# Essential Trace Elements

## Essential Trace Elements

### Introduction

- In pharmaceutical inorganic chemistry, trace elements refer to inorganic elements that are required in minute (trace) quantities by living organisms to maintain normal physiological and biochemical functions.
- These are not synthesized by the body and must be obtained from external sources, mainly through diet or pharmaceutical supplementation.
- They are termed "essential" because a deficiency or imbalance of these elements leads to disease, dysfunction, or death, while their presence in the right amount supports health and proper metabolic function.

### Definition

- Essential Trace Elements are inorganic micronutrients required in very small amounts, generally less than 100 mg/day, for vital biochemical and physiological processes.
- Despite their minute requirement, they are indispensable for enzyme function, redox balance, immune defense, and cell signaling.

### Classification of Essential Elements

- Essential elements in the human body are broadly classified into:
    1. **Bulk Elements (Macrominerals)** – e.g., Calcium, Potassium, Sodium, Magnesium
    2. **Trace Elements (Microminerals)** – e.g., Iron, Zinc, Copper, Iodine, Selenium, Manganese, Chromium, Molybdenum, etc.
- The focus here is on **Trace Elements**.

### General Characteristics of Trace Elements

| Property | Trace Elements |
|---|---|
| **Requirement** | <100 mg/day |
| **Function** | Catalytic, cofactor, structural |
| **Storage** | Limited (except iron, zinc) |
| **Toxicity** | Can be toxic at high concentrations |
| **Regulation** | Homeostatic mechanisms maintain optimal levels |

### Role of Pharmaceutical Inorganic Chemistry

- In **pharmaceutical inorganic chemistry**, trace elements are studied for:
    1. **Therapeutic Use** – as nutritional supplements or corrective agents

Copyright © 2025 by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

2. **Diagnostic Use** – e.g., radioactive iodine for thyroid imaging
3. **Formulation Science** – many inorganic salts used in formulations for stability or therapeutic purpose
4. **Toxicology Studies** – understanding toxicity profiles and safety limits

## Factors Affecting Bioavailability of Trace Elements

1. **Chemical Form** – Organic salts may be better absorbed than inorganic ones
2. **Interactions with other nutrients** – e.g., calcium inhibits iron absorption
3. **Physiological Conditions** – gastric pH, age, disease states
4. **Presence of Enhancers/Inhibitors** – vitamin C enhances iron absorption

# List of Essential Trace Elements

## A. Iron (Fe)

### Biological Role:

- Central component of **hemoglobin** (oxygen transport) and **myoglobin**
- Participates in **electron transport chain** as part of **cytochromes**
- Functions in **oxidation-reduction (redox)** reactions
- Essential for **cellular respiration** and **energy production**

### Sources:

- Red meat, liver, spinach, legumes, fortified cereals

### Deficiency:

- **Iron-deficiency anemia**
- Fatigue, pallor, dizziness, developmental delays in children

### Pharmaceutical Importance:

- Ferrous sulfate ($FeSO_4$)
- Ferrous gluconate, Ferrous fumarate used as iron supplements
- Parenteral iron formulations like Iron dextran

### Toxicity:

- Hemochromatosis (iron overload)
- Organ damage, especially in liver and heart

## B. Zinc (Zn)

Copyright © 2025 by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

### Biological Role:

- Co-factor for over 300 enzymes including DNA/RNA polymerases
- Involved in immune function, wound healing, protein synthesis, and growth
- Plays a role in taste and smell

### Sources:

- Meat, dairy, whole grains, legumes, nuts

### Deficiency:

- Growth retardation
- Delayed wound healing
- Hypogonadism, immune dysfunction, dermatitis

### Pharmaceutical Importance:

- **Zinc sulfate ($ZnSO_4$)** and **Zinc acetate** used in supplements
- Used topically as **zinc oxide** in **ointments, sunscreens**

### Toxicity:

- Nausea, vomiting, immunosuppression (in very high doses)

## C. Copper (Cu)

### Biological Role:

- Component of enzymes like cytochrome c oxidase, superoxide dismutase
- Involved in iron metabolism, collagen synthesis, melanin formation
- Plays role in nervous system development

### Sources:

- Shellfish, nuts, whole grains, liver

### Deficiency:

- **Menkes disease** (genetic disorder)
- Anemia, neutropenia, bone abnormalities

### Pharmaceutical Importance:

- **Copper sulfate ($CuSO_4$)** used in nutritional supplements
- Diagnostic purposes and algicides

### Toxicity:

- **Wilson's disease** (copper accumulation)
- Liver and neurological damage

Copyright © 2025 by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

## D. Iodine (I)

### Biological Role:

- Integral part of **thyroid hormones** – **$T_3$ (Triiodothyronine)** and **$T_4$ (Thyroxine)**
- Regulates **metabolic rate**, **growth**, **development**

### Sources:

- Iodized salt, seaweed, seafood, dairy

### Deficiency:

- **Goiter** (thyroid gland enlargement)
- **Cretinism** in children (mental retardation and stunted growth)
- Hypothyroidism

### Pharmaceutical Importance:

- **Potassium iodide (KI)** and **sodium iodide (NaI)** used for thyroid disorders
- **Iodine tincture** used as antiseptic

### Toxicity:

- Hyperthyroidism or thyroiditis in excess

## E. Selenium (Se)

### Biological Role:

- Component of **glutathione peroxidase** – an antioxidant enzyme
- Involved in **thyroid hormone metabolism**
- Protects against oxidative stress and inflammation

### Sources:

- Brazil nuts, seafood, meats, cereals

### Deficiency:

- **Keshan disease** (cardiomyopathy)
- Weak immunity, hypothyroidism

### Pharmaceutical Importance:

- **Sodium selenite ($Na_2SeO_3$)** used in supplements
- Antioxidant therapy

### Toxicity:

- **Selenosis** – hair loss, garlic breath odor, nerve damage

Copyright © 2025 by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

First Hope

FREE PREVIEW

Click here to visit our website

PHARMACY PREMIUM NOTES

# Complete subject and semesters are available on FirstHope app only.

Scan or click here

Click here to get the app >

Available on Google Play

JOIN THE FIRSTHOPE COMMUNITY

## Join our Telegram channel

Click here to join Telegram >

Scan or click here

@FirstHopeNotes

### Instagram

@firsthope.official

Click here to follow >

### YouTube channel

FirstHope-Pharmacy / Live streams

Click here to watch >

### WhatsApp channel

Follow FirstHope on WhatsApp

Click here to join >

### FirstHope website

firsthope.co.in

Click here to visit >

**B.Pharm / D.Pharm / M.Pharm / Pharm.D**

Preview notes. Complete subjects and semesters in the FirstHope app.