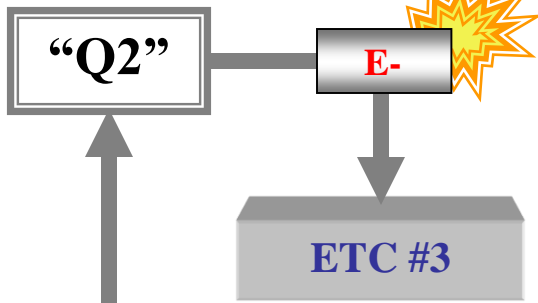


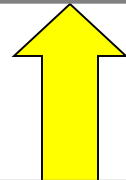


CYCLIC P-P

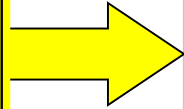


ENERGIZED E-

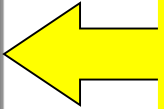
**PS-I
RXT-CENTER
CHL-A P700**



**LIGHT
ENERGY**



**PS-I
ANTENNA
MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES**



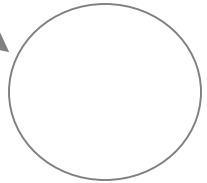
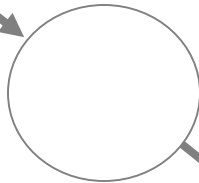
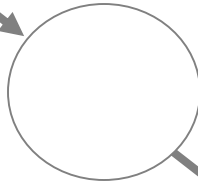
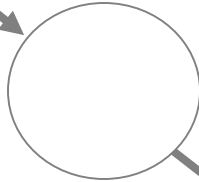
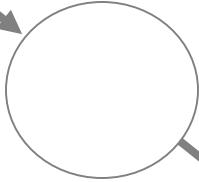
**LIGHT
ENERGY**

ELECTRON TRANSPORT CHAIN #3

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



 = ELECTRON TRANSPORT CHAIN COMPONENT

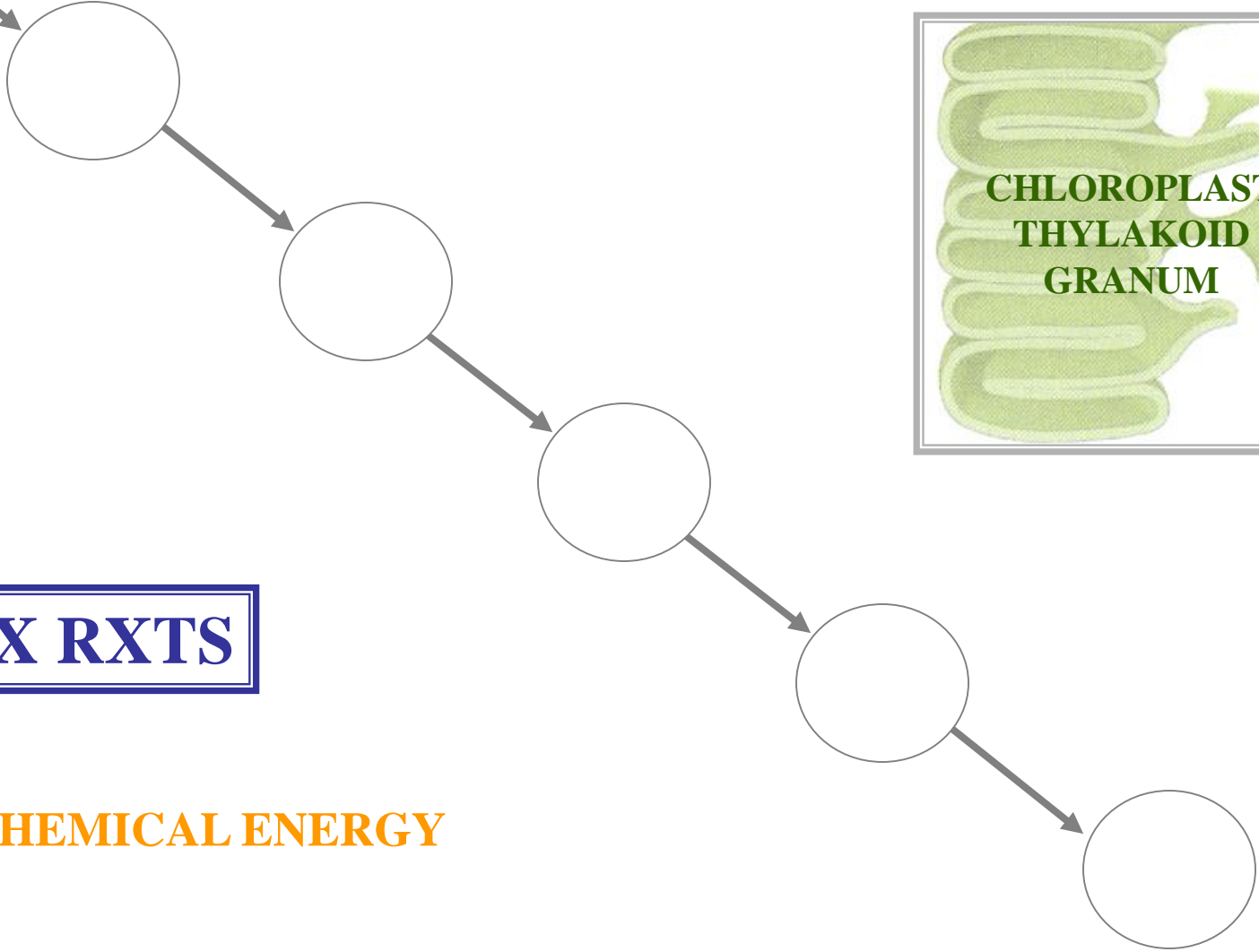
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



REDOX RXTS



= **CHEMICAL ENERGY**

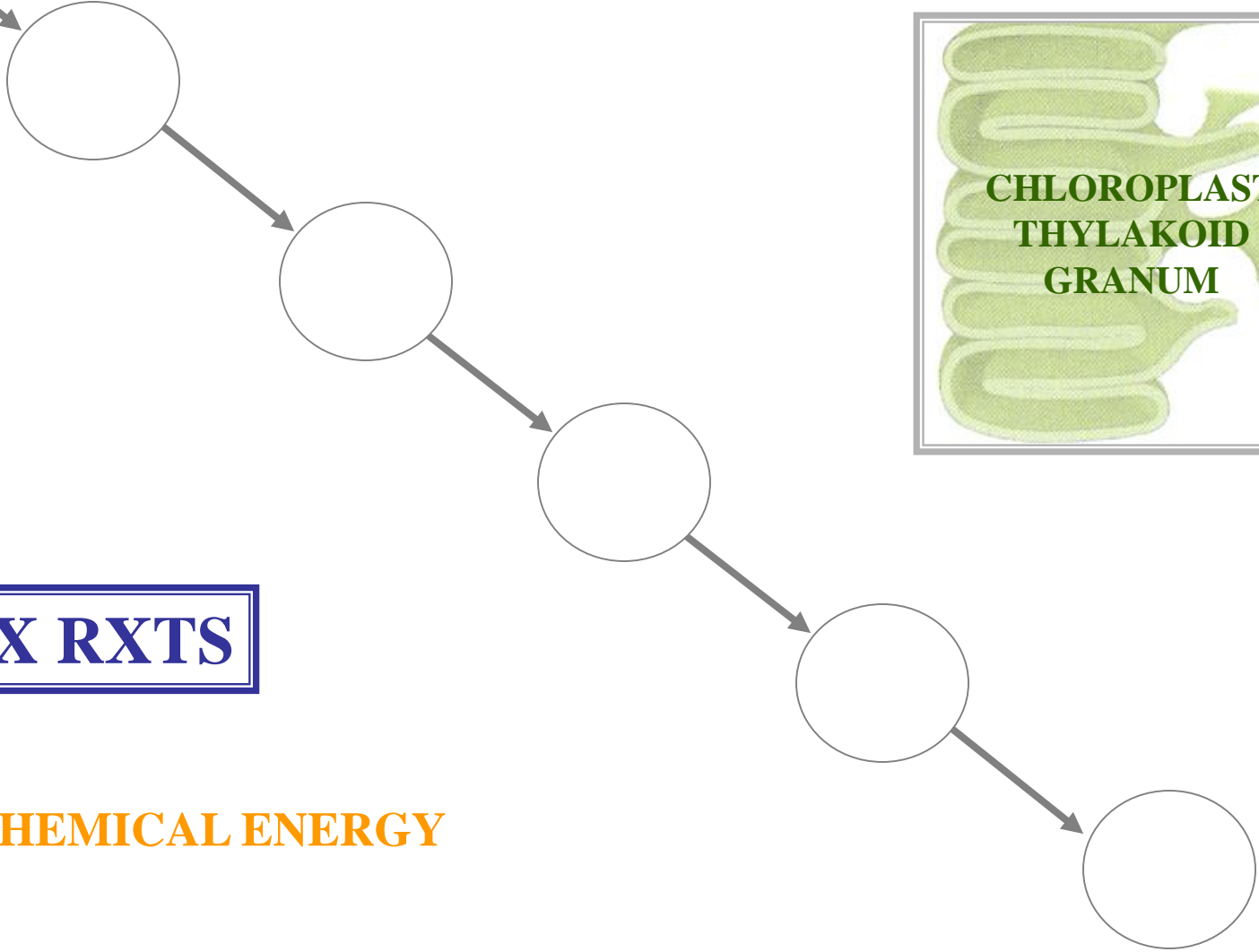


= **DISSIPATED HEAT ENERGY**

ELECTRON TRANSPORT CHAIN #3

E-

THYLAKOID GRANUM



REDOX RXTS

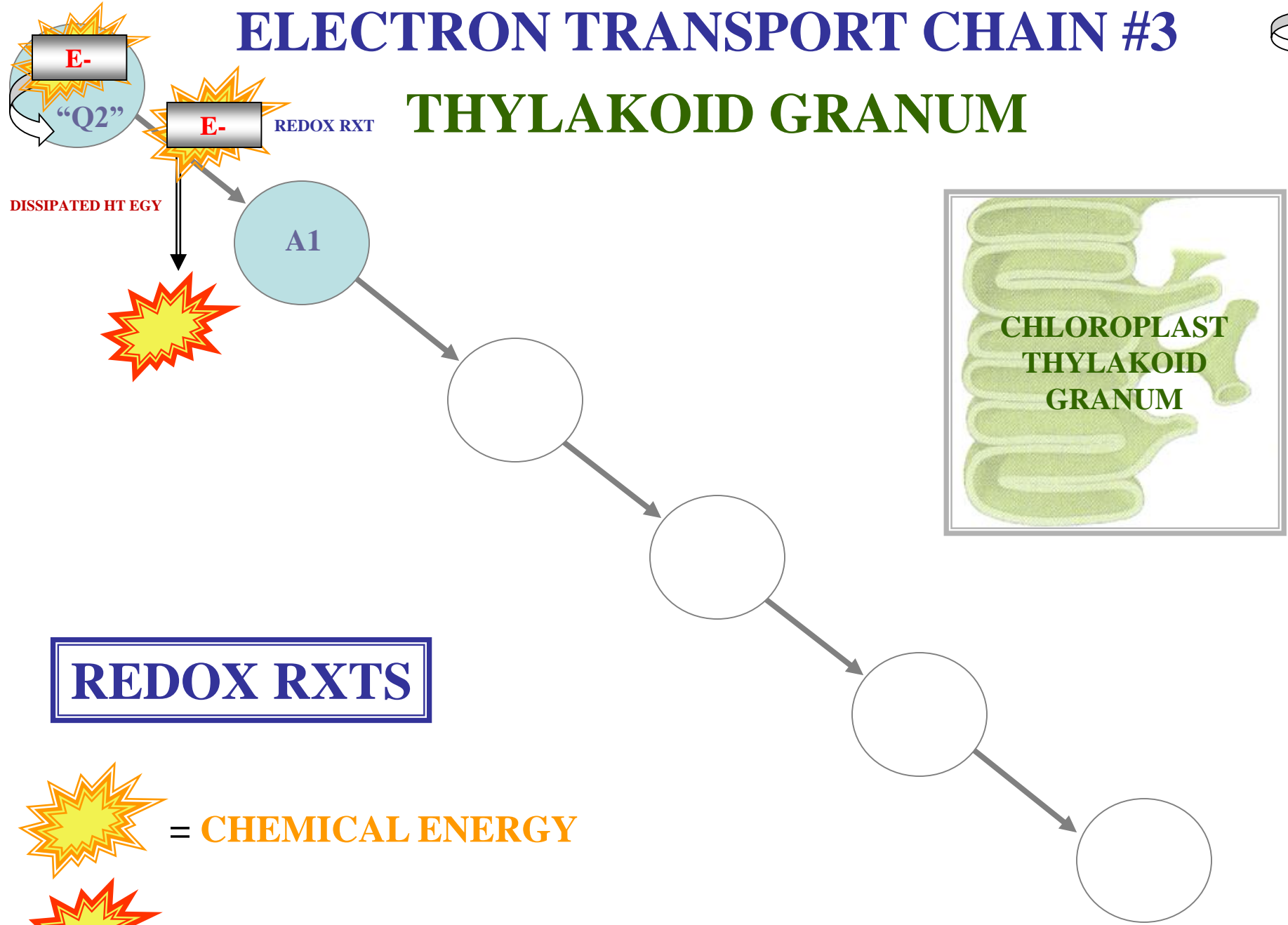
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



REDOX RXTS

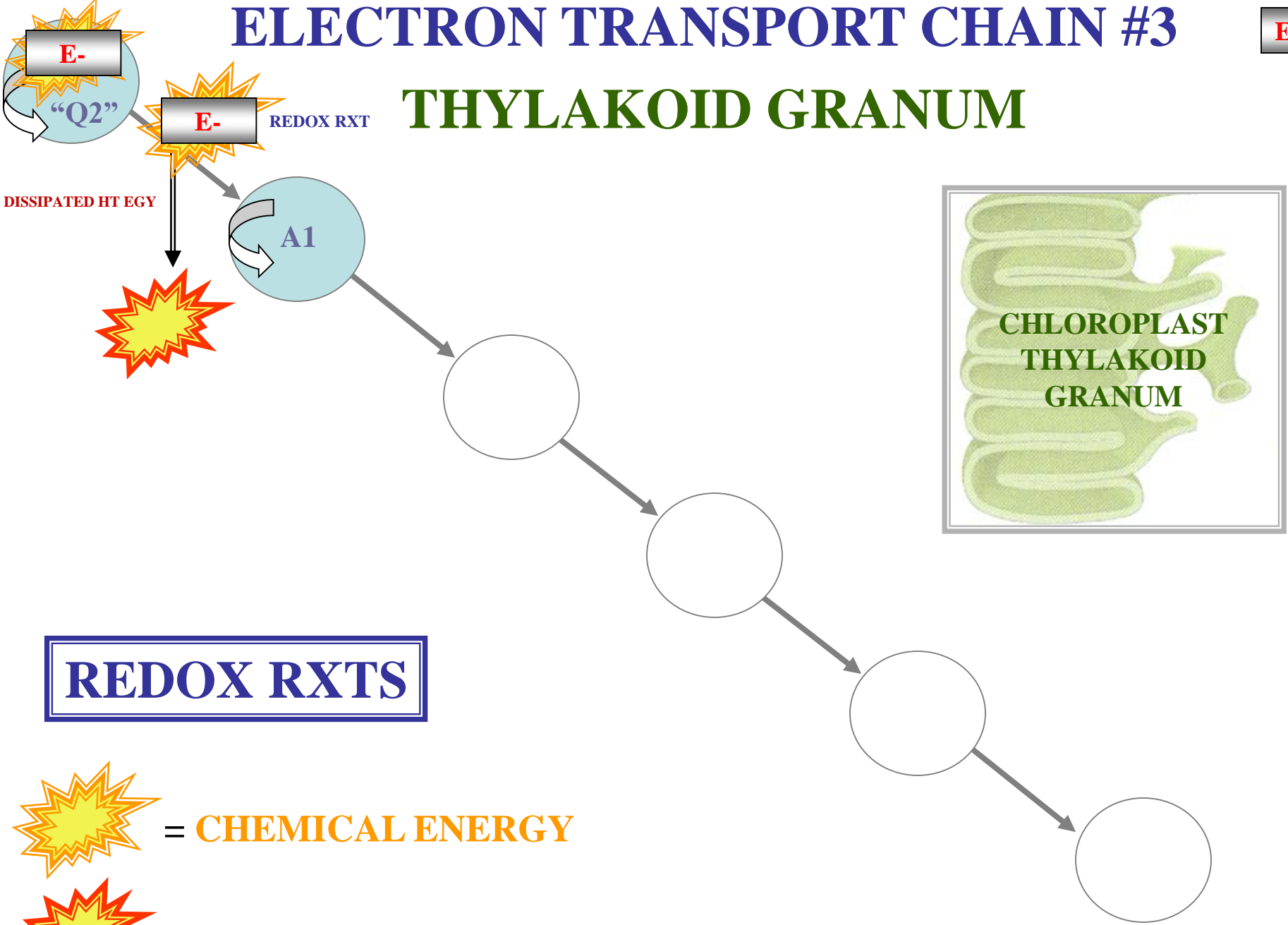
 = **CHEMICAL ENERGY**

 = **DISSIPATED HEAT ENERGY**

ELECTRON TRANSPORT CHAIN #3

E-

THYLAKOID GRANUM



REDOX RXTS

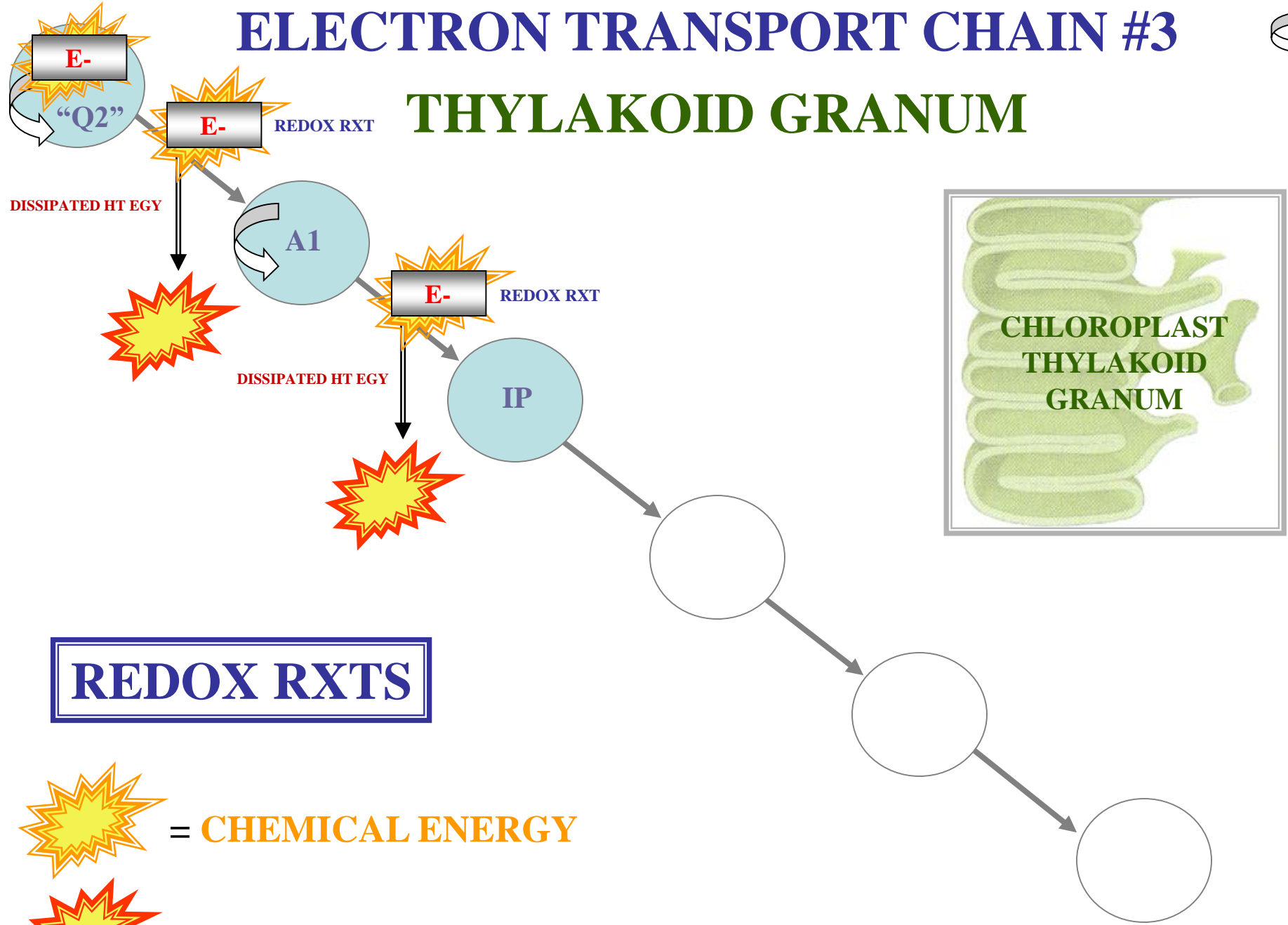
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



REDOX RXTS

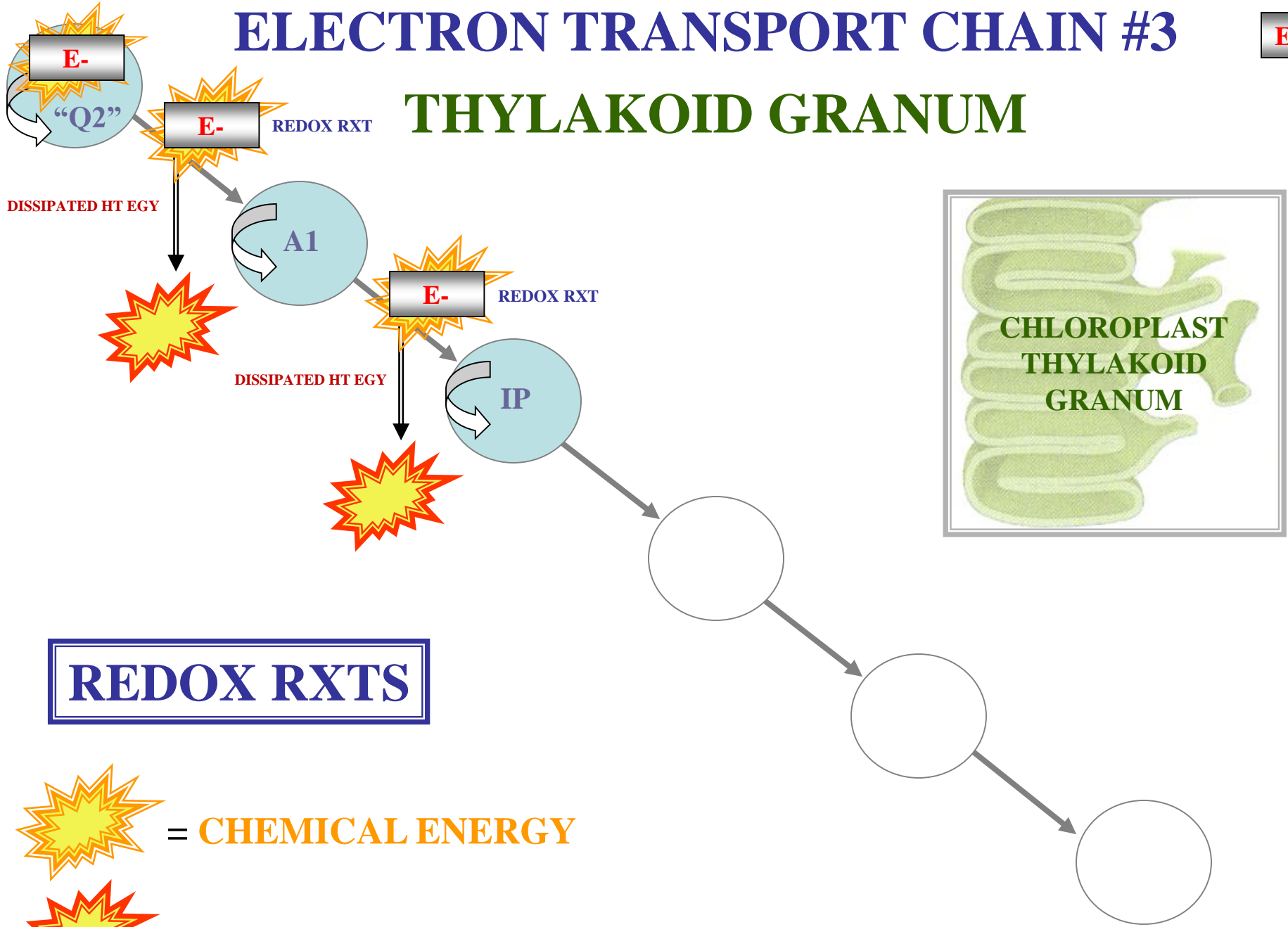
 = **CHEMICAL ENERGY**

 = **DISSIPATED HEAT ENERGY**

ELECTRON TRANSPORT CHAIN #3

E-

THYLAKOID GRANUM



REDOX RXTS

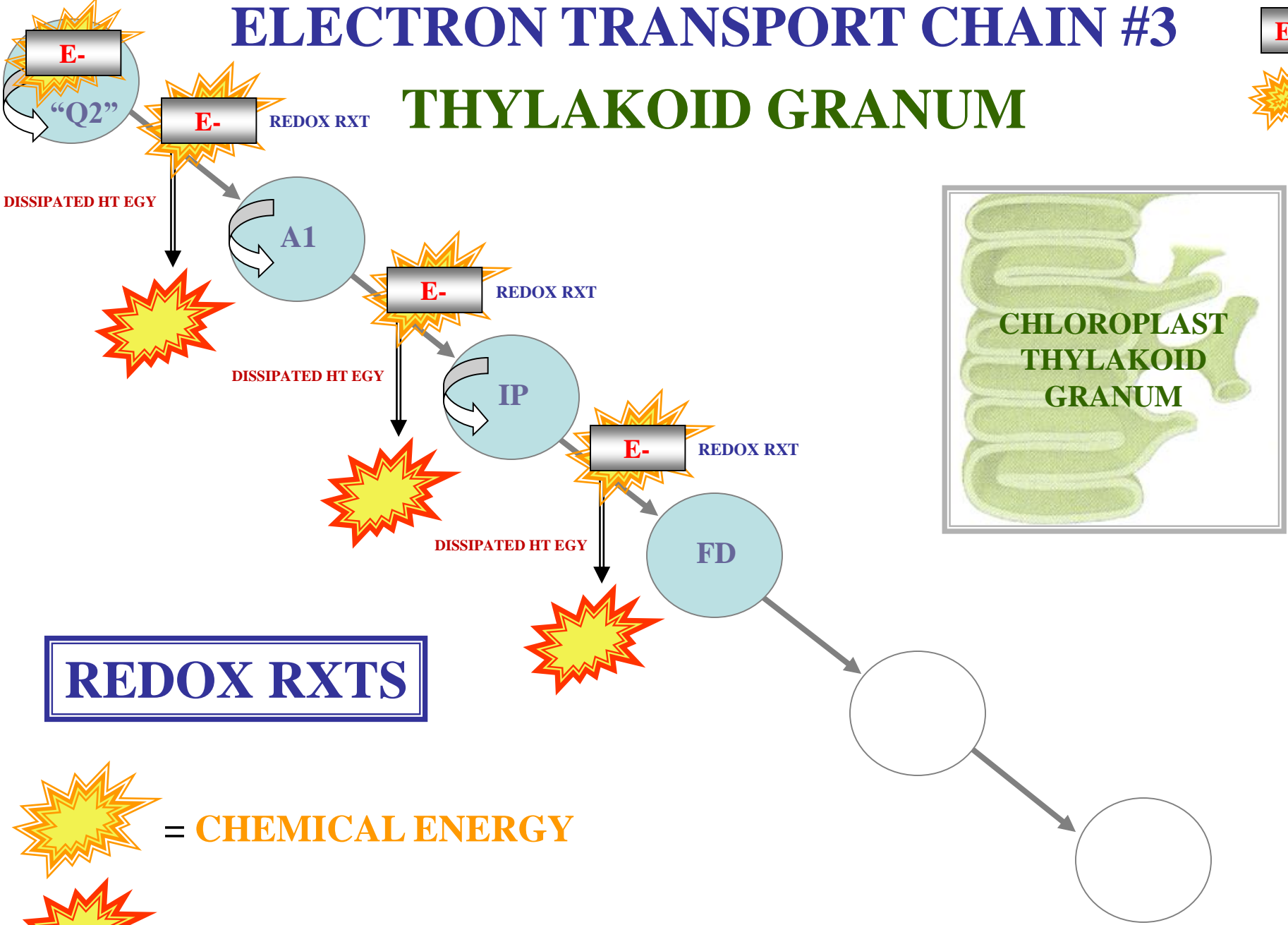
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3

E-

THYLAKOID GRANUM



REDOX RXTS



= CHEMICAL ENERGY

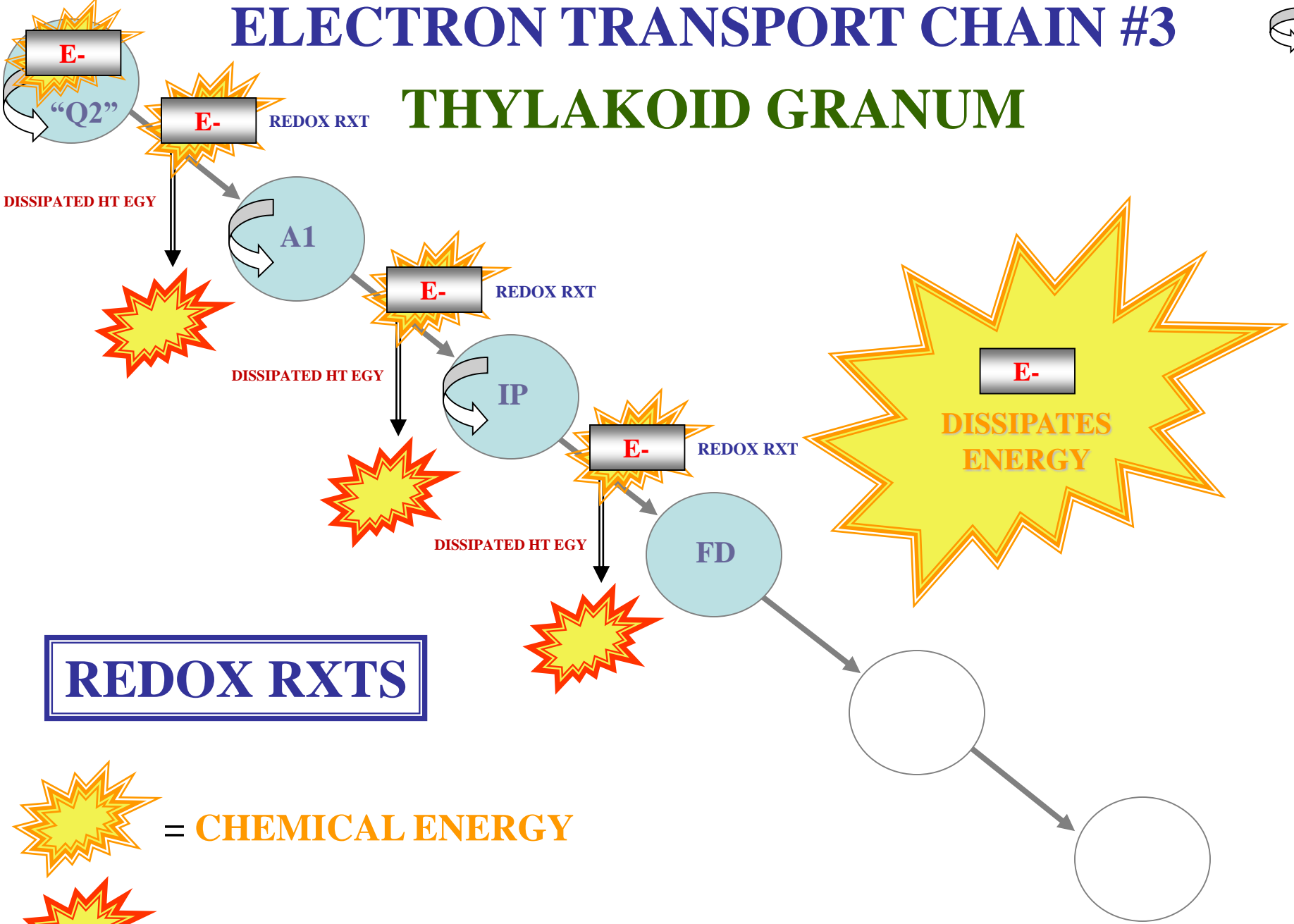


= DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



REDOX RXTS

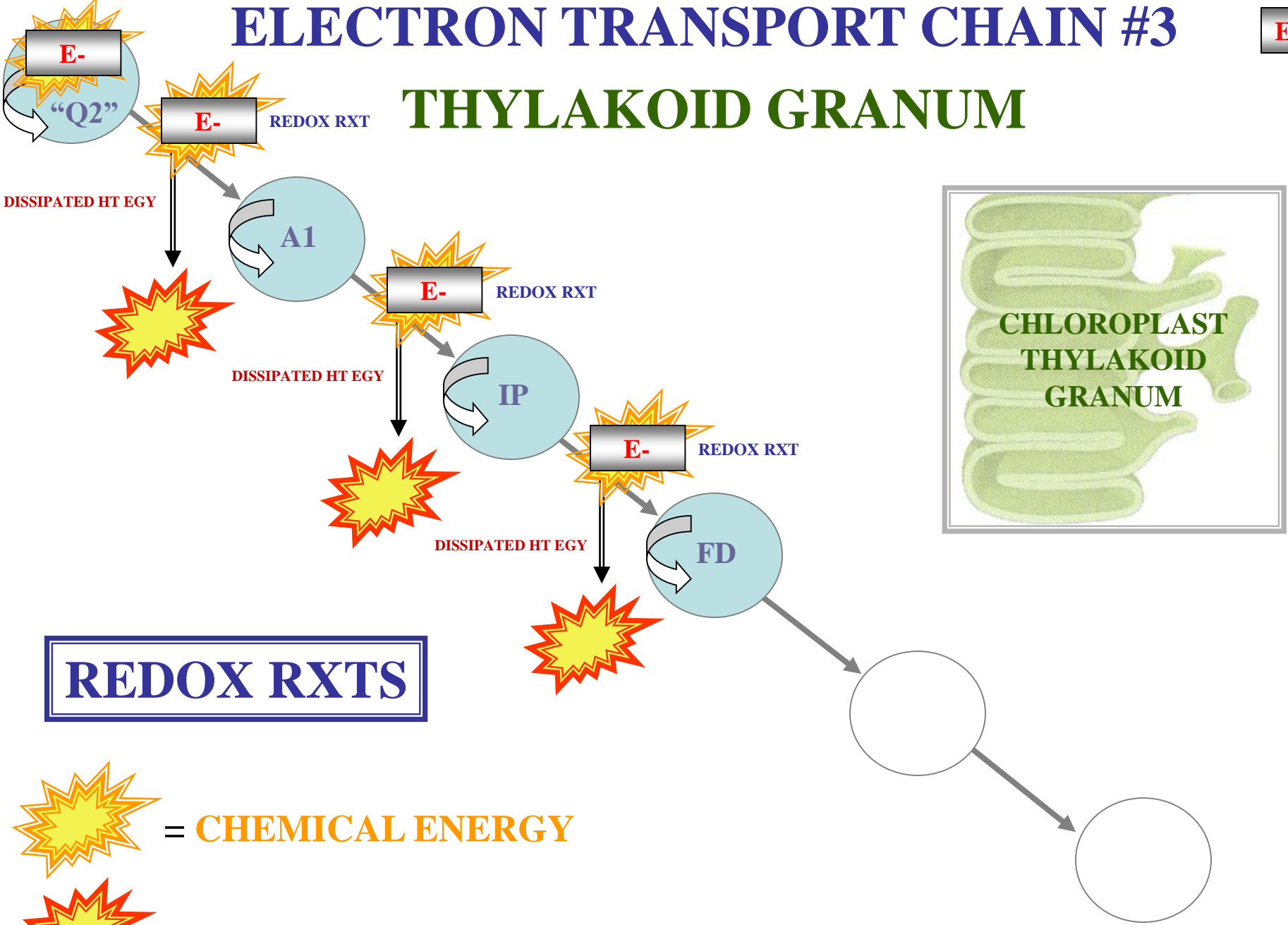
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3

E-

THYLAKOID GRANUM



REDOX RXTS

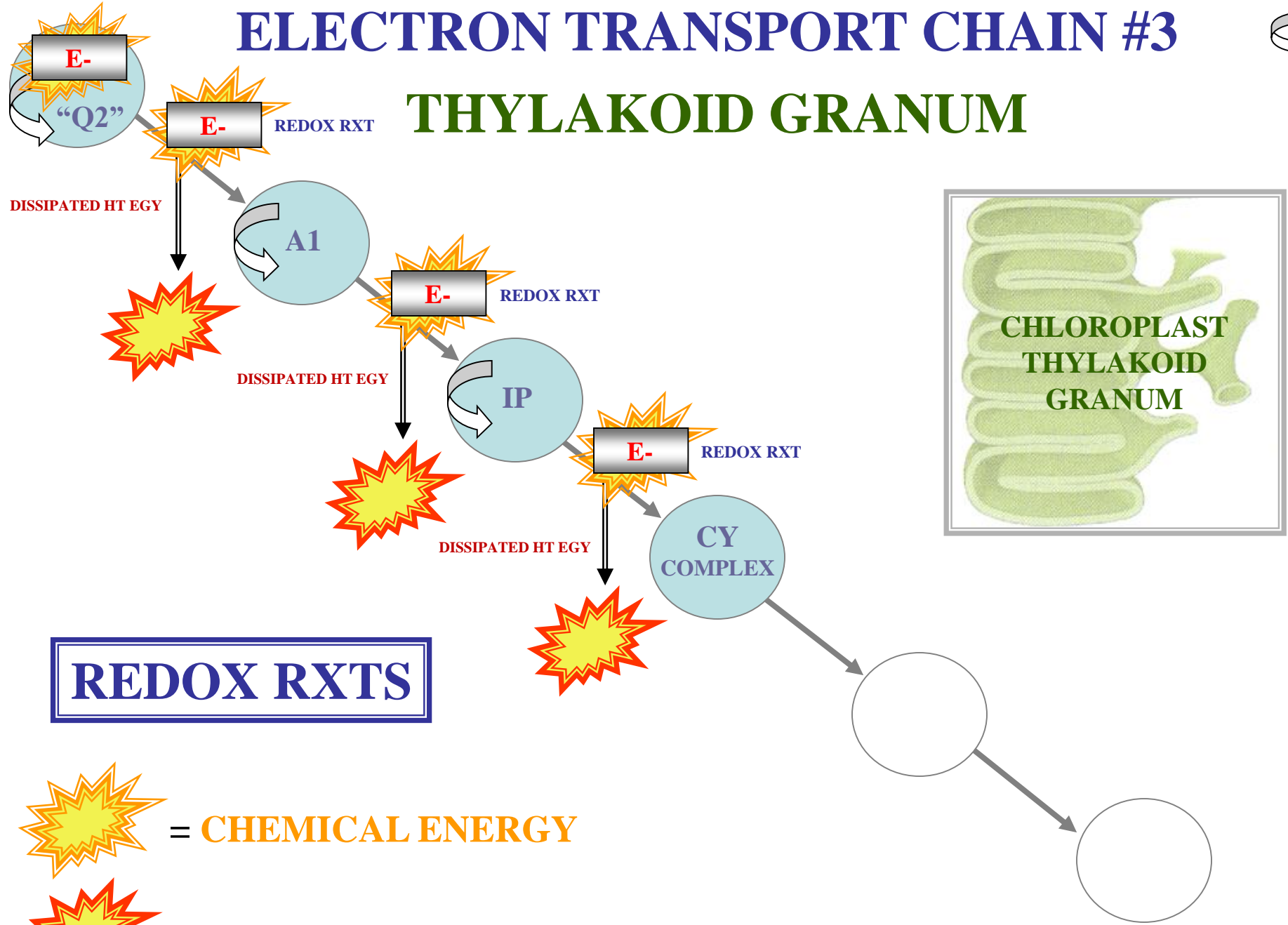
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



REDOX RXTS

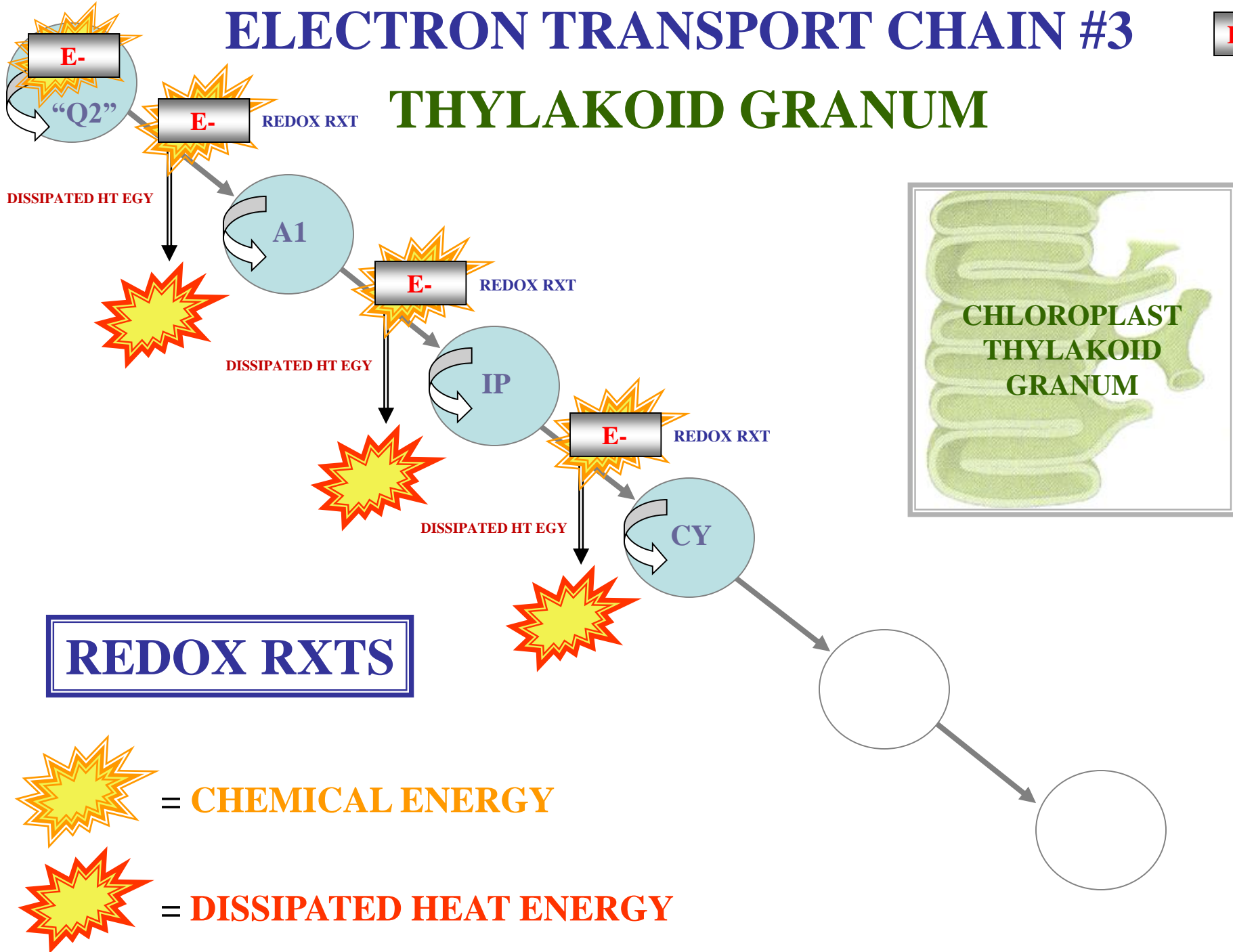
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3

E-

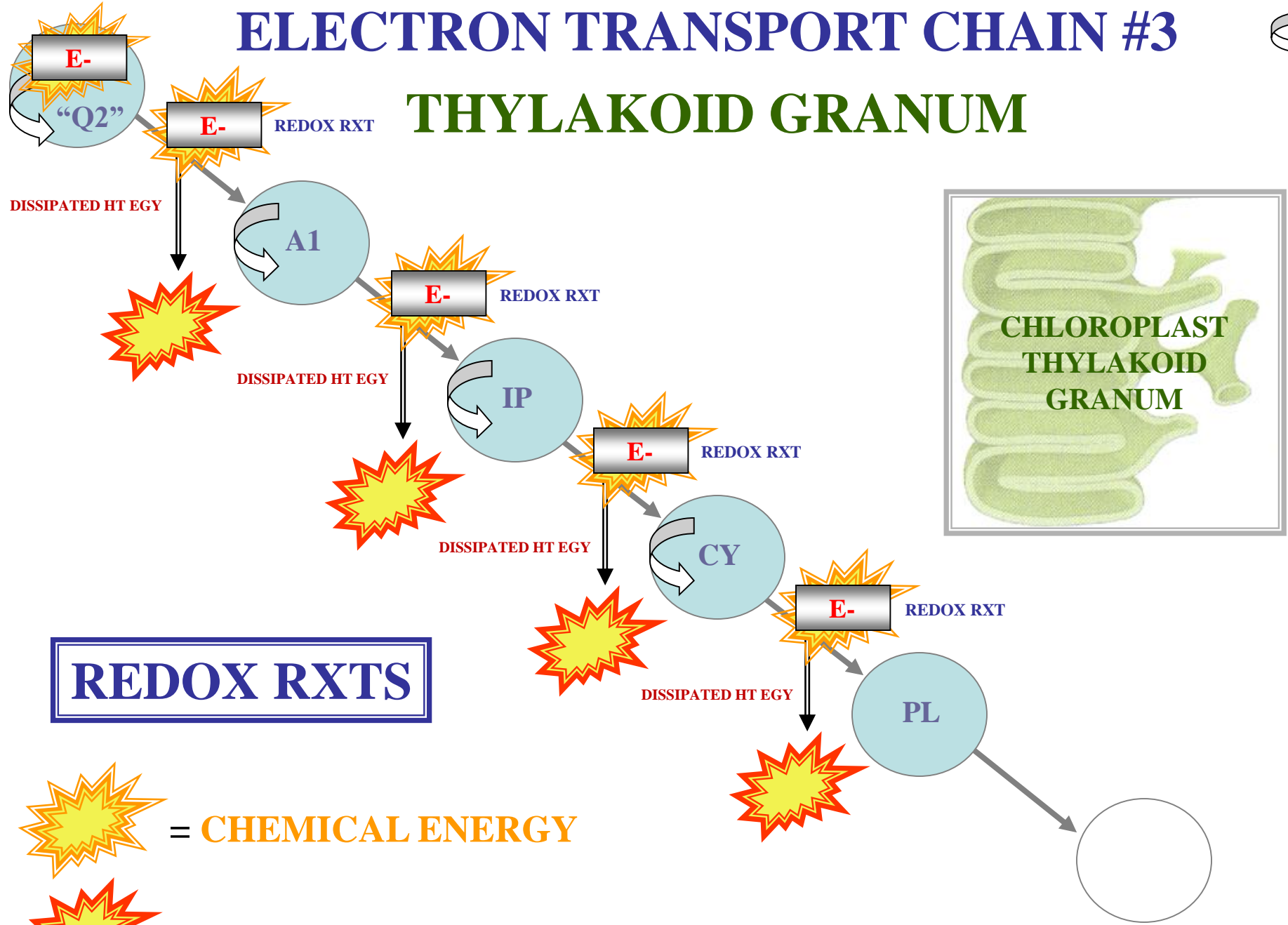
THYLAKOID GRANUM



ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



REDOX RXTS

 = CHEMICAL ENERGY

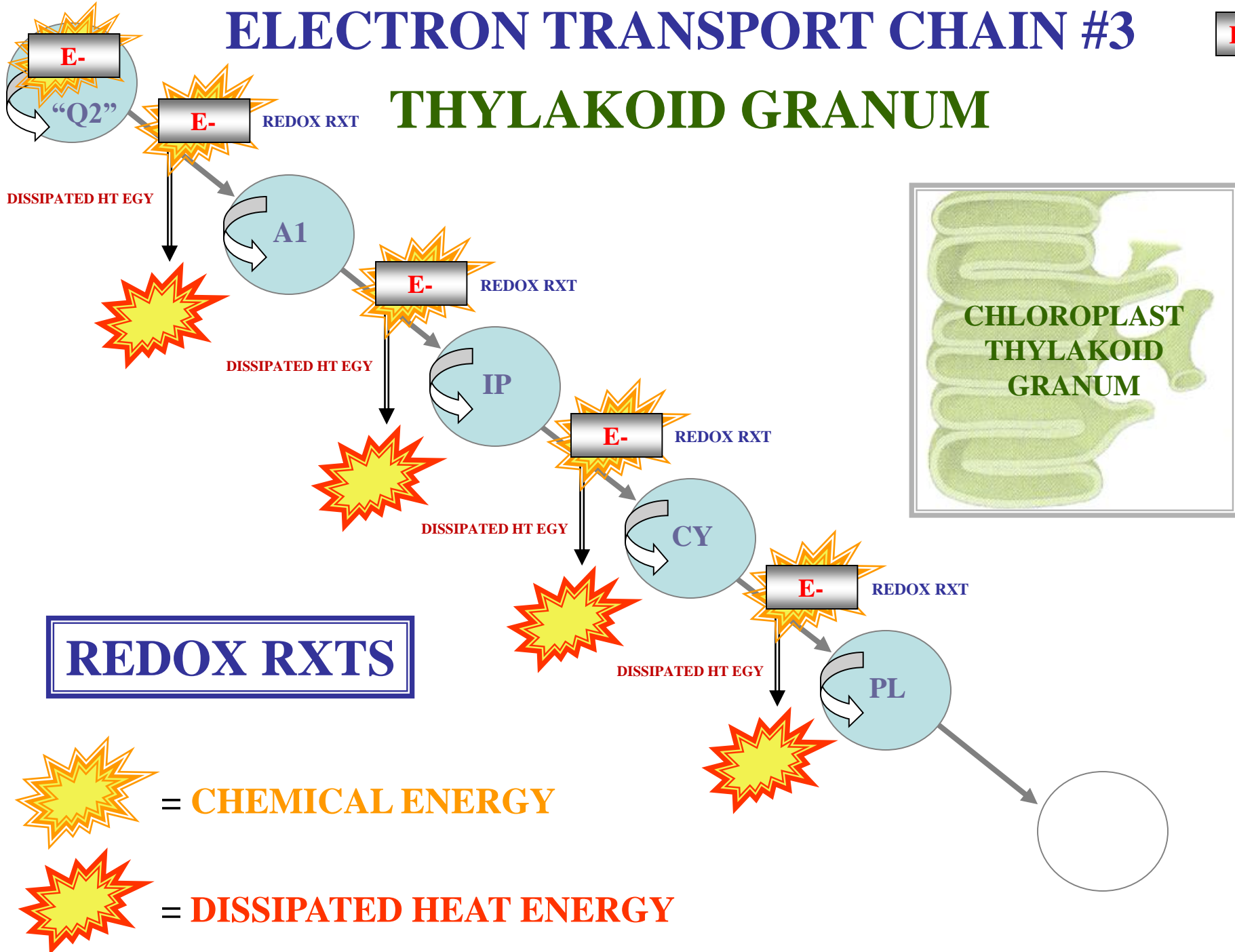
 = DISSIPATED HEAT ENERGY



ELECTRON TRANSPORT CHAIN #3

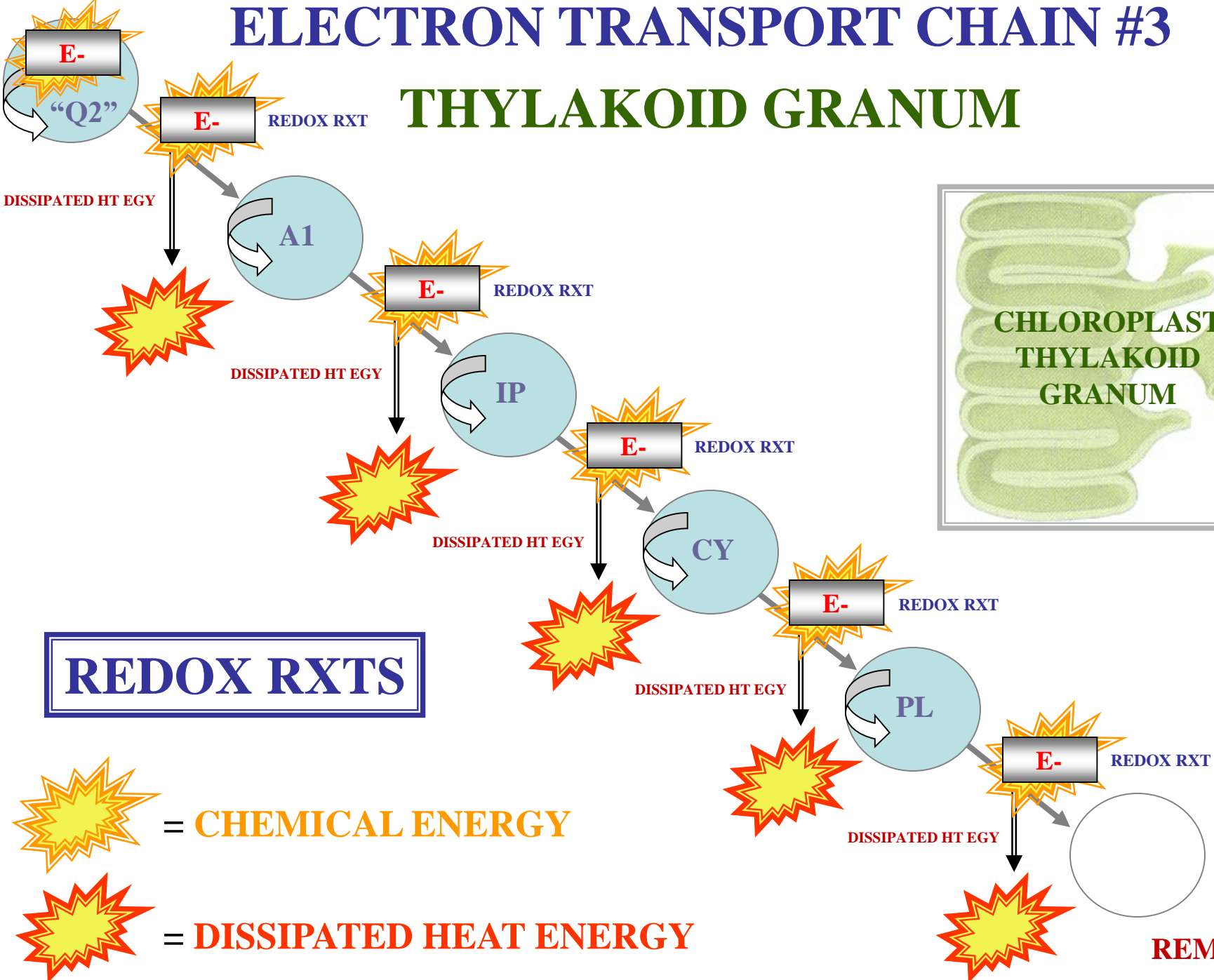
E-

THYLAKOID GRANUM

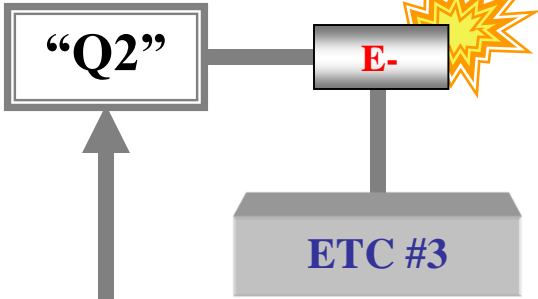


ELECTRON TRANSPORT CHAIN #3

THYLAKOID GRANUM



CYCLIC P-P



! REMEBER

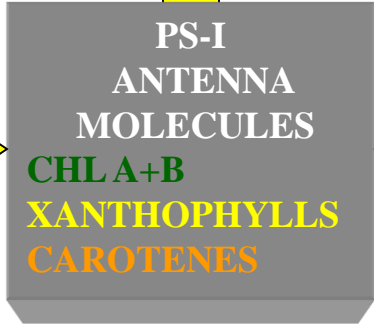
+

E-

I



LIGHT ENERGY

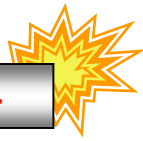


LIGHT ENERGY

CYCLIC P-P

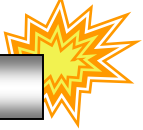
“Q2”

E-

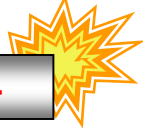


ETC #3

E-



E-



REMEBER

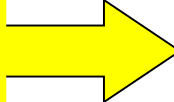
ETC3

E-

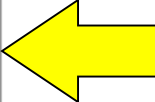
+

**PS-I
RXT-CENTER
CHL-A P700**

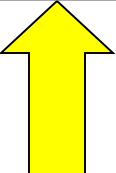
**LIGHT
ENERGY**



**PS-I
ANTENNA
MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES**



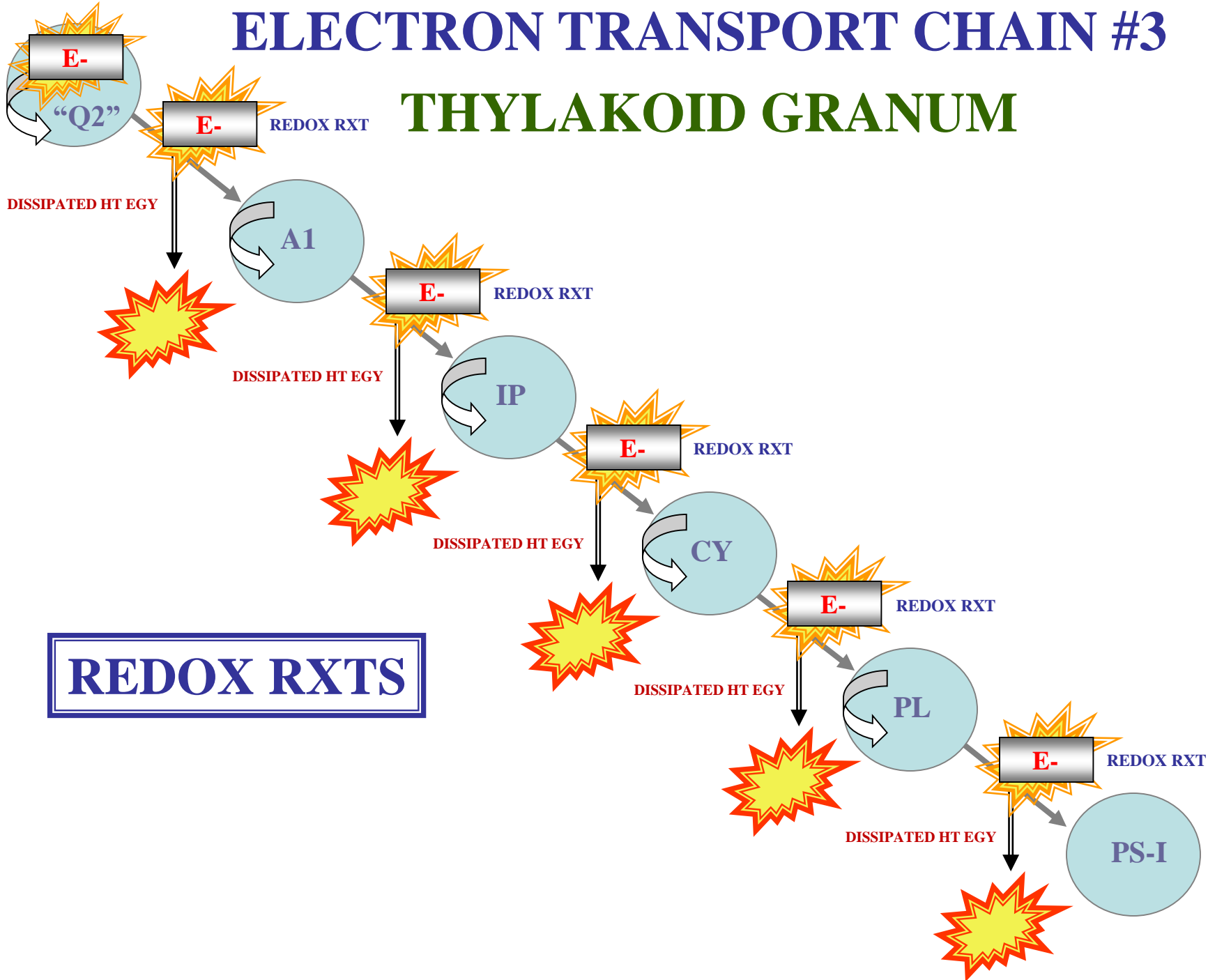
**LIGHT
ENERGY**



ELECTRON TRANSPORT CHAIN #3

E-

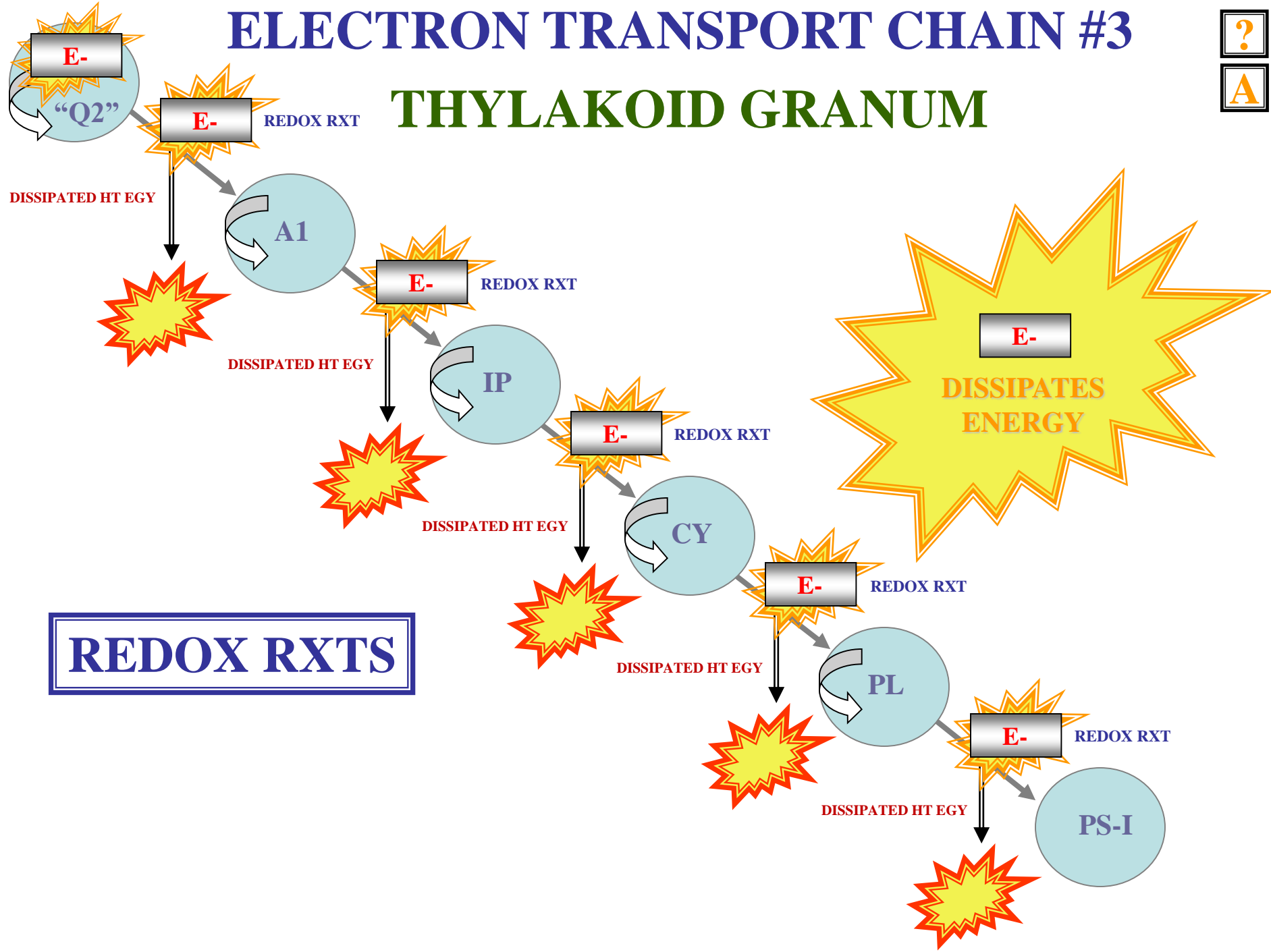
THYLAKOID GRANUM



ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM

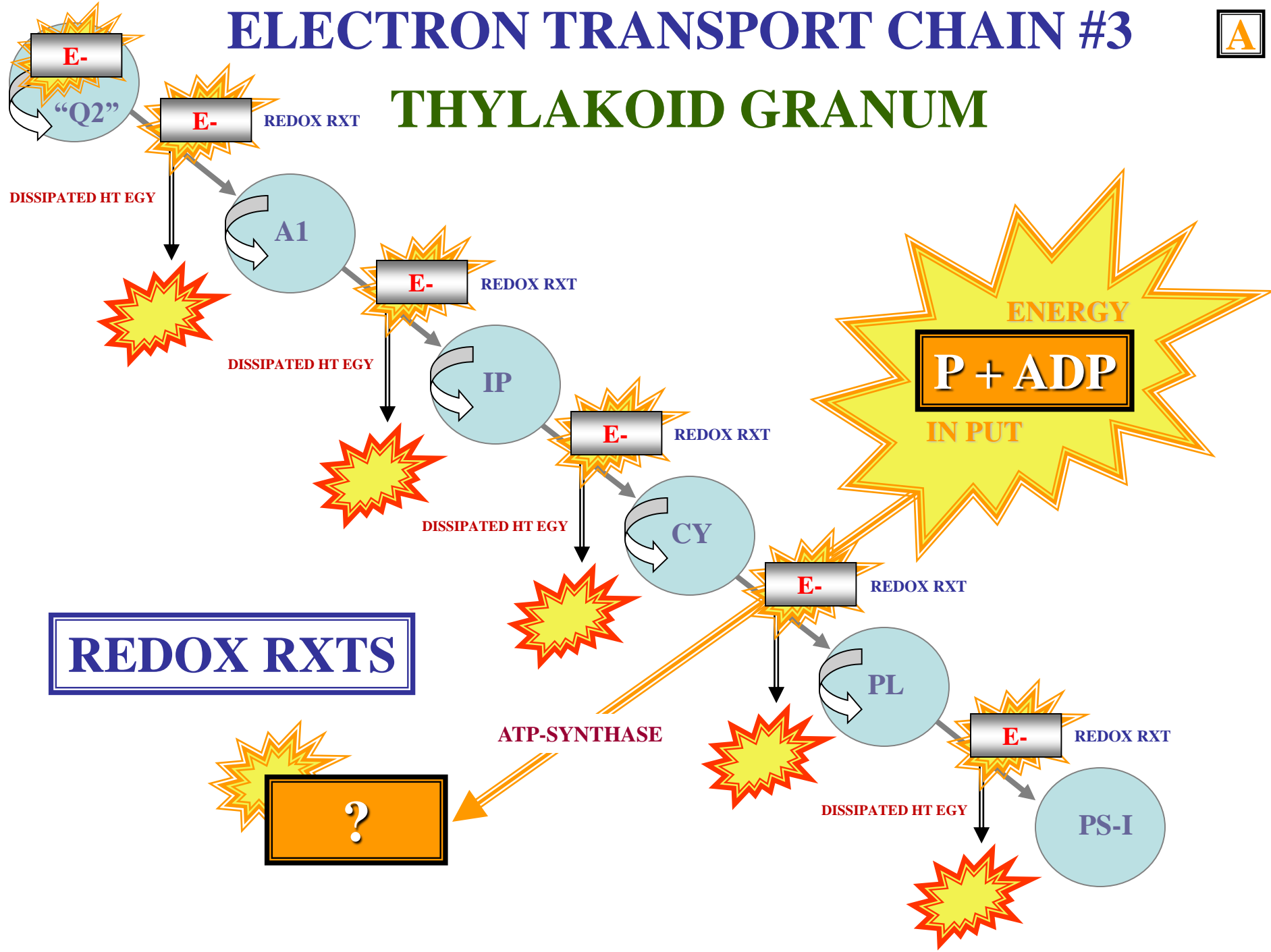


REDOX RXTS

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM

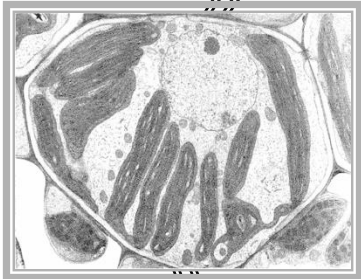
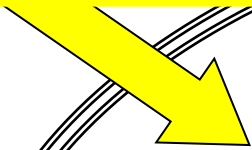


PHOTOSYNTHESIS

DK



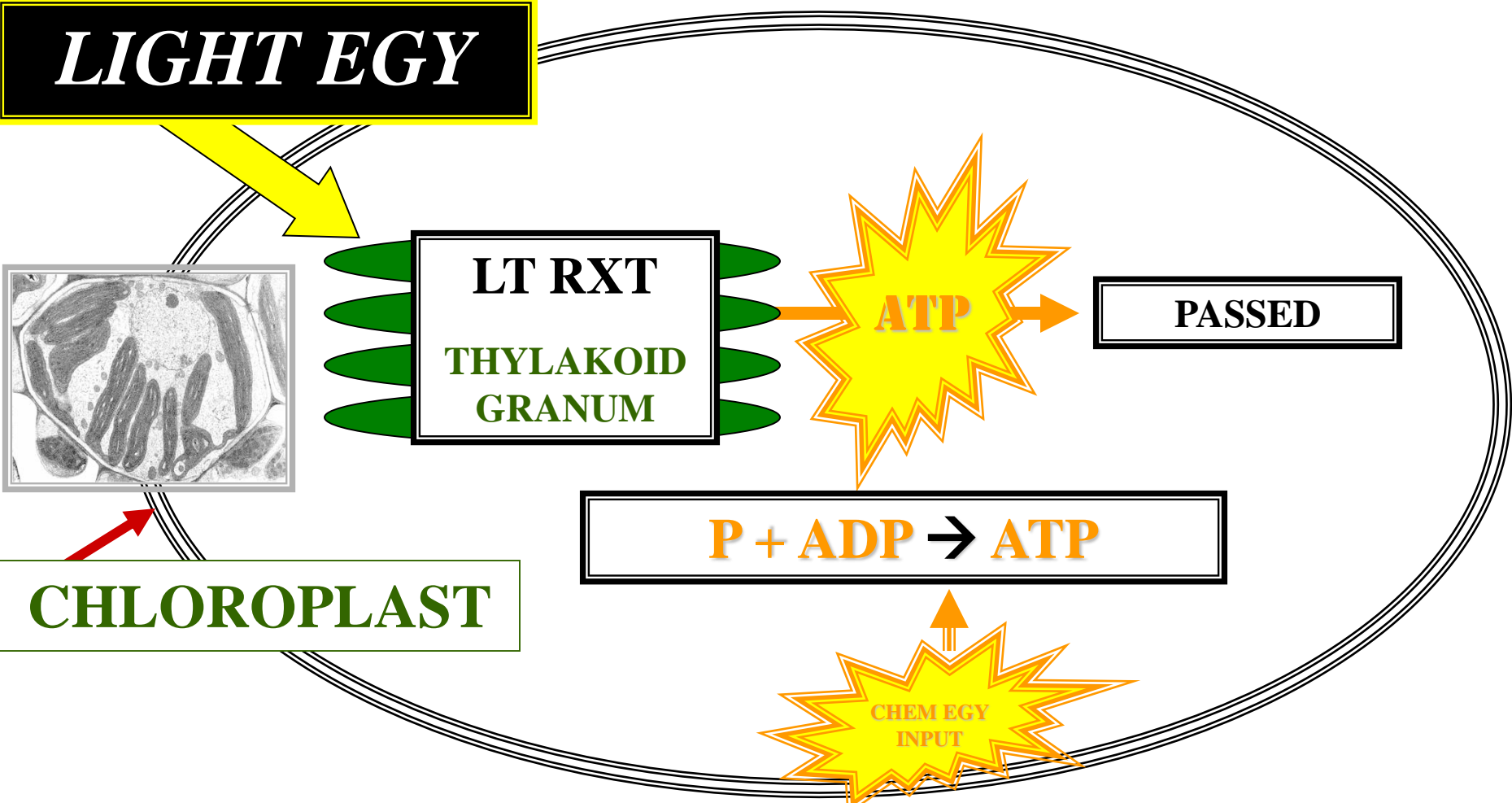
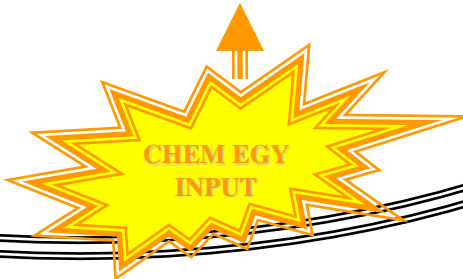
LIGHT ENERGY



CHLOROPLAST



PASSED



PHOTOSYNTHESIS

P



LIGHT ENERGY



CHLOROPLAST

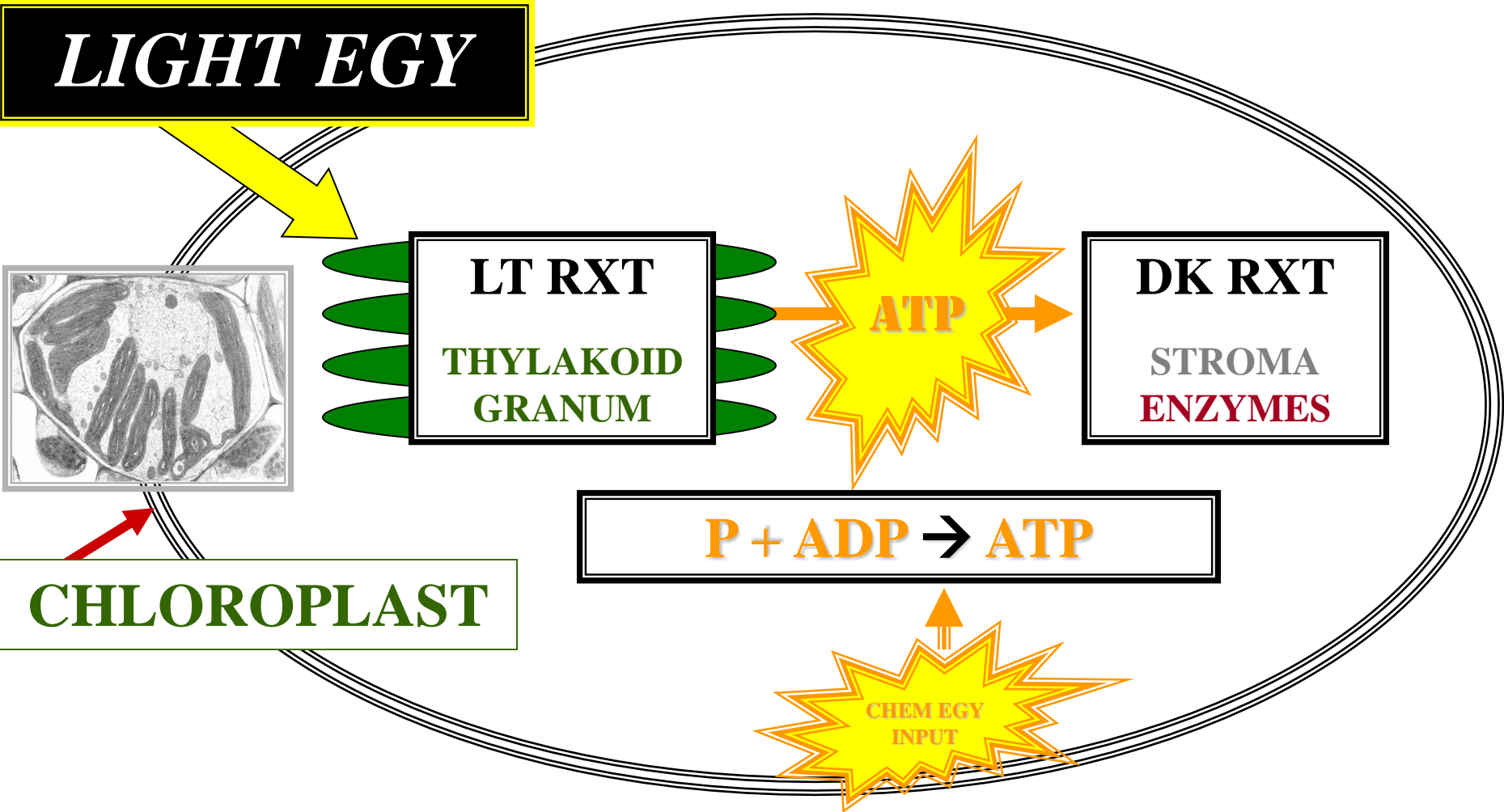
LT RXT
THYLAKOID
GRANUM

ATP

DK RXT
STROMA
ENZYMES



CHEMICAL
INPUT



PHOTOSYNTHESIS

LT

P

LIGHT EGY

PHOSPHORYLATION

LT RXT

THYLAKOID
GRANUM

ATP

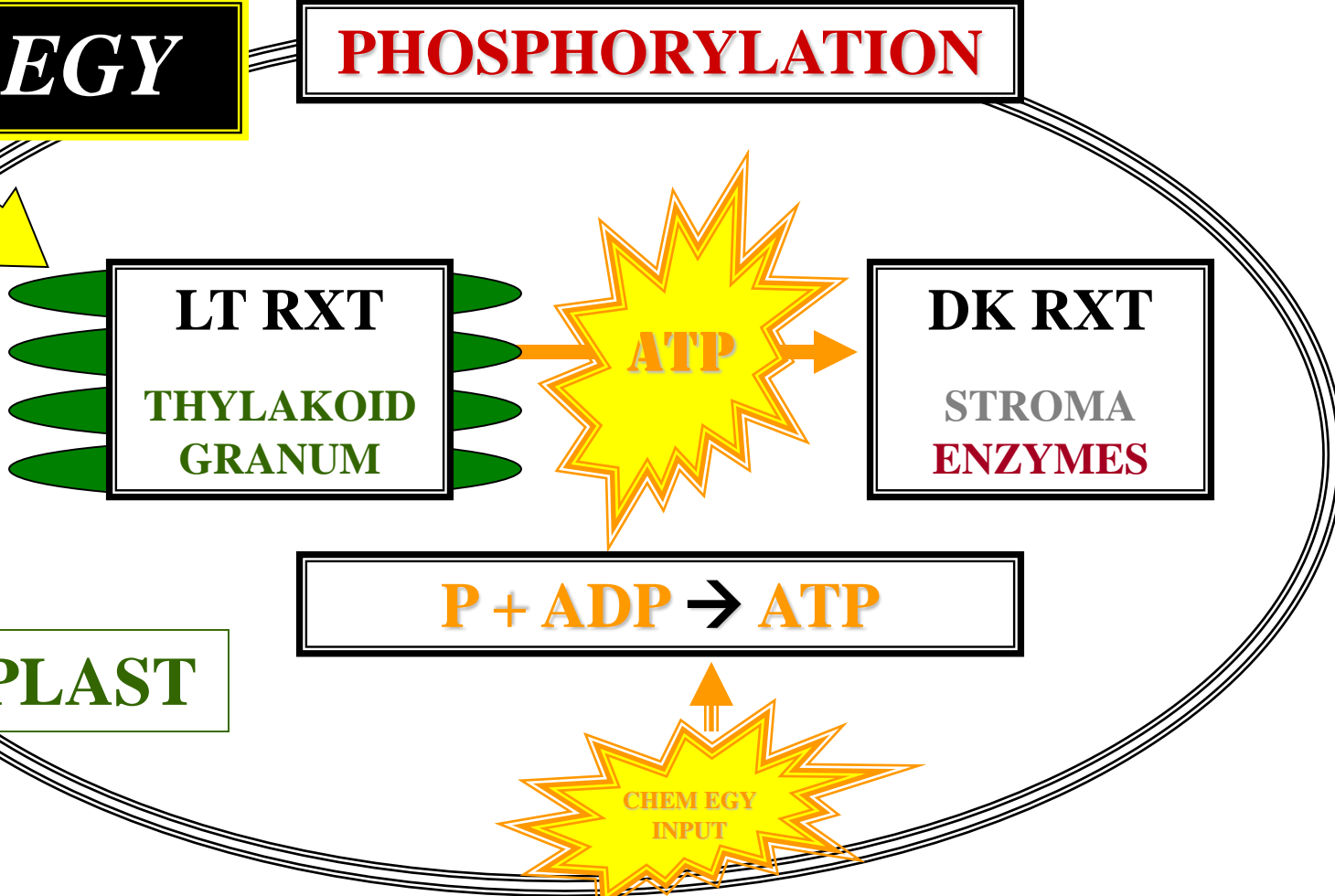
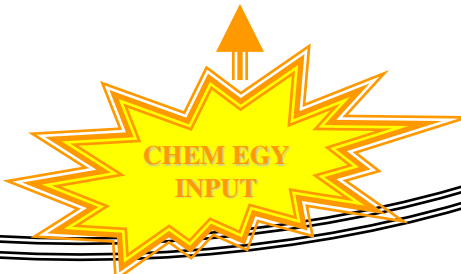
DK RXT

STROMA
ENZYMES

$P + ADP \rightarrow ATP$

CHEM EGY
INPUT

CHLOROPLAST



PHOTOSYNTHESIS



C

>

LIGHT ENERGY

PHOTO-PHOSPHORYLATION



LT RXT
THYLAKOID
GRANUM

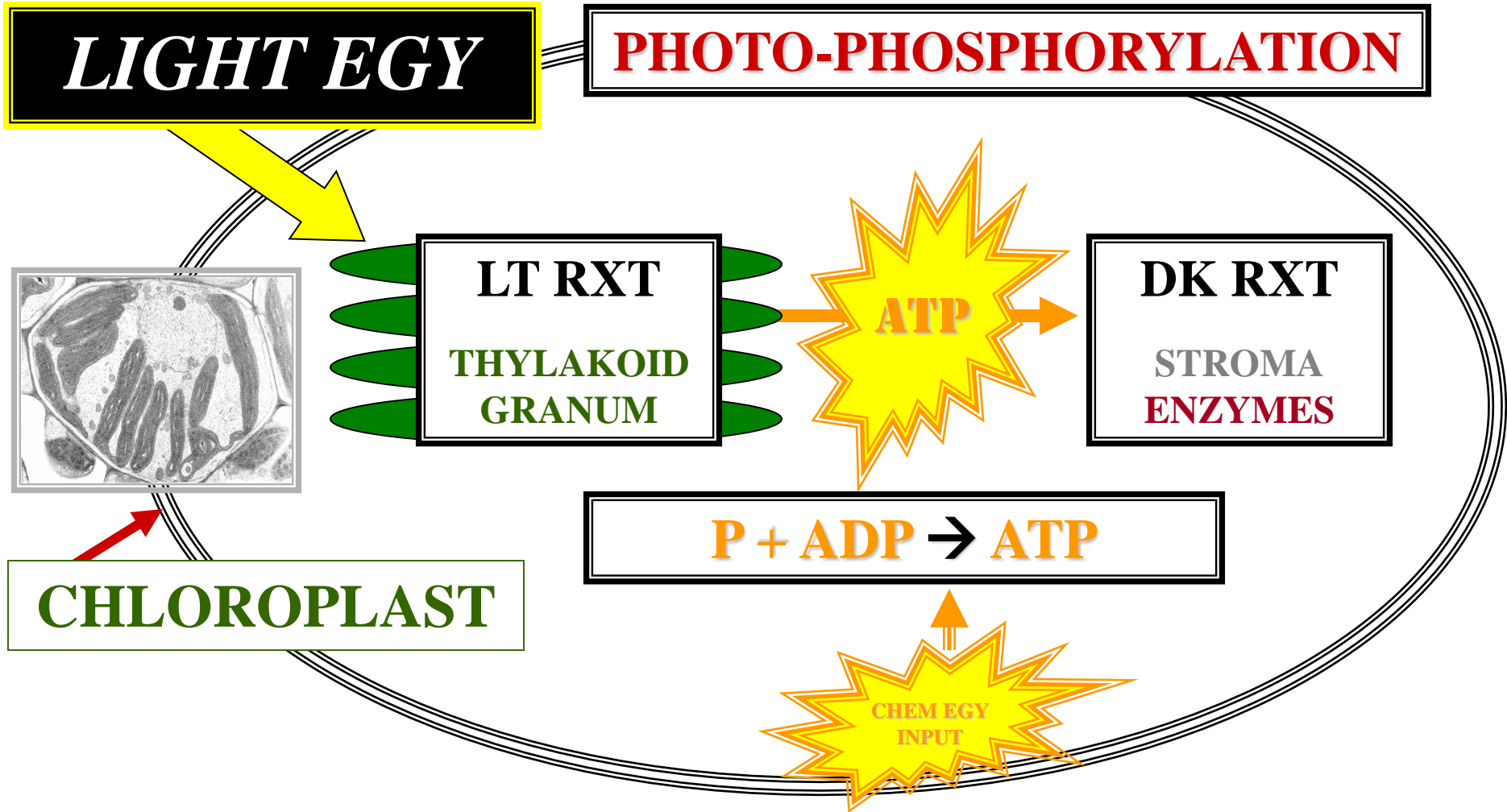
ATP

DK RXT
STROMA
ENZYMES

$P + ADP \rightarrow ATP$

CHLOROPLAST

CHEMICAL
INPUT



PHOTOSYNTHESIS

CYCLIC

LIGHT EGY

PHOTO-PHOSPHORYLATION

LT RXT

THYLAKOID
GRANUM

ATP

DK RXT

STROMA
ENZYMES

$P + ADP \rightarrow ATP$

CHEM EGY
INPUT

CHLOROPLAST



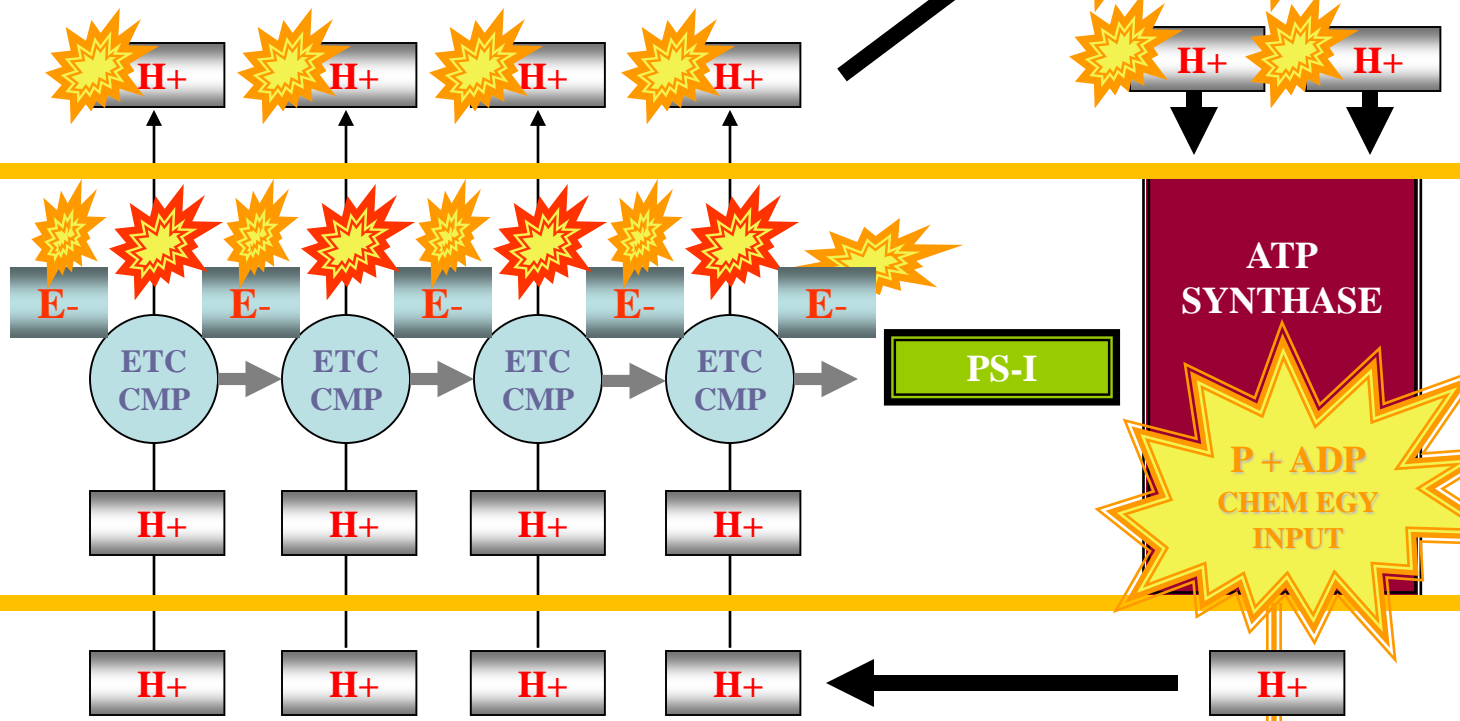
←→ S C

CHEMIOSMOTIC PHOSPHORYLATION MODEL

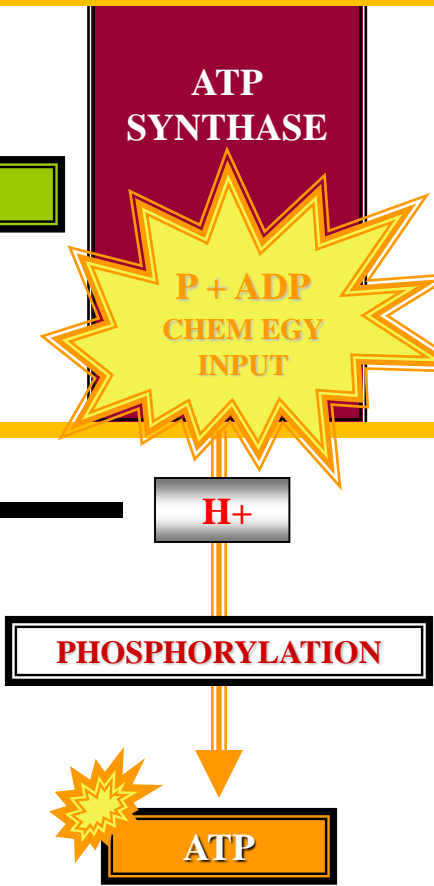
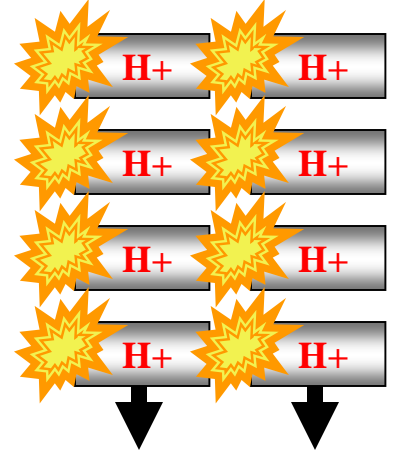
CHLOROPLAST THYLAKOID SPACE

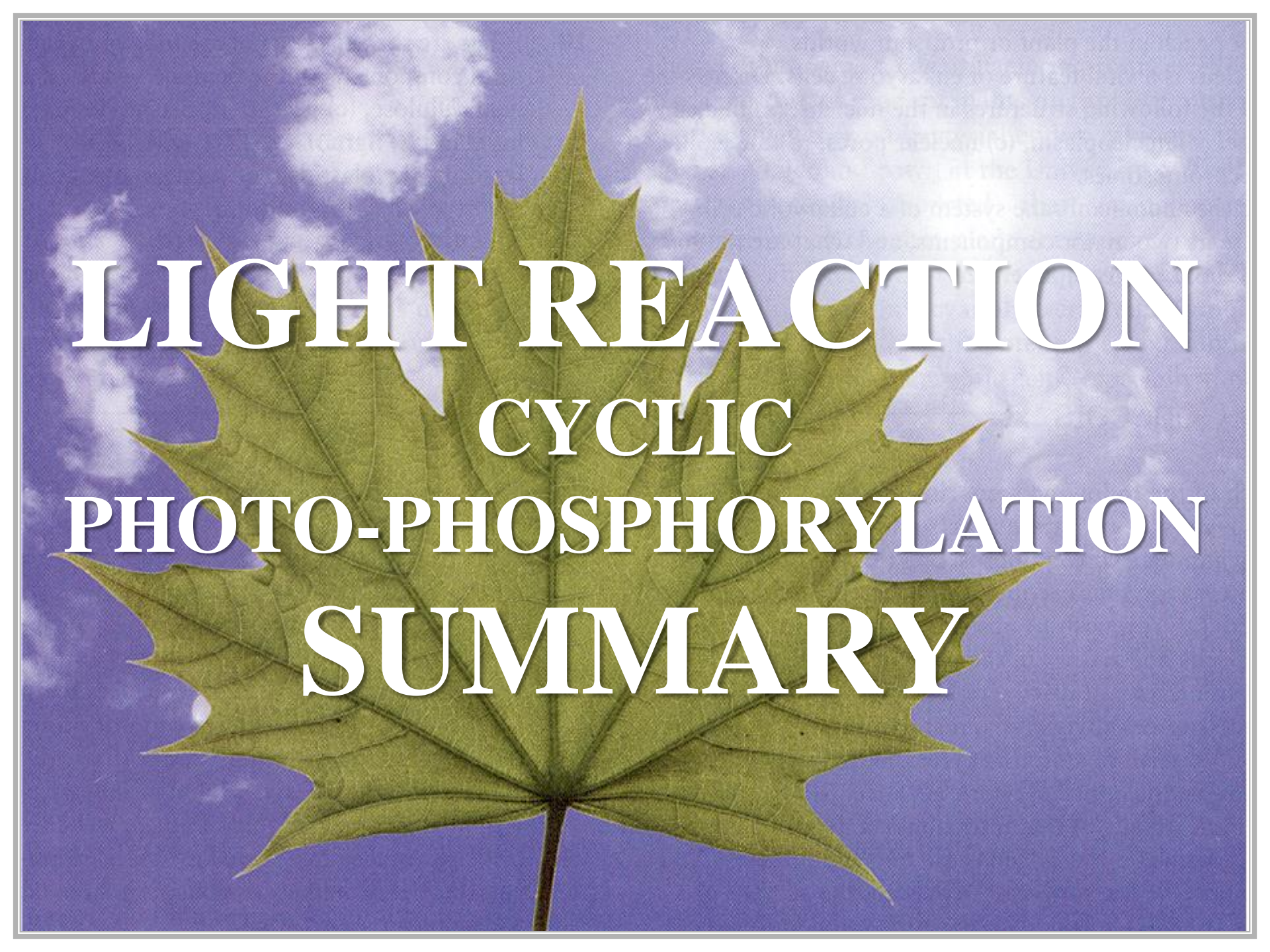
PS-II / PS-I
CHLOROPLAST THYLAKOID ETC

CHLOROPLAST STROMA

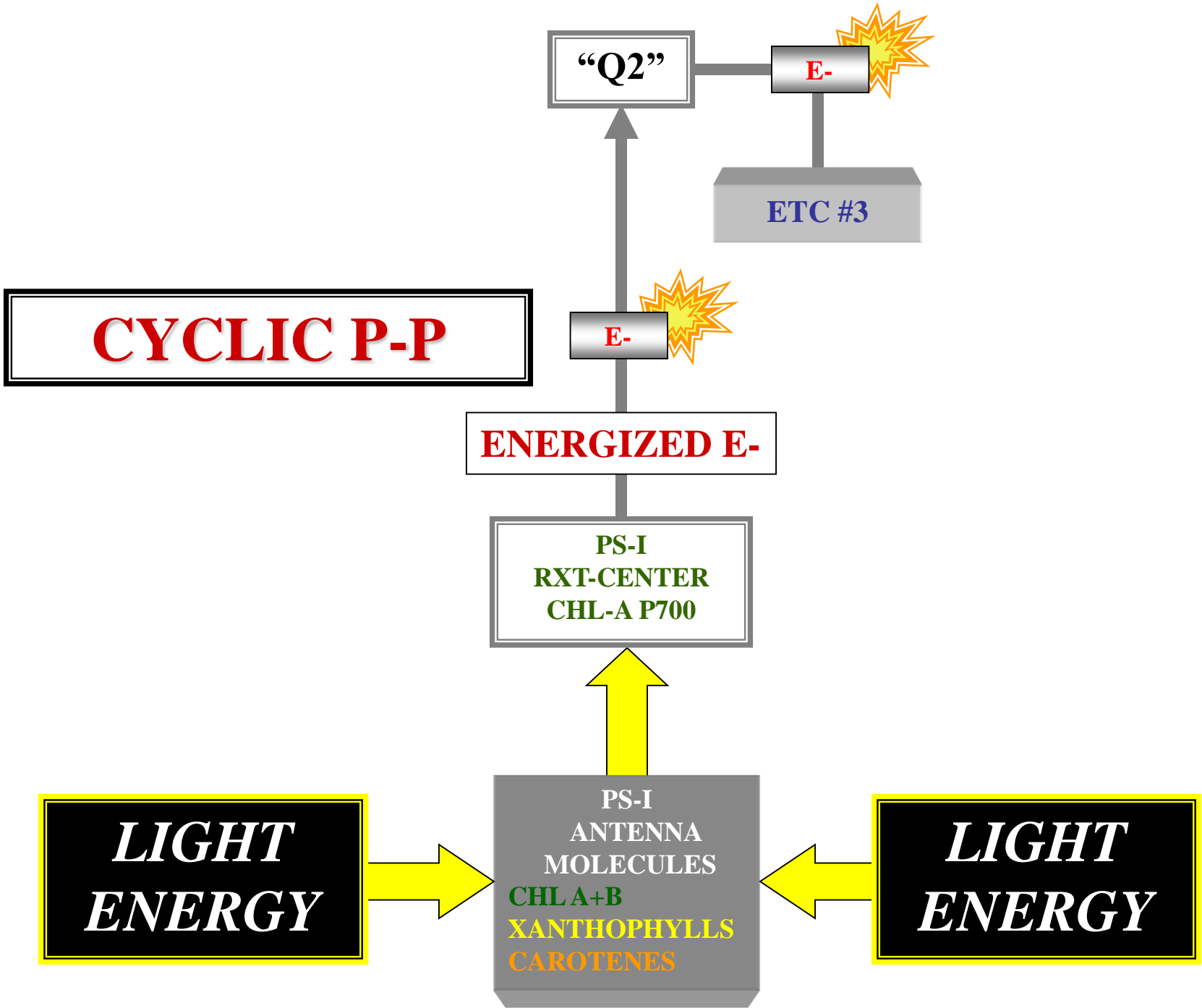


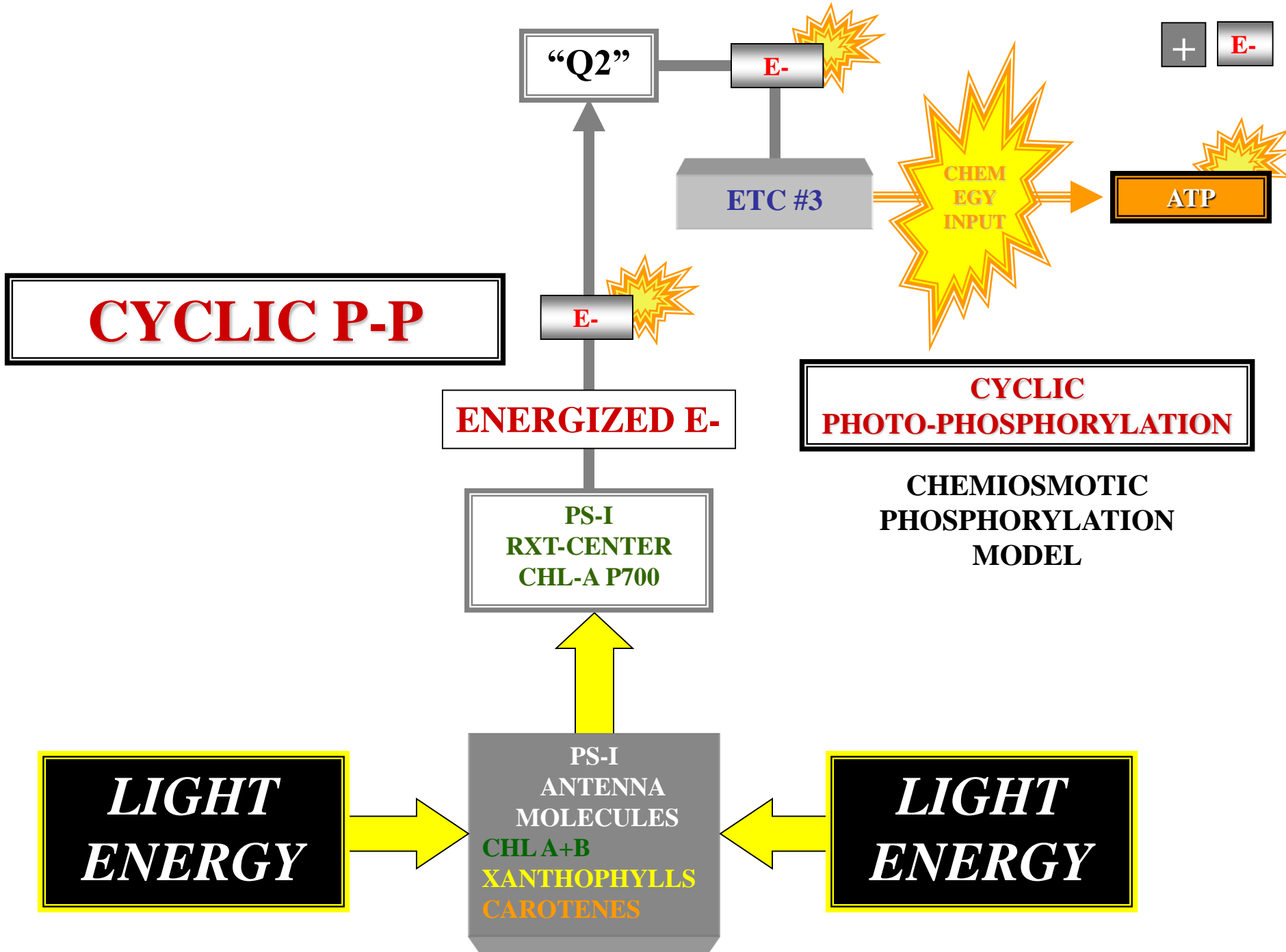
● = ELECTRON TRANSPORT CHAIN COMPONENT
★ = HEAT ENERGY ★ = CHEMICAL ENERGY

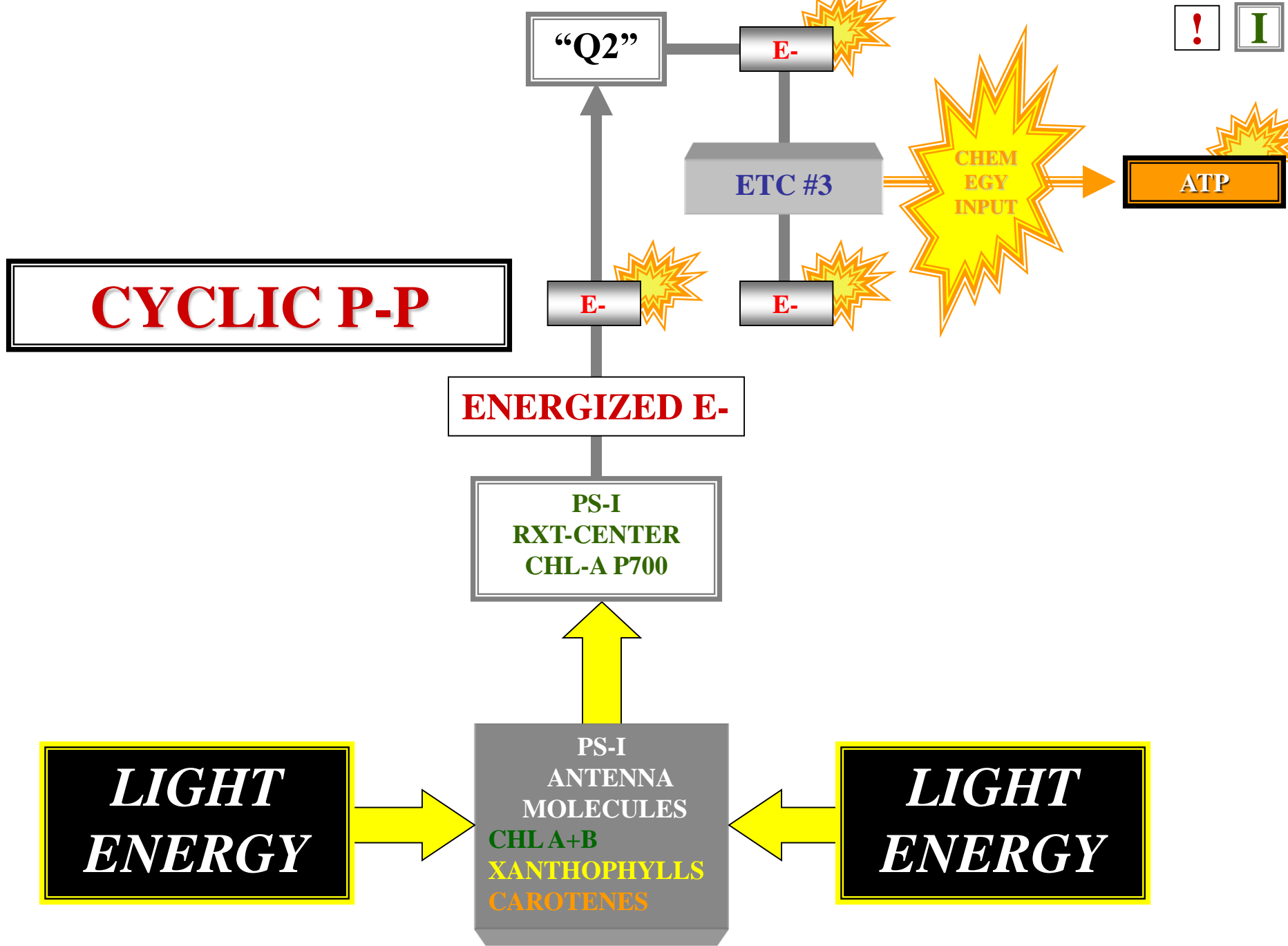


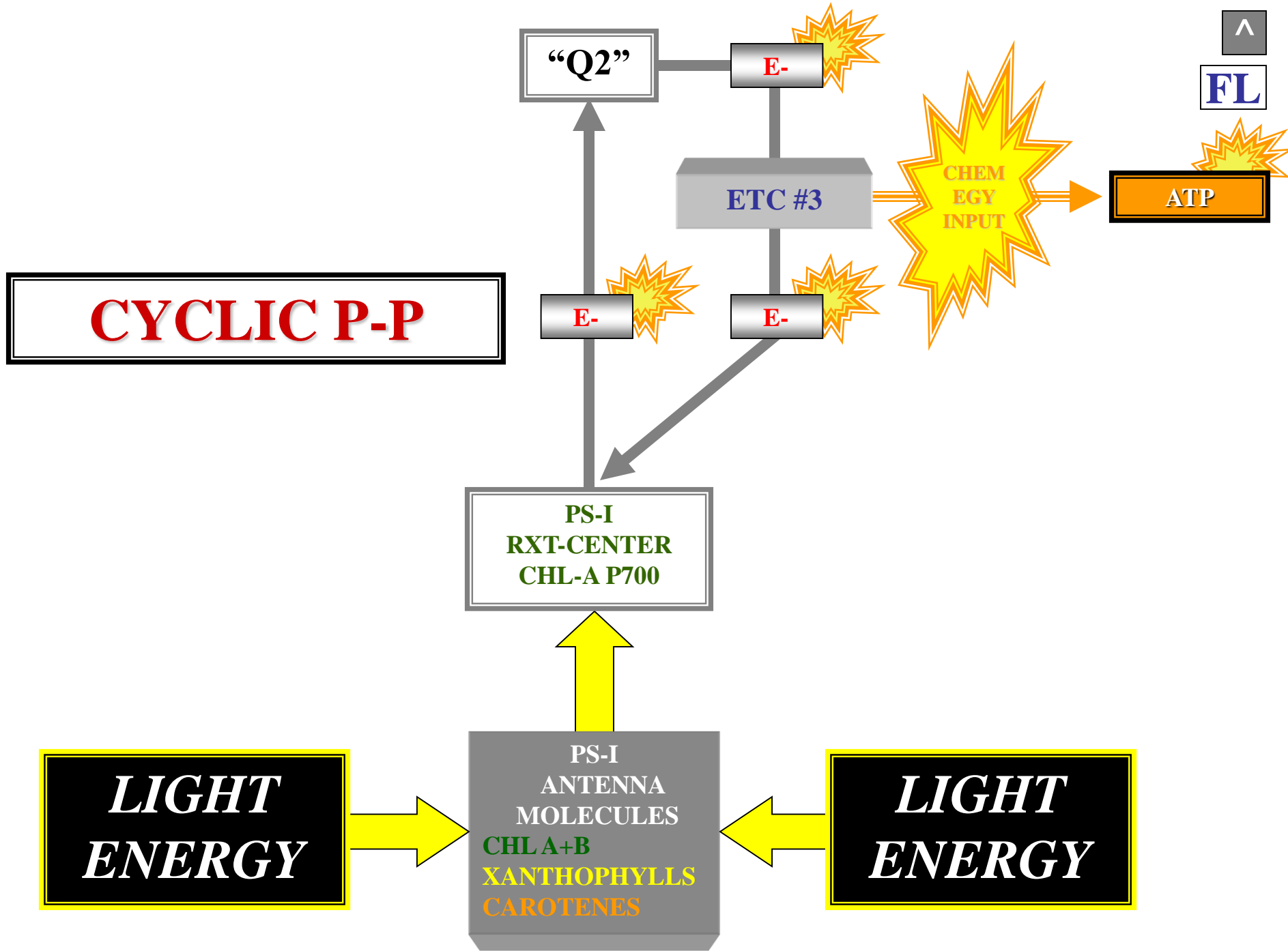
A green maple leaf is centered in the frame, set against a blue sky with scattered white clouds. The leaf's veins are clearly visible, and its stem points downwards. The text is overlaid on the leaf and sky.

LIGHT REACTION
CYCLIC
PHOTO-PHOSPHORYLATION
SUMMARY







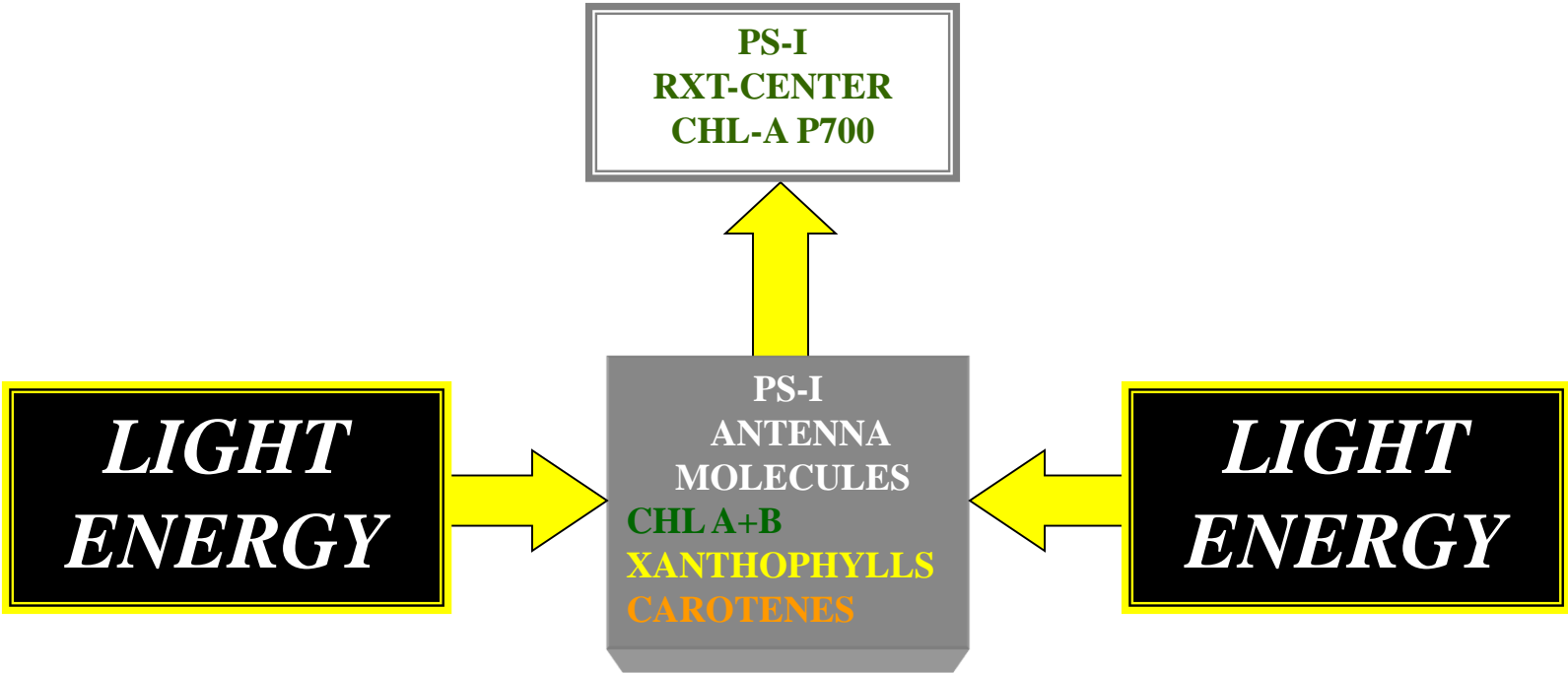




LIGHT REACTION
CYCLIC
PHOTO-PHOSPHORYLATION
E- FLOW



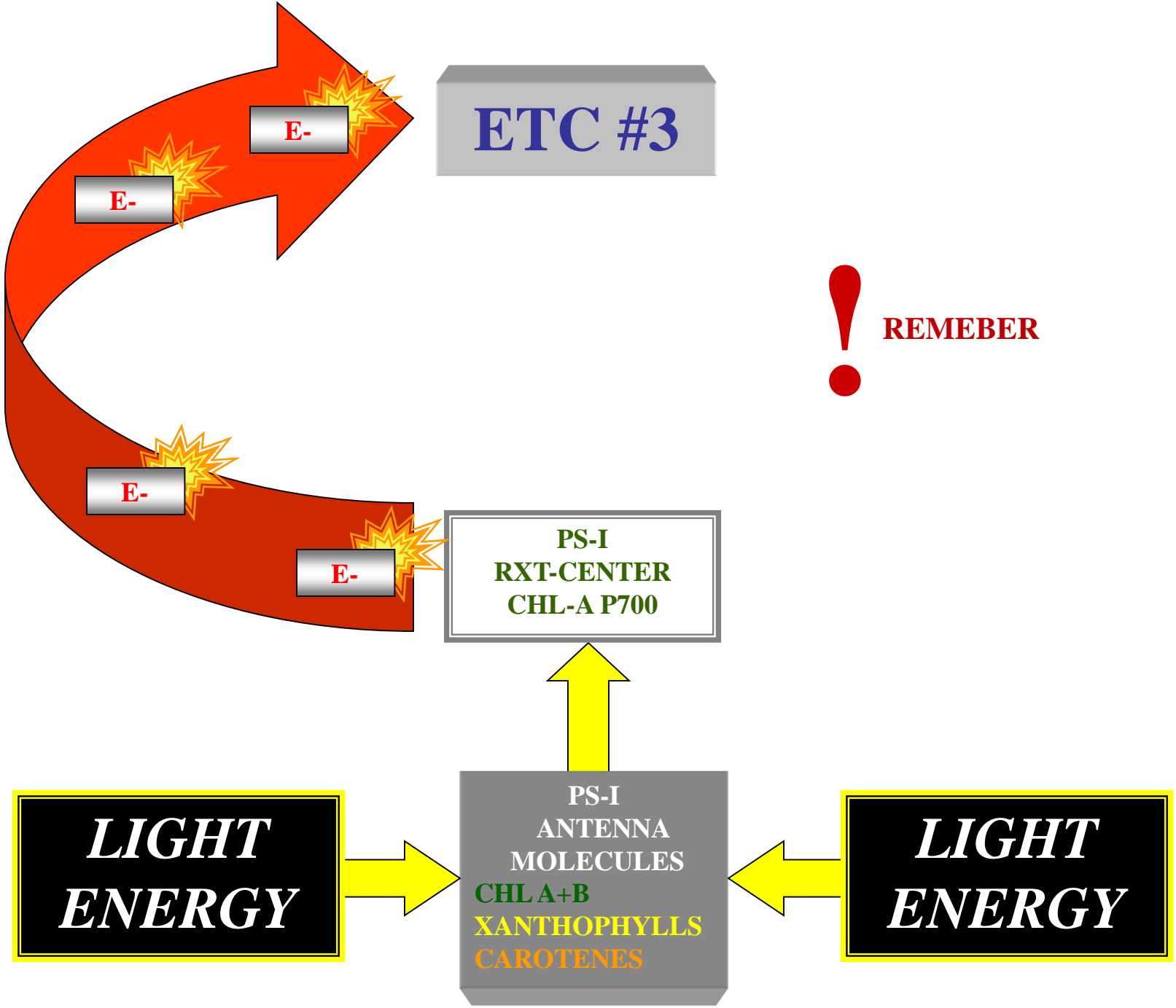
ETC #3



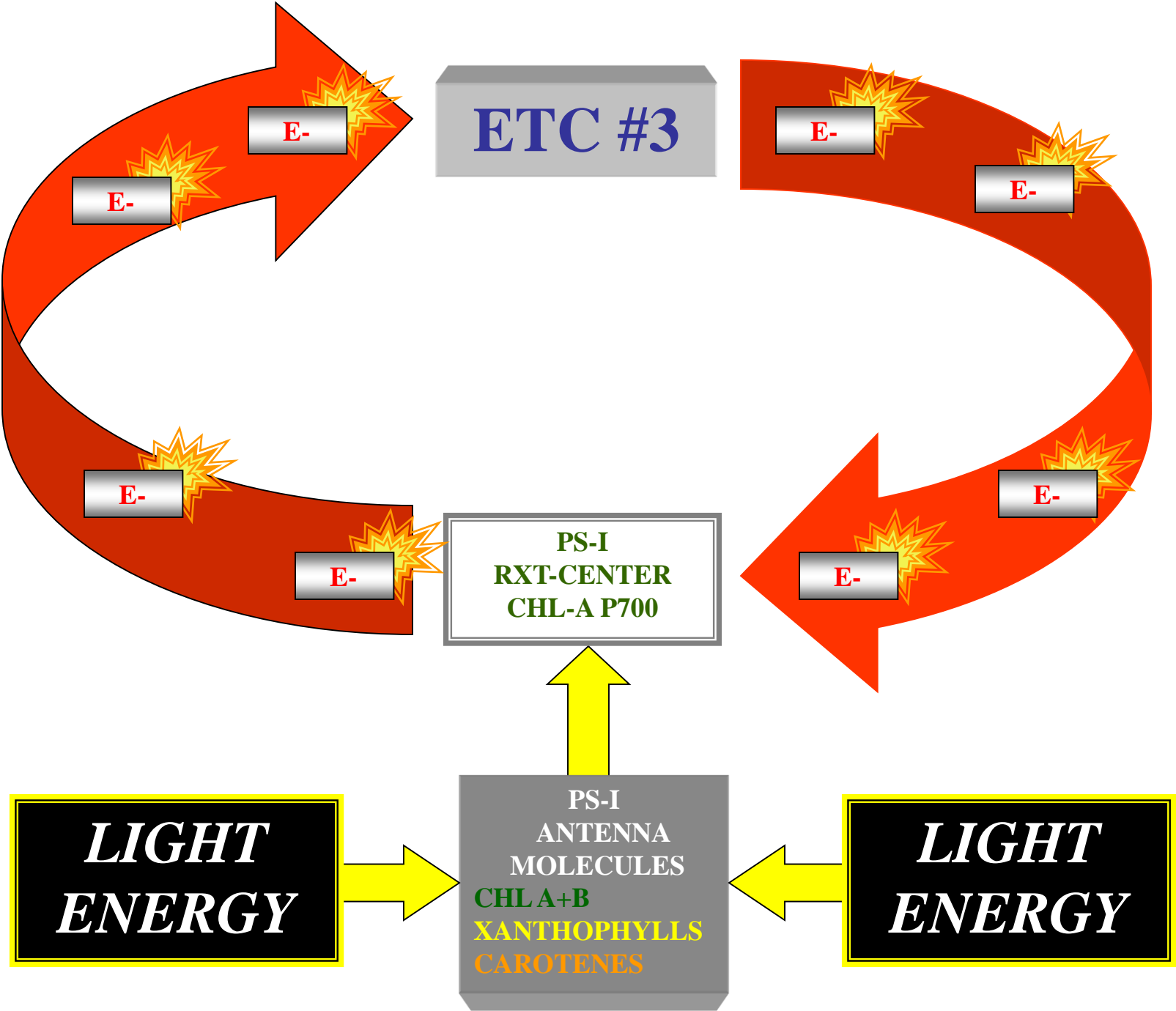
E-

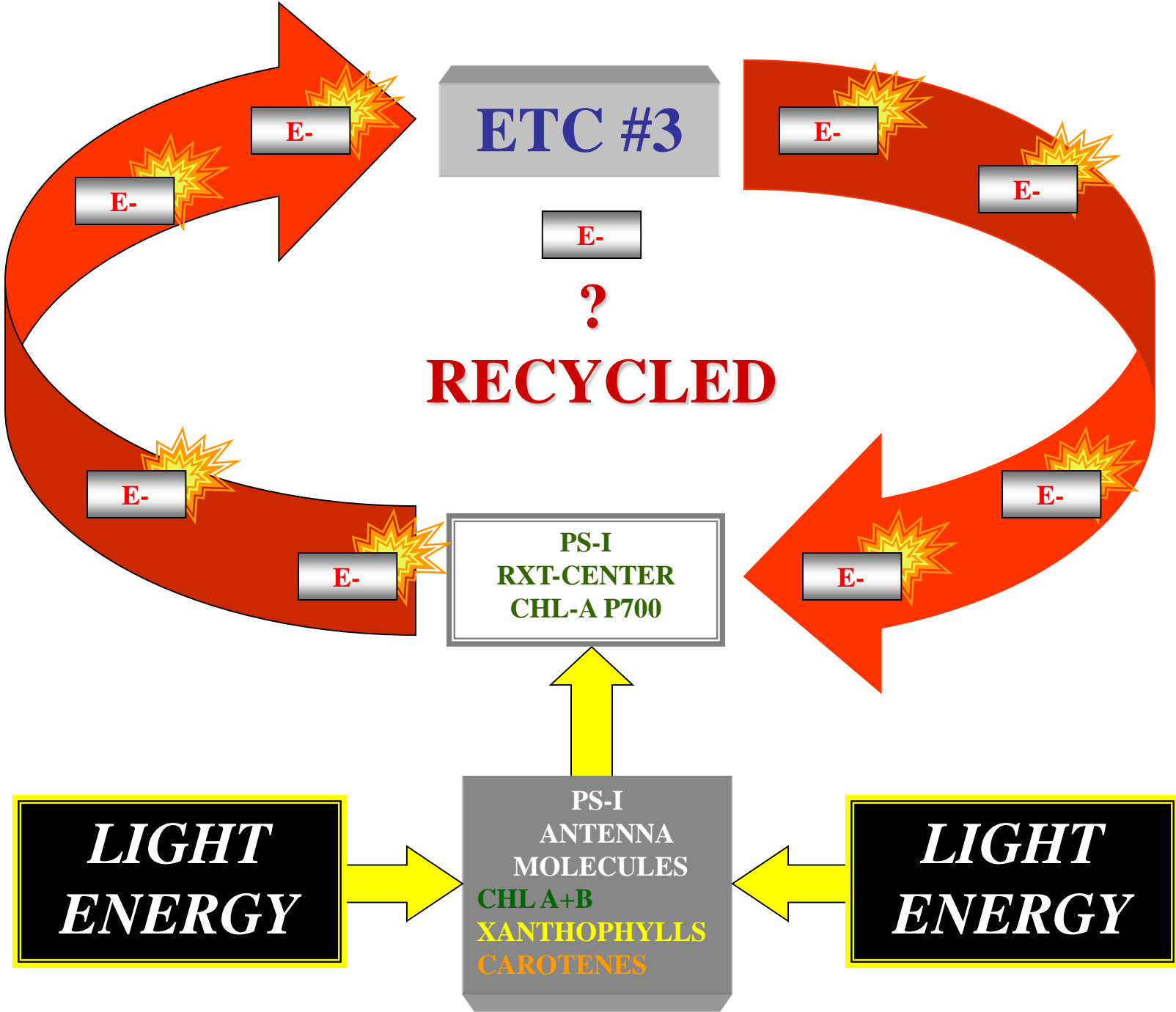


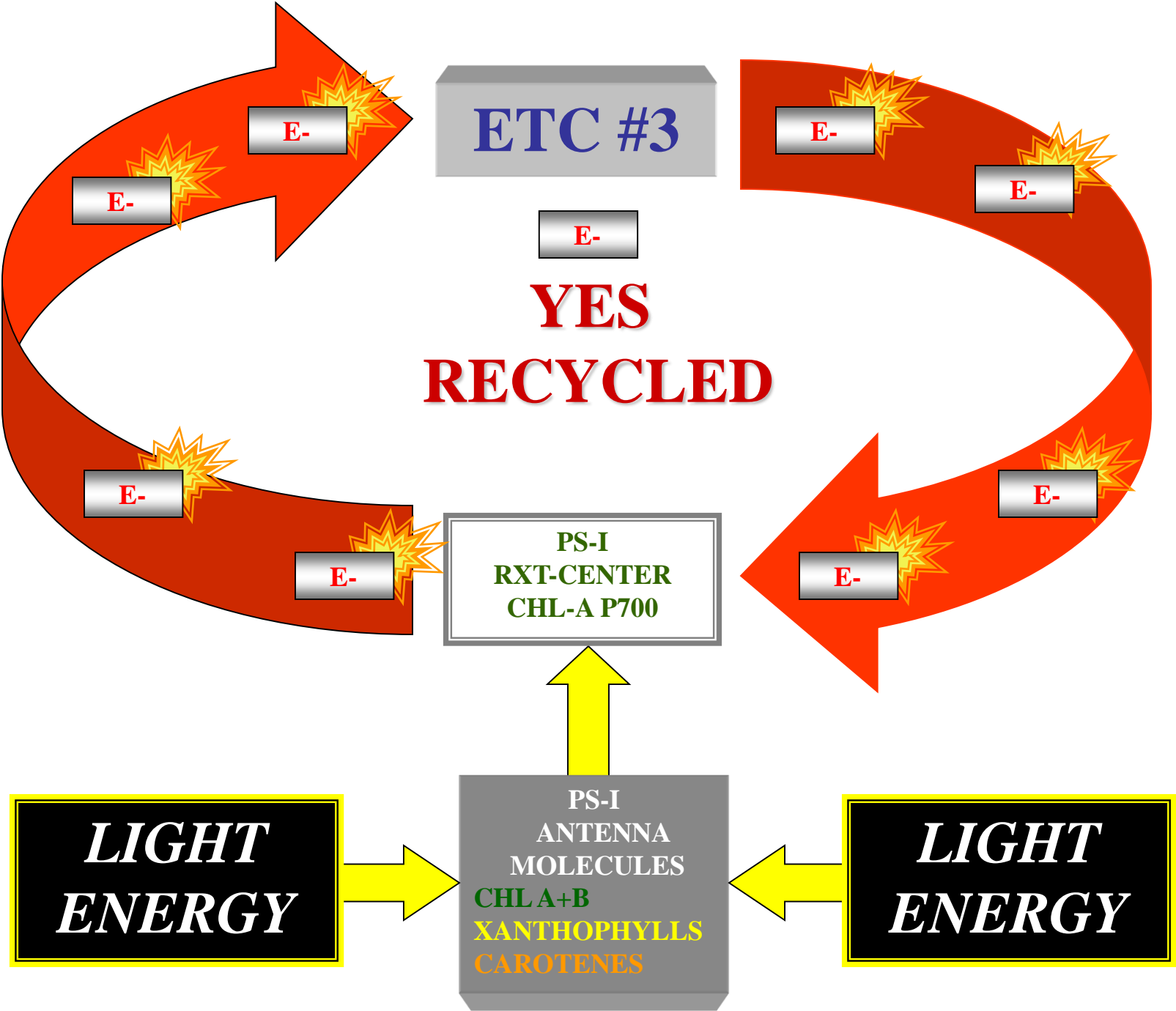
I

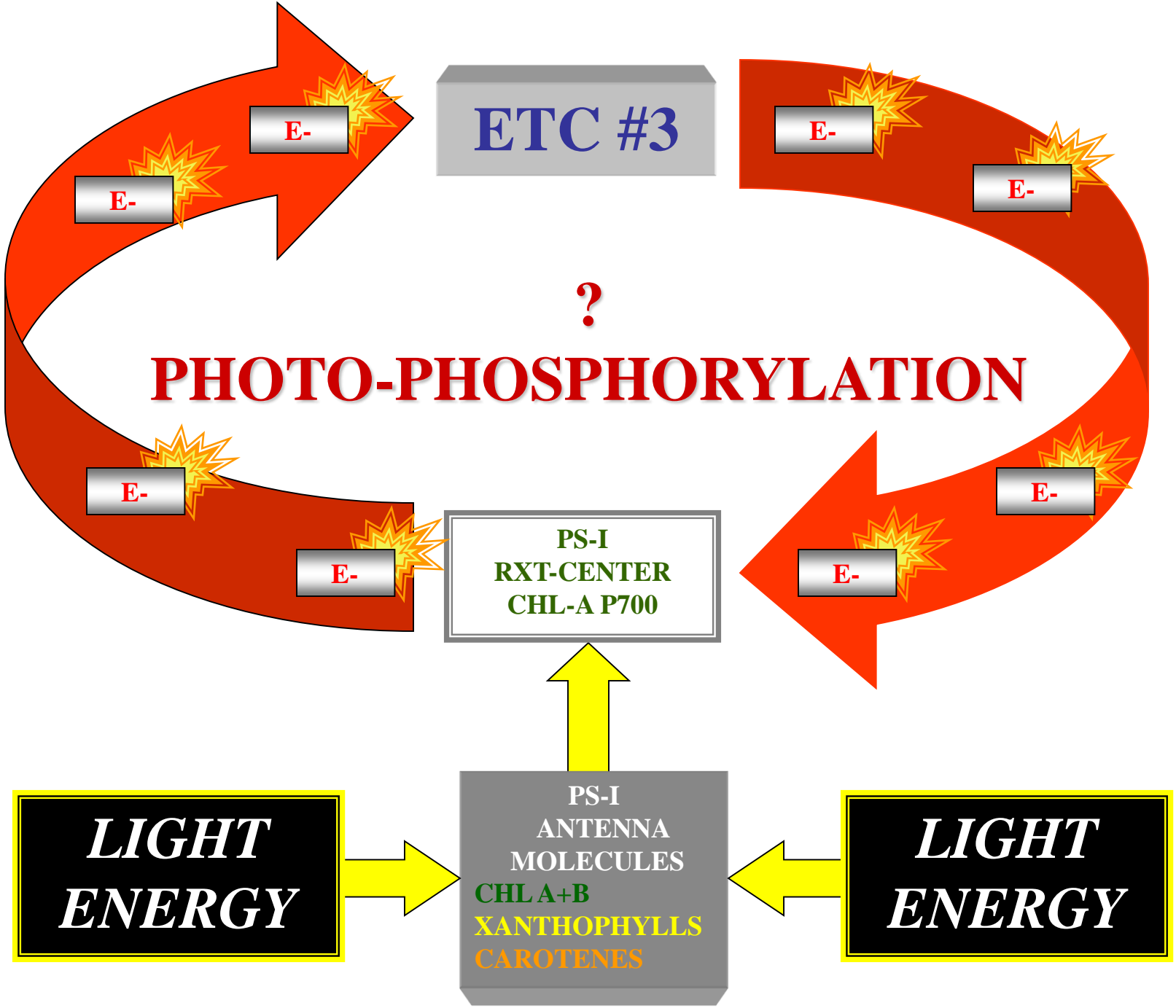


! REMEMBER









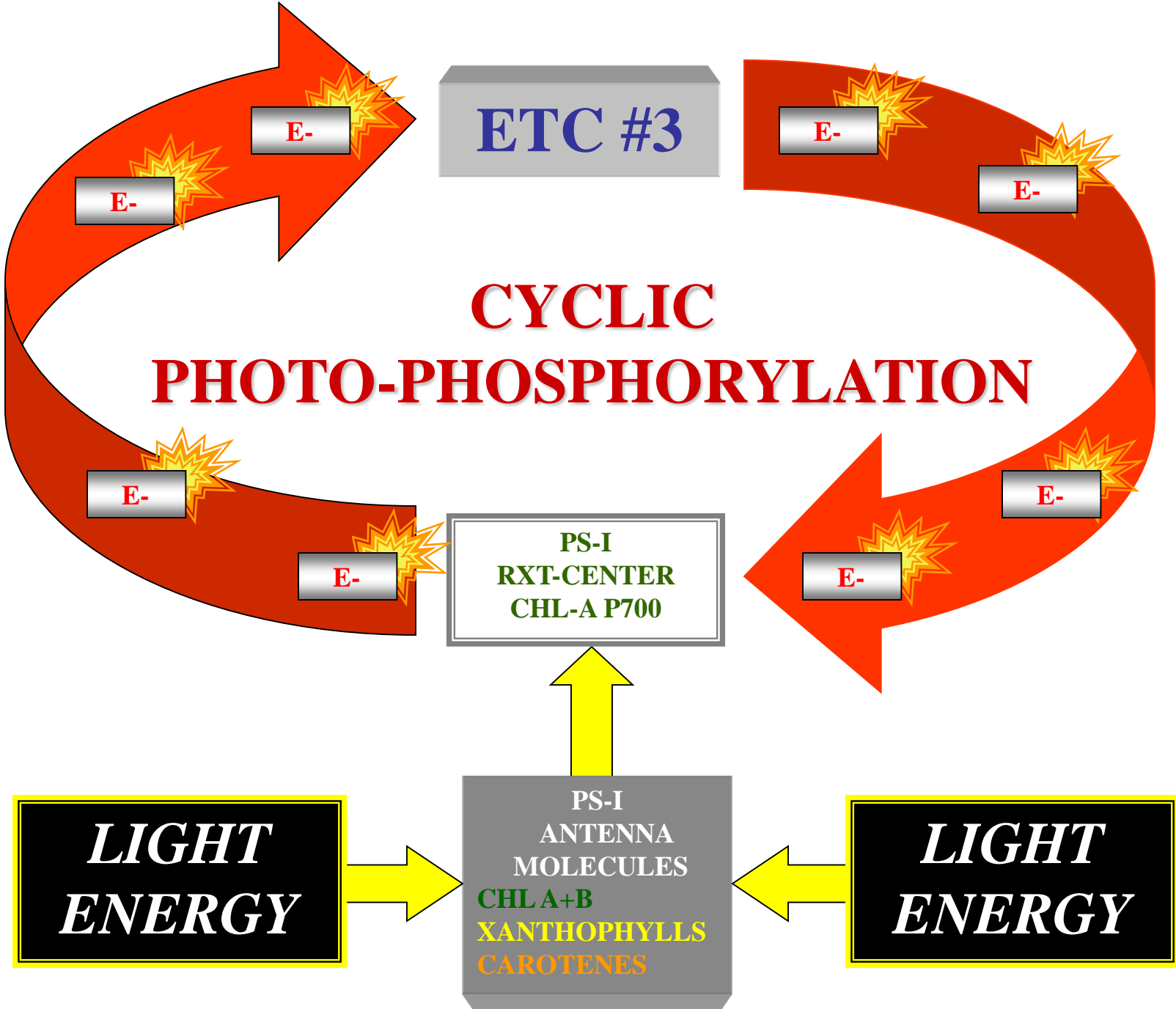
E-

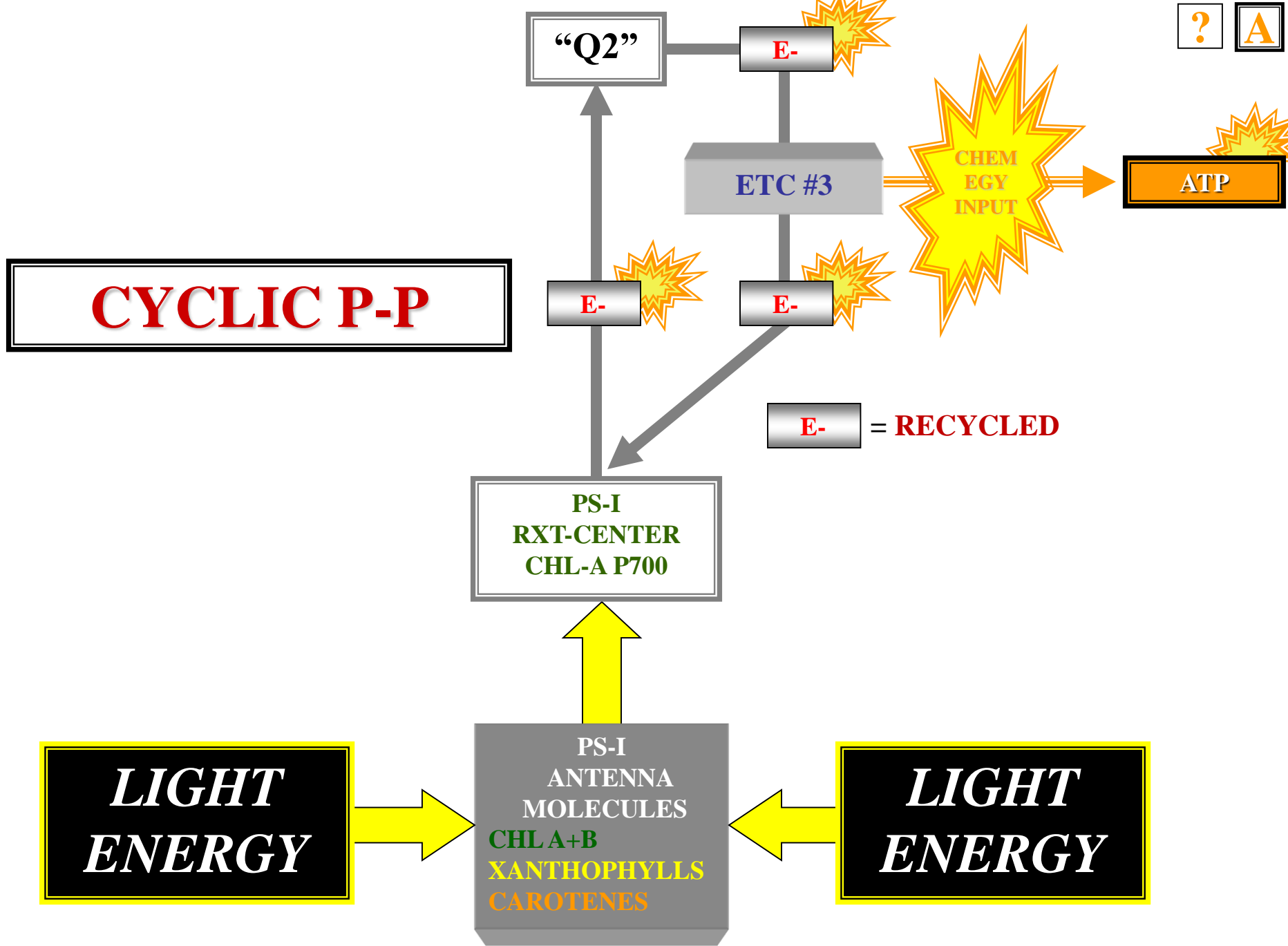
C



ETC #3

CYCLIC PHOTO-PHOSPHORYLATION



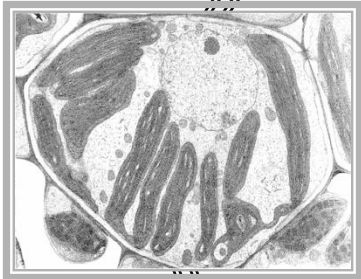


PHOTOSYNTHESIS

A



LIGHT ENERGY

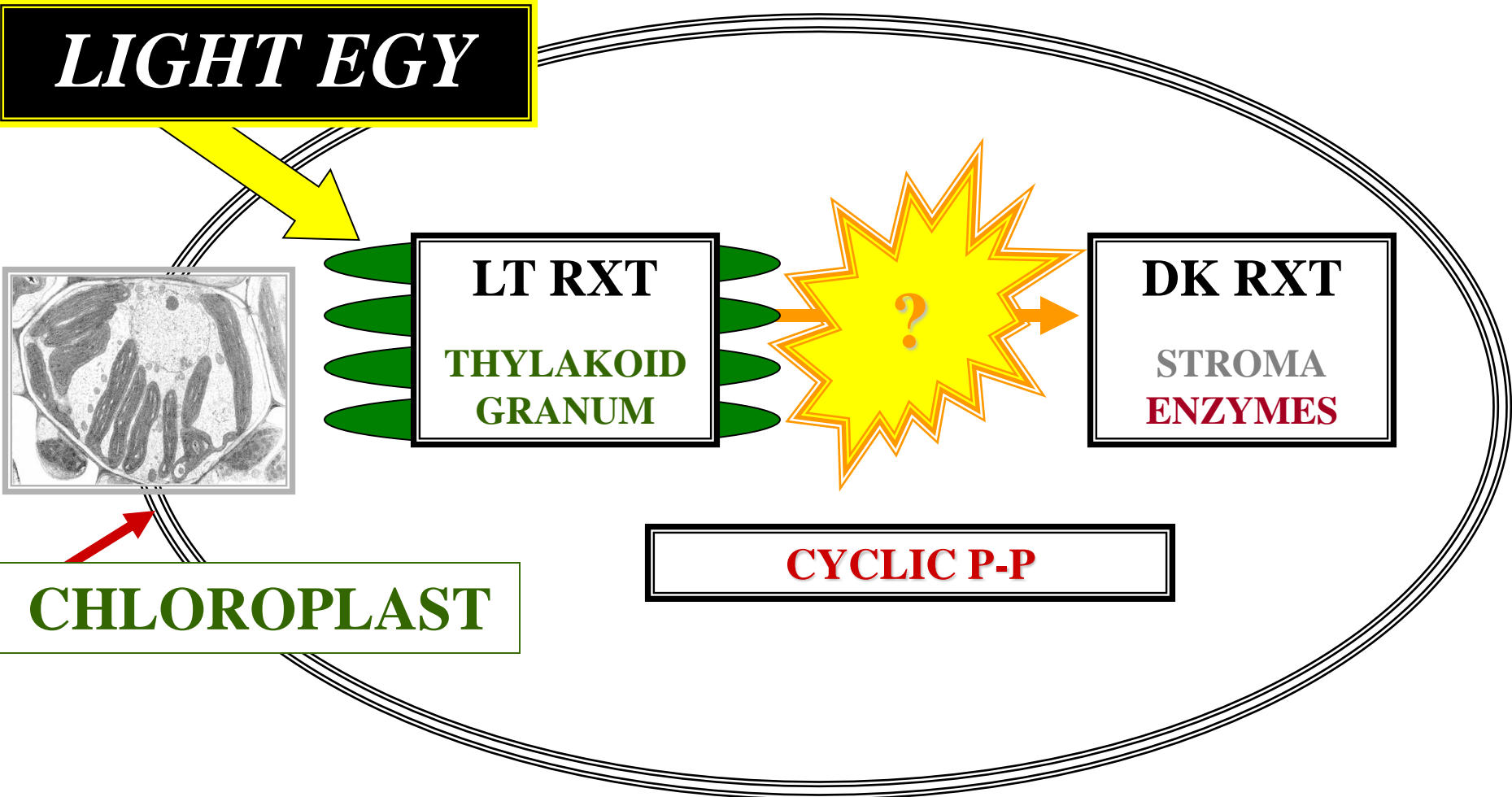


CHLOROPLAST

LT RXT
THYLAKOID
GRANUM

DK RXT
STROMA
ENZYMES

CYCLIC P-P



PHOTOSYNTHESIS



S

C



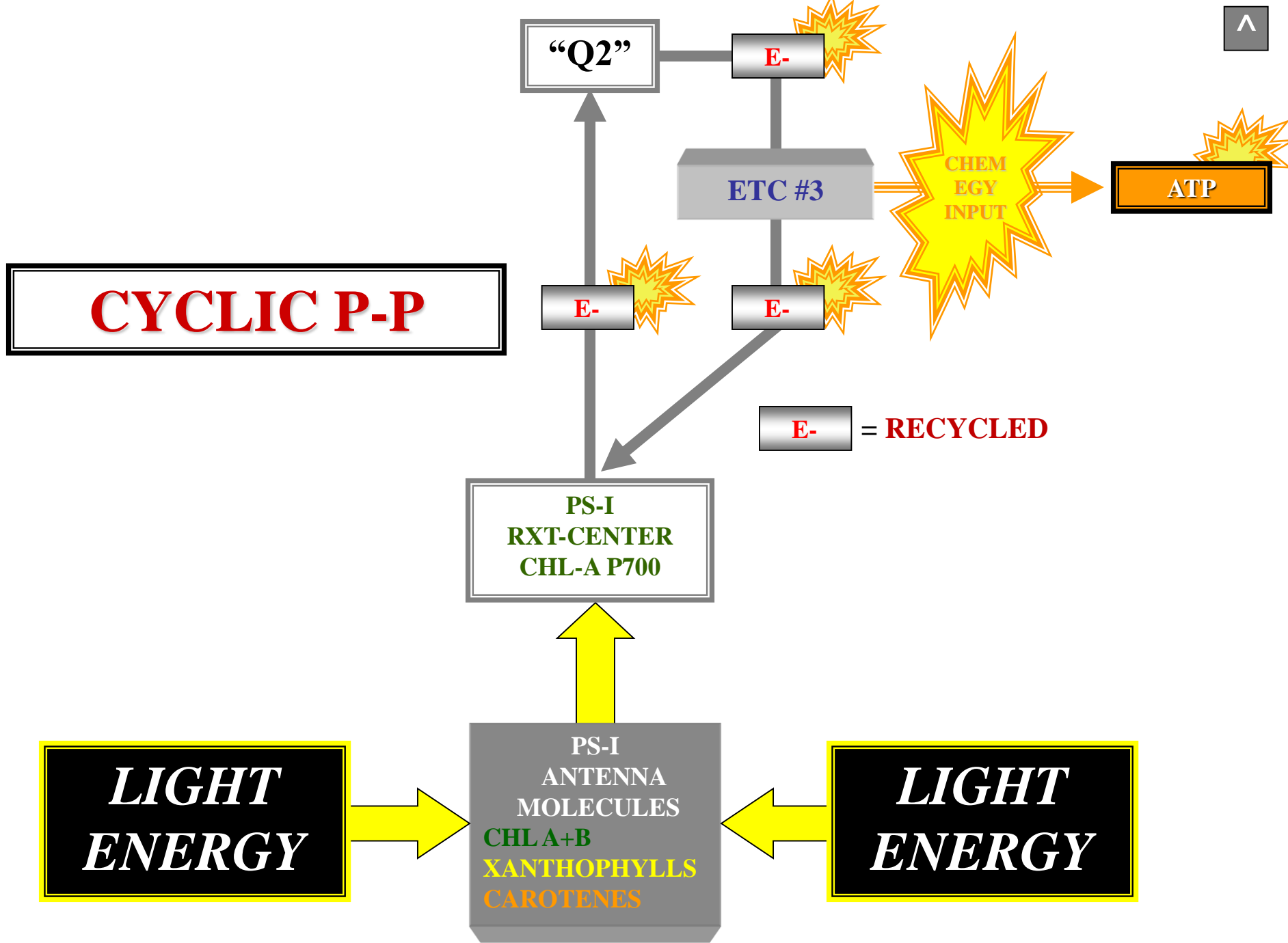
LIGHT ENERGY



CHLOROPLAST



CYCLIC P-P



CYCLIC PHOTO PHOSPHORYLATION IMPORTANCE

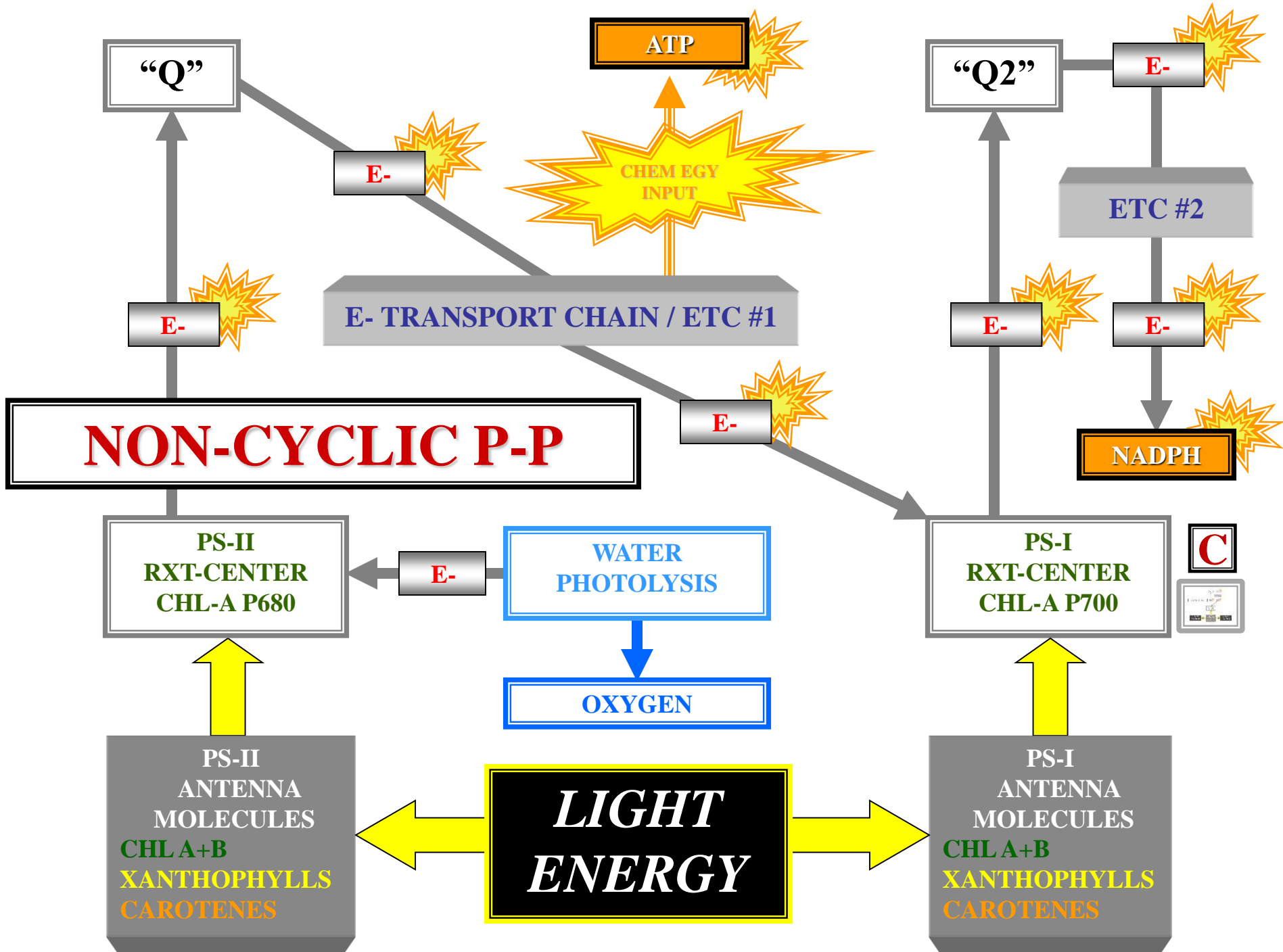
PHOTOSYNTHESIS

N



LIGHT REACTION

MAPLE



CYCLIC P-P

“Q2”

E-

ETC #3

CHEM
EGY
INPUT

ATP

E-

E-

E- = RECYCLED

PS-I
RXT-CENTER
CHL-A P700

LIGHT
ENERGY

PS-I
ANTENNA
MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES

LIGHT
ENERGY

DARK REACTION ^G

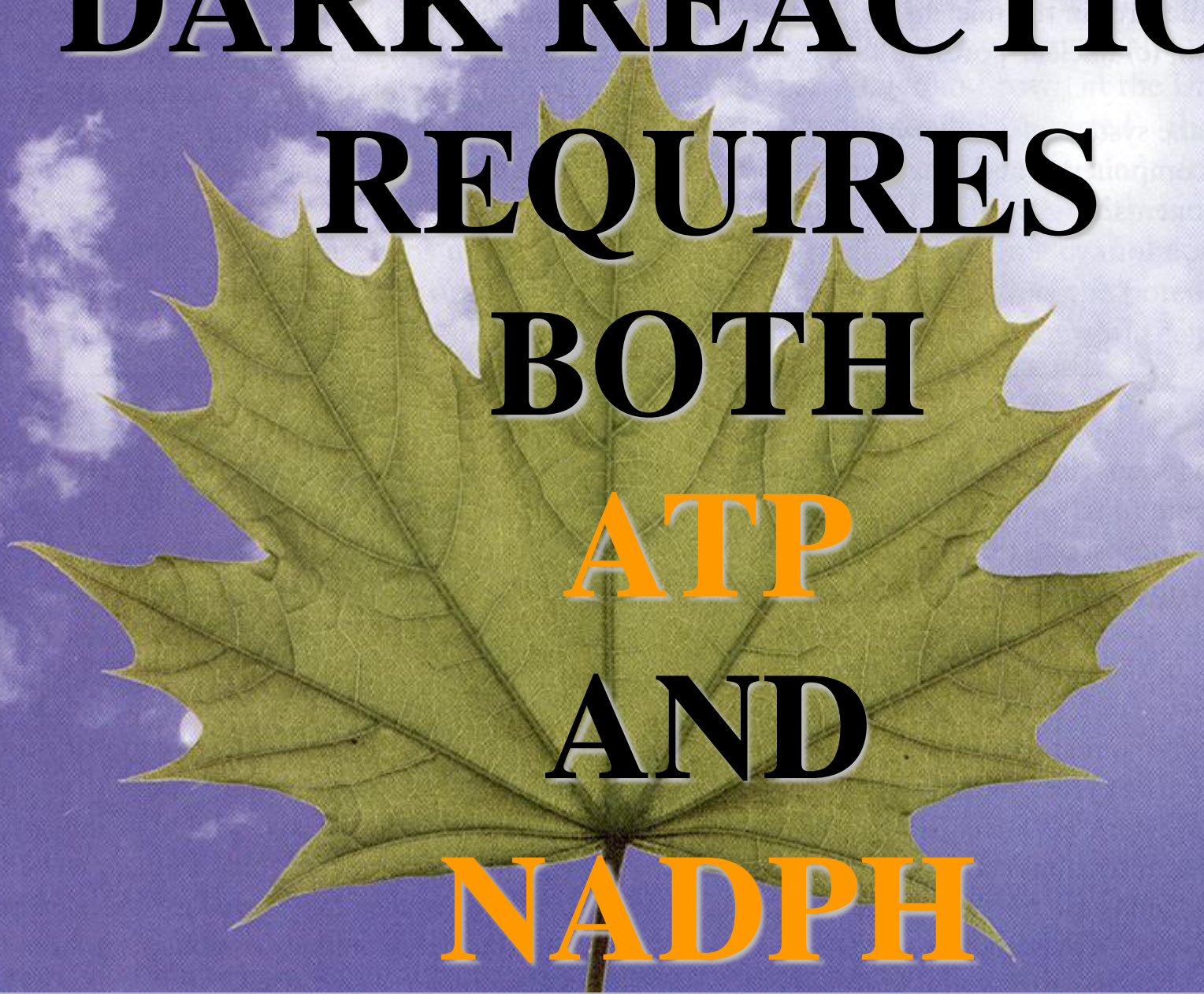
REQUIRES

BOTH

ATP

AND

NADPH





CO₂ + RIBULOSE BISPHOSPHATE / (RUBP)

RIBULOSE BISPHOSPHATE CARBOXYLASE (RUBP-CARBOXYLASE)



PHOSPHOGLYCERATE / (PGA)

UNSTABLE 6C COMPOUND

PHOSPHOGLYCERATE / (PGA)

ATP

ATP

?

C

BISPHOGLYCERATE / (BIPGA)

BISPHOGLYCERATE / (BIPGA)

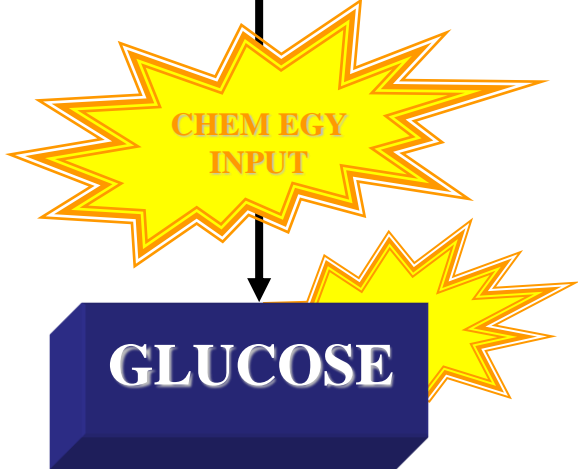
NADPH

NADPH

ALL RXTS REQUIRE A SPECIFIC ENZYME

PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)



DARK REACTION

COMPLEX SERIES CHEMICAL RXTS (CSCR)

ATP

RIBULOSE BISPHOSPHATE / (RUBP)

CYCLIC P-P

“Q2”

E-

ETC #3

CHEM
EGY
INPUT

ATP

E-

E-

E- = RECYCLED

PS-I
RXT-CENTER
CHL-A P700

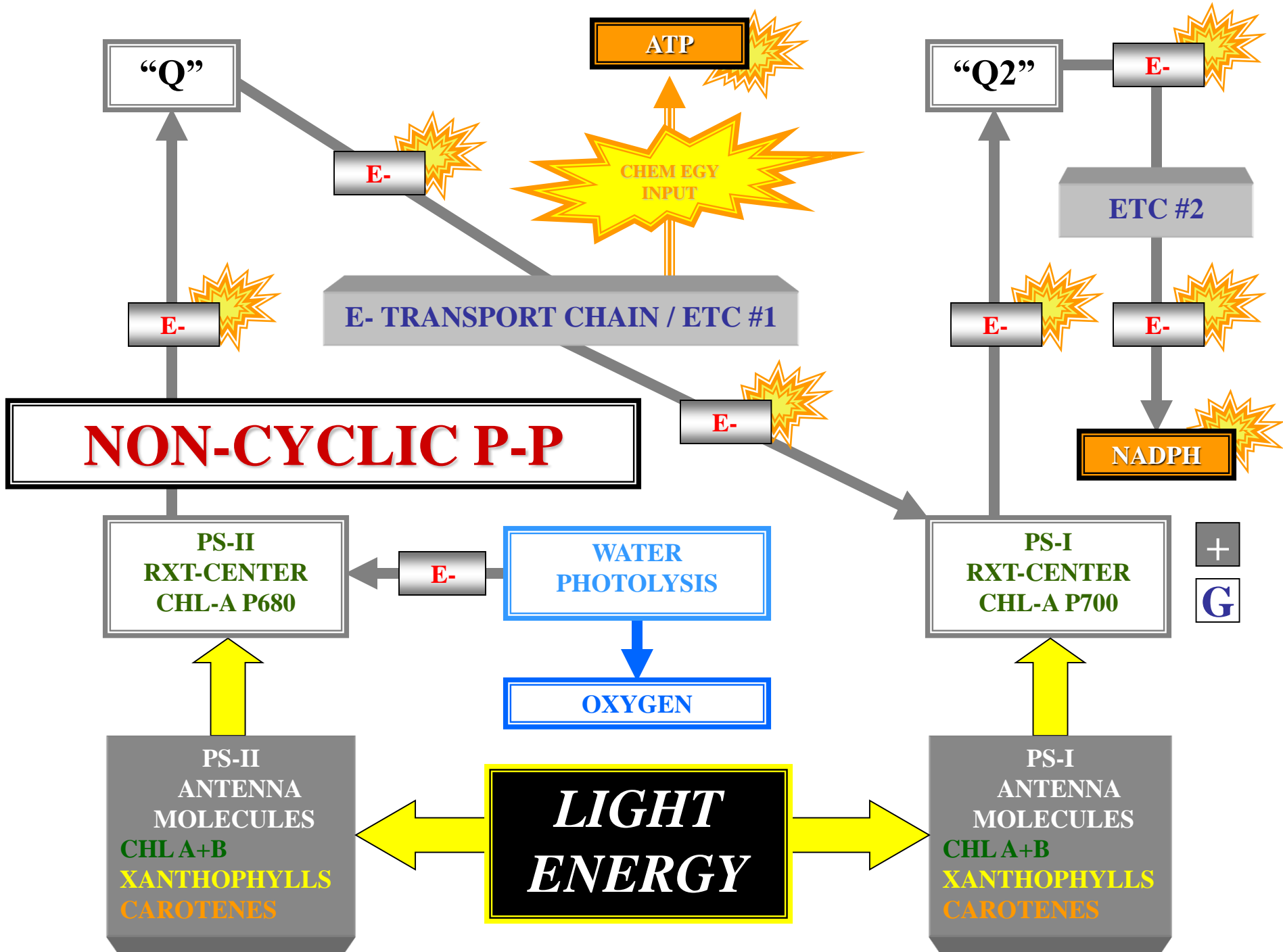
LIGHT
ENERGY

PS-I
ANTENNA
MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES

LIGHT
ENERGY

?

N





CO₂ + RIBULOSE BISPHOSEPHATE / (RUBP)

RIBULOSE BISPHOSEPHATE CARBOXYLASE (RUBP-CARBOXYLASE)



PHOSPHOGLYCERATE / (PGA)

UNSTABLE 6C COMPOUND

PHOSPHOGLYCERATE / (PGA)

ATP

ATP



BISPHOSEPHOGLYCERATE / (BIPGA)

BISPHOSEPHOGLYCERATE / (BIPGA)

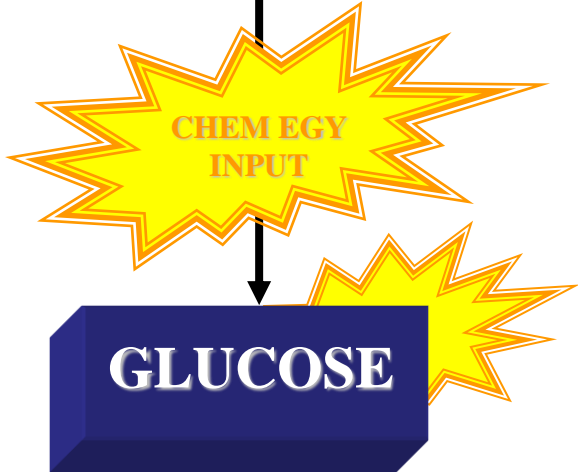
NADPH

NADPH

PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)

ALL RXTS REQUIRE A SPECIFIC ENZYME



DARK REACTION

COMPLEX SERIES CHEMICAL RXTS (CSCR)

ATP

RIBULOSE BISPHOSEPHATE / (RUBP)



**PLANTS PREFER
NON-CYCLIC P-P
OVER
CYCLIC P-P**

DARK REACTION ^G

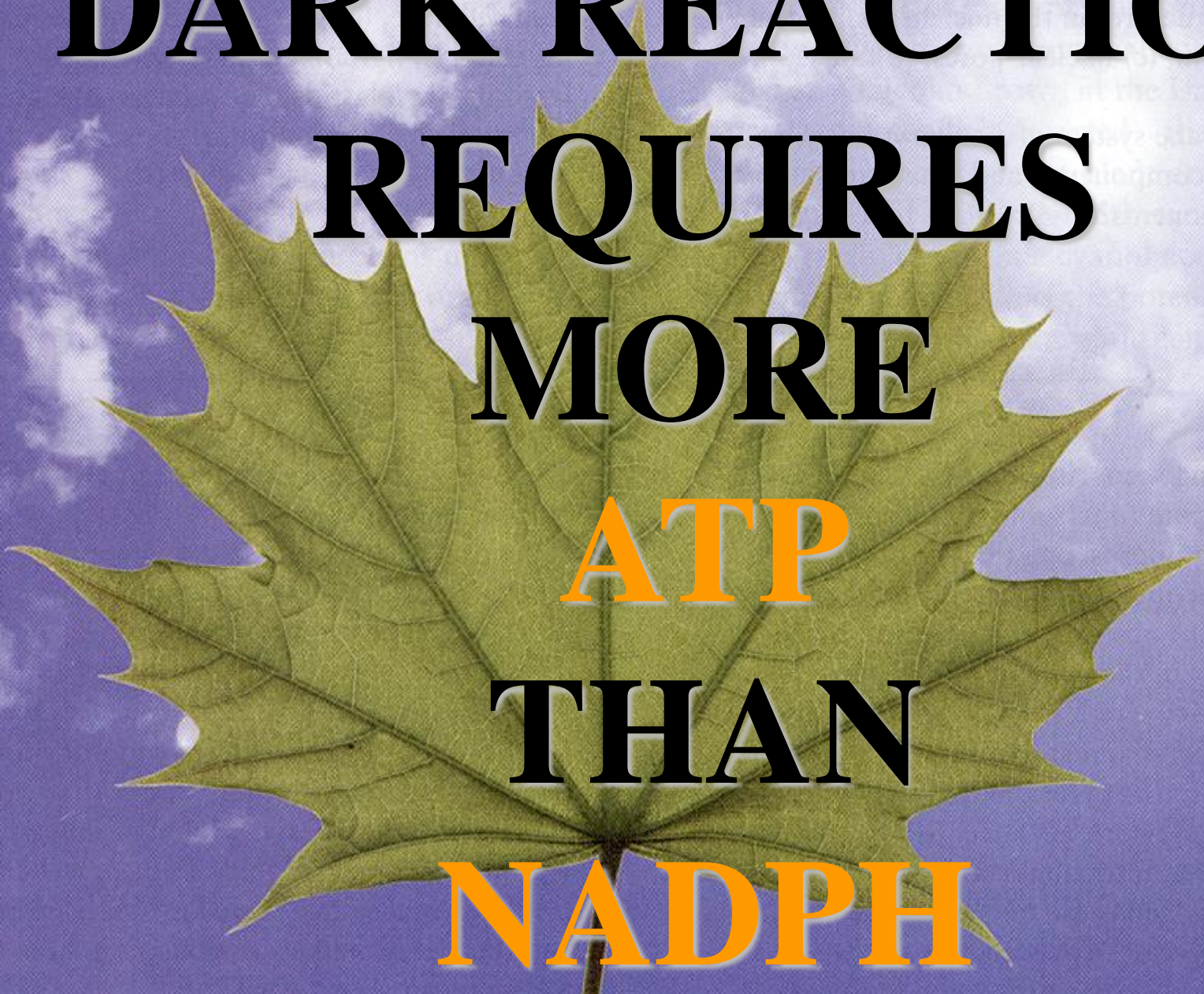
REQUIRES

MORE

ATP

THAN

NADPH





CO₂ + RIBULOSE BISPHOSPHATE / (RUBP)

RIBULOSE BISPHOSPHATE CARBOXYLASE (RUBP-CARBOXYLASE)



PHOSPHOGLYCERATE / (PGA)

UNSTABLE 6C COMPOUND

PHOSPHOGLYCERATE / (PGA)

ATP

ATP

3

BISPHOGLYCERATE / (BIPGA)

BISPHOGLYCERATE / (BIPGA)

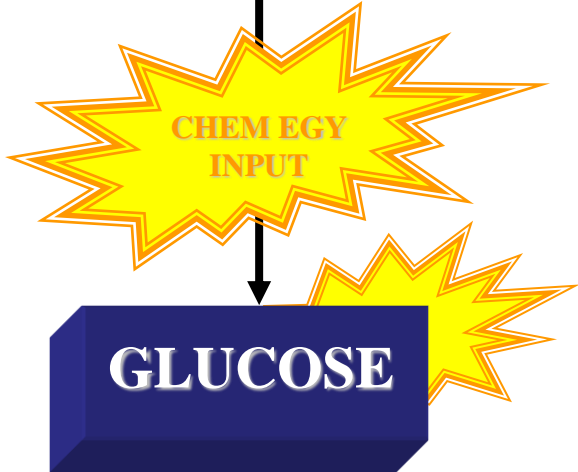
NADPH

NADPH

PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)

ALL RXTS REQUIRE A SPECIFIC ENZYME



DARK REACTION

COMPLEX SERIES CHEMICAL RXTS (CSCR)

ATP

RIBULOSE BISPHOSPHATE / (RUBP)



$\text{CO}_2 + \text{RIBULOSE BISPHOSEPHATE / (RUBP)}$

**RIBULOSE BISPHOSEPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)**



PHOSPHOGLYCERATE / (PGA)

UNSTABLE 6C COMPOUND

PHOSPHOGLYCERATE / (PGA)

ATP

ATP

BISPHOSEPHOGLYCERATE / (BIPGA)

BISPHOSEPHOGLYCERATE / (BIPGA)

+

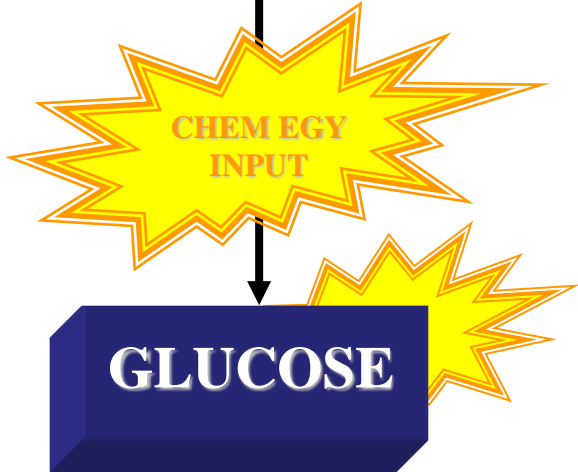
NADPH

NADPH

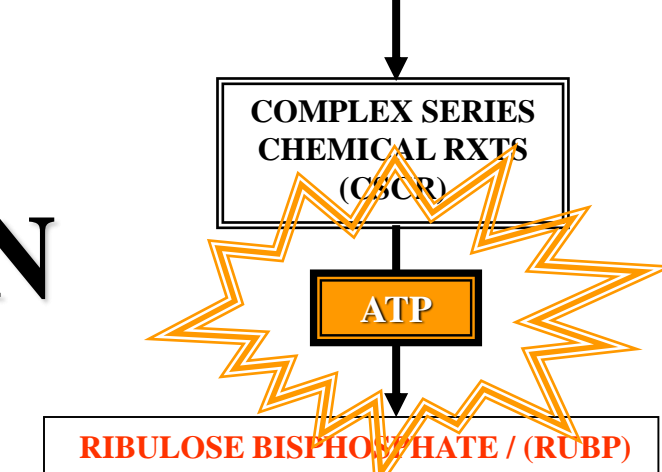
PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)

**ALL RXTS
REQUIRE
A SPECIFIC
ENZYME**



DARK REACTION





CO₂ + **RIBULOSE BISPHOSPHATE / (RUBP)**



**RIBULOSE BISPHOSPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)**

UNSTABLE 6C COMPOUND

PHOSPHOGLYCERATE / (PGA)

PHOSPHOGLYCERATE / (PGA)

ATP

ATP

N

1

BISPHOGLYCERATE / (BPGA)

BISPHOGLYCERATE / (BPGA)

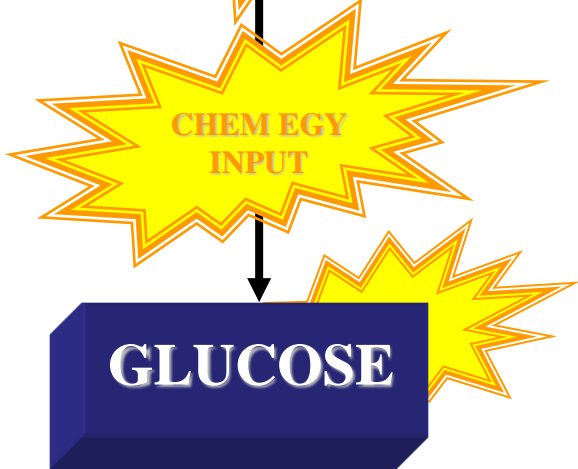
NADPH

NADPH

PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)

**ALL RXTS
REQUIRE
A SPECIFIC
ENZYME**

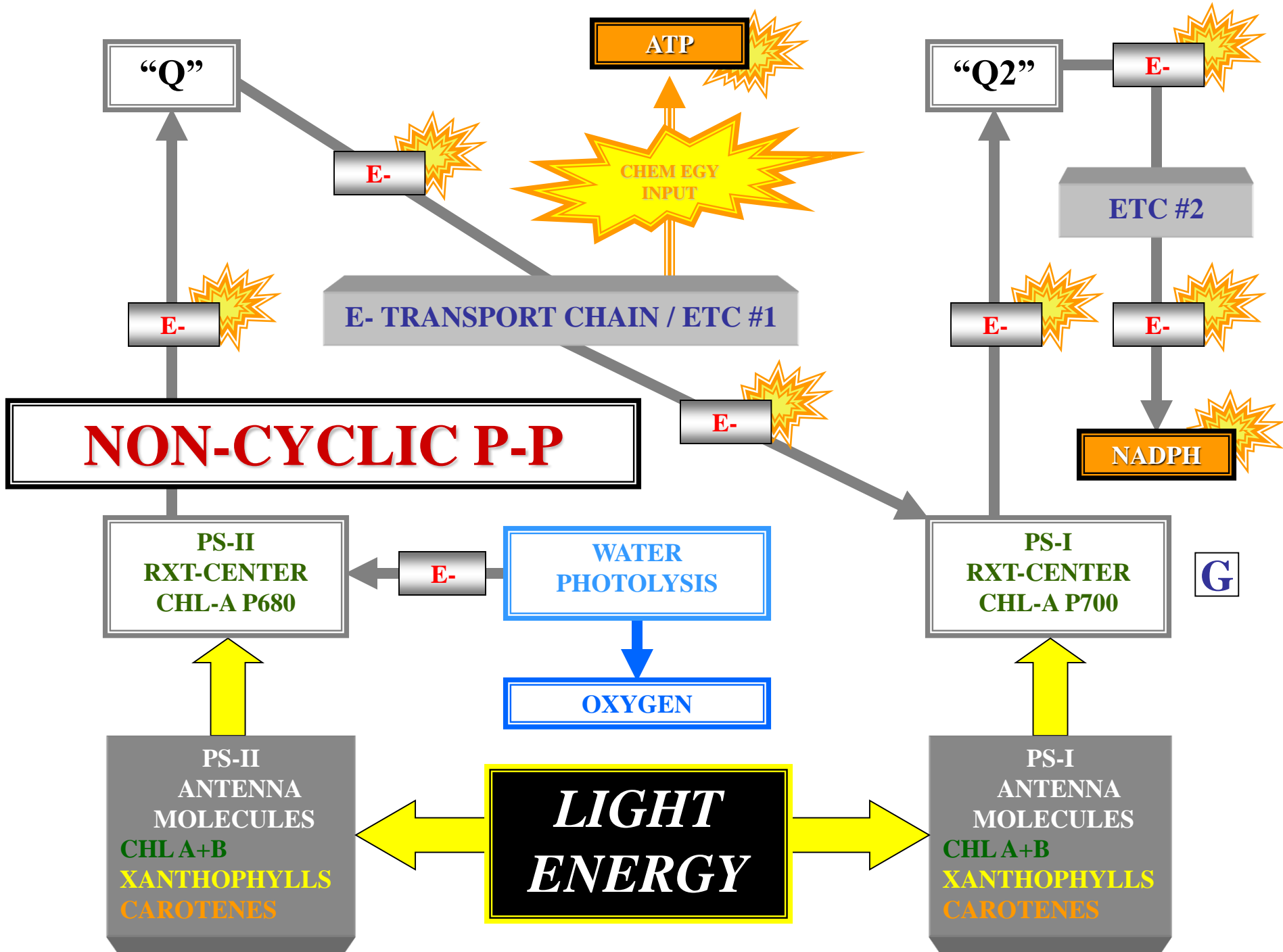


DARK REACTION

**COMPLEX SERIES
CHEMICAL RXTS
(CSCR)**

ATP

RIBULOSE BISPHOSPHATE / (RUBP)





CO₂ + RIBULOSE BISPHOSEPHATE / (RUBP)

RIBULOSE BISPHOSEPHATE CARBOXYLASE (RUBP-CARBOXYLASE)



PHOSPHOGLYCERATE / (PGA)

UNSTABLE 6C COMPOUND

PHOSPHOGLYCERATE / (PGA)

ATP

ATP

3

BISPHOGLYCERATE / (BIPGA)

BISPHOGLYCERATE / (BIPGA)

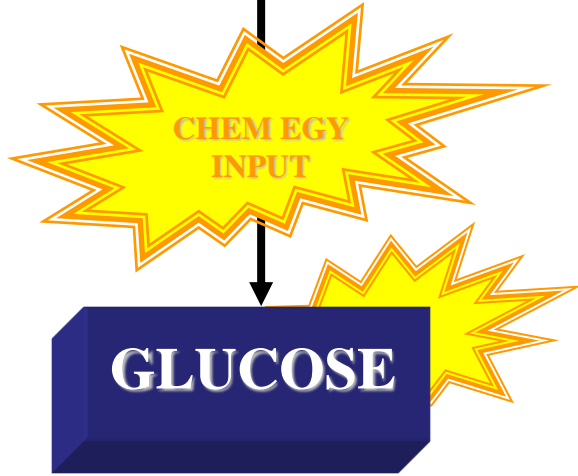
NADPH

NADPH

ALL RXTS REQUIRE A SPECIFIC ENZYME

PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)



DARK REACTION

COMPLEX SERIES CHEMICAL RXTS (CSCR)

ATP

RIBULOSE BISPHOSEPHATE / (RUBP)



$\text{CO}_2 + \text{RIBULOSE BISP HOSPHATE / (RUBP)}$

**RIBULOSE BISP HOSPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)**



PHOSPHOGLYCERATE / (PGA)

UNSTABLE 6C COMPOUND

PHOSPHOGLYCERATE / (PGA)

ATP

ATP

BISP HOSPHOGLYCERATE / (BIPGA)

BISP HOSPHOGLYCERATE / (BIPGA)

+

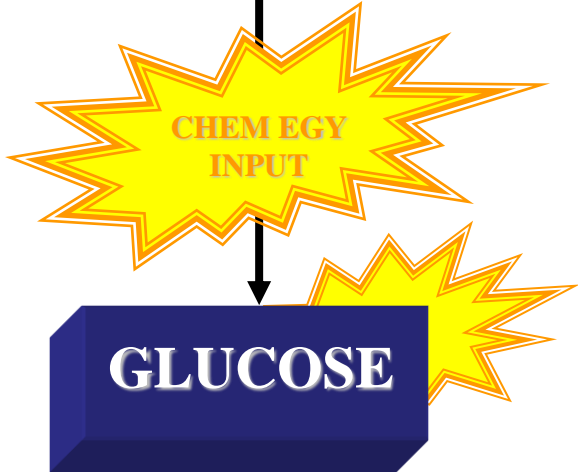
NADPH

NADPH

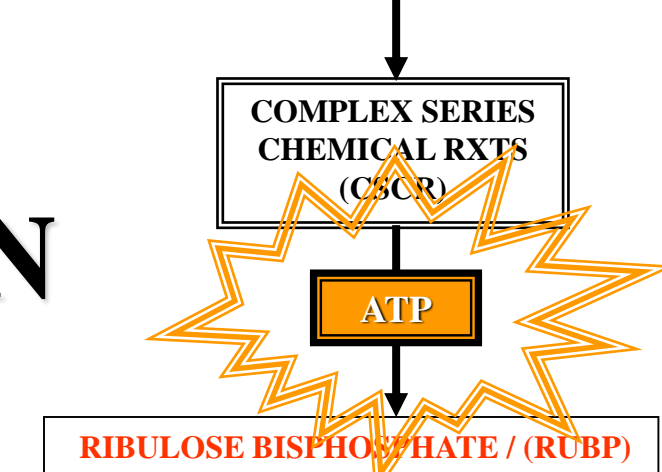
PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)

**ALL RXTS
REQUIRE
A SPECIFIC
ENZYME**



DARK REACTION





CO₂ + **RIBULOSE BISPHOSPHATE / (RUBP)**

**RIBULOSE BISPHOSPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)**



PHOSPHOGLYCERATE / (PGA)

UNSTABLE 6C COMPOUND

PHOSPHOGLYCERATE / (PGA)

ATP

ATP



BISPHOGLYCERATE / (BPGA)

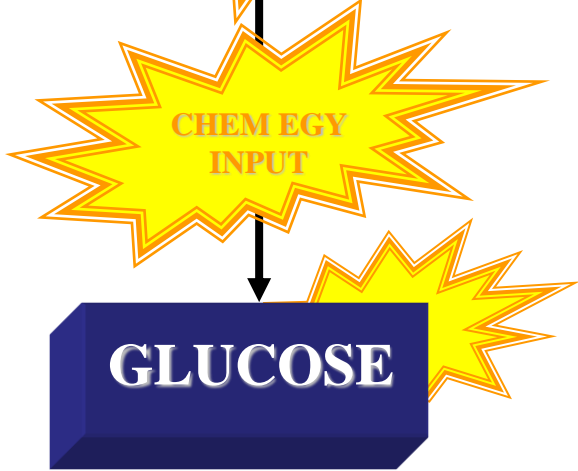
BISPHOGLYCERATE / (BPGA)

NADPH

NADPH

PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)



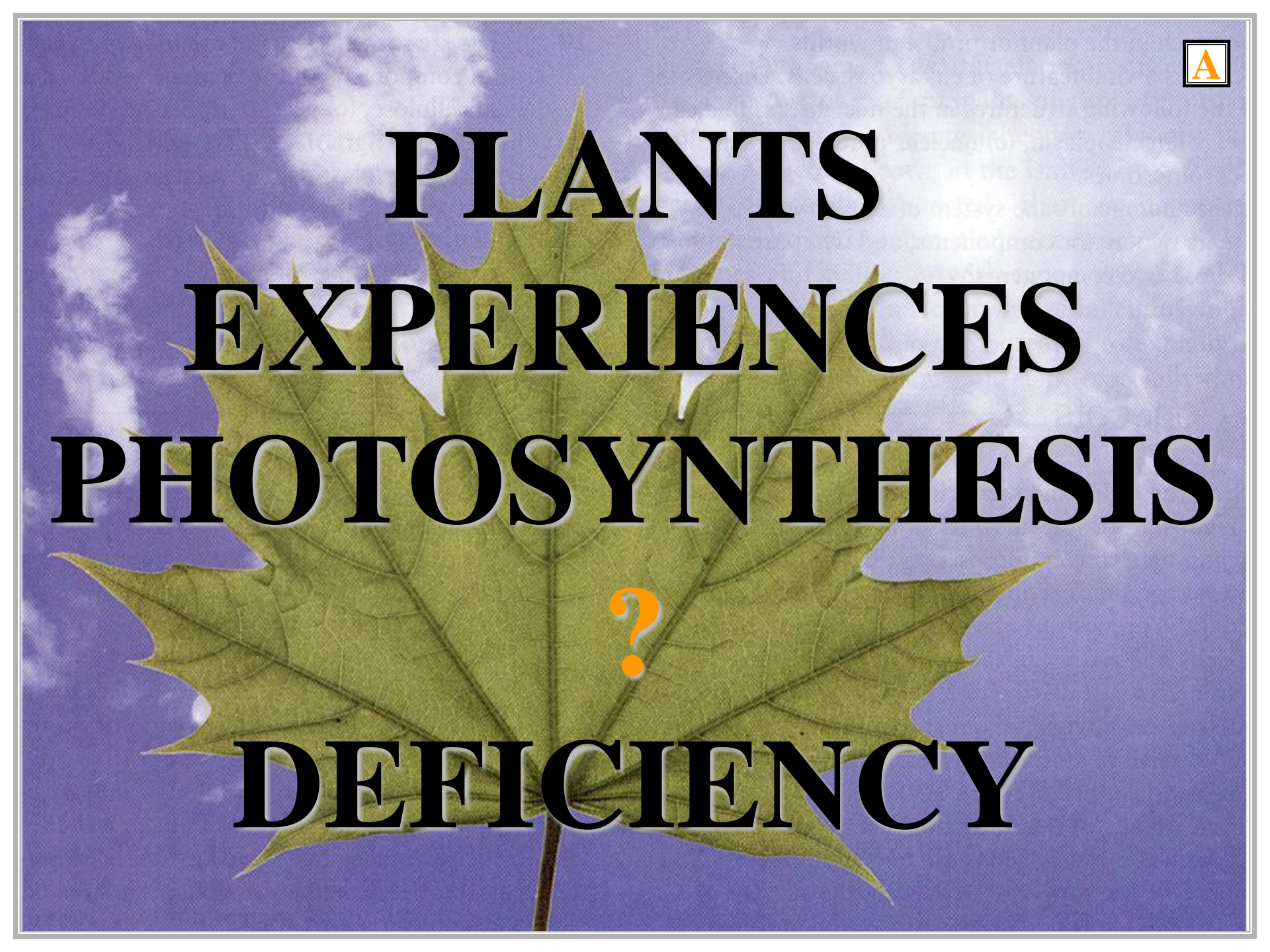
**ALL RXTS
REQUIRE
A SPECIFIC
ENZYME**

DARK REACTION

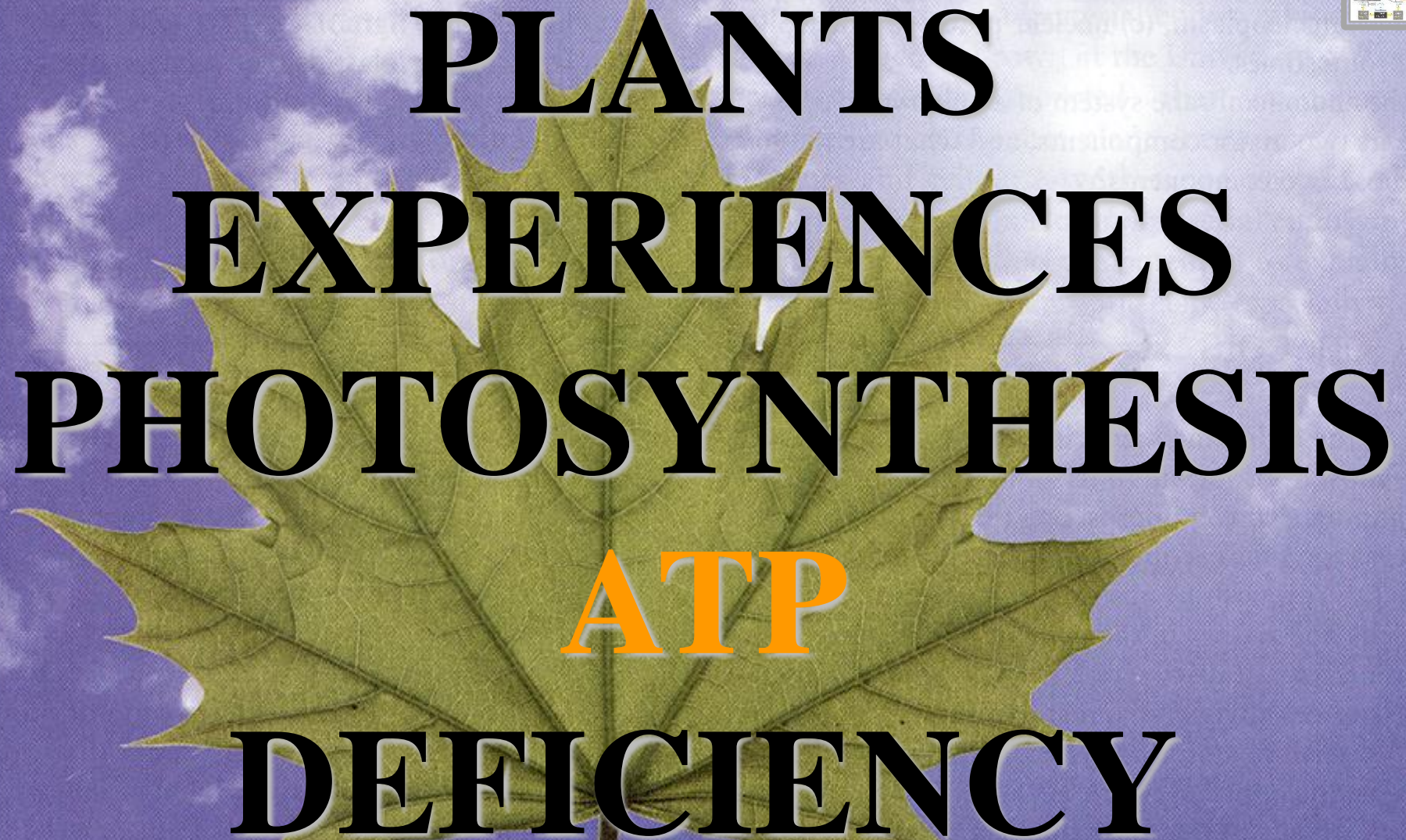
**COMPLEX SERIES
CHEMICAL RXTS
(CSCR)**

ATP

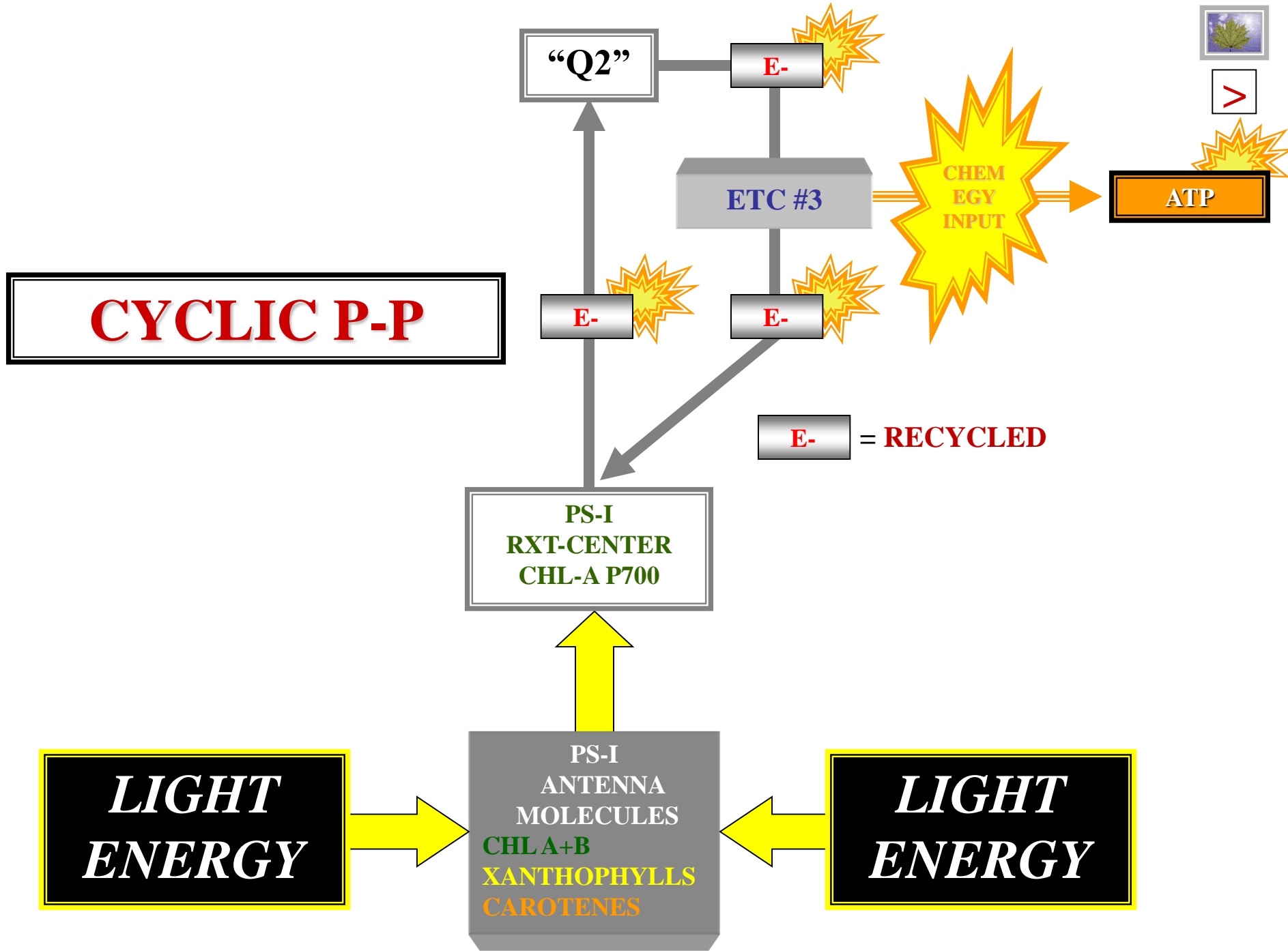
RIBULOSE BISPHOSPHATE / (RUBP)



PLANTS
EXPERIENCES
PHOTOSYNTHESIS
?
DEFICIENCY



PLANTS
EXPERIENCES
PHOTOSYNTHESIS
ATP
DEFICIENCY



**PLANTS RELY
CYCLIC P-P
ELIMINATE
PHOTOSYNTHESIS
ATP
DEFICIENCY**

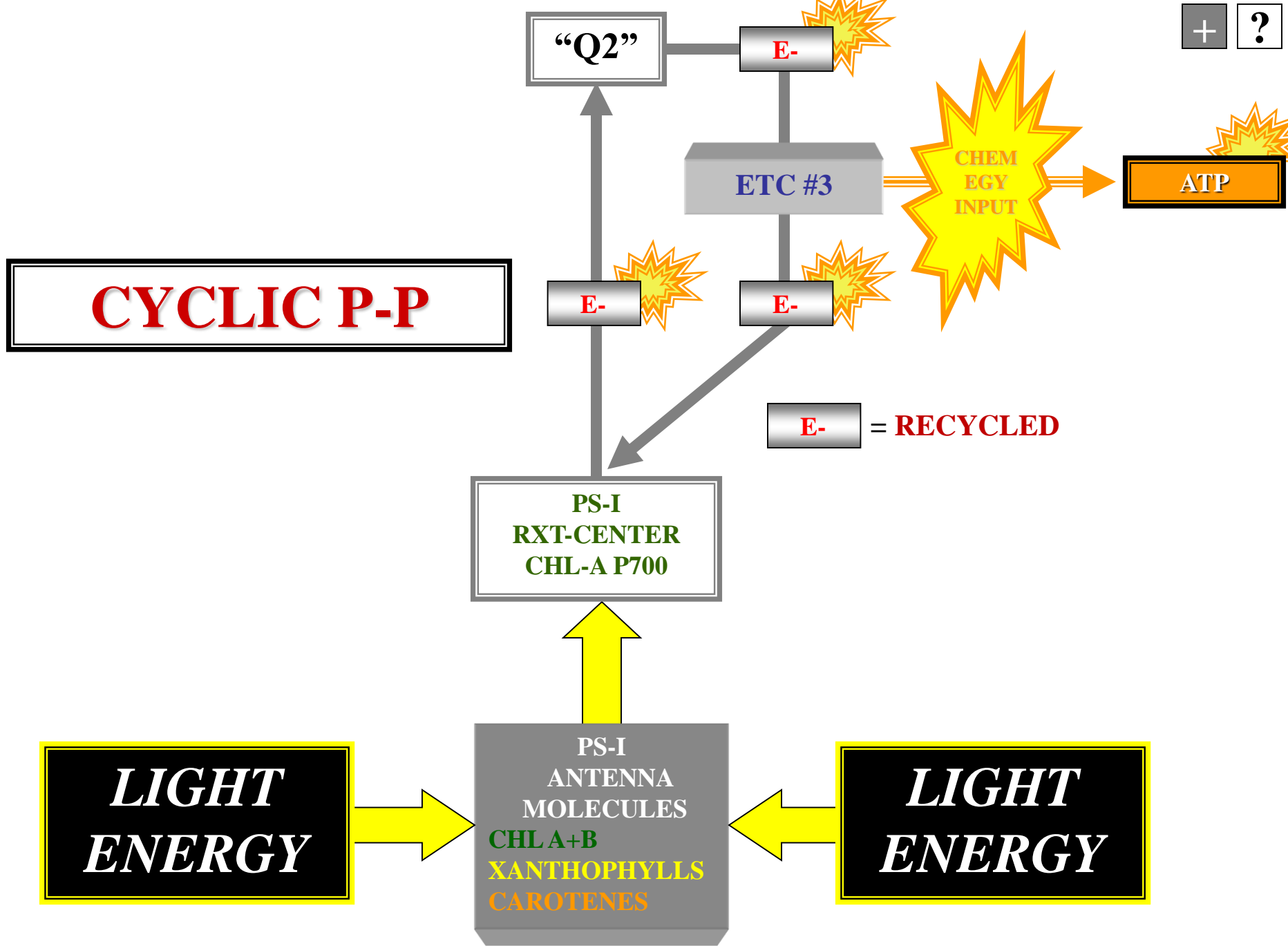




QUESTION

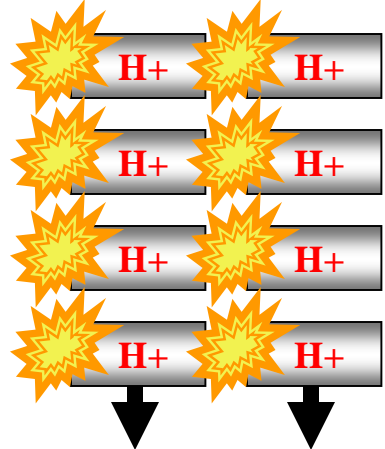
WHAT IS THE ACCEPTED
MODEL FOR ATP
PHOSPHORYLATION DURING
THE LIGHT REACTIONS?

QUESTION



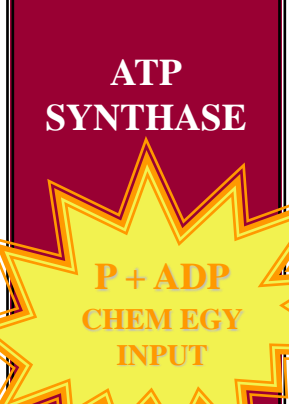
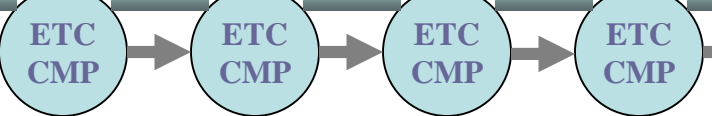
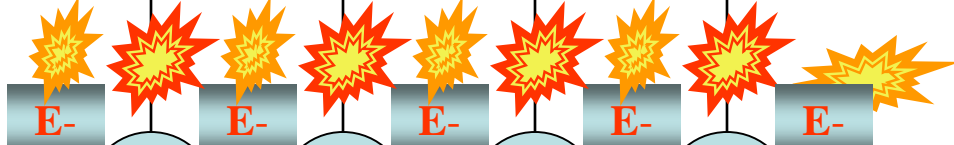


CHLOROPLAST THYLAKOID SPACE



PS-II / PS-I

CHLOROPLAST THYLAKOID MEMBRANE



CHLOROPLAST STROMA

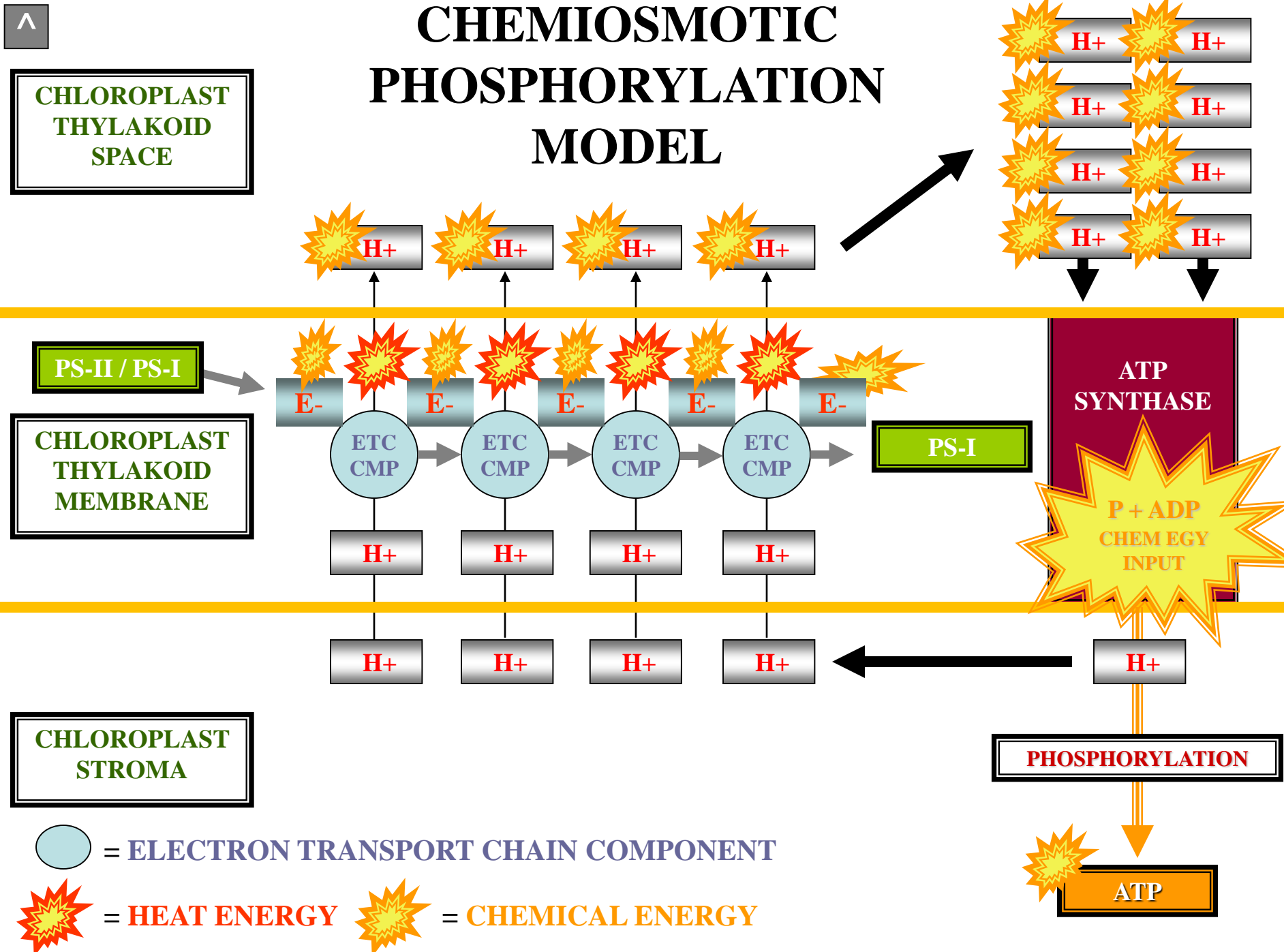
PHOSPHORYLATION



● = ELECTRON TRANSPORT CHAIN COMPONENT

★ = HEAT ENERGY ★ = CHEMICAL ENERGY

CHEMIOSMOTIC PHOSPHORYLATION MODEL



CHLOROPLAST THYLAKOID SPACE

PS-II / PS-I

CHLOROPLAST THYLAKOID MEMBRANE

CHLOROPLAST STROMA

ATP SYNTHASE

PHOSPHORYLATION

ATP

ETC CMP

PS-I

P + ADP CHEM EGY INPUT

● = ELECTRON TRANSPORT CHAIN COMPONENT

★ = HEAT ENERGY ★ = CHEMICAL ENERGY



CHEMIOSMOTIC PHOSPHORYLATION MODEL



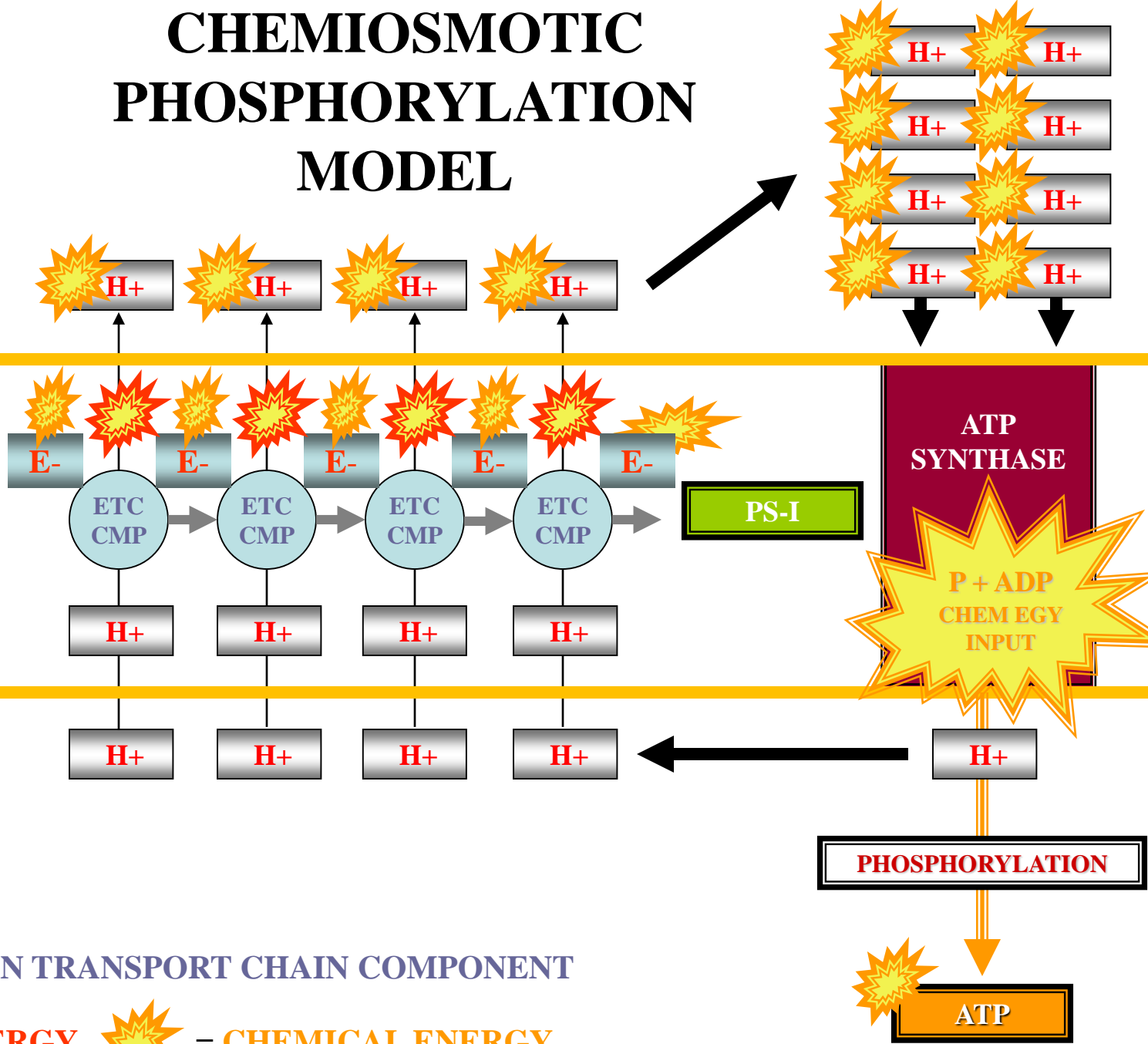
CHEMIOSMOTIC PHOSPHORYLATION MODEL

CHLOROPLAST THYLAKOID SPACE

PS-II / PS-I

CHLOROPLAST THYLAKOID MEMBRANE

CHLOROPLAST STROMA



● = ELECTRON TRANSPORT CHAIN COMPONENT

★ = HEAT ENERGY ★ = CHEMICAL ENERGY

PHOSPHORYLATION

ATP



**CHEMIOSMOTIC
PHOSPHORYLATION
MODEL**

***NOT FULLY
UNDERSTOOD***

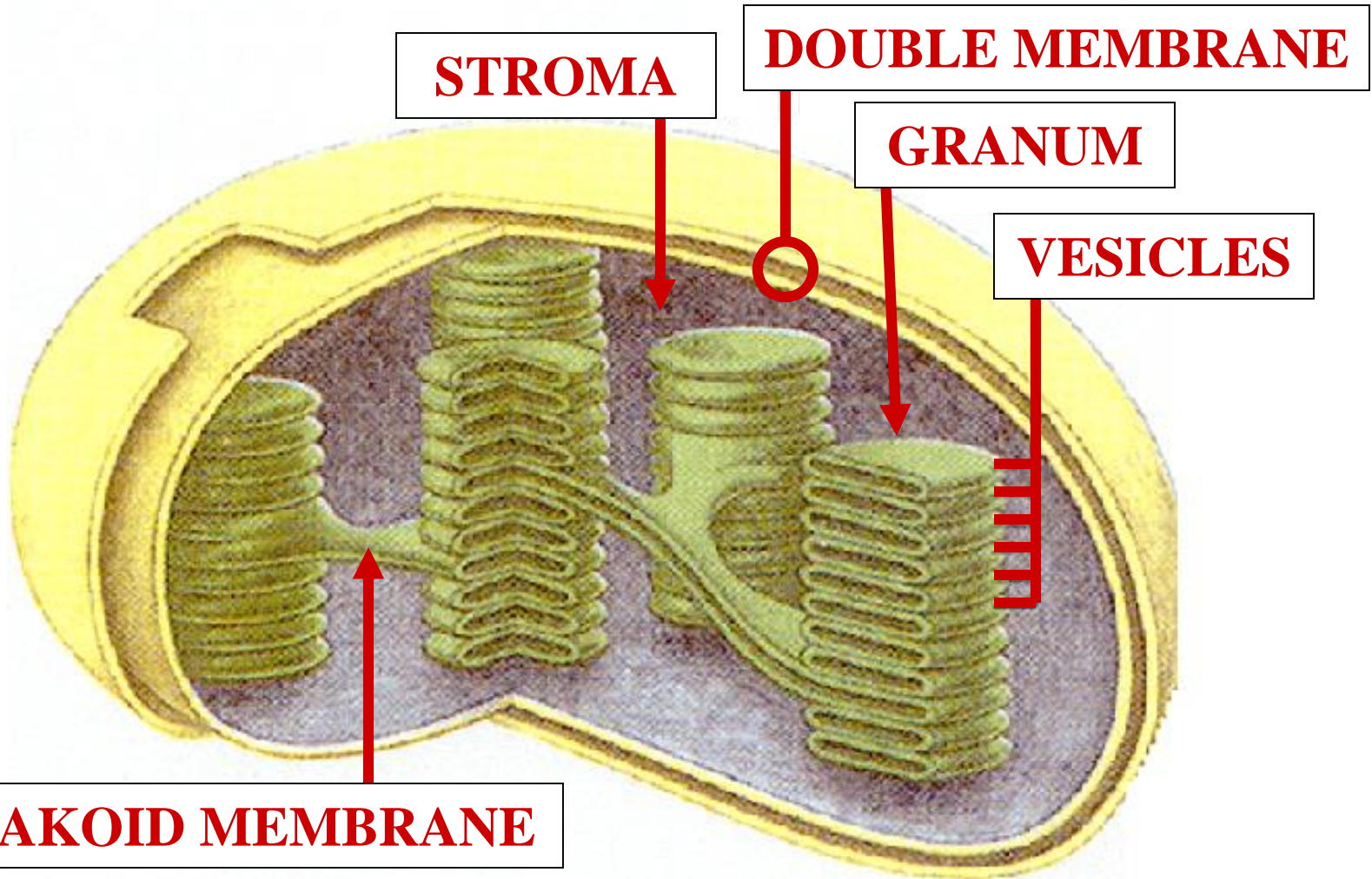


CHEMIOSMOTIC PHOSPHORYLATION CHLOROPLAST

CHLOROPLAST ULTRASTRUCTURE



N

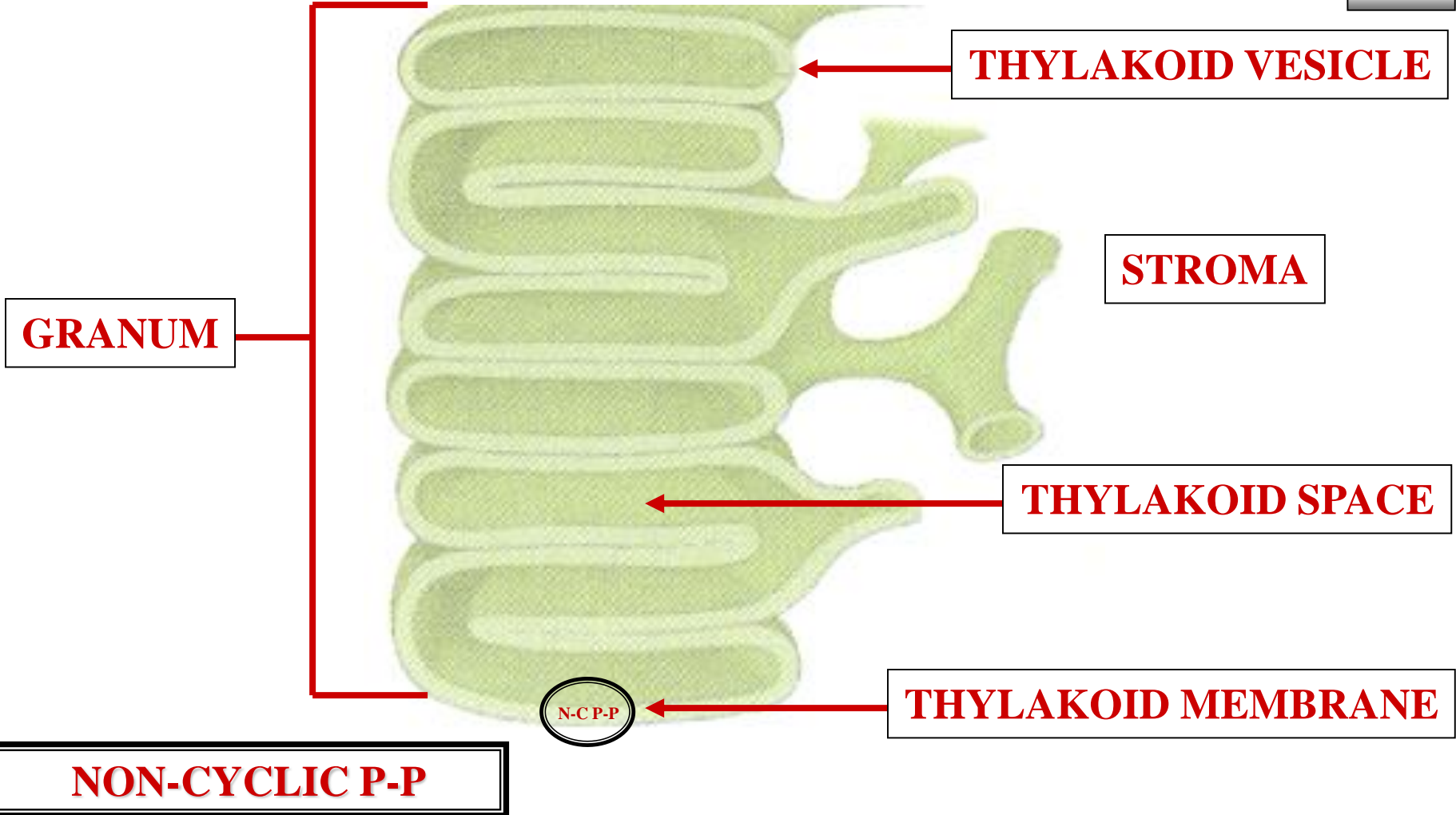


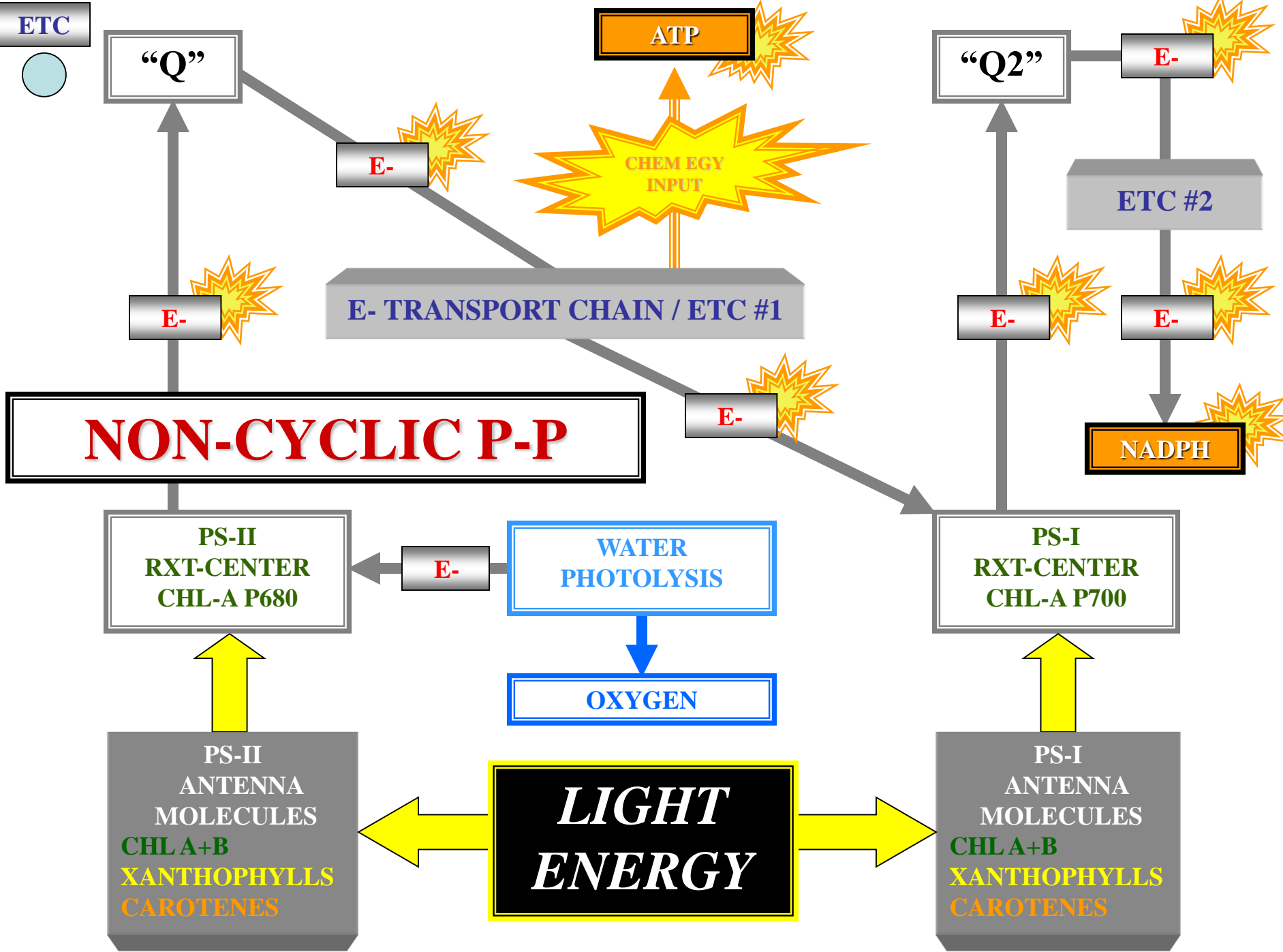


CHLOROPLAST THYLAKOID



ETC

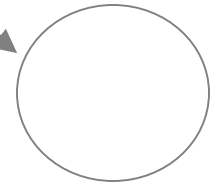
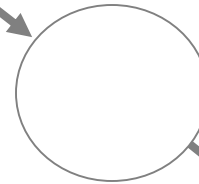
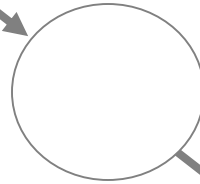
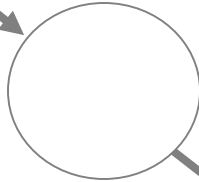
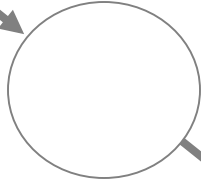




ELECTRON TRANSPORT CHAIN #1



THYLAKOID GRANUM



 = ELECTRON TRANSPORT CHAIN COMPONENT

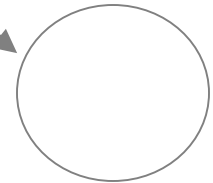
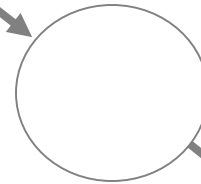
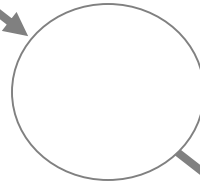
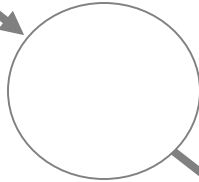
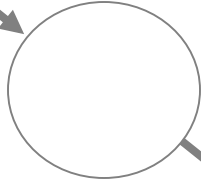
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #1



THYLAKOID GRANUM



REDOX RXTS



= **CHEMICAL ENERGY**

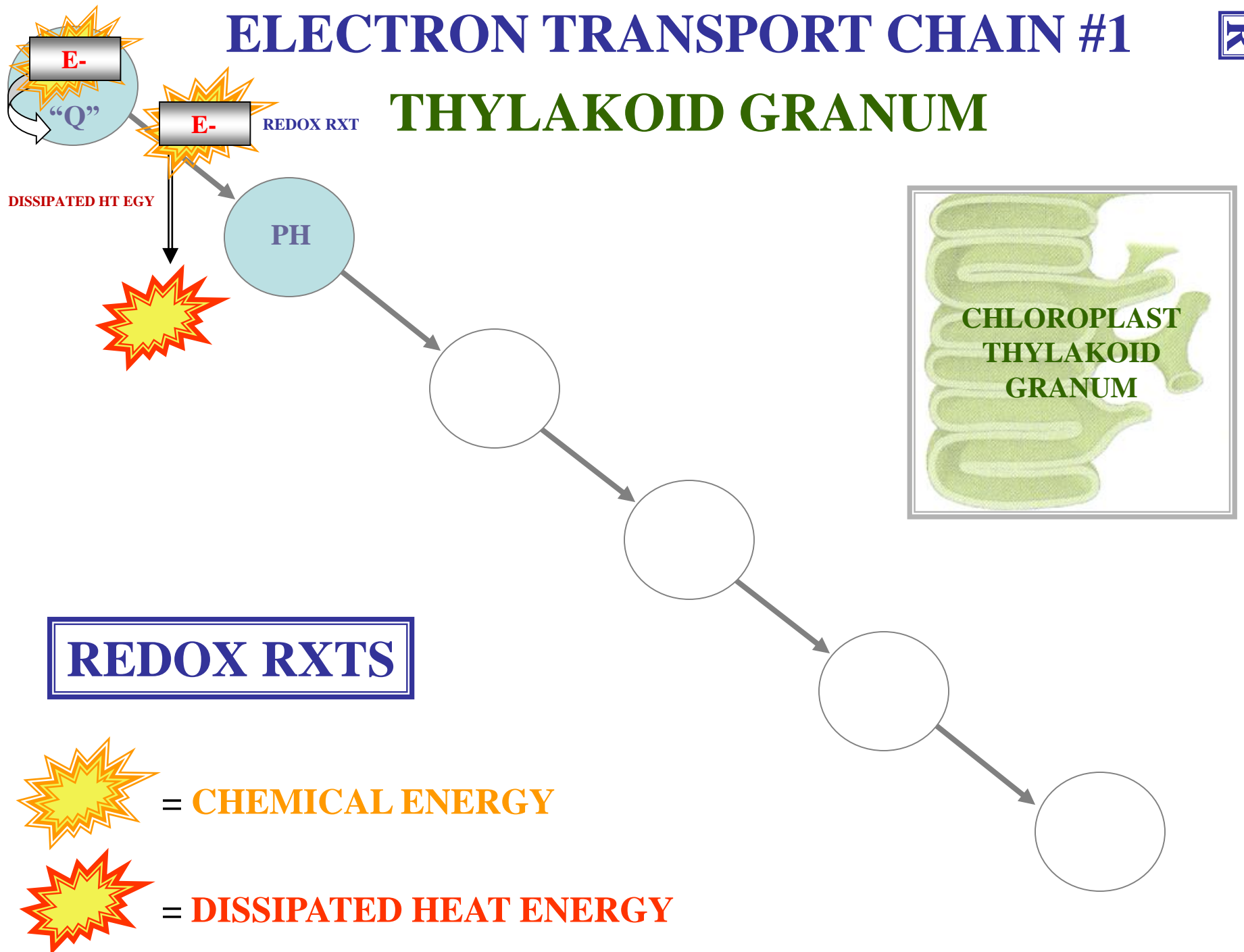


= **DISSIPATED HEAT ENERGY**

ELECTRON TRANSPORT CHAIN #1



THYLAKOID GRANUM



REDOX RXTS

 = CHEMICAL ENERGY

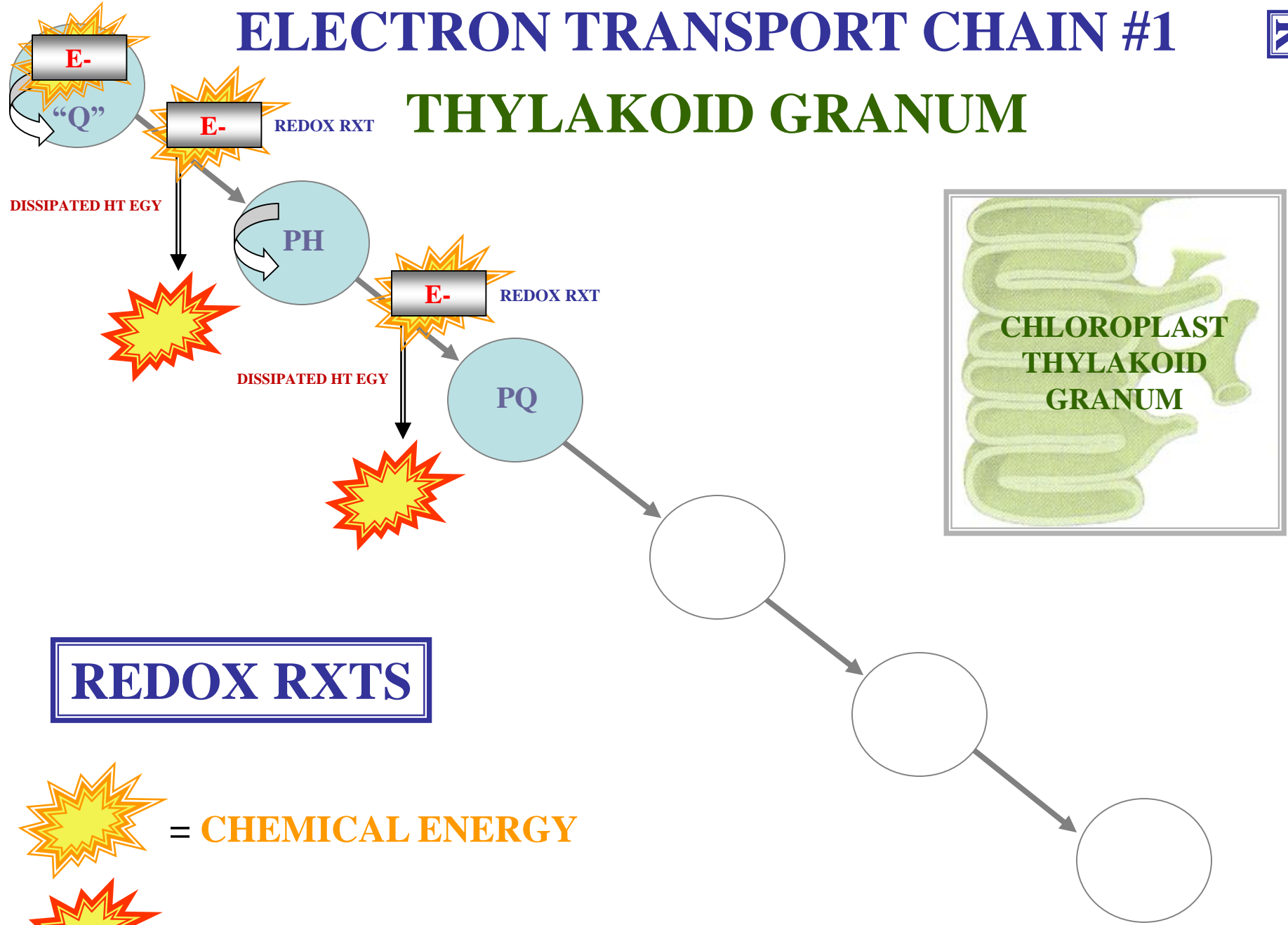
 = DISSIPATED HEAT ENERGY

**CHLOROPLAST
THYLAKOID
GRANUM**

ELECTRON TRANSPORT CHAIN #1



THYLAKOID GRANUM



REDOX RXTS

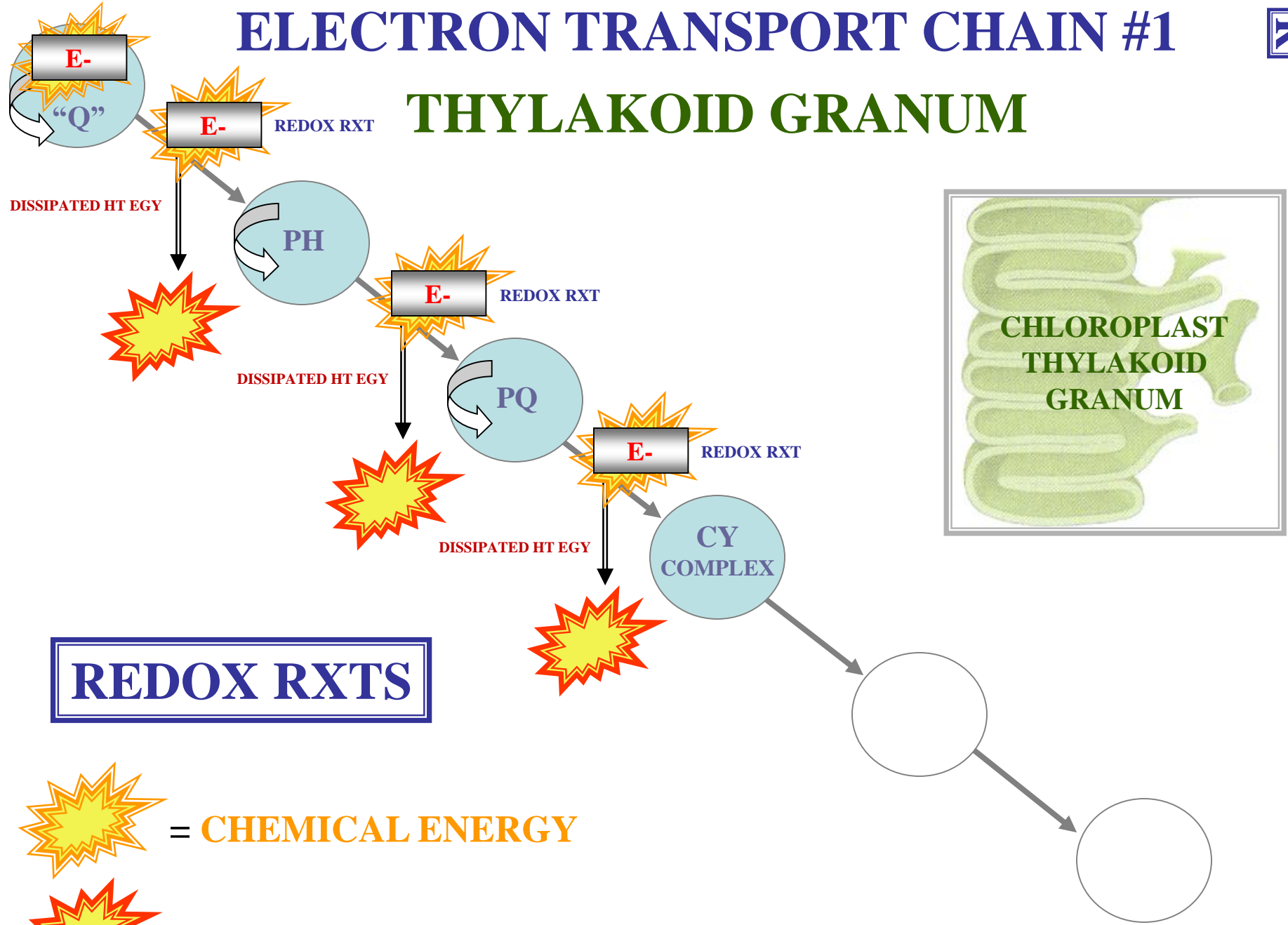
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #1



THYLAKOID GRANUM



REDOX RXTS

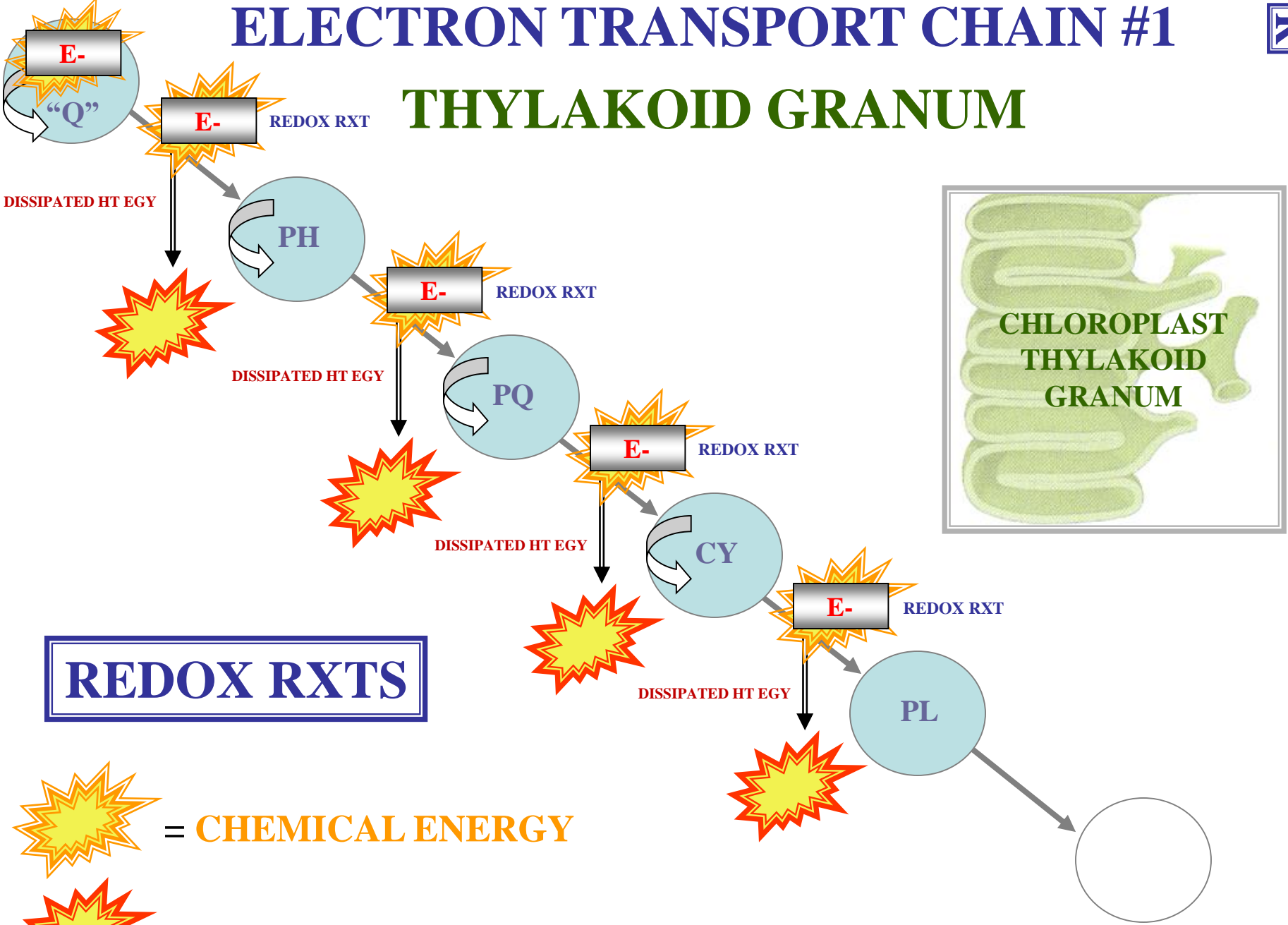
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #1



THYLAKOID GRANUM



REDOX RXTS

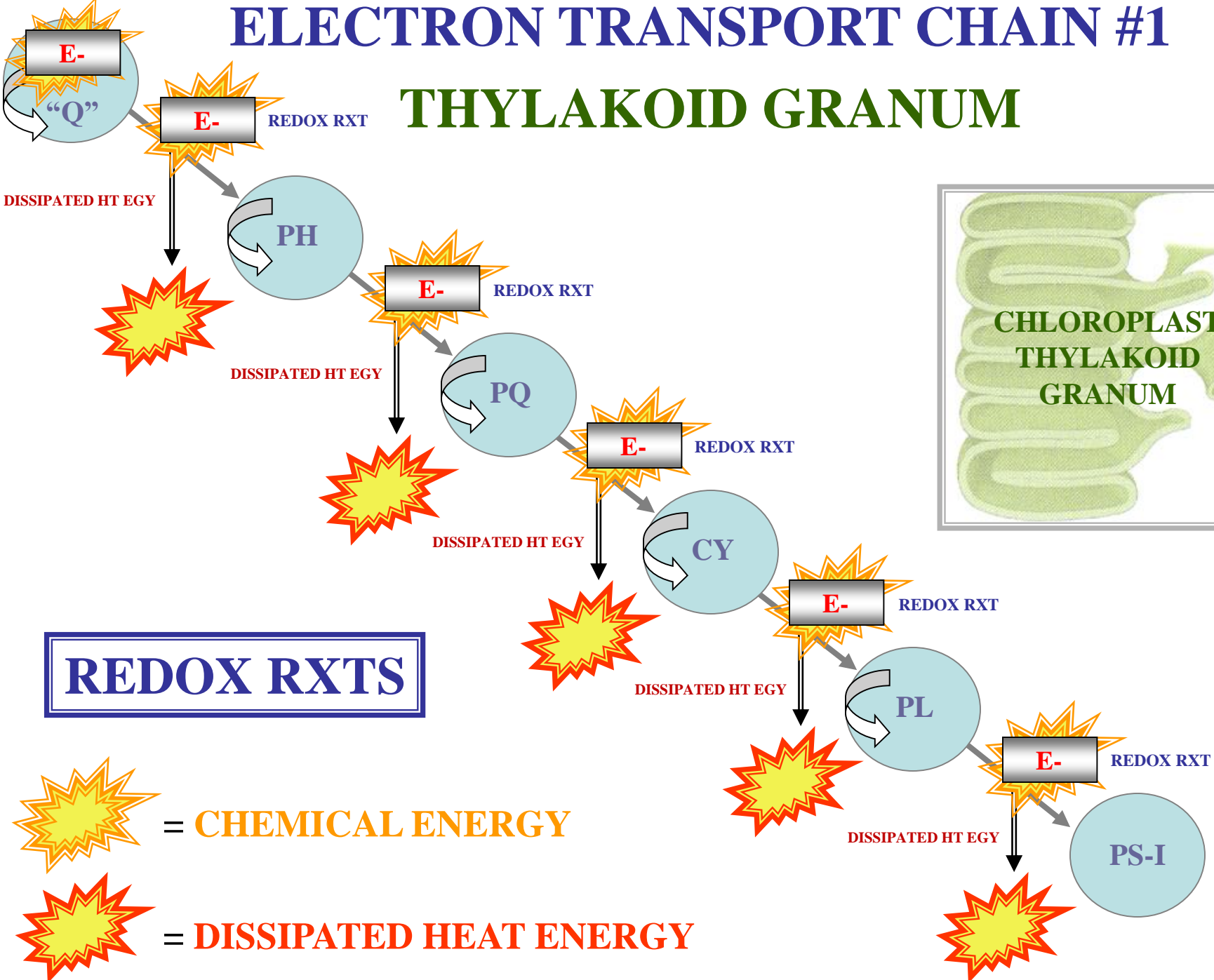
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #1

E-

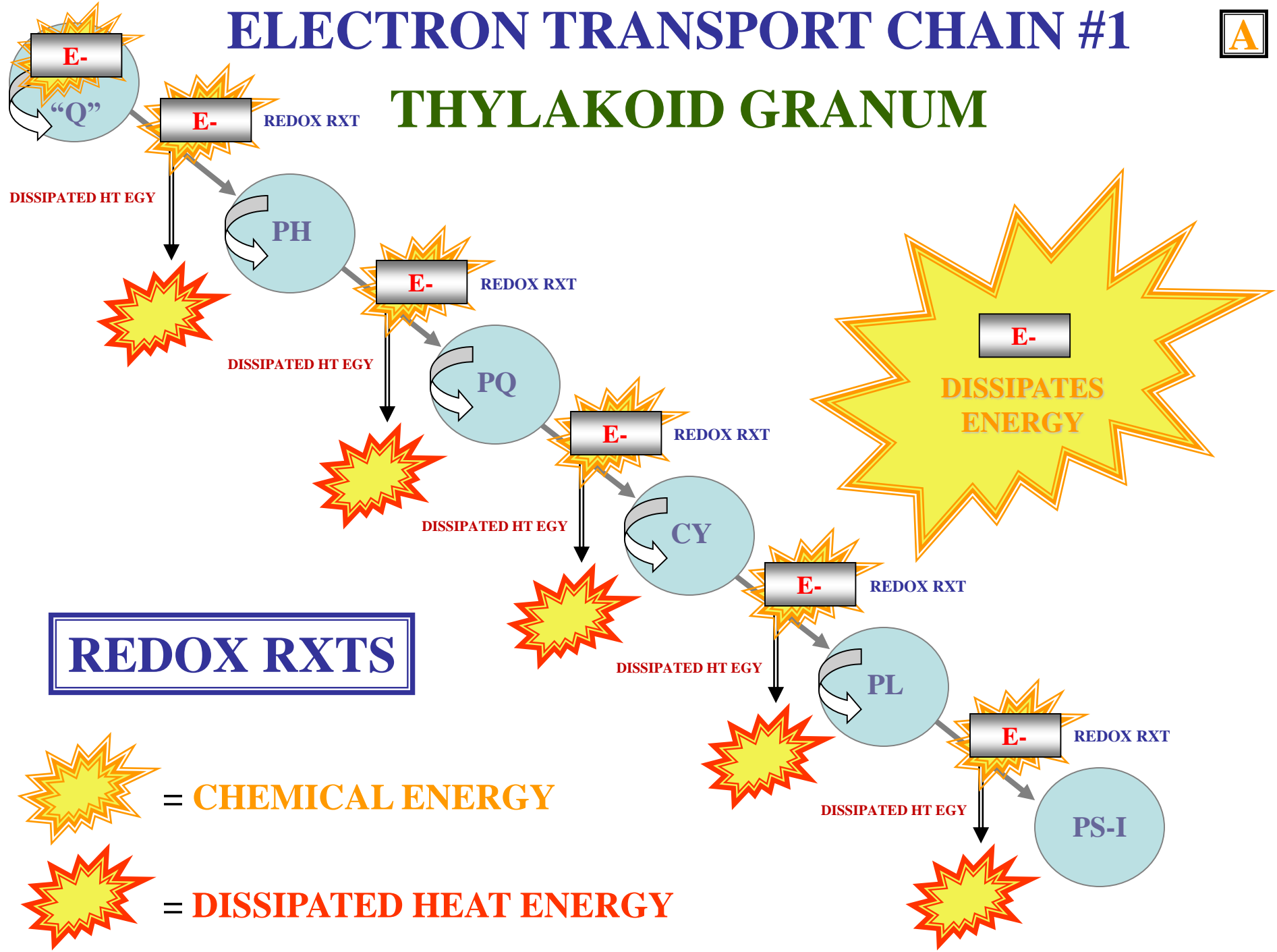
THYLAKOID GRANUM



ELECTRON TRANSPORT CHAIN #1



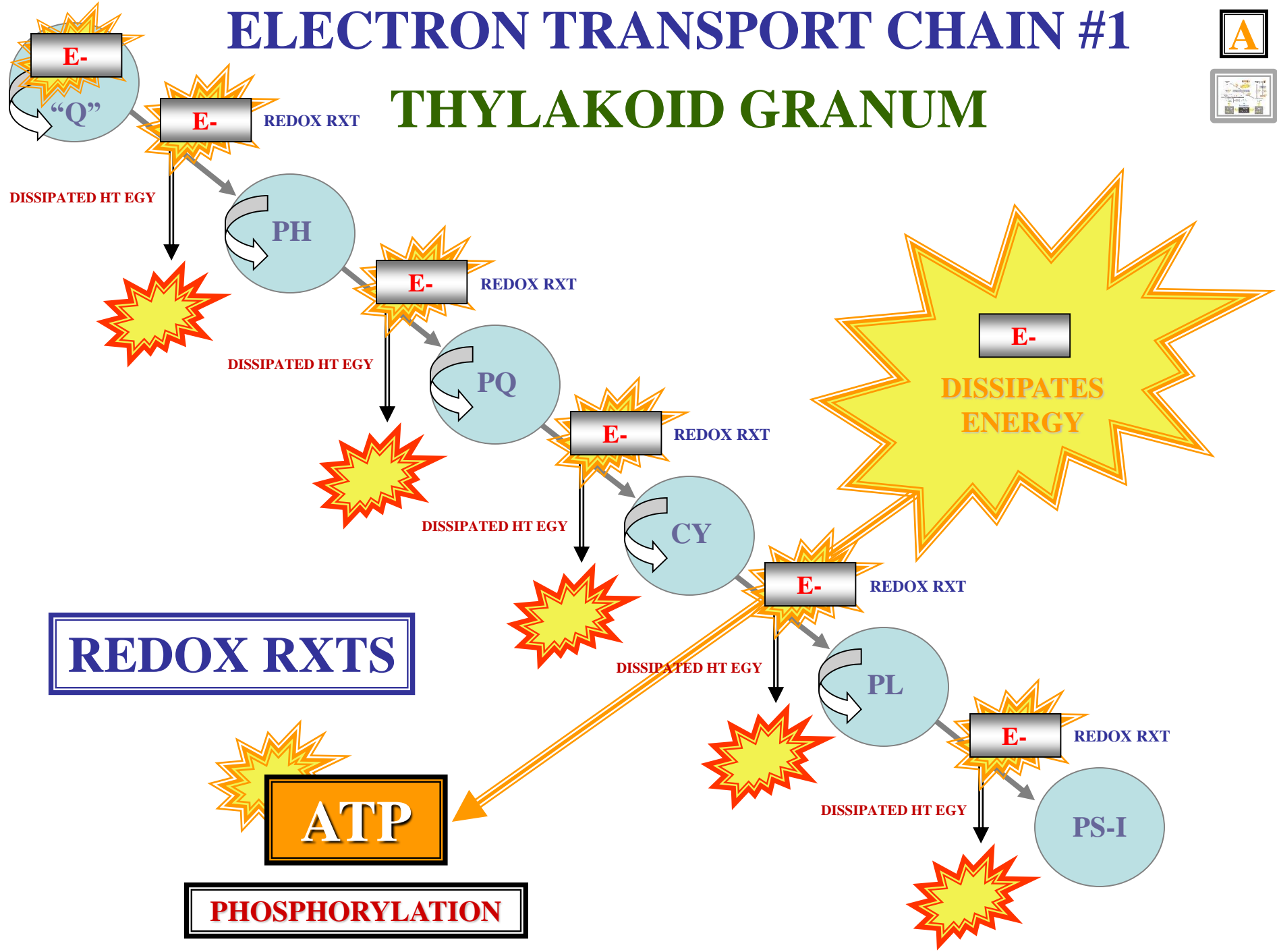
THYLAKOID GRANUM

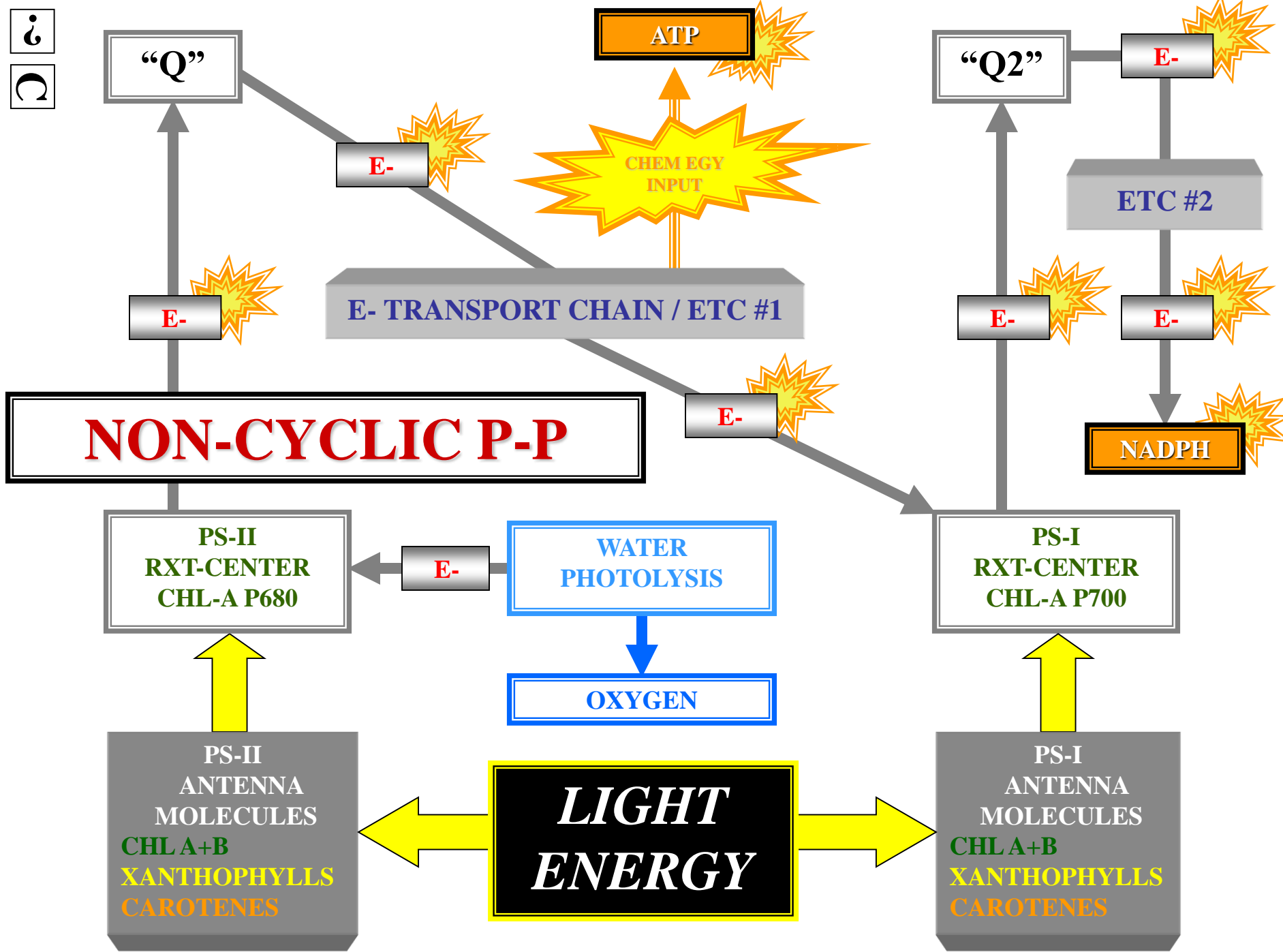


ELECTRON TRANSPORT CHAIN #1



THYLAKOID GRANUM





CHEMIOSMOTIC PHOSPHORYLATION MODEL

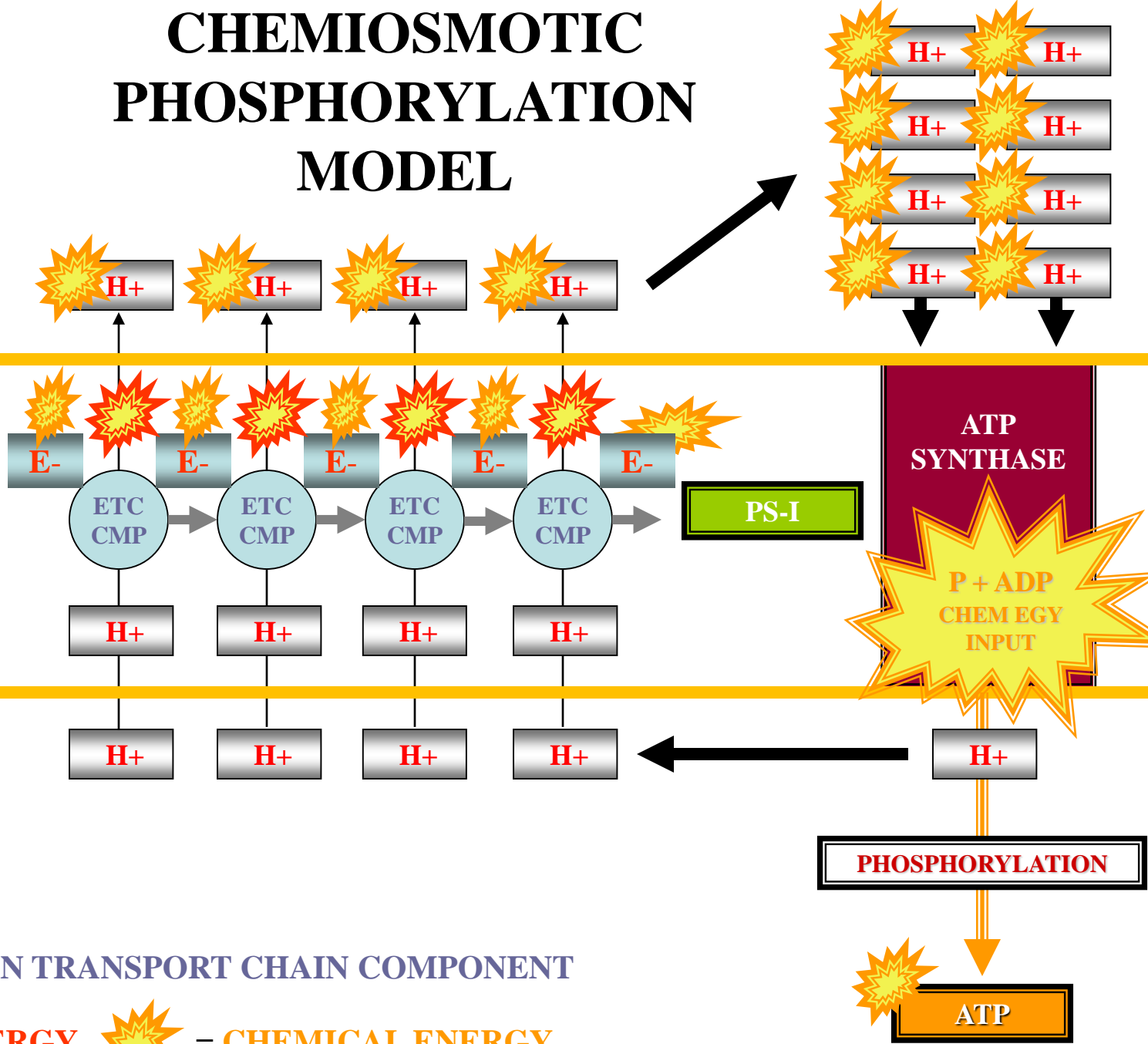
^ **C**

CHLOROPLAST THYLAKOID SPACE

PS-II / PS-I
CHLOROPLAST THYLAKOID MEMBRANE

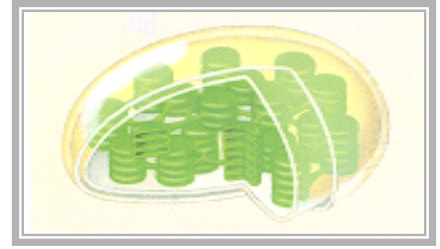
CHLOROPLAST STROMA

● = ELECTRON TRANSPORT CHAIN COMPONENT
☀ = HEAT ENERGY ☀ = CHEMICAL ENERGY

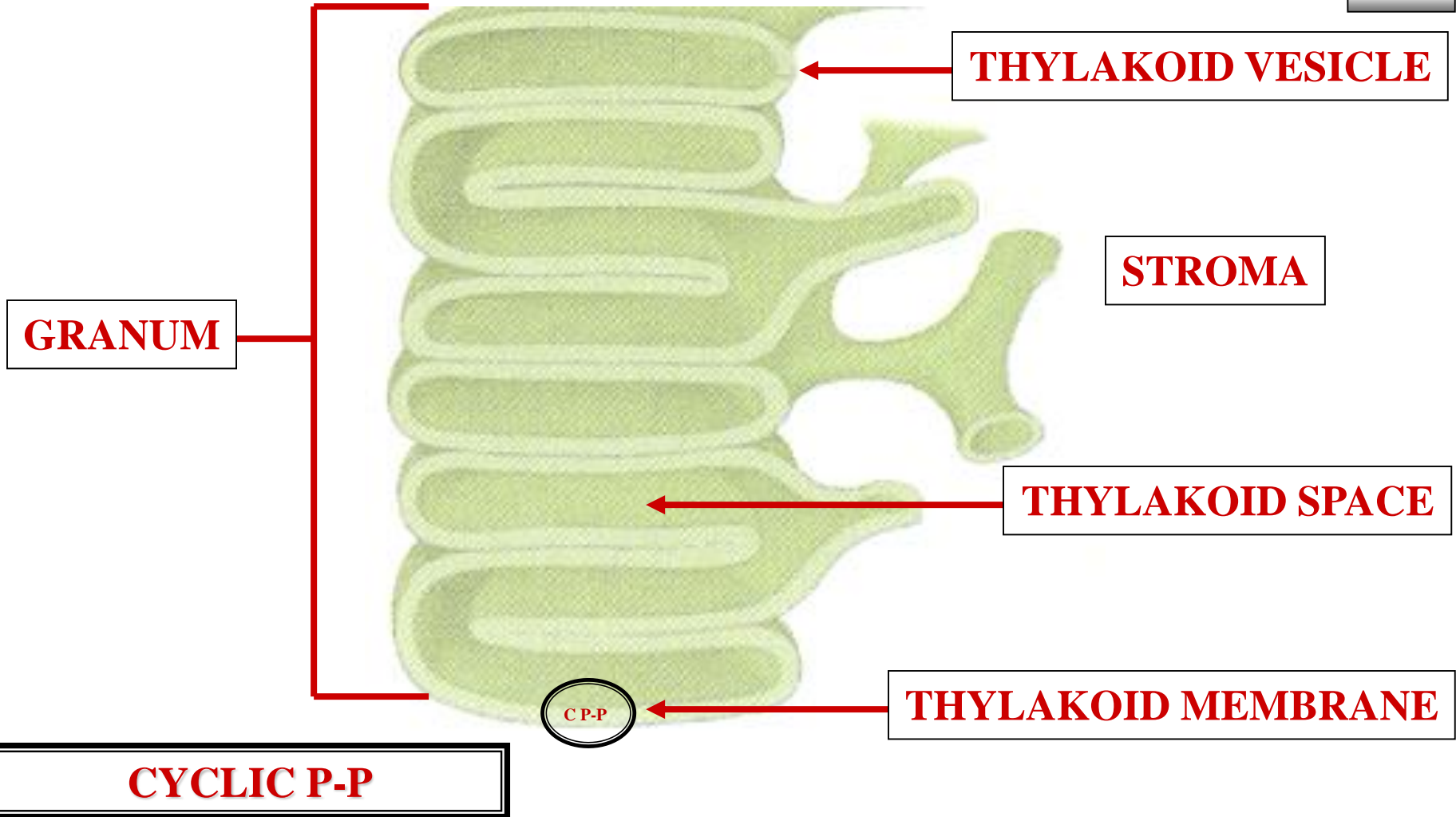




CHLOROPLAST THYLAKOID



ETC



ETC



CYCLIC P-P

“Q2”

E-

ETC #3

CHEM
EGY
INPUT

ATP

E-

E-

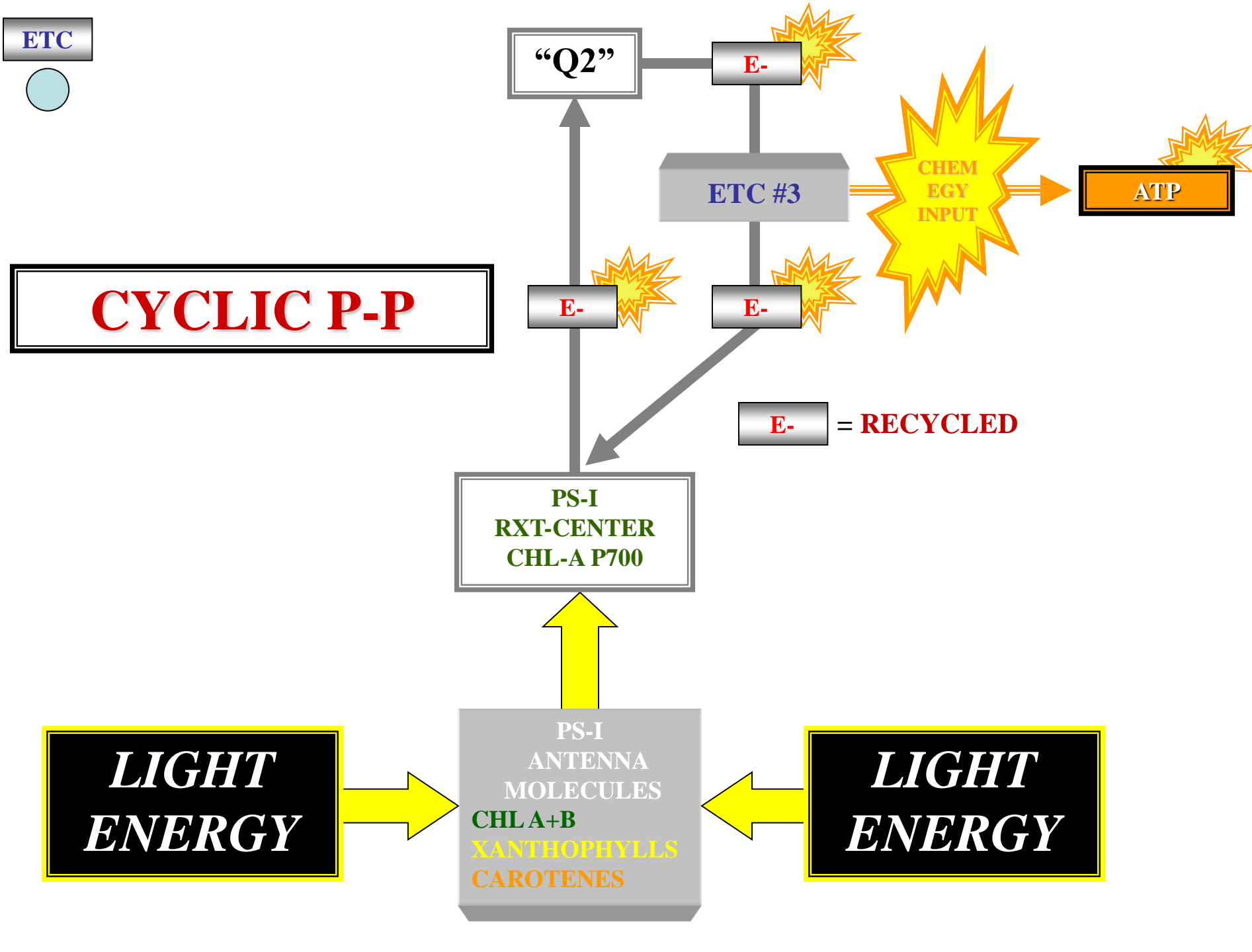
E- = RECYCLED

PS-I
RXT-CENTER
CHL-A P700

**LIGHT
ENERGY**

PS-I
ANTENNA
MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES

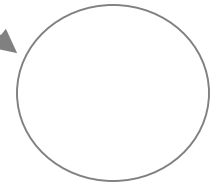
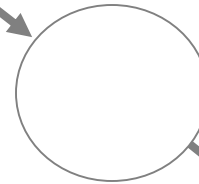
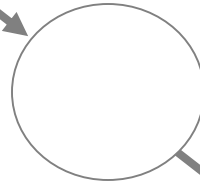
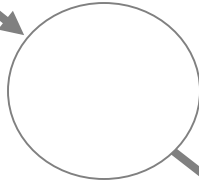
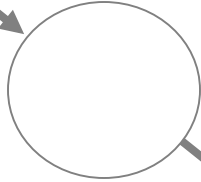
**LIGHT
ENERGY**



ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



 = ELECTRON TRANSPORT CHAIN COMPONENT

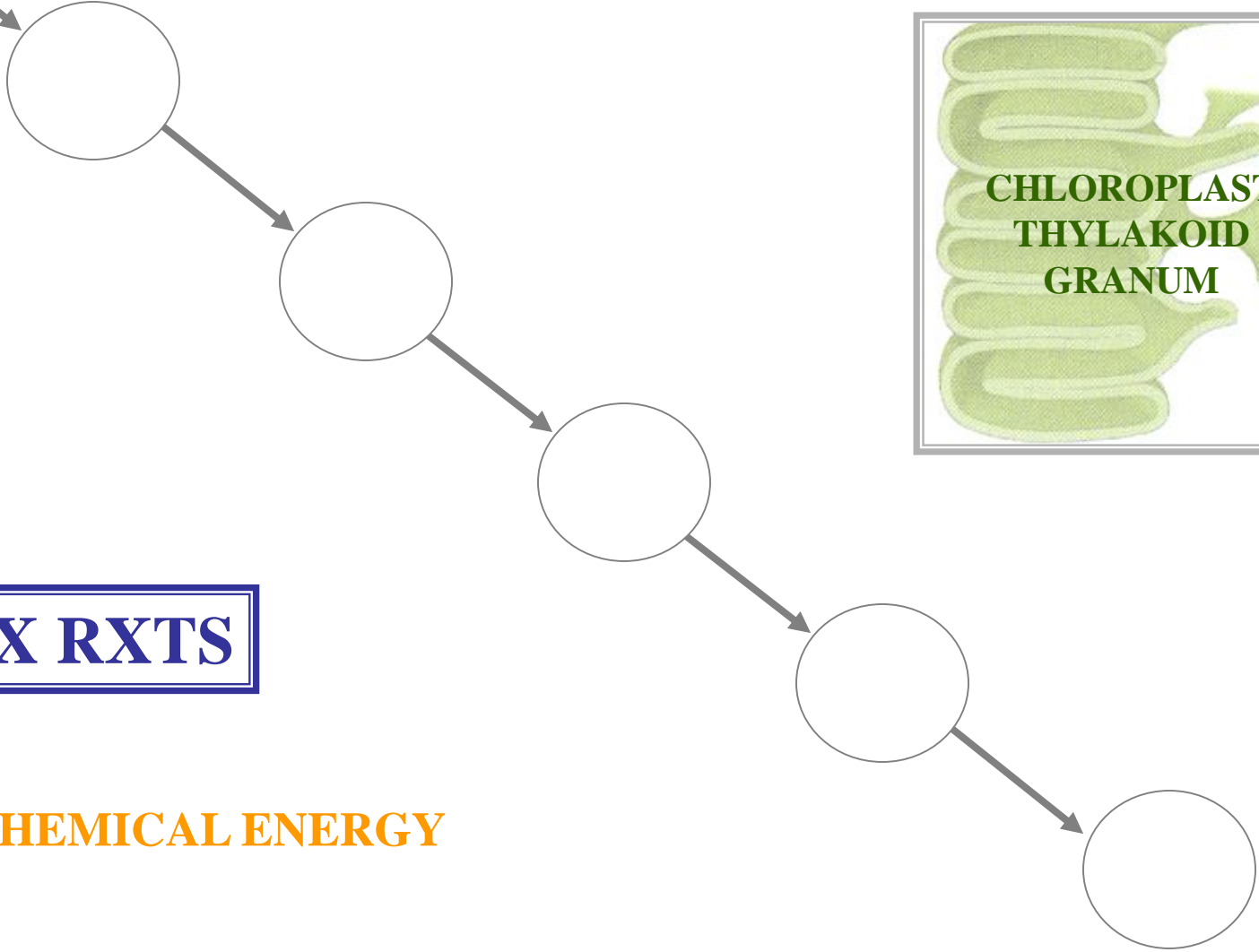
 = CHEMICAL ENERGY

 = DISSIPATED HEAT ENERGY

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



REDOX RXTS

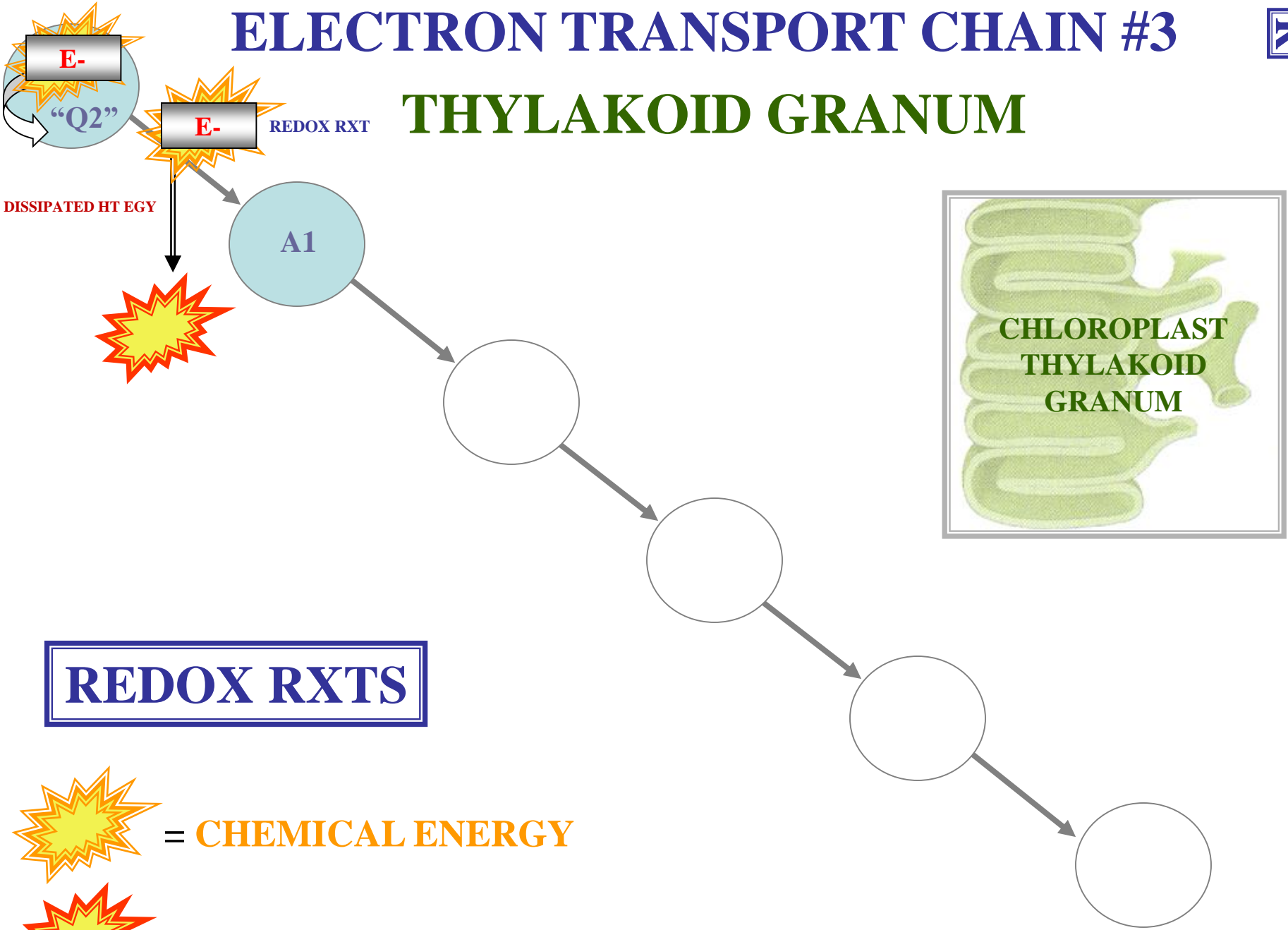
 = **CHEMICAL ENERGY**

 = **DISSIPATED HEAT ENERGY**

ELECTRON TRANSPORT CHAIN #3



THYLAKOID GRANUM



REDOX RXTS

 = **CHEMICAL ENERGY**

 = **DISSIPATED HEAT ENERGY**