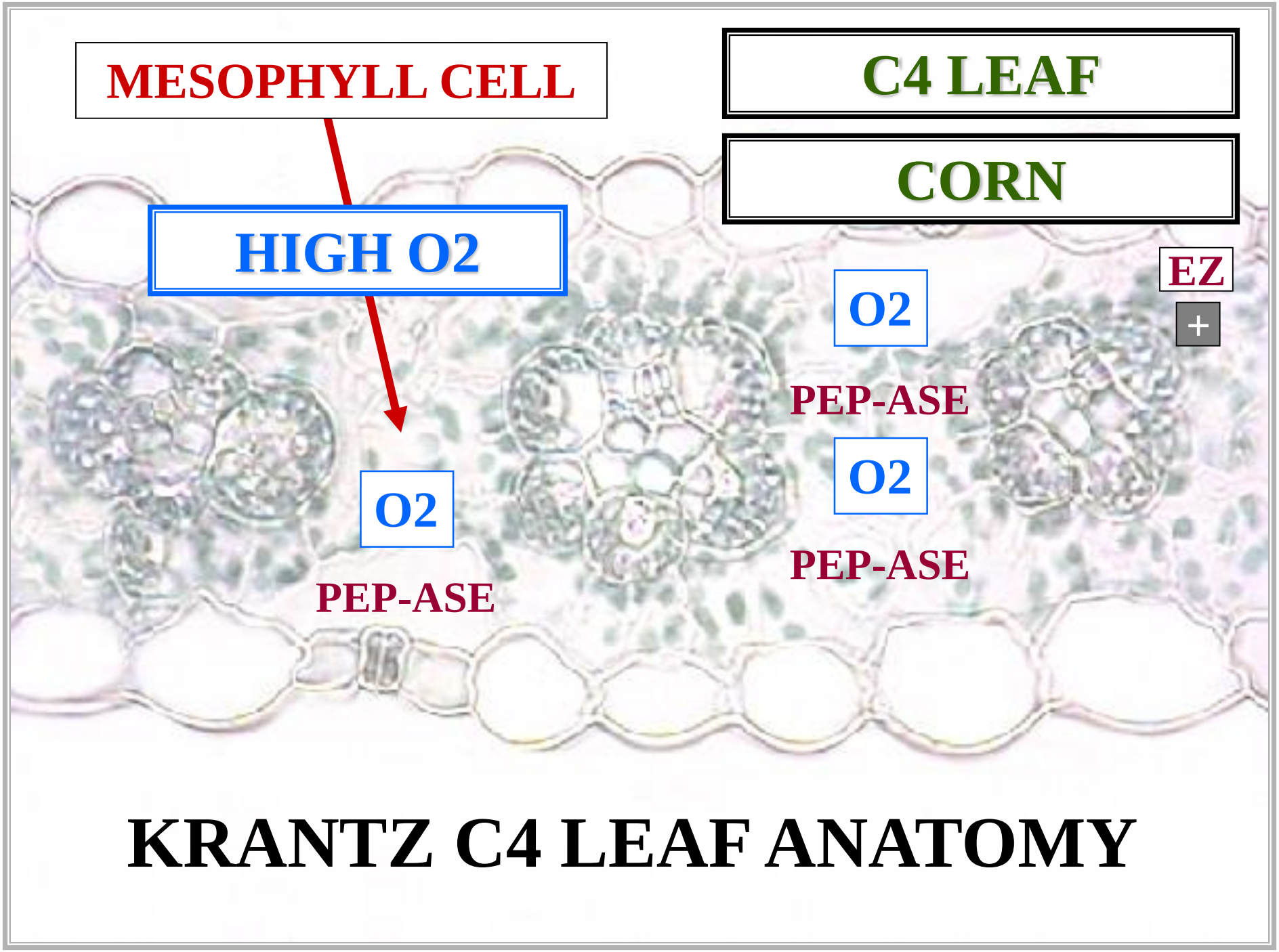


KRANTZ C4 LEAF ANATOMY

C4

O2
HIGH CONCENTRATION
CHLOROPLAST STROMA

↓

CO2 + PHOSPHOENOLPYRUVATE / (PEP)

PHOSPHOENOLPYRUVATE
ENZYME
(PEP-ASE)

↓

OXALOACETATE

OX

N

PHOSPHOENOLPYRUVATE ENZYME (PEP-ASE)

C4

O2
HIGH CONCENTRATION
CHLOROPLAST STROMA

↓

CO2 + PHOSPHOENOLPYRUVATE / (PEP)

PHOSPHOENOLPYRUVATE
ENZYME
(PEP-ASE)

↓

OXALOACETATE

CR
A

PEP-ASE

NEVER ACTS AS OXYGENASE

C4

CO2
HIGH CONCENTRATION
CHLOROPLAST STROMA

↓

CO2 + PHOSPHOENOLPYRUVATE / (PEP)

PHOSPHOENOLPYRUVATE
CARBOXYLASE
(PEP-CARBOXYLASE)

↓

OXALOACETATE

>

PEP-ASE

ALWAYS ACTS AS CARBOXYLASE

HATCH & SLACK CYCLE

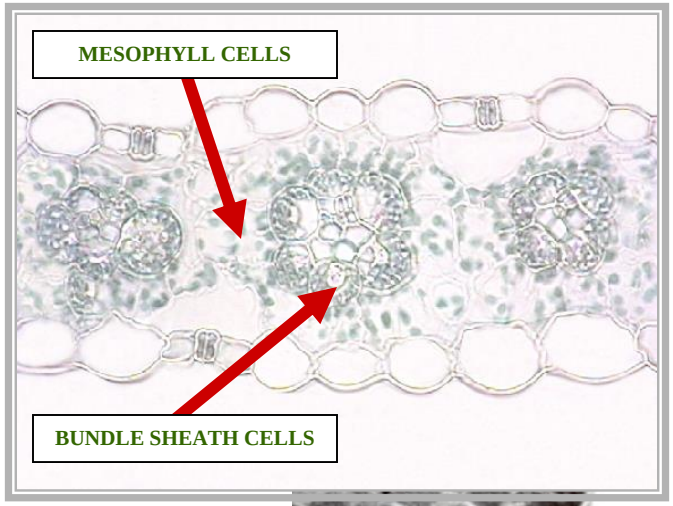
CORN

CO2

MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

ATMOSPHERE



C4 LEAF

= CHEMICAL ENERGY

BUNDLE-SHEATH CELL CHLOROPLAST

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4

P

HATCH & SLACK CYCLE

CORN

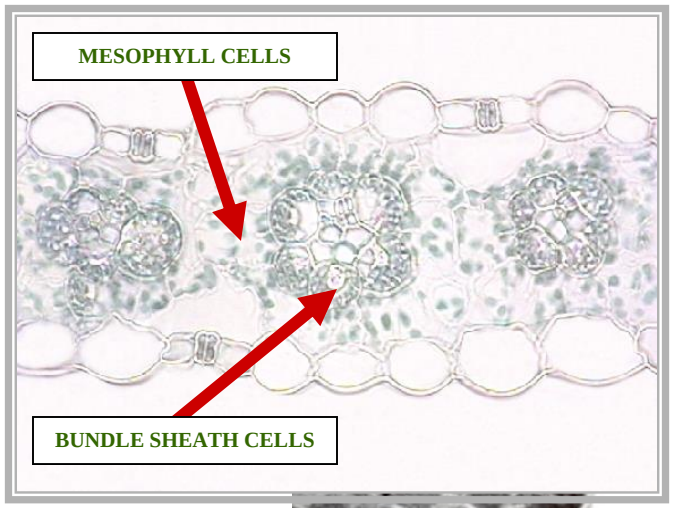
PEP

CO_2

MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

ATMOSPHERE



C4 LEAF

= CHEMICAL ENERGY

BUNDLE-SHEATH CELL CHLOROPLAST

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4

EZ

HATCH & SLACK CYCLE

CORN

PEP-ASE

PEP

CO2

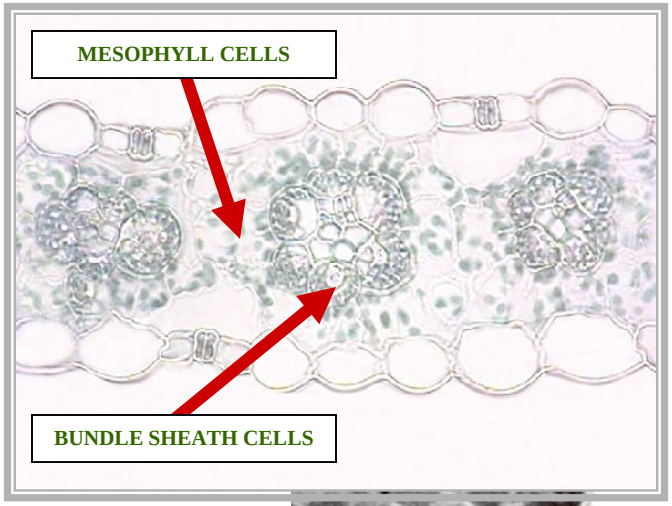
MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

ATMOSPHERE

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4



C4 LEAF

= CHEMICAL ENERGY

BUNDLE-SHEATH CELL CHLOROPLAST

HATCH & SLACK CYCLE

CORN

PEP-ASE

PEP

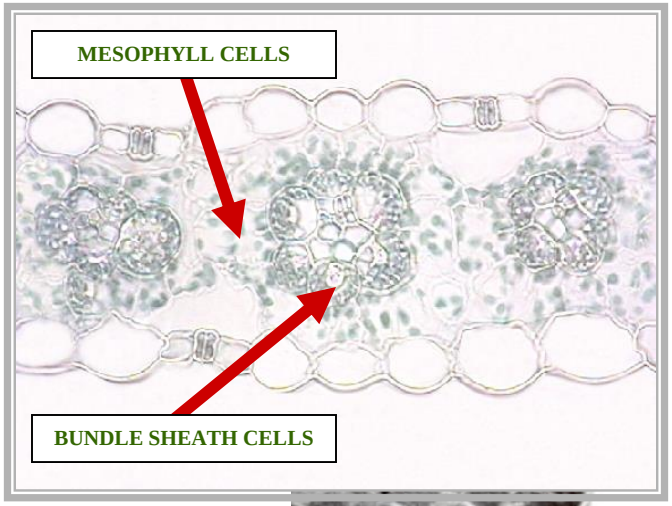
OXALOACETATE

CO2

MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

ATMOSPHERE



C4 LEAF

= CHEMICAL ENERGY

BUNDLE-SHEATH CELL CHLOROPLAST

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4

HATCH & SLACK CYCLE

CORN

PEP-ASE

PEP

OXALOACETATE

CO2

OXALOACETATE

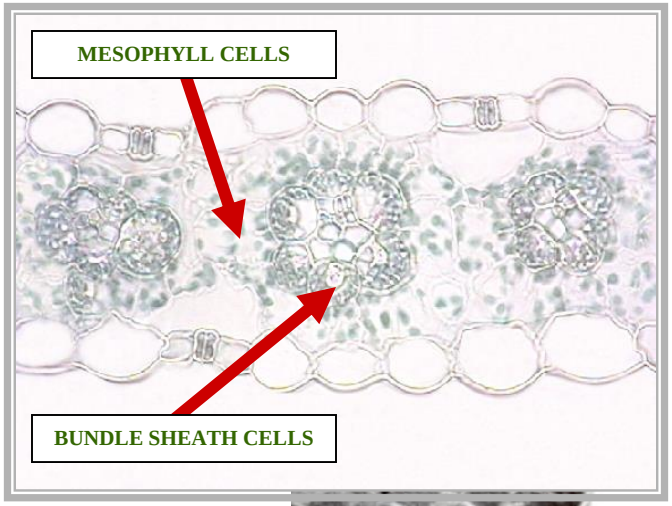
MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

ATMOSPHERE

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4



C4 LEAF

= CHEMICAL ENERGY

BUNDLE-SHEATH CELL CHLOROPLAST

HATCH & SLACK CYCLE

CORN

PEP-ASE

PEP

OXALOACETATE

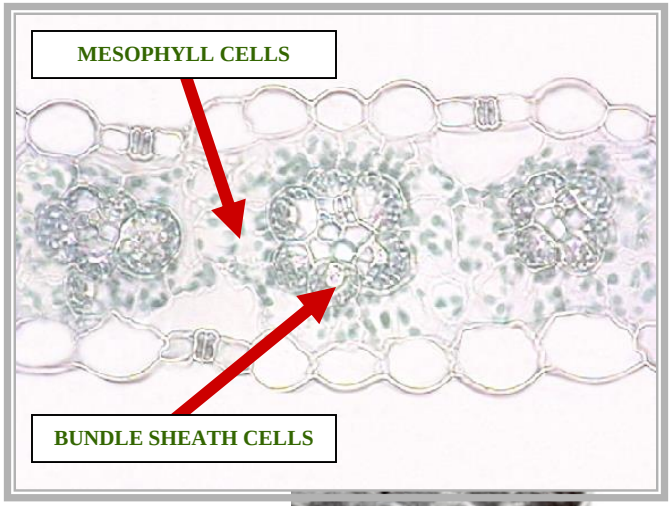
CO2

MALATE

MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

ATMOSPHERE



C4 LEAF

= CHEMICAL ENERGY

BUNDLE-SHEATH CELL CHLOROPLAST

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4

HATCH & SLACK CYCLE

CORN

PEP-ASE

PEP

OXALOACETATE

CO2

MALATE

MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

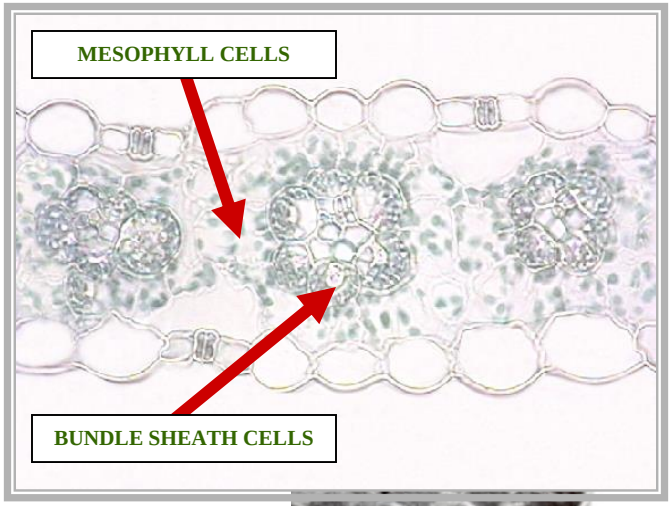
MALATE

BUNDLE-SHEATH CELL CHLOROPLAST

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4

ATMOSPHERE



C4 LEAF

= CHEMICAL ENERGY

HIGH MALATE CONTENT

MALATE MALATE

MALATE MALATE

MALATE MALATE

MALATE MALATE

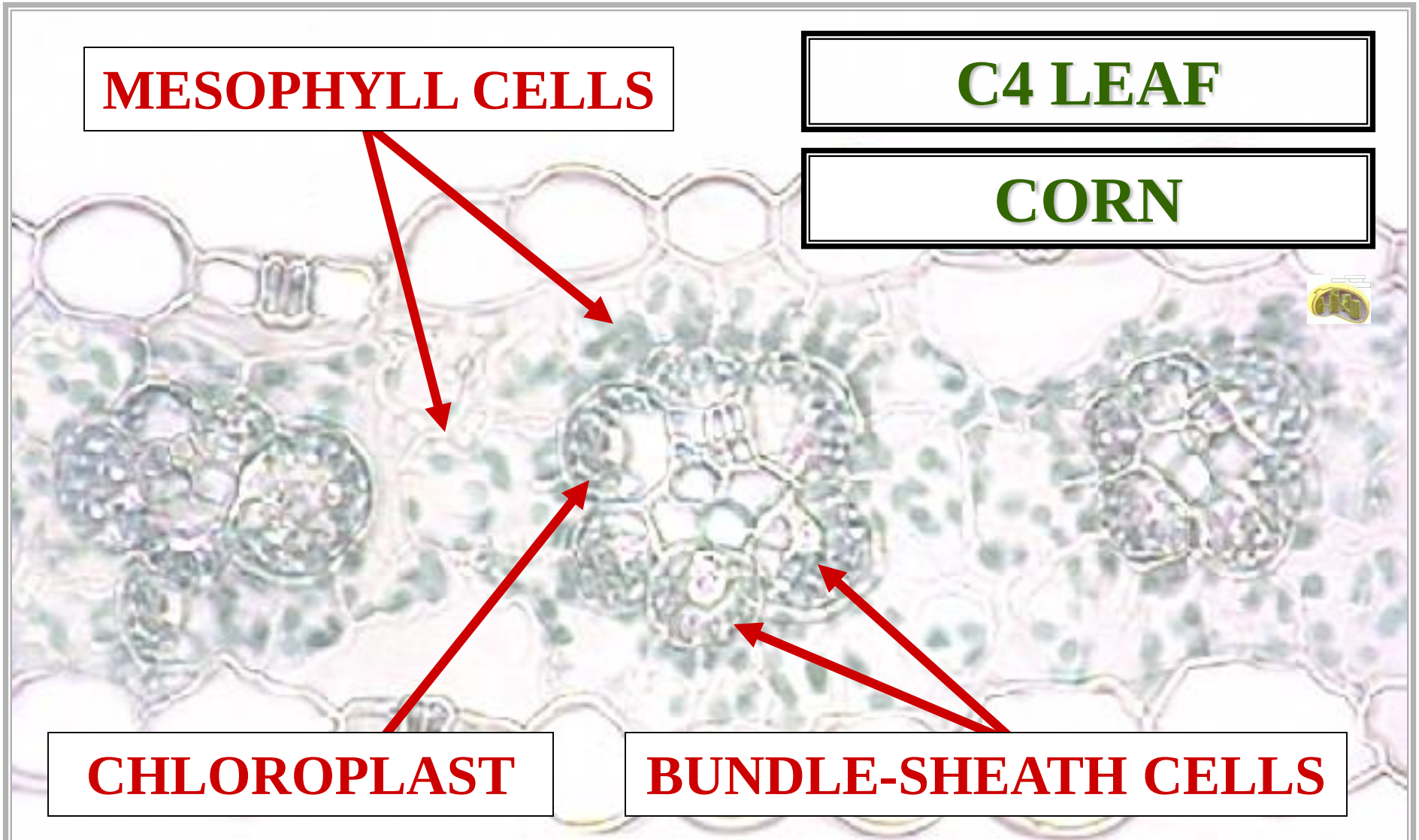
MALATE MALATE

MALATE MALATE

CHLOROPLAST STROMA

BUNDLE-SHEATH CELL

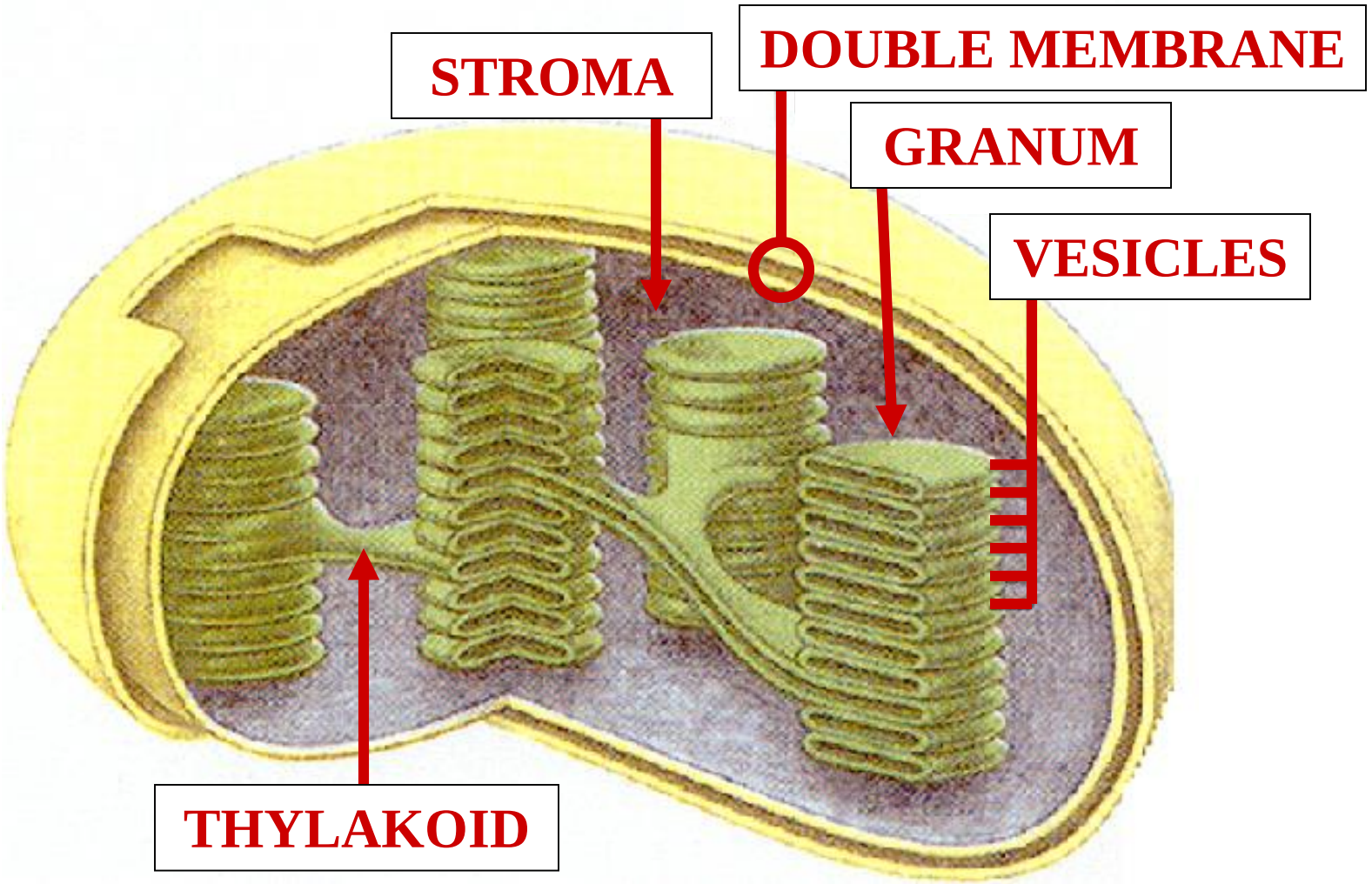
C4
BUNDLE-SHEATH
CELL
CHLOROPLAST



KRANTZ C4 LEAF ANATOMY

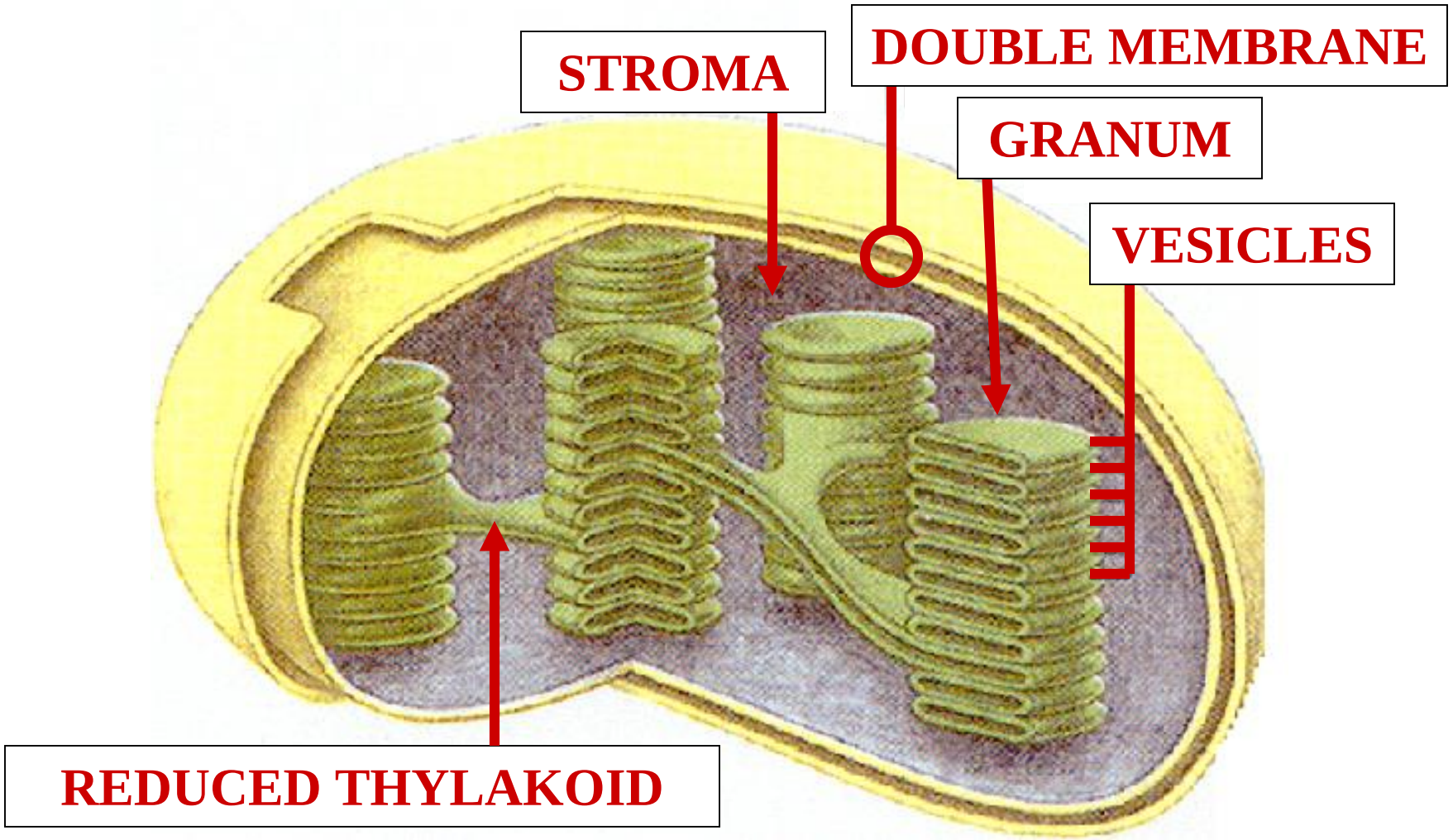
C4 BUNDLE SHEATH CHLOROPLAST ULTRASTRUCTURE

R



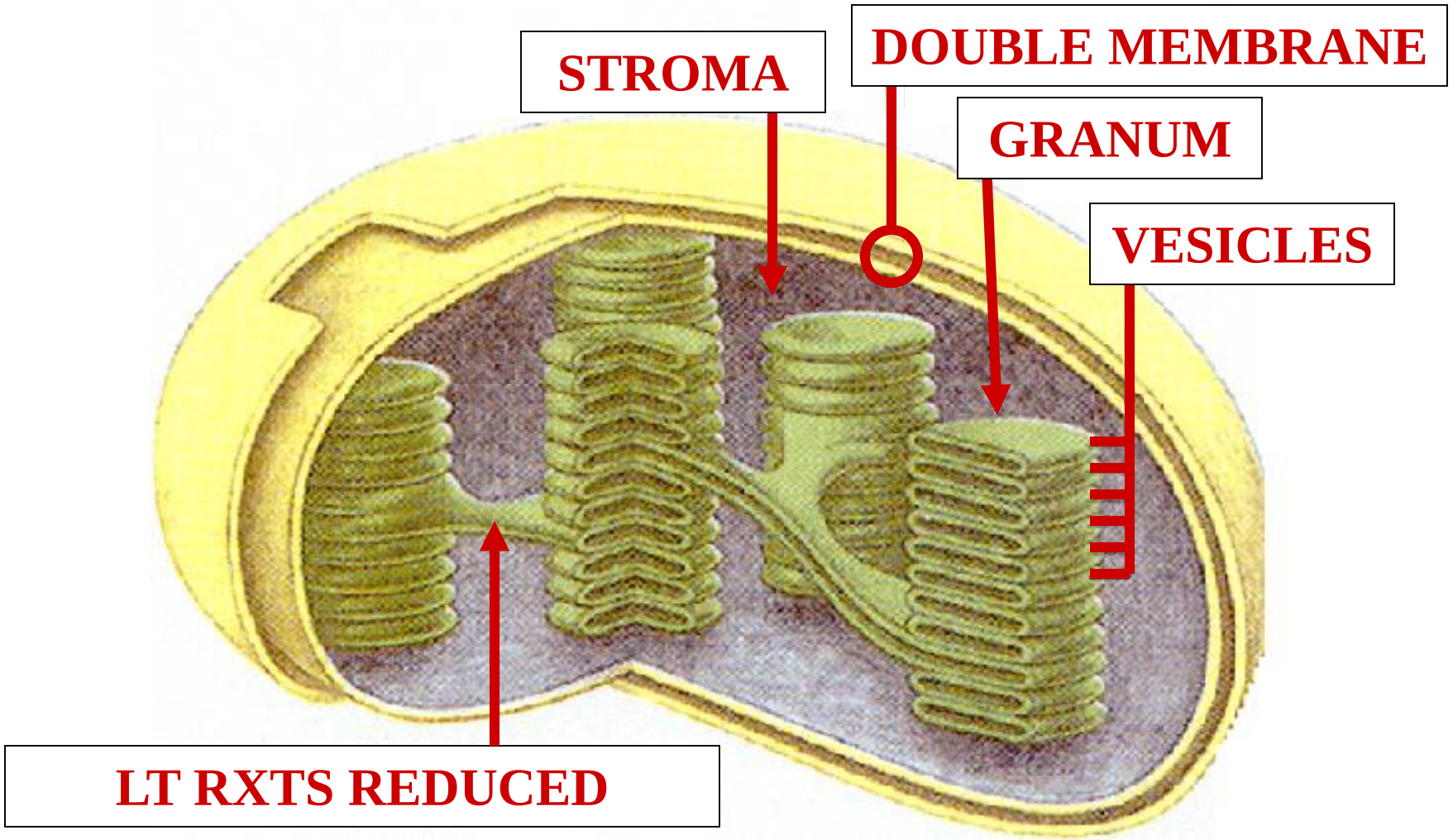
C4 BUNDLE SHEATH CHLOROPLAST ULTRASTRUCTURE

LT



C4 BUNDLE SHEATH CHLOROPLAST ULTRASTRUCTURE

O



PHOTOSYNTHESIS

WATER

O

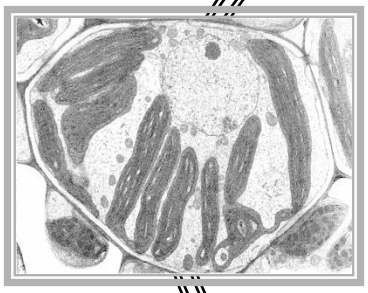
LIGHT EGY

E-

PHOTOLYSIS

LT RXT

THYLAKOID
GRANUM



CHLOROPLAST

OXYGEN

LOW O2 CONTENT

O2 O2

MALATE MALATE

MALATE MALATE

MALATE MALATE

MALATE MALATE

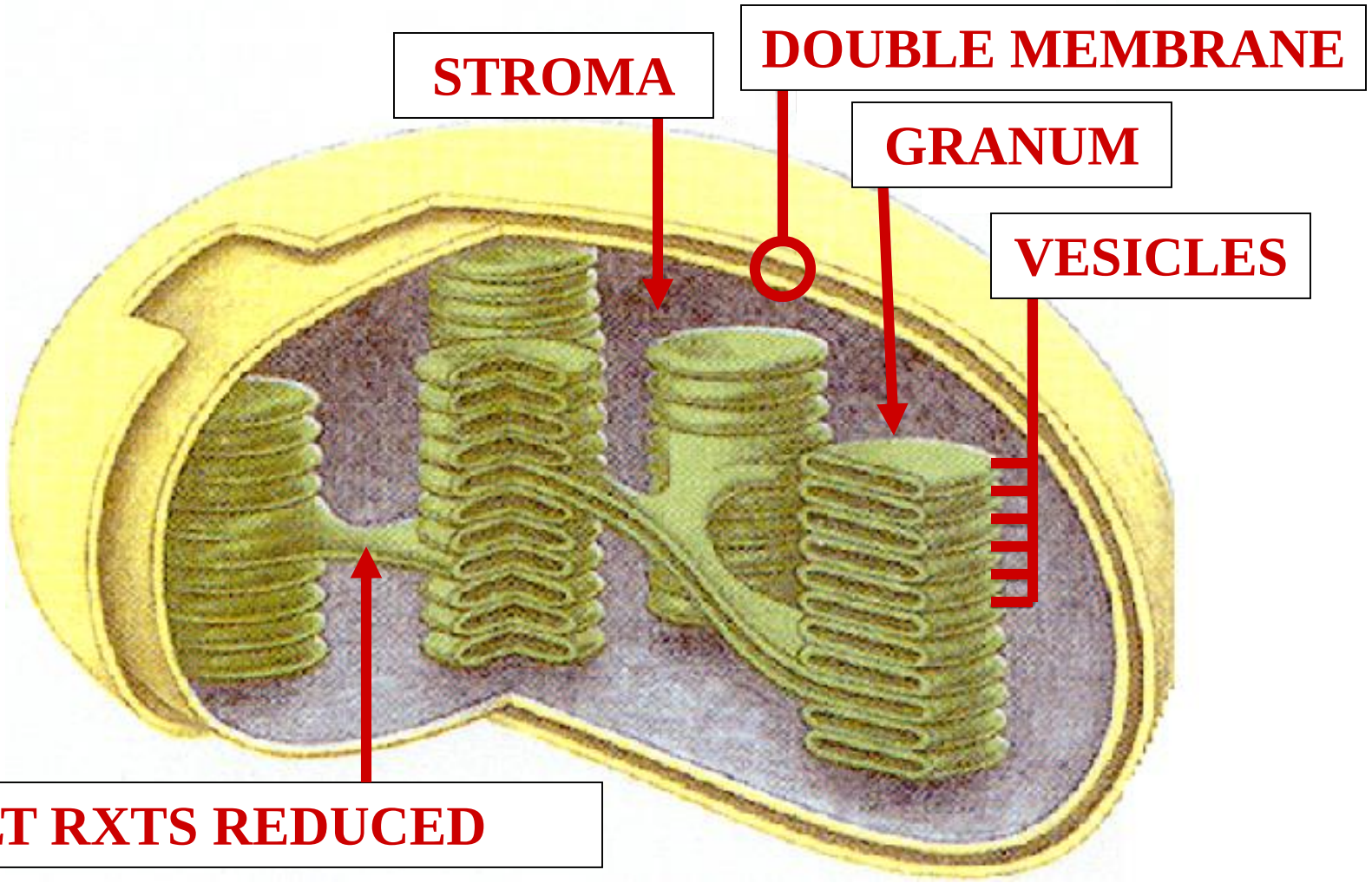
MALATE MALATE

CHLOROPLAST STROMA

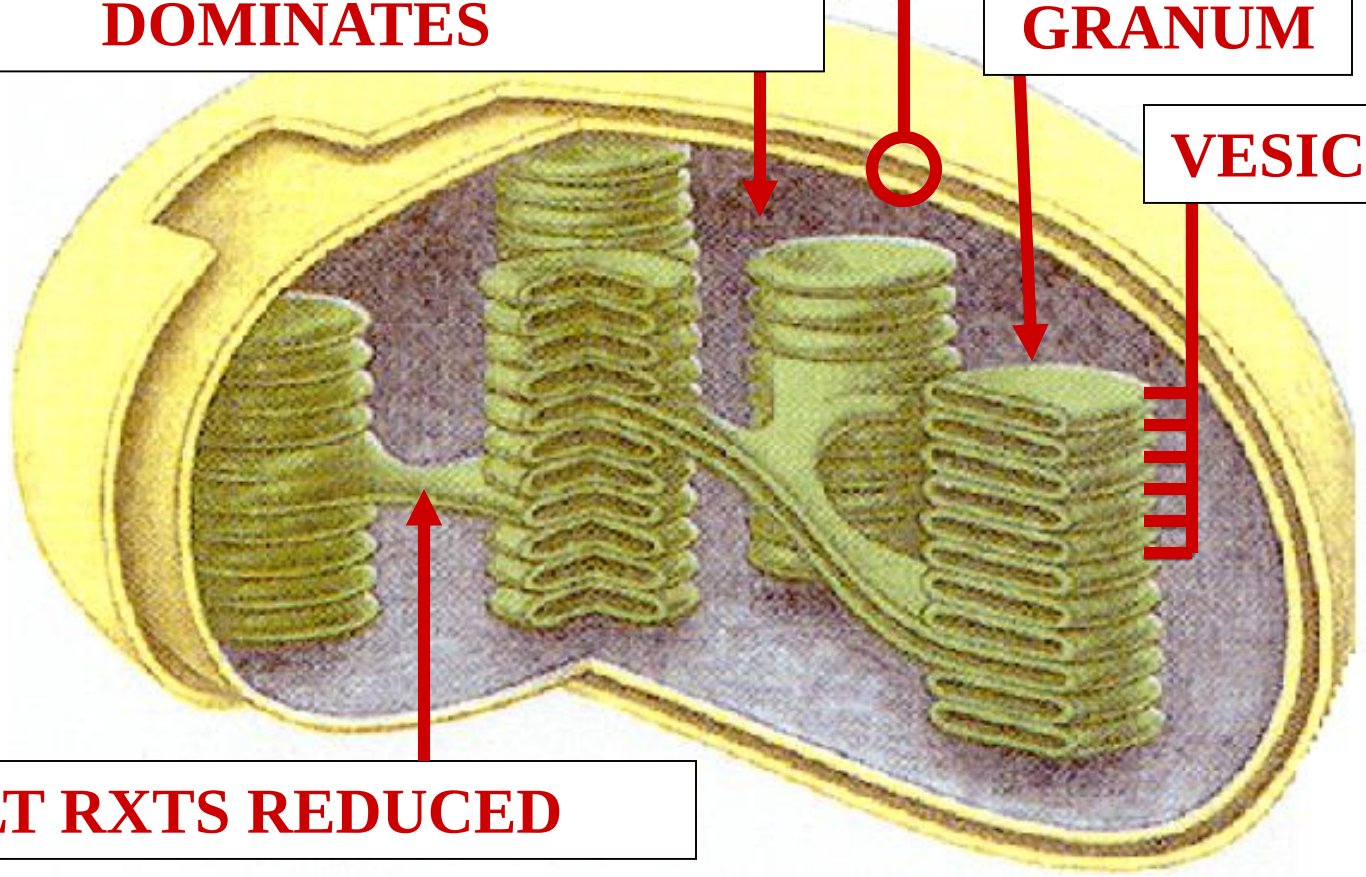
BUNDLE-SHEATH CELL

C4 BUNDLE SHEATH CHLOROPLAST ULTRASTRUCTURE

DK



C4 BUNDLE SHEATH CHLOROPLAST ULTRASTRUCTURE



C3 CALVIN CYCLE DOMINATES

O2

O2

MALATE

MALATE

MALATE

MALATE

MALATE

MALATE

MALATE

MALATE

MALATE

MALATE

CHLOROPLAST STROMA

BUNDLE-SHEATH CELL

¿

EZ

+

¿

EZ

+

C3 CALVIN CYCLE DOMINATES

O2 O2

MALATE PEP-ASE MALATE

MALATE PEP-ASE MALATE

MALATE PEP-ASE MALATE

MALATE PEP-ASE MALATE

MALATE PEP-ASE MALATE

CHLOROPLAST STROMA

BUNDLE-SHEATH CELL

C3 CALVIN CYCLE DOMINATES

O2 O2

MALATE RUBP-ASE MALATE

MALATE RUBP-ASE MALATE

MALATE RUBP-ASE MALATE

MALATE RUBP-ASE MALATE

MALATE RUBP-ASE MALATE

CHLOROPLAST STROMA

M

BUNDLE-SHEATH CELL

HATCH & SLACK CYCLE

CORN

PEP-ASE

PEP

OXALOACETATE

CO2

MALATE

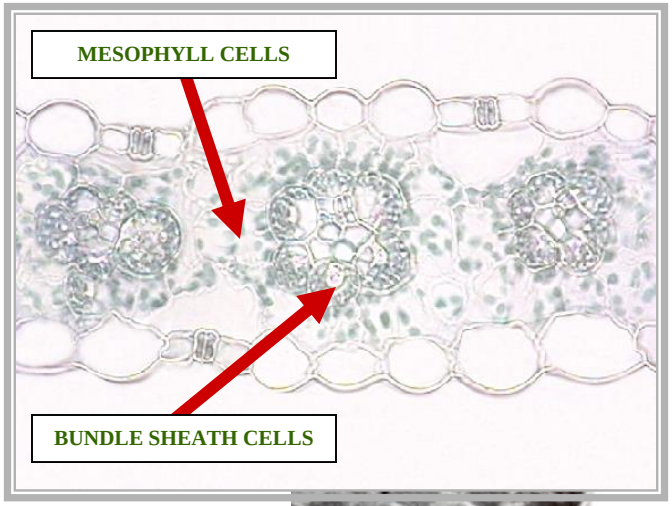
MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

MALATE

ALL RXTS REQUIRE A SPECIFIC ENZYME

ATMOSPHERE



C4

C4 LEAF

= CHEMICAL ENERGY

BUNDLE-SHEATH CELL CHLOROPLAST

D

HATCH & SLACK CYCLE

CORN

PEP-ASE

PEP

OXALOACETATE

CO2

MALATE

MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

MALATE

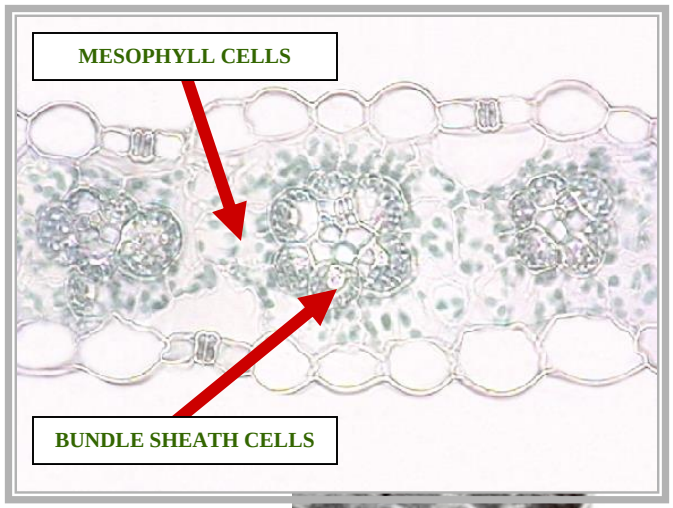
DECARBOXYLATED

BUNDLE-SHEATH CELL CHLOROPLAST

ATMOSPHERE

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4



C4 LEAF

= CHEMICAL ENERGY

C

HATCH & SLACK CYCLE

CORN

PEP-ASE

PEP

OXALOACETATE

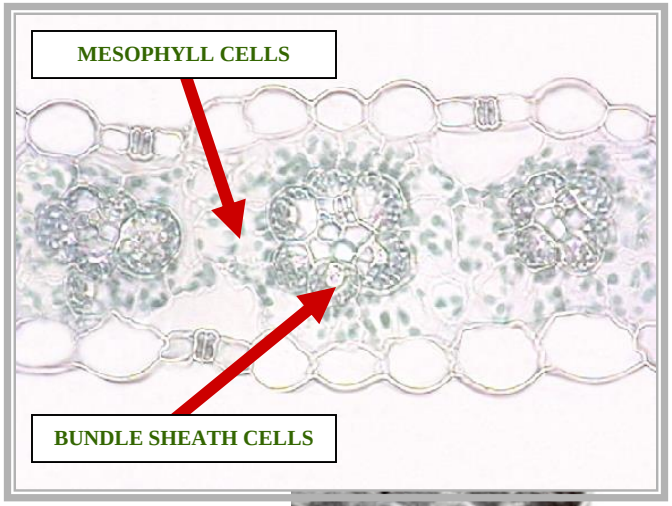
CO2

MALATE

MESOPHYLL CELL CYTOSOL

MESOPHYLL CELL CHLOROPLAST

ATMOSPHERE



C4 LEAF

CO2

MALATE

DECARBOXYLATED

= CHEMICAL ENERGY

BUNDLE-SHEATH CELL CHLOROPLAST

ALL RXTS REQUIRE A SPECIFIC ENZYME

C4

D

C3 CALVIN CYCLE

O2 O2

MALATE RUBP-ASE MALATE

CO2 CO2

MALATE RUBP-ASE MALATE

CO2 CO2

MALATE RUBP-ASE MALATE

CO2 CO2

MALATE RUBP-ASE MALATE

CO2 CO2

MALATE RUBP-ASE MALATE

CHLOROPLAST STROMA

BUNDLE-SHEATH CELL

C

C3 CALVIN CYCLE

O2 O2

MALATE RUBP-ASE MALATE
DECARBOXYLATED DECARBOXYLATED

MALATE RUBP-ASE MALATE
DECARBOXYLATED DECARBOXYLATED

MALATE RUBP-ASE MALATE
DECARBOXYLATED DECARBOXYLATED

MALATE RUBP-ASE MALATE
DECARBOXYLATED DECARBOXYLATED

MALATE RUBP-ASE MALATE

CHLOROPLAST STROMA

BUNDLE-SHEATH CELL

EZ

+

C3 CALVIN CYCLE

O2 O2

CO2 RUBP-ASE CO2

CO2 RUBP-ASE CO2

HIGH CO2 CONTENT

CO2 RUBP-ASE CO2

CO2 RUBP-ASE CO2

CHLOROPLAST STROMA

BUNDLE-SHEATH CELL

C3

CO2
HIGH CONCENTRATION
CHLOROPLAST STROMA

↓

CO2 + RIBULOSE BISPHOSPHATE / (RUBP)

RIBULOSE BISPHOSPHATE
ENZYME
(RUBP-ASE)

OX

¿

RIBULOSE BISPHOSPHATE ENZYME (RUBP-ASE)

CO2
HIGH CONCENTRATION
CHLOROPLAST STROMA

CO2 + RIBULOSE BISPHOSPHATE / (RUBP)

RIBULOSE BISPHOSPHATE
OXYGENASE
(RUBP-OXYGENASE)

EZ

+

PHOSPHOGLYCERATE / (PGA)

PHOSPHOGLYCOLATE

CALVIN
CYCLE

C3

GLUCOSE
ENTERS
METABOLISM

PHOTORESPIRATION

CALVIN CYCLE

C3

CO2
HIGH CONCENTRATION
CHLOROPLAST STROMA

↓

CO2 + RIBULOSE BISPHOSPHATE / (RUBP)

RIBULOSE BISPHOSPHATE
ENZYME
(RUBP-ASE)

CR

¿

RIBULOSE BISPHOSPHATE ENZYME (RUBP-ASE)

CO2
HIGH CONCENTRATION
CHLOROPLAST STROMA

CO2 + RIBULOSE BISPHOSPHATE / (RUBP)

RIBULOSE BISPHOSPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)

PHOSPHOGLYCERATE / (PGA)

UNSTABLE C6 COMPOUND

PHOSPHOGLYCERATE / (PGA)

CALVIN
CYCLE

C3

CALVIN
CYCLE

GLUCOSE
ENTERS
METABOLISM

GLUCOSE
ENTERS
METABOLISM

CALVIN CYCLE

CR

C3 CALVIN CYCLE

O2 O2

CO2 RUBP-ASE CO2

CO2 RUBP-ASE CO2

HIGH CO2 CONTENT

CO2 RUBP-ASE CO2

CO2 RUBP-ASE CO2

CHLOROPLAST STROMA

BUNDLE-SHEATH CELL

C3

CO2
ENTERS
CHLOROPLAST STROMA

↓

CO2 + RIBULOSE BISPHOSPHATE / (RUBP)

RIBULOSE BISPHOSPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)

↓

UNSTABLE 6C COMPOUND

I

C3

CO2
ENTERS
CHLOROPLAST STROMA

↓

CO2 + RIBULOSE BISPHOSPHATE / (RUBP)

↓

RIBULOSE BISPHOSPHATE CARBOXYLASE (RUBP-CARBOXYLASE)

↓

UNSTABLE 6C COMPOUND

INEFFICIENT ENZYME

E

C3 CALVIN CYCLE

O2 O2

CO2 RUBP-ASE CO2

CO2 RUBP-ASE CO2

HIGH CO2 CONTENT

CO2 RUBP-ASE CO2

CO2 RUBP-ASE CO2

CHLOROPLAST STROMA

BUNDLE-SHEATH CELL

C3

CO2
ENTERS
CHLOROPLAST STROMA

↓

CO2 + RIBULOSE BISPHOSPHATE / (RUBP)

↓

RIBULOSE BISPHOSPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)

↓

UNSTABLE 6C COMPOUND

⊗

EFFICIENT ENZYME

O2
ENTERS
CHLOROPLAST STROMA

O2 + RIBULOSE BISPHOSPHATE / (RUBP)

RIBULOSE BISPHOSPHATE
OXYGENASE
(RUBP-OXYGENASE)

>

PHOSPHOGLYCERATE / (PGA)

PHOSPHOGLYCOLATE

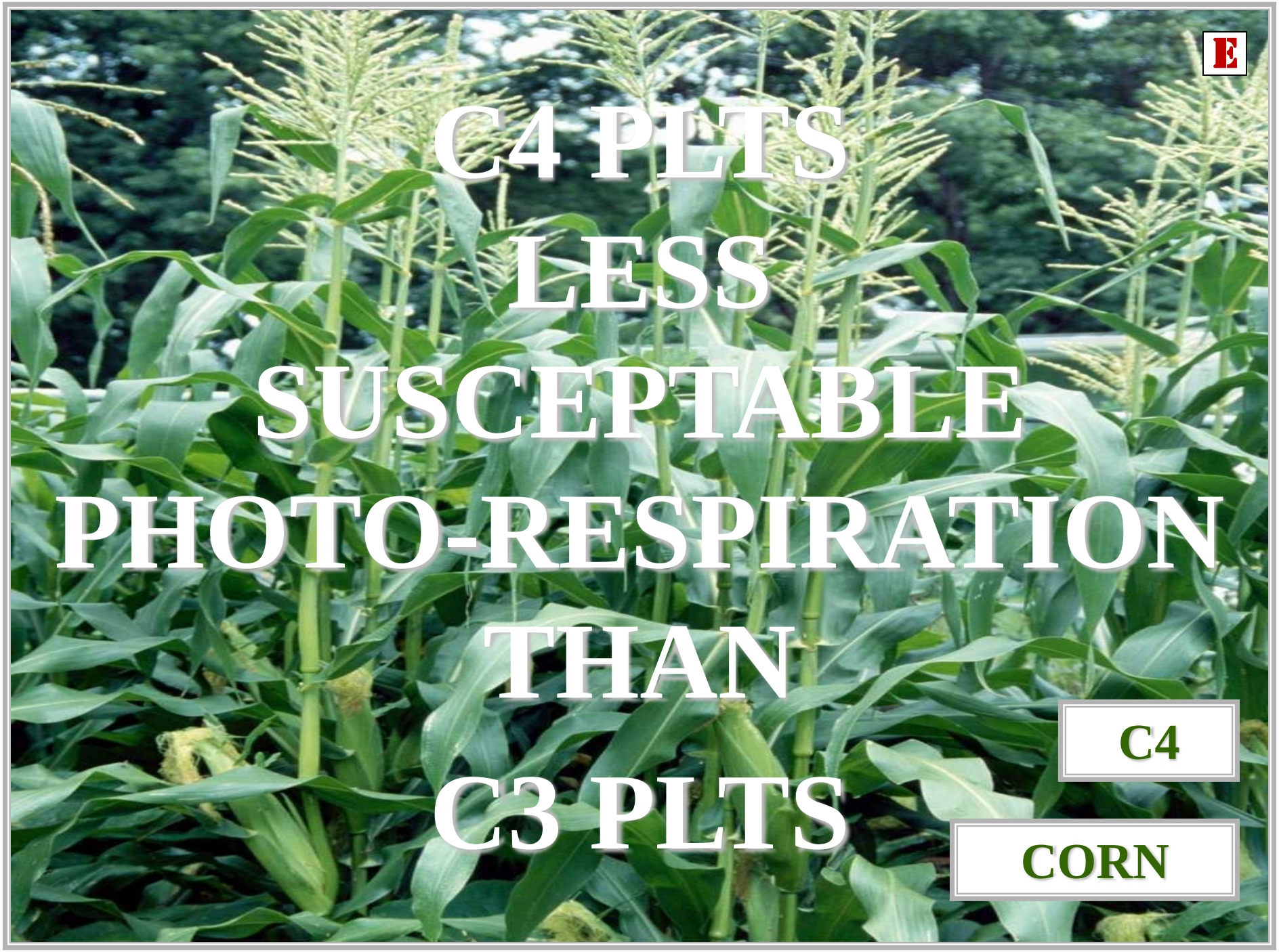
CALVIN
CYCLE

C3

GLUCOSE
ENTERS
METABOLISM

PHOTORESPIRATION

CALVIN CYCLE


E
C4 PLTS
LESS
SUSCEPTABLE
PHOTO-RESPIRATION
THAN
C3 PLTS
C4
CORN

END LECTURE MATERIAL 2ND EXAM