Minerals in the Body
The Major and Trace Minerals

BCH 282 (Lec. 6)

- The cells use minerals in the form of ion or electrolytes.
- Ion: Electrically charged particles such as Na^+ (+ve) or Cl^- (-ve).
- Electrolytes: compound that partly dissociate in water to form ions.
- Water and mineral play important role in maintaining fluid and electrolytes balance in the cell, since water cross the membrane of the cell freely, so the cell can pump minerals across their membrane to achieve this kind of balance e.g. Na^+ (outside), K^+ (inside) the cell.
- The minerals help manage another balance which is acid base balance or pH.
- Fluid electrolytes balance: distribution of fluid and dissolved particles among body compartments.
- Acid-base balance: equilibrium between acid and base concentration in body fluid.
- The body proteins and some minerals help prevent changes in acid-base balance by serving as buffer. (Buffers are substances that prevent pH changes in solution).

The Minerals present in the body are classified into:

I) Major Elements: (Macronutrients)
Calcium, magnesium, sodium, potassium, phosphorus, sulfur and chlordine. While the major minerals help to maintain the balances, each also plays some special roles of its own.

II) Trace Elements: These are present in small amount (i.e. μg or less). they are subdivided into two groups

1. Essential Elements: (Micronutrients): e.g. iron, iodine, copper, zinic, manganese, cobalt, molybdenum, selenium, chromium and fluorine.
2. Non-essential Trace Elements: e.g. aluminum, cadmium, arsenic, lead and mercury.

Calcium and Phosphorus:

- Many people have the idea that calcium and phosphorus, once deposit in bone, stay there forever (The bone like a rock), but is not). Bones are in a state of constant flux, with formation and dissolution taking place every minute.
- Distribution:
    - Calcium and phosphorus are the most abundant minerals in the body.

- Calcium exists in two forms that have quite different functions.
    1. 99% of total body calcium is present in the bone and teeth as crystals called hydroxyapatite.
    2. 1% of total body calcium is present in body fluids, where it is in part, ionized and this unbound ionic form (Ca^{2+}) is the important part for the physiologic activity.

Functions of Calcium: It is important for:

1. Calcification of bones and teeth.
2. Blood clotting as activator of thrombokinase.
3. It is important for normal contractility and therefore maintenance of the heart beat.
4. Regulate the transport of ions across cell membranes and it is particularly important in nerve transmission and muscle contraction.
5. It is cofactor for several enzymes.

Functions of phosphorus:

1. Enters in formation of bones and teeth.
2. Formation of high energy compounds as ATP.
3. Enters the formation of coenzymes as NADP.
4. Enters in the structure of nucleotides and nucleic acids (genetic material).
5. It is important for the biosynthesis of phospholipids present in cell membrane.
6. It is important in carbohydrate metabolism as hexose ester (glc-6-P and Fr-6-P).
7. It acts as buffer to maintain the acid-base balance of cellular fluid.

Calcium balance:

- Cells need continuous access to calcium, so the body maintains calcium conc. in the blood. The skeleton serves as a bank from which the blood can borrow and return Ca^{2+} as needed.
- Withdrawal and deposition of Ca2+ are regulated by hormones sensitive to blood levels of Ca2+. These hormones are:

1. Parathyroid hormone (PTH):
    - A fall in the calcium conc in the blood, stimulates the release of PTH from parathyroid gland.

    PTH: increase serum Ca^{2+} and decrease serum phosphorus:

    1. It increases urinary excretion of phosphorus and decrease urinary excretion of calcium.

2. Stimulates release of calcium from bone (T bone dissolution).
3. Increase the synthesis of 1,25 dihydroxycholecalciferol lactive form of vit. D) which increases absorption of calcium from the intestine.

2. Calcitonin: (Calcium lowering hormone)
    - Arise in the calcium con in the blood, stimulates the secretion of calcitonin by the thyroid gland.

Calciton: decrease serum Ca^{2+} level (opposite PTH) by:

1. Decrease withdrawal of Ca^{2+} from bone (dissolution of bone).
2. Increase Ca^{2+} excretion by the kidney.
3. Inhibit synthesis of 1,25 dihydroxycholecalciferol.

Abnormal levels of Ca^{2+}

May be due to disease of parathyroid, kidney or disturbed vit. D level.

1. Ca and osteoporosis (results with low calcium, high protein intake).

- Osteoporosis is a silent thief. It leads to progressive loss of bone mass that occurs in the elderly of both sexes but is pronounced in postmenopausal women (mostly women 45 years or more).
- It is characterized by frequent bone fractures, which are the major disability among the elderly.
- Of the 2 million fractures that occur each year in United States, approximately 1.3 million are directly due to osteoporosis.
- Patient life-style may influence calcium metabolism, immobilized or sedentary individual tends to show bone loss, while patients that exercise regularly tend to increase their bone mass.
- In addition to Ca^{2+} many vitamins and minerals help to form and stabilize the structure of bones.
- Although estrogen replacement is the most effective prevention of postmeno-pausal bone loss, calcium supplementation (often given in combination with vit D). Further reduces the risk of fracture due to bone loss, particularly in elderly patients.

Rickets:

- Faulty calcification of bones in infants due to low vit D content of the body (milk poor in vit D).
- There is low serum and urinary calcium and phosphorus level.

- The Ca x P product is low

  (Calcium / phosphorus product = Ca serum level in mg/dLX serum phosphorus level in ng/dl).

  (C X P product is important for normal calcification of bone).

- Osteomalasia: (↓ serum Ca and phosphorus)
  - Vit D deficiency in adult → osteomalacia
  - Structurally weak undermineralized bone.

Calcium recommendations and sources:

- Calcium recommendations during adolescence are set high (1300 mg/day) to ensure that the skeleton will be strong and dense.
- Between the ages of 19-50, recommendations are lowered to 1000 mg/day.
- Over 50, the recommendations are raised again to 1800 mg/d to minimize bone loss.

Sources of Calcium:

- Milk, milk products (cheese) are the major sources.
- A cup of milk offers about 300 mg of Ca^{++}, so drink 2 or 3 cups / day will meet your daily requirement. For this reason, it's prefer to have low fat or fat-free milk product.
- Egg yolk, vegetables and cereals are good sources for calcium.

Sources of Phosphorus

- Milk and milk products.
- Proteins as meat and fish products.