Ch 17 - Mineral nutrition

Need for Mineral Nutrition

- During photosynthesis green plants called autotrophs utilise the raw materials like carbon dioxide and water to make glucose molecules.
- Fertilizers bring about growth in plant. Such fertilizers are called minerals.
- With the exception of carbon and oxygen which are derived from air, the rest of minerals are absorbed from the soil and form mineral nutrition.

Essential Mineral Elements

- Some plant species accumulate selenium and others gold, while some plants grown near nuclear tests sites - radioactive Strontium.

Element	% dry weight
Oxygen	45-4
Carbon	43.6
Carbon hydrogen	6.15
Nitrogen	1.5
Silicon	1.2
Potassium	0.92
Calcium	0.13
Phosphorus	0.20
Mg	0.18
S	0.17
Al	0.10
Fe	0.08
Mn	0.04

Sources of some essential elements for plants.

- The elements which are obtained from weathering of parent rocks - mineral elements.
- The elements which are obtained from the atmosphere.

Carbon	Sources of element
Carbon	Obtained as CO_2 from the atmosphere
Oxygen	Obtained from air from water.
Hydrogen	Released from water.
Nitrogen	Absorbed from nitrate ions NO_3^-

SOIL AS RESERVOIR OF ESSENTIAL ELEMENTS

- The elements are derived from the rock minerals, their role in plant nutrition - mineral nutrition.

CRITERIA OF ESSENTIALITY OF ELEMENTS

(i) Element should be necessary for normal growth.

(ii) Element should not be replaced by another element.

Essential Elements Based on Quantitive Requirement

Essential nutrients (elements)

Micronutrients
- Required in minute quantities
- Less than 01 mg.
- Ex - Manganese, cobalt, molybdenum, iron, zinc, chlorine, vanadium.

Macronutrients
- Required in large quantities.
- At least 1-10 mg
- Carbon, hydrogen, Oxygen, nitrogen, Potassium, sulphur, phosphorus, calcium, magnesium.

- Again micronutrients can be classified into

(i) Elements for structural compon composition of cell - carbon, hydrogen, Oxygen.

(ii) Elements for energy - related compounds. magnesium, calcium.

(iii) Elements that can alter the ~~osmotic~~ osmotic potential of a cell.

Essential Elements

Essential elements	Examples
(i) Components of biomolecules	~~carb~~ C, H, O.
(ii) Energy related compounds	Mg, Ca, P.
(iii) Activators and inhibitors	Mg, P
(iv) Osmosirtic pot.	Potassium,

Hydroponics.

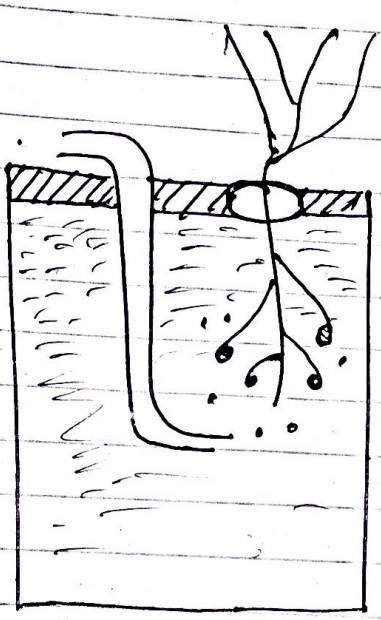
Basic

(i) Which element is essential for normal growth.

(ii) Which element is not essential.

(iii) How much quantity needed.

- Hydroponics is the process in which plants are grown directly in normal culture solution containg essential nutrient without the use of soil.



Important aspects of hydroponics.

(i) Large volume of nutrient

(ii) Concentration.

(iii) Vigorous bubbling of air.

Given by knop

Reinoral	Comp
KNO_3	0.2
$Ca(NO_3)_2$	0.8
KH_2PO_4	0.2
$MgSO_4 \cdot 7H_2O$	0.2
$FePO_4$	0.1

Given by Arnon and Hoagland.

Reinoral	Comp
KNO_3	1.02 g/L
$Ca(NO_3)_2$	0.492 g/L
$NH_4H_2PO_4$	0.23 g/L
$MgSO_4 \cdot 7H_2O$	0.49 mg/L
H_3BO_3	2.86 g/L
$MnCl_2 \cdot 4H_2O$	1.81 g/L
$CuSO_4 \cdot 5H_2O$	0.08 g/L
$SnSO_4 \cdot 7H_2O$	0.22 g/L
$H_2MoO_4 \cdot H_2O$	0.09 g/L
$FeSO_4 \cdot 7H_2O$	0.6 mL/L
Tartaric acid	0.6 mL/L

V- Violet
I= Indigo
B =Blue
G - Green
Y
O
R

Nutrient	Form	Region	Role	Deficiency
Nitrogen (N)	NO_3^-, NO_2^-, NH_4^+	• All parts • Meristematic • Required by plant	Synthesis of proteins, nucleic acid, hormones	Yellowing of leaves Stunted growth Dormancy
P	$H_2PO_4^-$, HPO_4^-	Young tissues withdraw from older meristematic	Cell membrane Phosphorylated reactions	Delay in seed germination Purple of red spots Premature fall of leaves.
K	Absorbed as k^+	meristematic tissues, buds leaves	• Anion-cation balance Opening of stomata Common in cell sap	Induced scorched leaf tips, Dieback in shoots Chlorosis
Ca	Ca^{2+}	meristematic tissue, differentiation tissue	Cell wall development Enzymes for growth spindle in cell division	Stunted growth leaf tips become hooked chlorosis
Mg	Mg^{2+}	All leaves	• Chlorophyll • phosphate metabolism respiration photosynthesis	chlorosis Necrosis Premature leaf.
S	SO_4^{2-}	Stem and young leaves	cysteine, amino acids constituent of enzymes	chlorosis stunted growth Accumulation

Iron	Fe^{3+}	leaves	Constituent of proteins Activator enzymes Essential for chlorophyll	chlorosis
Mn	Mn^{2+}	All tissues	Photosynthesis, respiration, splitting of water.	stunted growth leaf bound leaves.
Cu	Cu^{2+}	All tissues	oxidation - reduction reaction component of oxidase enzyme.	Necrosis Exanthema Dieback of shoot
Boron	BO_3^{2-}, $B_4O_7^-$	Leaves and seeds	Uptake of calcium ions Essential for growth of pollen tube	Death of root and shoot tip loss of apical dominance
Mo	MoO_4^{2+}	Roots	Nitrogenase and nitrate enzymes	Nitrogen deficiency Interveinal chlorosis curled margins
Cl	Chloride anion	All tissues	Along with Na^+ & K^+ helps anion cation balance	Wilted leaves Reduced fruiting

Deficency Symptoms of Various Elements

- ~~The comm~~

- **Critical Concentration**
  The concentration of an element below which the plant growth gets restarted is called critical concentration.

Deficiency Symptoms

- The deficiency of an element brings about certain morphological changes in plants that and these are seen as deficiency symptoms in plants.
- The symptoms develop as hunger signs.
- The part of the plant that show deficiency symptoms depends on the mobility of the element in the plant.

(i) For actively mobilised element - appear first in older tissues
eg - N, K, Mg.

(ii) For relatively immobile element - appear first in younger tissues
eg - S, Ca.

Major Deficiency Symptoms or Hunger Signs.

Name	Deficiency symptoms	Causes
Chlorosis	Yellowing of leaf	N, K, Mg, S, Fe.
Necrosis	localised death of tissues	Ca, Mg, Cu, K.
Inhibition	death of shoot tip	N, K, S, Mg.

Delayed flowering	delayed flowering	N, S, Mo

APPLICATION OF FERTILISERS

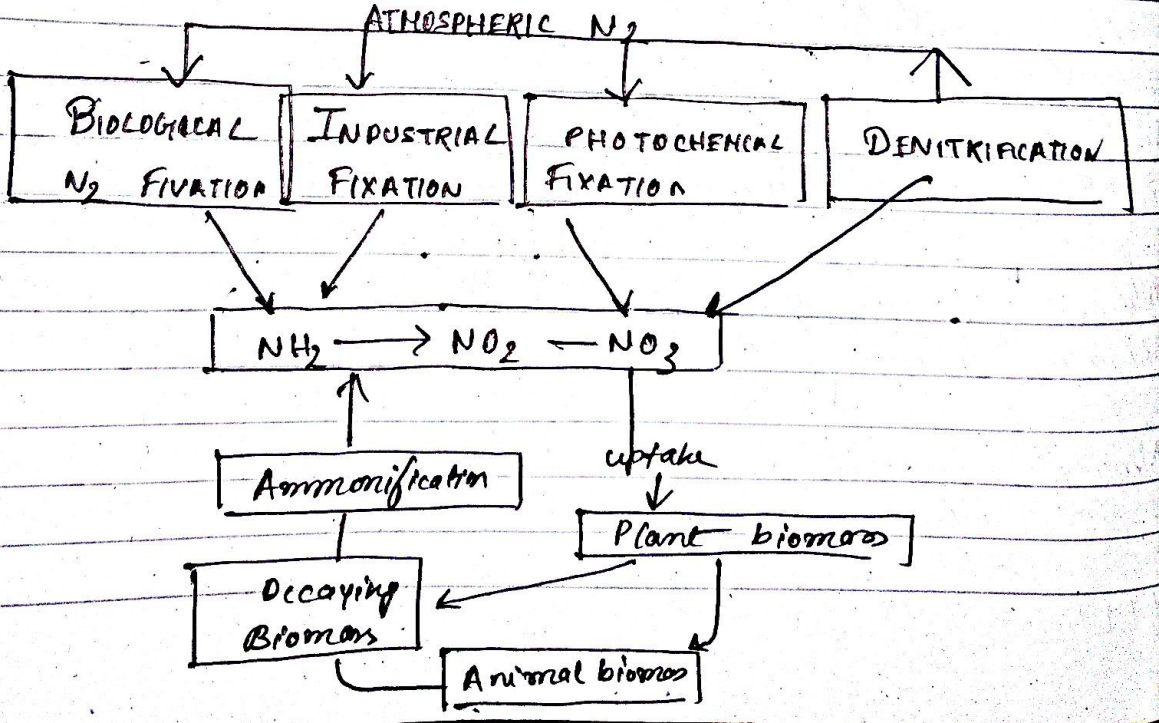
- The most common fertiliser - NPK fertilisers.
- Common sources of NPK - nitrates of soda, ammonium nitrate, ammonium chloride, urea, calcium ammonium nitrate, super phosphate, bone meal, rock phosphate, calcium, magnesium phosphate.

TOXICITY OF MICRONUTRIENTS

- When the concentration of any element increases more than the normal concentration then the element is considered toxic.
- eg - Manganese toxicity causes deficiency of - Iron, Magnesium, Chlorine.

METABOLISM OF NITROGEN

1. NITROGEN CYCLE



1. Nitrogen fixation

- Biological fixation - free living - Azobacter
  Symbiotic - Rhizobium
- Photochemical fixation - by action of lightning.

2. Fixed nitrogen used by plants

- Nitrogen mainly fixed as NH_4^+
- utilised in the form of ammino acid, protins, nucleic acid.

3. Ammonification

- Break down of organic nitrogen to ammonia.

4. Nitrification

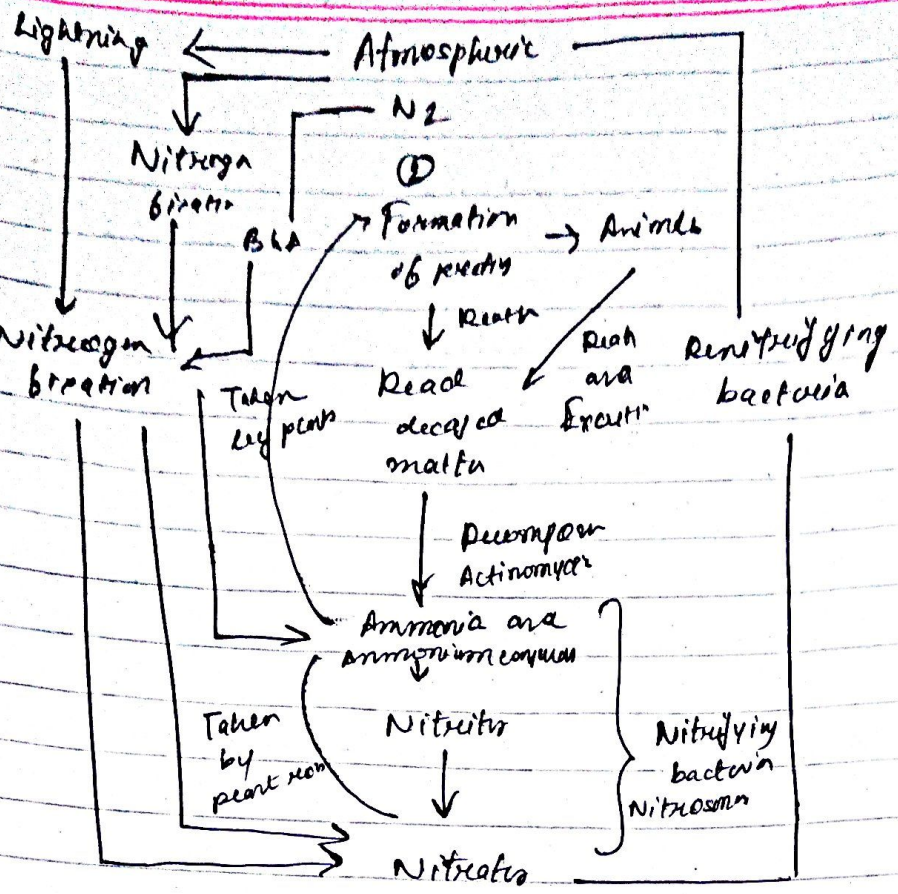
- Conversion of ammonia into nitrates and nitrates.

$NH_3^+ \xrightarrow{\text{Nitrosomonas}} NO_2^- \xrightarrow{\text{Nitrobacter.}} NO_3^-$

5. Denitrification

- Conversion of nitrates to ~~ammonia~~ nitrogen

Nitrates $\xrightarrow[\text{Thiobacillus.}]{\text{Pseudomonas}}$ Nitrogen



Biological Nitrogen Fixation

(i) Free living - Azobacter, Rhodospirillum, Clostridium

(ii) Symbiotic - Rhizobium

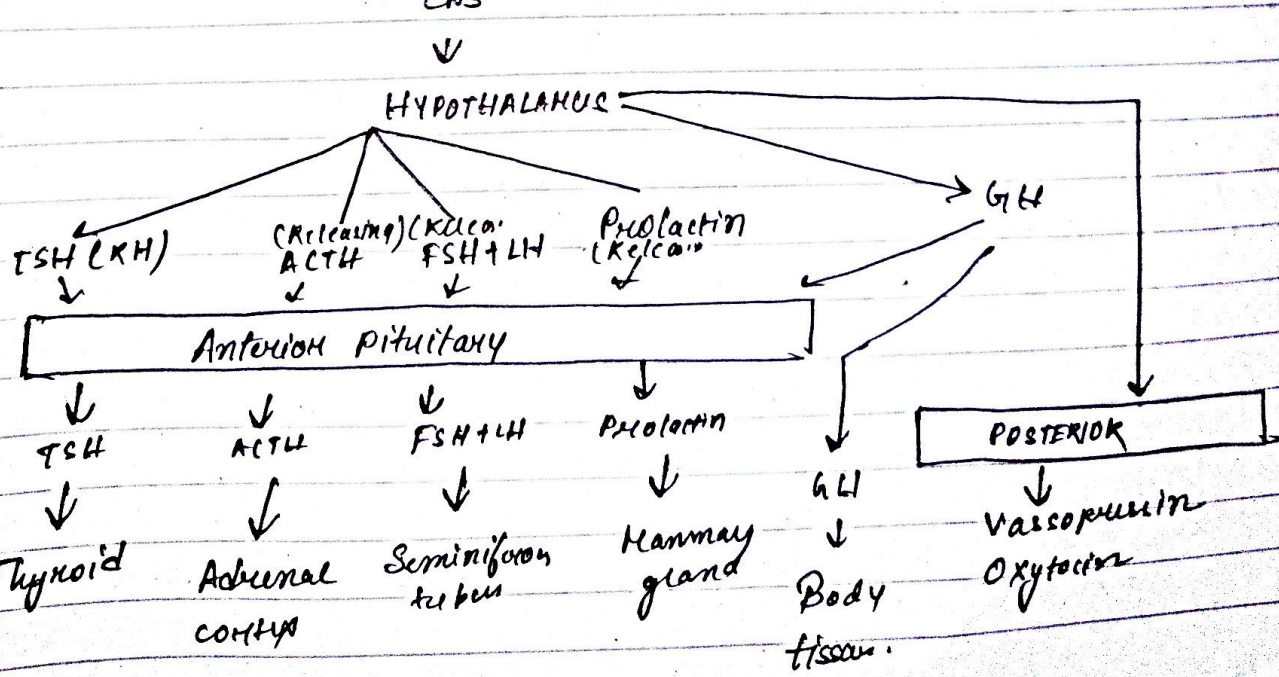
- The pigment leghaemoglobin (pinkish in colour) combines with nitrogen and protects the enzyme - nitrogenase.
- Nitrogenase - only enzyme for splitting nitrogen for nitrogen fixation.
  The enzyme nitrogenase is an Fe-Mo protein.

(i) Releasing hormones - gonadotropin releasing hormone (GnRH)

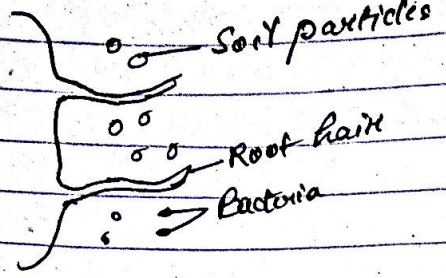
(ii) Inhibiting hormone - somatostatin

Releasing hormones	Hormones released in response.
(i) Tsh releasing hormone or thyrotropin	(i) TSH
(ii) ACTH releasing hormone	(ii) ACTH.
(iii) Gonadotropin releasing hormone.	(iii) FSH (Follicle releasing) (iv) LH (luteinizing) (v) LTH (luteotropin)
(iv) GH releasing hormone	GH or STH

RELATIONSHIP OF HYPOTHALAMUS, PITUITARY AND ORGANS

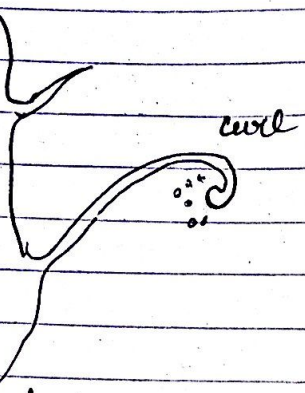


Root Nodule Formation



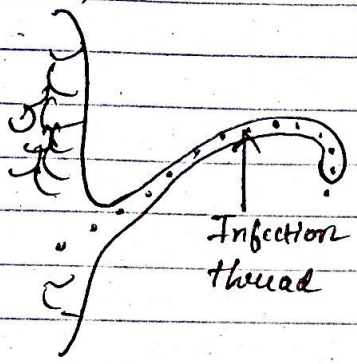
(a)

(i) Root hair comes in contact with bacteria, bacteria divides near it and upon infection it causes it to curl.



(b)

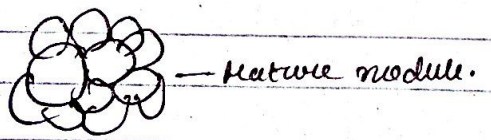
(ii) Root hair curls, the bacteria invades at the curling and start proliferating through the root hair.
Some bacteria forms bacteroids.



(c)

(iii) The plant respond to this by forming an infection thread made up of plasma membrane which grows inwards. The infection thread carries dividing bac.

(iv) The bacteroids causes the cortical and pericycle cell to divide. It is said that cytokinins from the invading bacteria and Auxins from plant cell causes cell division. Cell division of cortex and pericycle forms root nodule.



(d)

* Root nodule forms a direct vascular connection between host and bacteria.

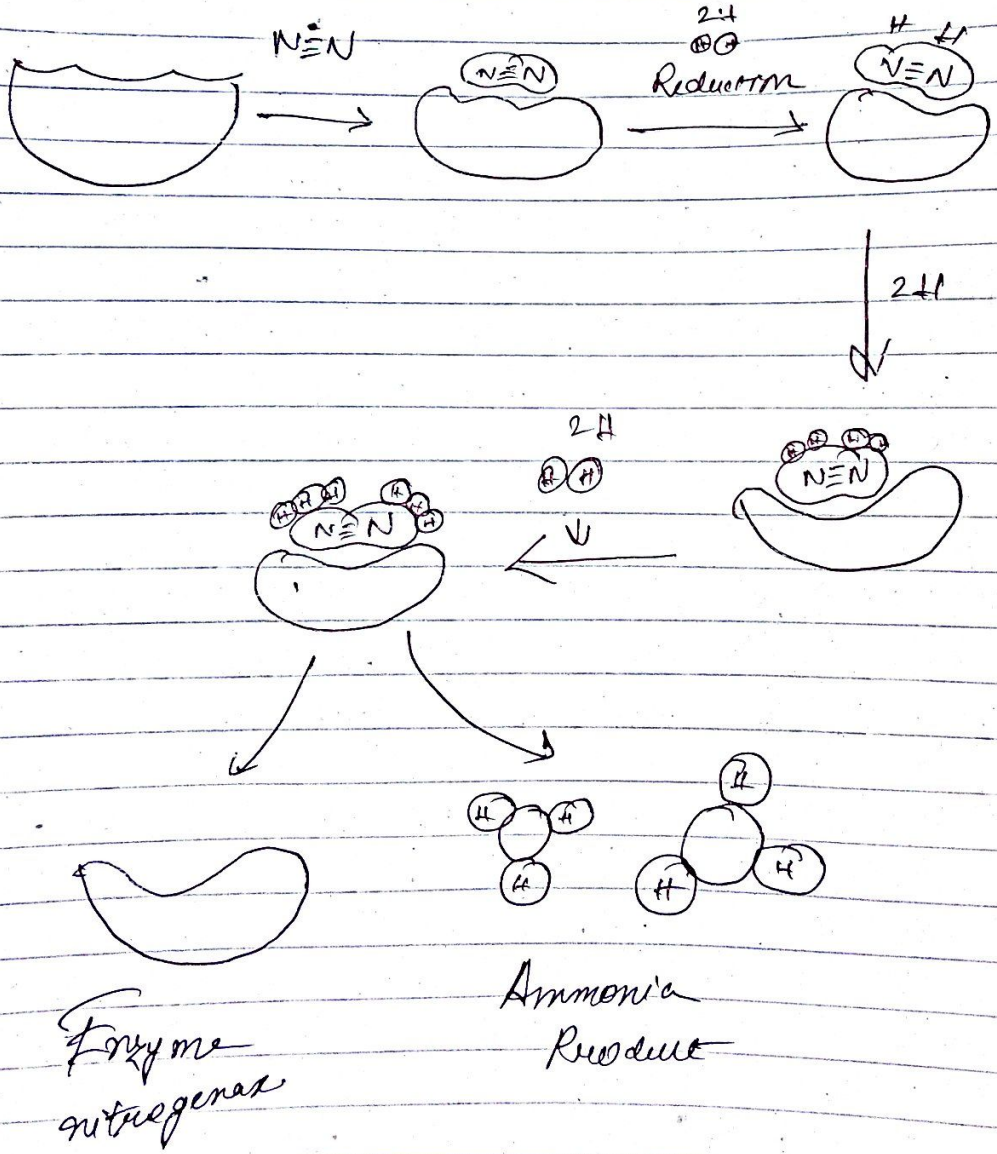
Importance of enzyme nitrogenase

- Nitrogen fixation takes place with the help of enzyme nitrogenase.

(i) A strong reducing agent - flavin adenine dinucleotide.

(ii) ATP molecules - provided by respiration.

(iii) Enzyme nitrogenase - catalyse reaction



Nitrate assimilation in plants

(i) Nitrate reductase - reduces nitrate to nitrite.

(ii) Nitrite reductase - reduces nitrite to ~~ammonia~~ ammonium ions.

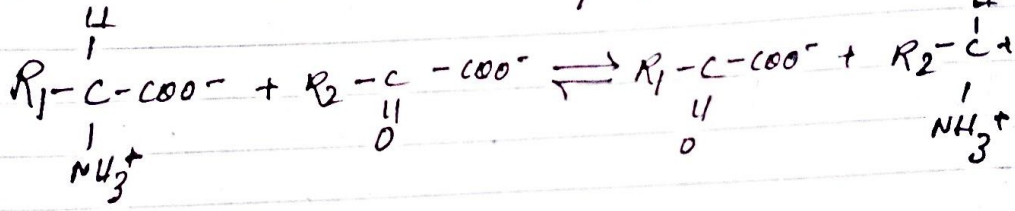
From ammonia to amino-acids

(i) Reductive amination

NH_4^+ + α-Ketoglutaric acid $\xrightarrow[NADPH\ NADP]{\text{Glutamate dehydrogenase}}$ Glutamate + H_2O.

(ii) Transamination

Glutamic acid + Keto acid → Formation of a specific amino acid.



From amino acids to amides

Glutamic acid + NH_4^+ $\xrightarrow{\text{Glutamine synthetase}}$ Glutamine.

- Aspartic acid + NH_4^+ $\xrightarrow{\text{Asparagine synthetase}}$ Asparagine

4. From amino acids to proteins