3
Minerals

Minerals

Minerals are inorganic substances required by the organism in very small amounts for its growth and maintenance of its functional activity.

Function of minerals:

i. Minerals are essential constituent of all cells.
ii. Maintenance of osmotic pressure of body fluids.
iii. Needed in the formation of bones and teeth and coagulation of blood.
iv. They regulate the excitability of muscular and nervous system.
v. Play an important role in water metabolism and regulation of blood volume.
vi. Essential in the transport of gases.

Types of minerals :

Minerals are divided into two types :

1. *Principal elements:* These occur in the body in greater concentration (60-80%). These include- sodium, potassium, calcium, magnesium, phosphorus, sulpher and chlorine.
2. *Trace elements:* These occur in the body in lower concentration. These include- arsenic, chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, nickel, selenium, silicon, vanadium, zinc.

Trace elements believed essential for life.

(Ref. Ganong 21th Edition; Page-313)

Required daily amounts of minerals :

Minerals	*Per day*
Na	3.0 gm
K	1.0 gm
Cl	3.5 gm
Ca	1.2 gm
P	1.2 gm
Fe	18.0 mg
I	150.0 µg
Mg	0.4 gm
Zn	15.0 mg
Co	Unknown
Mn	Unknown
Cu	Unknown

(Ref. Guyton 11th Edition; Page-879)

Sodium

Sources : Table salt, most cereals, milk, fruits vegetables.

Normal Blood level :

Whole blood contains of 160 mg% or 70 mEq/L.

Daily requirement :

3.0 gm (Guyton), Content in adult man - 6.3 gms.

Absorption : Na is absorbed mainly from small intestine & some may from large intestine and stomach. The process is mostly by diffusion.

Excretion : Main channel of excretion is kidney. Only 5% is excreted through urine. Some amount of Na excretes through sweat.

Significance :

i. It is the main base of the body . It is the chief extra cellular cations.
ii. It is one of the important cations responsible for maintaining the internal environment of the body.
iii. It maintains the neuro-muscular conductivity and irritability.
iv. It maintains cardiac rhythmicity and contractility.
v. It froms the alkali reserve of the body.

Potassium

Sources : Cereals, bananas, orange, chicken, beef, liver, vegetables, water etc.

Blood level :

1. Whole blood : 200 mg% or 50 mEq/L
2. Plasma : 20 mg% or 4-5 mEq/L
3. Corpuscles : 440 mg% or 112 mEq/L

Daily requirement : 1 gm

(Ref, Guyton& Hall-11th Edition)

Absorption : It is absorbed from GI Tract along with Na and Cl in the same way as sodium is absorbed.

Excretion :

a. Mostly are excreted through urine. Potassium is not only excreted in the urine but it also added to the urine from distal tubule in exchange for Na^+.
b. Small amount are also excreted through sweat and digestive juice.

Functions :

i. With sodium, it forms the main base of the body. It is the chief intracellular cation.
ii. It is responsible for maintaining the membrane potential of all irritable cells.
iii. It influence the activity of cardiac muscle.
iv. Essential in conduction of nerve impulse.

Hyperkalemia

Definition : Increased level of potasium in serum.

Cause :

i. Addison's disease
ii. Advanced chronic renal failure
iii. Dehydration
iv. Shock
v. Intravenous administration of potassium.

Symptoms :

1. Bradycardia
ii. Peripheral vascular collapse
iii. Cardiac arrest
iv. Mental confusion
v. Weakness of respiratory muscles
vi. Flaccid Paralysis of Limbs.

Hypokalemia

Definition : Decreased level of potassium in serum.

Cause :

i. Chronic wasting disease with malnutrition
ii. Prolonged negetive nitrogen balance
iii. Dirrhoea
iv. Cushing syndrome etc.

Symptoms :

i. Tachycardia
ii. Dilatation of heart.
iii. Muscle weakness
iv. Kidney hypertrophy etc.

Calcium

Sources :

1. Milk (120 mg/100 ml)
2. Milk products (800mg/ 100 ml)
3. Eggs, meats
4. Green vegetable, nuts, potato, rice etc.

Normal plasma calcium level :
10 mg/dl (5 meq/L, 2.5 mmol/L)

(Ganong 22th Edition, page 382)

In plasma calcium remains in three forms :

i. Ionized calcium : 50% (*1.2 mmol/L*), this physiologically active and diffusible.

ii. Protein bound calcium : 41% (*1 mmol/L*), in combination with plasma protein.

iii. Calcium complexed to anions : 9% (*0.2 mmol/L*), is diffusible but is combined with citrate & phosphate.

(Ref. Guyton & Hall-11th Edition, page 978, 979)

or

Distribution (mmol/L) of calcium in normal human plasma :

Total diffusible		1.34
Ionized (Ca^{++})	1.18	
Complexed to HCO3- , citrate etc.	0.16	
Total nondiffusible (protein-bound)		1.16
Bound to albumin	0.92	
Bound to globulin	0.24	
Total plasma calcium		2.50

It is the free, ionized calcium in the body fluids that is a vital second messenger and is necessary for blood coagulation, muscle contraction, and nerve function.

(Ref. Ganong 22th edition, Page-383)

Total body calcium level : 1100 gm
: 27.5 mol

(Ref. Ganong 22th edition, Page-383)

Daily requirement :

1. Average human being : 0.5 gm
2. Adolecent children : 0.7 gm
3. Pregnant and lactating mother : 1.0 gm
4. *Normal* : *1.2 gm.*

(Ref. Guyton& Hall-11th edition)

Absorption : Calcium though presents in nature in both organic and inorganic form, it is absorbed only as inorganic salt in the small intestine mainly in duodenum.

Excretion :

a. Mainly excreted through faeces (0.4 - 0.8 gm).
b. Small amount also excrete through urine (120 - 150 mgm).

Storage : 99% of the body calcium stored in the skeleton.

Significance of calcium :

i. Calcium helps in the formation of bones and teeth.
ii. It helps in clotting of blood and curdling of milk.
iii. It is essential for maintaining neuromuscular excitability.
iv. It helps to maintain cardiac contractility. Excess calcium will make the heart to stop in systole.
v. It is believe to be actively involved in the membrane transport mechanism.

Factors influencing absorption :

1. Calcium-equilibrium of the body : The calcium deficient body absorbs more calcium.
2. Phosphate & Magnesium proportion of diet : High phosphate and low magnesium concentration diet facilitates Ca absorption.
3. P^H of intestinal lumen : Acidic p^H enhance where as alkaline p^H retards absorption.
4. Fatty meal: High fatty diet retards absorption.
5. High protein diet : Helps Ca absorption.

6. Oxalic acid : Retards absorption.
7. Vitamin D : Enhance absorption.

Deficienecy symptom :

i. *Children* : Rickets.
ii. *Adult* : Osteomalacia.

N.B. Features of Rickets descrided in vitamin - D.

Regulation of calcium metabolism

Three hormones are primarily concerned with the regulation of calcium metabolism.

1. *1,25-Dihydroxy-cholecalciferol* : Is a steroid hormone formed from vitamin D by successive hydroxylations in the liver and kidneys.
   Function : Its primary action is to increase calcium absorption from the intestine.
2. *Parathyroid hormone (PTH)* : Is secreted by the parathyroid glands.*Function* : Its main action is to mobilize calcium from bone and increase urinary phosphate excretion.
3. *Calcitonin* : A calcium-lowering hormone that in mammals is secreted primanly by cells in the thyroid gland,.
   Function : Inhibits bone resorption.

Although the role of calcitonin seems to be relatively minor, all three hormones probably operate in concert to maintain the constancy of the Ca^{2+} level in the body fluids.

A fourth hormone, *parathyroid hormone-related protein (PTHrP)*, acts on one of the PTH receptors and is important in skeletal development in utero. There may also be a phosphate-regulating hormone, and glucocorticoids, growth hormone, estrogens and various growth factors also affect calcium metabolism.

Other *electrolytes* and *pH* affect the Ca^{2+} level. Thus for example, *symptoms of tetany* appear at much higher total calcium levels if the patient ***hyperventilates,*** increasing plasma pH. Plasma proteins are more ionized when the pH is high, providing more protein anion to bind with Ca^{2+}.

(Ref. Ganong 22th edition, Page-382)

Calcium metabolism in an adult human

(ingesting 25 mmol; 1000 mg of calcium :

In bones : The calcium in bone is of two types : a *readily exchangeable reservoir* and a much larger pool of *stable calcium* that is only slowly exchangeable.

There are two *independent but interacting homeostatic systems* affecting the calcium in bone.

1. *One is the system* that regulates plasma Ca^{2+} and in the operation of this system, about 500 mmol of Ca^{2+} per day moves into and out of the readily exchangeable pool in the bone.
2. *The other system* is the one concerned with bone remodeling by the constant interplay of bone resorption and deposition, which, in the adult, accounts for 95% of bone formation. However, the Ca^{2+} interchange between plasma and this stable pool of bone calcium is only about 7.5 mmol/L.

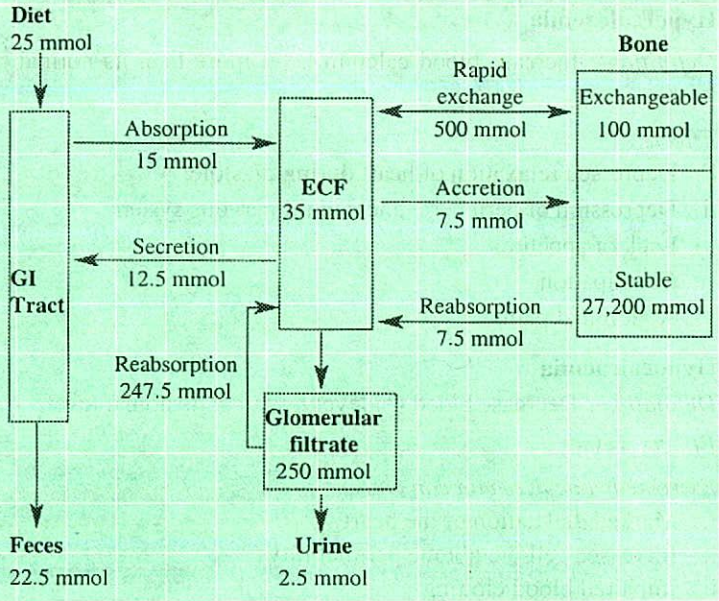

Figure 8-14. *Calcium metabolism in an adult human ingesting 25 mmol (1000 mg) of calcium per day.* (Ref. Ganong 22 th edition; page 383)

In kidneys : A large amount of calcium is filtered in the kidneys. but 98-99% of the filtered calcium is reabsorbed. About 60% of the reabsorption occurs in the *proximal tubules* and the remainder in the *ascending limb of the loop of Henle* and the *distal tubule*. Distal tubular reabsorption is regulated by parathyroid hormone.

In gastrointestinal tract : The absorption of Ca^{2+} from the gastrointestinal tract is actively transported out of the intestine by a system in the brush-border of the epithelial cells that involves a calcium-dependent ATPase, and this process is regulated by 1,25-dihydroxy cholecalciferol. There is also some absorption by passive diffusion. When Ca^{2+} intake is high, 1,25 dihydroxy cholecalciferol levels fall because of the increased plasma Ca^{2+}. Consequently, Ca^{2+} absorption undergoes adaptation; ie, it is high when the calcium intake is low and decreased when the calcium intake is high. Calcium absorption is also decreased by substances that form insoluble salts with Ca^{2+} (eg, phosphates and oxalates) or by alkalis, which favor formation of insoluble calcium soaps. A high-protein diet increases absorption in adults.

(Ref. Ganong 22th edition, Page-382, 383)

Hypocalcemic tetany : A decrease in extracellular Ca^{2+} exerts a net excitatory effect on nerve and muscle cells in vivo. The result is *hypocalcemic tetany*

Characteristics :

1. *Extensive spasms of skeletal muscle*, involving especially the muscles of the extremities and the larynx.
2. *Laryngospasm* becomes so severe that the airway is obstructed and fatal asphyxia is produced.

Ca^{2+}plays an important role in clotting in vivo, however, the level of plasma Ca^{2+} at which fatal tetany occurs is still above the level at which clotting defects would occur.

(Ref. Ganong 22th edition, Page-382)

Hypercalcaemia

Definition : Increase blood calcium level more than its normal level.

Effects :

i. Depressed relaxation of heart during diastole.
ii. Depression of peripheral and central nervous system .
iii. Lack of appetite.
iv. Constipation.
v. Abdominal pain.

Hypocalcaemia

Defination : Decrease blood Ca level less than its nomal level.

Effect : Tetany

Extreme hypocalcaemia can cause :

i. Marked dialatation of the heart
ii. Increased cell membrane permiability
iii. Impaired blood clotting
iv. Changes in cellular enzyme activity.

Tetany

Aetiology :

There is an increased excitability of peripheral nerves due either to a low serum calcium or to alkalosis in which the proportion of the serum calcium in the ionised form is decreased, although the total calcium concentration remains unaltered. Magnesium depletion should also be considered as a possible contributing factor, particularly in malabsorption. The most common cause of hypocalcaemia is a low serum concentration of albumin which does not result in tetany.

Causes of tetany

1. Due to hypocalcaemia
   - Malabsorption
   - Osteomalacia
   - Hypoparathyroidism
   - Acute pancreatitis
   - Chronic renal failure
2. Due to alkalosis
   - Repeated vomiting of gastric juice
   - Excessive intake of oral alkalis
   - Hyperventilation
   - Primary hyperaldosteronism.
   - Coincident acidosis usually prevents tetany.

Clinical features :

i. *In children :* a characteristic triad of carpopedal spasm, stridor and convulsions occurs, though one or more of these may be found independently of the others. The hands in carpal spasm adopt a characteristic position.The metacarpophalangeal joints are flexed, the interphalangeal joints of the fingers and thumb are extended and there is opposition of the thumb (main díaccoucheur). Pedal spasm is much less frequent. Stridor is caused by spasm of the glottis.

ii. *Adult :* Complain of tingling in the hands, feet and around the mouth. Less often there is painful carpopedal spasm while stridor and fits are rare.

Phosphorus

About 80% of the body phosphate is in the bones. Of the rest, the vast majority is organic phosphate and occurs mostly intracellularly. Common examples of such organic phosphates are, nucleotides, ATP, phospholipids, glucose -6-phosphate and so on.

A small amount of phosphate in our blood is inorganic phosphate. In the plasma of blood, both organic and inorganic phosphates are present. A term *acid soluble phosphate* is used by the clinical biochemists, most of the acid soluble phosphate is inorganic phosphate.

The ultimate source of phosphorous of our body is food. Phosphate excretion occurs via urine.

Syndrome due to phosphate deficiency is perhaps unknown. In renal failure serum acid soluble phosphate may become high. Phosphate excretion via kidney is dependent on PTH and vit D.

Sources : Milk, cheese, egg, meat, nuts, peas, vegetables cereals. etc.

Total body phosphorus : 500-800 gm
: 16.1-25.8 mol
85-90% of which is in the skeleton.

Total plasma phosphorus is about : 12 mg/dL

1. *Organic compounds* : two-thirds of the total plasma phosphorus.
2. *Inorganic phosphorus* : Remaining one-third; inorganic phosphorus (Pi) mostly in PO_4^{3-}, PO_4^{2-} and $H_2PO_4^-$.

The amount of phosphorus normally entering bone : is about 3 mg/kg/d (97 µmol/kg/d), with an equal amount leaving via reabsorption.

Aabsorption in GIT : Phosphorus is absorbed in the *duodenum* and *small intestine* by both *active transport* and *passive diffusion*. However, unlike the absorption of Ca^{2+} the absorption of Pi is linearly proportionate to dietary intake. Many stimuli that increase Ca^{2+} absorption, including 1,25-dihydroxycholecalciferol also increase Pi absorption.

Reabsorption in kidneys : The Pi in the plasma is filtered in the glomeruli, and 85-90% of the filtered Pi is reabsorbed. Active transport in the proximal tubule accounts for most of the reabsorption, and this active transport process is powerfully inhibited by parathyroid hormone.

(Ref. Ganong 22th Edition; page 383)

Phosphorus store :

1. In skeleton about : 80 - 85%
2. The rest is distributed through out the body.

Functions :

i. Essential constituent along with calcium for formation of bones and teeth.
ii. Essential in the formation of high energy compounds i.e. ATP.

iii. Essential in the synthesis of RNA, DNA and phospholipids.
iv. Play an important part in all metabolism
v. It comes into the composition of some co-enzyme.

Magnesium

50% of the body Mg occurs in the bone. Of the rest, about 45% occurs within the cell and the remaining 5% in the ECF.
Plasma Mg concentration is between 2 to 4 mg/100ml.

Sources : Vegetables , cereals , egg, milk, soyabean etc.

Daliy requirement : 0.4 gm.

Functions

i. Magnesium ions (Mg^{++}) act as cofactor in many enzyme actions, particularly in those where the action involves splitting of ATP.
ii. Mg^{++} to some extent behaves like the calcium on the neuromuscular system. Mg^{++} deficiency can lead to tetany (but clinically the condition is very rare).

Regulation of magnesium metabolism is poorly known, partly perhaps because of the fact that syndrome due to magnesium deficiency or excess is rare,thus magnesium metabolism has received less attention.

Sulphur

Sources : Nearly whole of the body's sulphur comes from the sulphur containing amino-acids.

a. *Major sources :* Methionine, cysteine, cystine.
b. *Minor sources :*
   1. Glycoproteins
   2. Sulpholipid.

Table 2-1. ***Food and Nutrition Board, National Academy of Sciences- National Research Council recommended dietary allowances, revised 1989.***[12]

Minerals

Category	*Age (years) or Condition*	*Weight*[3]		*Height*[3]		*Calcium* (mg)[8]	*Phosphorus* (mg)	*Magnesium* (mg)	*Iron* (mg)	*Zinc* (mg)	*Iodine* (µg)	*Selenium* (µg)
		Kg	lb	Cm	Inch							
Infants	0.0-0.5	6	13	60	24	400	300	40	6	5	40	10
	0.5-1.0	9	20	71	28	600	500	60	10	5	50	15
Children	1-3	13	29	90	35	800	800	80	10	10	70	20
	4-6	20	44	112	44	800	800	120	10	10	90	20
	7-10	28	62	132	52	800	800	170	10	10	120	30
Males	11-14	45	99	157	62	1200	1200	270	12	15	150	40
	15-18	66	145	176	69	1200	1200	400	12	15	150	50
	19-24	72	160	177	70	1200	1200	350	10	15	150	70
	25-50	79	174	176	70	800	800	350	10	15	150	70
	51+	77	170	173	68	1200	800	350	10	15	150	70
Females	11-14	46	101	157	62	1200	1200	280	15	12	150	45
	15-18	55	120	163	64	1200	1200	300	15	12	150	50
	19-24	58	128	164	65	1200	1200	280	15	12	150	55
	25-50	63	138	163	64	800	800	280	15	12	150	55
	51+	65	143	160	63	1500	800	280	10	12	150	55
Pregnant						1200	1200	320	30	15	175	65
Lactating	1st 6 months					1200	1200	355	15	19	200	75
	2nd 6months					1200	1200	340	15	16	200	75

[1] Modified,and reproduced, with permission, from Recommended Dietary Allowances, 10th ed, National Academy Press, 1989. Copyright © 1989 by the National Academy of sciences. Couttesy of the National Academy Press, Washington, D.C.

[2] The allowances, expressed as average daily intakes over time, are intended to provide for individual variations among most normal persons as they live in the United States under usual environmental stresses. Diets should be based on a variety of common foods to provide other nutrients for which human requirements have been less well defined.

[3] Weights and heights of Reference Adults are actual medians for the U.S. population of the designated age. The median weights and heights of those under 19 years of age are not necessary the ideal values.

[8] Calcium values increased after age 50.

(Ref. Ganong 22th Edition; Page-312)

3. Inorganic sulphate of food
4. A trace of organic food sulphate
5. Thiocyanates etc.

Normal blood sulphur level : 3-5mg % , present in three forms -

i. Inorganic : 0.1 -- 1 mg%
ii. Ehtereal sulphate : 0.1 -- 1 mg%
iii. Neutral sulphur : 2.2 -- 4.5 mg%

Functions :

It is an essential constituent of the protein, keratin which helps in the formation of nail, horns and feathers.

Chlorine

Chlorine is the chief anion of the body. About two thirds of the total anions consists of chloride.

Blood level : 365 gm/100ml.

Significance :

i. The chloride of the HCl of gastric juice comes from chloride of the plasma.
ii. It contributes to the maintenance of electrolyte and water balance.

Iron

Sources :

1. *Vegetable sources :* Raw banana, some green vegetables, wheat, nuts, pulses, etc.
2. Animal sources: Egg, meat, liver, kidney etc.

Normal blood level : 50-60 mg /100 ml

Total amount : About 3-6 gms (average 4 gm).

Daily requirement :

a. Infant : 10 - 15 mg
b. Children :
   1 - 3 years : 15 mg
   4 - 10 years : 10 mg
c. Males :
   11 - 18 yrs : 18 mg
   after 19 yrs : 10 mg
d. Female :
   11 - 50 yrs : 18 mg
   after 51 yrs : 10 mg
e. Adult : 18 mg.

(Ref. Guyton 11th Edition)

Absorption & transport of Iron : Iron is absorbed from the small intestine by active absorptive process or pinocytosis (moderate amount) in ferrous form. It immediately combines with a beta globulin, apotransferrin, to form transferrin, which is then transported in the blood plasma and is distributed throughout the body. Excess iron in the blood is deposited in all cells of the body but specially in the liver cells where it combines mainly with a protein, apoferrin, to form ferrin. This iron stored in ferrin is called storage iron. Smaller quantities of the iron in the storage pool are stored in an extremely insoluble form called hemosiderin.

Excretion : About 0.5-0.4 mg of iron is excreted daily. About 2/3rd of this is in the faeces & sweat; reamaining 1/3rd in the urine.

Storage of iron in body :

a. In haemoglobin : 65%
b. In myoglobin : 5%
c. In liver, spleen, kidney : 15%
d. Only small amount is found in the cytochrome enzymes (e.g. respiratory enzymes).
e. Rest in plasma : 80 - 150 microgram /100ml.

Functions :

i. It is essential for formation of haemoglobin, myoglobin and cytochromes, catalase, peroxidase and certain other enzyme systems.
ii. Necessary for O_2 carries in the blood .
iii. It is an essential constituent of myoglobin and respiratory enzymes.
iv. Iron deficiency leads to hypochromic microcytic anaemia.

Factors affecting absorption :

1. *Acidity of stomach :* Helps absorption by reducing ferric iron present in diet.
2. *Presence of reducing agent :* Like Vit-C, glutathione, S-H group of sulphar containing aminoacids helps absorption of iron.
3. *Excess phosphate :* Hampers absorption.
4. *Iron reserve of the body :* If the reserve is depleted, iron absorption increases.
5. *Form of iron :* Inorganic form is readily absorbed.
6. *Pyridoxine :* Helps iron absorption.

Haemosiderosis : It is a condition of iron deposit in tissues in the form of haemosiderin.

Cause : Malaria, Black water fever & Haemolytic anaemia - causing increased breakdown of R.B.C. and release of excess iron from Hb which then deposit in tissue.

Haemochromatosis : This is a pathological condition, where great increase in haemosiderin (55% iron) deposit takes place in liver, spleen, kidney and other tissue.

Cause : The cause is not definitely known, possibly there occurs excessive absorption of iron from diet, specially rich in iron.

Iodine

Sources : Water (mainly sea water) sea fish, Cod liver oil, iodized salt etc.

Iodine Metabolism : Iodine is a raw material essential for thyroid hormone synthesis. Ingested iodine is converted to iodide and absorbed.

1. *Minimum daily iodine intake* : The minimum daily iodine intake that will maintain normal thyroid function is 150 µg in adults, but in the United States the average dietary intake is approximately 500 µg/d.
2. *Normal plasma I^- level* is about : 0.3 µg/dL.

3. *I^- is distribution :*
   a. I^- is distributed in a 'space' of approximately 25 L (35% of body weight). The principal organs that take up the I^- are the thyroid, which uses it to make thyroid hormones, and the kidneys, which excrete it in the urine.
   b. About 120 µg/d enter the thyroid at normal rates of thyroid hormone synthesis and secretion. The thyroid secretes 80 µg/d as iodine in T_3 and T_4.
   c. 40 micrograms of I^- per day diffuses into the ECF.
   d. The secreted T_3 and T_4 are metabolized in the liver and other tissues, with the release of 60 mg of I^- per day into the ECF.

   The total amount of I^- entering the ECF is thus 500 + 40 + 60, or 600 µg/d; 20% of this I^- enters the thyroid, whereas 80% is excreted in the urine.
5. *Excretion* : Some thyroid hormone derivatives are excreted in the bile, and some of the iodine in them is reabsorbed (enterohepatic circulation), but there is a net loss of I^- in the stool of approximately 20 µg/d.

(Ref. Ganong 22th Edition)

Functions : Iodine is essential for the synthesis of thyroid hormones (thyroxine, tri-iodothyronine).

Deficiency disease :

i. Children : Cretinism.
ii. Adult : Goiter and hypothyrodism, Myxedema.

Fate of Iodine : After absorbtion from the intestine iodides do not remain in blood for a long time because the kidneys have high iodide clearance about 35ml/min. So, 4/5th of ingested iodide are lost in urine within first three days and remaining 1/5th is used for thyroid hormone synthesis.

(Ref. Guyton 11th edition)

Manganese

Sources : Liver, Kidney, blueberries, lettuce, pineapple, spinach etc.

Function :

i. It catalyzes along with copper, the synthesis of haemoglobin.
ii. It activates some enzyme action- phosphatase, carboxylase and peptidase etc.

Flourine

Sources : Water, diet.

Function : It is found in bone and teeth, where it prevent caries.

Cobalt

Sources : Foods of animal origin.

Functions :

It stimulates RBC formation by helping formation of Vit -B_{12}.

Zinc

Sources : Meat, liver, eggs and sea food are good sources. Milk and whole grain products, whole wheat or dye bread, oatmeal are also good sources.

Functions :

i. Zinc is a component of certain enzymes such as carboxy peptidase, carbonic anhydrase, alcohol dehydrogenase etc.
ii Zinc is an integral and essential element of insulin and hence necessary for optimal insulin action.
iii. It is also necessary to maintain normal concentration of vitamin A in the plasma. It is required to mobilize vitamin A from the liver.
iv. Necessary for tissue repair and wound healing.
v. Necessary for taste buds.

Daily requirement :

i. Pre-adolescent children : 6-10 mg/day.
ii. Adolescent children : 13 mg/day.
iii. Adult : 15 mg/day.
iv. During pregnancy & lactation : Additional allowance of 15 mg & 10 mg should be added respectively.

Deficiency sign :

i. Growth failure and sexual infantalism in adolescent.
ii. Loss of taste acuity
iii. Delayed wound healing
iv. Hepatosplenomegaly
v. Delayed closure of the epiphysis of long bones
vi. Anaemia
vii. Necessary for tissue repair and wound healing.