MSc. SEM IV

Nutrient Disorders in Plants: Micronutrients

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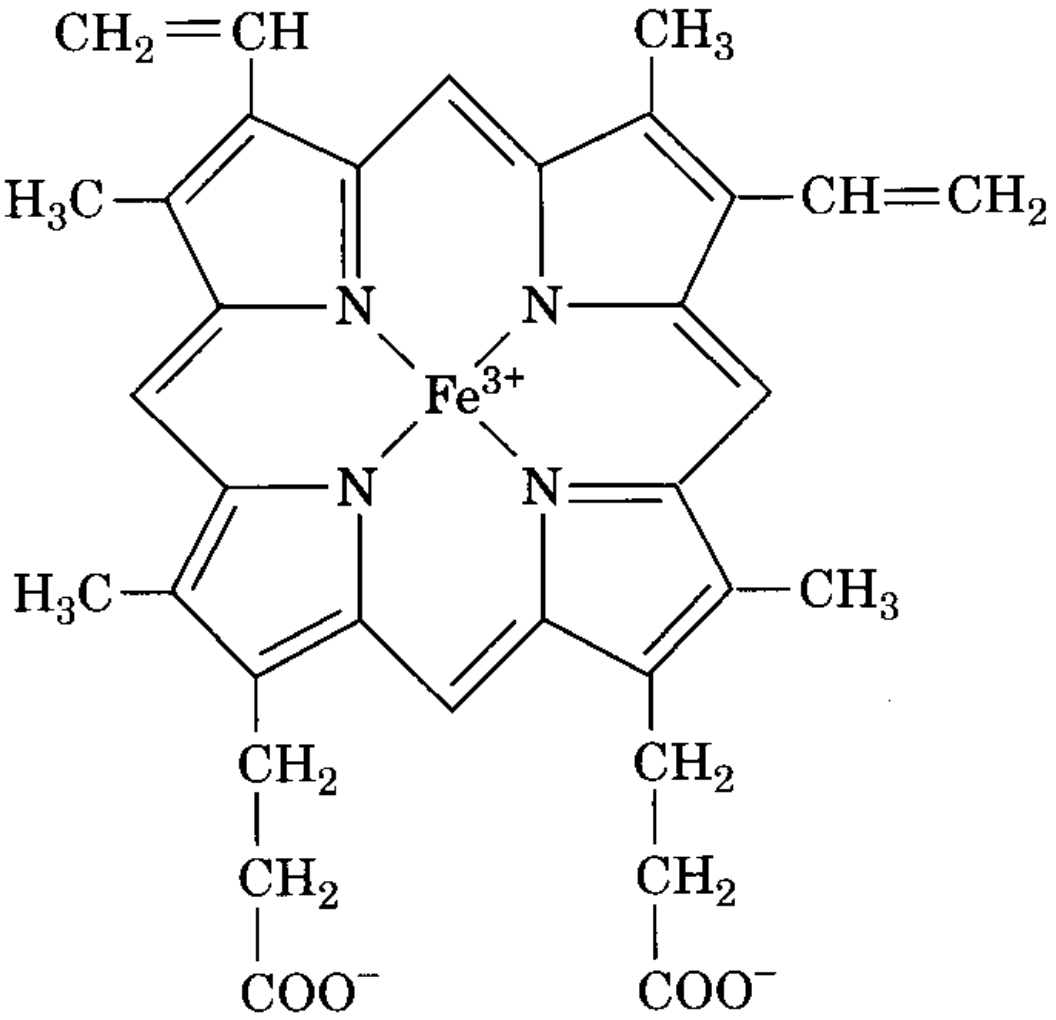
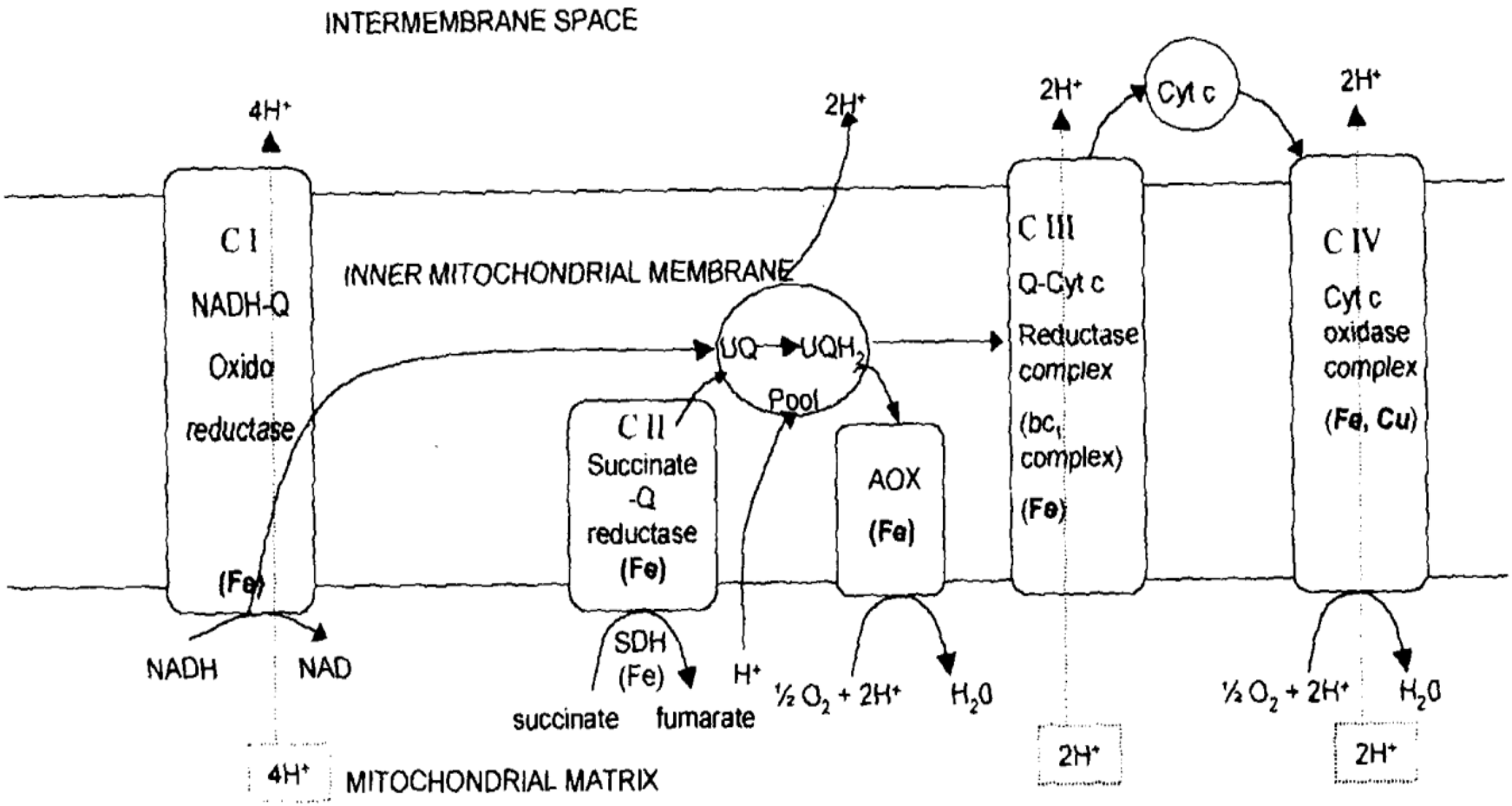
Iron: $Fe^{3+} \leftrightarrow Fe^{2+}$

- **Non-heme Enzymes:** SOD, Alternate oxidase, Lipoxygenase, Aconitase, Nitrite reductase, Sulphite reductase, Succinate DH, NADH-Q oxidoreductase.
- **Heme enzymes:** Catalase, Peroxidase, Succinate Q reductase Cyt-c-oxidase.
- **Fe Proteins:** 2Fe-2S-ferredoxins, cytochromes, leghemoglobin, phytoferritin.
- **Mitochondrial Electron Transport.**
- **Photosynthetic Electron Transport.**
- **Fatty Acid Metabolism:** NADH-cytochrome b5 reductase, cytochrome b5 desaturase.
- **Detoxification of reactive oxygen species.**

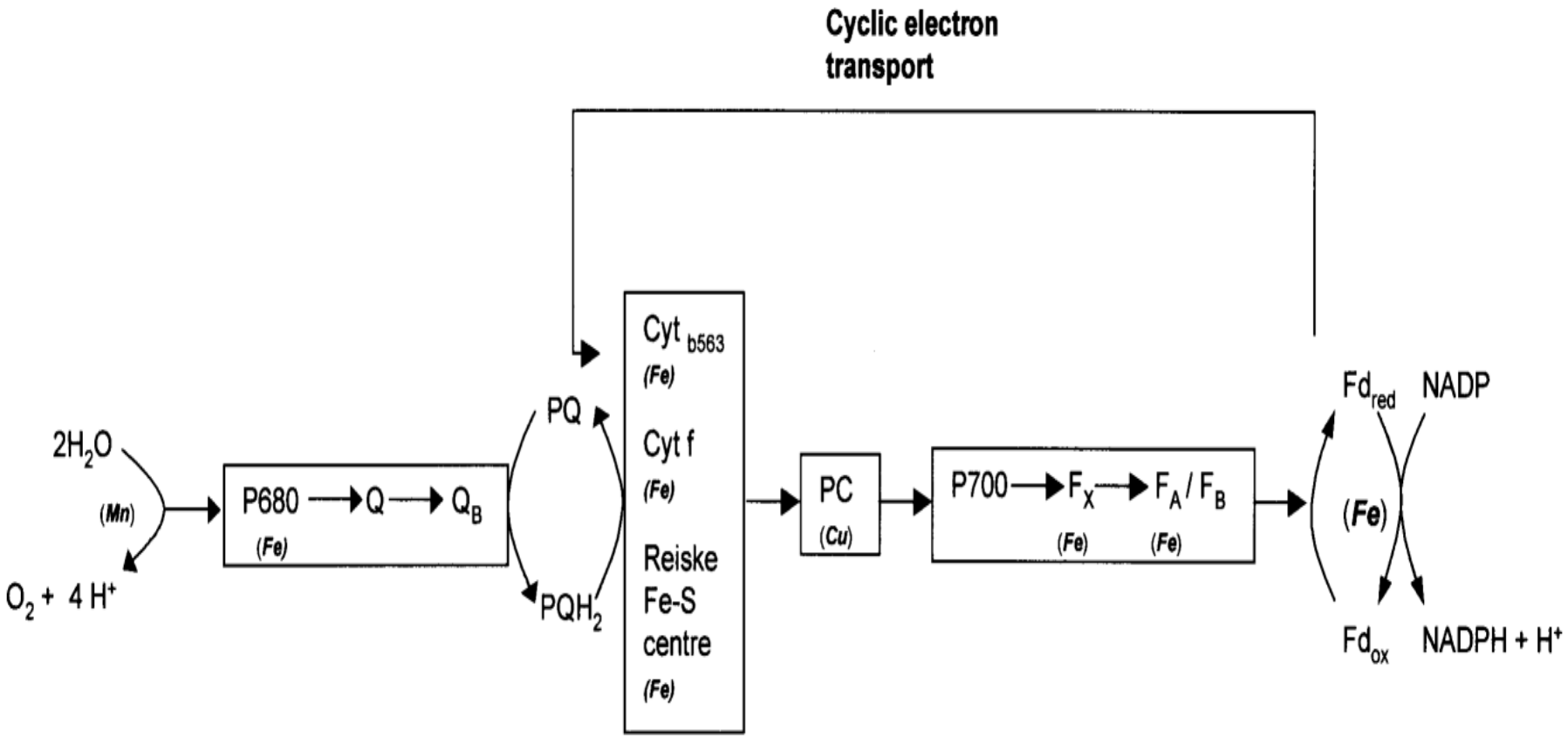


Heme *b*
(iron–protoporphyrin IX)

Mitochondrial ETC showing role of Fe and Cu



Photosynthetic ETC showing role of Fe and Mn



Manganese: Mn^{2+}, Mn^{3+}, Mn^{4+} and Mn^{5+}

- **Photosynthesis:** photolysis of water.
- **Enzymes:** Superoxide dismutase, Phosphoenol pyruvate carboxykinase, NAD^+ - Malic enzyme $NADP^+$ - Malate enzyme Isocitrate DH, Phosphoenol pyruvate carboxylase, Glutamine synthetase/
- **Secondary metabolism**: 3-deoxyarbino heptulosonate -7-phosphate synthetase, mevalonate kinase, kaurene synthase.

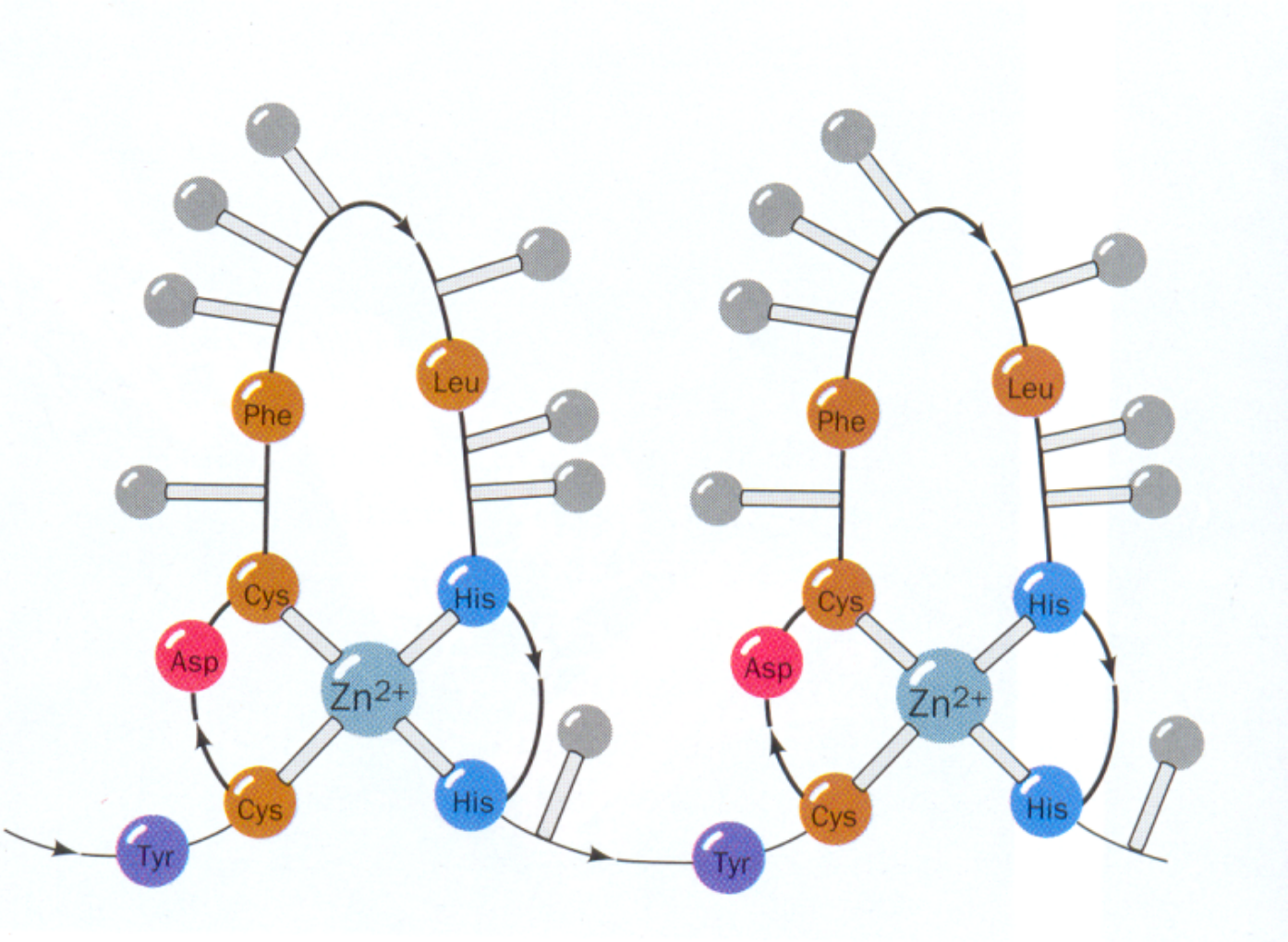
Copper : $Cu^{2+} \rightarrow Cu^{+}$

- **Enzymes:** Ascorbate oxidase, Phenol oxidase (catechol oxidase and Tyroxinse), Diamine oxidase, SOD, Cyt c oxidase.
- **Photosynthesis:** plastocyanin, ferredoxin oxidoreductase.
- **Lignin biosynthesis:** Low Cu leads to accumulation of phenolics.
- **Copper proteins:** Plastocyanin, Cytochrome-c-oxidase cyclic transport of electrons coupled to ATP production.
- **Tolerance:** metallothioneins, phytochelatins.
- **Reproductive biology:** Poor lignification of anther walls, accumulation of IAA.
- **Detoxification of reactive oxygen species.**

Zinc: Zn^{2+} tetrahedral geometry

- **Enzyme action (300)-** Carbonic anhydrase, SOD, Alcohol DH, carboxy peptidase, aldolase.
- **Regulatory proteins-** *zinc fingers* (nucleotide base recognition and binding regulate gene expression. 45 transcription factors contain zinc finger motifs).
- **Zn/Cd, Zn-** metallothioneins, phytochelatins.
- **Membrane integrity-** Zn reacts with negatively charged molecules giving stability to membranes.
- **Anti oxidative activity-** SOD, NADPH oxidase
- **Auxin metabolism-** trytophan synthase.
- **Reproduction** – flowering, floral development, anthesis, gametogenesis, fertilization and seed maturation.

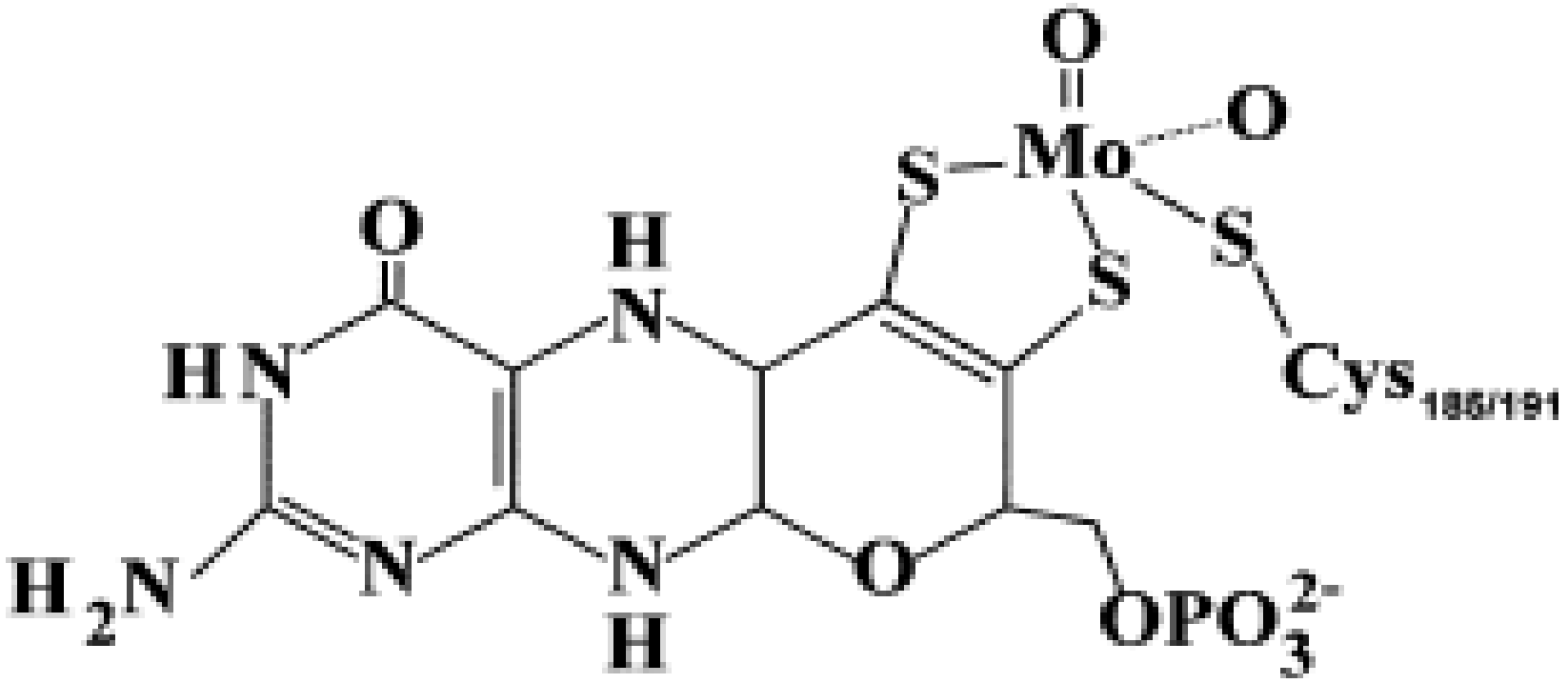
Zinc fingers



Molybdenum: Mo(III), Mo(IV), Mo(V), Mo(VI), $Mo(VI)O_2^{2-}$

- **Nitrogen fixation -** nitrogenase (Fe Mo Co)
- **Assimilation of nitrate-** Nitrate reductase
- **MoCo cofactor of several enzymes (30)-** xanthine oxidase, aldehyde oxidase, sulphite oxidase, xanthine DH.
- **Reproductive development-** poor tassels and pollen viability.
- **Mo** deficiency-reduces seed dormancy and causes pre-harvest sprouting of cereals grains.

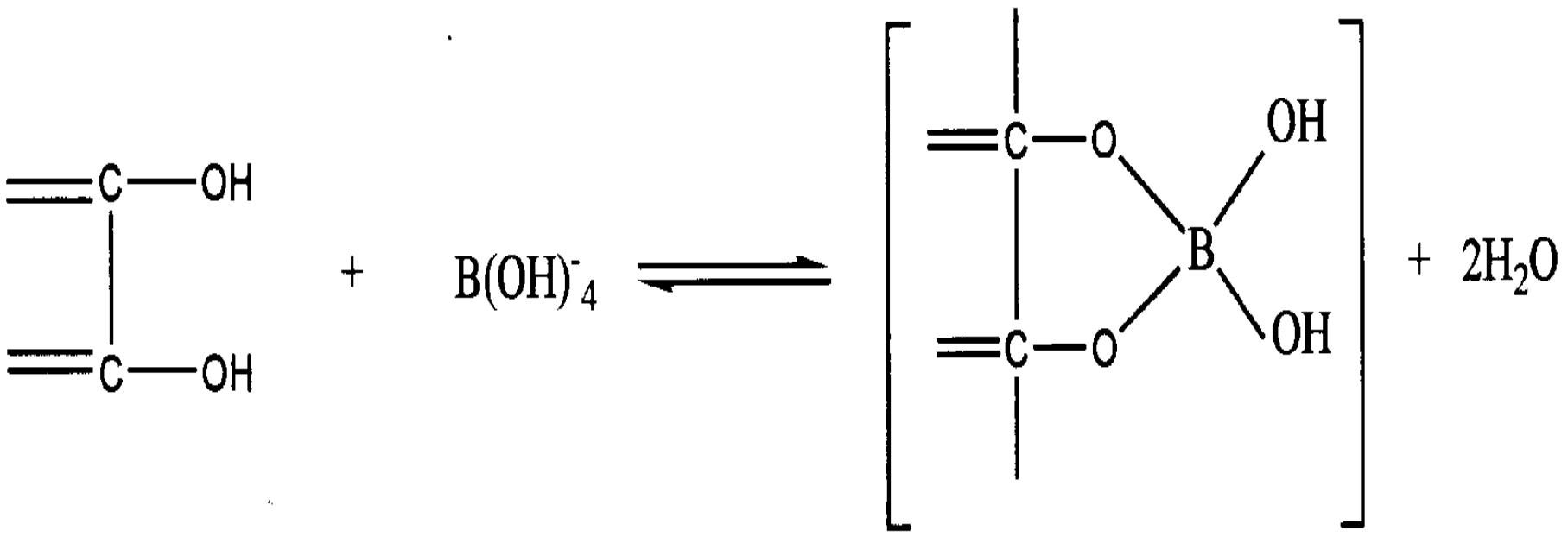
Model of molybdopterin (Mo-MPTcofactor). Molybdenum is bound to the dithiolene group of pterin- MoCo



Boron

- **Cell wall structure-**form diester bonds with diol group of polysaccharides B-rhamnogalacturonan II complex (B-RG II).
- **Membrane integrity-** generating a proton gradient across the plasmalemma by uptake of ions.
- **Deficiency of B leads to-** accumulation of phenolic compounds, particularly caffeic acid and quinones leads to enhanced generation of the superoxide ions ($O_2^{\cdot -}$) which are known to cause peroxidative damage and increase leakiness of the plasma membranes.
- **Reproductive development-** pollen development and fertility, poor pollen tube growth.

Cis-Diol borate complex

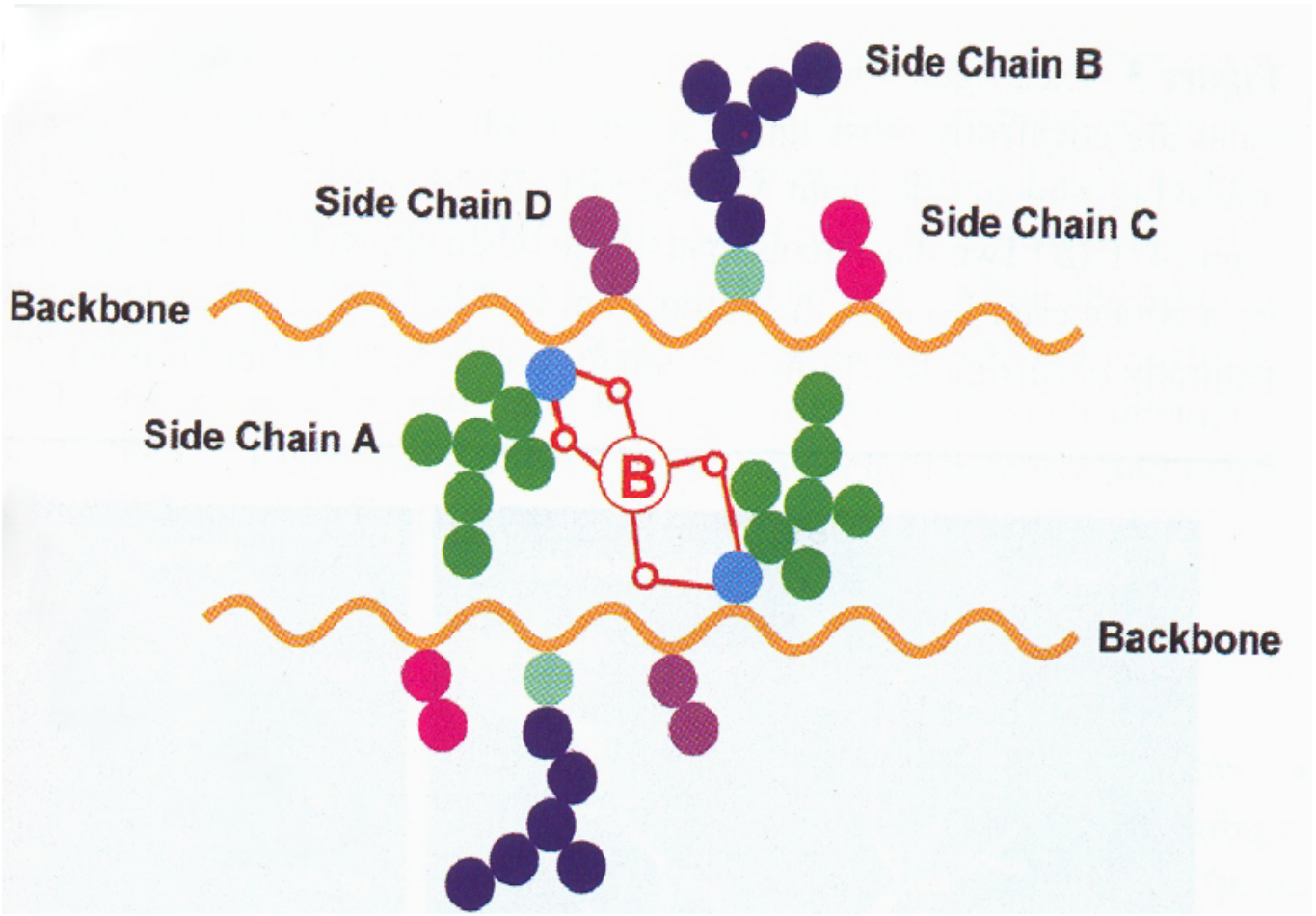


Cis-diol

Boric acid

Borate ester

Boron cross-linking two rhamnogalacturonan II (RG II) molecules, each possessing four side chains-A, B, C, and D. The apiosyl residue in the side chain A of the two molecules become covalently cross-linked by a 1:2 borate-diol ester.



Chlorine

- **Free anion (Cl^-)-** bound to exchange sites or as organic molecules, 4-chloroindole acetic acid shows high auxin activity.
- **Photosynthesis -**Chlorine is a structural Mn containing component of oxygen evolution complex (OEC) of photosystem II.
- **Maintenance of turgor and osmoregulation.**
- **Stomatal functioning.**
- **Seismonastic movements.**