

## 1.1.6 MINERAL ELEMENTS

- Minerals may be classified according to :
  - A : Macrominerals.**
  - B : Microminerals.**

### A : MACROMINERALS

- Seven minerals that are present in the body in amounts greater than 0.01% of body weight are the macrominerals, or major minerals.
  - Sodium (Na)
  - Potassium (K)
  - Chlorine (Cl)
  - Calcium (Ca)
  - Phosphorous (P)
  - Magnesium (Mg)
  - Sulphur (S) needed in organic form.

### B : MICROMINERALS / TRACE ELEMENTS

- Minerals that are present in the body in extremely small amounts and are required in amounts less than 100mg per day are trace elements.
  - Iron.
  - Iodine.
  - Manganese.
  - Zinc.
  - Fluorine.



Unauthorised publication, distribution or reproduction of these notes is prohibited.

### ELECTROLYTES

- Electrolytes are minerals in blood and other body fluids that carry an electric charge.
- For example, Calcium, Phosphorous, Potassium, Sodium.
- They affect the amount of water in your body, pH of blood, muscle function.

### CALCIUM (Ca)

- Almost all the Calcium in the body is found in the bones and teeth as calcium phosphate (calcium hydroxyapatite)
- A small amount is found in blood and body fluids.
- Macromineral.

### A : CALCIFICATION

- Calcification is defined as the laying down of calcium and phosphorous in the bones and teeth.
- It begins around week 13-14 of pregnancy and continues until peak bone mass is achieved around the age of 20-30 years old.
- During early childhood, calcification takes place more than any other time.

RESULT : HARD BONE.

ABSORPTION OF CALCIUM	
+	-
<ul style="list-style-type: none"><li>Vitamin D</li><li>phosphorous</li><li>parathormone</li><li>protein</li><li>Vitamin C</li></ul>	<ul style="list-style-type: none"><li>excess fatty acids</li><li>excess protein</li><li>phytic acid</li><li>oxalic acid.</li></ul>



Collagen framework



Ca and P are deposited (calcium phosphate crystals) in the soft collagen framework of babies bones.

## B : RICKETS

- When something goes wrong with the calcification process during early childhood (ie) : inhibiting factors exist, the bones are soft and weak.
- When toddlers start to walk, the weight of their upper body puts pressure on the legs and they become curved (bow legs)

Figure 2. Photograph of a patient with rickets showing bowing of the legs (A) with classical radiological findings (B). of rickets.



(A)



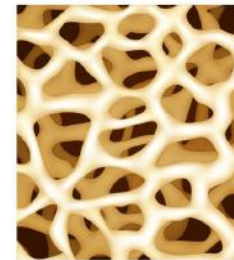
(B)

## C : OSTEOMALACIA

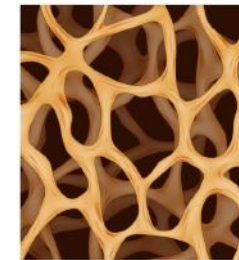
- The condition may develop in women particularly (middle aged women)
- It is a loss of bone density (eg) : after a number of pregnancies, the foetuses may drain calcium from the mother's bones and this calcium may not be replaced in the diet.
- Also, during the menopause, the drop in the level of the female hormone oestrogen can accentuate the onset of osteomalacia.

## D : OSTEOPOROSIS

- This is a bone disease common in the elderly.
- It is caused by an excessive decrease in bone density.
- Particularly common in women (8 times more likely to occur in women than men) :
  - 1 : Women have a lower bone density.
  - 2 : Pregnancy can drain calcium supplies.
  - 3 : Low levels of oestrogen.
- Sometimes called brittle bone disease (**Menopause**)
- 75% of all cracks and fractures in old people's bones is due to osteoporosis.
  - More detail on osteoporosis in 'Diets'.



Normal Bone



Bone with Osteoporosis



## CALCIUM (Ca)

<b>Sources</b>	<b>Functions</b>	<b>Effects of Deficiency</b>	<b>RDA's</b>
<ul style="list-style-type: none"> <li>○ <b>Dairy foods</b> → Milk, Yoghurt, Cheese.</li> <li>○ <b>Leafy green veg</b> → Broccoli, Kale, Spinach.</li> <li>○ <b>Fruits</b> → Oranges.</li> <li>○ <b>Beans/Peas</b> → Tofu, Peanuts, Baked Beans.</li> <li>○ <b>Fish</b> → Salmon, Sardines.</li> <li>○ <b>Others</b> → Fortified White Flour.</li> </ul> <p><b>NOTE</b> : Only give <u>2</u> dairy sources in an exam.</p>	<ul style="list-style-type: none"> <li>● <b>Calcification</b> : Calcium is deposited in bones and teeth from early pregnancy along with phosphorous in the form of calcium phosphate. This process begins during week 13-14 of pregnancy and continues until mid 20's-30 years old.</li> <li>● Assists in normal <b>blood clotting along</b> with Vitamin K.</li> <li>● Helps maintain <b>proper nerve and muscle function/muscle tone</b>.</li> <li>● Regulates <b>heart rhythm</b> and helps lower blood pressure.</li> <li>● Reduces blood cholesterol levels.</li> </ul>	<ul style="list-style-type: none"> <li>● Arm and leg muscle spasms/joint pains.</li> <li>● Softening of bones due to (eg) : osteomalacia (middle aged women), osteoporosis (elderly). It is also the cause of rickets (bow legs) in children.</li> <li>● Because of Calcium's role in the movement of blood, deficiency can elevate blood pressure and cholesterol.</li> <li>● Messages from the nervous system to the brain can be affected resulting nervousness, insomnia, depression and confusion.</li> </ul>	<p style="text-align: center;"><b>Children/Adult/Teen</b> 800 mg</p> <p style="text-align: center;"><b>Teen Male</b> 1000 mg</p> <p style="text-align: center;"><b>Pregnant and Lactating Mothers</b> 1000 - 1200 mg</p>



*Unauthorised publication, distribution or reproduction of these notes is prohibited.*

## FACTORS THAT AFFECT CALCIUM (Ca) ABSORPTION

<i>Help Absorption (+)</i>	<i>Hinder Absorption (-)</i>
<ul style="list-style-type: none"> <li>● <b>Vitamin D</b> – causes protein to be made in the first part of the small intestine which in turn stimulates the reabsorption of excreted calcium in the kidney (Loop of Henle)</li> <li>● <b>Phosphorous</b> – Ca:P, 1:1.5. Phosphorous combines with calcium to form calcium phosphate.</li> <li>● <b>Vitamin C (Ascorbic Acid)</b> provides an acidic environment which helps the absorption of calcium.</li> <li>● <b>Parathormone</b> – secreted from the parathyroids in the thyroid gland helps control the level of calcium in the blood.</li> </ul>	<ul style="list-style-type: none"> <li>● <b>Excess Phytic Acid</b> can combine with soluble calcium and form phytates and insoluble calcium. Phytic acid is present in plant derived foods (Seeds, Grains, Legumes, Nuts)</li> <li>● <b>Excess Oxalic Acid</b> can combine with calcium and form calcium oxalate (insoluble calcium). Oxalic acid is present in Rhubarb, Spinach, Kale, Cocoa Powder.</li> <li>● <b>Excess Protein</b> (eg) : Dukan diet, Atkins diet etc. Can increase excretion of calcium from the body in urine.</li> <li>● <b>Too many fatty acids</b> in the diet can combine with calcium and inhibit it's absorption.</li> </ul>



## POTASSIUM (K)

<b>Sources</b>	<b>Functions</b>	<b>Effects of Deficiency</b>	<b>RDA's</b>
<ul style="list-style-type: none"> <li>○ Fruit/Fruit Juice.</li> <li>○ Vegetables.</li> <li>○ Meat.</li> <li>○ Milk.</li> <li>○ Fish.</li> <li>○ Nuts.</li> </ul> <p><b>NOTE :</b> Present in nearly all foods, especially those of vegetable origins.</p>	<ul style="list-style-type: none"> <li>● Necessary for the <b>transmission of nerve impulses.</b></li> <li>● <b>Muscle contraction</b> including the beating of the heart.</li> <li>● Maintains the concentration of cellular foods.</li> <li>● Necessary for cell formation.</li> </ul>	<ul style="list-style-type: none"> <li>● Potassium deficiency is more serious than sodium deficiency.</li> <li>● Weakness.</li> <li>● Paralysis.</li> <li>● Mental confusion.</li> <li>● Muscular weakness.</li> </ul>	<p><b>Children</b> 800-1000 mg</p> <p><b>Adult</b> 3500 mg</p> <p><b>Pregnant and Lactating Mothers</b> 3500 mg</p> <p><b>Elderly</b> 3500 mg</p>



*Unauthorised publication, distribution or reproduction of these notes is prohibited.*

## SODIUM (Na)

<i>Sources</i>	<i>Functions</i>	<i>Effects of Deficiency</i>	<i>RDA's</i>
<ul style="list-style-type: none"> <li>○ Sausages.</li> <li>○ Smoked Fish.</li> <li>○ Salted Butter.</li> <li>○ Canned Vegetables (Peas/Beans)</li> <li>○ Bread</li> <li>○ Convenience Foods (Frozen Pizzas/ Pot Noodles)</li> </ul>	<ul style="list-style-type: none"> <li>● Necessary for the <b>transmission of nerve impulses.</b></li> <li>● <b>Muscle contraction</b> including the beating of the heart.</li> <li>● Essential for the correct water balance of the body (Osmoregulation)</li> <li>● Keeps blood and body fluids alkaline.</li> </ul>	<ul style="list-style-type: none"> <li>● Muscular cramps.</li> <li>● Loss of appetite.</li> <li>● Low blood pressure.</li> <li>● Tiredness/Apathy</li> </ul>	<p style="text-align: center;"><b>Children 1-3 Years</b> 500 mg</p> <p style="text-align: center;"><b>Children 7-10 Years</b> 1.2 g</p> <p style="text-align: center;"><b>Adults</b> 1.6 g</p>

***Sodium is the ONLY micronutrient measured in grammes.***



*Unauthorised publication, distribution or reproduction of these notes is prohibited.*

## IRON (Fe)

<b>Functions</b>	<b>Deficiency</b>
<ul style="list-style-type: none"><li>• Iron is needed to make the conjugated protein haemoglobin.</li><li>• Iron is important in the neurological development of the human embryo.</li><li>• Iron is an important part of enzyme systems and is necessary for our immune function.</li><li>• The 'Haem' part of haemoglobin has a special property which is its ability to pick up oxygen and form oxyhaemoglobin. Oxyhaemoglobin carries oxygen to cells and tissues of the body.</li></ul>	<ul style="list-style-type: none"><li>• <b>Iron Deficiency Anaemia</b> : Low levels of haemoglobin (ie) : low levels of iron in the blood therefore not enough oxygen can be picked up by the blood. <b>Symptoms</b> – Paleness of skin, shortness of breath, fatigue, inability to exercise normally.</li><li>• <b>Dry and damaged Hair and Skin</b> : This is because when your body is iron deficient, it directs its limited oxygen to more important functions (eg) : organs. When hair is deprived of oxygen → dry and weak. Severe iron deficiency could lead to hair loss.</li><li>• <b>Swelling and Soreness of the Tongue and Mouth</b> : The tongue can become swollen, inflamed or strangely smooth. Dry mouth, sore red cracks at the corner of the mouth or mouth ulcers.</li><li>• <b>Restless Leg Syndrome</b> : An strong urge to move your legs at rest, also possible itchy sensations.</li></ul>



# IRON (Fe)

RDA's	Excess Iron Intake							
<p><b>Teen Male</b> 8 mg</p> <p><b>Men</b> 9 – 10 mg</p> <p><b>Women (From Puberty)</b> 14 – 15 mg</p> <p><b>Pregnant and Lactating Mothers</b> 15 – 18 mg</p>	<table border="1"> <thead> <tr> <th data-bbox="831 400 1406 485">Nutritional Iron Overload</th> </tr> </thead> <tbody> <tr> <td data-bbox="831 485 1406 900"> <ul style="list-style-type: none"> <li>- Condition called <u>Siderosis</u></li> <li>- usually over 40mg of iron in diet per day</li> <li>- also iron cooking pans</li> </ul> </td> </tr> <tr> <td data-bbox="831 900 1406 1150"> <p><u>Symptoms</u></p> <p>diabetes Heart disease Joint pain constipation</p> </td> </tr> </tbody> </table>	Nutritional Iron Overload	<ul style="list-style-type: none"> <li>- Condition called <u>Siderosis</u></li> <li>- usually over 40mg of iron in diet per day</li> <li>- also iron cooking pans</li> </ul>	<p><u>Symptoms</u></p> <p>diabetes Heart disease Joint pain constipation</p>	<table border="1"> <thead> <tr> <th data-bbox="1429 400 1951 485">Genetic iron overload</th> </tr> </thead> <tbody> <tr> <td data-bbox="1429 485 1951 900"> <ul style="list-style-type: none"> <li>- condition called <u>Haemochromatosis</u></li> <li>- genetic disorder</li> <li>- Caused by failure for iron to be absorbed (small int)</li> </ul> </td> </tr> <tr> <td data-bbox="1429 900 1951 1150"> <p><u>Symptoms</u></p> <p>enlarged liver grey pallor / skin diabetes – Maybe death!</p> </td> </tr> </tbody> </table>	Genetic iron overload	<ul style="list-style-type: none"> <li>- condition called <u>Haemochromatosis</u></li> <li>- genetic disorder</li> <li>- Caused by failure for iron to be absorbed (small int)</li> </ul>	<p><u>Symptoms</u></p> <p>enlarged liver grey pallor / skin diabetes – Maybe death!</p>
Nutritional Iron Overload								
<ul style="list-style-type: none"> <li>- Condition called <u>Siderosis</u></li> <li>- usually over 40mg of iron in diet per day</li> <li>- also iron cooking pans</li> </ul>								
<p><u>Symptoms</u></p> <p>diabetes Heart disease Joint pain constipation</p>								
Genetic iron overload								
<ul style="list-style-type: none"> <li>- condition called <u>Haemochromatosis</u></li> <li>- genetic disorder</li> <li>- Caused by failure for iron to be absorbed (small int)</li> </ul>								
<p><u>Symptoms</u></p> <p>enlarged liver grey pallor / skin diabetes – Maybe death!</p>								





## DIFFERENTIATE BETWEEN HAEM AND NON HAEM IRON

	<i><b>Haem Iron</b></i>	<i><b>Non Haem Iron</b></i>
<b>STATE</b>	<ul style="list-style-type: none"> <li>○ Exists in the ferrous state.</li> </ul>	<ul style="list-style-type: none"> <li>○ Exists in the ferric state</li> </ul>
<b>ABSORPTION</b>	<ul style="list-style-type: none"> <li>○ Very easily absorbed by the body.</li> </ul>	<ul style="list-style-type: none"> <li>○ Vitamin C (reducing agent) is needed to remove a molecule of oxygen from ferric iron to reduce it to ferrous iron for absorption.</li> </ul>
<b>FOOD SOURCES</b>	<ul style="list-style-type: none"> <li>○ Red meat (Beef)</li> <li>○ Offal</li> <li>○ Black pudding</li> <li>○ Fish</li> </ul> <p style="text-align: center;"><b>(Mainly Animal Sources)</b></p>	<ul style="list-style-type: none"> <li>○ Eggs</li> <li>○ Nuts</li> <li>○ Dried fruits</li> <li>○ Beans</li> <li>○ Cereals</li> <li>○ Green leafy vegetables (eg) : Cabbage.</li> </ul> <p style="text-align: center;"><b>(Mainly Vegetable Sources)</b></p>

**REVISE !** : **Pernicious Anaemia** → Lack of Vitamin B12,  
**Macrocytic Anaemia** → Lack of Vitamin B6, Lack of Folate/Folic Acid,  
**Iron Deficiency Anaemia** → Lack of iron.



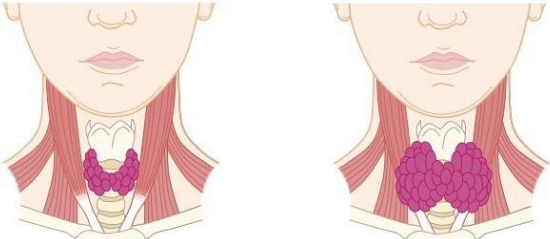
*Unauthorised publication, distribution or reproduction of these notes is prohibited.*

## FACTORS THAT AFFECT IRON (Fe) ABSORPTION

<i>Help Absorption (+)</i>	<i>Hinder Absorption (-)</i>
<ul style="list-style-type: none"> <li>• <b>Vitamin C</b> – helps absorption of iron. It acts as a reducing agent, capable of removing one molecule of oxygen from ferric iron to reduce it to ferrous iron.</li> <li>• <b>Combining Haem and Non Haem sources of iron together at the same meal.</b> Meat, Fish and Poultry, not only provide a good source of absorbable haem iron but can also stimulate the absorption of non haem iron. Several studies have reported that the addition of Beef, Chicken or Fish to a cereal based meal (eg) : Brown Rice, can result in 2-3 times greater non haem absorption.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Excess Phytic Acid</b> (Phytic Acid can be found in large amounts in Peanuts, Kidney Beans, Oats, Bran). Phytates are formed when excess phytic acid combines with iron which can inhibit iron absorption.</li> <li>• <b>Excess Oxalic Acid</b> (Oxalic Acid can be found in large amounts in Kale, Spinach, Beetroot, Rhubarb). Oxalates form when combined with iron, this can inhibit iron absorption.</li> <li>• <b>Polyphenols</b> are major inhibitors of iron absorption (found in Cocoa, Coffee and some Herbs). <b>Tannins are water soluble polyphenols</b> found in Teas, Coffees, Cocoa, Walnuts, Apples, Raspberries, Blackberries and all have the ability to inhibit iron absorption by as much as 60%.</li> </ul>



## IODINE (I)

<b>Sources</b>	<b>Functions</b>	<b>Effects of Deficiency</b>	<b>RDA's</b>
<ul style="list-style-type: none"> <li>○ Cod Liver Oil.</li> <li>○ Seafood (eg) : Salmon, Herring, Cod.</li> <li>○ Milk.</li> <li>○ Milk Products.</li> <li>○ Vegetables grown near the sea.</li> <li>○ Seaweed.</li> </ul>	<ul style="list-style-type: none"> <li>● Iodine is needed to make the hormones thyroxine and tri-iodothyronine.</li> <li>● Helps to regulate metabolism.</li> <li>● Essential for brain development in the womb/early childhood.</li> </ul>	<ul style="list-style-type: none"> <li>● <b>Goitre</b> – enlargement of the thyroid gland.</li> <li>● Lack of energy.</li> <li>● Cretinism – mental backwardness.</li> <li>● Weight gain due to underactive thyroid gland.</li> </ul> <div style="text-align: center;">  <p style="display: flex; justify-content: space-around; margin-top: 5px;"> <span data-bbox="1151 1098 1279 1114">Normal Thyroid</span> <span data-bbox="1518 1098 1576 1114">Goitre</span> </p> </div>	<p><b>Children</b> 100 µg</p> <p><b>Teenagers</b> 130 µg</p> <p><b>Adults</b> 140 µg</p> <p><b>Pregnancy</b> 140 µg</p>



## ZINC (Zn)

<b>Sources</b>	<b>Functions</b>	<b>Effects of Deficiency</b>	<b>RDA's</b>
<ul style="list-style-type: none"> <li>○ Oysters.</li> <li>○ Meat.</li> <li>○ Milk.</li> <li>○ Bread.</li> <li>○ Legumes.</li> <li>○ Cereal Products.</li> </ul>	<ul style="list-style-type: none"> <li>● Zinc is a constituent of many enzymes, particularly an enzyme found in red blood cells.</li> <li>● Maintenance of health.</li> <li>● It is necessary for protein and carbohydrate metabolism.</li> <li>● Forms part of Gustin, the zinc protein found in saliva.</li> </ul>	<ul style="list-style-type: none"> <li>● Not known in healthy people.</li> <li>● Those suffering from alcoholism, senile dementia, diabetes may lack zinc.               <ul style="list-style-type: none"> <li>- Poor digestion.</li> <li>- Delayed healing of wounds.</li> </ul> </li> </ul>	<p><b>Children</b> 4 - 7 mg</p> <p><b>Teenagers</b> 9 mg</p> <p><b>Adults</b> 7 - 9 mg</p> <p><b>Pregnancy</b> 13 - 15 mg</p>



## SAMPLE QUESTIONS

### 2006 Q2(B) HIGHER LEVEL (18 MARKS)

- (a) State:
- (i) **four** possible ill-effects of a diet deficient in calcium;
  - (ii) the recommended dietary allowance (RDA) of calcium for (a) adults and (b) pregnant women.
- (18)

#### (i) 4 Points @ 3M each = 12M

- Softening of bones due to decrease in bone density (eg) : Osteomalacia (middle aged women), Osteoporosis (elderly).
- Because of it's role in the movement of blood, Calcium deficiency can elevate blood pressure and cholesterol levels in the blood.
- Arm and leg muscle spasms/joint pain.
- Messages from the brain can be affected resulting in nervousness, insomnia, depression and confusion.

#### (ii) 2 Points @ 3M each = 6M

- RDA Male Adult : 800mg.
- RDA Pregnant Women : 1200mg.

### 2010 Q1(B) HIGHER LEVEL (21 MARKS)

- (b) Meat makes an important contribution to the intake of micronutrients such as iron. Give an account of iron and refer to:
- sources in the diet
  - biological functions
  - recommended daily allowance (RDA) for adults.
- (21)

#### (i) 3 Points @ 3M each = 9M

- **Haem Iron Sources**
  - Offal (Liver)
  - Red Meat.
- **Non Haem Iron Sources**
  - Eggs.
  - Green Leafy Vegetables (Spinach, Kale)

#### (ii) 3 Points @ 3M each = 9M

- Iron is important in the neurological development of the human embryo.
- The 'Haem' part of the haemoglobin has a special property, which is that it has the ability to pick up oxygen to form oxyhaemoglobin. Oxyhaemoglobin carries oxygen to cells and tissues of the body.
- Iron is an important part of enzyme systems and is necessary for our immune systems.

#### (iii) 1 Point @ 3M = 3M

- RDA Pregnancy/Lactation : 15 – 18mg.

### 2010 Q1(B) HIGHER LEVEL (15 MARKS)

- (c) Identify and explain **three** factors which affect the absorption of iron in the body. (15)

*(See Table in Notes)*

**NB** : If a question ever asks about **Calcium** or **Iron** absorption, **ALWAYS** give **BOTH** factors that **ASSIST** and **HINDER** absorption ... you don't know what they're looking for so give them both!



### 2015 Q1(B) HIGHER LEVEL (18 MARKS)

- (b) Poor food choices have contributed to 42% of teenage girls and 23% of teenage boys not getting enough calcium in their diet.

Give an account of *calcium* and include reference to:

- sources
- biological functions
- factors assisting/inhibiting absorption.

(18)

#### (i) 3 Points @ 2M each = 6M

- **Dairy Foods** : Milk, Yoghurt, Cheese.
- **Leafy Green Vegetables** : Broccoli, Kale, Spinach.
- **Beans/Peas** : Tofu, Peanuts, Baked Beans.

#### (ii) 3 Points @ 2M each = 6M

- **Calcification** : Calcium is deposited in bones and teeth from early pregnancy along with Phosphorous in the form of Calcium Phosphate. This process begins during week 13-14 of pregnancy and continues until late 20's – 30 year olds.
- Helps maintain proper nerve and muscle formation/muscle tone.
- Assists in normal blood clotting along with Vitamin K.

#### (i) 3 Points @ 2M each = 6M

*(See Table in Notes)*

## HOMEWORK

### 2019 Q1(B) HIGHER LEVEL (18 MARKS)

- (d) Dairy based snacks can contribute to micro-nutrient intake.

Give an account of calcium under each of the following headings:

- sources
- biological functions
- effects of deficiency.

(18)

### MARKING SCHEME

- **Sources** : 3 Points @ 2M each (Graded 2:1:0)
- **Functions** : 3 Points @ 2M each (Graded 2:1:0)
- **Effects of Deficiency** : 3 @ 2M each (2:0)

