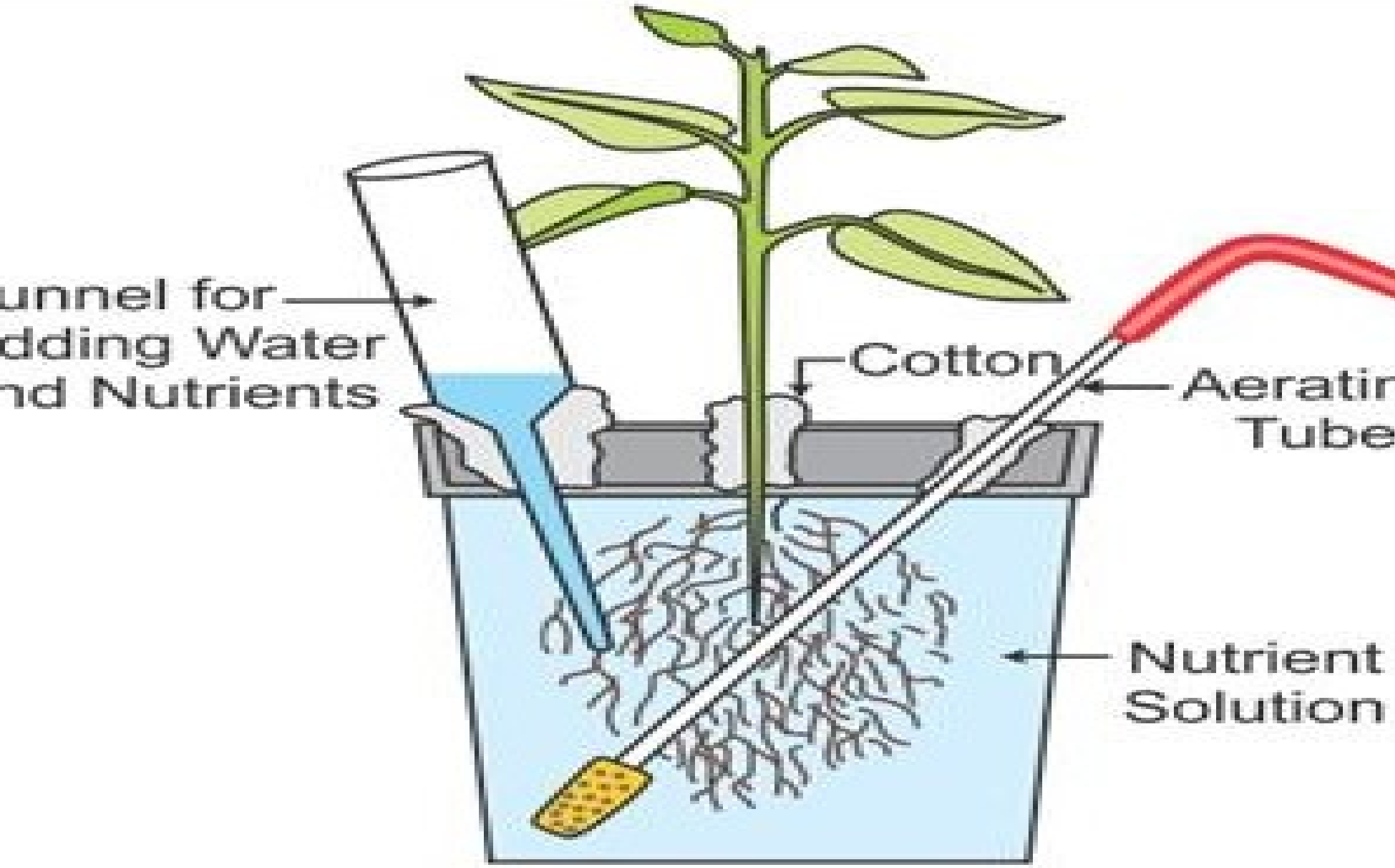
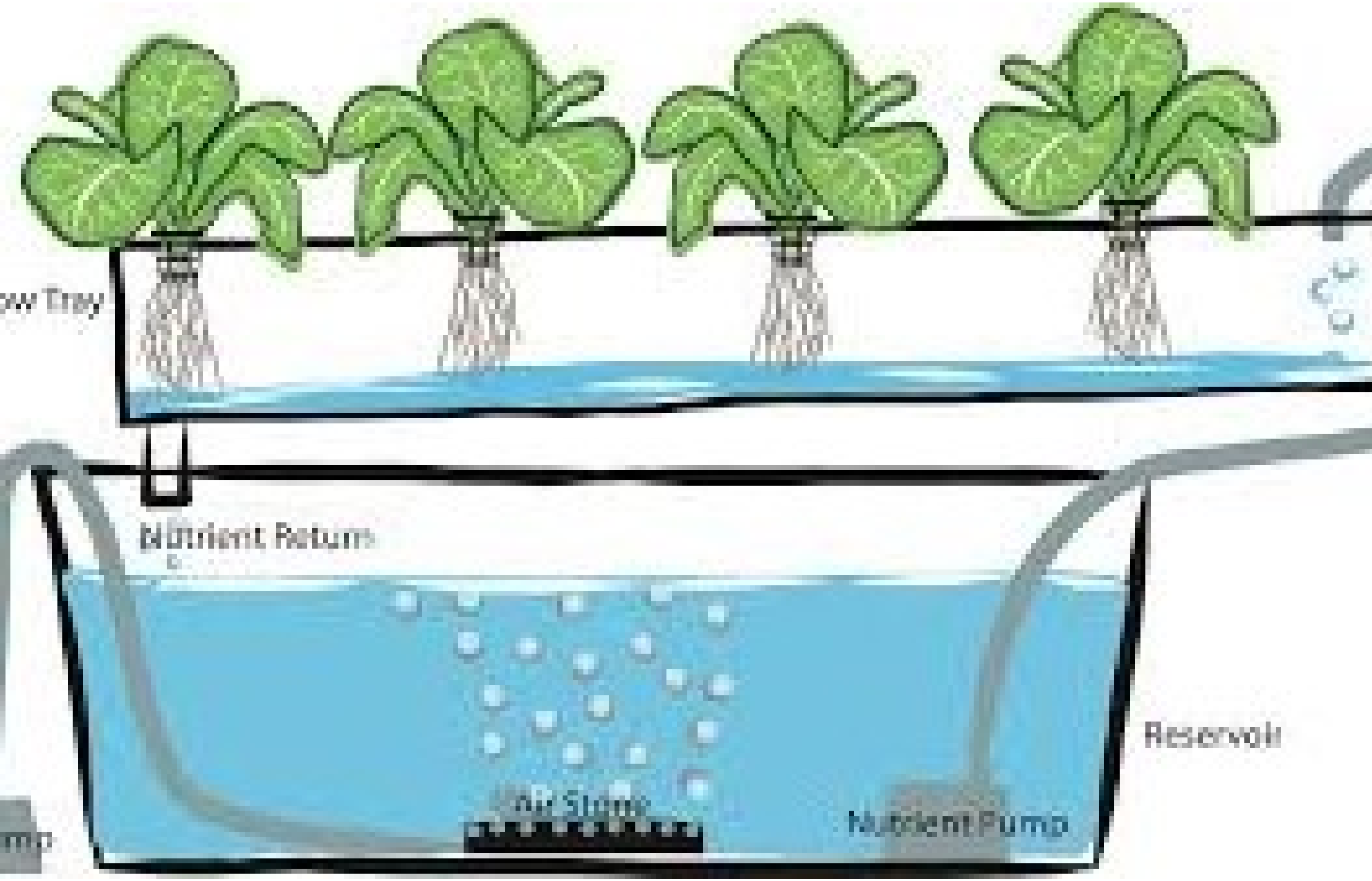

The shoot which first weighed 5 pounds (2 ¼ kilograms)
was now a tree weighing 169 pounds (76 ½ kilograms).
an Helmont then dried and weighed the remaining so

Mark **Z**uckerberg ne **F**ace **B**ook **M**e **C**hat aur **C**all **N**ikali !

Mn Zn Fe B Mo Cl Cu Ni


unnel for
dding Water
nd Nutrients
Cotton
Aeratir
Tube
Nutrient
Solution


Nutrient Return
Reservoi
Nutrient Pump

COMMON HUNGER SIGNS OR DEFICIENCY SYMPTOMS

osis is yellowing of leaf due to destruction orophyll. It is caused by the deficiency of Mg, S, Fe, Mn, Zn, and Mo e are several types of chlorosis treme chlorosis of meristems or white Zn) mple chlorosis-uniform yellowing of leaves ottled chlorosis-Chlorotic yellow patches(K) terveinal chlorosis or green veins(Fe,Mg)	Dieback is death of shoot meristem(apex). caused by deficiency of Cu
tail disease caused due to Mo deficiency. e and midribs become prominent as the lade develops poorly or falls down	Purple Colouration Anthocyanin develops more in amounts tha chlorophyll in leaves, stems, fruits. It is due deficiency of nitrogen

thema is disease characterized by g of leaves, reduction in fruit bearing city of trees and splitting of bark to e gums and gum pockets in citrus s. It is caused by deficiency of Cu	Necrosis brown spots due to death o tissue. It is caused by deficiency of Ca Mg, Cu, K
nature abscission of flower buds, s and leaves. It is caused mainly due hosphorus, mg and Cu deficiency	Leaf curl/ leaf Malformation/ leaf resetting. Caused to Zn deficiency
ition of cell division due to iency of N, K, S and Mo	Bronze colouration of leaves caused to Cl deficiency
ting-Stunted growth due to N iency	Late flowering, i.e. delay in flowering caused by deficiency of N,S, Mo.


B

ROLE OF NUTRIENT ELEMENTS AND THEIR DEFICIENCY SYMPTOMS

nt	Constituent of	Major Functions	Deficiency symptoms
en absorbed as r NO_3^- (in some plants $^-$, NH_4^+	Amino acid (proteins), nucleotides, hormones, chlorophyll, coenzymes, ATP, vitamins, cytochromes, etc.	(i) Cell division (ii) Growth (iii) Metabolism (iv) Photosynthesis (required by all parts of plants particularly meristems)	(i) CHlorosis starting f older leaves (ii) Stunted growth du decreased protein syr (iii) Smaller cells and inhibition of cell divisi (iv) Premature leaf fal (v) Anthocyanin development
horus absorbed as or PO_4^-	ATP, Nucleotides, NAD^+, $NADP^+$, Membranes (as phospholipids), some proteins	(i) Energy transfer reactions (ii) Cell division (iii) Membrane formation (iv) Phosphorylation reactins	(i) Necrosis first in old leaves. (ii) Stunted growth (iii) Premature absciss (iv) Delayed flowering seed germination (v) Poor vascular tissu

t	Constituent of	Major Functions	Deficiency symptoms
um absorbed as K^+ ions	Not a constituent of any organic substance. Required in more amounts in meristems	(i) Maintains cell turgidity (ii) Opening and closing of stomata (iii) Maintains cation anion balance (iv) Co-factor of upto 40 enzymes of photosynthesis, respiration, etc. (v) Increases membrane permeability (vi) Maintains osmotic potential	(i) Mottled chlorosis star with older leaves (ii) Marginal yellowing sc and curling of leaf (iii) Loss of apical domin (iv) Cereals show lodging (v) Shortening of interno (vi) Stunted growth, inhi of cell division
n absorbed as Ca^{2+} obile element)	(i) Components of middle lamella as calcium pecate (ii) Activator of enzymes of chromosome formation	(i) Regulates selective permeability of membranes (ii) Formation of spindle (iii) Regulates metabolism (iv) Prevention of toxicity (v) Activates certain enzymes (required by meristematic and differentiating tissues)	(i) Stunted growth (ii) Degeneration of mer specially root apex, dieb (iii) Chlorosis, necrosis, c first in younger leaves (iv) Premature flower abscission

t	Constituent of	Major Functions	Deficiency symptoms
sium absorbed as Mg^{2+}	(i) Constituent of chlorophyll (ii) As Mg pectate in middle lamella	(i) Chlorophyll formation (ii) Growth and metabolism (iii) Activator of photosynthetic enzymes RuBisCO and PEPCase, respiration, enzymes of phosphate transfer, fat-carbohydrate metabolism, DNA and RNA synthesis, ribosome binding	(i) Marginal curling and necrosis (ii) Interveinal chlorosis a anthocyanin developme in older leaves (iii) Green veins
r absorbed as SO_4^{2-} y mobile)	(i) Occurs in amino acids (cysteine and methionine), so a component of proteins (ii) Coenzyme A(Co-A) component (iii) Component of ferredoxin (iv) Vitamin component of thiamine, Biotin (v) Allyl oils of onion and garlic	(i) Protein synthesis (ii) Metabolism (iii) Nodulation in legumes	(i) Chlorosis first in youn leaves (ii) Leaf curl (iii) Decreased nodulatio legumes (iv) Defoliation in tea (v) Inhibition of cell divis (vi) Delay in flowering

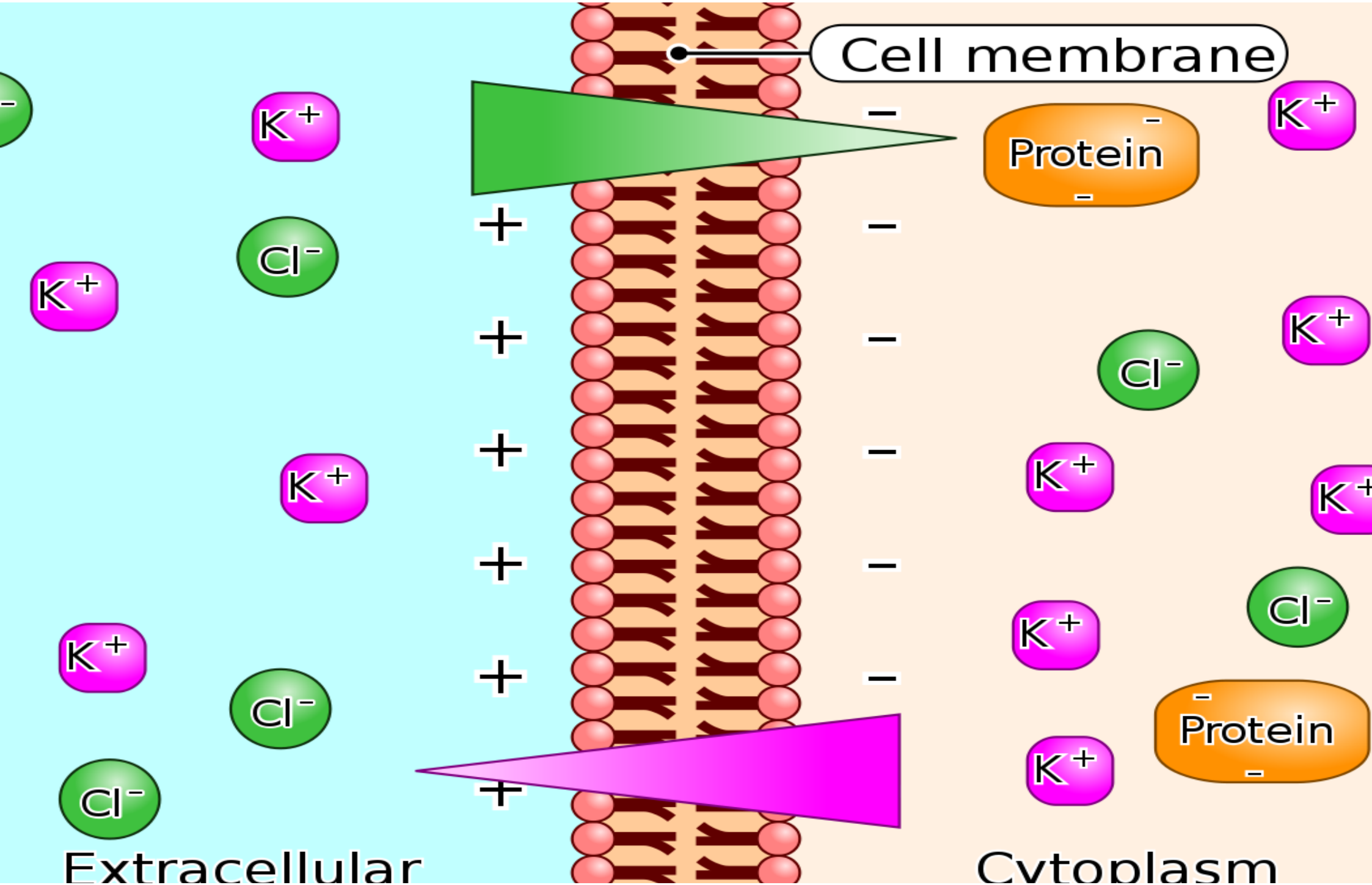
MICRONUTRIENTS

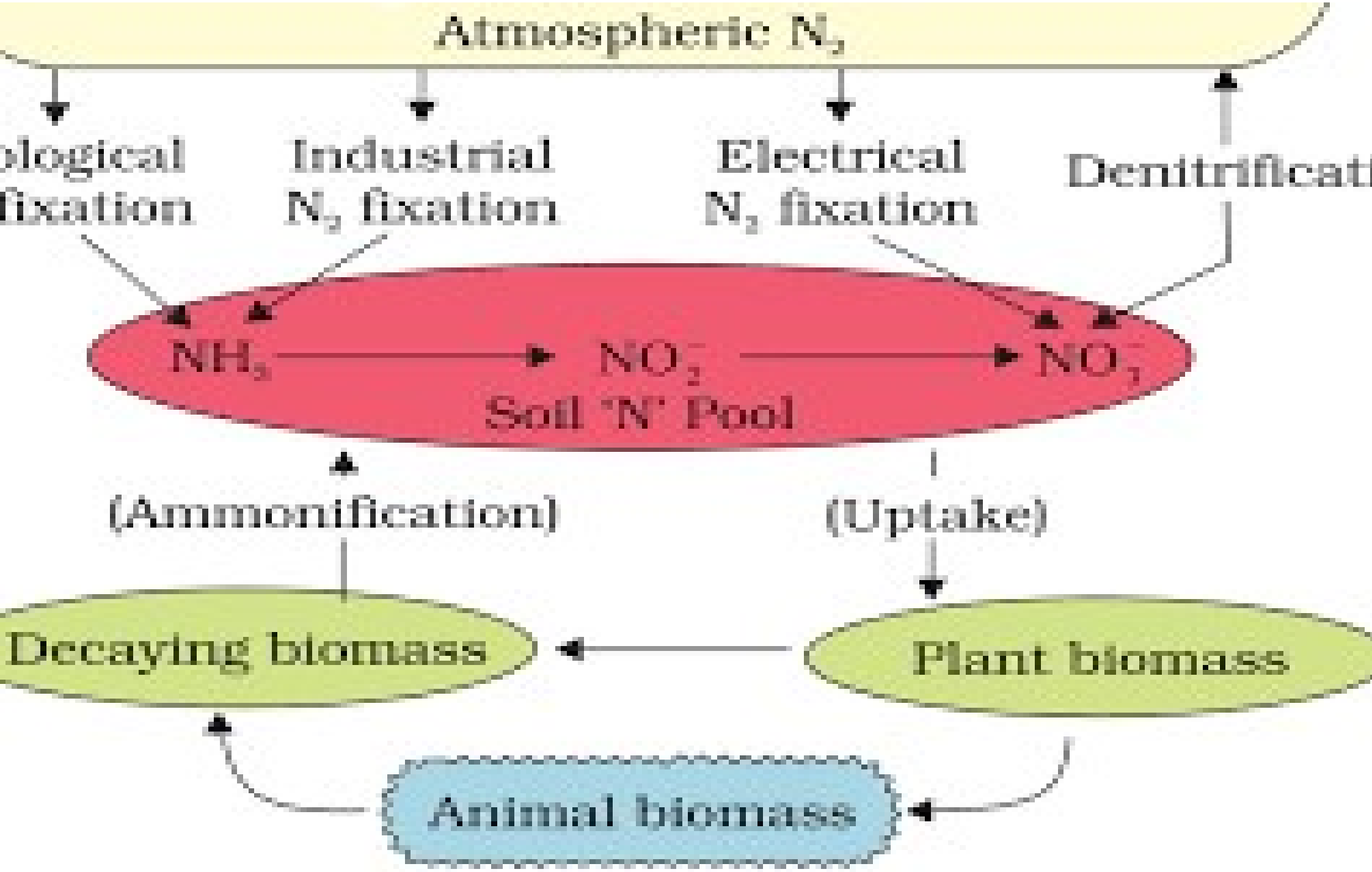
bsorbed as Non-mobile ent)	Component of cytochromes, ferredoxin and enzyme nitrogenase	(i) Electron transport in photosynthesis and respiration (ii) Chlorophyll formation (iii) Activator of enzyme aconitase, catalase	(i) Interveinal chlorc first in young leaves (ii) Green veins (iii) Stunted growth
anese absorbed as (Semi-mobile)	As a component of oxygen evolving complex or Z enzyme complex of photolysis in photosynthesis	(i) Involved in metabolism, photolytic oxygen evolution. (ii) Activator of enzymes involved in oxidation-reduction reactions, decarboxylation, respiration, photosynthesis and nitrogen metabolism	(i) Interveinal chlorc (ii) Grey spots or str (iii) Marsh spot dise (Brown spots on cotyledons of legum (iv) Sterile flowers (v) Stunted growth

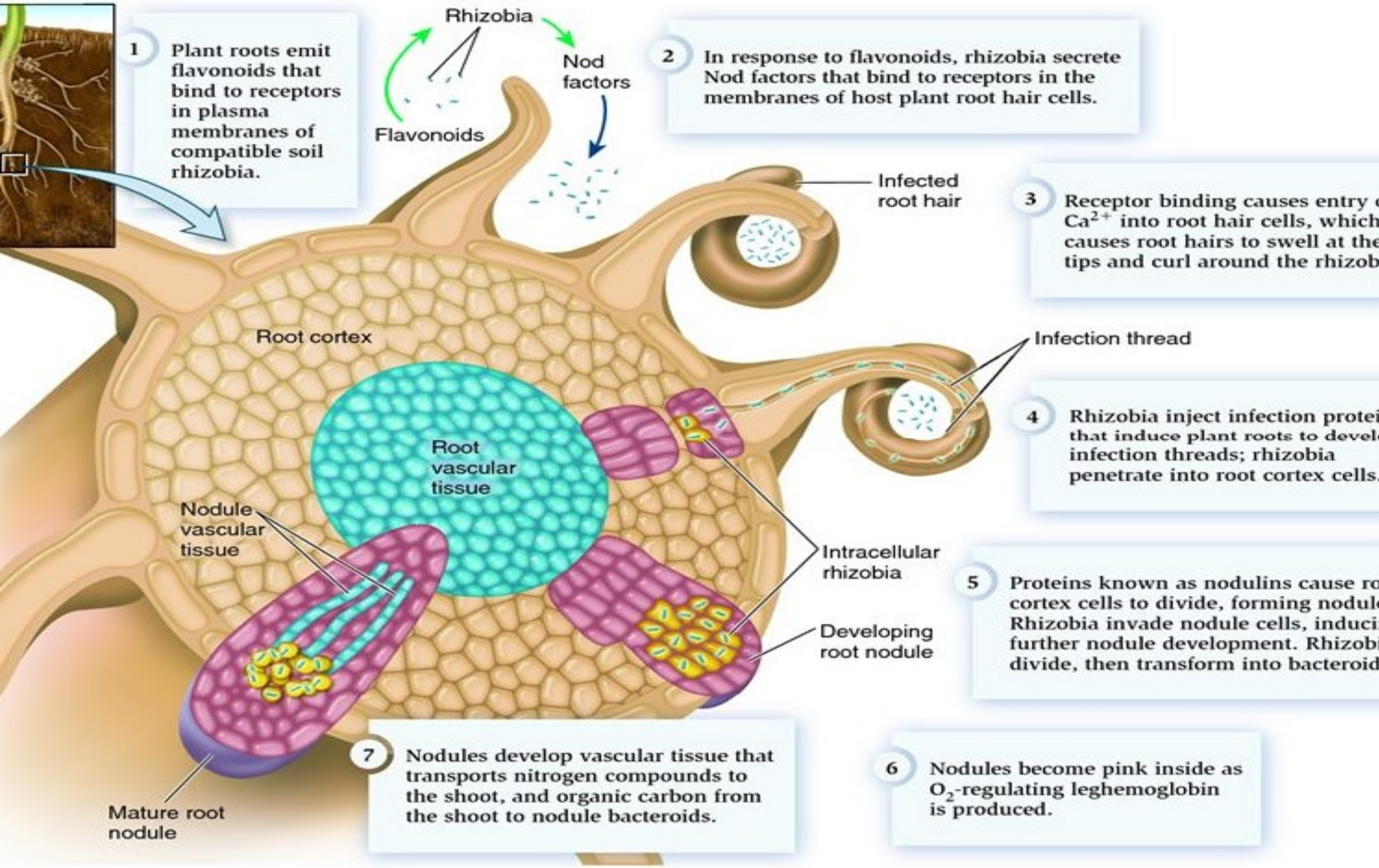
bdenum absorbed O_4^{2-}	Component of several enzymes like nitrogenase and nitrate reductase as well as dehydrogenases	(i) Nitrogen metabolism (ii) Ascorbic acid synthesis (iii) Oxidation reduction reactions	(i) Mottled chlorosis marginal necrosis of lower leaves (ii) Whiptail disease lamina/ or upper ha lamina falls down (iii) Loosening of inflorescence (iv) Inhibition of cell division (v) Delay of floweri
absorbed as BO_3^- O_7^{2-}	Component of young leaves	(i) Uptake and utilization of calcium (ii) Carbohydrate transport through phloem (iii) Pollen germination (iv) Pectin synthesis	(i) Disintegration of softer parts (ii) Brown heart of t (iii) Internal cork of (iv) Heart rot of bee (v) Drought spot of

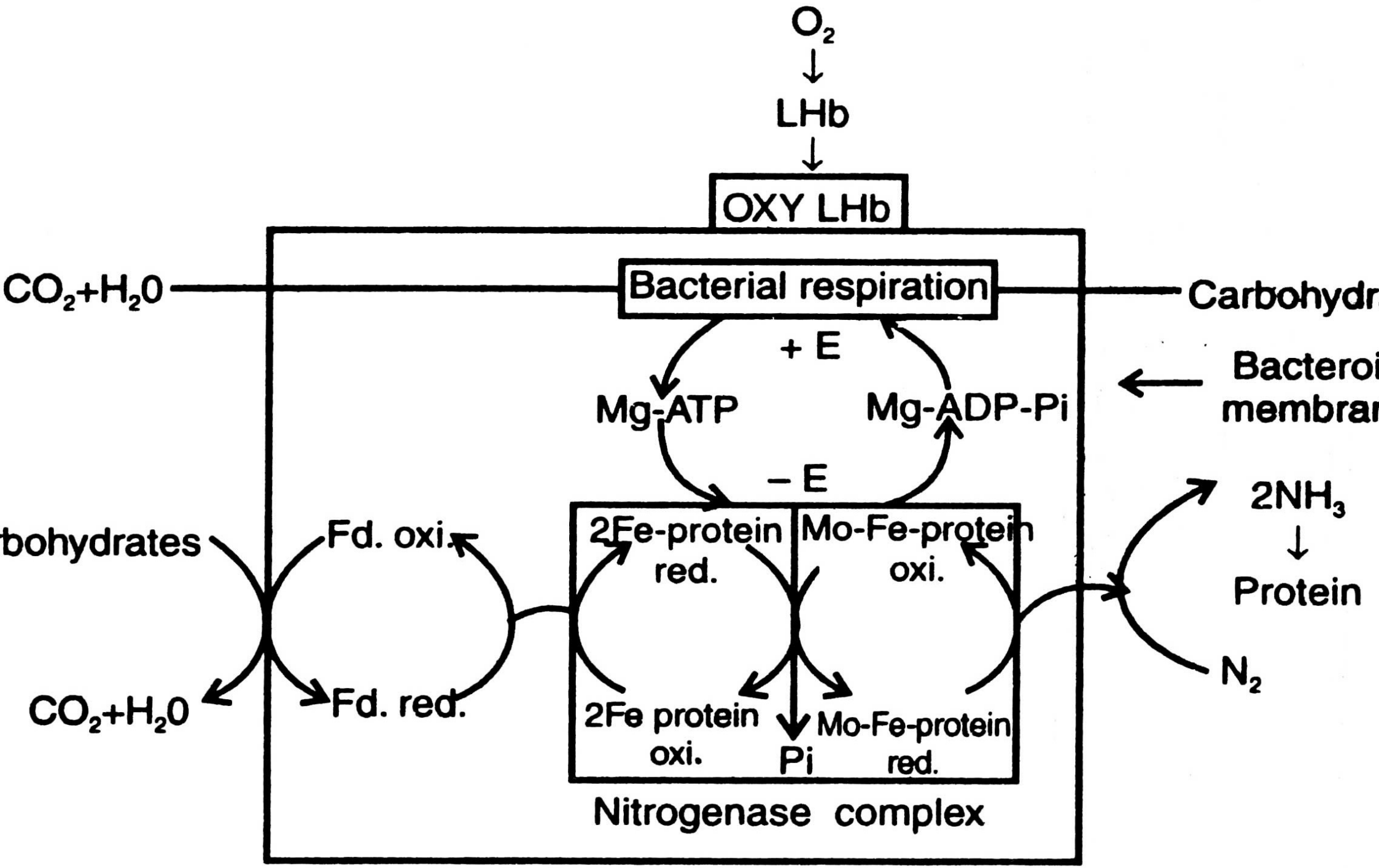
er absorbed as	Component of plastocyanin, cytochrome oxidase complex in respiratory ETS	(i) Electron transport (Redox reactions) (ii) Carbohydrate/ Nitrogen balance (iii) Chlorophyll synthesis	(i) Dieback (ii) Exanthema-ski splitting leading to gummosis of fruit (iii) Reclamation disease of cereals having chlorotic a necrotic leaf tip, fa to set seeds
bsorbed as Zn^{2+}	Component or activator of enzymes like carbonic anhydrase, dehyrodegenases, carboxylases	(i) IAA, RNA and protein synthesis (ii) Evolution and utilization of CO_2	(i) Leaf malformat such as little leaf, rosettes (ii) Interveinal chlo in older leaves (iii) White Bud (kh disease in rice)

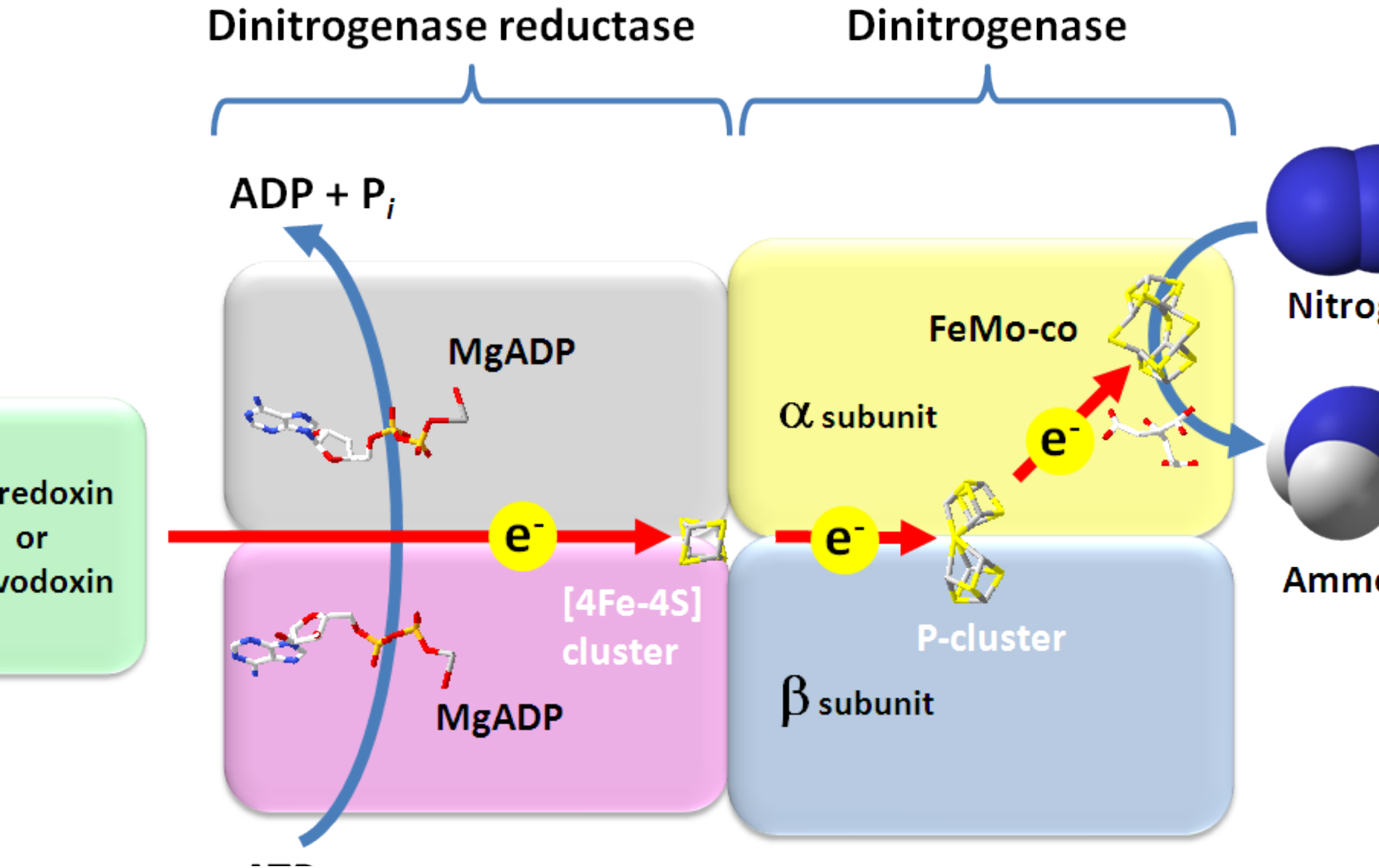
rine absorbed	Component of oxygen evolving complex or Z-enzyme complex photolysis in photosynthesis and Amylase	(i) Photo-evolution of oxygen by photolysis of water (ii) Maintains solute concentration and Anion-cation balance (iii) Normal production of fruits	(i) Bronze coloration of lea (ii) Leaf wilting (iii) Chlorosis, necrosis (iv) Swollen root (v) Flower abscission (vi) Reduced fru
el absorbed as	A constituent of enzyme urease, also required for hydrogenase	It can substitute for Fe and Zn as Co-factor in some enzymes	Necrotic lesions leaf tip


Cell membrane
Protein
Protein
K+
Cl−
Extracellular
Cytoplasm


Atmospheric N_2
ological fixation
Industrial N_2 fixation
Electrical N_2 fixation
Denitrificat
NH_3
NO_2^-
NO_3^-
Soil 'N' Pool
(Ammonification)
(Uptake)
Decaying biomass
Plant biomass
Animal biomass


1 Plant roots emit flavonoids that bind to receptors in plasma membranes of compatible soil rhizobia.
Rhizobia
Nod factors
Flavonoids
2 In response to flavonoids, rhizobia secrete Nod factors that bind to receptors in the membranes of host plant root hair cells.
Infected root hair
3 Receptor binding causes entry of Ca^{2+} into root hair cells, which causes root hairs to swell at the tips and curl around the rhizob
Root cortex
Infection thread
4 Rhizobia inject infection protei that induce plant roots to develo infection threads; rhizobia penetrate into root cortex cells.
Root vascular tissue
Nodule vascular tissue
Intracellular rhizobia
5 Proteins known as nodulins cause ro cortex cells to divide, forming nodul Rhizobia invade nodule cells, induci further nodule development. Rhizobi divide, then transform into bacteroid
Developing root nodule
Mature root nodule
7 Nodules develop vascular tissue that transports nitrogen compounds to the shoot, and organic carbon from the shoot to nodule bacteroids.
6 Nodules become pink inside as O_2-regulating leghemoglobin is produced.


O_2
LHb
OXY LHb
CO_2+H_2O
Bacterial respiration
Carbohydr
+ E
Mg-ATP
Mg-ADP-Pi
Bacteroi
membran
– E
bohydrates
Fd. oxi.
2Fe-protein red.
Mo-Fe-protein oxi.
$2NH_3$
Protein
CO_2+H_2O
Fd. red.
2Fe protein oxi.
Pi
Mo-Fe-protein red.
N_2
Nitrogenase complex


Dinitrogenase reductase
Dinitrogenase
ADP + P$_i$
MgADP
FeMo-co
α subunit
e$^-$
e$^-$
e$^-$
[4Fe-4S]
cluster
P-cluster
MgADP
β subunit
redoxin
or
vodoxin
Nitro
Amm