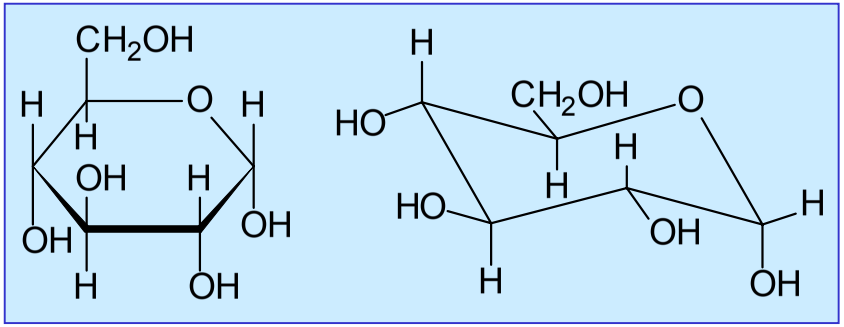
Non-sugars: Polysaccharides

Not sweet, not water soluble, cannot be crystallized

CARBOHYDRATES

- Simple carbohydrates are called sugars. One of the simplest carbohydrates is the six-carbon glucose. Others are: mannose, galactose, etc. They form ring structures.
- Simple sugars each contain 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms. [$C_6(H_2O)_6$]





Glucose

CARBOHYDRATES

- Carbohydrates are produced by photosynthesis in green plants and are nature's way of storing energy from sunlight.

- They differ in the positions of oxygen and hydrogen around the ring.
- These differences in the arrangement of the elements result in differences in the solubility, sweetness, rates of fermentation by microorganisms and other properties of sugars.

CARBOHYDRATES

- Two glucose units may be linked together with the splitting out of a molecule of water. The result is the formation of a molecule of a disaccharide.
- Two glucose molecules form a maltose (malt sugar) molecule.
- Sucrose (cane or beet sugar) is formed from glucose and fructose.
- Lactose (milk sugar) from glucose and galactose.

CARBOHYDRATES

- A large number of glucose units may be linked together in polymer fashion to form polysaccharides.
- Simple sugars are the building blocks of the more complex polysaccharides, the disaccharides and trisaccharides, the dextrins, which are intermediate in the length, on up to the starches, celluloses and hemicelluloses.
- Chemical derivatives of the simple sugars linked together yield the pectins and carbohydrate gums.
- Their breakdown in human body can be accomplished with acid or by specific enzymes.

CARBOHYDRATES

They:
- may serve as structural components (cellulose)
- be stored as energy reserves (starch- in plants and glycogen- in animals)
- function as essential components of nucleic acids (ribose)
- function as components of vitamins (ribose of riboflavin)

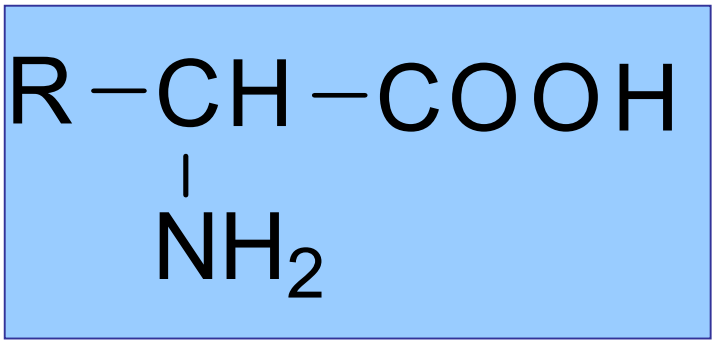
- Carbohydrates can be oxidized to furnish energy.
- Glucose in the blood is a ready source of energy for humans and animals.

PROTEINS

- Proteins are made by linking individual amino acids together in long chains.
- Amino acids are made up principally of carbon, hydrogen, oxygen and *nitrogen*. Some amino acids also contain other elements such as sulfur.
- Where two amino acids have reacted, a dipeptide is formed, with the peptide bond at the center.

PROTEINS

Amino acids have the $-NH_2$ or amino group, and the -COOH or carboxyl group attached to the same carbon atom.



R: functional group

PROTEINS

- Proteins are essential to all life.
- In animals they help to form supporting and protective structures such as cartilage, skin, nails, hair, and muscle.
- They are major constituents of enzymes, antibodies, many hormones, and body fluids such as blood, milk, and egg-white.
- There are 20 different major amino acids and a few minor ones that make up human tissues, blood proteins, hormones, and enzymes.

PROTEINS

- Eight of these are essential amino acids since they cannot be synthesized by humans in adequate amounts to sustain growth and health and must be supplied by the diet.
- The remaining amino acids are also necessary for health but can be synthesized by humans from other amino acids and nitrogenous compounds and are non-essential amino acids.

Essential Amino Acids:

Leucine	Lysine	Methionine
Isoleucine	Phenylalanine	Threonine
Tryptophan	Valine	Histidine*

* To meet the demands of growth during childhood

PROTEINS

Non-essential Amino Acids:

Alanine	Cysteine	Glycine
Arginine	Cystine	Proline
Aspartic acid	Glutamic acid	Serine
Hydroxyproline	Tyrosine	

• There is enormous variation among the proteins. This variation arises from :

combinations of different amino acids,

differences in the sequence of amino acids within a chain

differences in the shapes the chains assume.

PROTEINS

• These differences are largely responsible for the differences in the taste and texture of chicken muscle, beef muscle and milk curd.

- When the organized molecular or spatial configuration of a protein is disorganized, we say the protein is denatured.
- This can be done with heat, chemicals, excessive stirring of protein solutions, and acid or alkali.
- When egg-white is heated, it becomes a solid rather than a liquid because it is irreversibly denatured. When milk is coagulated by heat and acid, protein precipitates forming cheese curd.

PROTEINS

Expression of the value of protein:

- Protein Efficiency Ratio

PER = weight gain/ grams of protein eaten

- Net Protein Utilization

NPU = (weight gain-weight loss)/grams of protein

- Biological Value

BV = proportion of absorbed Nitrogen that is retained in the body (retained N/absorbed N)

- Digestibiliy (D): proportion of consumed food N that is absorbed
- Net Protein Value (NPV)=NPU x amount of protein in food

PROTEINS

- A complete protein is one that contains all of the essential amino acids in amounts and proportions to maintain life and support growth when used as the only source of protein.
- Such a protein is said to have high biological value.
- Many animal proteins such as meat, poultry, fish, milk and eggs generally are of high biological value.

FATS & OILS

- Fats differ from carbohydrates and proteins in that they are not polymers of repeating molecular units.
- They do not form long molecular chains and they do not contribute structural strength to plant and animal tissues.
- Fats are smooth, greasy substances that are insoluble in water.
- A typical fat molecule consists of glycerol combined with three fatty acids.

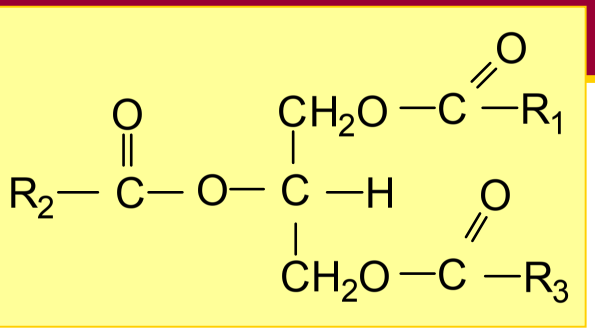
2 FOOD COMPONENTS: FOOD CHEMISTRY AND NUTRITION

FATS & OILS

- Fat is mainly a fuel source for the animal or plant in which it is found, or for the animal that it eats.
- It contains about 9Kcal/g (2 1/4 times the calories found in an equal dry weight of protein and carbohydrate).
- Reduction in the caloric content of foods is often accomplished by replacing fat with protein or carbohydrate.
- Fat always has other substances associated with it in natural foods, such as the fat-soluble vitamins (A, D, E, K), the sterols, cholesterol in animal fats and ergosterol in vegetable fats and certain natural lipid emulsifiers (phospholipids).

FATS & OILS

❖ Glycerol has three reactive hydroxyl groups, and fatty acids have one reactive carboxyl group. Therefore, three fatty acid molecules can combine with each glycerol molecule, eliminating three molecules of water. Such fats are called *triglycerides.*



❖There are about 20 different common fatty acids that are connected to glycerol in natural fats.
❖These fatty acids differ in length and in the number of hydrogen atoms they contain.
Capric, butyric, propionic acids.....short f.a.
Stearic, oleic, linoleic acids .....long f.a.

FATS & OILS

Fat molecules can differ with respect to:

- Lengths of their fatty acids
- The degree of unsaturation of their fatty acids
- The position of specific fatty acids with respect to three C atoms of glycerol(omega-3 and omega-6 f.a.)
- Orientation in the chain of unsaturated fatty acids(trans and cis positions).

An oil is simply a fat that is liquid at room temperature.

WATER

- ✓ Water is present in most natural foods to the extent of 70% of their weight or greater.
- ✓ Fruits and vegetables may contain 90% or even 95% water. Cooked meat still contains 60%.
- ✓ Water greatly affects the keeping qualities of food, which is one reason for removing it from foods, either partially as in evaporation and concentration, or nearly completely as in food dehydration.
- ✓ When foods are frozen, water as such is removed, since water is most active in liquid form.

WATER

- ✓ As a liquid in foods, it is the solvent for numerous food chemicals and thus promotes chemical reactions between the dissolved constituents.
- ✓ It is also necessary for microbial growth
- ✓ Another reason for removing water from foods is to reduce the weight and bulk of the food and save on packaging and shipping costs.

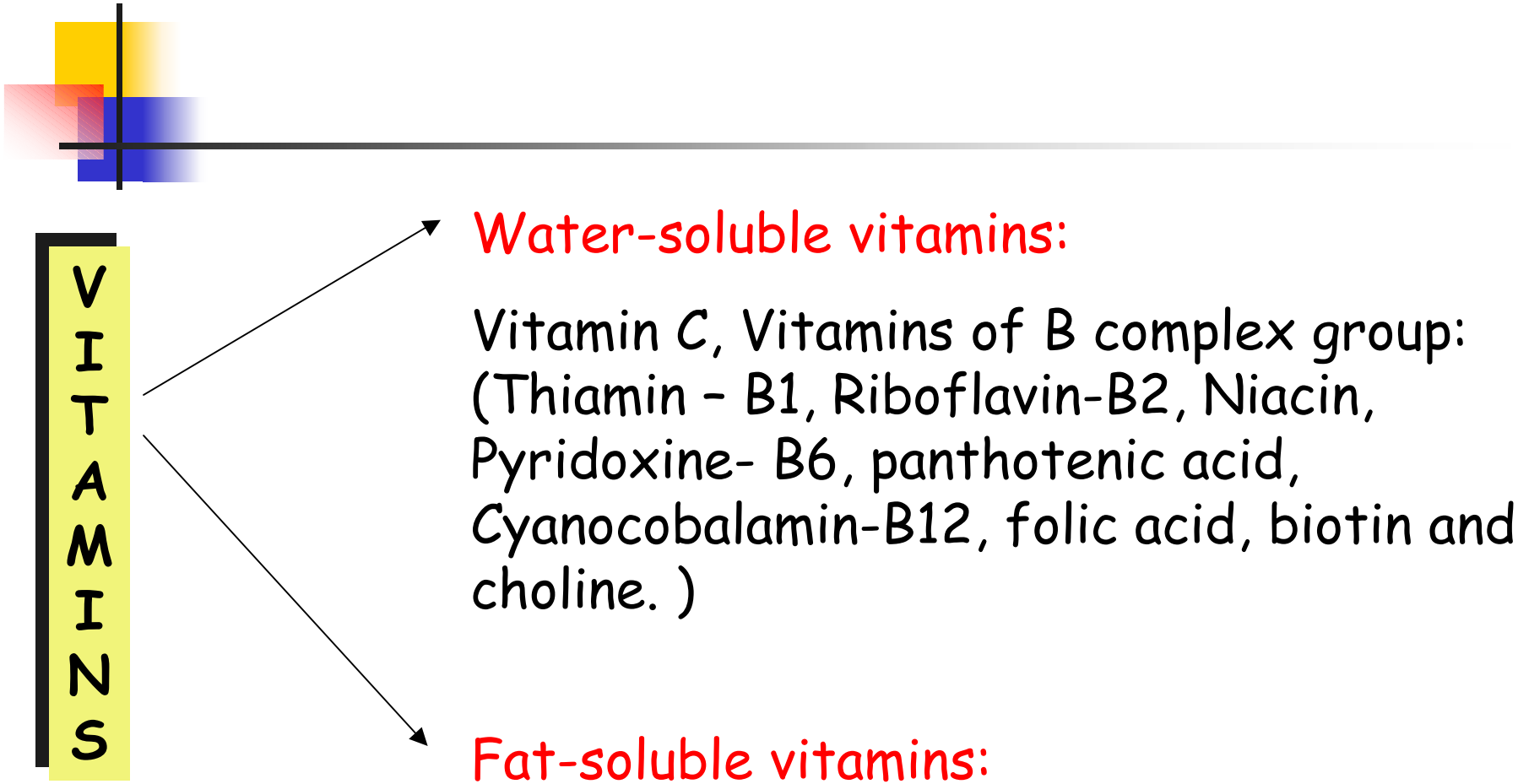
WATER

- ✓ Water exists in foods in various ways:
- Free water – tomato juice
- Droplets of emulsified water- butter
- Tied up in colloidal gels – gelatin desserts
- Thin layer of adsorbed water on the surfaces of solids - caking in dried milk
- Chemically bound water- sugar crystals

VITAMINS

✓ Vitamins are organic chemicals, that must be supplied to a human being or animal in small amounts to maintain health.

✓Vitamins function in enzyme systems which facilitate the metabolism of proteins, carbohydrates, and fats. But there is growing evidence that their roles in maintaining health extend further.


VITAMINS
Water-soluble vitamins:
Vitamin C, Vitamins of B complex group: (Thiamin – B1, Riboflavin-B2, Niacin, Pyridoxine- B6, panthotenic acid, Cyanocobalamin-B12, folic acid, biotin and choline.)
Fat-soluble vitamins:
Vitamin A, D, E and K

VITAMINS

Vitamin A (Retinol)

Sources: Animal sources: meat, milk, eggs, liver, fish oils, butterfat

Plant sources : Orange and yellow colored vegetables, and green leafy vegetables

(carrot, squash, spinach and kale) contain ß-carotene which is the precursor of vit A.

Deficiency Diseases: Blindness, failure of normal bone and tooth development in the young, decrease in the resistance to infection.

Excessive doses can be toxic.

Vitamin D

VITAMINS

Sources: Liver, fish oils, dairy products, eggs.

Formed in the skin of animals and humans by activation of sterols by ultraviolet light from the sun.

Deficiency Diseases: Bone defects, rickets.

Excessive intake provides no benefits and is potentially harmful.

VITAMINS

Vitamin E (α-tocopherol)

Sources: Vegetable oils
Is a strong antioxidant and prevents the formation of harmful peroxidized fatty acids.
Deficiency: Rare

Vitamin K

Sources: Green vegetables such as spinach and cabbage, also synthesized by bacteria in the human intestinal tract.
Deficiency Diseases: Essential for normal blood-clotting, causes liver disease.

VITAMIN C (Ascorbic Acid)

VITAMINS

Sources: Citrus fruit, tomatoes, cabbage, and green peppers.

Deficiency Diseases: Fragile capillary walls, easy bleeding of gums, loosening of teeth, bone joint diseases (scurvy).

VITAMINS

Thiamin (vit B_1)

Sources: Wheat germ, whole cereals containing bran, liver, pork, yeast and egg yolk
Deficiency disease: Beri beri

Riboflavin (vit B_2)

Sources: Liver, meat, eggs, milk, green leafy vegetables. Essential for cellular growth and tissue maintenance.
Deficiency disease: abnormal skin conditions such as cracking at the corners of the mouth.

VITAMINS

Niacin (Nicotinic Acid)

Sources: Yeast, meat, fish, poultry, peanuts, legumes, and whole grain cereals.
Deficiency diseases: Adversely affects tissue respiration and oxidation of glucose (pellagra disease). Skin and mucous membrane disorders, depression and confusion.

Vitamin B_6 (Pyridoxine, pyridoxal)

Sources: Muscle meat, liver, green vegetables, grain cereals with bran.
Deficiency diseases: Does not cause a well-recognized disease, essential in the human diet for specific enzyme systems and normal metabolism.

VITAMINS

Pantothenic acid

Sources: Easily supplied in a normal diet, is wide-spread in foods.
Deficiency disease: Obvious symptoms of its deficiency are rare in humans.

Cyanocobalamin (vit B_{12})

Sources: Liver, meats and seafoods

Deficiency disease: Pernicious anemia

VITAMINS

Folacin, Folate

Sources: Liver, leafy vegetables, legumes, cereal grains and nuts. Involved in the synthesis of nucleic acids.
Deficiency disease: Anemia

Biotin and Choline

Sources: Diet adequate in the other B vitamins.They are active in the metabolism of fatty acids and amino acids and functions in the transmission of nerve impulses.

Deficiency disease: nervous system and hair loss

MINERALS

Calcium and Phosphorus: Deficiency results in bone and teeth diseases. Milk and dairy products are excellent sources.Deficiency disease: poor bonesand skeletal structure

Magnesium: Important in maintaining electrical potential in nerves and membranes, liberate energy for muscle contraction,necessary for normal metabolism of Ca and P

Iron and Copper: Iron is required as a component of blood hemoglobin, which carries oxygen, muscle myoglobin, which stores oxygen. Copper aids in the utilization of iron and in hemoglobin synthesis. Deficiency disease: Anemia

MINERALS

Zinc: Deficiency results in impaired growth and development, skin lesions, and loss of appetite.
Sodium and Chloride: They maintain osmotic equilibrium and body-fluid volume.
Potassium: Regulates osmotic pressure and pH equilibria.
Iodine: Essential for the prevention of goiter in humans.Deficiency disease: Impaired thyroid functions
Fluorine: Acts in the development of sound teeth and resistance to tooth decay.
Deficiency: Tooth decay
Other elements: Cobalt, manganese, chromium, molybdenum, selenium, nickel, etc.

NUTRITION

Food scientist must consider the nutritive aspects of food from two points of view:

- What nutrients do foods contain and What is a human's requirement for these
- What are the relative stabilities of these nutrients and how are they affected by food processing, storage and preparation.

NUTRITION

"Metabolism" is the machinery of life.
The series of processes necessary for building up body cells and for keeping them functioning to sustain life and health.

Metabolic Activities

- Anabolism
- Catabolism

NUTRITION

Anabolism:

Processes by which new substances are synthesized from simpler compounds (i.e. Protein synthesis from amino acids).

Endothermic –requires energy

Catabolism:

Breakdown of complex substances to simpler compounds.(i.e. Glucose to energy, water and carbon dioxide, proteins to amino acids)

Exothermic- produces energy

NUTRITION

Homeostatis:

Dynamic equilibrium between anabolic and catabolic reactions.

Body temperature: 36-37°C

Blood plasma pH: 7.3-7.5

Saliva pH: 6.5-7.5

Basal Metabolism:

The minimum energy necessary for the body functions of human for survival.

70 Cal/hr --------→1680 kcal/day

NUTRITION

- The energy value of foods is measured in heat units called "calories".

1 cal = 4200 joules = 4.2 kilojoules = 48 watts

1 kcal = 1000 calories

Carbohydrates provide about 4 kcal/g

Proteins provide about 4 kcal/g

Fats provide about 9 kcal/g

- Calories are needed to satisfy the body's energy requirements for production of body heat, synthesis of body tissue, and performance of work.
- An adult male's daily requirement (depending on the physical activity) range from about 2500 to 5000 kilocalories.

NUTRITION

An example for Metabolic Reactions:
Digestive System:

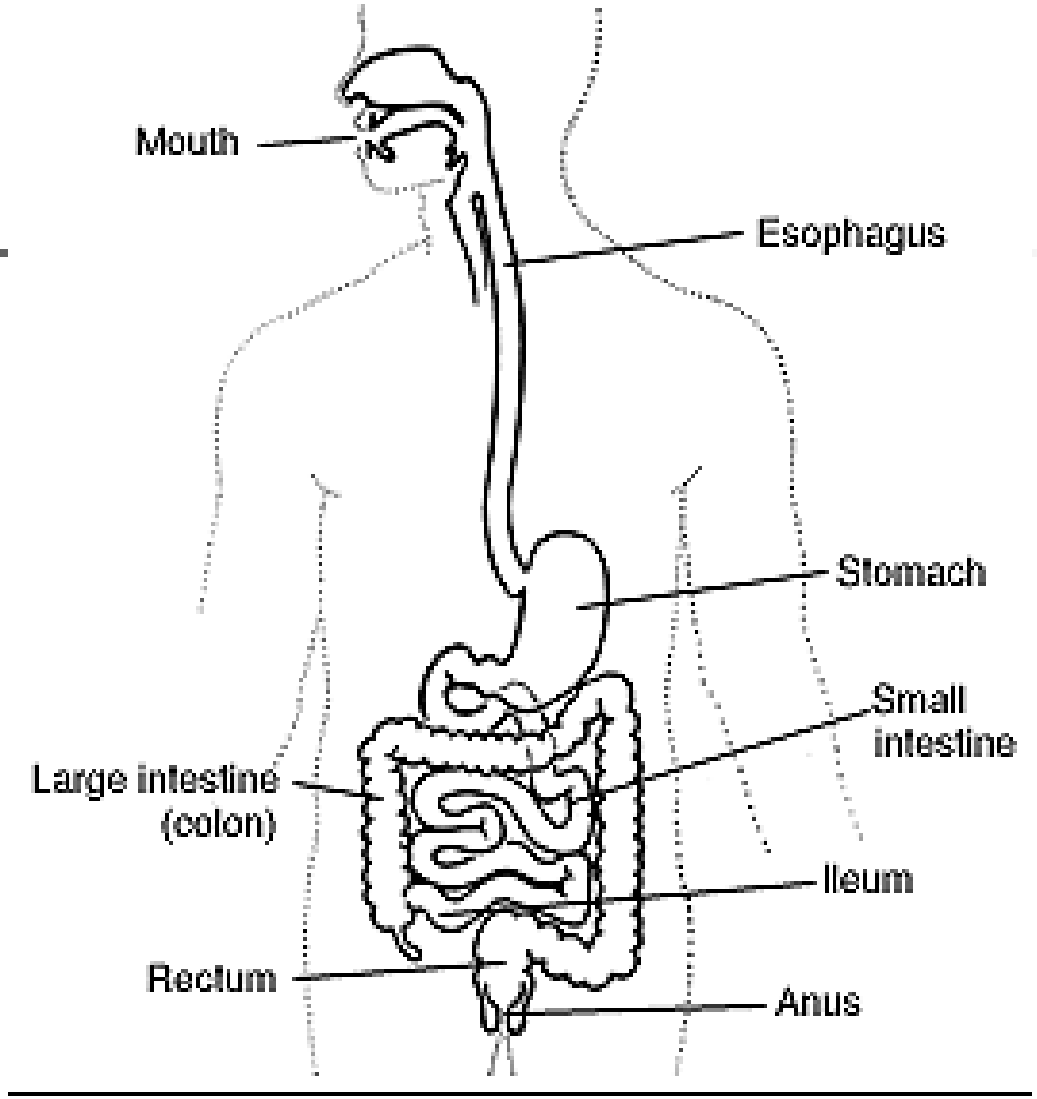
Stages: Ingestion

Digestion

Absorption

Transportation

Excretion


Mouth
Esophagus
Stomach
Small intestine
Large intestine (colon)
Ileum
Rectum
Anus

NUTRITION

Ingestion: involves mastication (chewing)

Reduces food to small particles, mixing it with saliva and preparing for swallowing.

Digestion: Takes place in GIT: Gastro-intestinal system: is a tube of ~ 9 meters long.

Mouth, esophagus, stomach, small intestines, colon (large intestines), rectum

Liver and pancreas excrete specific chemicals that stimulate production of digestive hormones and enzymes, so they are vital in digestion.

NUTRITION

Digestion:

Bringing foods into such a state as to be capable of being absorbed into blood stream.

"chyme" – the state of food when it is ready to leave stomach.

a) CHO: Glucose (simple carbohydrate) is absorbed as is. Starch polymers are broken down into simple sugars before absorption.
b) Proteins: Polymers must be broken down to amino acids.
c) Fats: the triglycerides must be split into fatty acids.
d) Vitamins and minerals: readily absorbed.

NUTRITION

Absorption:

The components permeate through the walls of the digestive tract into our blood stream.

Transport: The blood system then carries them to appropriate storage depots (adipose tissue: surplus absorped food components).

Excretion: The indigestible residues pass through the intestinal tract and are excreted.

NUTRITION

Enzymes and hormones act as catalysts in these metabolic processes. Body temperature and pH also affects metabolic reactions.

Recommended Dietary Allowances (RDA): Expressed as average daily intakes of nutrients over time, are intended to provide for individual variations among most normal persons as they live in a specific country under usual environmental stress.

Diet and Chronic Diseases

Recent research indicates diet is significant factor in following chronic diseases:

1.Atherosclerotic [Cardiovascular] Diseases (correlatd with saturated fats, cholesterol intakes)

2.Hypertension (correlated with sodium intakes)

3.Diabetes mellitus(şeker) (correlated with obesity)

4.Osteoporosis(calcium, phosphorus, Vitamin D intakes)

5. Cancers(high fat, excess cured foods, alcohol, low fiber??)

NUTRITION

Policy Guidelines for Healthy Eating – Issued by scientists from FAO-WHO:

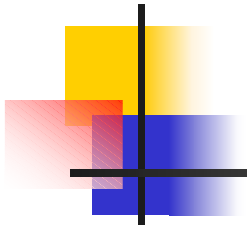
✓ Avoid being overweight (avoid obesity – too much fat, saturated fat, cholesterol)
✓ Consume wide variety of foods

Body mass index = weight in kg/(height in m)^2
should be < 25
25-29 overweight, > 30 obese

You should get ; <30% of calories from fat
<10% of cal. from saturated fats
<300 mg of cholesterol/day

NUTRITION

- ✓ You should get high fiber containing food.
- ✓ You should avoid getting too much sugar
- ✓ Avoid too much Na (salt)
- ✓ Be moderate in alcohol intake.
- ✓ Increase consumption of fruits and vegetables



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