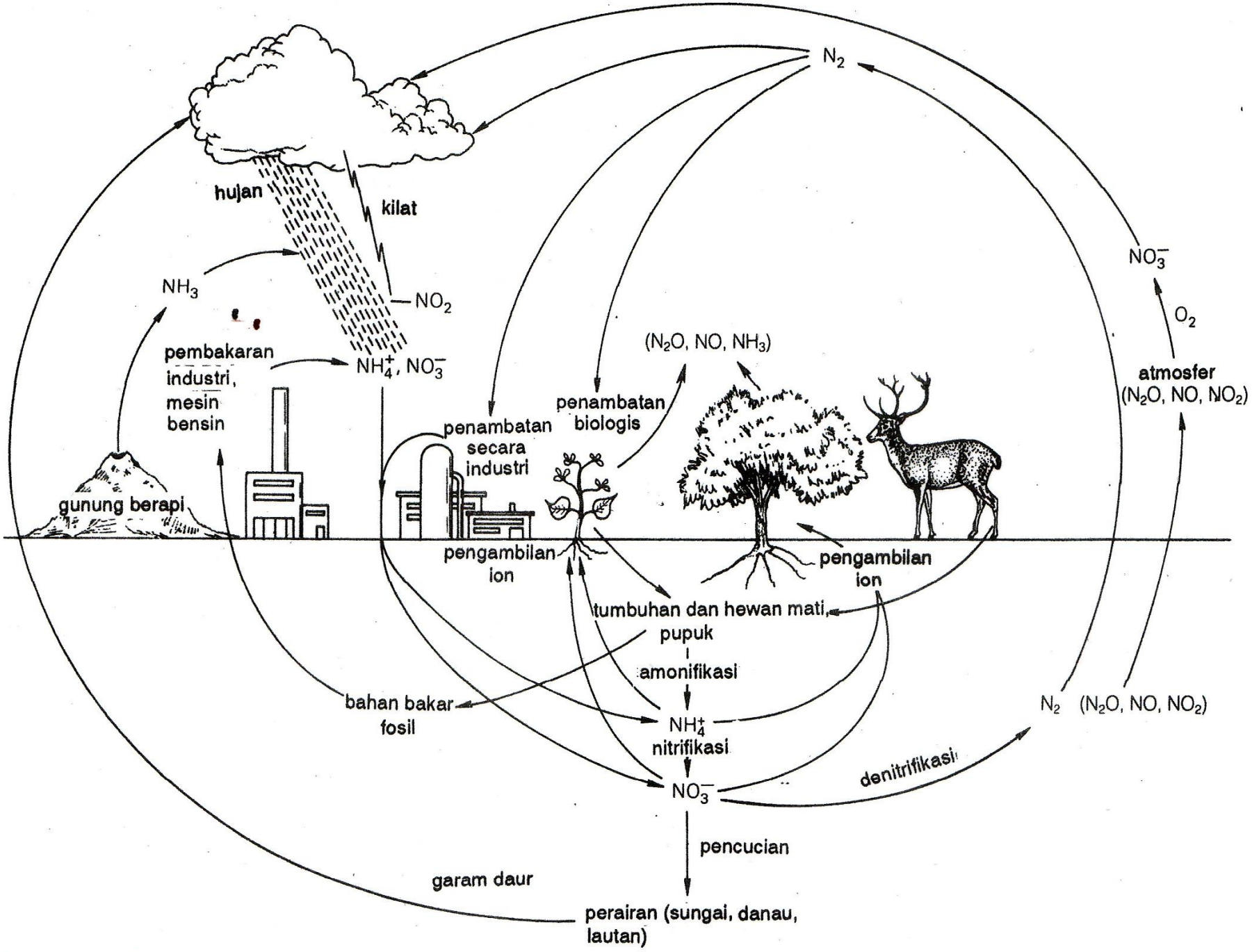
Pengambilan dan Asimilasi Nitrogen (N) pada Kondisi Cekaman Abiotik



Gambar 14.1 Daur nitrogen

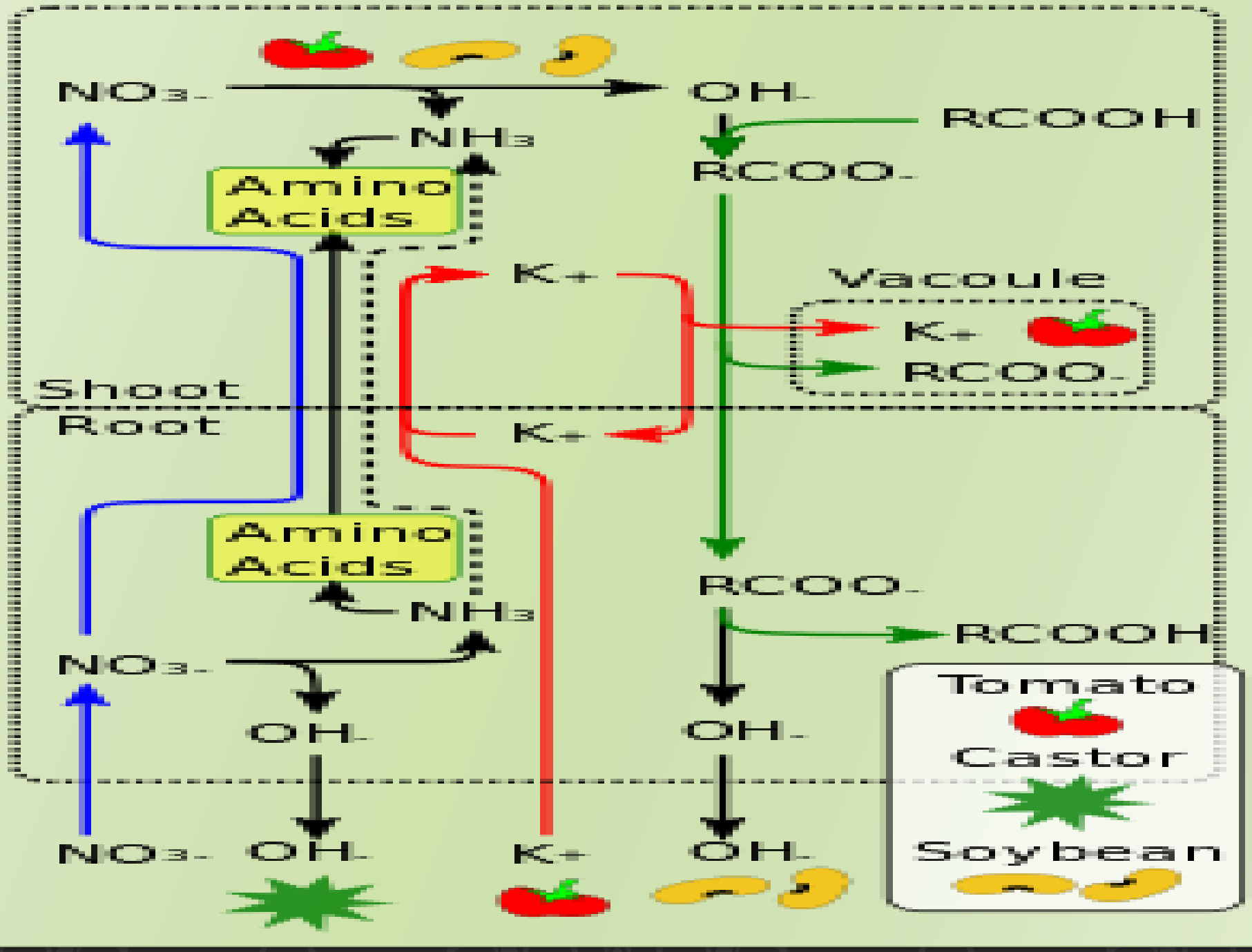
❖SUMBER N

- ATMOSFER (KONSENTRASI N 80%)
- BAHAN ORGANIK (DI BIOMASSA TUMBUHAN N 1-25%)

❖ N KE DALAM TUMBUHAN DLM BENTUK NO_3^-, NH_4^+,N_2
DIABSORPSI MELALUI AKAR & DAUN ATAU FIKSASI N ATMOSFER (SIMBIOSIS DENGAN MIKROORGANISME)

❖TRANSPORTASI DALAM TUBUH TUMBUHAN

- NO_3 TRANSPORTASI DALAM XILEM BERBENTUK KNO_3


NO3-
OH-
RCOOH
NH3
Amino Acids
RCOO-
K+
Vacoule
K+
RCOO-
Shoot
Root
K+
Amino Acids
RCOO-
NH3
RCOOH
NO3-
OH-
OH-
Tomato
Castor
NO3-
OH-
K+
OH-
Soybean

- N_2

  DIUBAH DULU MENJADI NH_3/NH_4 (PERLU FEREDOKSIN, Fe-PROTEIN, Mo-Fe-PROTEIN DAN Mg-ATP)

  TRANSPORTASI DALAM BENTUK GLUTAMIN, AS. GLUTAMAT & ASPARAGIN UREIDA (MIS. SITRULIN)

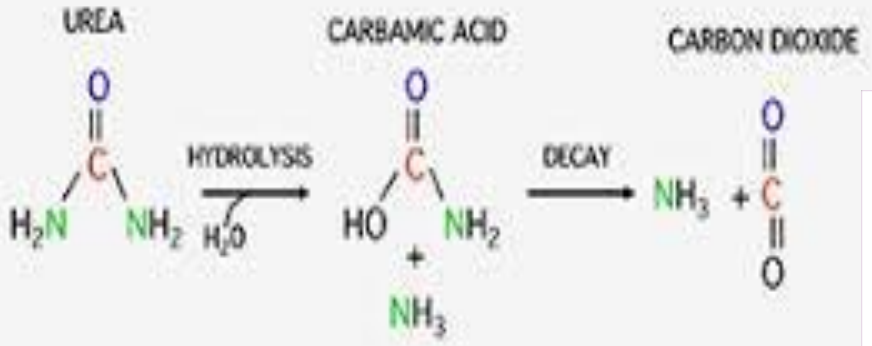
  NH_4 ⟶ AMIDA

- UREA

  DIUBAH DULU MENJADI NH_3 (KATALIS ENZIM UREASE) + ORNITIN MENJADI ARGININ

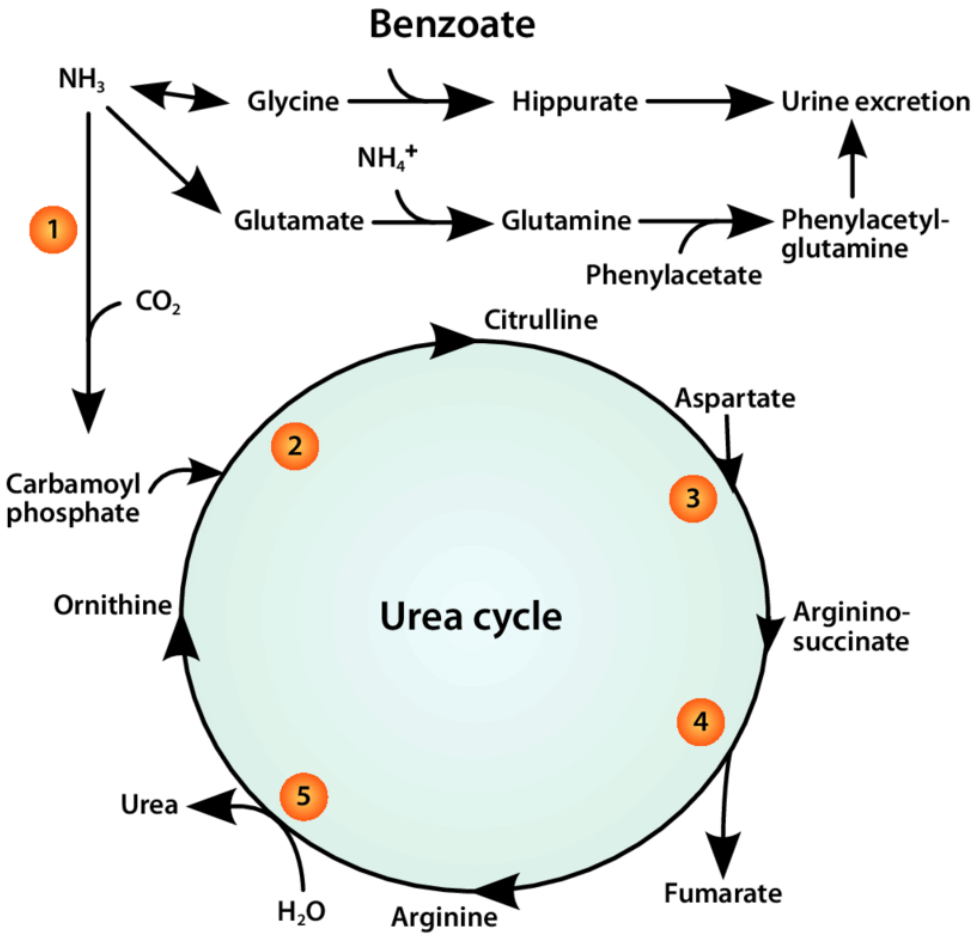
  DITRANSPORTASIKAN MELALUI FLOEM DAUN

UREASE REACTION

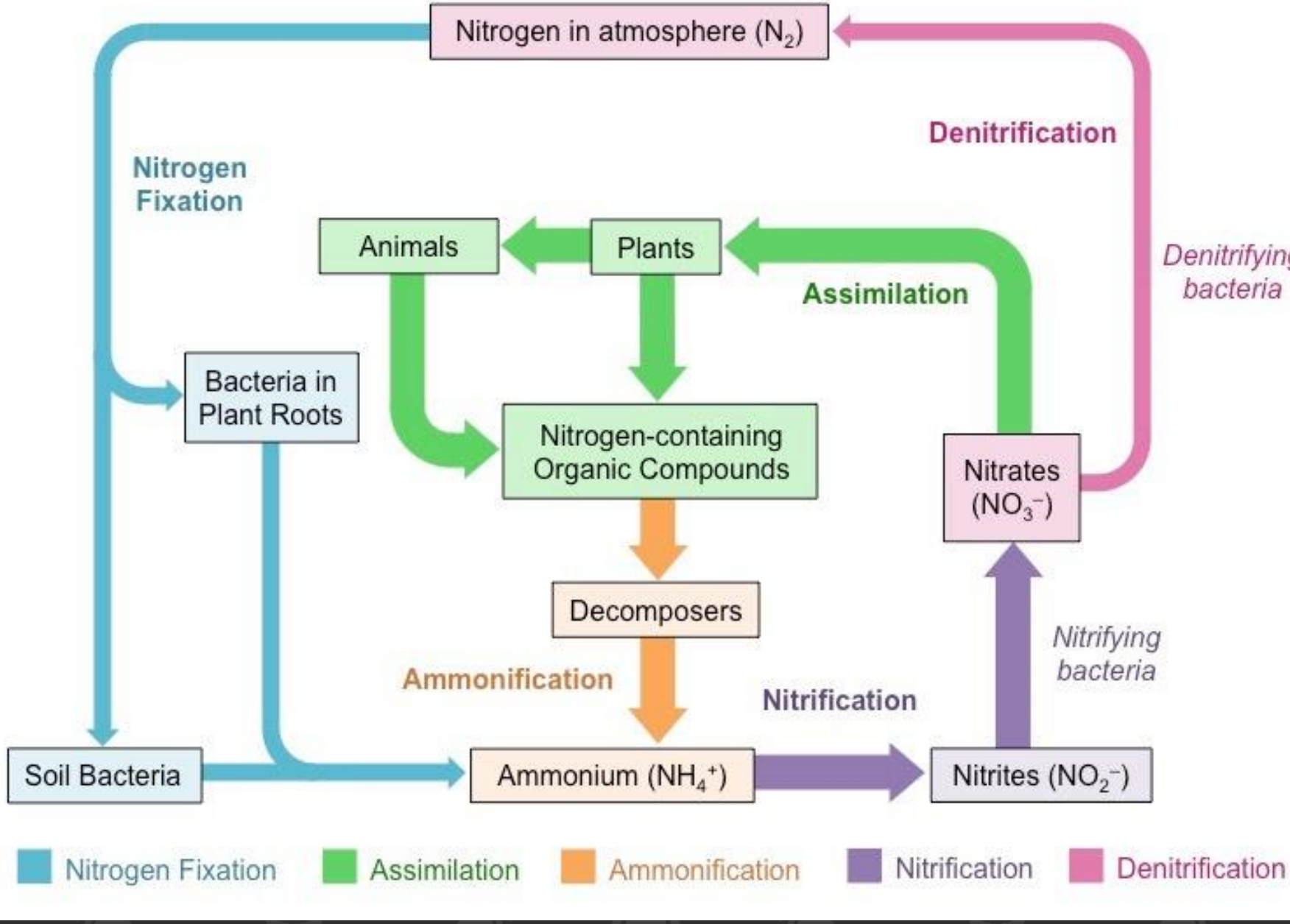


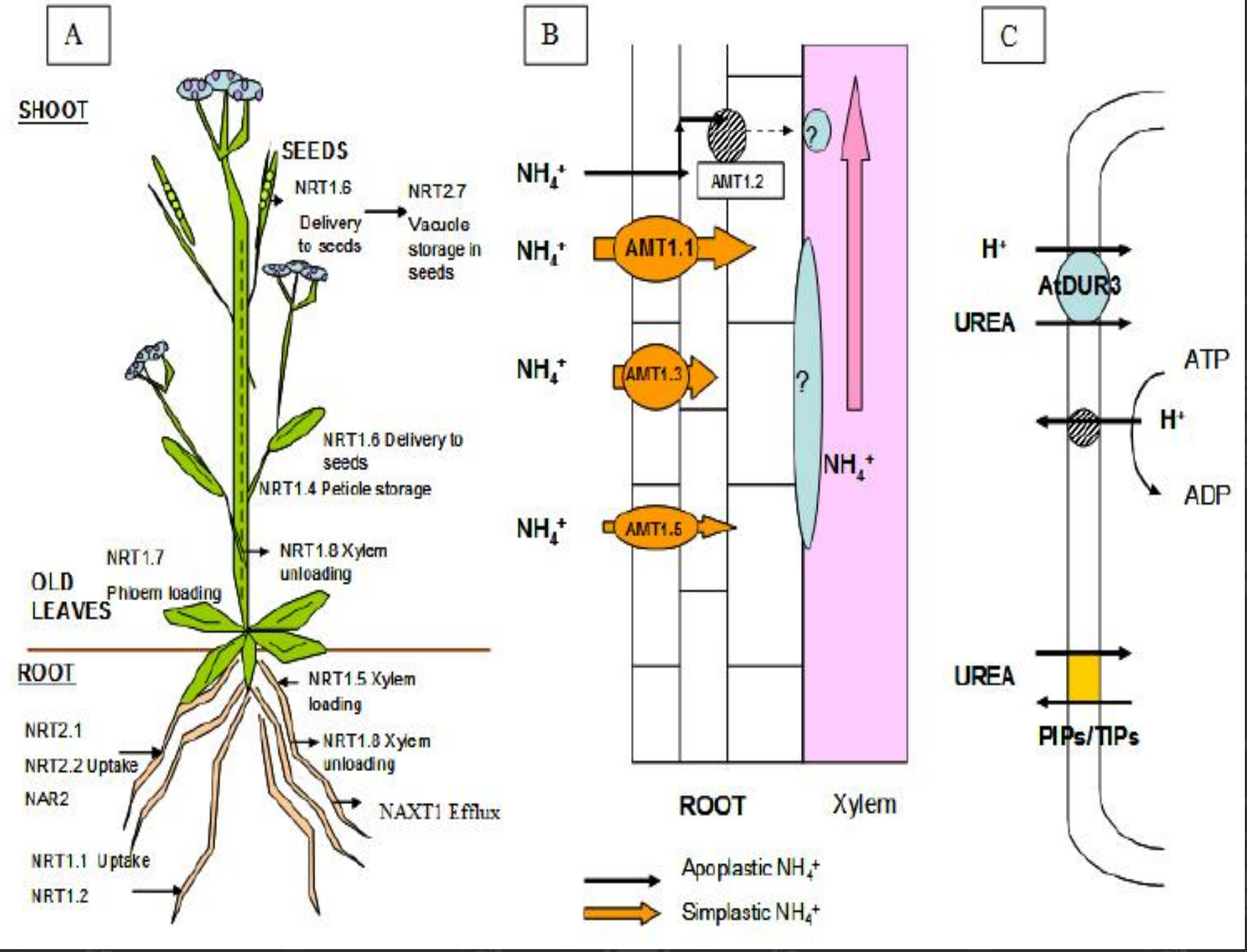
AMMONIA PROTONATION TO AMMONIUM ION

$NH_3 + H^+ \longrightarrow NH_4^+$



1. Carbamoyl phosphate synthase
2. Ornithine carbamoyltransferase
3. Argininosuccinate synthase
4. Argininosuccinate lyase
5. Arginase


Nitrogen in atmosphere (N_2)
Denitrification
Nitrogen Fixation
Animals
Plants
Assimilation
Denitrifying bacteria
Bacteria in Plant Roots
Nitrogen-containing Organic Compounds
Nitrates (NO_3^-)
Decomposers
Nitrifying bacteria
Ammonification
Nitrification
Soil Bacteria
Ammonium (NH_4^+)
Nitrites (NO_2^-)
Nitrogen Fixation
Assimilation
Ammonification
Nitrification
Denitrification


A
SHOOT
SEEDS
NRT1.6
Delivery to seeds
NRT2.7
Vacuole storage in seeds
NRT1.6 Delivery to seeds
NRT1.4 Petiole storage
NRT1.8 Xylem unloading
NRT1.7
Phloem loading
OLD LEAVES
ROOT
NRT1.5 Xylem loading
NRT2.1
NRT2.2 Uptake
NAR2
NRT1.8 Xylem unloading
NAXT1 Efflux
NRT1.1 Uptake
NRT1.2
B
NH4+
AMT1.2
NH4+
AMT1.1
NH4+
AMT1.3
NH4+
AMT1.5
?
?
NH4+
ROOT
Xylem
Apoplastic NH4+
Simplastic NH4+
C
H+
AtDUR3
UREA
ATP
H+
ADP
UREA
PIPs/TIPs

❖ N DALAM TUBUH TUMBUHAN

- N_2, NO_3^- DAN UREA ⟶ NH_4^+
- NO_3^- ⟶ NH_4^+ MELALUI

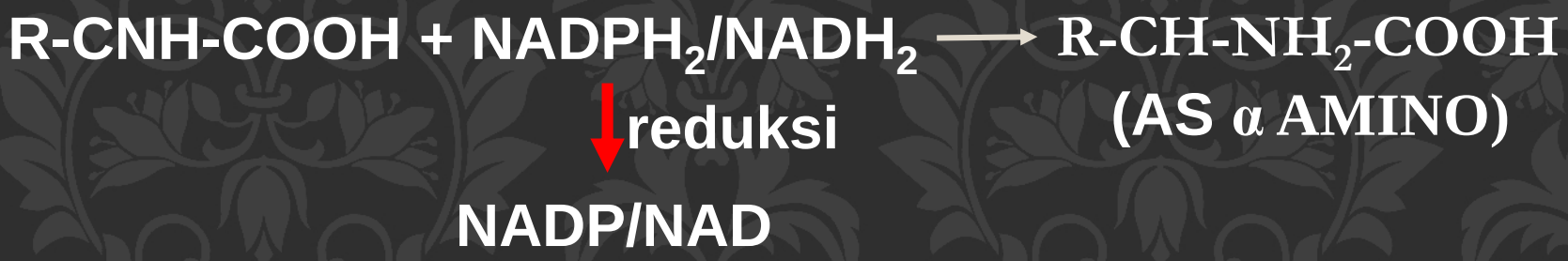
a. NO_3^- —(NITRAT REDUKTASE; NADH/NADPH)→ NO_2^- (SITOSOL)

b. NO_2^- —(NITRIT REDUKTASE; FEREDOKSIN ATP/FADH)→ NH_4^+ (KHLOROPLAST)

NH_4^+ KEMUDIAN DIUBAH MENJADI **ASAM AMINO** MELALUI **AMINASI REDUKTIF DAN TRANSAMINASI**

AMINASI REDUKTIF

REAKSI AMONIA + ASAM α KETO



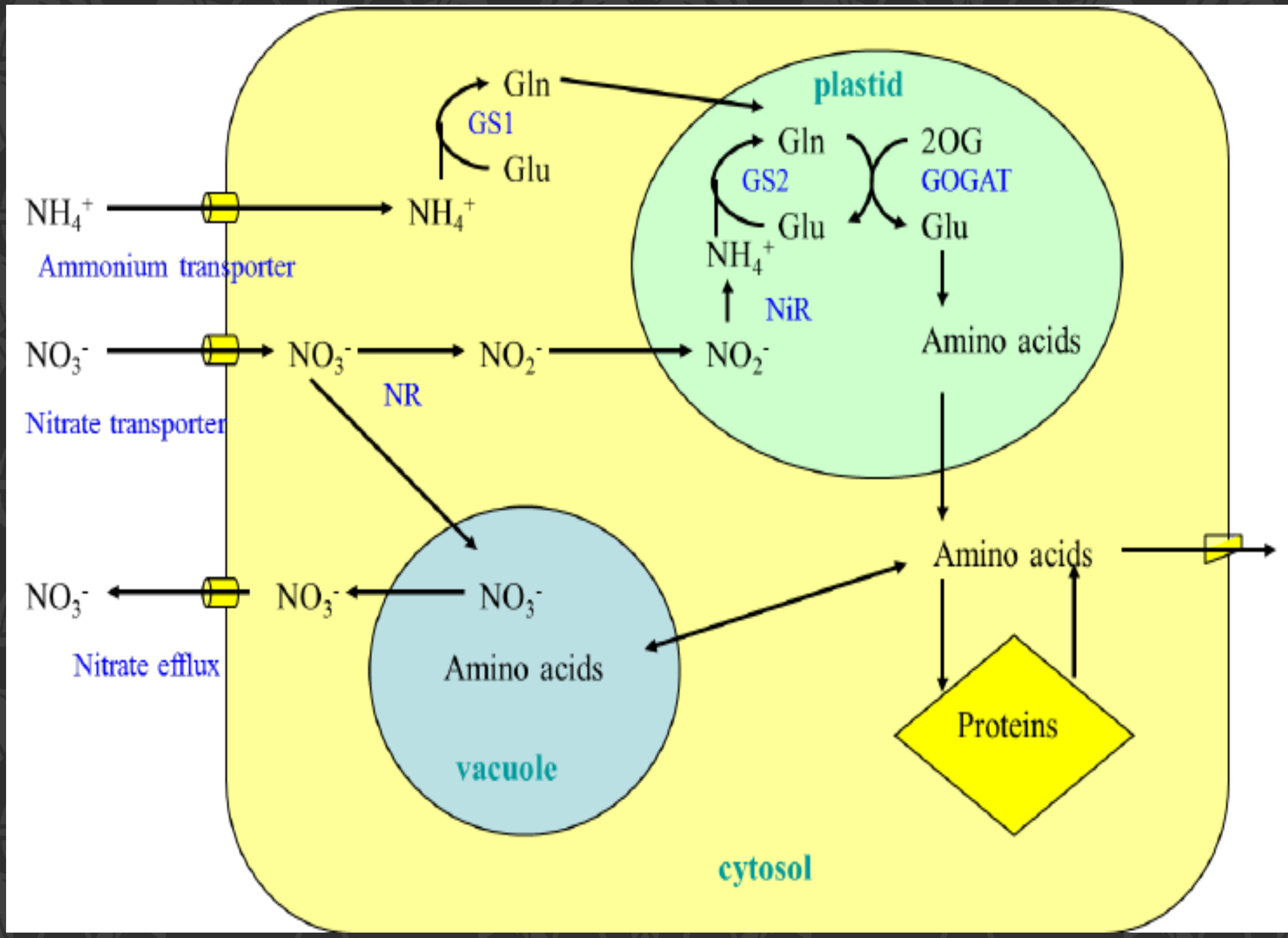
SUMBER α KETO (TUMBUHAN) DARI DAUR KREBS DAN $NADPH_2$/NAD DARI RESPIRASI

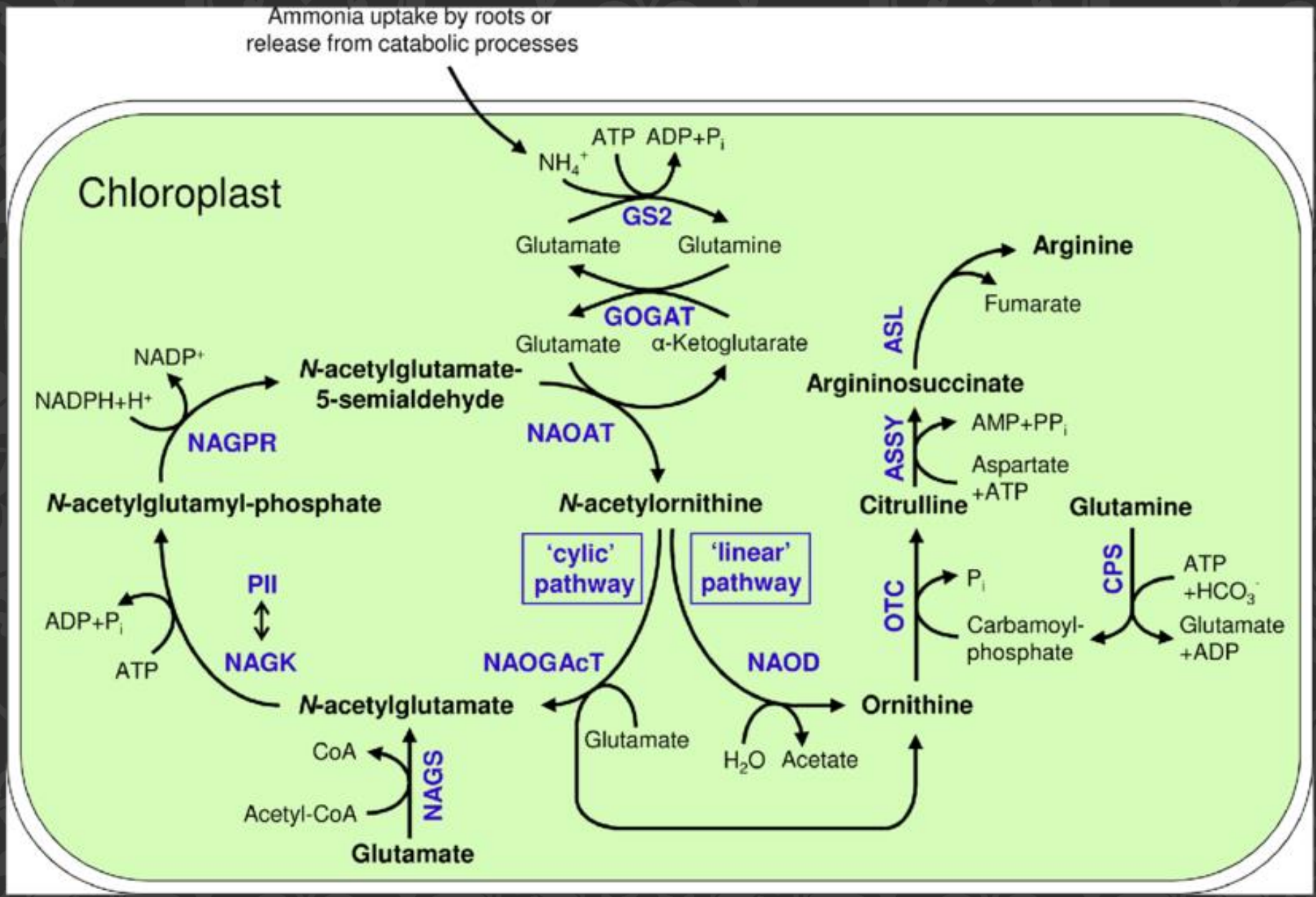
ASAM AMINO PERTAMA TERBENTUK

- **AS. GLUTAMAT (DARI ASAM α KETOGLUTARAT)**
- **AS. ASPARTAT (DARI ASAM OKSALO ASETAT)**
- **ALANIN (DARI ASAM PIRUVAT)**
- **AMIDA ⟶ GLUTAMIN, ASPARAGIN**

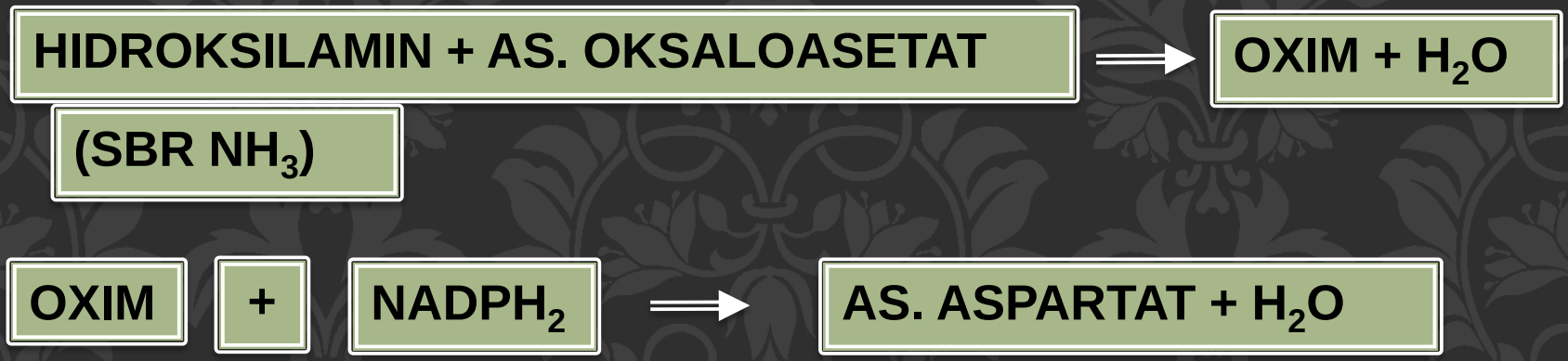
- **AS. ASPARTAT + NH_3 ⟷ ASPARAGIN**
  asparaginase dan ATP **$+H_2O+ADP+Pi$**

- **AS. GLUTAMAT + NH_3 ⟷ GLUTAMIN**
  glutamin dan ATP **$+H_2O+ADP+Pi$**


Gln
GS1
Glu
plastid
Gln
2OG
GS2
GOGAT
Glu
Glu
NH_4^+
NH_4^+
NH_4^+
Ammonium transporter
NiR
NO_3^-
NO_3^-
NO_2^-
NO_2^-
Amino acids
NR
Nitrate transporter
Amino acids
NO_3^-
NO_3^-
NO_3^-
Nitrate efflux
Amino acids
Proteins
vacuole
cytosol


Ammonia uptake by roots or release from catabolic processes
Chloroplast
ATP ADP+Pi
NH4+
GS2
Glutamate
Glutamine
GOGAT
Glutamate
α-Ketoglutarate
NADP+
NADPH+H+
NAGPR
N-acetylglutamate-5-semialdehyde
NAOAT
N-acetylglutamyl-phosphate
N-acetylornithine
'cylic' pathway
'linear' pathway
PII
ADP+Pi
ATP
NAGK
N-acetylglutamate
NAOGAcT
NAOD
Glutamate
H2O
Acetate
CoA
Acetyl-CoA
NAGS
Glutamate
ASL
Arginine
Fumarate
Argininosuccinate
ASSY
AMP+PPi
Aspartate +ATP
Citrulline
OTC
Pi
Carbamoyl-phosphate
Glutamine
CPS
ATP +HCO3-
Glutamate +ADP
Ornithine

LINTASAN LAIN (Virtanen)



PADA AKAR LEGUM BILA BERSIMBIOSIS DG RHIZOBIUM

SINTESIS AS. ASPARTAT, GLUTAMAT DAN AMIDANYA TERJADI DI AKAR DAN BAG. ATAS TANAMAN

AMINASI REDUKTIF SAMPAI PEMBENTUKAN AMIDA TERJADI DI AKAR KEMUDIAN DITRANSPORTASIKAN KE DAUN MELALUI XILEM

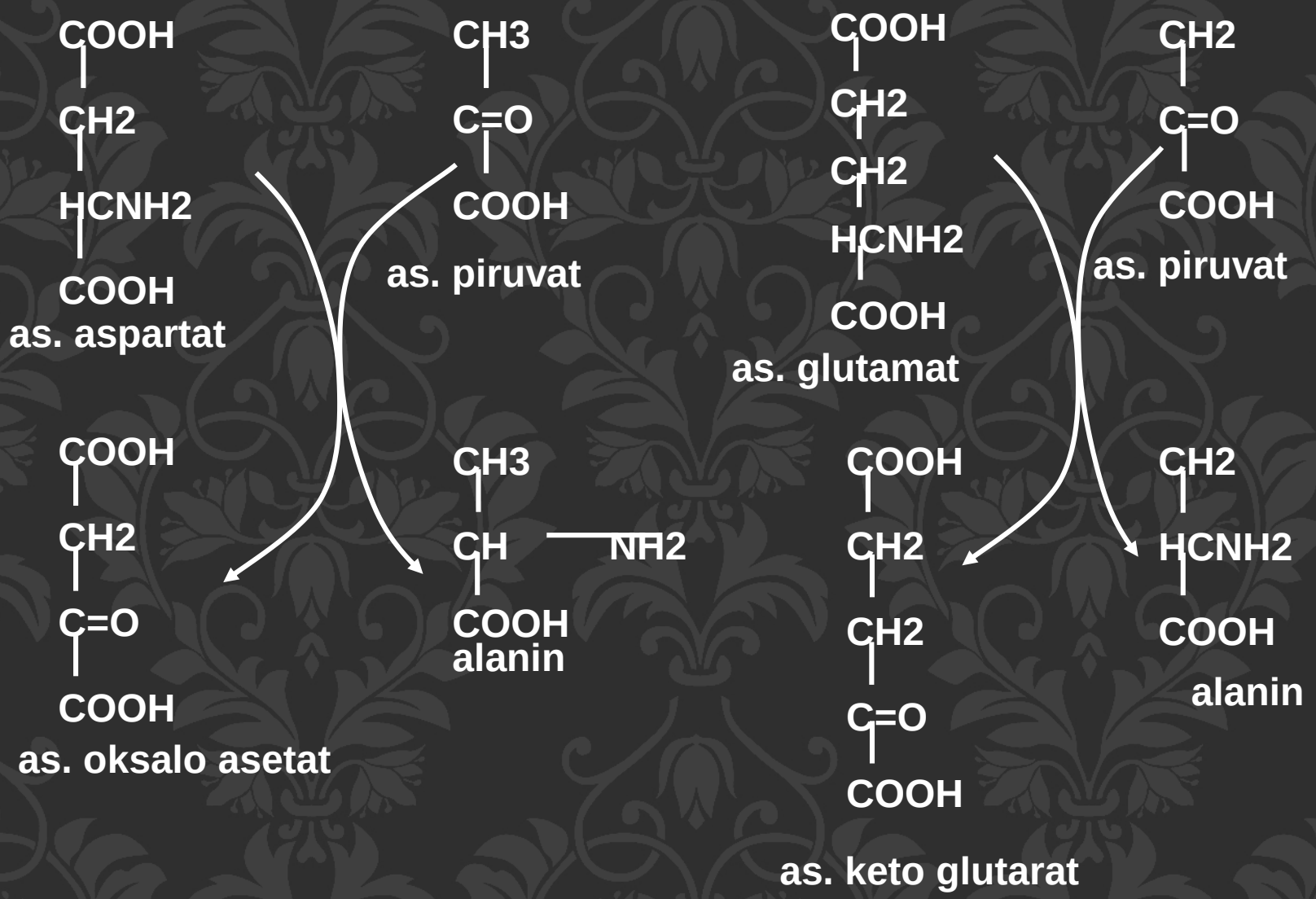
FUNGSI AMIDA SEBAGAI PEMBAWA DAN SUMBER AMONIA

TRANSAMINASI: PROSES PEMINDAHAN GUGUS AMINO KE SENYAWA ASAM α KETO MENGHASILKAN ASAM AMINO BARU

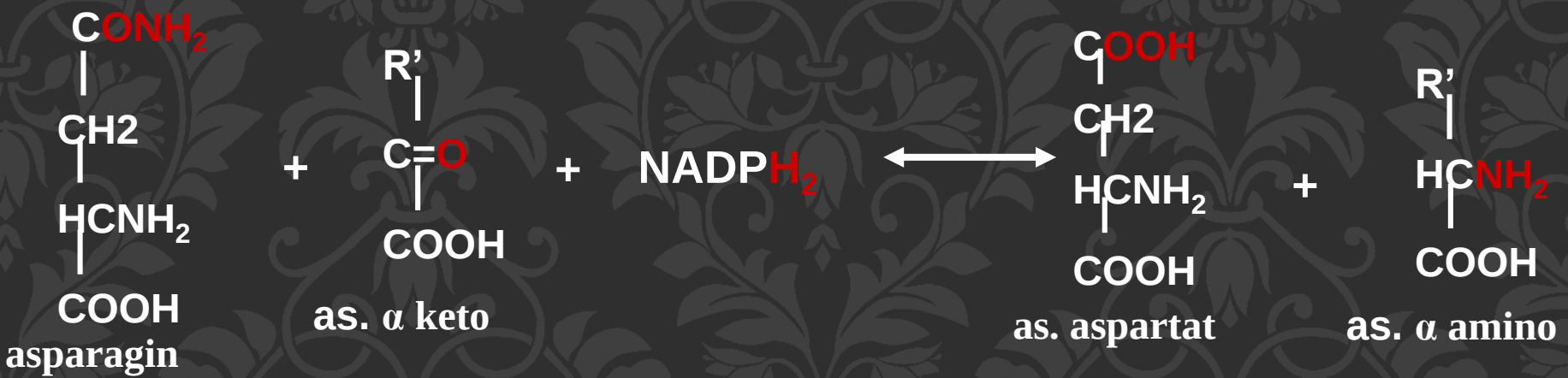
TRANSFER GUGUS AMINO DARI As. ASPARTAT KE ASAM α KETO KEMUDIAN KE PIRUVAT MENGHASILKAN ALANIN SELANJUTNYA ALANIN MEMINDAHKAN GUGUS AMINO KE SENYAWA LAIN MEMBENTUK AMINO LAIN

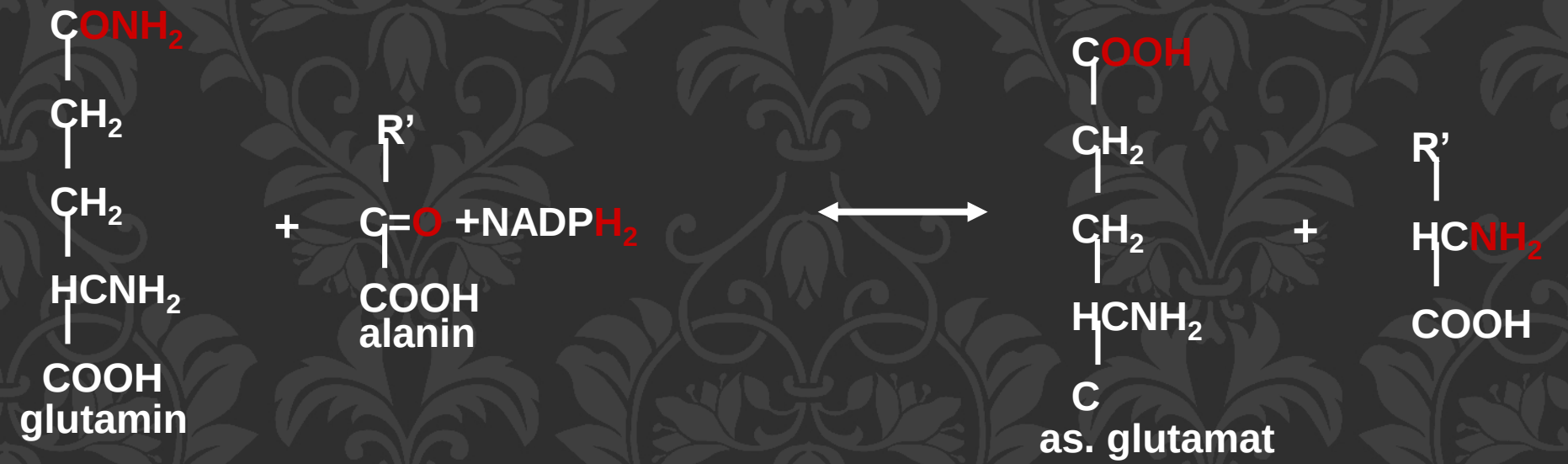
As. ASPARTAT+As. α KETO ⟷ As. OKSALOASETAT+ As. α AMINO LAIN

As. GLUTAMAT+As. α KETO ⟷ As. KETOGLUTARAT+ As. α AMINO LAIN

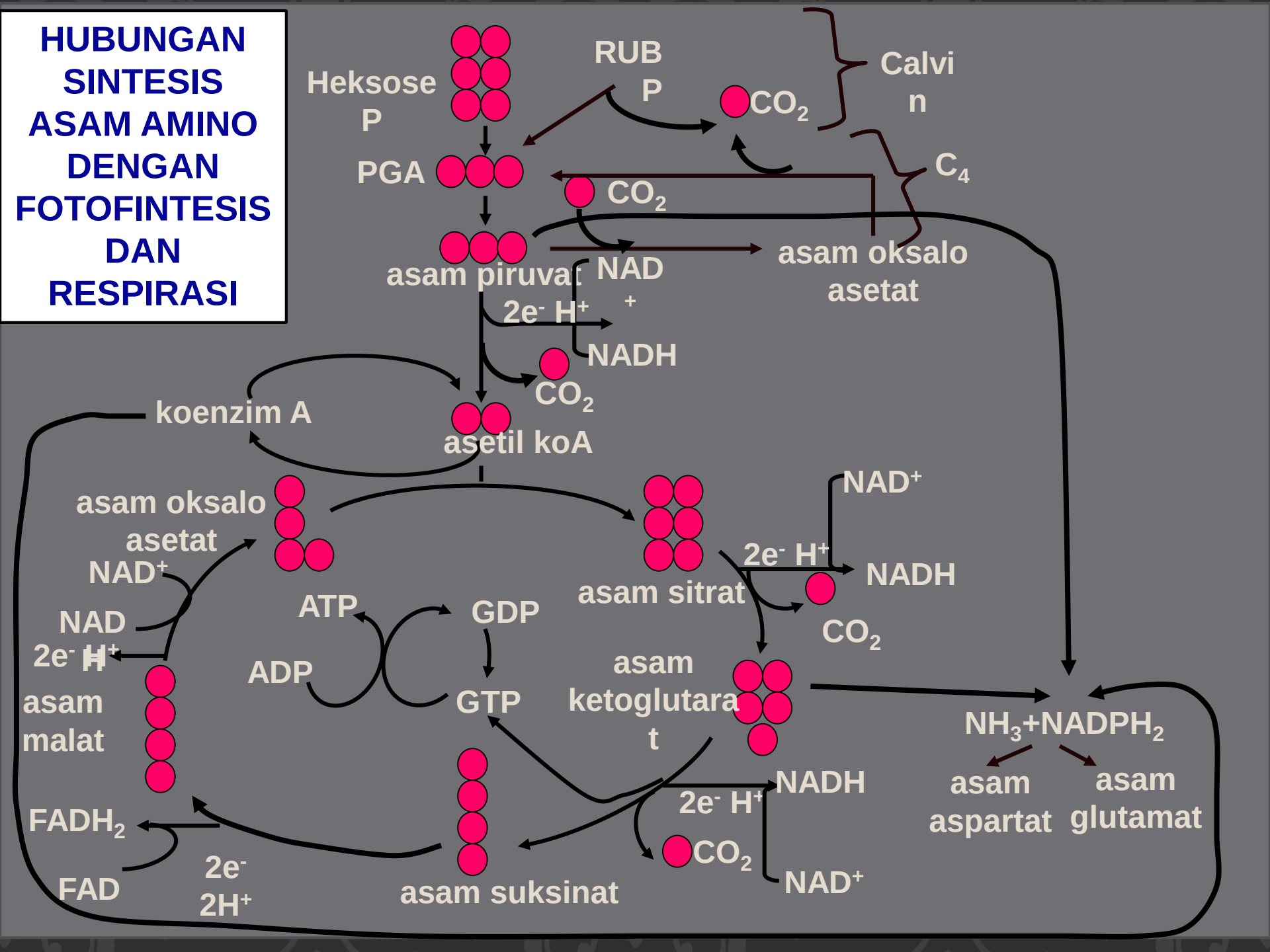

COOH
CH2
HCNH2
COOH
as. aspartat
CH3
C=O
COOH
as. piruvat
COOH
CH2
C=O
COOH
as. oksalo asetat
CH3
CH
NH2
COOH
alanin
COOH
CH2
CH2
HCNH2
COOH
as. glutamat
CH2
C=O
COOH
as. piruvat
COOH
CH2
CH2
C=O
COOH
as. keto glutarat
CH2
HCNH2
COOH
alanin

BENTUK AMIDA

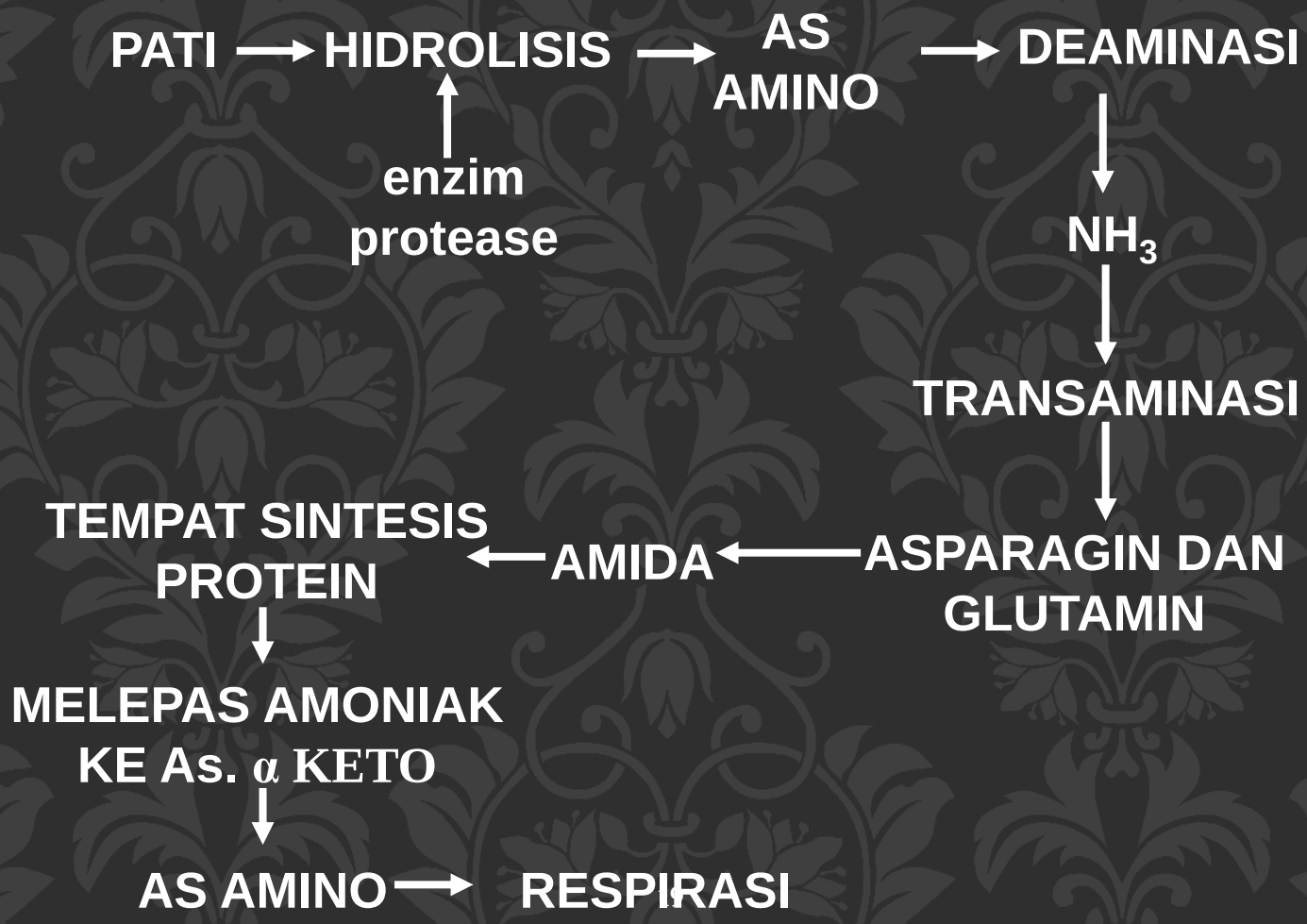


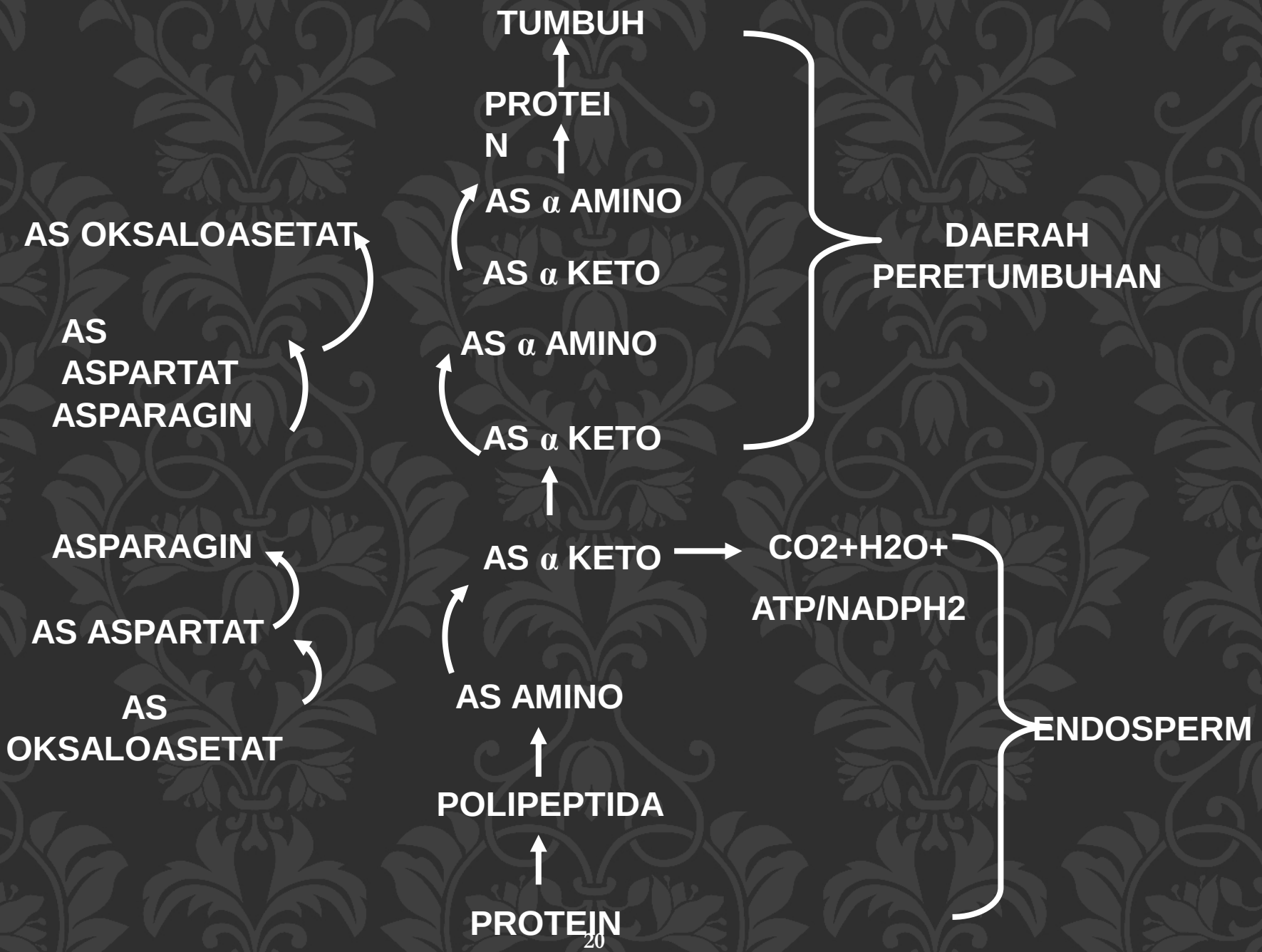


HUBUNGAN SINTESIS ASAM AMINO DENGAN FOTOFINTESIS DAN RESPIRASI



METABOLISME N
PADA PERKECAMBAHAN BIJI

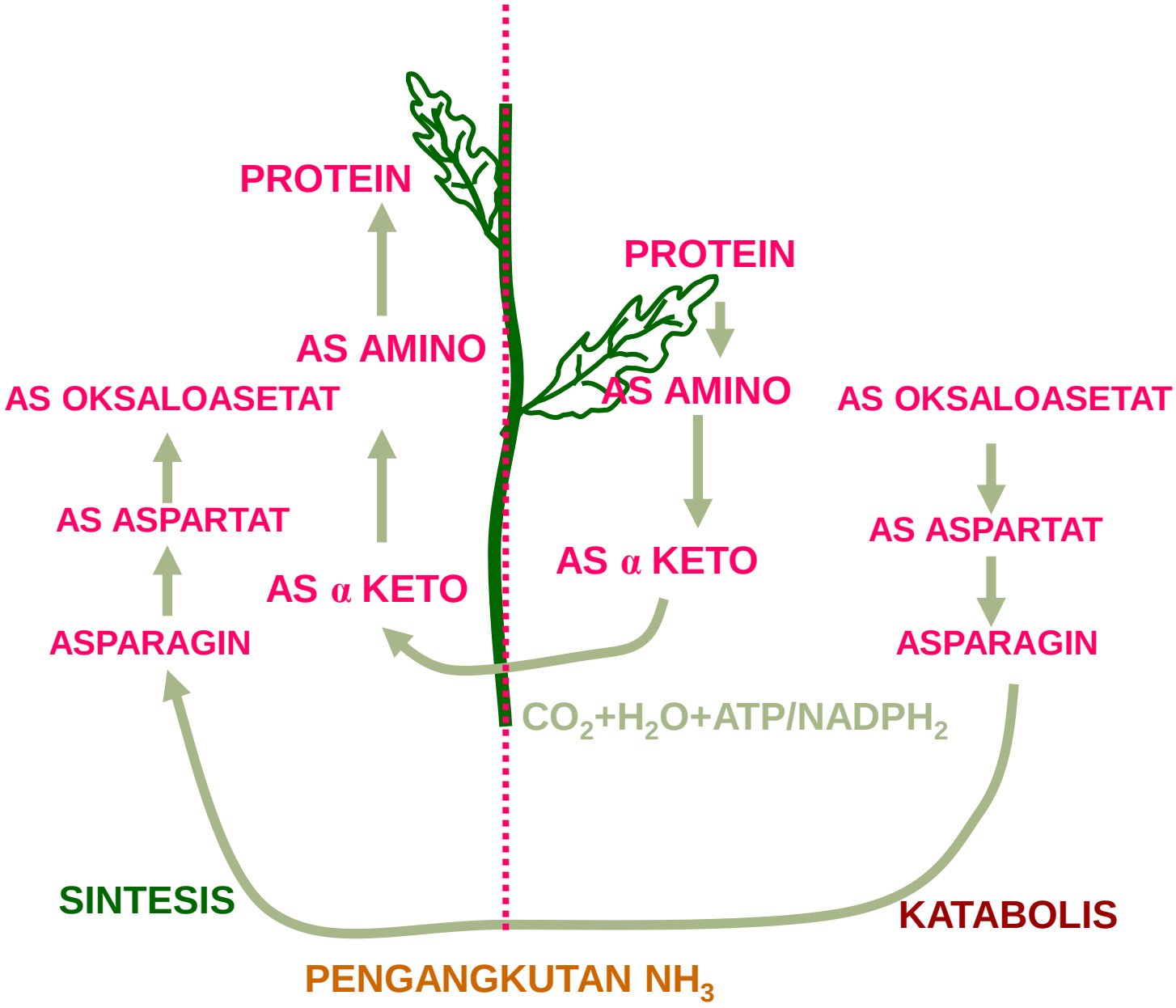



TUMBUH
PROTEIN
AS α AMINO
AS α KETO
AS α AMINO
AS α KETO
DAERAH PERETUMBUHAN
AS OKSALOASETAT
AS ASPARTAT ASPARAGIN
ASPARAGIN
AS ASPARTAT
AS OKSALOASETAT
AS α KETO
CO2+H2O+ ATP/NADPH2
AS AMINO
POLIPEPTIDA
PROTEIN
ENDOSPERM

PEROMBAKAN PROTEIN TERJADI PULA PADA BAGIAN TUMBUHAN DENGAN KONDISI

- DITEMPAT GELAP (ETIOLASI)
- DEFISIENSI KARBOHIDRAT
- DEFISIENSI N (Dari TANAH)

PROTEIN DAUN TUA DIROMBAK, AMONIA DIANGKUT OLEH AMIDA KE DAERAH MERISTEM DIUBAH MENJADI As. AMINO KEMUDIAN DISINTESIS MENJADI PROTEIN UNTUK TUMBUH


PROTEIN
AS AMINO
AS OKSALOASETAT
AS ASPARTAT
ASPARAGIN
AS α KETO
PROTEIN
AS AMINO
AS α KETO
AS OKSALOASETAT
AS ASPARTAT
ASPARAGIN
CO_2+H_2O+ATP/$NADPH_2$
SINTESIS
KATABOLIS
PENGANGKUTAN NH_3

FIKSASI N SECARA BIOLOGI

REAKSI UMUM

$N_2 + 6H^+ + 6e^- + nMg\ ATP \xrightarrow{\text{nitrogenase}} 2NH_3 + nMgATP + nPi$

ORGANISME

- ASIMBIOTIK
  - BAKTERI AEROBIK

    AZOTOBACTERACEAE
    AZOTOBACTER
    AZOSPIRILLUM
    BEIJERINCKIA

  - GANGGANG BIRU HIJAU (CYANOBACTERIA) ANABAENA DAN NOSTOC

❖SIMBIOTIK MEMBENTUK BINTIL

- **PEMBENTUK BINTIL AKAR**

  RHIZOBIUM → LEGUME
  ACTINOMYCETES → ANGIOSPERM BERKAYU
  GANGGANG BIRU HIJAU → GYMNOSPERM

- **PEMBENTUK BINTIL DAUN (FILOSFER)**

  PADA SPESIES BERKAYU DIHUTAN TROPIK

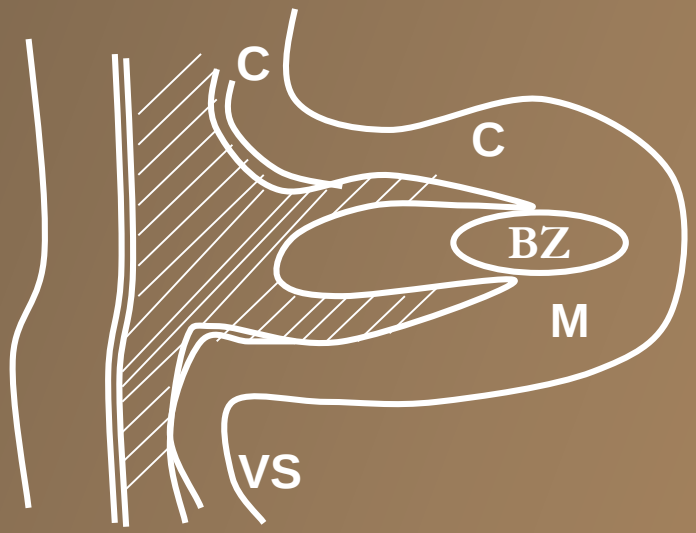
❖SIMBIOTIK TDK MEMBENTUK BINTIL

- **GANGGANG BIRU HIJAU BERASOSIASI DENGAN PAKU-PAKUAN (AZOLLA), LUMUT KERAK**

- **BAKTERI (AZOTOBACTERIACEAE) BERASOSIASI DENGAN RERUMPUTAN**

  Azospirillum brasilense
  Spirillum lipoferum
  Azotobacter paspali

IRISAN MELINTANG BINTIL AKAR



C: KORTEKS

VS: BERKAS PENGANGKUTAN

M: MERISTEM

BZ: ZONA BAKTEROID

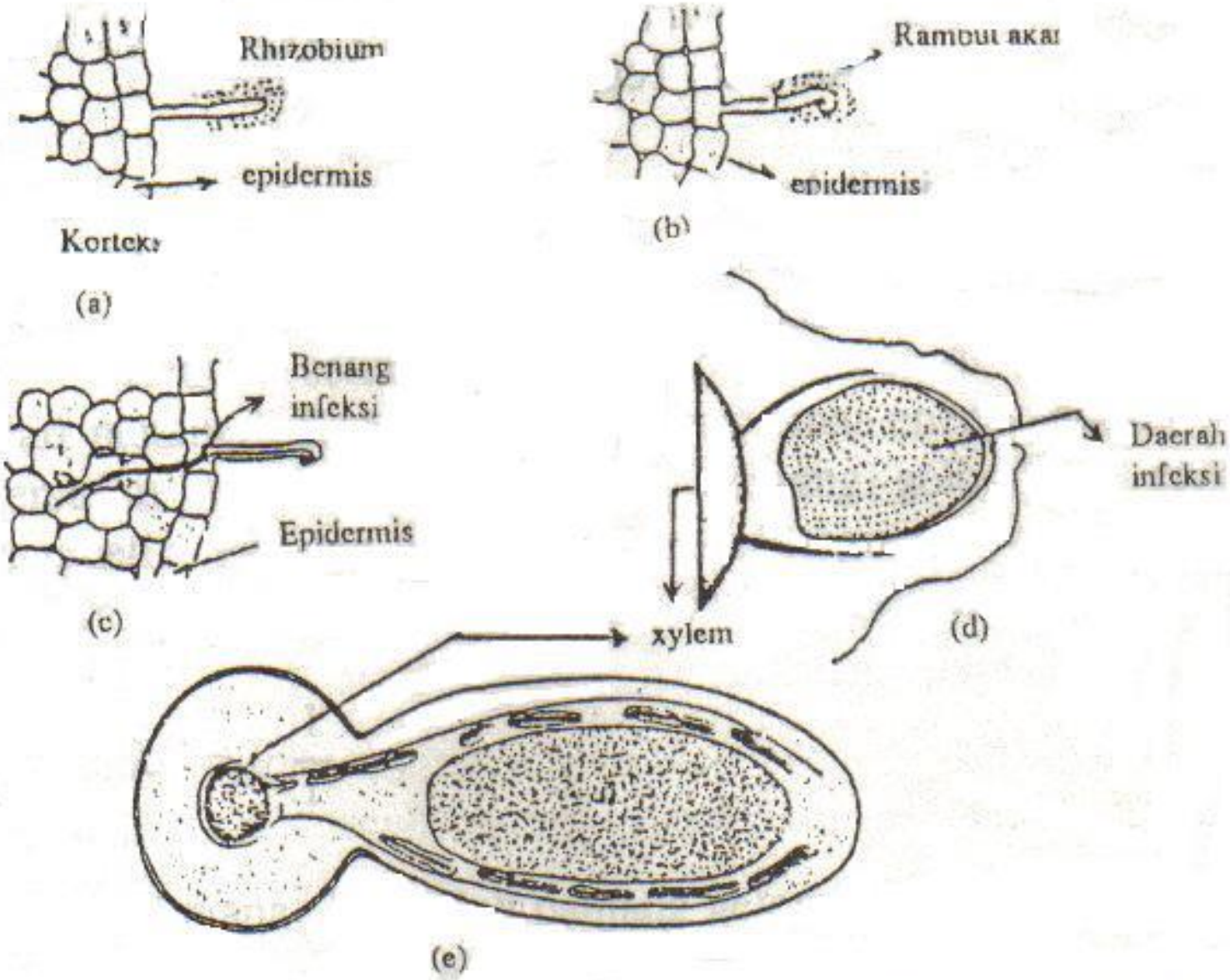
FIKSASI N_2 MEMERLUKAN

Mo UNTUK REDUKSI N_2 ⟶ NH3

Co ⟶ VIT B12 ⟶ LEGHEMOGLOBIN

PIGMEN MERAHMUDA DALAM NODUL BERPERAN DALAM TRANSPOR ELEKTRON (MENGANDUNG Fe)

PROSES PEMBENTUKAN BINTIL AKAR



NODULASI TERGANTUNG

- GENOTIP INANG
- BAKTERI
- LINGKUNGAN

DAYA TAHAN RHIZOBIUM DLM TANAHTERGANTUNG

- KONDISI TANAH (pH)
- KELEMBABAN
- BAHAN ORGANIK
- JARAK WAKTU KEBERADAAN INANG

SERAPAN NITROGEN PADA CEKAMAN DEFISIT AIR

Nitrogen absorption by crops is automatically reduced under dry conditions, even when mineral N is present in the soil colonized by roots

The absorption of N by roots requires the presence of water in the soil, as it is the agent that transports solutes to the soil-root interface

N uptake clearly depends on (i) water flows from the soil to the root system (Keller, 2005), and distribution of N and roots within the soil profile is essential, and (ii) ion diffusion fluxes in the rhizosphere

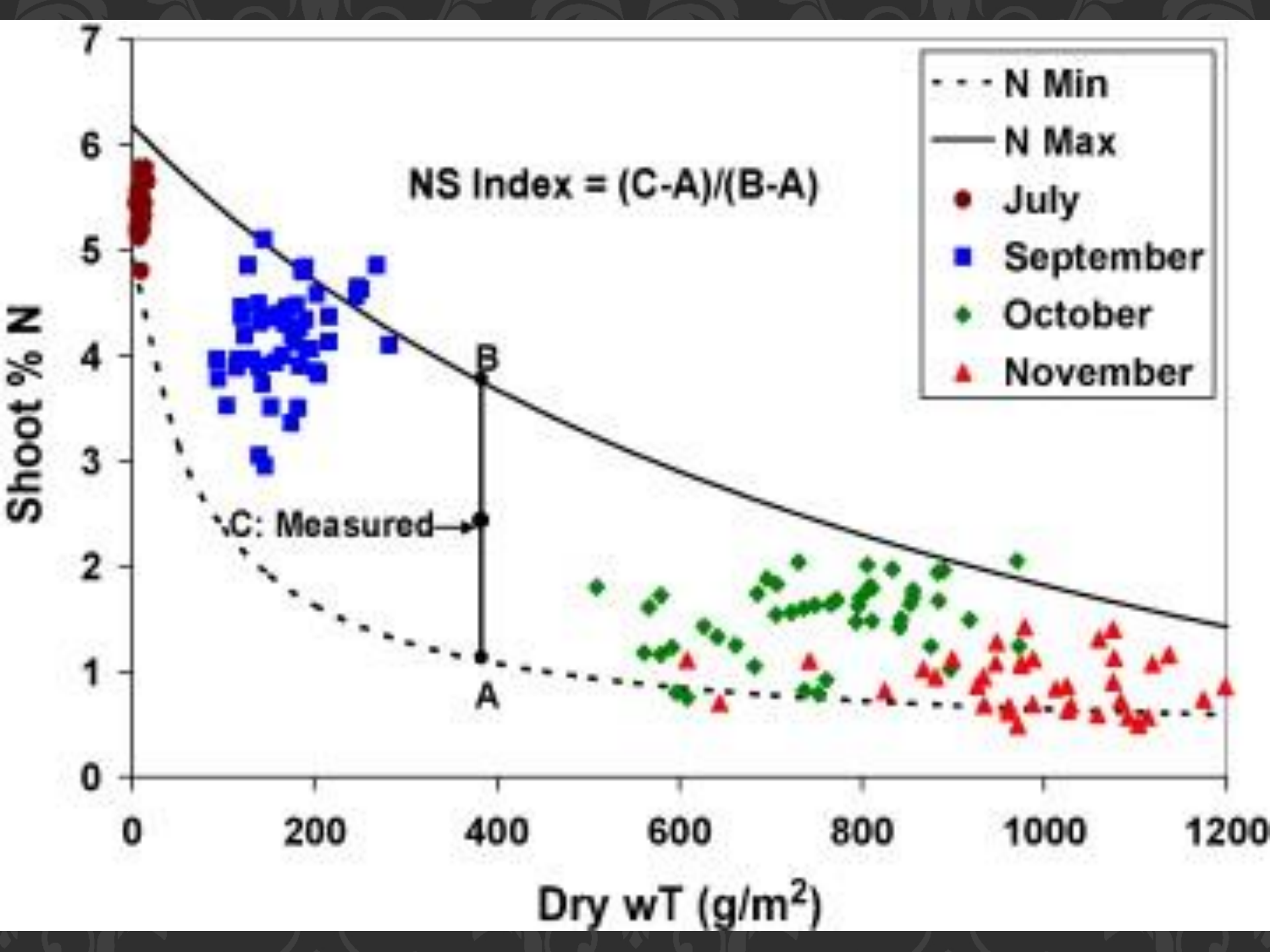
SERAPAN NITROGEN PADA CEKAMAN DEFISIT AIR

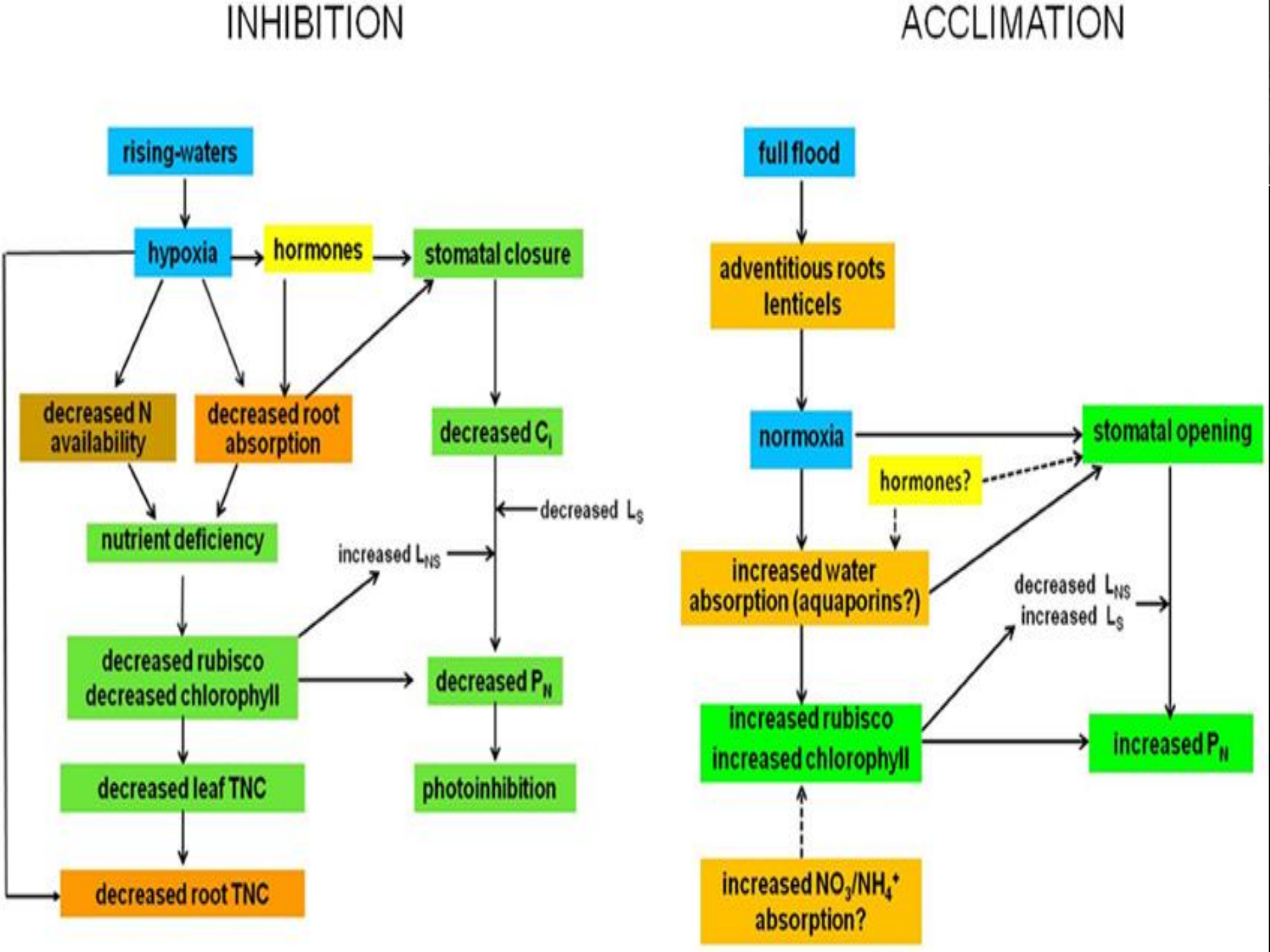
Nitrogen uptake is an active process. Based on an analysis of root respiration, Bloom et al. (1992) showed that the amount of energy required to absorb 1 mol NO^{-}_{3} was equivalent to 1 to 2 adenosine triphosphates (ATP), or 0.16 to 0.32 mol CO_2. As for NH^{+}_{4}, Bloom et al. (1992) estimated that 0.33 mol CO_2 were needed to absorb and assimilate one mol of NH^{+}_{4}

ASIMILASI NITROGEN PADA CEKAMAN DEFISIT AIR

In water deficit situations, plants that reduce nitrate in leaves are more efficient than those where the reduction takes place in roots.

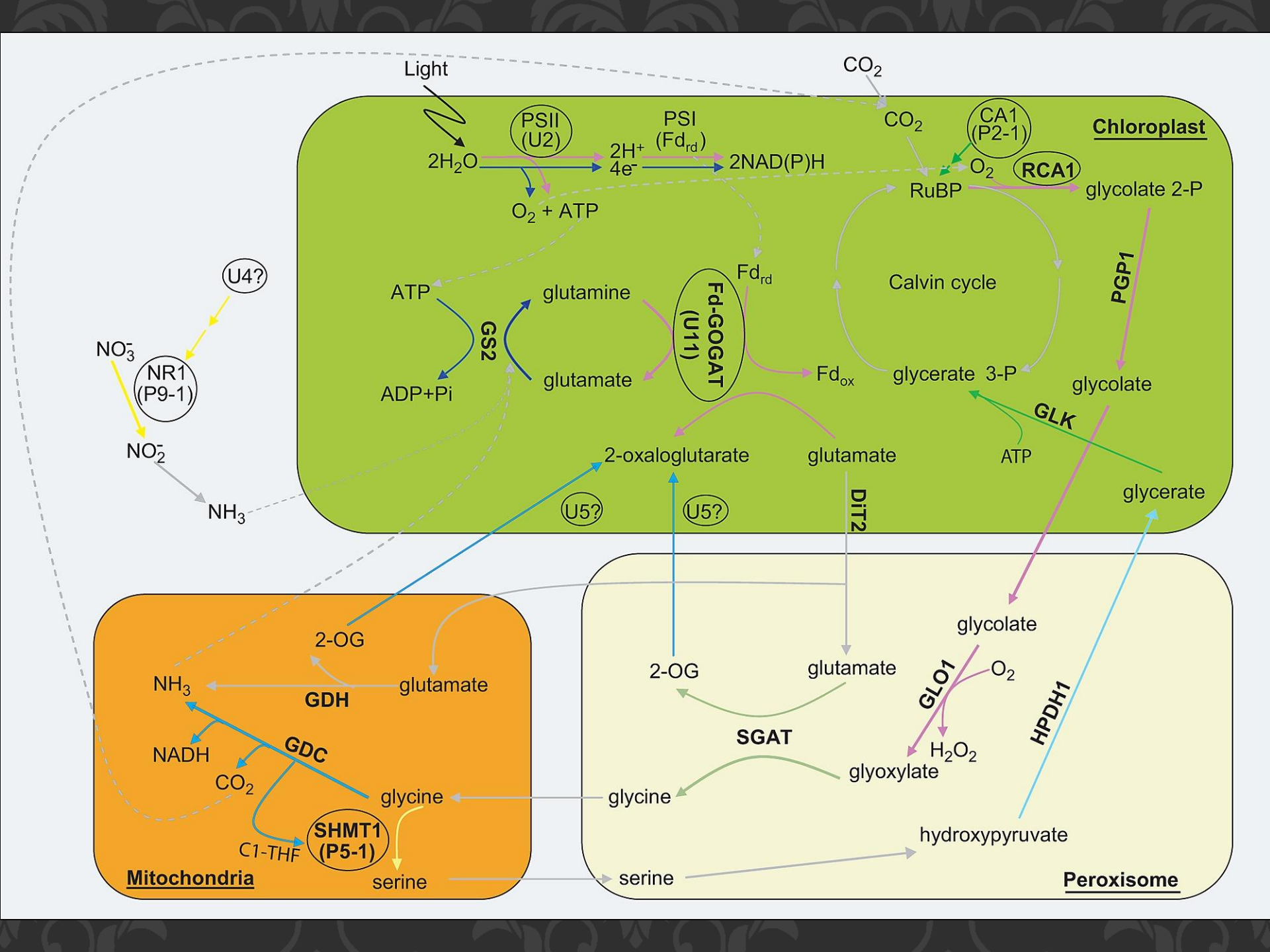
water deficit could have a more marked effect on N assimilation than on the uptake process, s, as nitrate reductase activity diminished sharply.


N Min
N Max
July
September
October
November
NS Index = (C-A)/(B-A)
B
C: Measured
A
Shoot % N
Dry wT (g/m2)
0
1
2
3
4
5
6
7
0
200
400
600
800
1000
1200

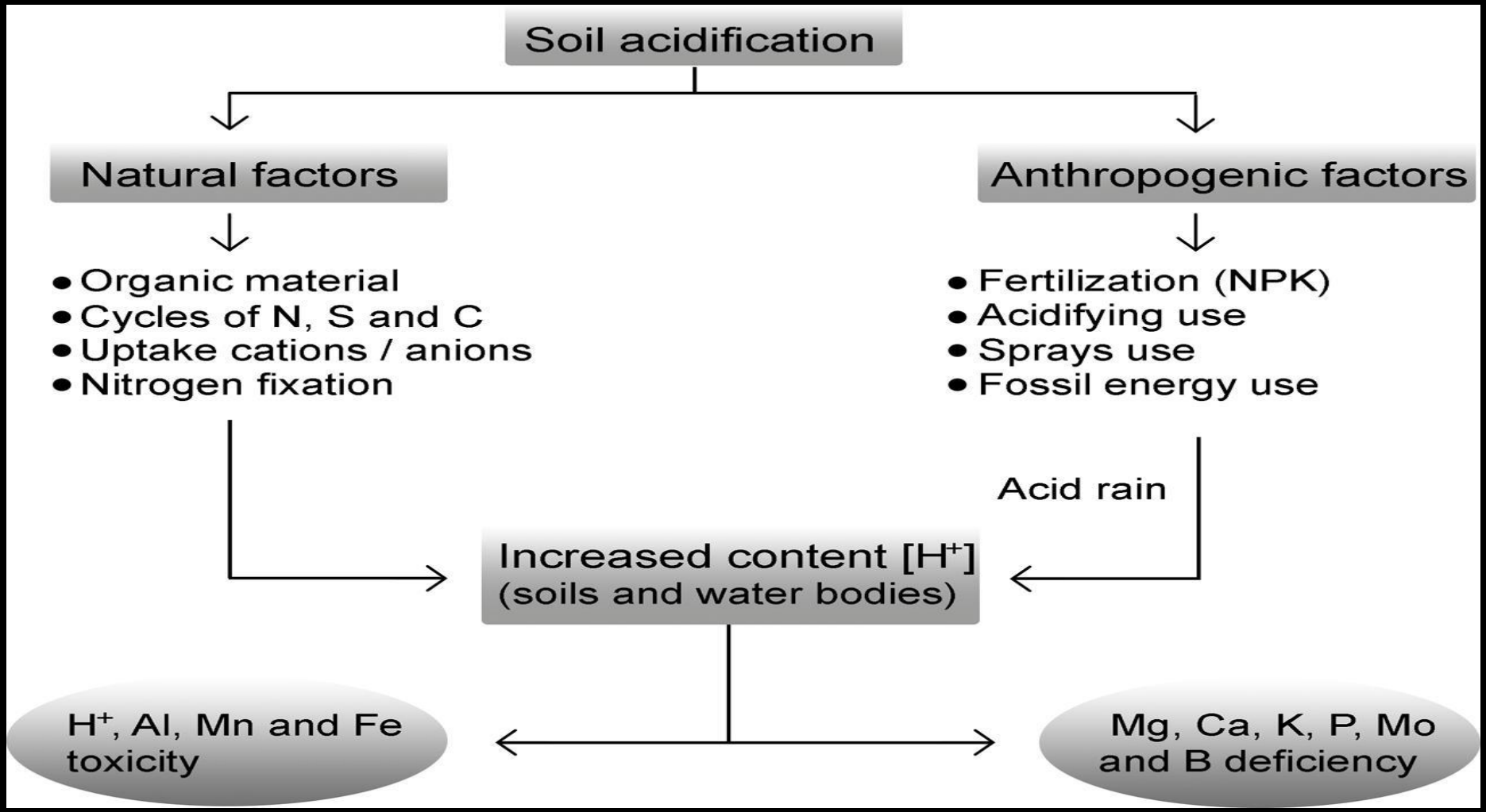

INHIBITION
rising-waters
hypoxia
hormones
stomatal closure
decreased N availability
decreased root absorption
decreased C_i
decreased L_S
nutrient deficiency
increased L_{NS}
decreased rubisco
decreased chlorophyll
decreased P_N
decreased leaf TNC
photoinhibition
decreased root TNC
ACCLIMATION
full flood
adventitious roots
lenticels
normoxia
stomatal opening
hormones?
increased water absorption (aquaporins?)
decreased L_{NS}
increased L_S
increased rubisco
increased chlorophyll
increased P_N
increased NO_3/NH_4^+ absorption?

ASIMILASI NITROGEN PADA CEKAMAN CAHAYA

Peningkatan cahaya menyebabkan menurunnya konsentrasi internal NO_3 dan menurunkan akumulasi NO_2 di akar atau tajuk


Light
CO_2
CO_2
CA1 (P2-1)
Chloroplast
PSII (U2)
PSI (Fd_{rd})
$2H_2O$
$2H^+$ $4e^-$
2NAD(P)H
O_2
RCA1
RuBP
glycolate 2-P
O_2 + ATP
U4?
NO_3^-
NR1 (P9-1)
NO_2^-
NH_3
ATP
GS2
glutamine
glutamate
ADP+Pi
Fd-GOGAT (U11)
Fd_{rd}
Fd_{ox}
Calvin cycle
PGP1
glycerate 3-P
glycolate
GLK
ATP
glycerate
2-oxaloglutarate
glutamate
U5?
U5?
DiT2
2-OG
NH_3
GDH
glutamate
NADH
GDC
CO_2
glycine
C1-THF
SHMT1 (P5-1)
serine
Mitochondria
glycolate
2-OG
glutamate
GLO1
O_2
SGAT
H_2O_2
glyoxylate
HPDH1
glycine
hydroxypyruvate
serine
Peroxisome

PENYERAPAN NITROGEN PADA CEKAMAN KEMASAMAN TANAH

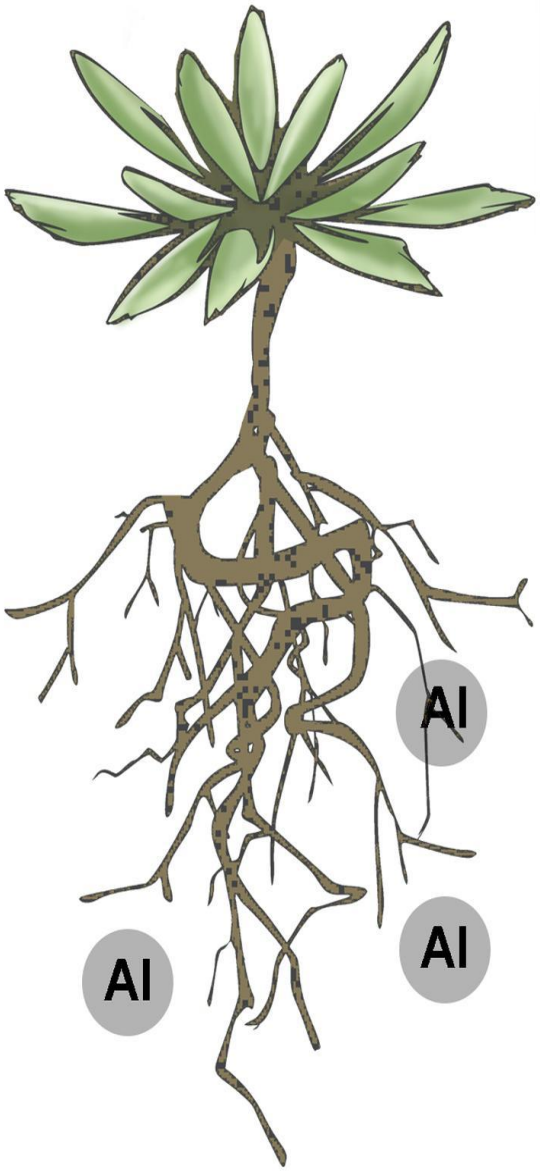


1 Toxic effect

- Inhibition of root growth
- Inhibition uptake of water and nutrients
- Lipid peroxidation
- Modification of the cytoskeleton
- Inhibition of cell division

2 Beneficial effect

- Stimulate plants growth (roots and shoots)
- Promote nutrient uptake
- Increases defense pathogens
- Alleviation of abiotic stress
- Increased metabolism and antioxidant activity
- Modulate colors flowers



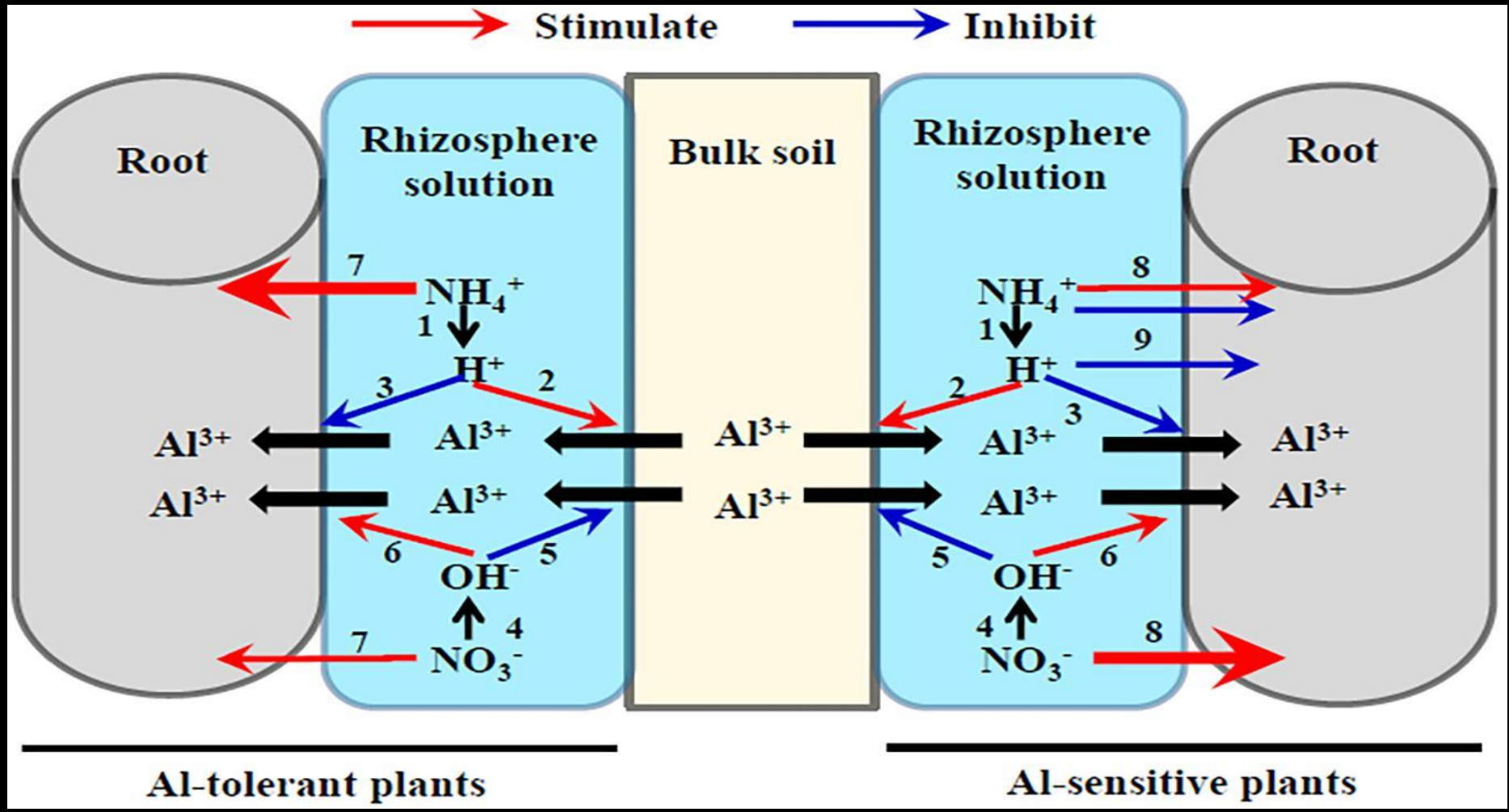
Exclusion tolerance 3

- Changes in pH of the rhizosphere
- Plasma membrane properties and cell wall composition
- Excretion chelating molecules and secretion of mucilage
- Alleviation toxicity aluminum with elements, auxins, and others
- Cap type structures in the root apex

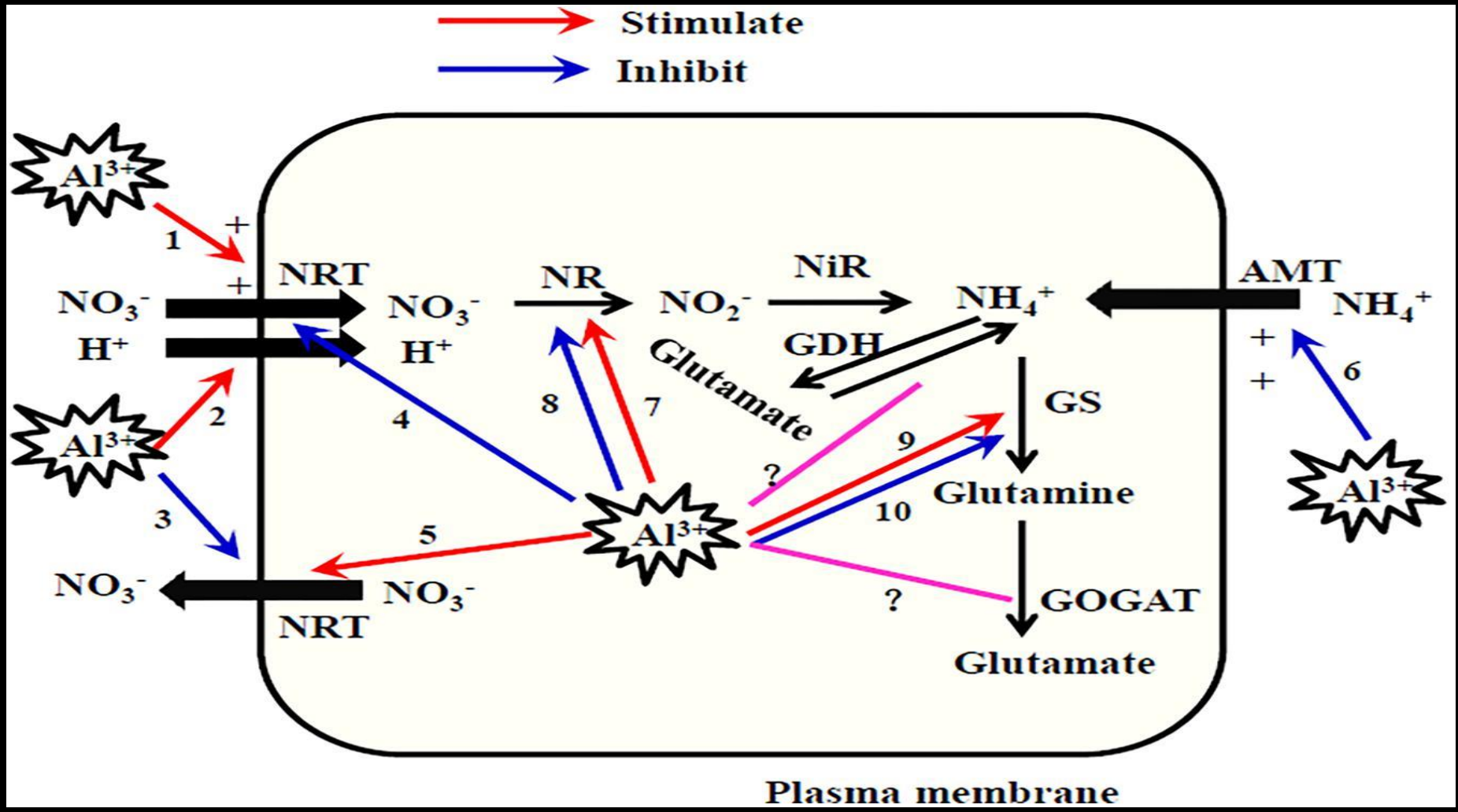
Internal tolerance 4

- Chelation Al in the cytosol (organic acids, proteins and others organic ligands)
- Al transporters
- Vacuolar compartmentalization and vesicular trafficking
- Modification plant metabolism and DNA checkpoints
- Alleviation toxicity aluminum

PENYERAPAN NITROGEN PADA CEKAMAN KEMASAMAN TANAH



ASIMILASI NITROGEN PADA CEKAMAN ALUMINIUM



In *Q. serrata*, stimulation of root growth was associated with the activation of the nitrate reductase and the increase in NO_3^- uptake (Tomioka et al., 2007, 2012).

SOAL UJIAN

- Jelaskan pengaruh cekaman salinitas terhadap fiksasi N2 udara oleh bakteri
- Jelaskan mekanisme adaptasi rhizobia sebagai tanggapan terhadap cekaman salinitas