Metabolism of Minerals

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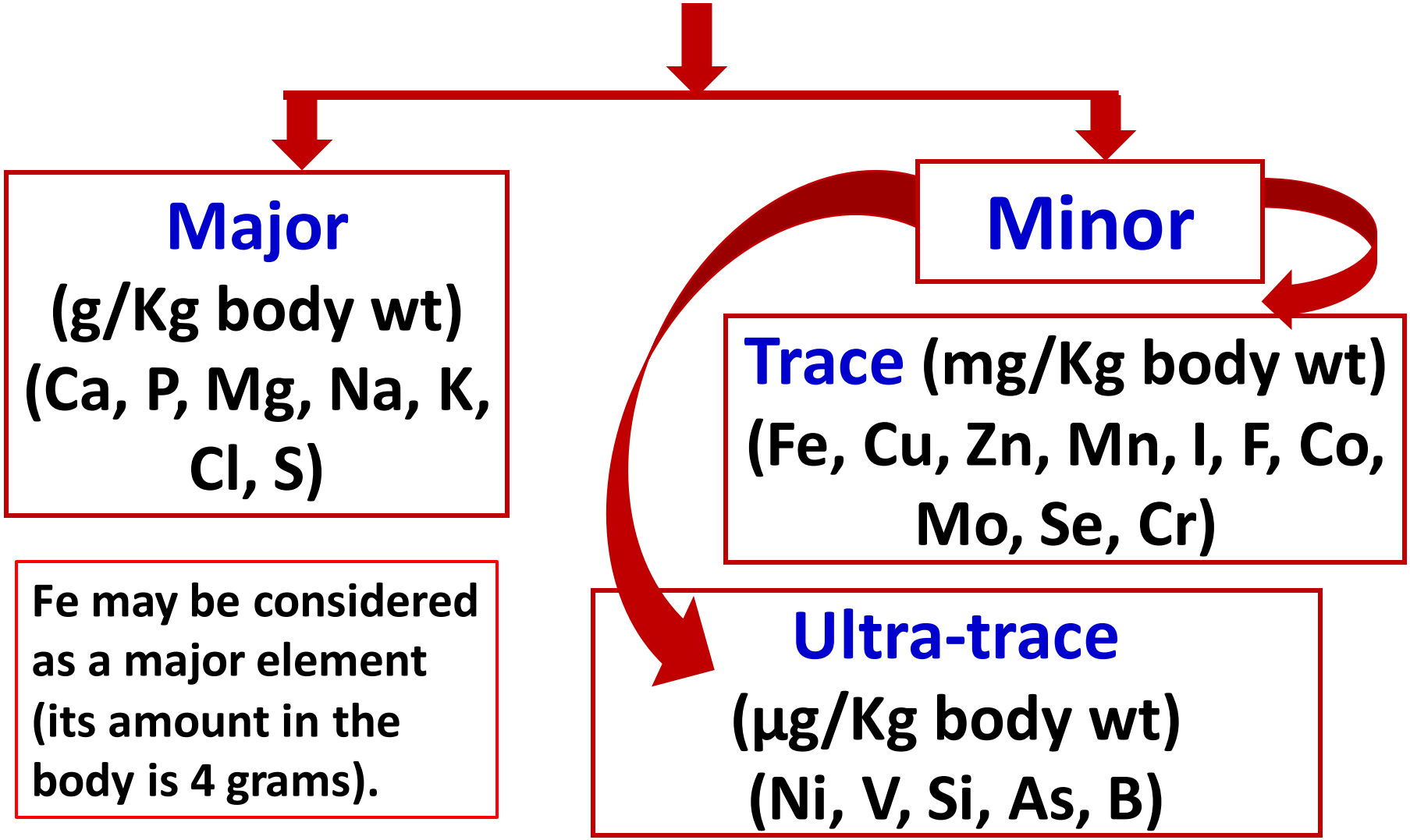
Classification of minerals:

According to their **concentration** in biological tissues



Fe may be considered as a major element (its amount in the body is 4 grams).

Magnesium (Mg):

Sources:

1. Animal: Liver, kidney, heart, meat, & fish.

2. Plant: Vegetables especially chlorophyll, legumes & nuts.

Absorption:

* About **40%** of the ingested Mg is absorbed
* usually from the **upper** small intestine.
* Absorption of Mg is affecting by the factors affecting Ca absorption

Magnesium (Mg):

Distribution:

- Mg is distributed in **skeleton, tissues, & body fluids**
- The total body Mg is about **21 gm**.
- About **70%** in **bone**,
- **30%** in **tissues** & **body fluids** **(mainly intracellular)**
- Mg concentrat. in **muscles: 110** times that of plasma

Blood magnesium:

- The plasma Mg level is 2.2 ± 0.5 mg/dl.
- It is diffusible (80%) & non- diffusible form (20%).
- Its concentration in RBCs is higher than plasma.

Magnesium (Mg):

Factors affecting plasma magnesium:

1. Aldosterone:

- Aldosterone ⟶ Na & H_2O retention
- Aldosterone ⟶ K & Mg excretion

} **Hypo-magnesaemia**

2. Parathyroid hormone (Parathormone):

- Parathormone ⟶ ↑ Mg absorption from intestine.
- Parathormone ⟶ ↑ Mg^{2+} mobilization from bone;
  (The net effect is increased plasma Mg level.)
- Prolonged **hyperparathyroidism** ⟶ depletes Mg stores
  Hyperparathyroidism ⟶ hypomagnesaemia and tetany

3. Kidney function: Plasma **Mg increases** in **renal failure** due to failure of its excretion.

Magnesium (Mg):

N.B.: In renal failure, the followings occur;

Hypocalcaemia, why? Due to loss of activation of vitamin D at C1 by 1 α-hydroxylase

Hyperphosphataemia (failure of excretion)

Hypermagnesaemia (failure of excretion)

Magnesium (Mg):

Functions:

1. **Mg enters in the structure of bone.**
2. **Mg is important for normal contraction of muscle.**
   Hypomagnesaemia → muscle weakness & paralysis
3. **Mg is important for transmission of nerve impulse.**
   Hypomagnesaemia → somnolence & anesthesia
4. **Mg decreases neuromuscular excitability**; so,
   Hypomagnesaemia → tetany,
   (cannot be treated by calcium injection)
5. **It activates many enzymes** as:
   (phosphorylases, kinases, & phosphatase)

Magnesium (Mg):

Excretion:

- **In feces (70%):** Most of unabsorbed Mg is excreted in the form of **Mg phosphates**.

- **In urine (30%):** About **150 mg/day** of Mg is excreted through urine.

Requirements:

- RDA for adult is 0.3 gm/day.
- **Dietary deficiency is rare in man.**

Sodium (Na), potassium (K), & chloride (Cl):

Sources:

- **Salt of diet** (Table salt, NaCl) is present in cheese, milk bread, cereals, legumes, nuts & some vegetables.
- **Potassium** is present in vegetable fruits, potatoes, liver, kidney, heart, meat, & fish.

Absorption:

- Absorption of **Na mainly in the ileum**.
- Absorption of **K** mainly in **upper small intestine**

Sodium (Na), potassium (K), & chloride (Cl):

Distribution:

- ~ 2/3 of total Na, K, & Cl are in tissues & body fluids
- The remaining one – third is in the skeleton.

Blood level:

- Na^+ and Cl^- are chiefly extracellular,
- K^+ is chiefly intracellular ion.
- Plasma Na is 135 – 150 mmol/L.
- Plasma K is 2.5 – 5.0 mmol/L.
- Plasma Cl is 90 – 110 mmol/L.

Factors affecting plasma Na, K, & Cl:

1. Vomiting:

- **Short period** vomiting → hypochloraemia & alkalosis
- **Prolonged** vomiting → hyponatraemia, hypokalaemia and acidosis.

2. Diarrhea:

→ hyponatraemia, hypokalaemia & acidosis.

3. Fluid infusion:

- fluids **rich** in Na, K, & Cl → **hyper**natraemia, **hyper**kalaemia & **hyper**chloraemia.
- fluids **poor** in Na, K & Cl → **hypo**natraemia, **hypo**kalaemia & **hypo**chloraemia.

Factors affecting plasma Na, K, & Cl:

4. Sweating:

- Excessive sweating ⟶ water loss in proportion to Na & Cl ⟶ hypernatraemia & hyperchloraemia.
- If fluids are given without replacing NaCl, we get hyponatraemia, and hypochloraemia.

5. Diabetes insipidus:

- This type of diabetes has the same effect like **sweating** on Na & Cl levels.

6. Renal failure:

- Either acute or chronic ⟶ hyponatraemia,
- Hyperkalaemia is more in acute renal failure.
- Little changes of plasma K in chronic renal failure.

Factors affecting plasma Na, K, & Cl:

7. Diuretics:

Some drugs (e.g. diamox and chlorothiazides)
→ **hyponatraemia, and hypokalaemia.**

8. Suprarenal function:

- **Hyperfunction (Cushing's syndrome & hyperaldosteronism): →**
  - Hypernatremia (Na & H_2O retention) → ↑ Bl P., &
  - K & Cl excretion, (**hypokalaemia** & **hypochloraemia** with subsequent **alkalosis**).
- **Hypofunction (Addison's disease):** → the **opposite** occurs (**hyponatraemia** with ↓ Bl P., **hyperkalaemia** & **hyperchloraemia** with subsequent **acidosis**).

Factors affecting plasma Na, K, & Cl:

9. Acid – base balance:

a. Acidosis: → **hyperkalemia** & **hyponatremia**

The urine becomes alkaline.

This condition is called **paradoxical acidosis**.

a. Alkalosis: → **hypokalemia & hypernatremia**.

The urine becomes acidic.

This condition is called **paradoxical alkalosis**.

Sodium (Na), potassium (K), & chloride (Cl):

Functions:

➢ Functions of Na & K:

1. Na^+ is the main **extracellular cation**.
2. K^+ is the main **intracellular cation**.
3. Na^+ & K^+ enter in the formation of **buffers**.
4. Na^+ & K^+ maintain **Bl volume, osmotic pressure & Bl P.**
5. Na^+ & K^+ are essential for **muscle contraction** & transmission of **never impulse**.

➢ Functions of Cl:

1. Cl^- enters in the formation of **gastric HCl**
2. Cl^- **activates amylase** enzyme.
3. It helps in buffering of **carbonic anhydrase** in the plasma through **chloride shift phenomenon**.

Sodium (Na), potassium (K), & chloride (Cl):

Excretions:

- Excretion of Na^+, K^+, & Cl^- is controlled by Aldosterone.
- The major route of excretion is urine (95 %)
- Feces and sweats are minor routes (only 5%).

Requirements:

- The RDA of K^+ is 3 – 5 gm in the form of KCL
- The RDA of Na^+ is 10 – 15 gm in the form of NaCl

Sulfur (S)

Sources:

1. **Amino acids:** cysteine, cystine, & methionine.
2. **Vitamins:** thiamine, lipoic acid, & biotin.
3. **Sulfolipids.**
4. **Mucopolysaccharides.**

Absorption:

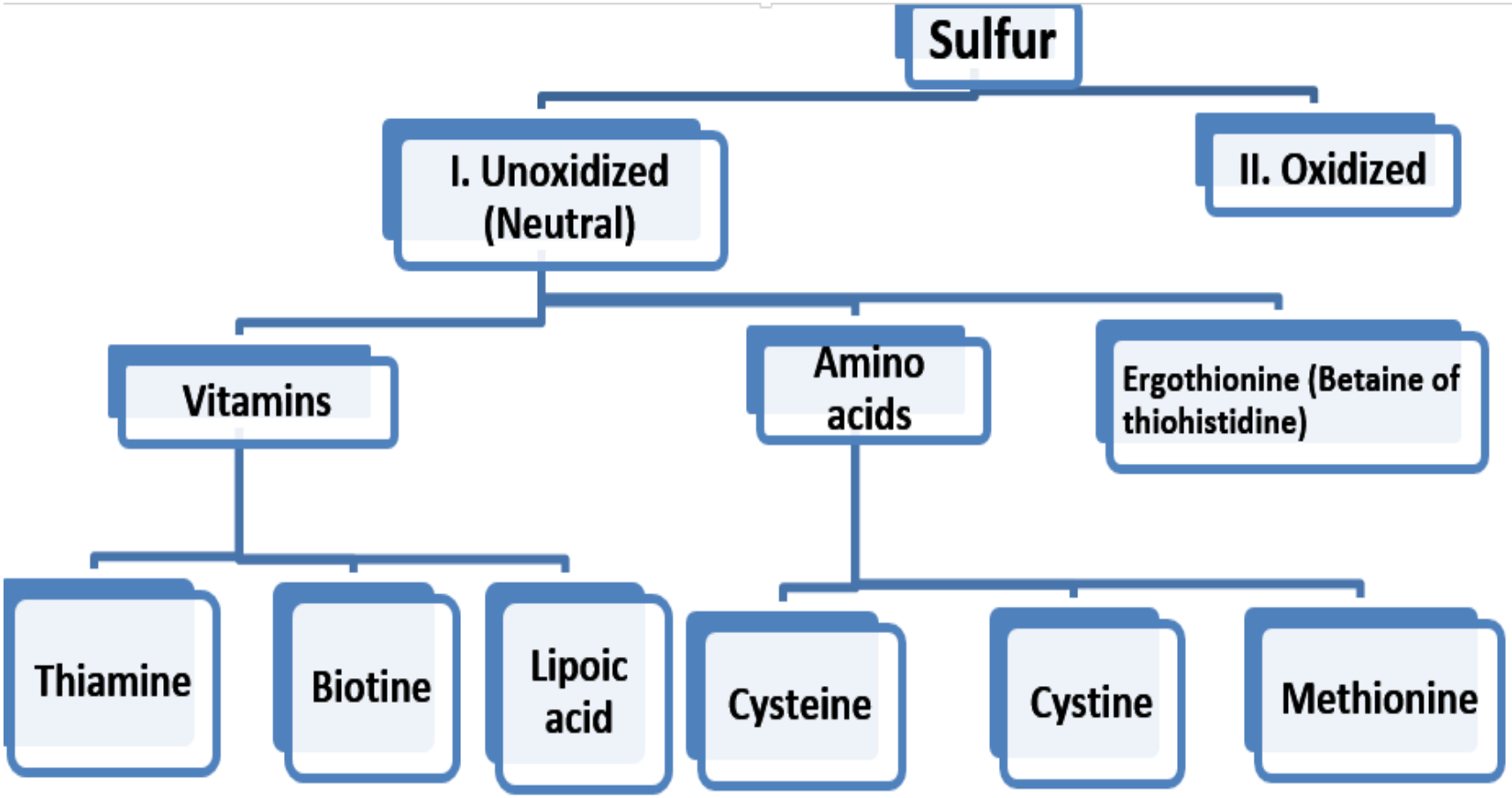
- It occurs mainly from the small intestine.
- Inorganic sulfate is poorly absorbed

Blood level:

- Sulfur level: 2.5 mg/dl.
- RBCs contains glutathione, & ergothionine, in addition to sulfur containing compounds present in plasma.

Sulfur (S)

Sulfur containing compounds in the body:

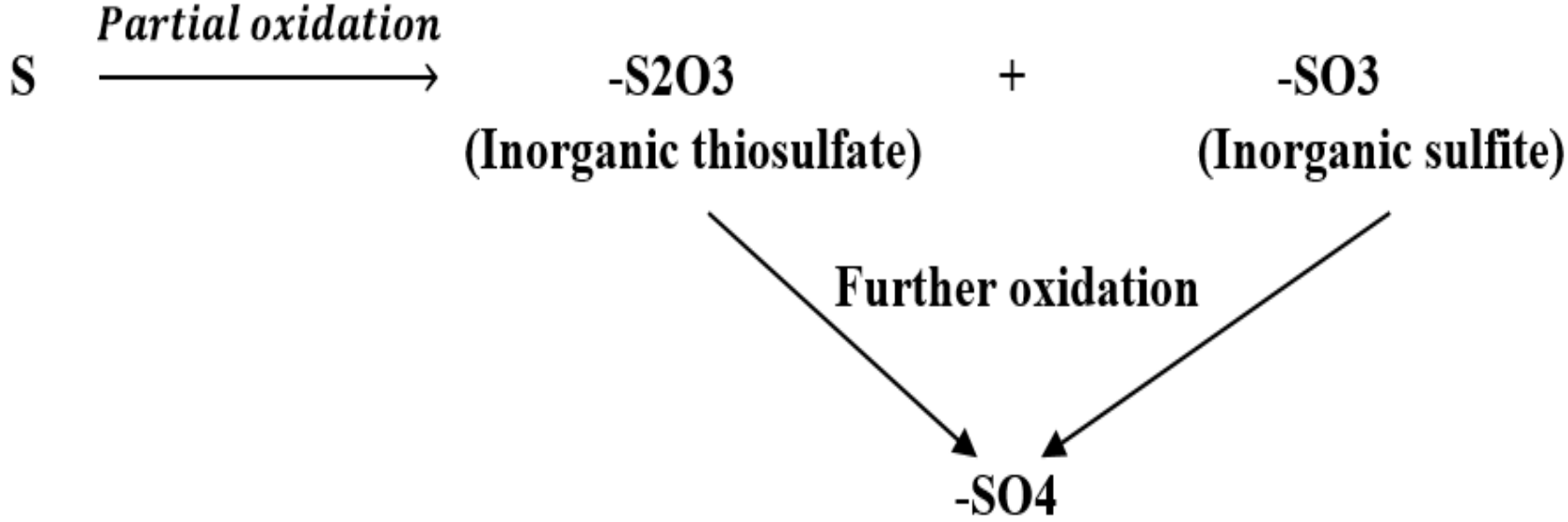


(N.B.): Ergothionine is present in liver, semen & erythrocytes.

Sulfur (S)

Metabolism of sulfur-containing amino acids:

1. **Oxidation:** This occurs in the liver.



(N.B.): Taurine is formed from partial oxidation of cysteine

Sulfur (S)

Metabolism of sulfur-containing amino acids:

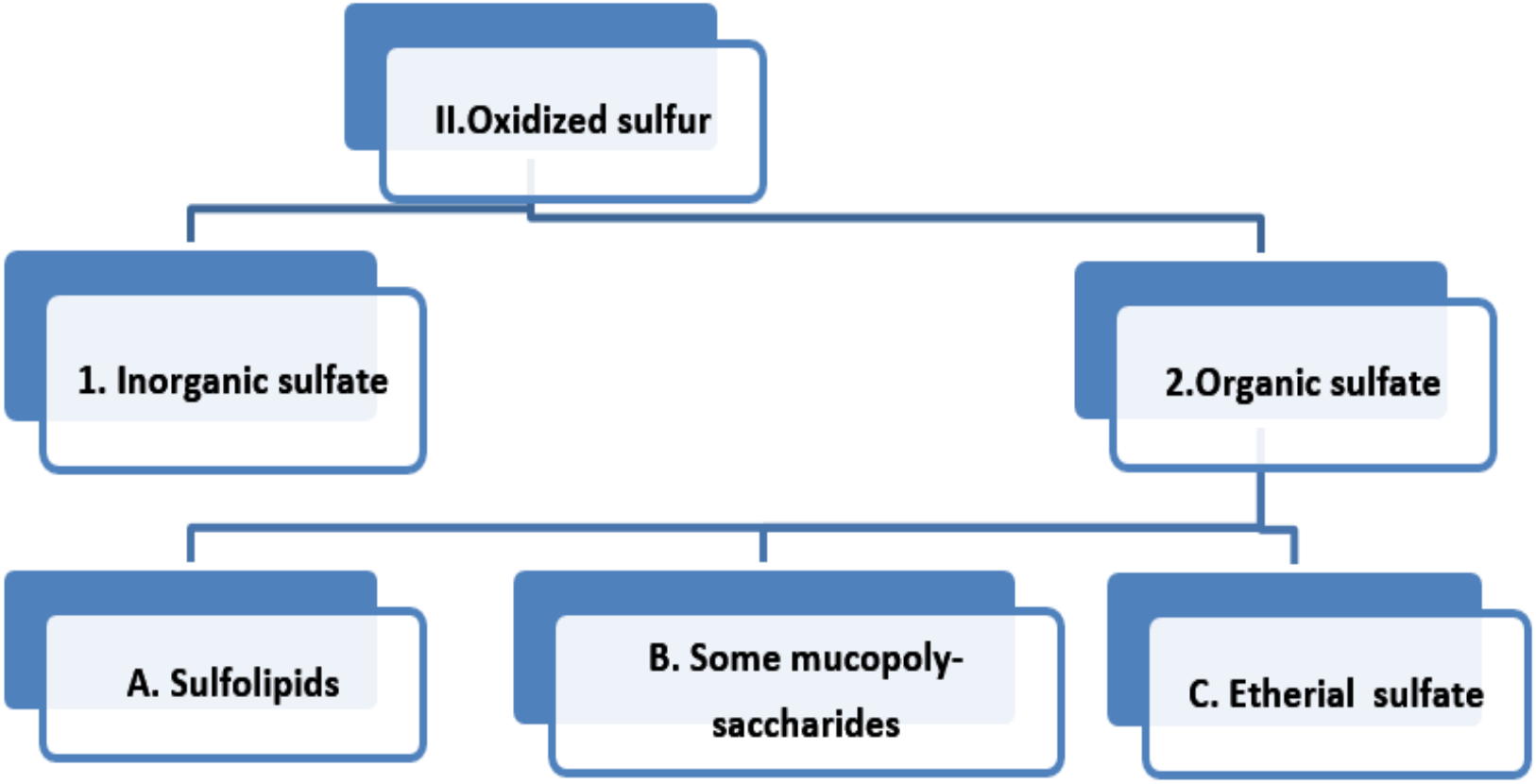
2. Conversion to other neutral sulfur compounds:

- Proteins (mostly **keratin**).
- **Glutathione** (formed of glycine, cysteine, & glutamic).
- Amino ethyl **mercaptan** (in **COASH**).
- **Homocysteine** (their sulfur being oxidized into inorganic sulfate).
- **Thiocyanate** (detoxification).
- **Urochrome** (present in urine as a peptide substance).
- **The later 3 compounds are excreted in urine.**

3. Excretion in urine:

Under normal conditions, the three sulfur containing amino acids are excreted in urine in little amounts.

Sulfur (S)


II.Oxidized sulfur
1. Inorganic sulfate
2.Organic sulfate
A. Sulfolipids
B. Some mucopoly-saccharides
C. Etherial sulfate

Sulfur (S)

1. Inorganic sulfate

They are mostly used in the biosynthesis of PAPS (3'-phosphoadenosine-5'-Phosphosulfate)

ATP + Sulfate ⟶ adenosine-5'-phosphosulfate

Adenosine-5'-pohosphosulfate + ATP ⟶ 3'-Phosphoadenosine-5'-phosphosulfate+ ADP

Sulfur (S)

2. Organic sulfate

A. Sulfolipids

(e.g.): Sulfated galactolipids → Inorganic sulfate

B. Some mucopolysaccharides

1. Chondroitin sulfate
2. Heparin
3. Heparan sulfate
4. Dermatan sulfate.
5. Keratan sulfate

C. Etherial Sulfate

1. Alcohols
* Skatoxyl sulfate
* 17-Ketosteroids

2. Phenols
* Phenols
* Indoxyl sulfate
* Estrogen

Sulfur (S)

Excretion:

Urine
- About 1.0 gm/day in the form of unoxidized sulfur (10%) and oxidized sulfur (90%)

Feces
- The feces contains hydrogen sulfide, mercaptane and taurocholic acid

Other routes
- They include hairs, nails and skin

Sulfur (S)

Excretion:

1- Unoxidized sulfur (10%):

- **3** sulfur containing aa (cysteine, cystine & methionine)
- **3** sulfur containing vitamins (lipoic acid, biotin & thiamine)
- **3** sulfur compounds (urochrome, thiocyanate & mercupturic acid).

2- Oxidized sulfur (90.0%):

- **Inorganic sulfates (80%):** e.g. Na & K sulfate.
- **Ethereal sulfates (10%):** detoxification of phenols & alcohols, e.g. indican (indoxyl K sulfate), skatoxyl K sulfate, phenol sulfate & steroid hormone sulfate.

Requirements: Diet adequate in protein is sufficient.

Good Luck