

ESSENTIAL PLANT NUTRIENTS

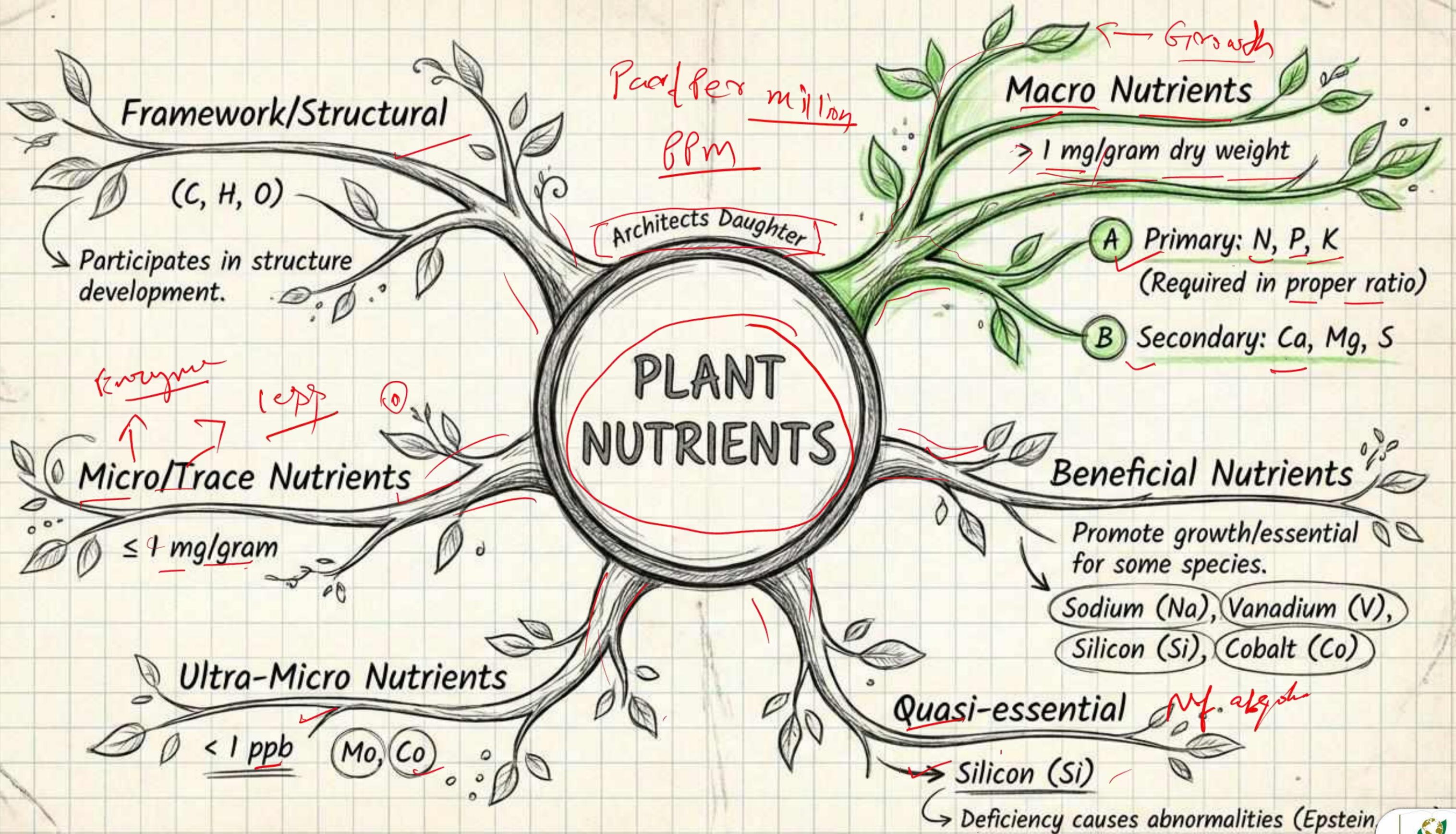
Classification, Roles, & Deficiency Symptoms

Definition: The element is involved directly in the nutrition of the plant quite apart from its possible effects in correcting some unfavourable microbiological or chemical condition of the soil or other culture medium.

The 3 Criteria for Essentiality (Arnon & Stout, 1939):

- ✓ 1. Deficiency makes it impossible for the plant to complete its life cycle.
- ✓ 2. The deficiency is specific to that element and not replaceable by another.
- ✓ 3. The element is a constituent of an essential metabolite or required for enzyme system action.

Update: According to Arnon, there were 16 elements. Ni (Nickel) was added as an essential element in 2009.



ARChitects' Daughters

A - N (Nitrogen)

R - (P) Phosphorus

C - (K) Potassium

H - (Ca) Calcium

M - (Mg) Magnesium

T - (S) Sulfur

E - (Fe) Iron

C - (Mn) Manganese

Z - (Zn) Zinc

B - (Cu) Copper

D - (B) Boron

A - (Mo) Molybdenum

U - (Cl) Chlorine

Ni - (Ni) Nickel

H - (C) Carbon

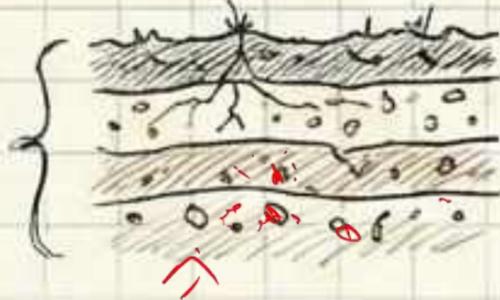
T - (H) Hydrogen

O - (O) Oxygen

R - (Help to Remember)

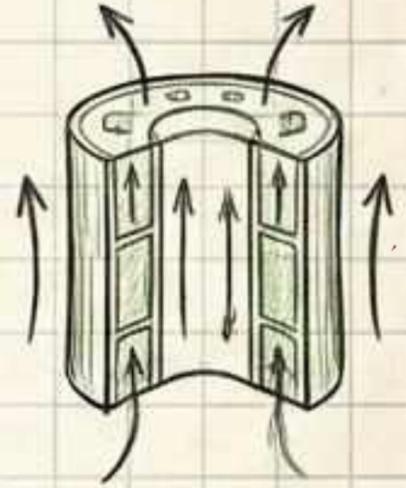
CLASSIFICATION BY MOBILITY

Mobility in Soil Patrick Hand SC

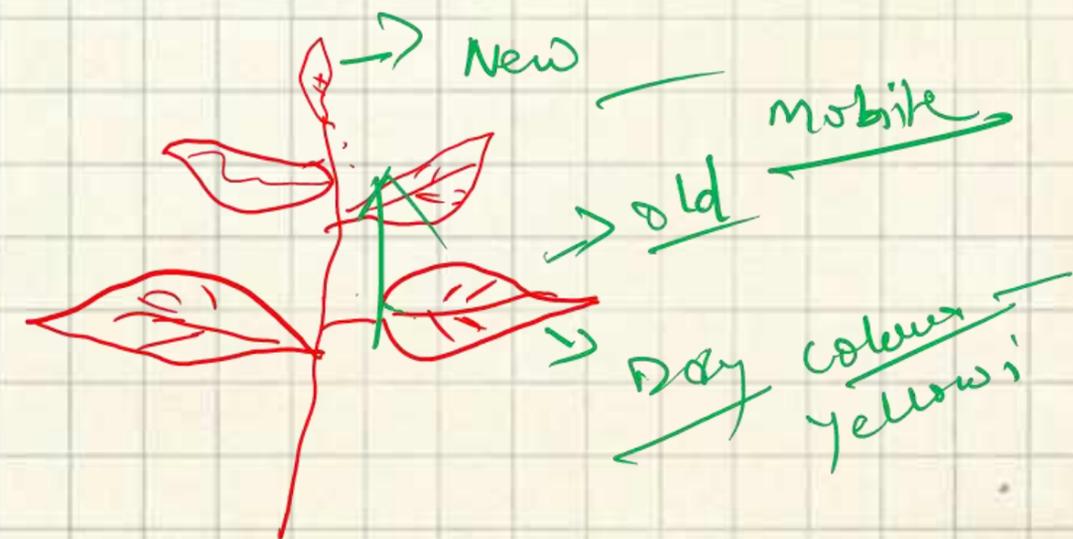


- Mobile Nutrients: Highly soluble, not adsorbed on clay.
↳ NO_3^- , SO_4^{2-} , BO_3^{2-} , Cl^- , Mn^{2+}
- Less Mobile: Soluble but adsorbed on clay complex.
↳ NH_4^+ , K^+ , Ca^{2+} , Mg^{2+} , Cu^{2+}
- Immobile: Highly reactive ions, fixed in soil.
↳ H_2PO_4^- , HPO_4^{2-} , Zn^{2+}

Mobility within Plant Patrick Hand SC



- Highly Mobile: N, P, K
- ✓ Moderately Mobile: Zn
- ✓ Less Mobile: S, Fe, Mn, Cl, Mo, Cu
- ✓ Immobile: Ca, B



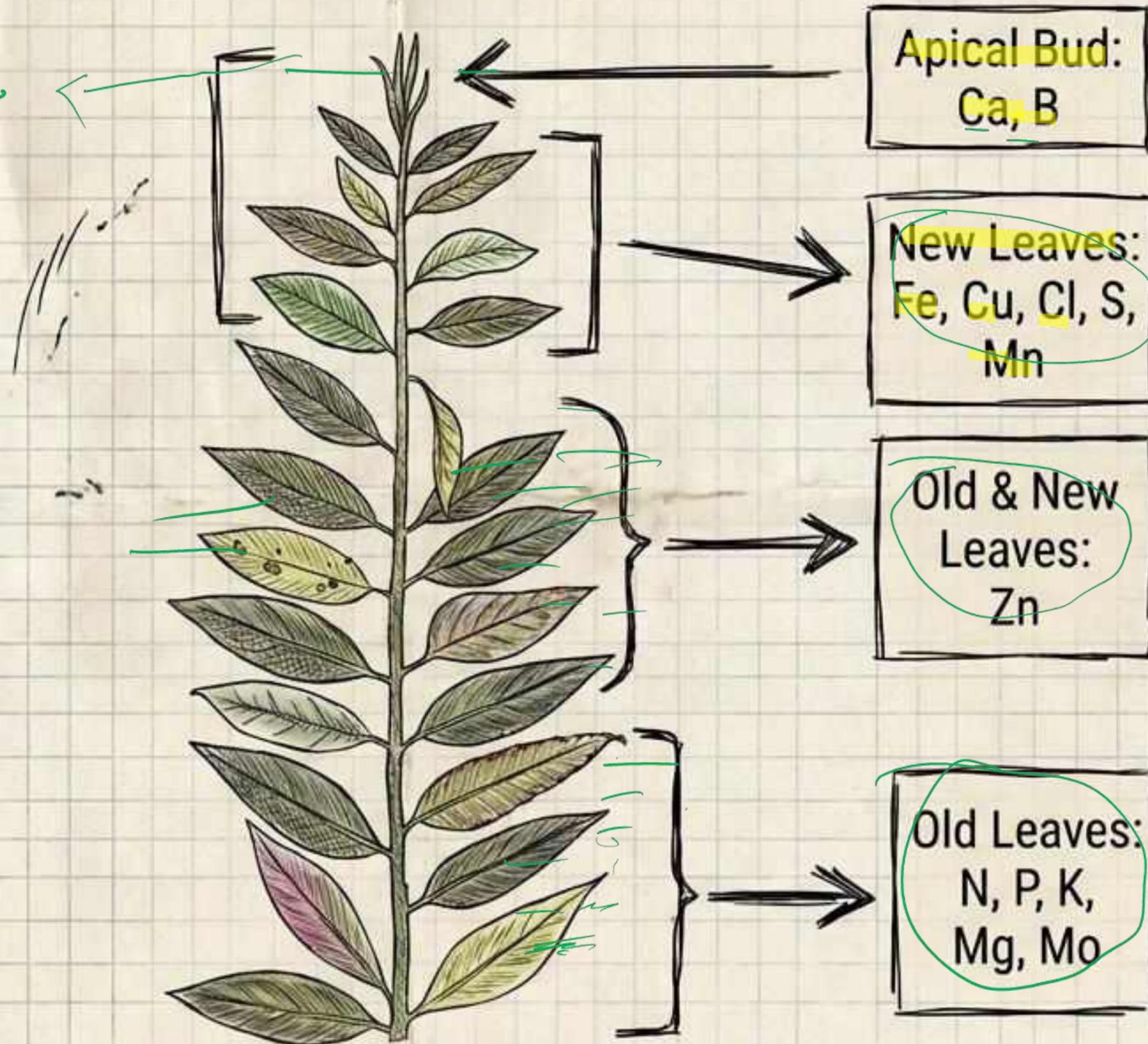
MASTER DATA SHEET: SYMBOL, FORM, & CONCENTRATION

Nutrient	Symbol	Principal Forms for Uptake	Source	Plant Tissue Concentration (%)	ppm <small>Part per million</small>
Carbon	C	CO_2	Air	45.0%	450,000
Hydrogen	H	H_2O	Water	6.0%	60,000
Oxygen	O	H_2O, O_2	Air/Water	45.0%	450,000
Nitrogen	N	NH_4^+, NO_3^-	Soil	1.4%	14,000
Phosphorus	P	$H_2PO_4^-, HPO_4^{2-}$	Soil	0.1%	1,000
Potassium	K	K^+	Soil	1.0%	10,000
Calcium	Ca	Ca^{2+}	Soil	0.5%	5,000
Magnesium	Mg	Mg^{2+}	Soil	0.2%	2,000
Sulfur	S	SO_4^{2-}, SO_2	Soil	0.1%	1,000
Iron	Fe	Fe^{2+}, Fe^{3+}	Soil	0.01%	100
Manganese	Mn	Mn^{2+}	Soil	0.005%	50
Boron	B	H_3BO_3	Soil	0.002%	20
Zinc	Zn	Zn^{2+}	Soil	0.002%	20
Copper	Cu	Cu^{2+}	Soil	0.0006%	6
Molybdenum	Mo	MoO_4^{2-}	Soil	0.00001%	0.1
Chlorine	Cl	Cl^-	Soil	0.01%	100

VISUAL GUIDE: WHERE DO DEFICIENCIES APPEAR?

AgriFair.in

TIP



Location depends on Mobility in Plant.

NITROGEN (N)

Function

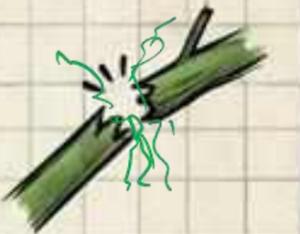
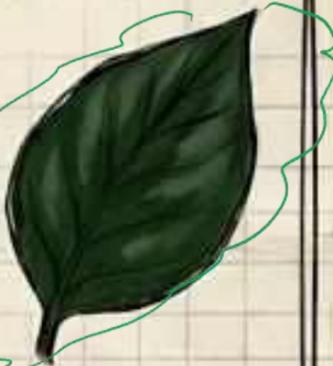
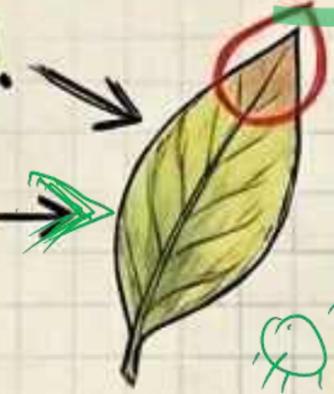
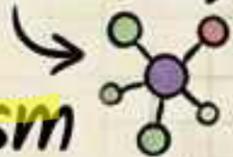
- Building blocks of proteins (Amino acids).
- Forms protoplasm (site for cell division).
- Constituent of all plant enzymes & Chlorophyll.
- Improves quality of leafy vegetables & protein in grains.

Deficiency Symptoms

- Stunted growth (reduced cell division).
- Chlorosis (pale green/yellow) appearing first on OLDER leaves (starts at tips).
- Early maturity reduced yield.
- Susceptible to weather stress/disease.

Toxicity

- Vigorous vegetative growth (Dark green).
- Delayed crop maturity.
- Crop lodging.
- Lower resistance to disease.



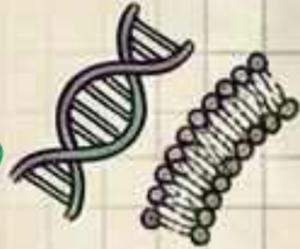
PHOSPHORUS (P)

Function

- The Energy Currency: Component of ATP.



- Essential for DNA, RNA, and Phospholipids (membranes).



- Root system development & Seed formation.



Deficiency Symptoms

- Slow, weak, stunted growth.



- Dark to Blue-Green coloration on OLDER leaves.



- Purpling of leaves and stems (Severe).

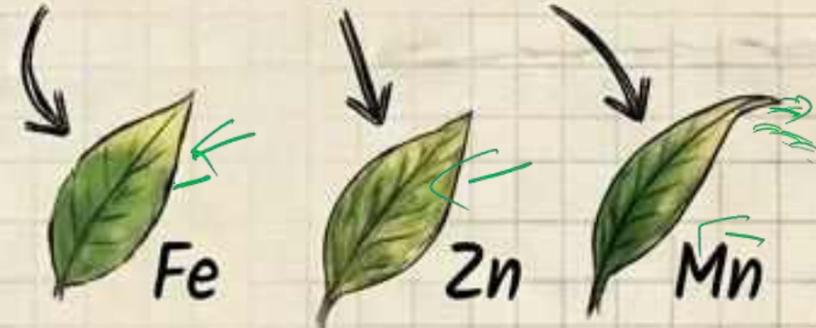


- Delayed maturity.



Toxicity

- Appears as micronutrient deficiency (Fe, Zn, Mn).

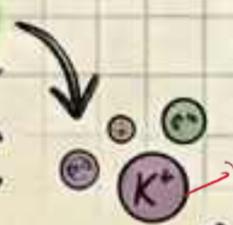


- Can cause typical Ca deficiency.

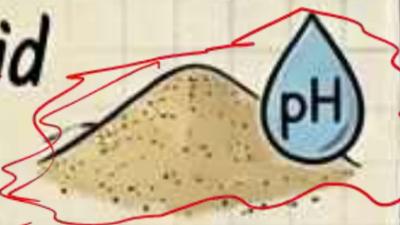


POTASSIUM (K)

Function

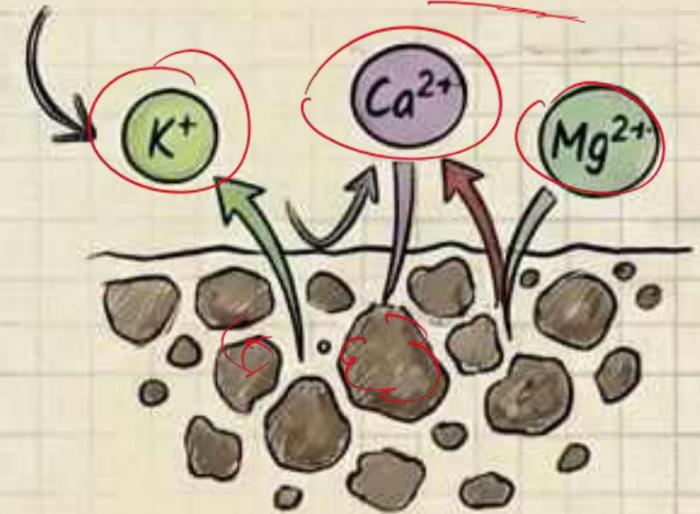
- Patrick Hand SC Ionic form (not structural). 
- Regulation of water usage (stomata). 
- Disease resistance & Stem strength. 
- Photosynthesis & Protein synthesis. 
- Improves quality/shelf life. 

Deficiency Symptoms

- Patrick Hand SC Scorching or firing along leaf margins. 
- Weak stalks (Lodging). 
- Small shriveled fruit/seeds. 
- Common in acid sandy soils. 

Toxicity

- Patrick Hand SC Causes Ca deficiency due to cation imbalance.



SECONDARY NUTRIENTS

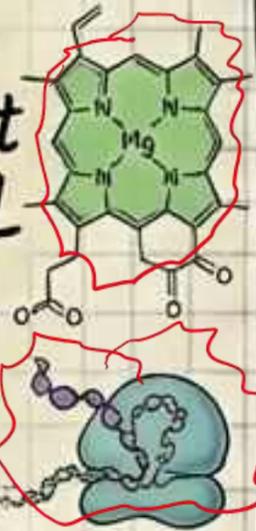
Function

- Cell wall formation (Ca-Pectate).
- Enzyme activator.
- Detoxifies organic acids.
- Seed production (peanuts).



Function

- Central component of CHLOROPHYLL molecule.
- Protein synthesis (Ribosomes).



CALCIUM (Ca)

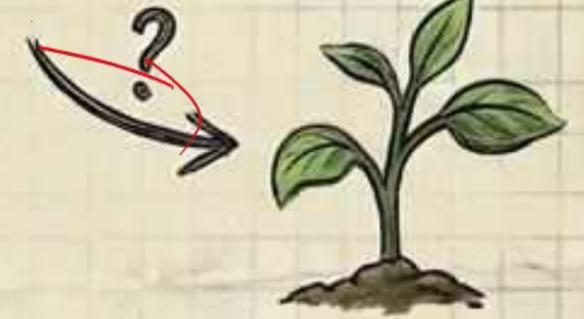
Deficiency Symptoms

- Failure of terminal buds/apical tips.
- Roots turn black/rot.



Toxicity

- Rare.



MAGNESIUM (Mg)

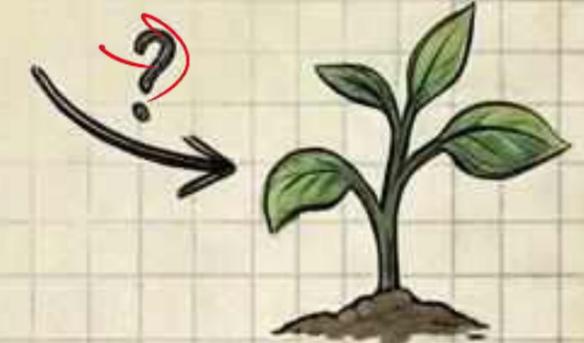
Deficiency Symptoms

- Interveinal Chlorosis (veins green, tissue yellow/red) on OLDER leaves.



Toxicity

- Rare.

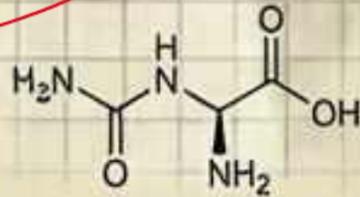


SULFUR & BORON

SULFUR (S)

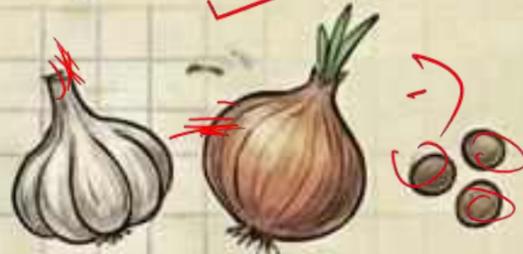
Function

- Patrick Hand SC
- Amino acids (Cystine, Methionine).
- Vitamins (B), Oil content, Nodulation.



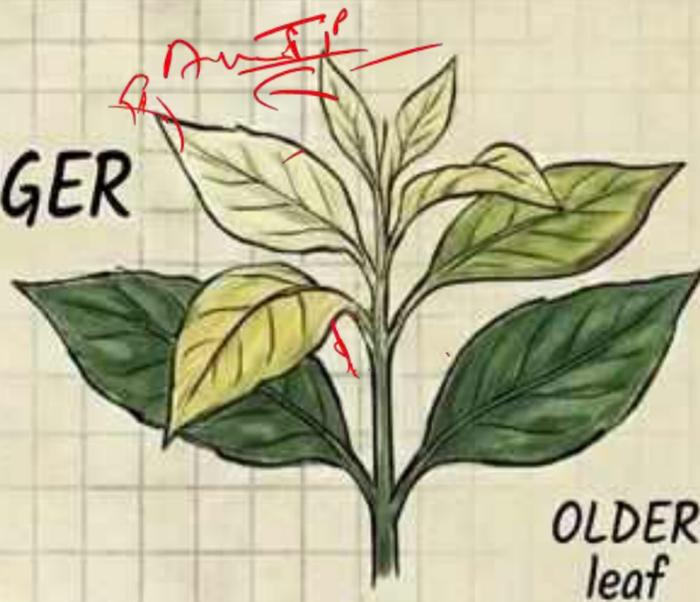
Odor

- Garlic/Onion/Mustard.



Deficiency!!

- Chlorosis on YOUNGER leaves (Contrast with N on old leaves).
- Stunted growth.



BORON (B)

Self.

Deficiency!!

- Death of Apical Bud.
- Heart rot/corking.
- Distorted branches.
- Flower abortion.

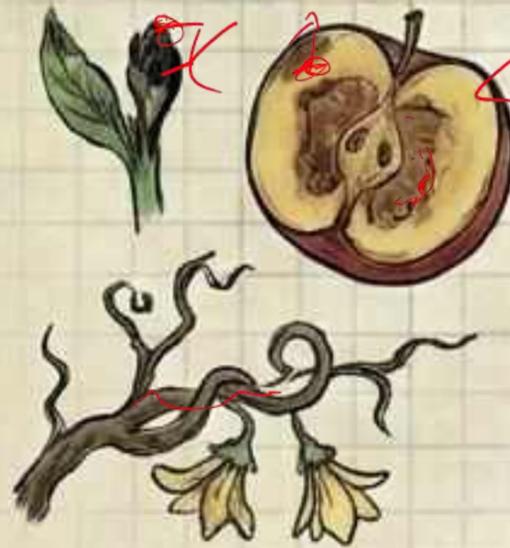
Toxicity

- Patrick Hand SC
- Pollen germination & tube growth.
- Sugar translocation.
- Cell wall.



Toxicity

- Yellowing leaf tip followed by necrosis.



COPPER & IRON

COPPER (Cu)

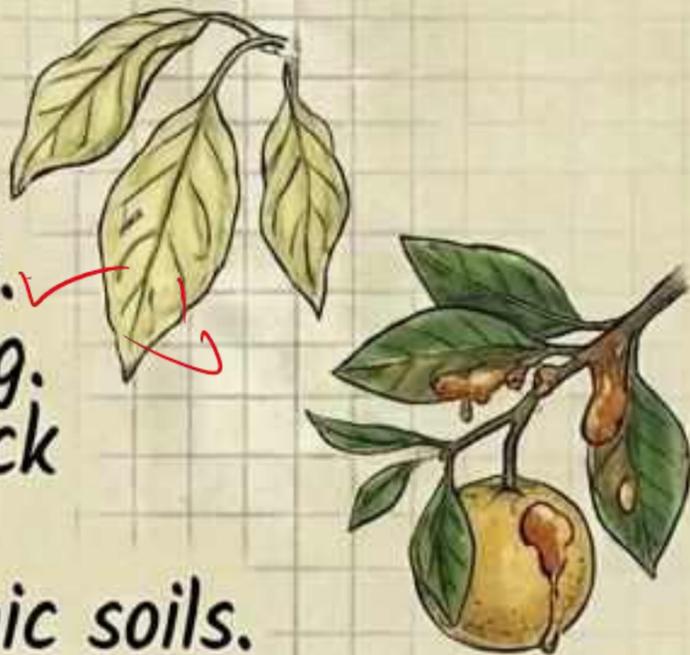
Function

- Electron transport (Plastocyanin).
- Chlorophyll stability.
- Photosynthesis enzymes.



Deficiency!!

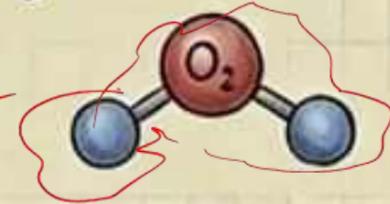
- Pale yellow leaves.
- Lack turgor/wilting.
- Gummosis/Die-back (citrus).
- Common in Organic soils.



IRON (Fe)

Function

- Catalyst in Chlorophyll synthesis (O_2 carrier).
- Redox reactions.



Deficiency!!

- Interveinal Chlorosis on NEW leaves.
- Severe: Leaves turn white.



Causes!!

- High pH, lime-induced.

Toxicity

- Bronzing/brown spots.

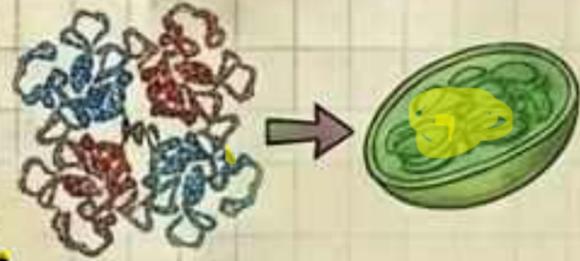


MANGANESE & ZINC

MANGANESE (Mn)

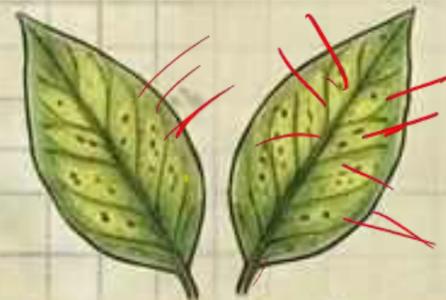
Function

- Enzyme catalyst.
- Chlorophyll synthesis.



Deficiency

- Interveinal chlorosis.
- Brownish-black specks.



Interveinal chlorosis & specks

Disease: "Pahala blight" (Sugarcane).



Crinkle leaf

Pahala blight

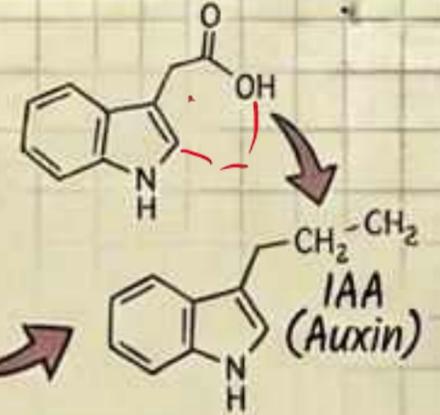
Toxicity

- Crinkle leaf (cotton).

ZINC (Zn)

Function

- Synthesis of IAA (Auxin) from Tryptophan.
- Enzymes.



Deficiency

- Short internodes (Rosetting).
- Interveinal chlorosis (Old & New).



Rosetting

Old leaf

New leaf

Specific Diseases:

- Khaira disease (Rice)
- White bud (Maize)
- Little leaf (Cotton/Mango)



Khaira disease



White bud



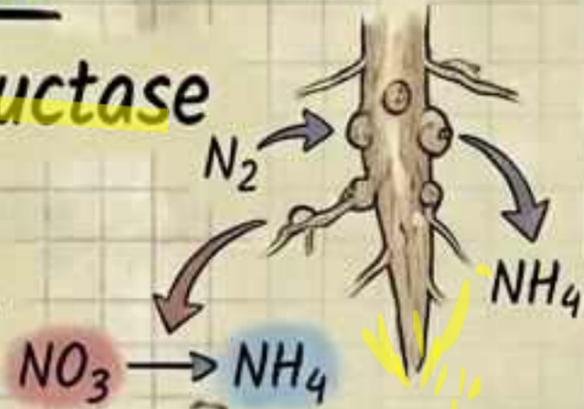
Little leaf

MOLYBDENUM, CHLORINE, & NICKEL

MOLYBDENUM (Mo)

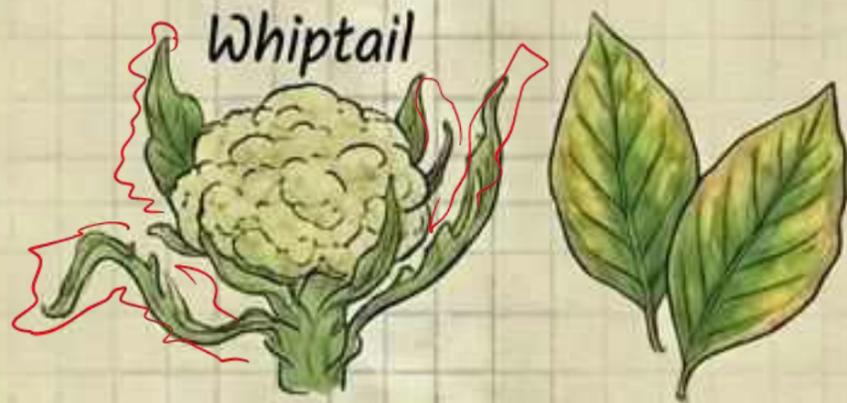
Function

- Function: Nitrate Reductase ($\text{NO}_3 \rightarrow \text{NH}_4$).
- N-fixation (Rhizobia).

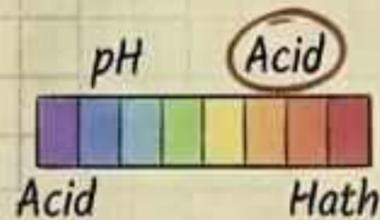


Deficiency

- "Whiptail" in Cauliflower.
- Chlorosis on older leaves.



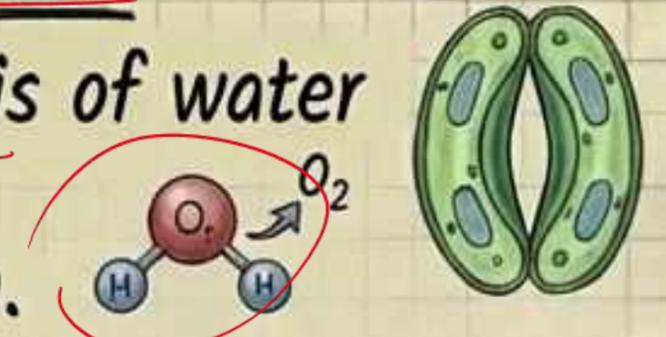
Note: Deficiency occurs in Acid soils (opposite to other micros).



CHLORINE (Cl)

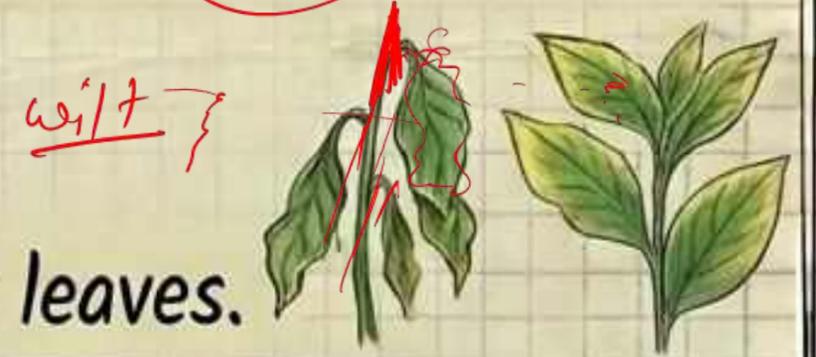
Function

- Function: Photolysis of water (O_2 evolution).
- Stomata regulation.



Deficiency

- Wilting.
- Chlorosis upper leaves.



Function: NICKEL (Ni)

- Urease enzyme component.
- Seed viability.



Deficiency: 'Mouse ear' in Pecan.

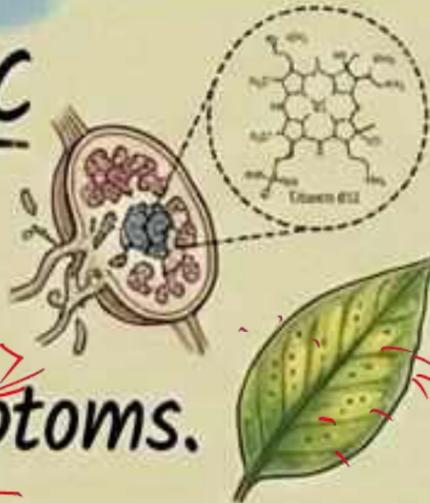


BENEFICIAL & OTHER ELEMENTS

COBALT (Co)

Patrick Hand SC

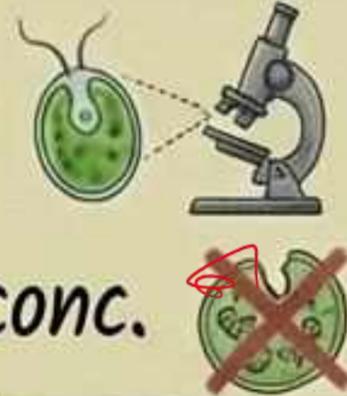
- Symbiotic N-fixation (Leghemoglobin/Vit B12).
- Deficiency causes N symptoms.



VANADIUM (V)

Patrick Hand SC

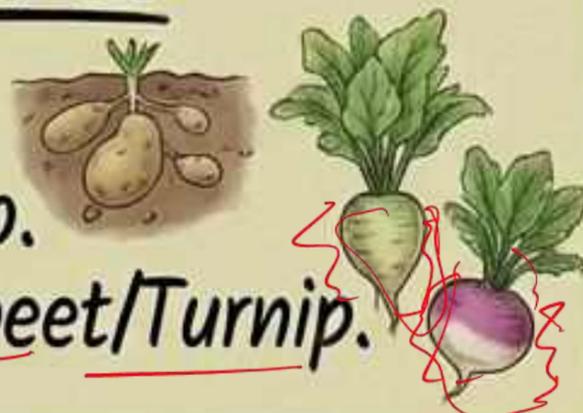
- Essential for green algae.
- Toxic to Chlorella at high conc.



SODIUM (Na)

Patrick Hand SC

- Osmotic balance. Tuberization in Potato.
- Beneficial for Sugar beet/Turnip.



SILICON (Si) - 'Quasi-essential'

Patrick Hand SC

- Cell wall diagram.
- Cell wall rigidity (upright growth).
- Disease suppression (Rice blast/Mildew).
- Insect resistance (Stem borers).
- Stress alleviation (Drought/Salt).



Uptake Forms: Co^{2+} , V^{+} , Na^{+} , $\text{Si}(\text{OH})_4$

PRACTICE & REVIEW

Multiple Choice:

Patrick Hand SC

1. Beneficial nutrient theory given by? (Arnon, Satrtut, Nicolsan, DeCandoli)
2. Ni considered essential in year? (2010, 2011, 1999, 2009)
3. Yellowing disease in tea due to deficiency of? (Ca, Zn, S, B)
4. Deficiency seen on apical bud? (N, Fe, Ca, Mg)
5. Secondary nutrient? (N, C, Mg, Zn)
6. Oxygen carrier? (B, Fe, Ca, Mg)
7. Crop logging due to toxicity of? (N, C, Mg, Zn)

Fill in the Blanks:

1. Sodium (Na) is known as _____ agent.
2. _____, _____, _____ are primary nutrients.
3. Calcium (Ca) has a major role in _____.
4. Phosphorus (P) is essential for _____/_____.
5. N and Mg are major parts of _____ molecule.