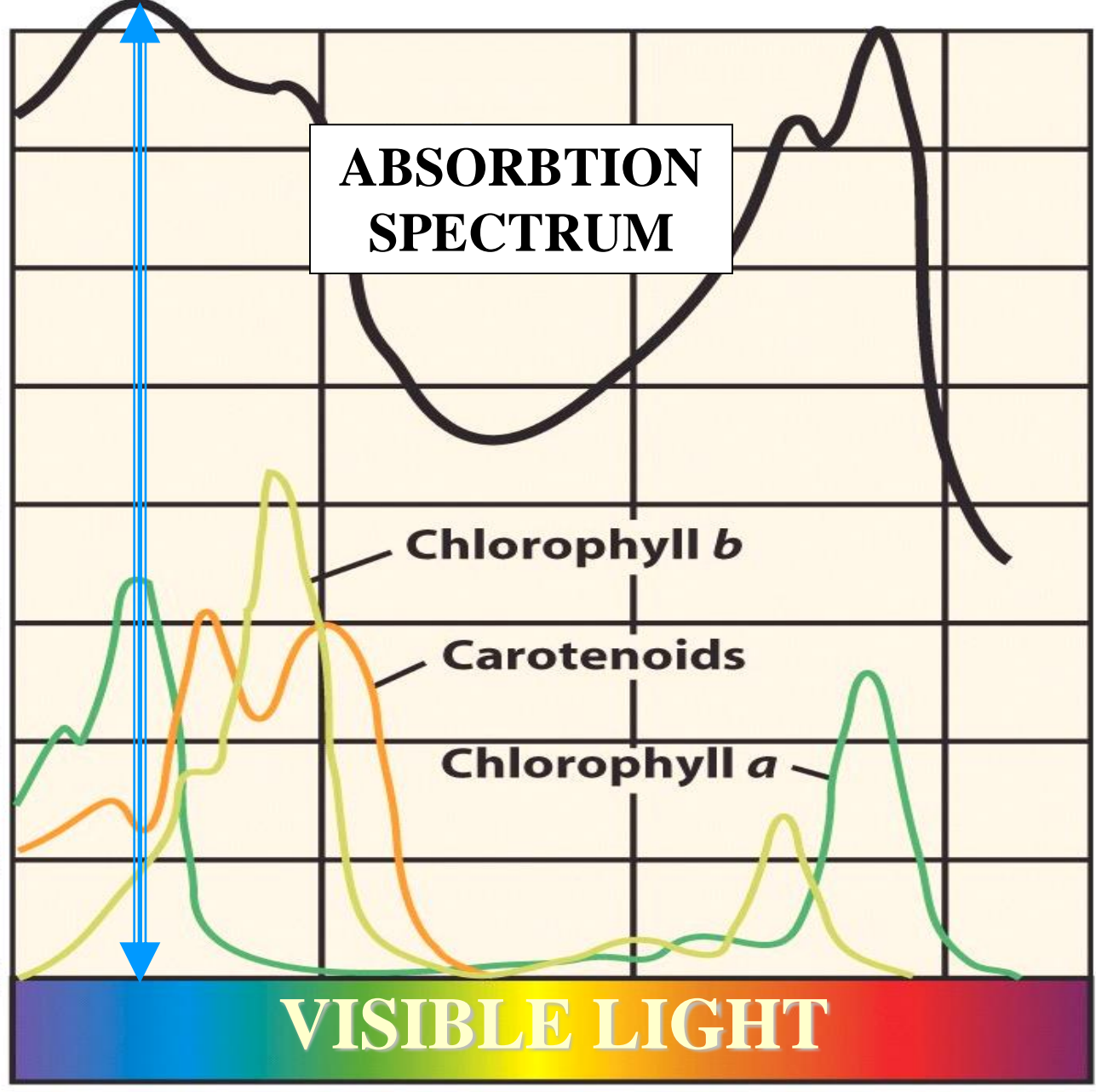


Estimated absorption (percent)

Rate of photosynthesis  
(as % of rate at 670 nanometers)

**ABSORPTION SPECTRUM**

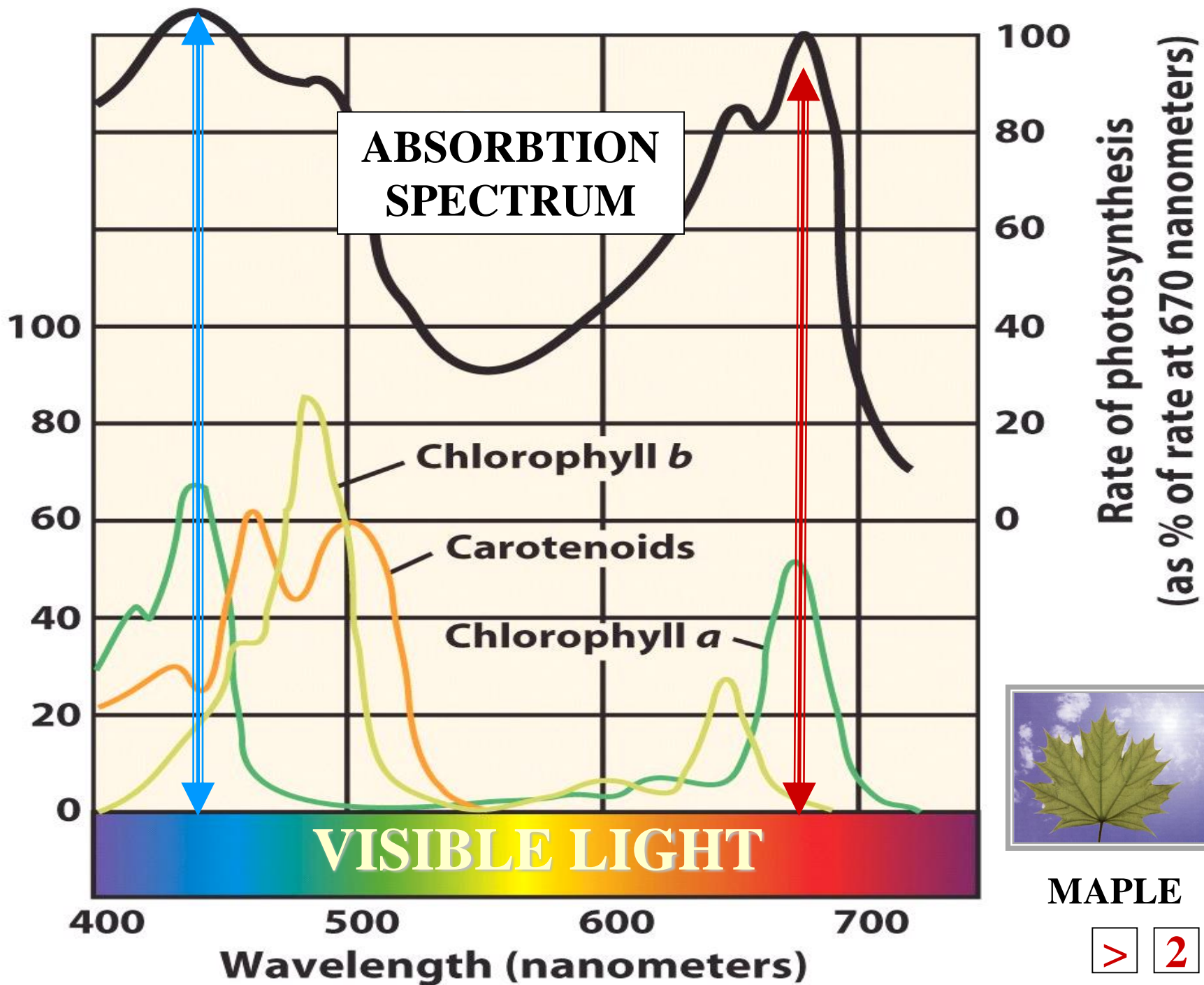


**MAPLE**



400 500 600 700  
Wavelength (nanometers)

Estimated absorption (percent)



MAPLE



PHOTOSYNTHESIS

**BLUE LT** & **RED LT**

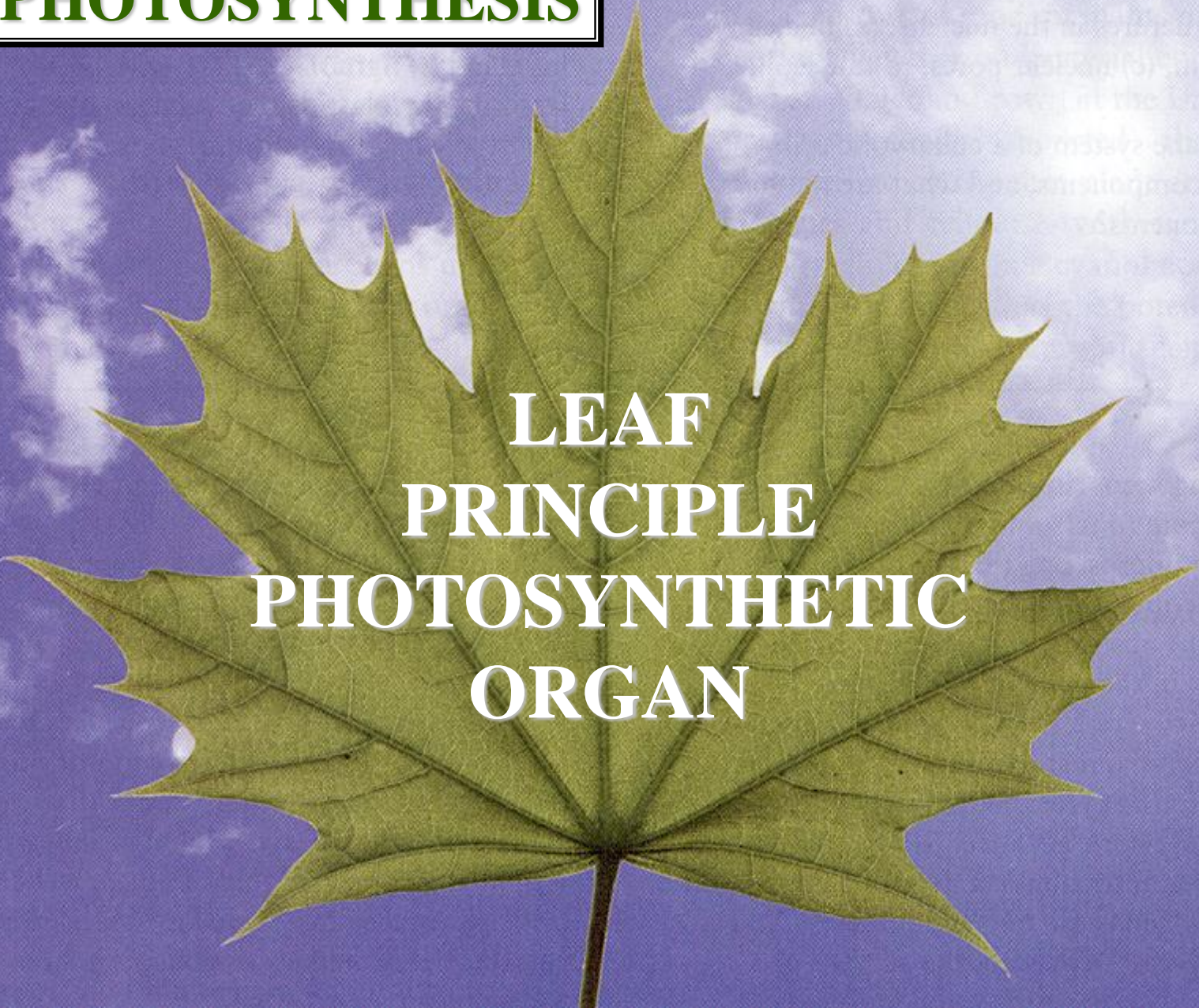
MOST EFFICIENT

WAVELENGTHS

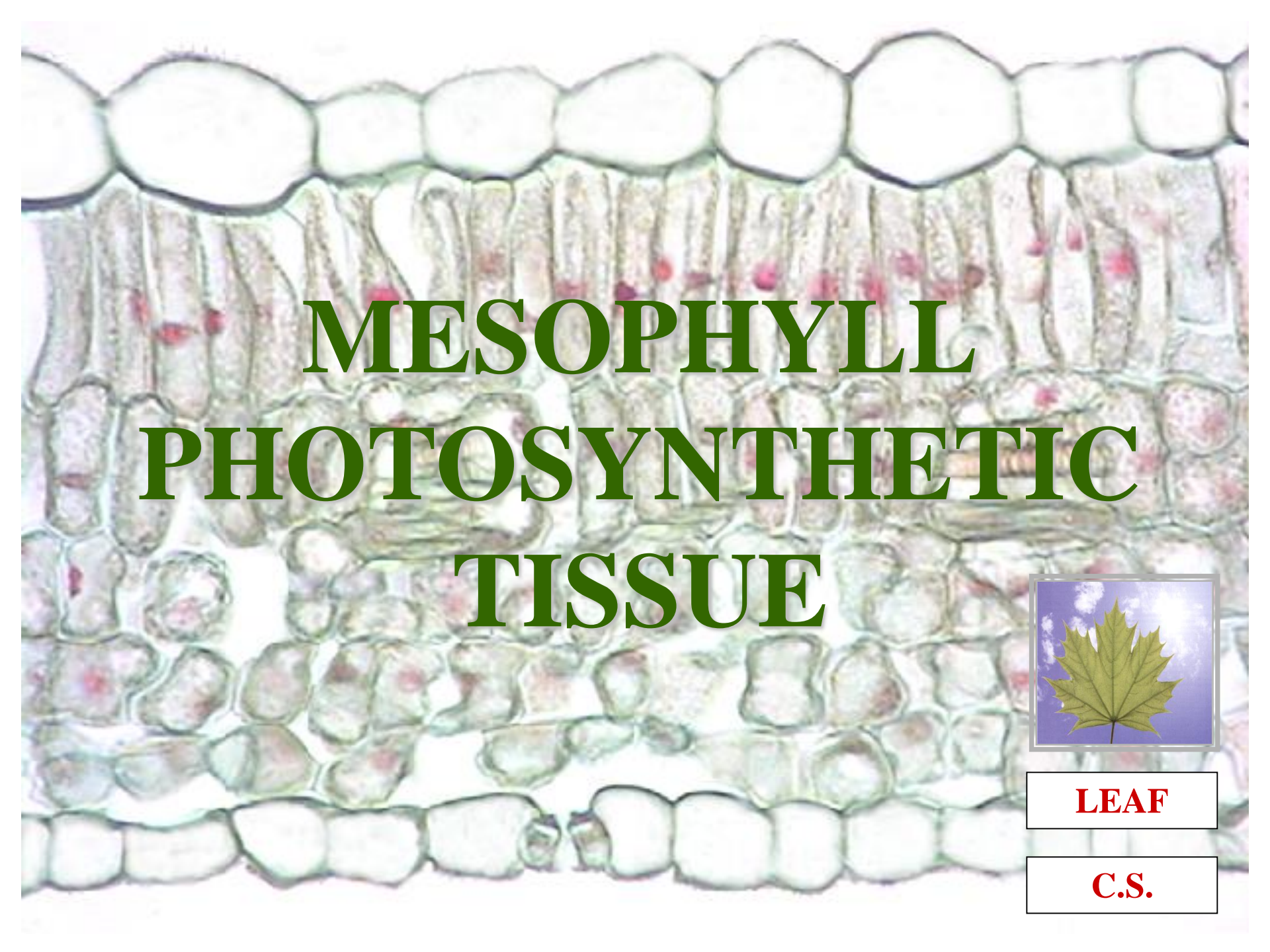
A vibrant green maple leaf is the central focus, set against a bright blue sky with scattered white clouds. The leaf's veins are clearly visible, and its lobes are pointed. The overall image has a fine, woven texture.

# PHOTOSYNTHESIS SUMMARY

# **PHOTOSYNTHESIS**



**LEAF  
PRINCIPLE  
PHOTOSYNTHETIC  
ORGAN**

A microscopic cross-section of a leaf showing the mesophyll tissue. The image displays several layers of cells. The uppermost layer consists of a single layer of large, rounded cells, likely the palisade mesophyll. Below this is a layer of smaller, more irregularly shaped cells, which is the spongy mesophyll. The lowermost layer consists of a single layer of cells, likely the epidermis. The central part of the image is dominated by the spongy mesophyll, which is the primary site of photosynthesis. The text "MESOPHYLL PHOTOSYNTHETIC TISSUE" is overlaid in large, green, bold letters across the center of the image.

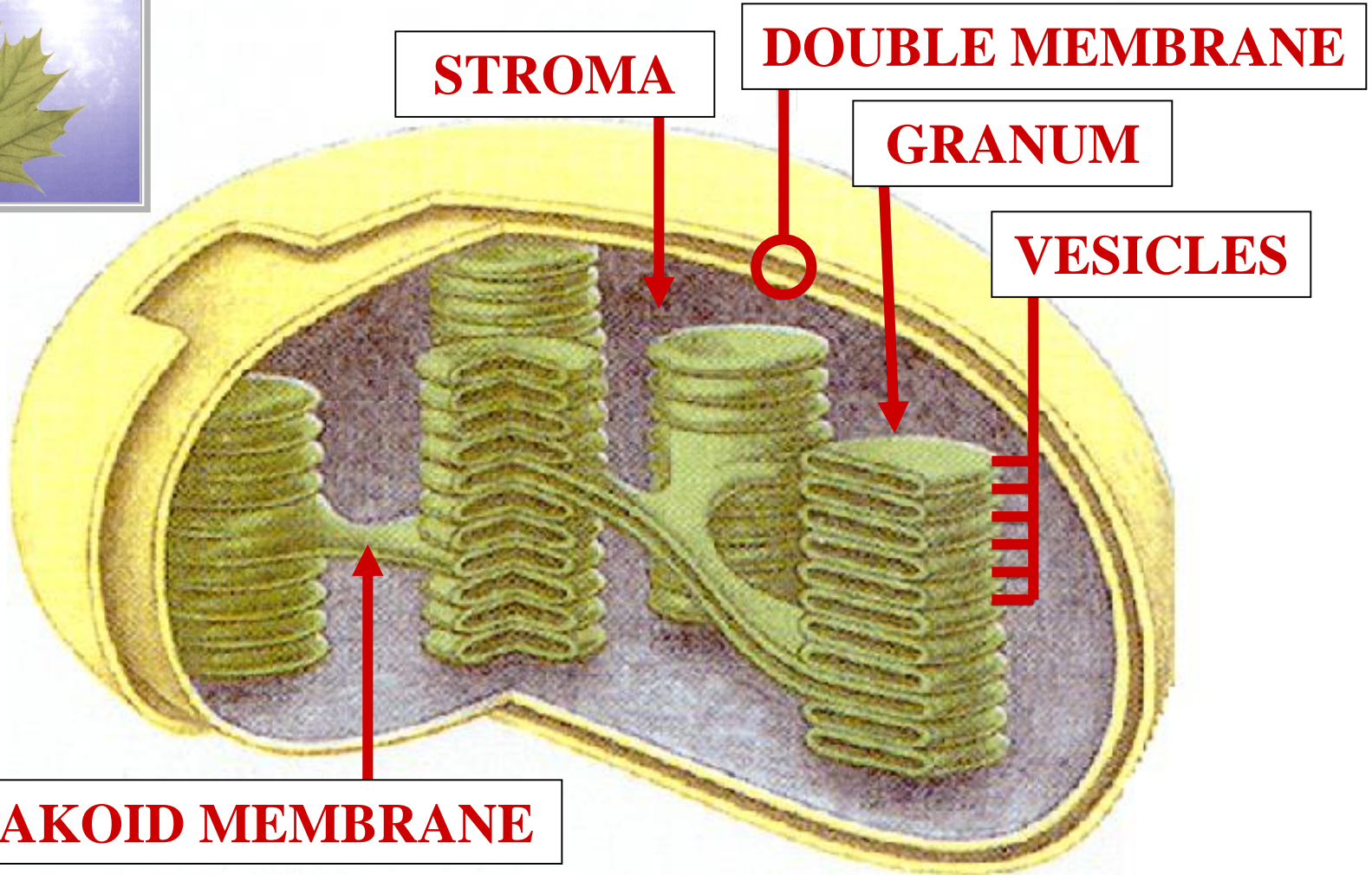
**MESOPHYLL  
PHOTOSYNTHETIC  
TISSUE**



**LEAF**

**C.S.**

# CHLOROPLAST ULTRASTRUCTURE



**STROMA**

**DOUBLE MEMBRANE**

**GRANUM**

**VESICLES**

**THYLAKOID MEMBRANE**

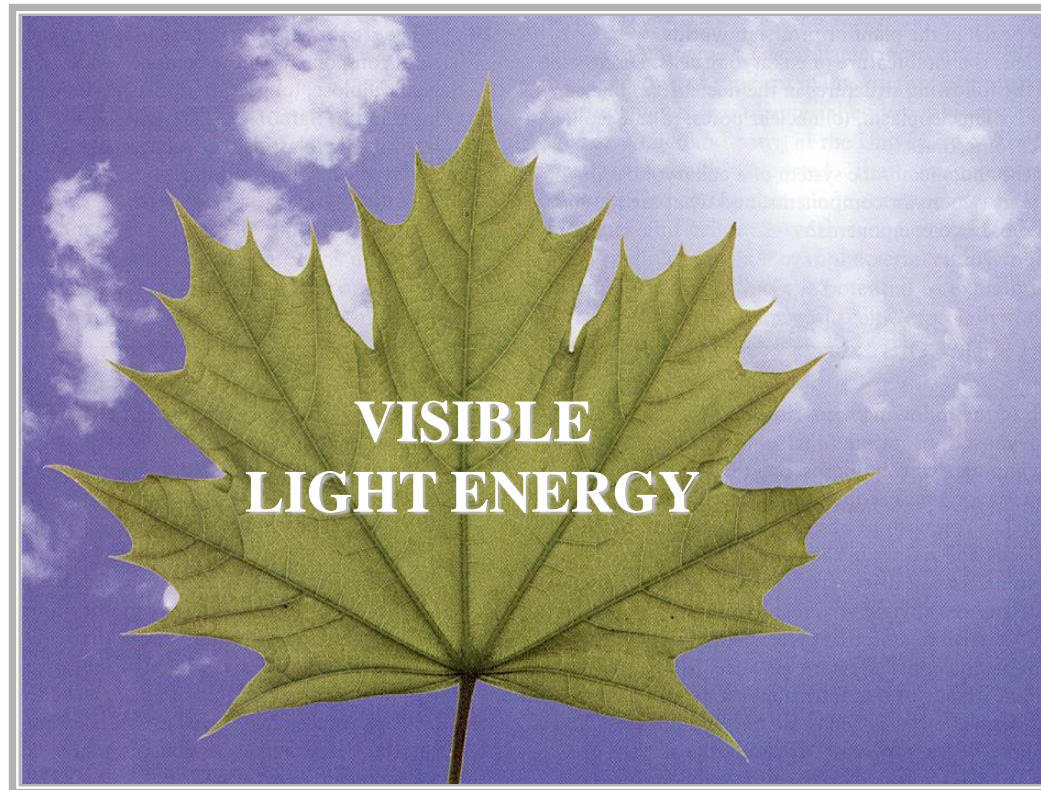
A vibrant green maple leaf is the central focus, set against a bright blue sky with scattered white clouds. The leaf's veins are clearly visible, and its edges are sharply pointed. The overall scene is bright and clear, suggesting a sunny day.

# VISIBLE LIGHT ENERGY



# VISIBLE LIGHT ENERGY

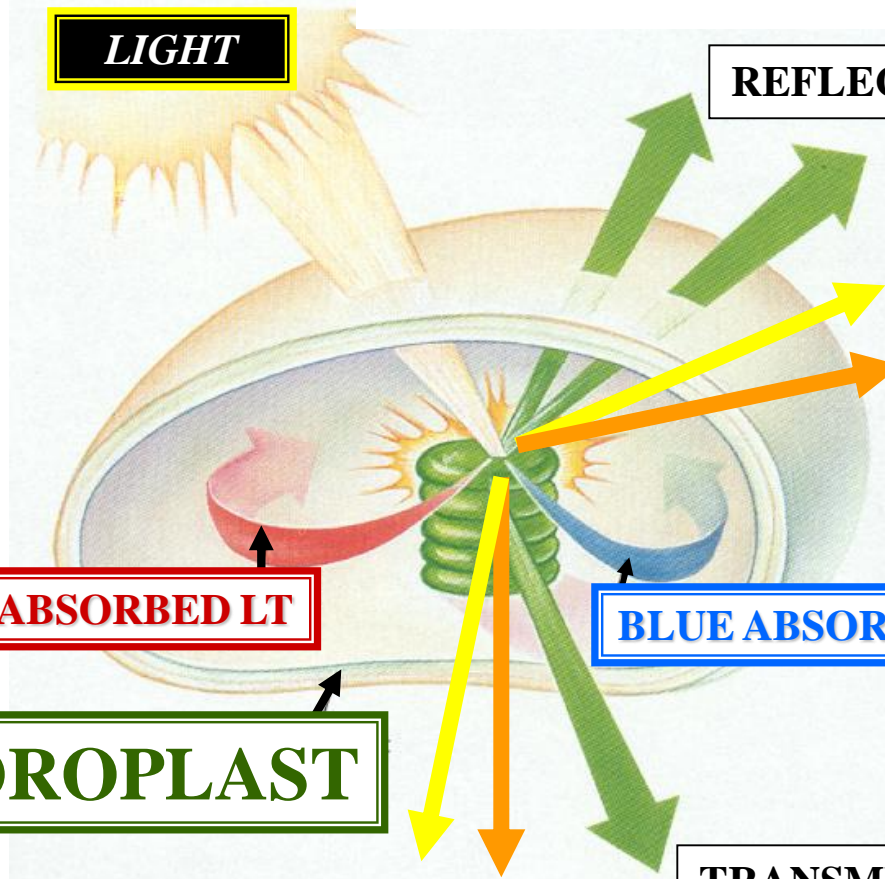
## VISIBLE LIGHT SPECTRUM



# WAVELENGTH EFFICIENCY



RD



**CHLOROPLAST**

**RED ABSORBED LT**

**BLUE ABSORBED LT**

**TRANSMITTED LT**

**LIGHT**

**REFLECTED LT**

# PHOTOSYNTHESIS



LIGHT RXN  
CONSISTS MOSTLY  
REDUCTION / OXIDATION  
REACTIONS

# REDUCTION OXIDATION REACTIONS

**REDUCTION  
OXIDATION  
REACTIONS**

**SYNONYMOUS**

**REDOX  
REACTIONS**

# **REDOX REACTION**



# **REDOX REACTION**

**BIO-CHEMICAL  
E- TRANSFER OCCURS**



# **REDOX REACTION**



# REDOX REACTION

BIO-CHEMICAL  
E- TRANSFER OCCURS



REDUCTION RXT

# REDOX REACTION



# REDOX REACTION

BIO-CHEMICAL  
E- TRANSFER OCCURS



REDUCTION RXT

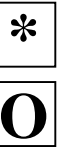
&

OXIDATION RXT

# REDOX REACTION

# **REDUCTION REACTION**

# REDUCTION REACTION



BIO-CHEMICAL  
COMPOUND

GAINS E-

&

GAINS ENERGY

# REDUCTION REACTION

# **OXIDATION REACTION**

**OXIDATION REACTION**

**BIO-CHEMICAL**

**COMPOUND**

**LOSES E-**

**&**

**LOSES ENERGY**

**OXIDATION REACTION**



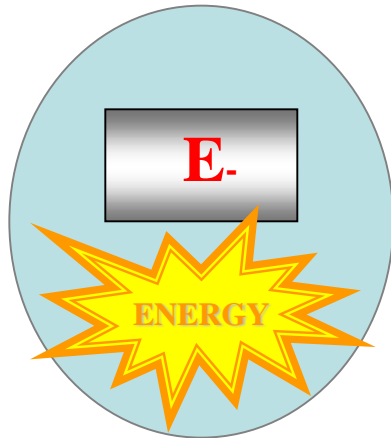
**REDOX**  
**REACTION**  
**APPLIED**

# REDOX REACTION

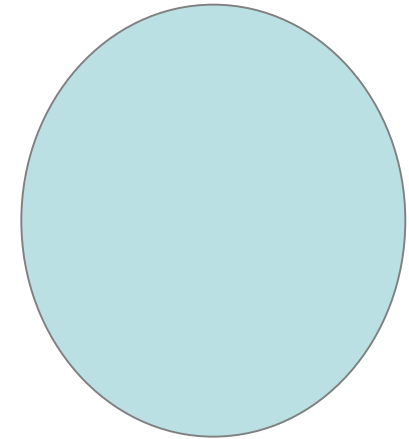
R

## REDUCTION RXT – OXIDATION RXT

CMP-A



CMP-B



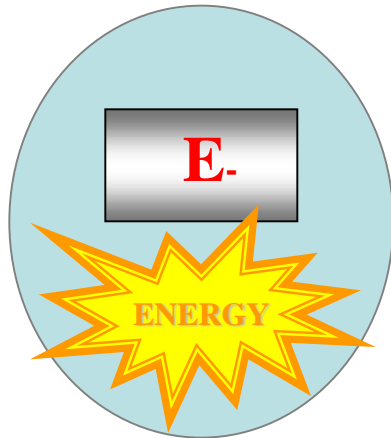
 = CHEMICAL ENERGY

# REDOX REACTION

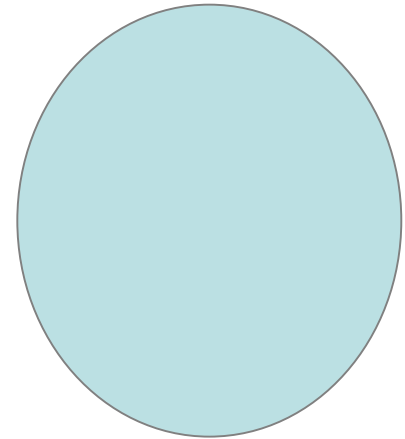
$E^- \rightarrow$

## REDUCTION RXT – OXIDATION RXT

**CMP-A**



**CMP-B**



**REDOX  
REACTION**

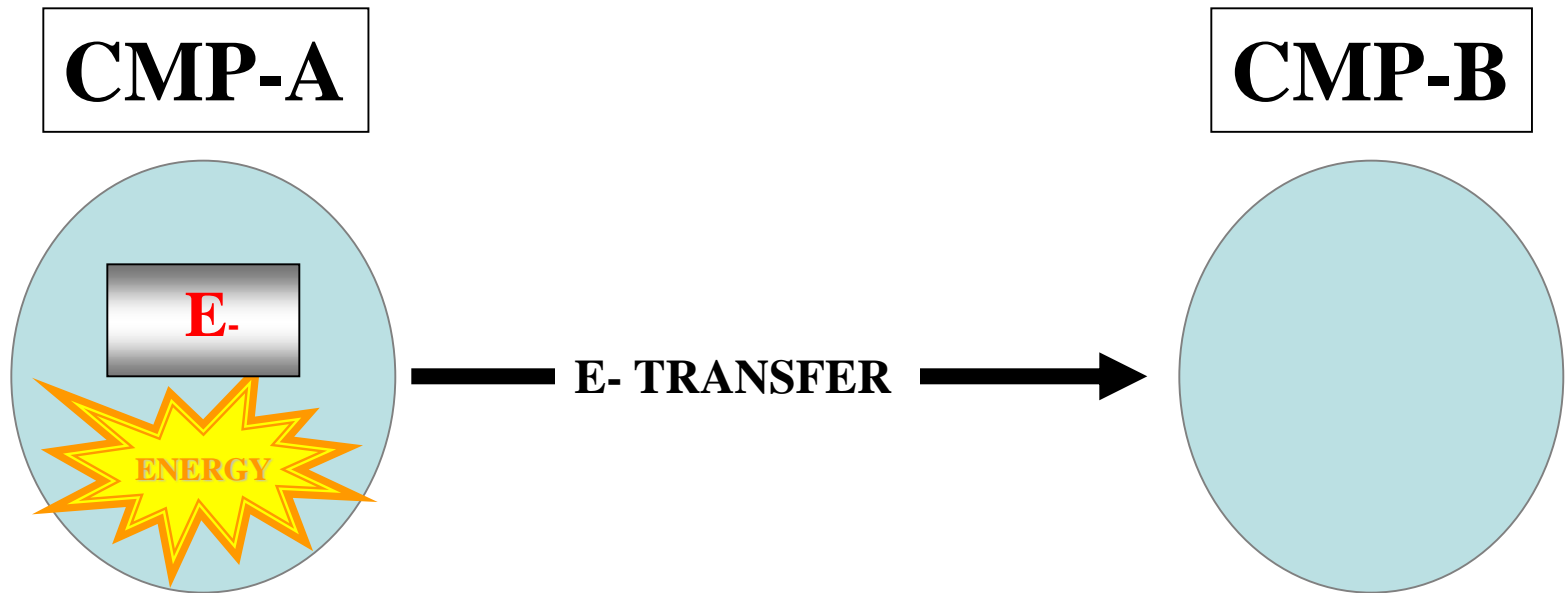
 = **CHEMICAL ENERGY**



# REDOX REACTION

E

## REDUCTION RXT – OXIDATION RXT

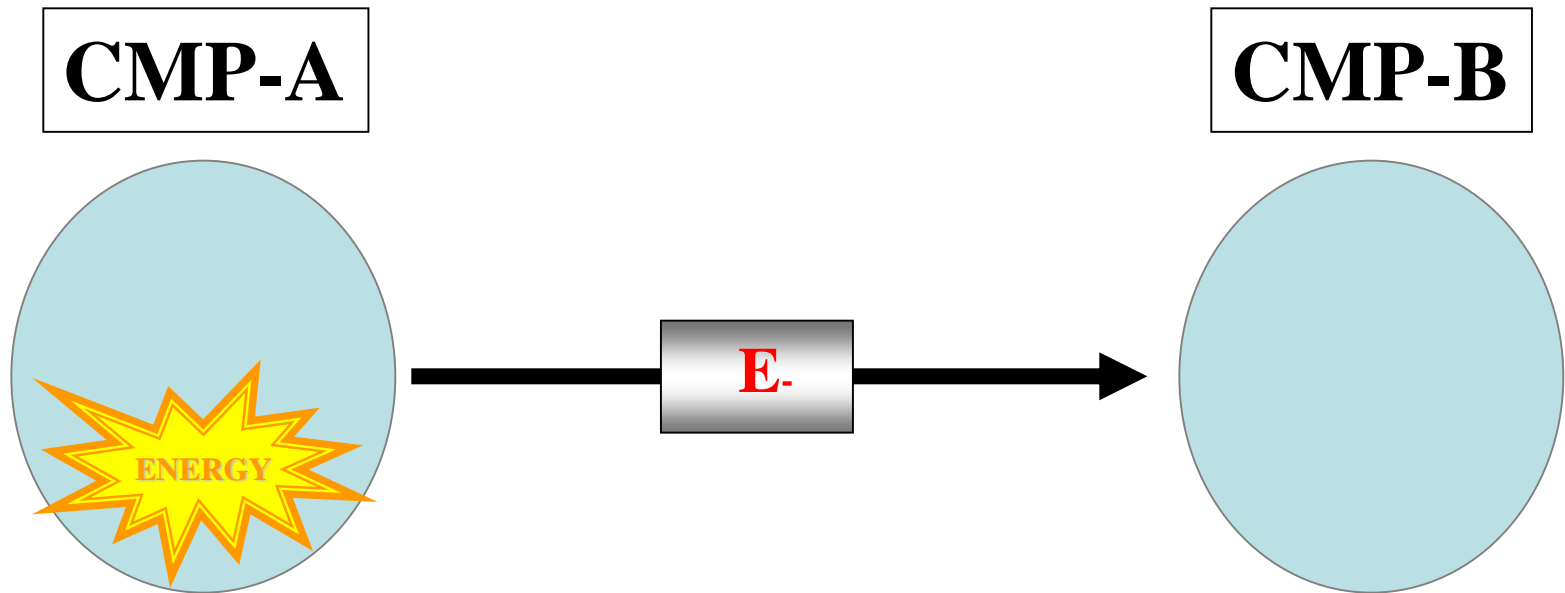


 = CHEMICAL ENERGY

# REDOX REACTION

E

## REDUCTION RXT – OXIDATION RXT

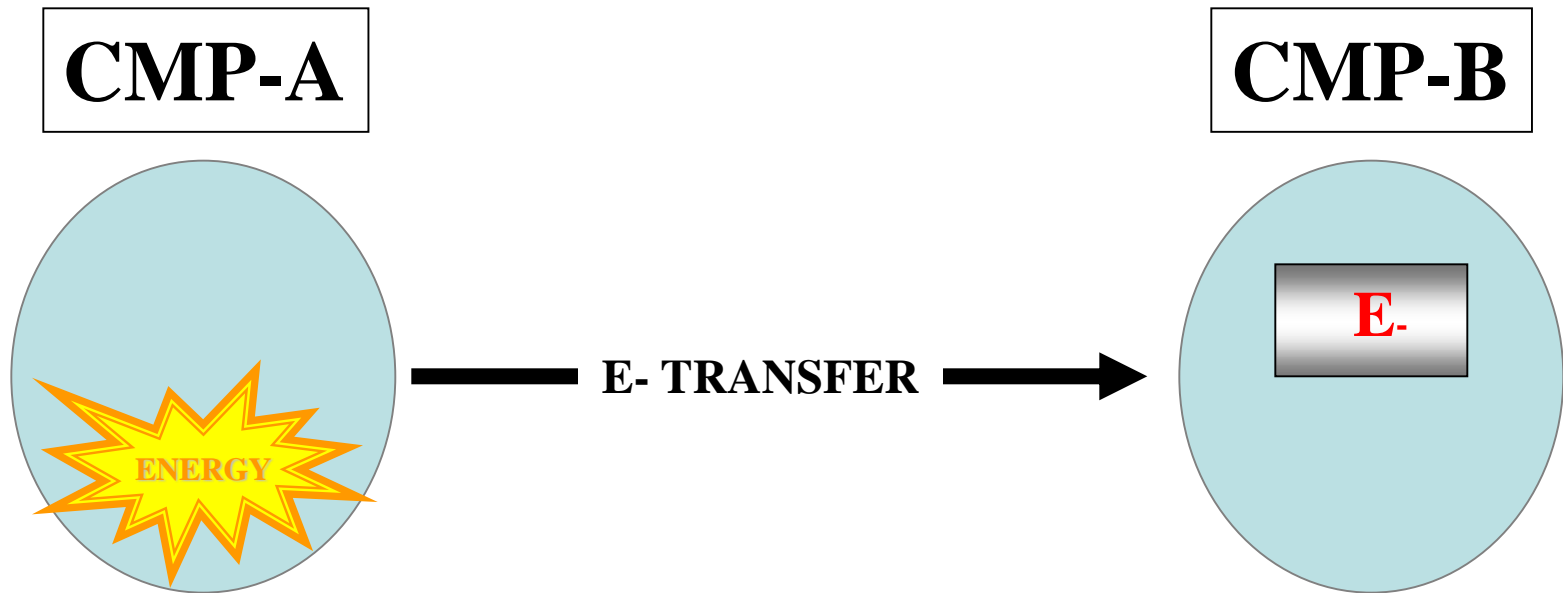


 = CHEMICAL ENERGY

# REDOX REACTION



## REDUCTION RXT – OXIDATION RXT

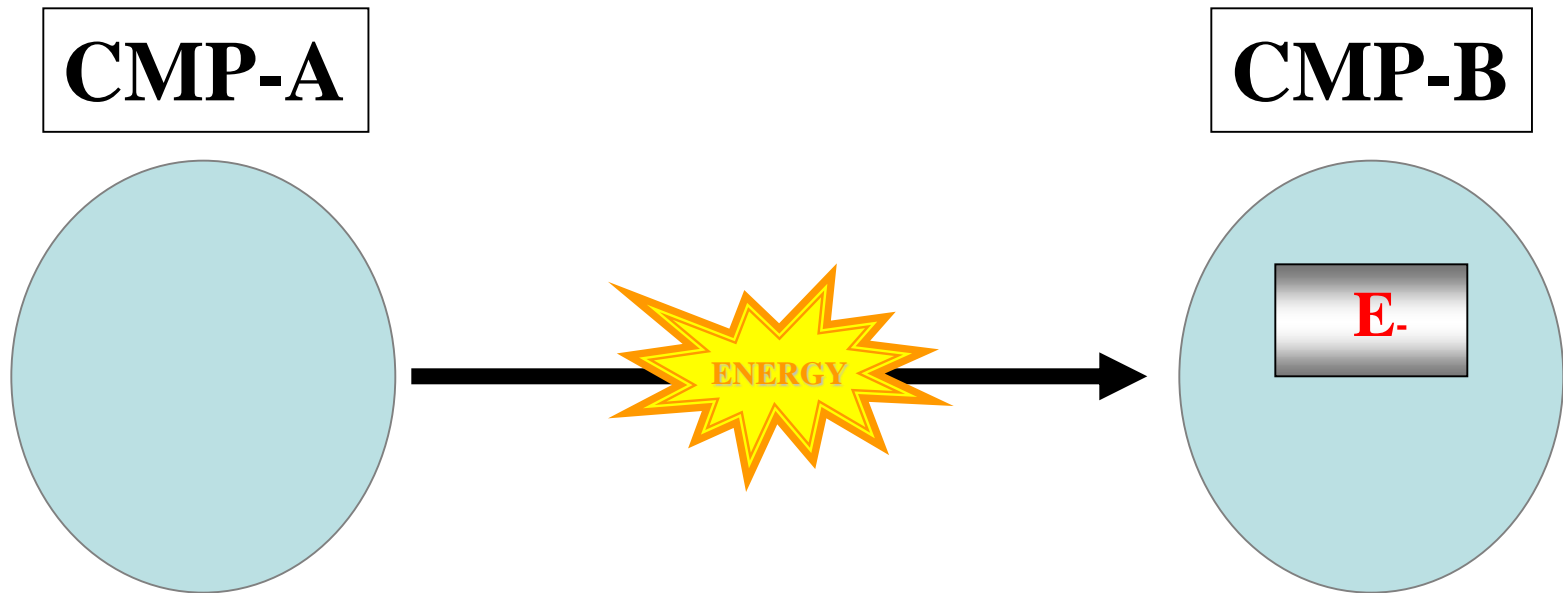


 = CHEMICAL ENERGY

# REDOX REACTION

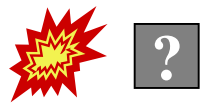


## REDUCTION RXT – OXIDATION RXT

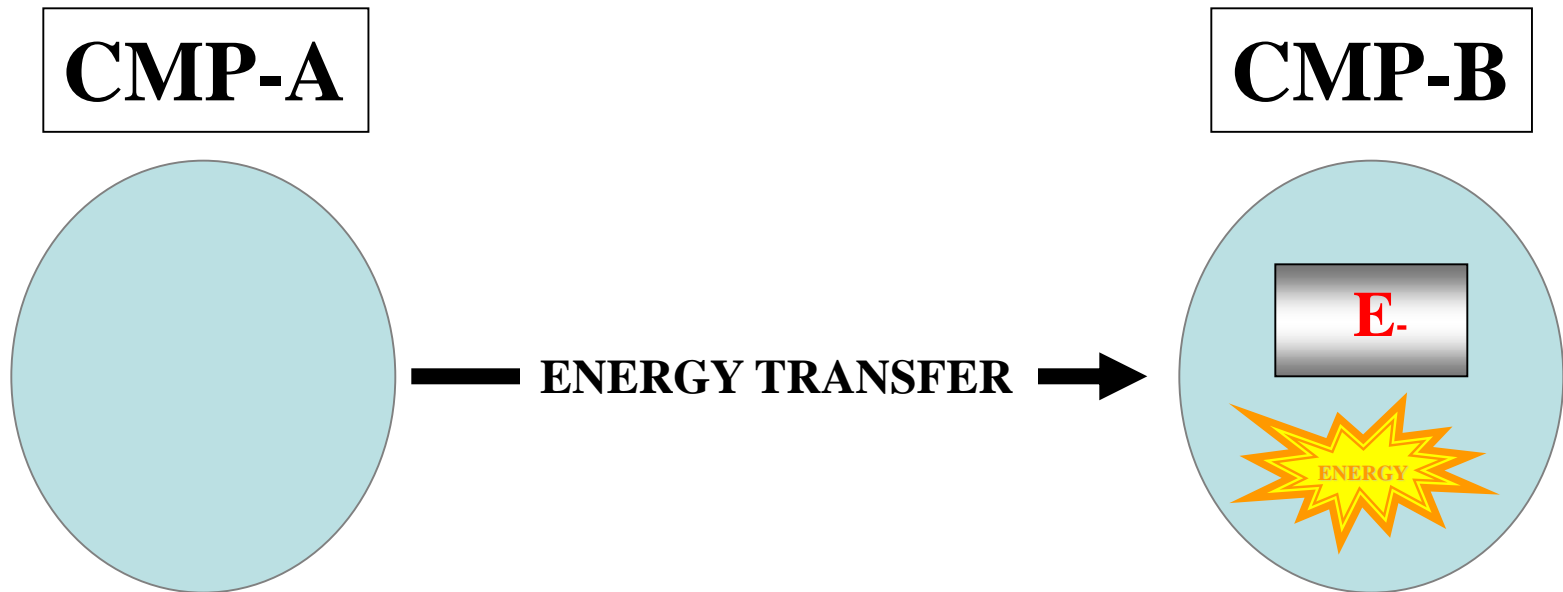


 = CHEMICAL ENERGY

# REDOX REACTION



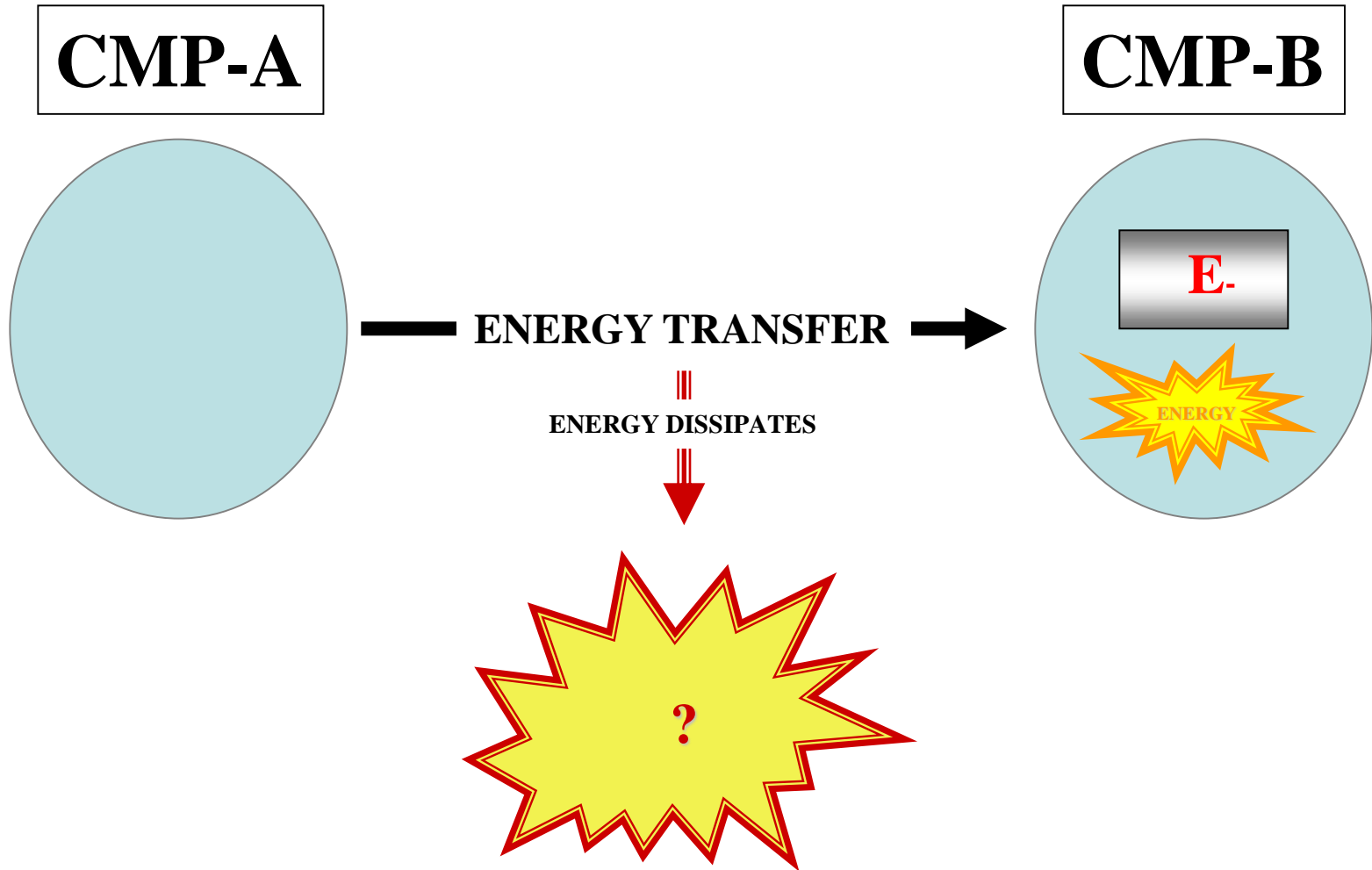
## REDUCTION RXT – OXIDATION RXT



 = CHEMICAL ENERGY

# REDOX REACTION

## REDUCTION RXT – OXIDATION RXT

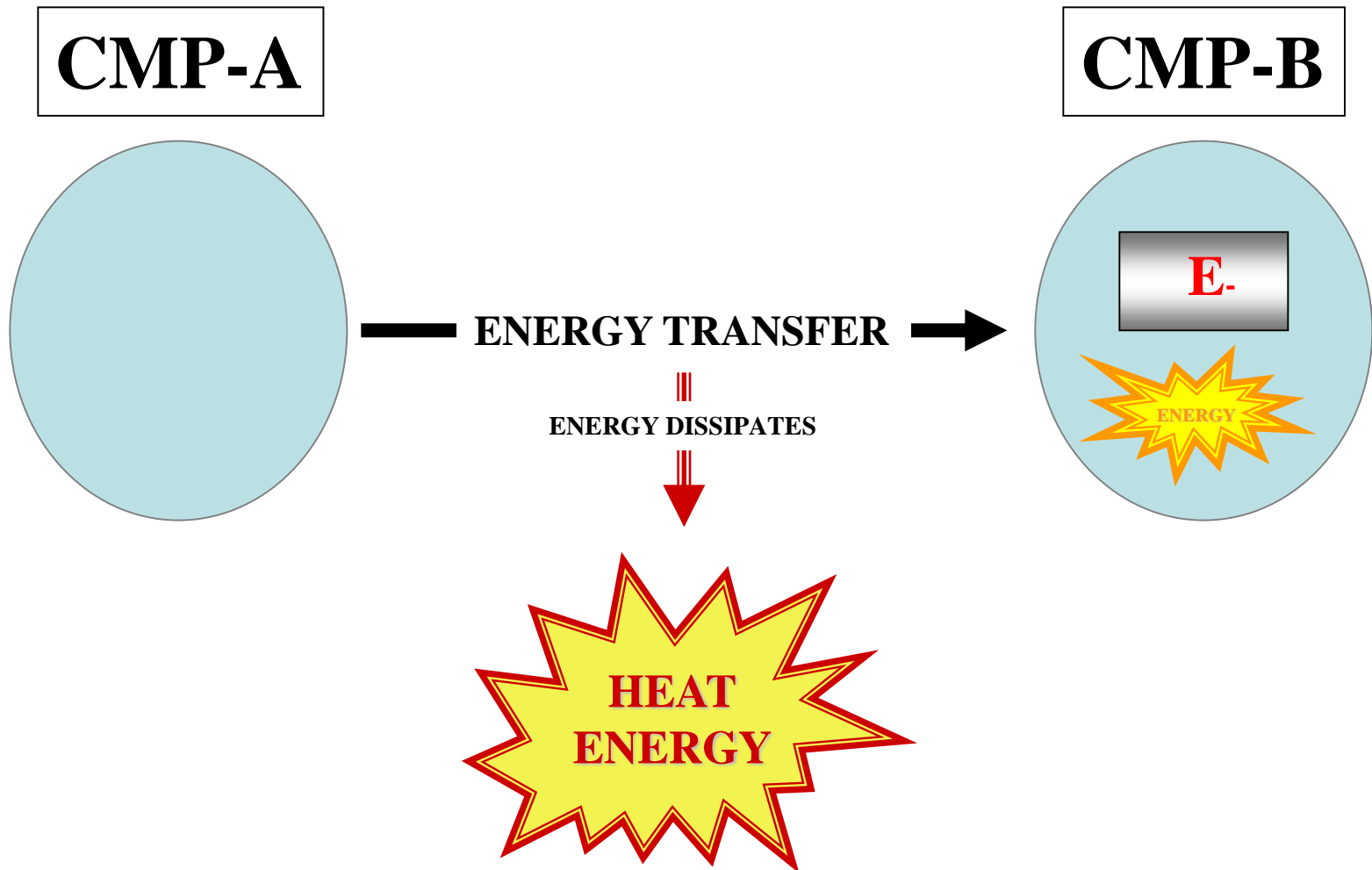


 = **CHEMICAL ENERGY**

# REDOX REACTION

OX

## REDUCTION RXT – OXIDATION RXT

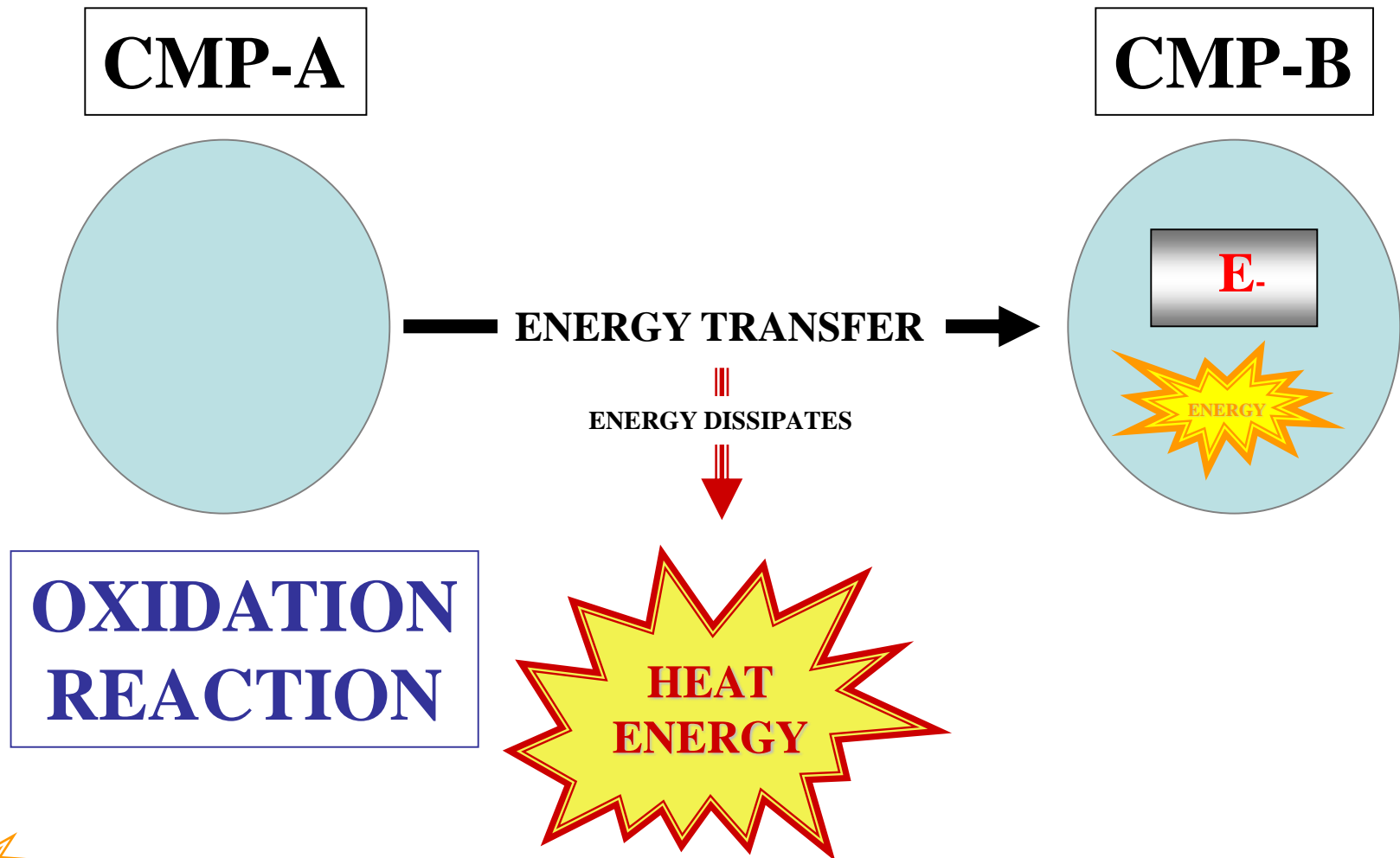


 = **CHEMICAL ENERGY**

# REDOX REACTION

RE

## REDUCTION RXT – OXIDATION RXT



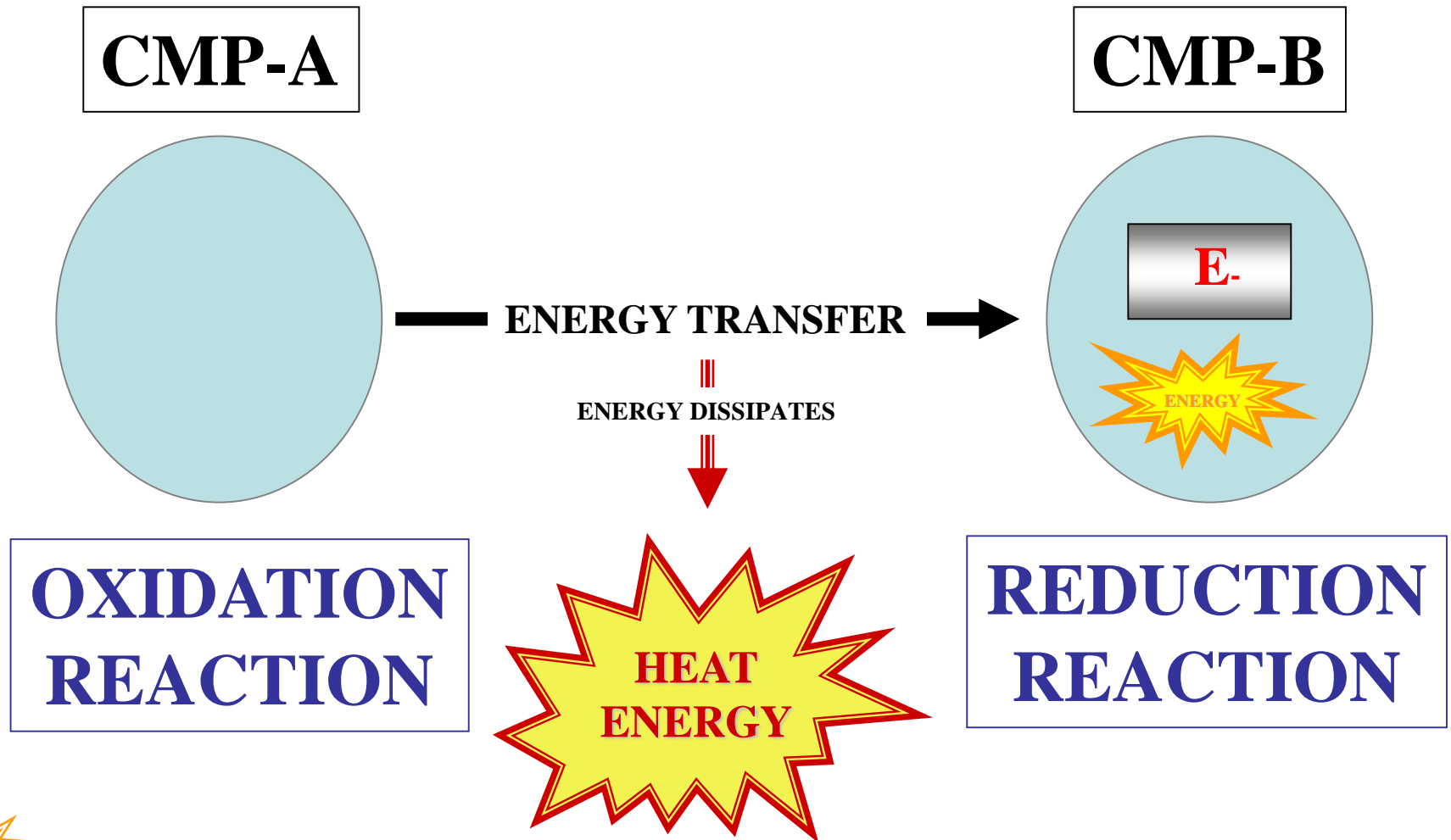
 = **CHEMICAL ENERGY**



# REDOX REACTION



## REDUCTION RXT – OXIDATION RXT



 = **CHEMICAL ENERGY**



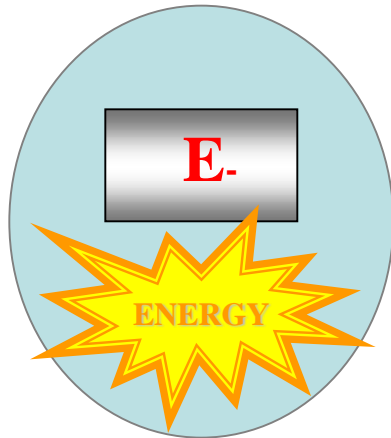
# REDOX REACTION SUMMARY

# REDOX REACTION

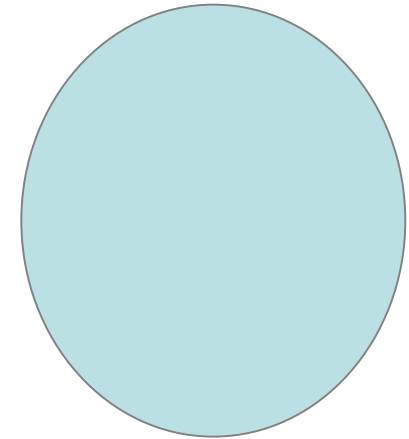
R

## REDUCTION RXT – OXIDATION RXT

CMP-A



CMP-B



 = CHEMICAL ENERGY

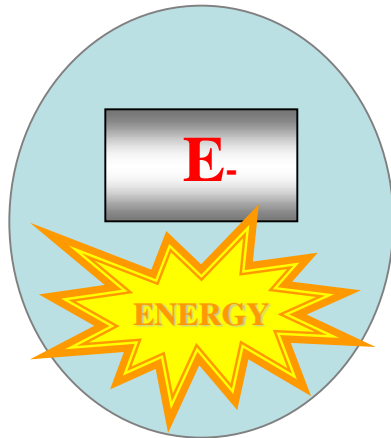
# REDOX REACTION

$E^- \rightarrow$

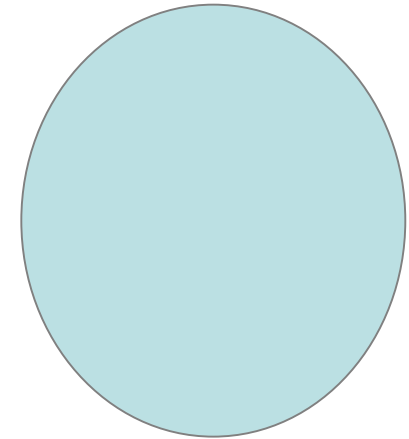
## REDUCTION RXT – OXIDATION RXT

**CMP-A**

**CMP-B**



**REDOX  
REACTION**

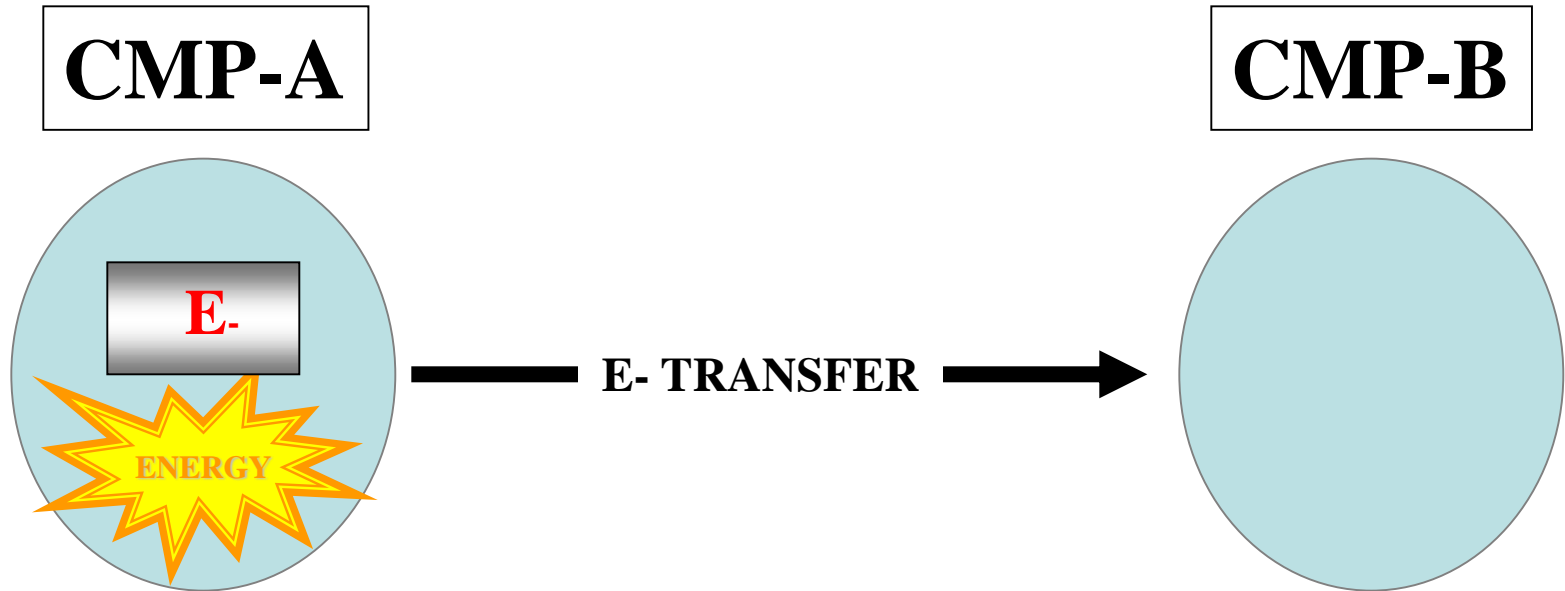


 = **CHEMICAL ENERGY**

# REDOX REACTION

E

## REDUCTION RXT – OXIDATION RXT

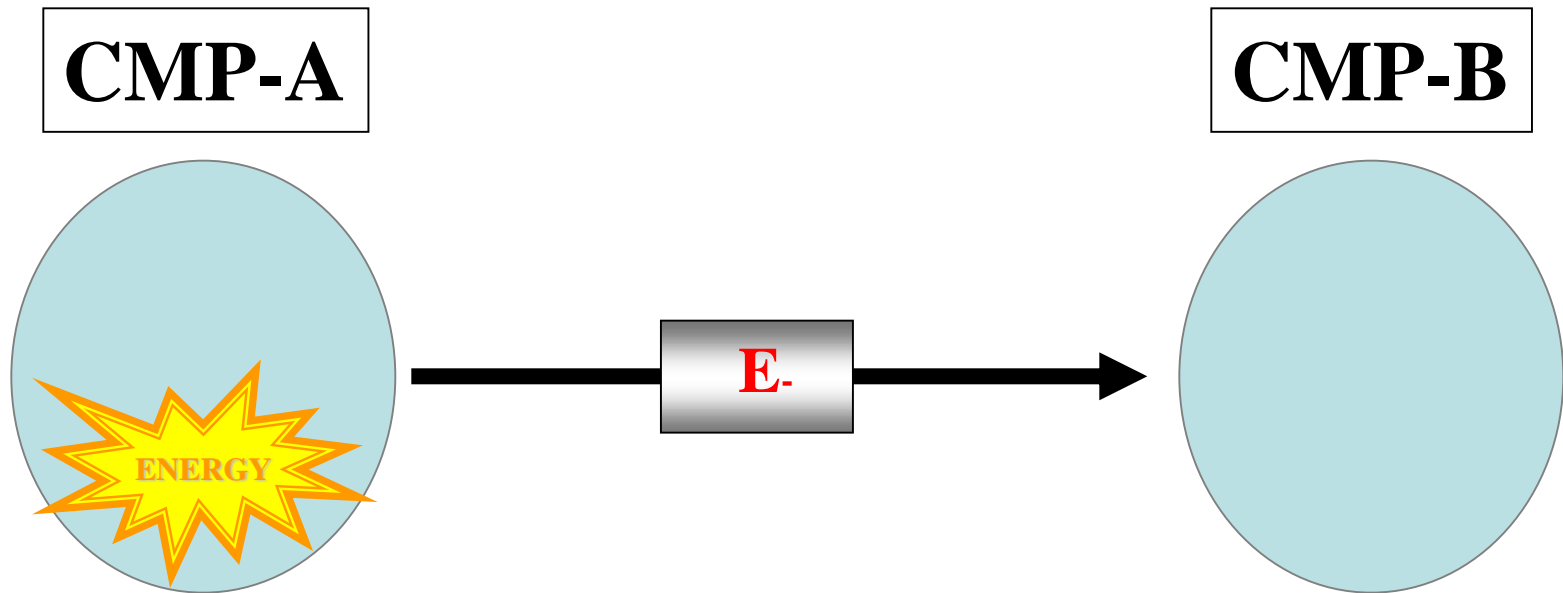


 = CHEMICAL ENERGY

# REDOX REACTION

E

## REDUCTION RXT – OXIDATION RXT

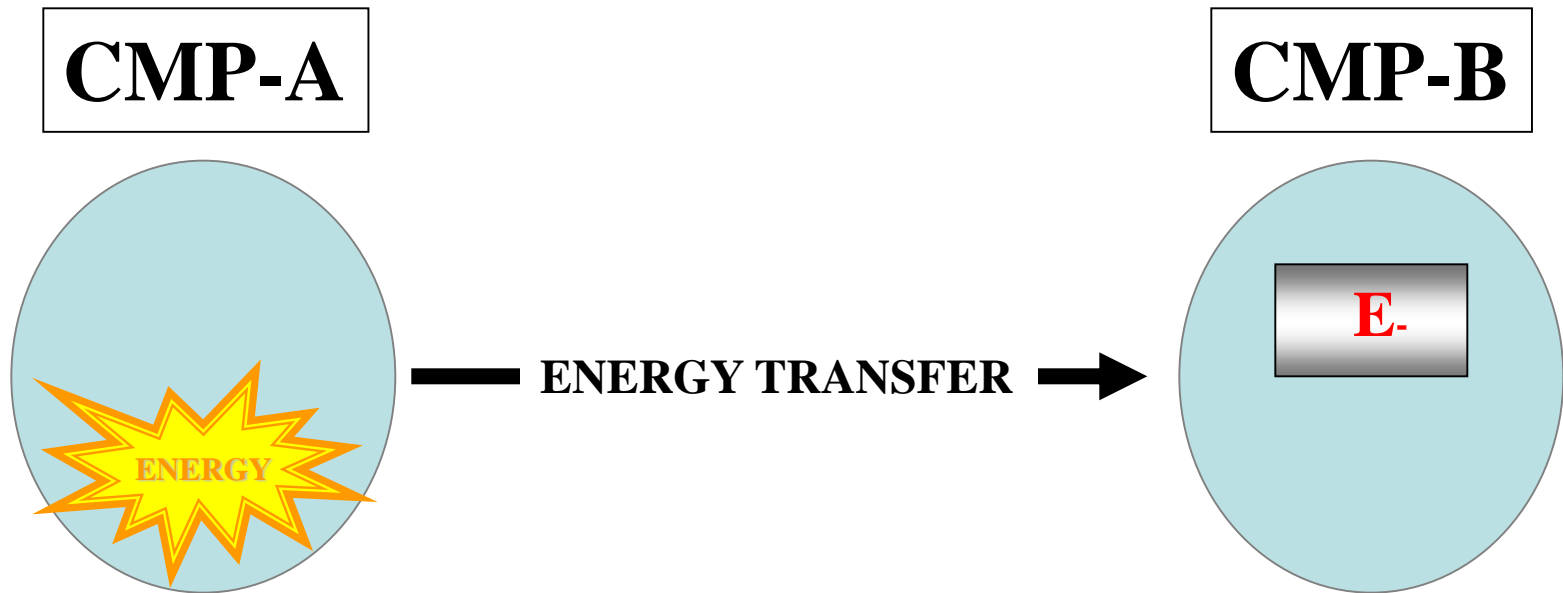


 = CHEMICAL ENERGY

# REDOX REACTION



## REDUCTION RXT – OXIDATION RXT

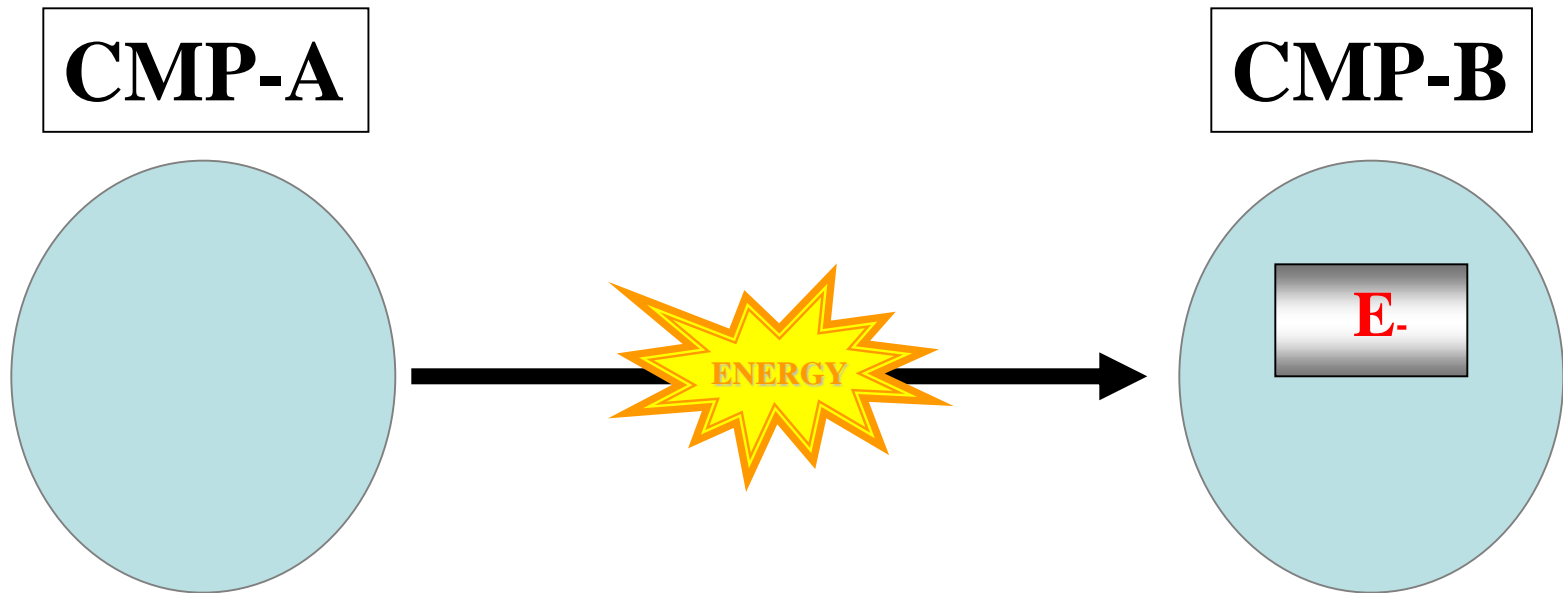


 = CHEMICAL ENERGY

# REDOX REACTION



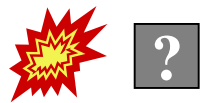
## REDUCTION RXT – OXIDATION RXT



 = CHEMICAL ENERGY



# REDOX REACTION



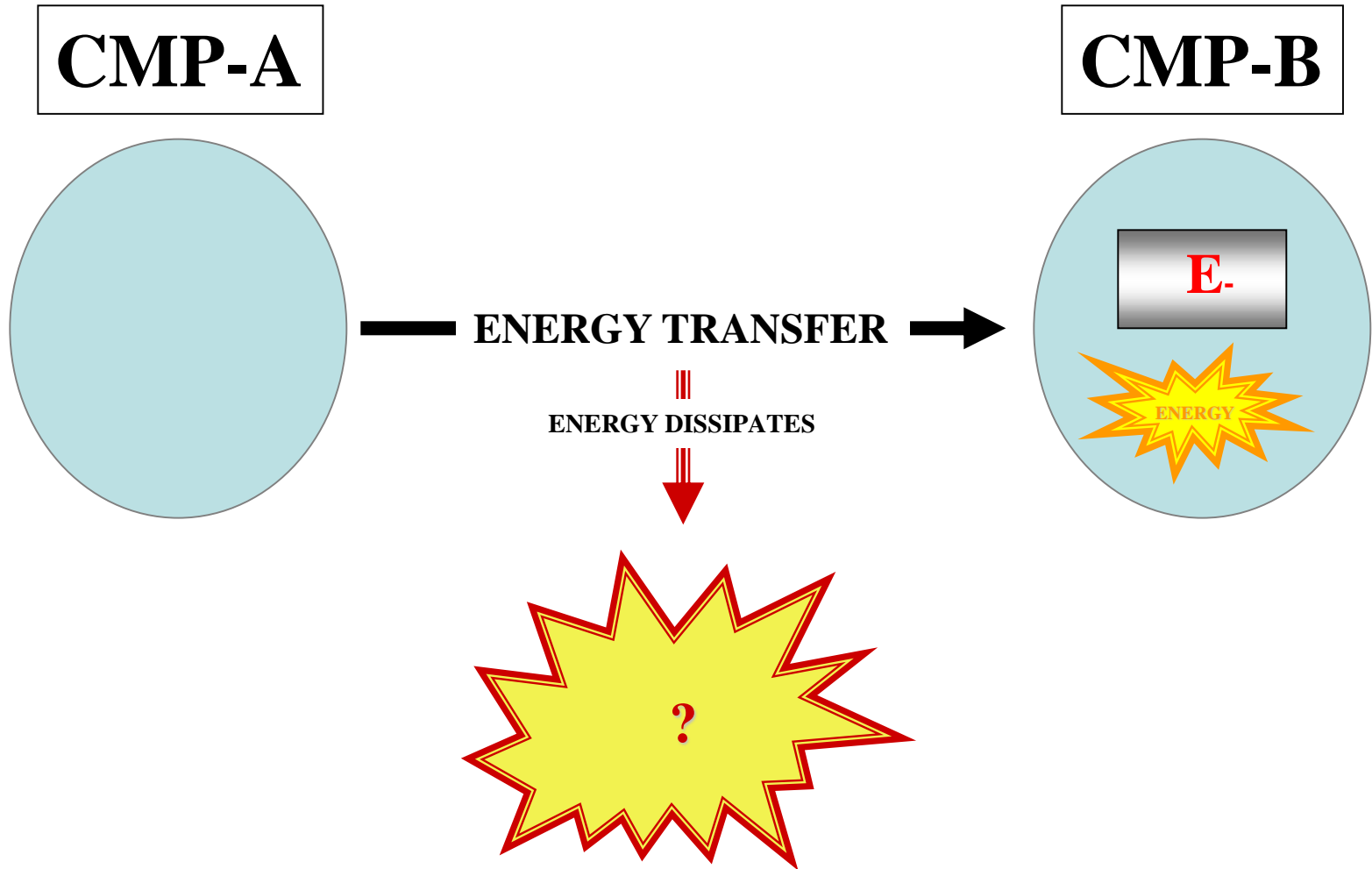
## REDUCTION RXT – OXIDATION RXT



 = CHEMICAL ENERGY

# REDOX REACTION

## REDUCTION RXT – OXIDATION RXT

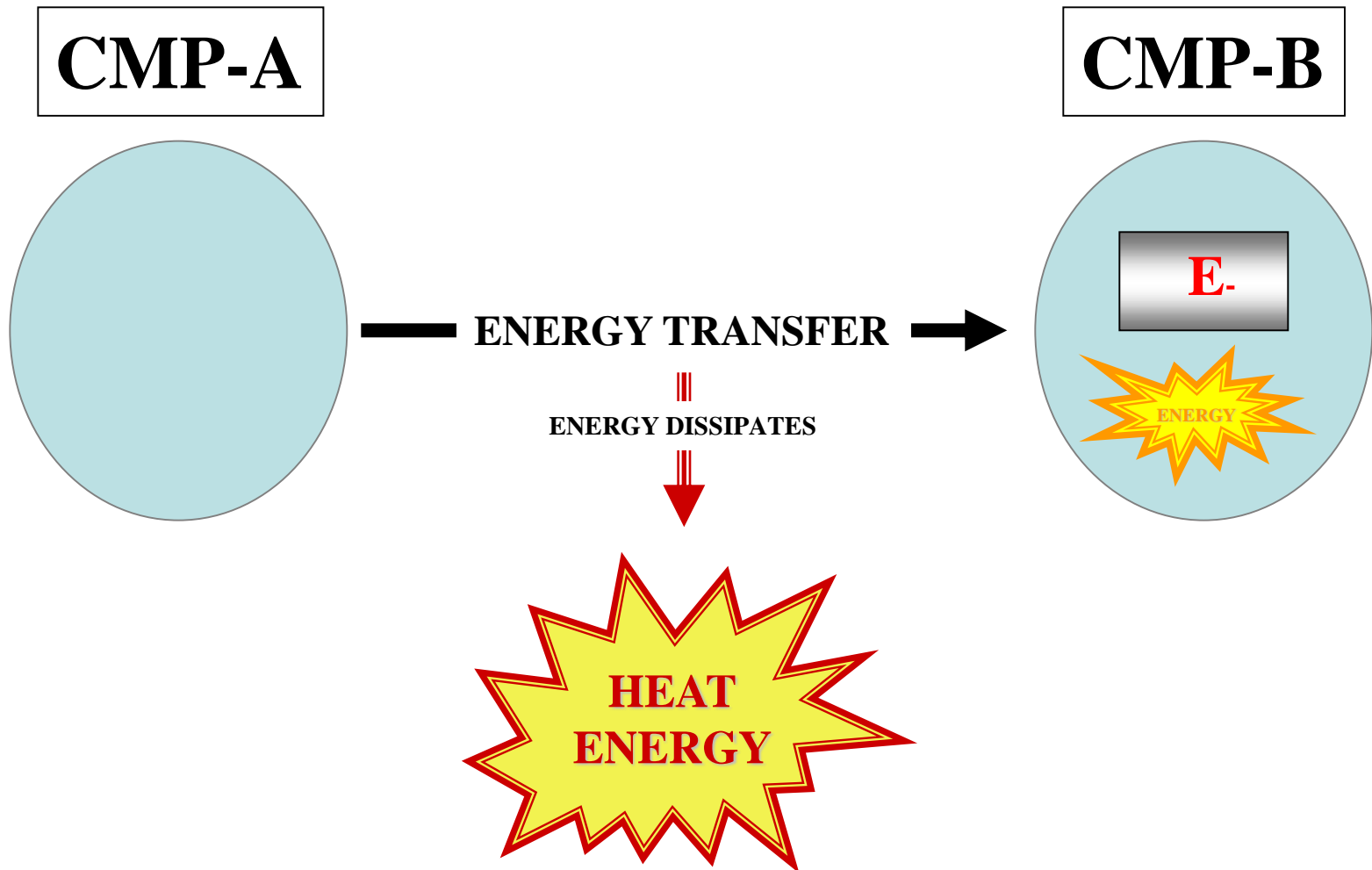


 = CHEMICAL ENERGY

# REDOX REACTION

OX

## REDUCTION RXT – OXIDATION RXT

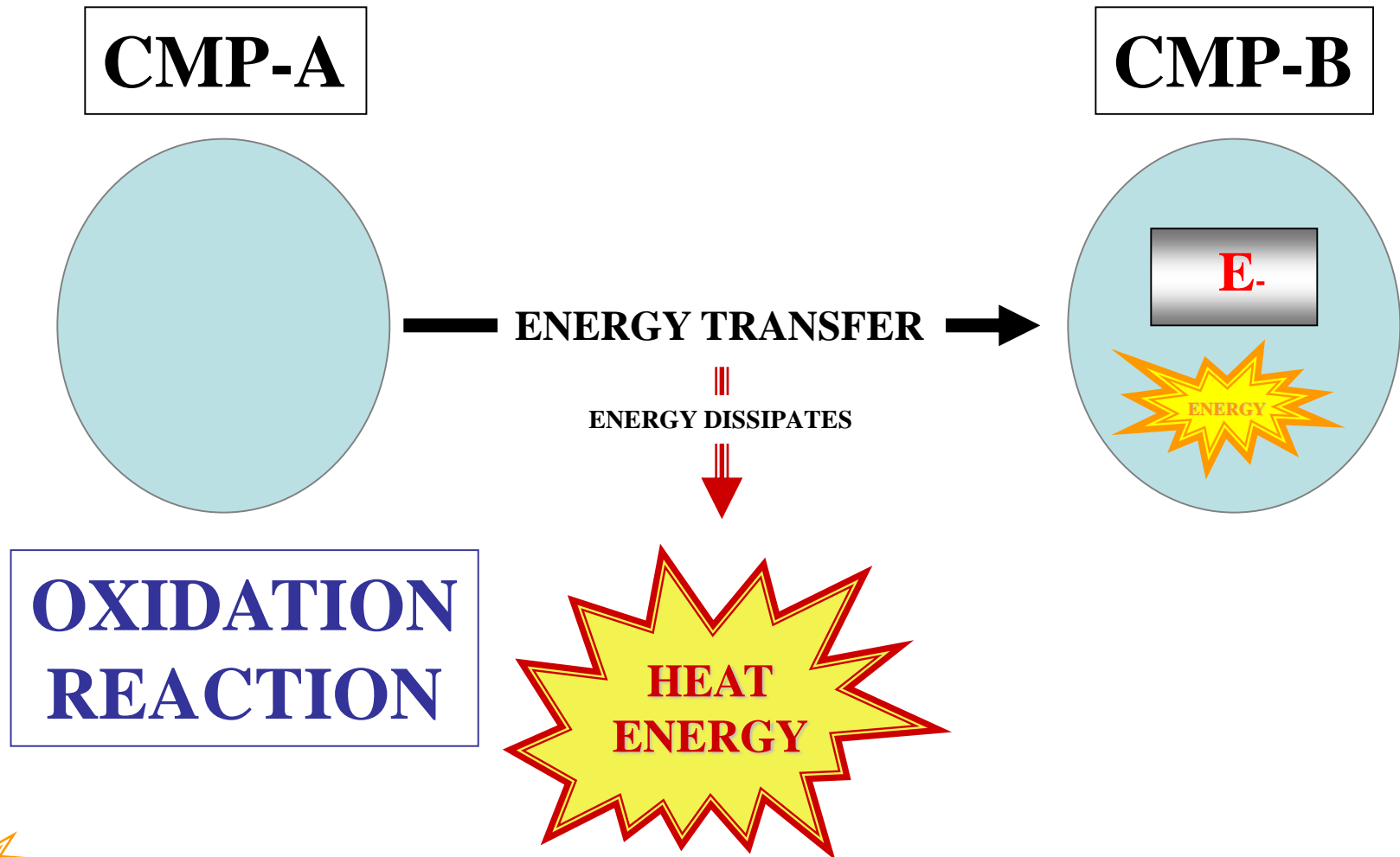


 = **CHEMICAL ENERGY**

# REDOX REACTION

RE

## REDUCTION RXT – OXIDATION RXT

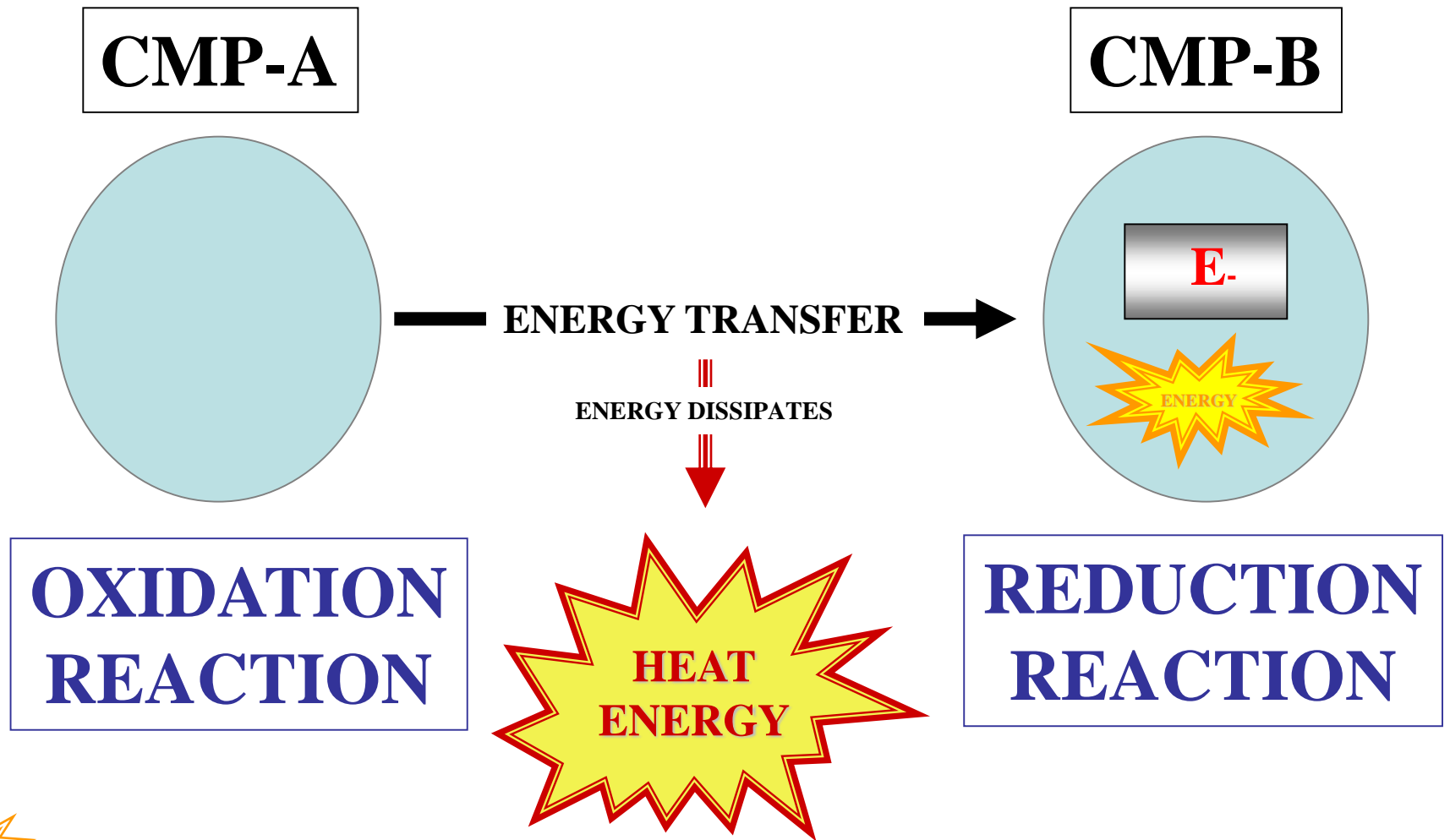


 = **CHEMICAL ENERGY**

# REDOX REACTION



## REDUCTION RXT – OXIDATION RXT



 = **CHEMICAL ENERGY**

**REDUCTION  
REACTIONS  
&  
OXIDATION  
REACTIONS  
?**



**CATABOLIC  
METABOLISM  
&  
ANABOLIC  
METABOLISM  
?**





**EXERGOIC  
REACTIONS  
&  
ENDERGOIC  
REACTIONS  
?**



**LIGHT  
REACTION  
&  
DARK  
REACTION  
?**

^

+

**REDUCTION  
REACTIONS  
&  
OXIDATION  
REACTIONS  
?**

REDUCTION

REACTIONS

&

OXIDATION

REACTIONS

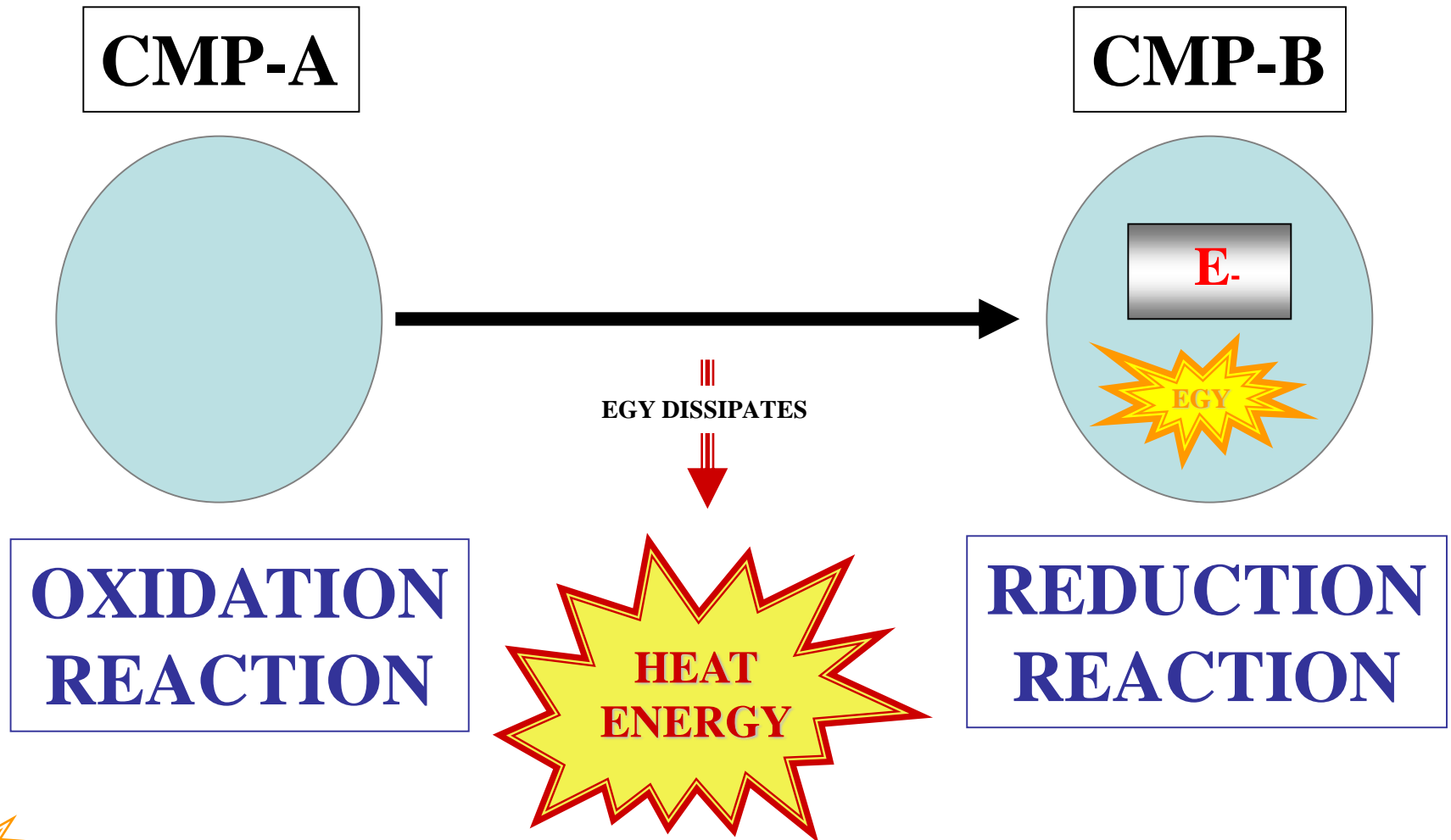
**!!!COUPLED!!!**



# REDOX REACTION

CP > 2

## REDUCTION RXT – OXIDATION RXT



 = **CHEM ENERGY**

REDUCTION

REACTIONS

&

OXIDATION

REACTIONS

**!!!COUPLED!!!**





*REDOX RXTS*

*ESSENTIAL*

*PSYN*

*LIGHT RXTS*

# LIGHT REACTION TYPES

**LIGHT  
REACTION  
TYPES**

**NON-CYCLIC PHOTO-PHOSPHORYLATION**

**TYPES  
REACTION  
TYPES**





# LIGHT REACTION TYPES

NON-CYCLIC PHOTO-PHOSPHORYLATION  
CYCLIC PHOTO-PHOSPHORYLATION

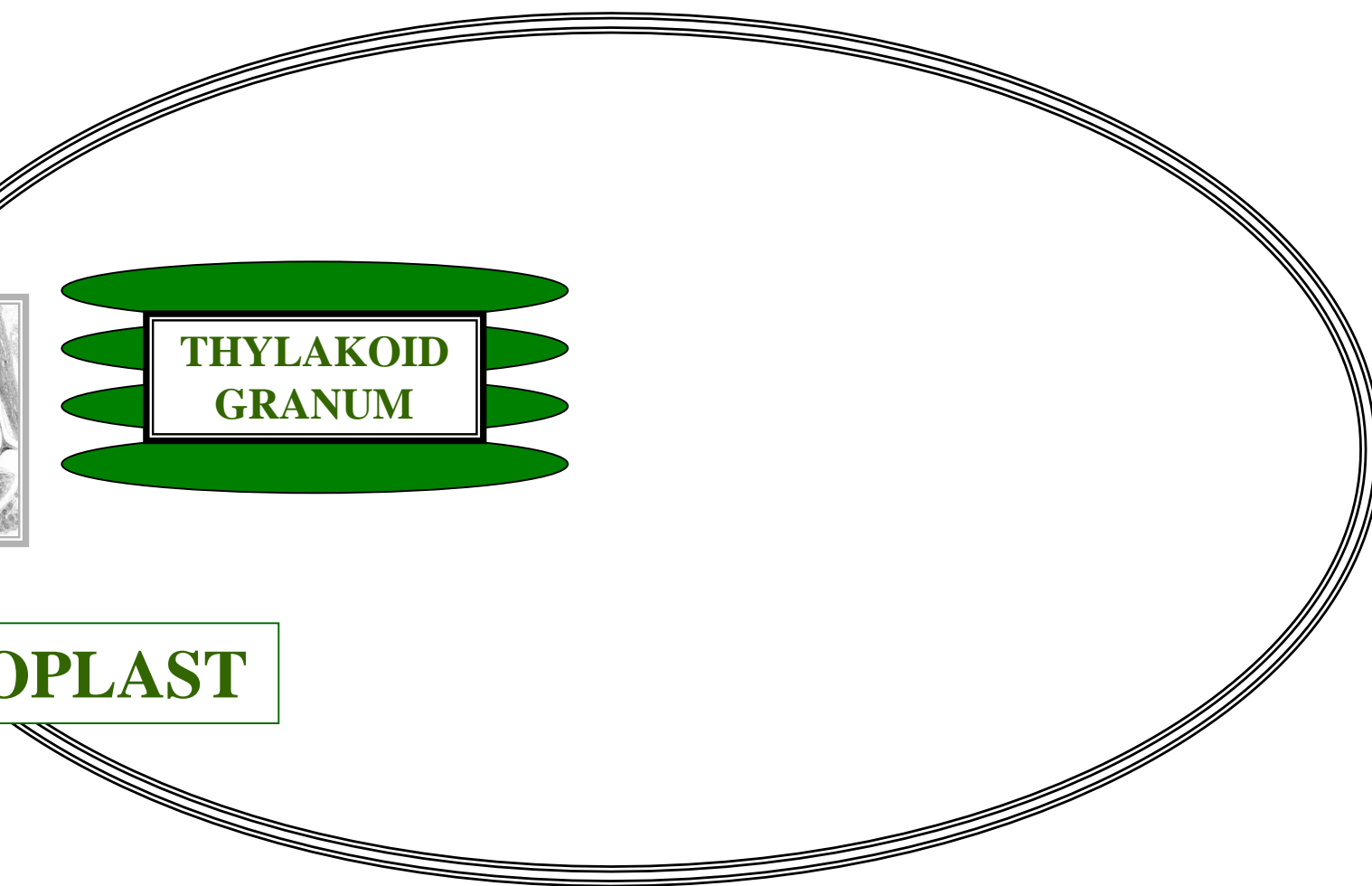
# TYPES REACTION TYPES

# PHOTOSYNTHESIS

LR



**CHLOROPLAST**



# PHOTOSYNTHESIS

**LT**



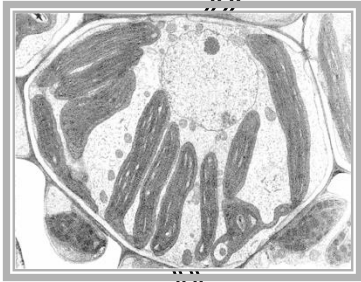
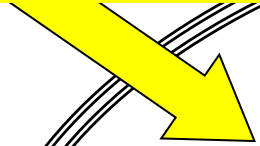
**NON-CYCLIC PHOTO-PHOSPHORYLATION  
&  
CYCLIC PHOTO-PHOSPHORYLATION**

**CHLOROPLAST**

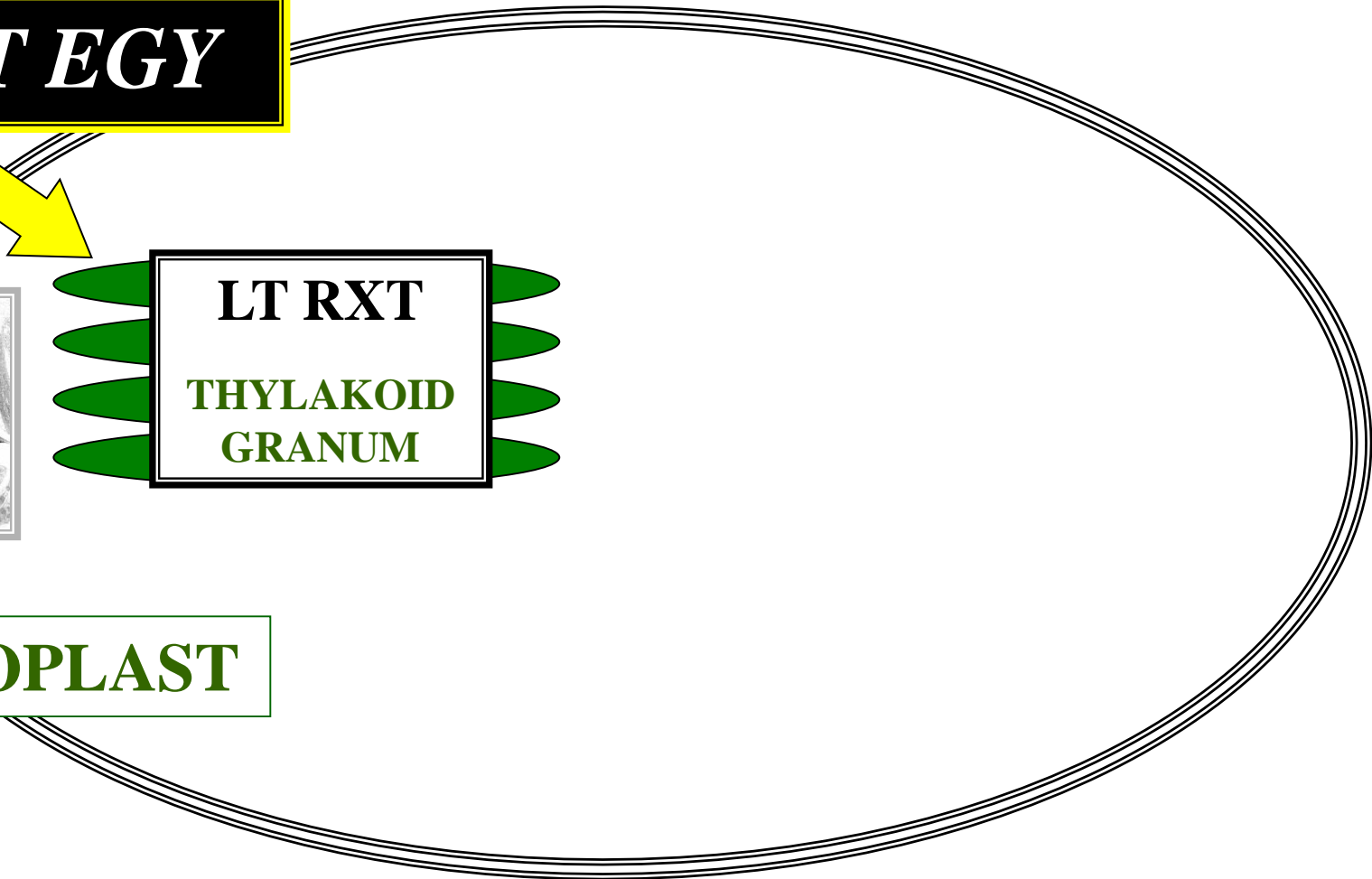
# PHOTOSYNTHESIS



**LIGHT ENERGY**



**CHLOROPLAST**



# PHOTOSYNTHESIS

C



WATER

**LIGHT ENERGY**

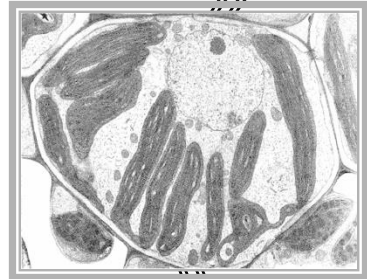
E-

PHOTOLYSIS

LT RXT

THYLAKOID  
GRANUM

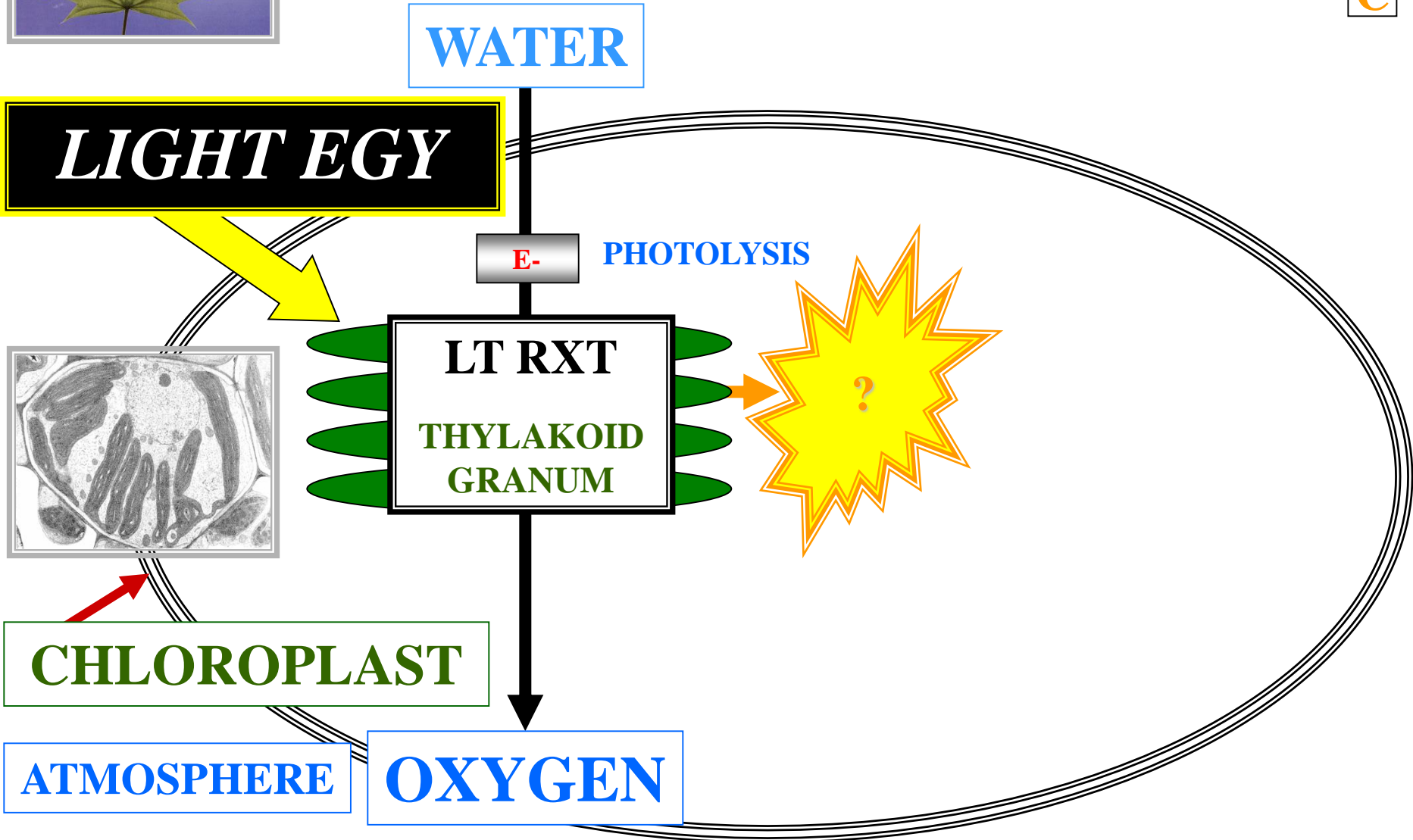
?



CHLOROPLAST

ATMOSPHERE

OXYGEN



# PHOTOSYNTHESIS

A



WATER

**LIGHT ENERGY**

E-

PHOTOLYSIS

LT RXT

THYLAKOID  
GRANUM

CHEMICAL  
ENERGY

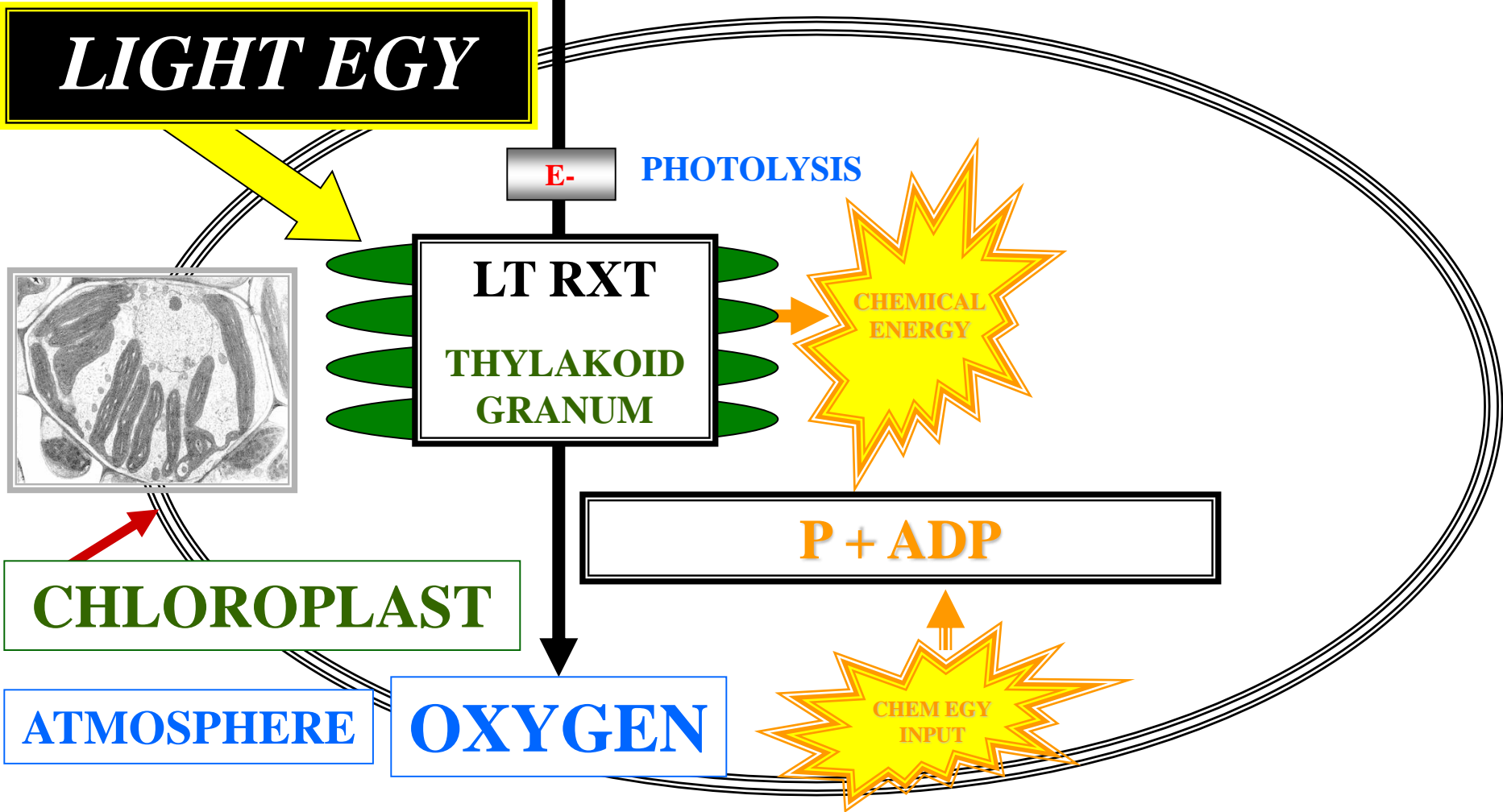
P + ADP

CHLOROPLAST

ATMOSPHERE

OXYGEN

CHEMICAL  
INPUT



# PHOTOSYNTHESIS

P



WATER

**LIGHT ENERGY**

E-

PHOTOLYSIS

LT RXT

THYLAKOID  
GRANUM

ATP

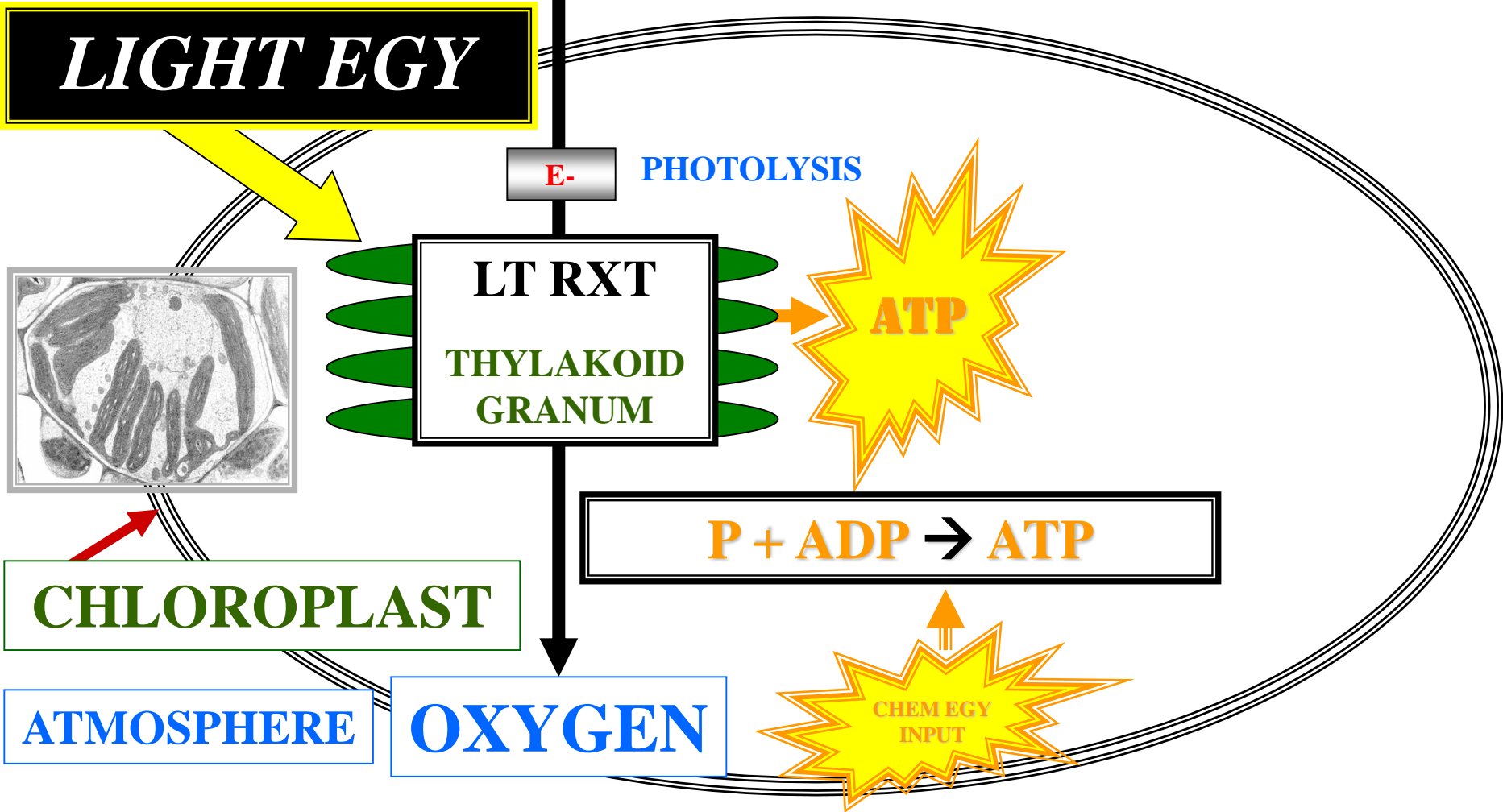
$P + ADP \rightarrow ATP$

CHEMICAL  
INPUT

CHLOROPLAST

ATMOSPHERE

OXYGEN



# PHOTOSYNTHESIS



?

LT

P

WATER

**LIGHT ENERGY**

E-

PHOTOLYSIS

LT RXT

THYLAKOID  
GRANUM

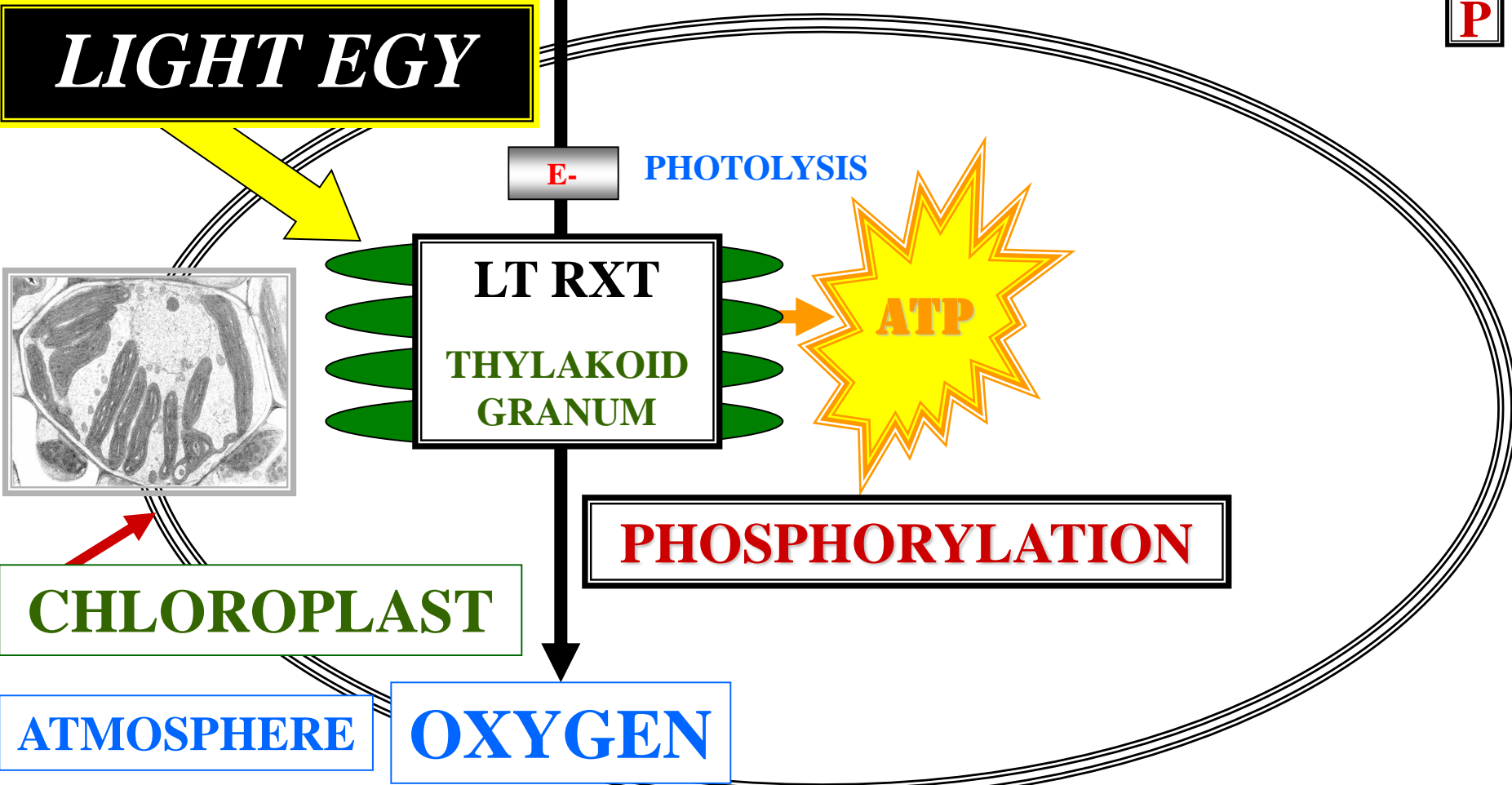
ATP

PHOSPHORYLATION

CHLOROPLAST

ATMOSPHERE

OXYGEN





# PHOTOSYNTHESIS



+

PP

WATER

**LIGHT ENERGY**

**PHOTO**

E-

PHOTOLYSIS

LT RXT

THYLAKOID  
GRANUM

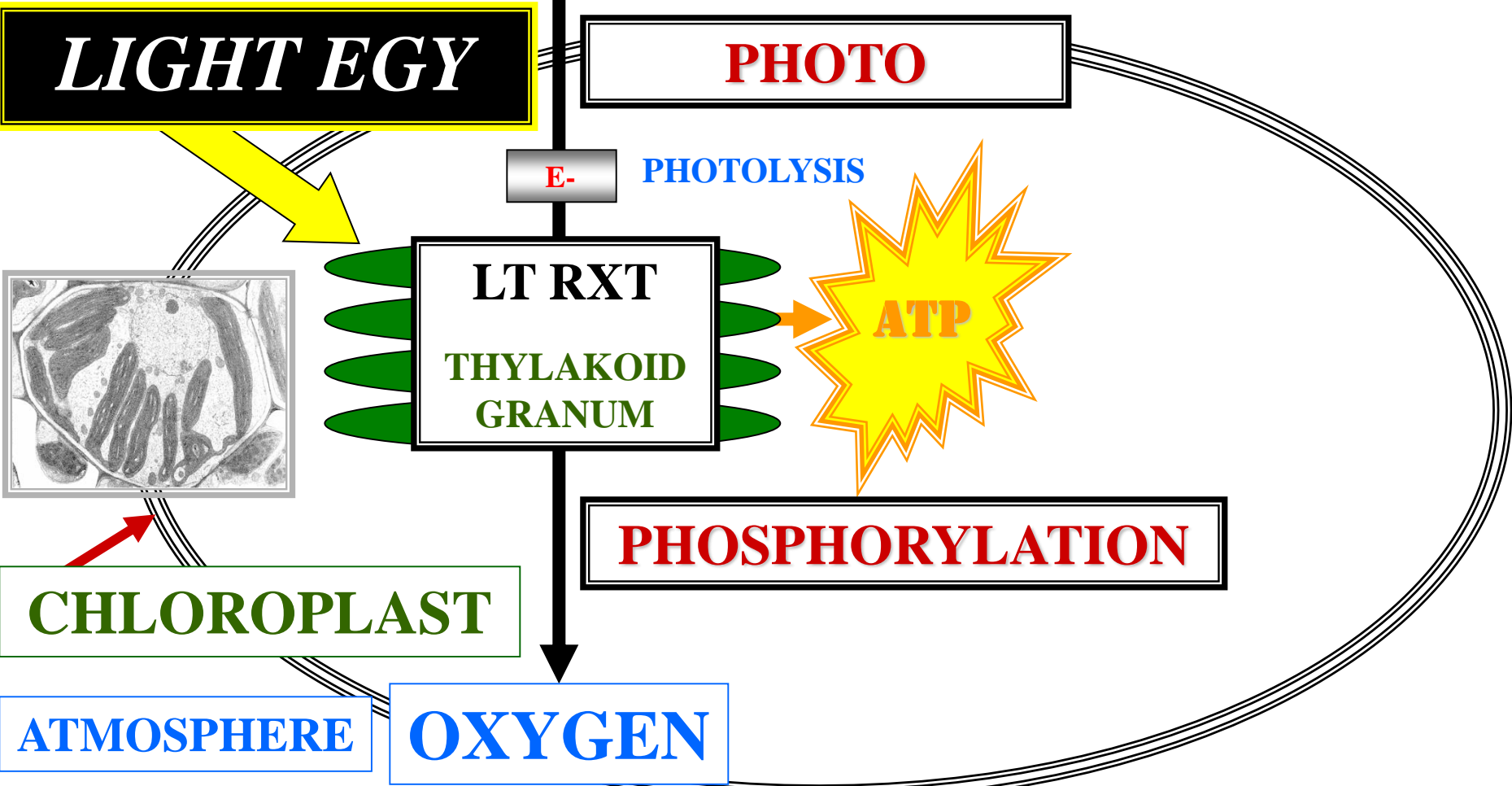
ATP

**PHOSPHORYLATION**

**CHLOROPLAST**

ATMOSPHERE

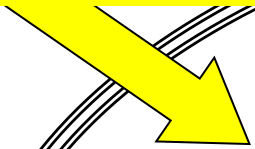
**OXYGEN**



# PHOTOSYNTHESIS



**LIGHT ENERGY**



**NON-CYCLIC PHOTO-PHOSPHORYLATION  
&  
CYCLIC PHOTO-PHOSPHORYLATION**

**CHLOROPLAST**





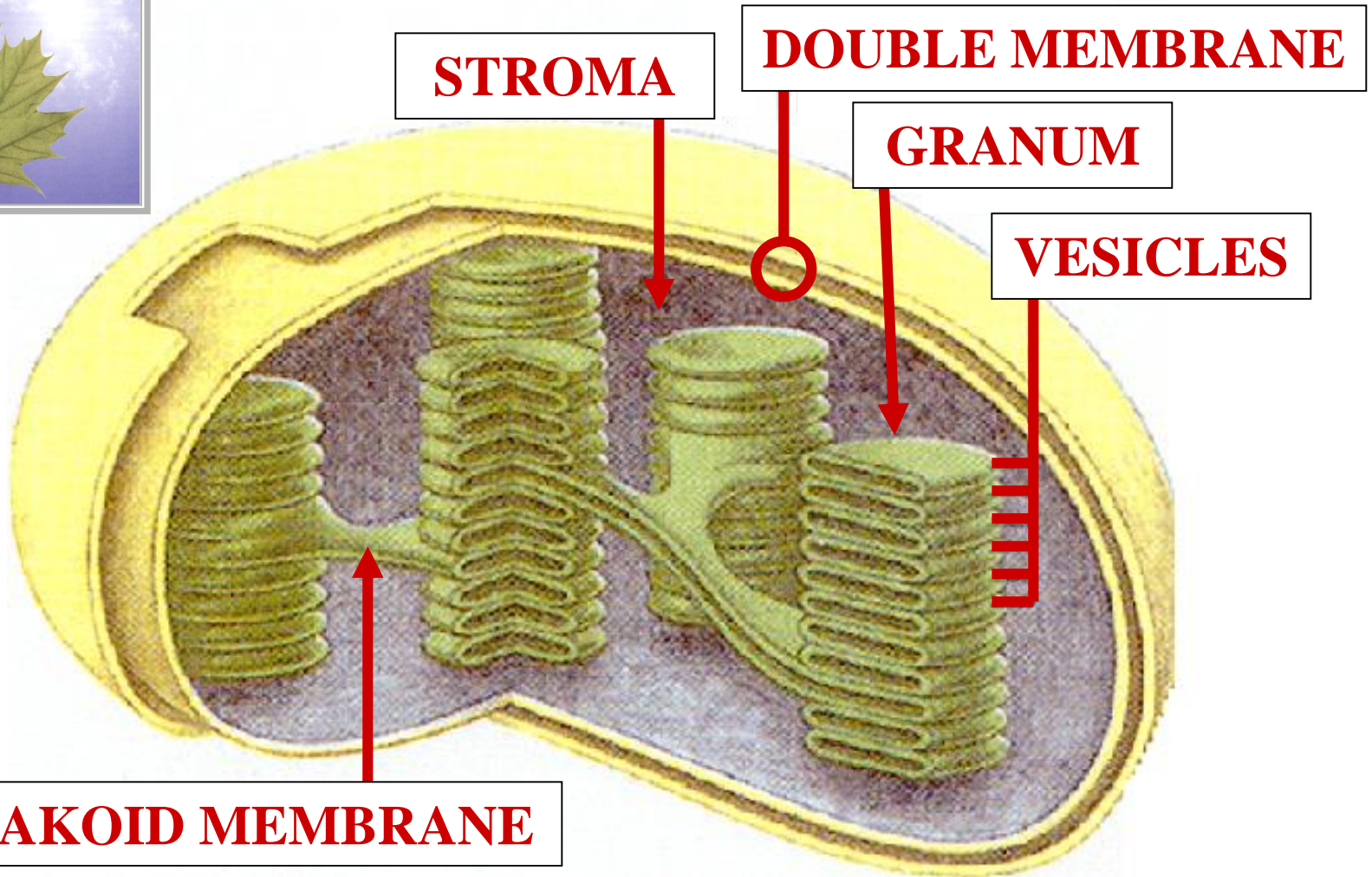
# **LIGHT REACTION**

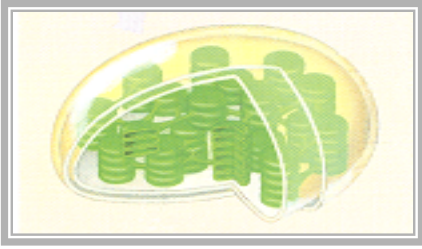
## **NON-CYCLIC**

### **PHOTO-PHOSPHORYLATION**

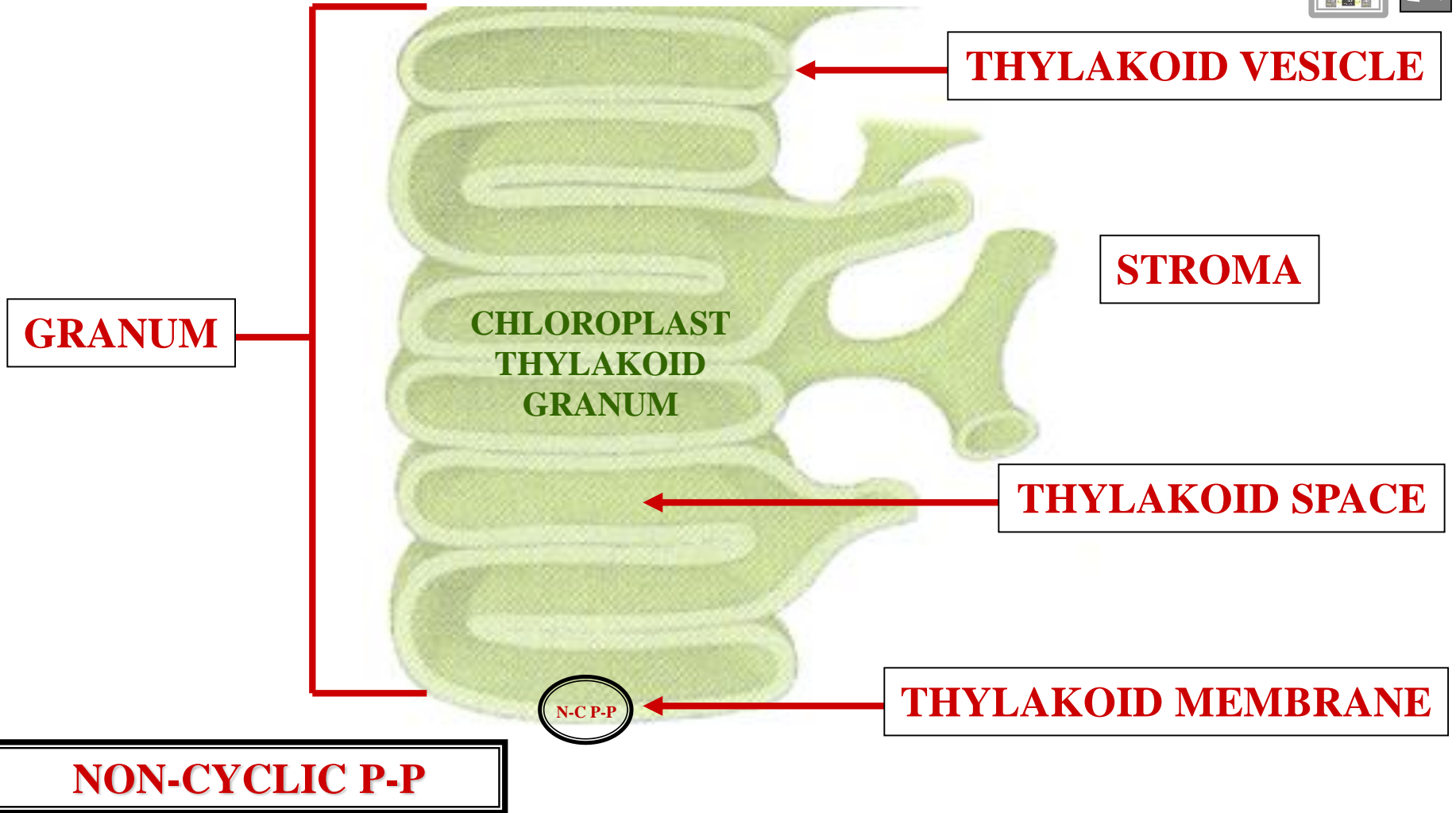
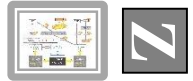


# CHLOROPLAST ULTRASTRUCTURE





# CHLOROPLAST THYLAKOID



**GRANUM**

**CHLOROPLAST  
THYLAKOID  
GRANUM**

**THYLAKOID VESICLE**

**STROMA**

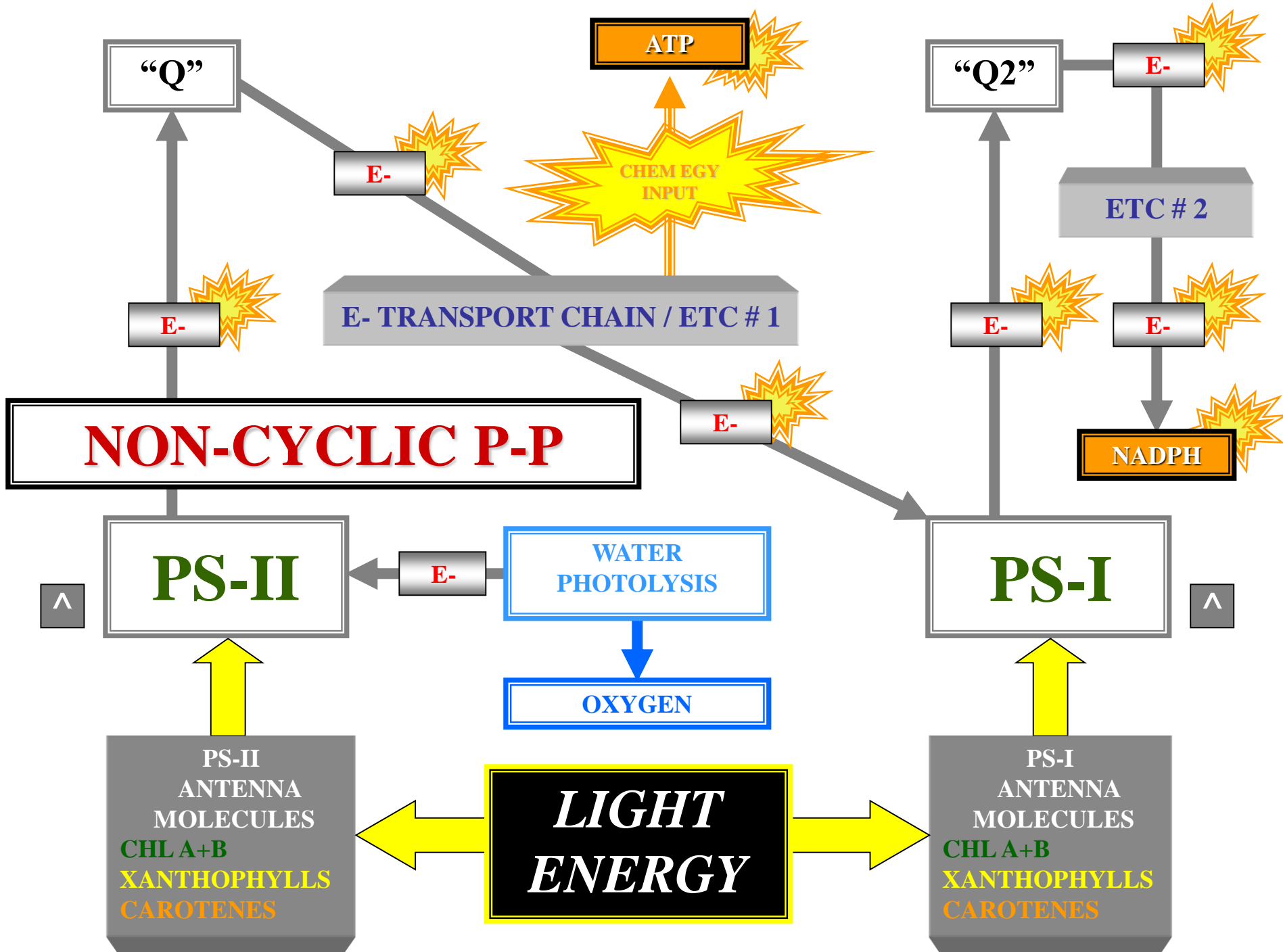
**THYLAKOID SPACE**

**N-C-P-P**

**THYLAKOID MEMBRANE**

**NON-CYCLIC P-P**







# PHOTOSYSTEM II



**QUESTION**

**WHY ARE WE  
STARTING WITH PS-II  
AND NOT WITH PS-I?**

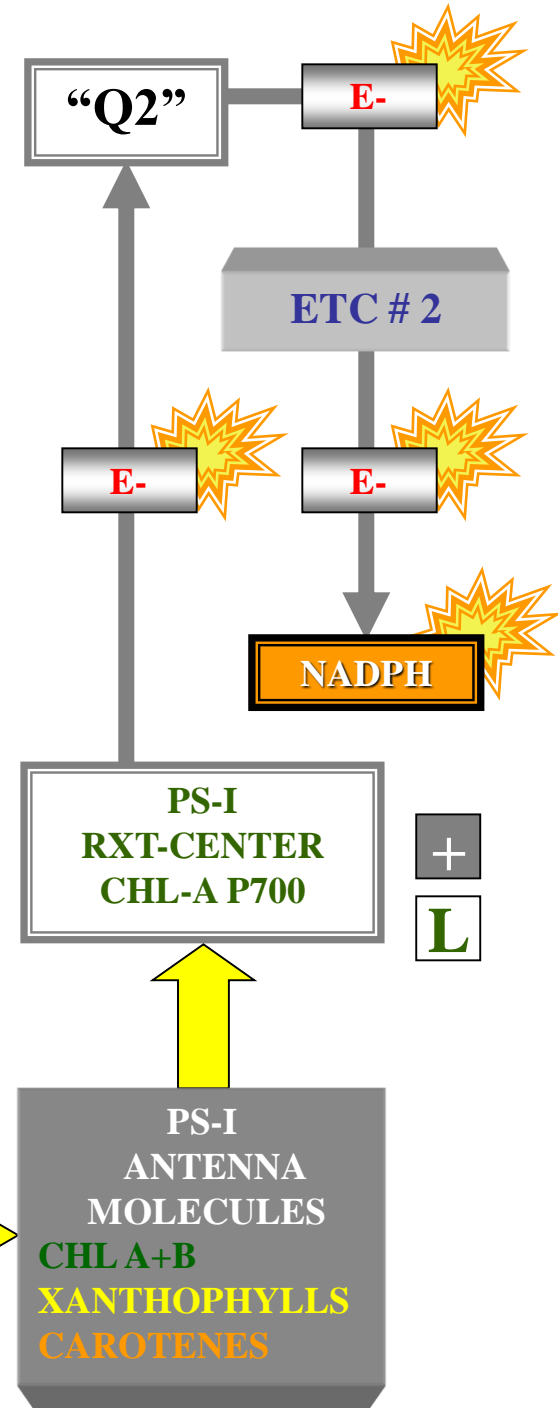
**QUESTION**

**PLANT  
PHYSIOLOGISTS  
FIRST  
DISCOVERED  
PS-I**

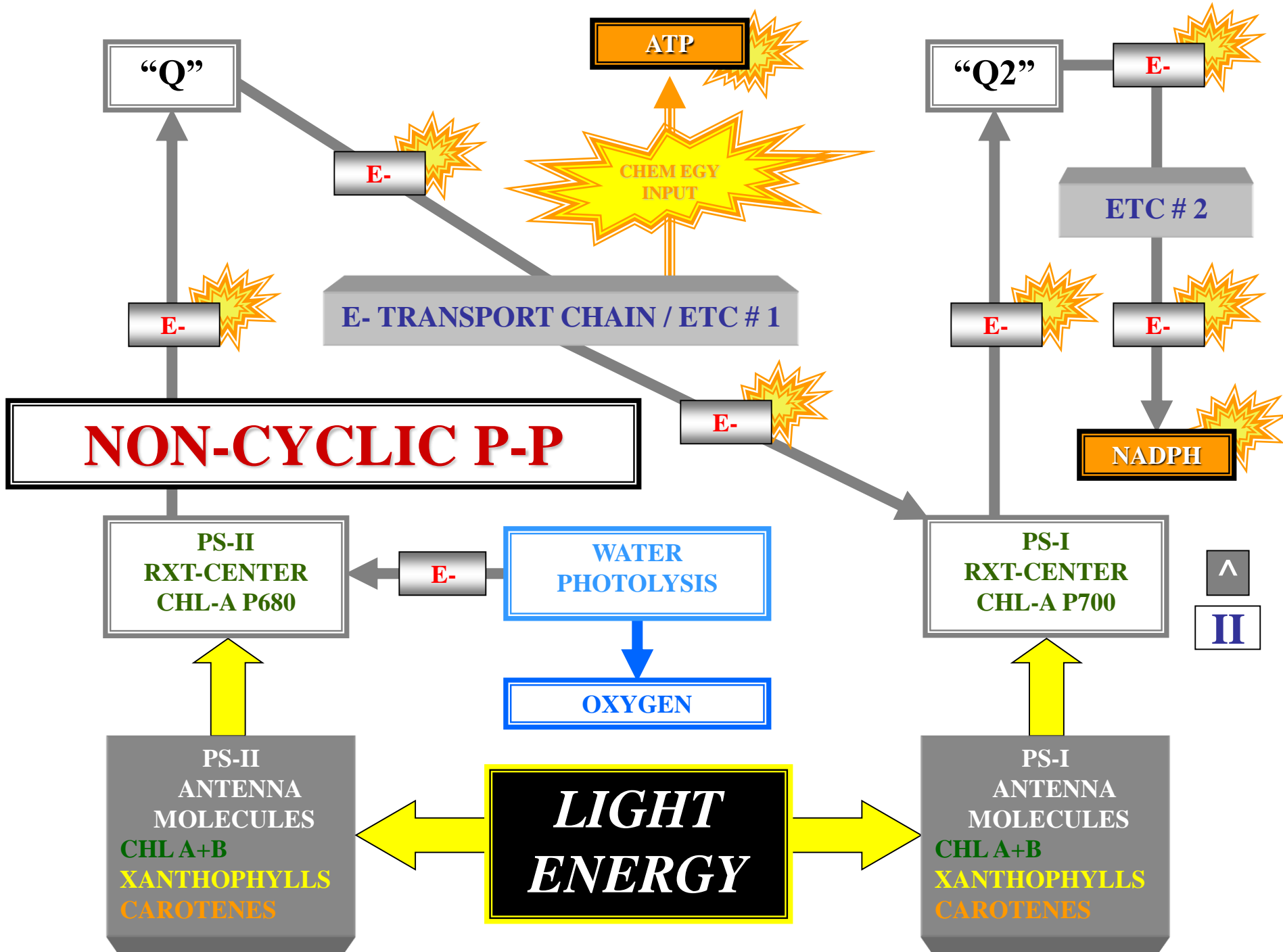


PLANT  
PHYSIOLOGISTS  
FIRST  
DISCOVERED  
PS-I

**LIGHT  
ENERGY**







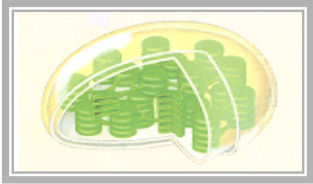


# PHOTOSYSTEM II

**CHLOROPLAST**

**PS-II**

**THYLAKOID**



+

**II**

**GRANUM**

**THYLAKOID VESICLE**

**STROMA**

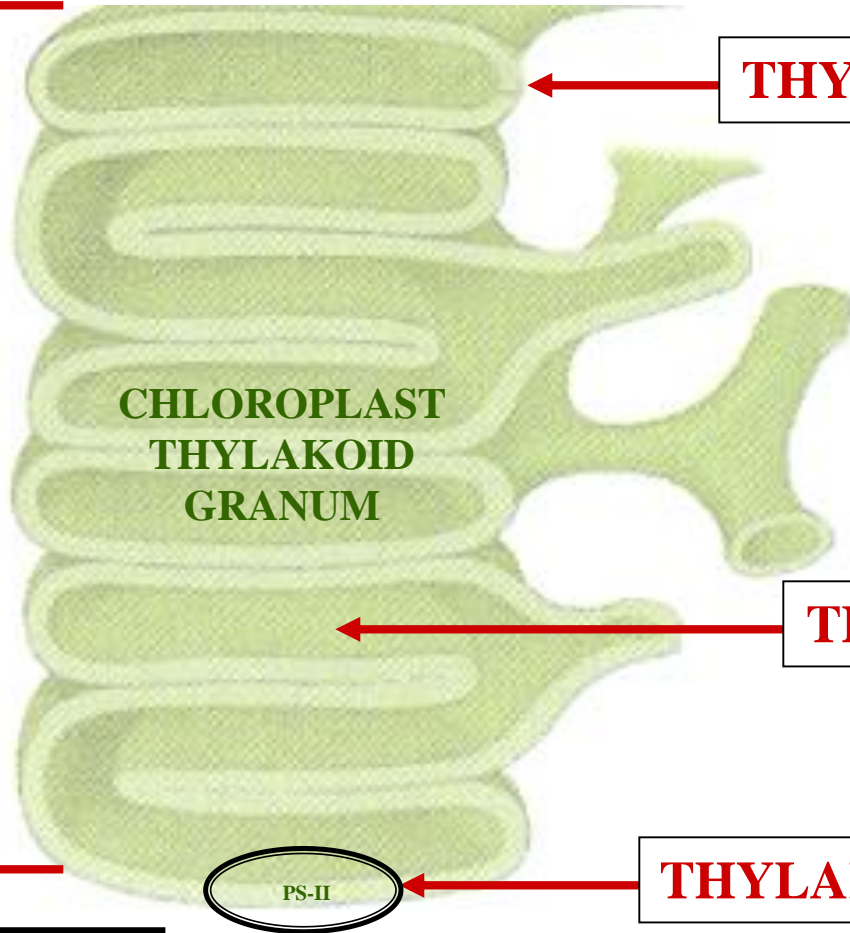
**CHLOROPLAST  
THYLAKOID  
GRANUM**

**THYLAKOID SPACE**

**THYLAKOID MEMBRANE**

**NON-CYCLIC P-P**

PS-II



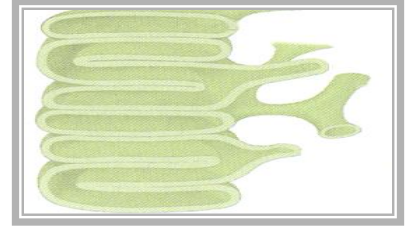
**CHLOROPLAST**

**PS-II**

**THYLAKOID**



**PIGMENT  
MOLECULES**



**A**



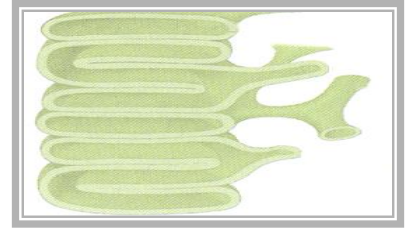
**CHLOROPLAST**

**PS-II**

**THYLAKOID**



**ANTENNA  
MOLECULES**



**A**

# **ANTENNA MOLECULES**



**ANTENNA MOLECULES**

**ABSORB LIGHT ENERGY**



**ANTENNA MOLECULES**

# ANTENNA MOLECULES

ABSORB LIGHT ENERGY



REACTION CENTER

ANTENNA MOLECULES

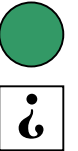
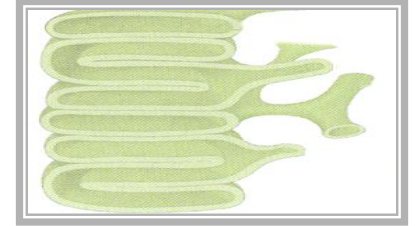
**CHLOROPLAST**

**PS-II**

**THYLAKOID**



**ANTENNA  
MOLECULES**



**ANTENNA MOLECULES**  
**=**  
**PRIMARY & SECONDARY**  
**PHOTOSYNTHETIC**  
**PIGMENTS**

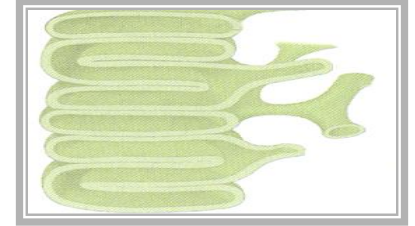
**CHLOROPLAST**

**PS-II**

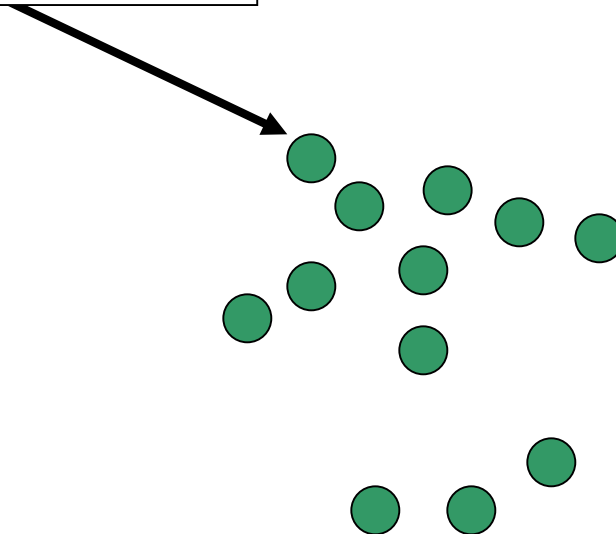
**THYLAKOID**



**ANTENNA  
MOLECULES**



**CHLOROPHYLLA**



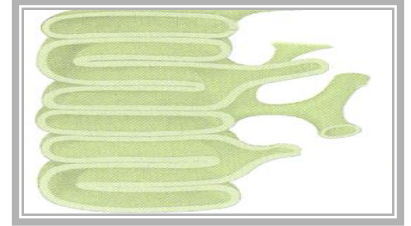
**CHLOROPLAST**

**PS-II**

**THYLAKOID**

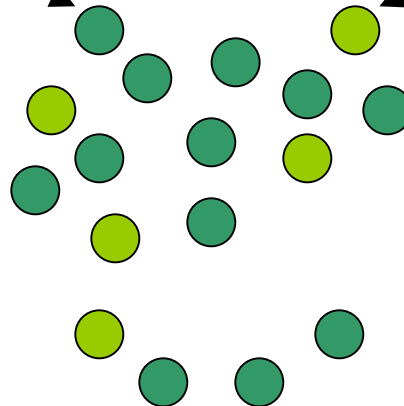


**ANTENNA  
MOLECULES**



**CHLOROPHYLL A**

**CHLOROPHYLL B**



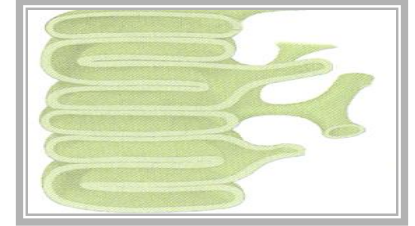
**CHLOROPLAST**

**PS-II**

**THYLAKOID**



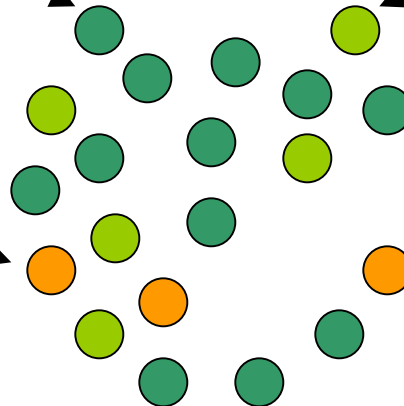
**ANTENNA  
MOLECULES**



**CHLOROPHYLL A**

**CHLOROPHYLL B**

**CAROTENES**





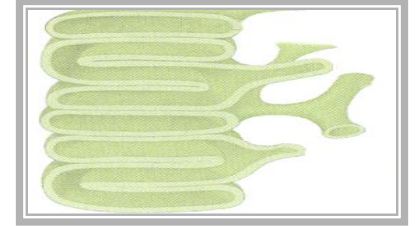
**CHLOROPLAST**

**PS-II**

**THYLAKOID**



**ANTENNA  
MOLECULES**

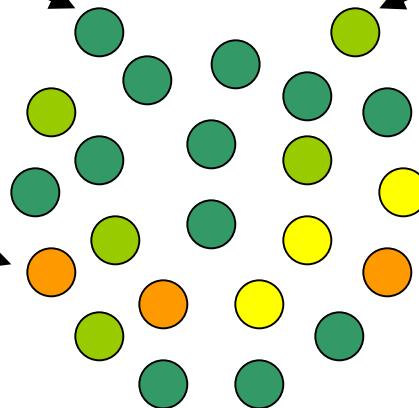


**CHLOROPHYLL A**

**CHLOROPHYLL B**

**CAROTENES**

**XANTHOPHYLLS**



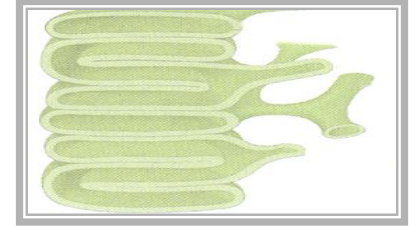
**CHLOROPLAST**

**PS-II**

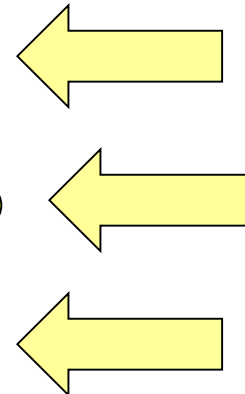
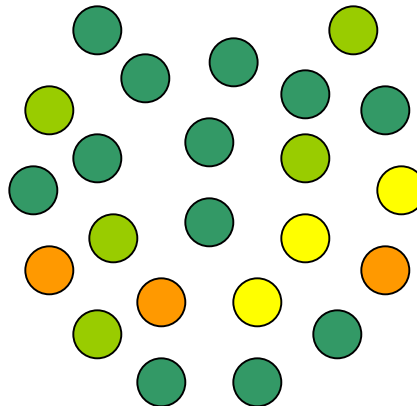
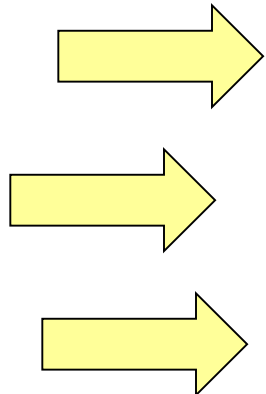
**THYLAKOID**



**ANTENNA  
MOLECULES**



**LTEGY**



**LTEGY**

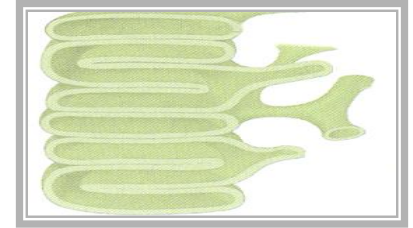
**CHLOROPLAST**

**PS-II**

**THYLAKOID**



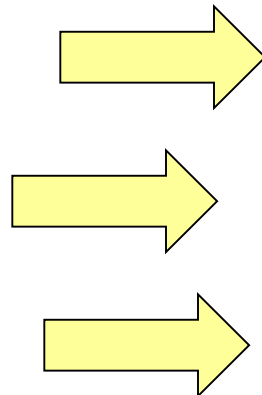
**ANTENNA  
MOLECULES**



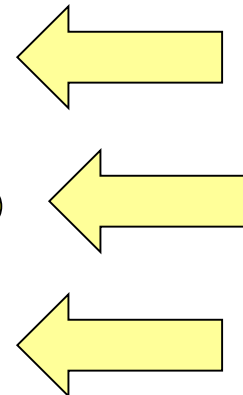
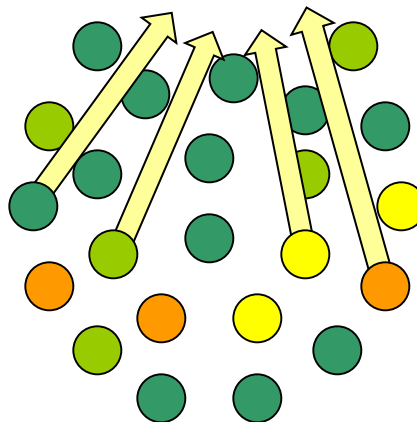
**RC**



**LTEGY**



**LTEGY**



**LTEGY**

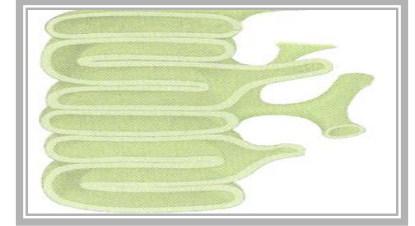
**CHLOROPLAST**

**PS-II**

**THYLAKOID**



**ANTENNA  
MOLECULES**

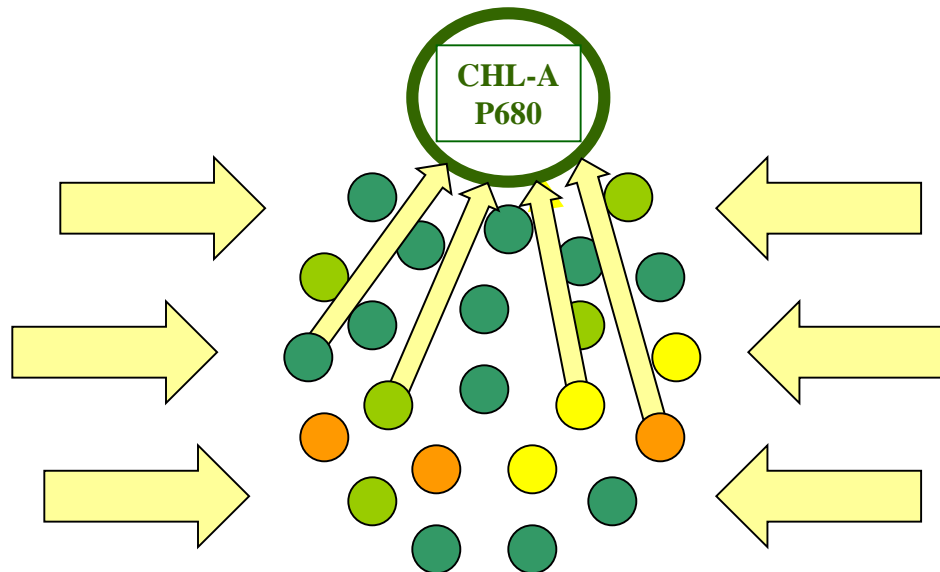


**R**

**REACTION CENTER**



**LTEGY**



**LTEGY**

**REACTION  
CENTER  
PS-II**



# REACTION CENTER PS-II

CHL A/PROTEIN COMPLEX

PIGMENT 680

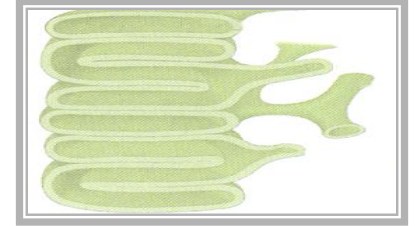
P680

REACTION CENTER PS-II

**CHLOROPLAST**

**PS-II**

**THYLAKOID**



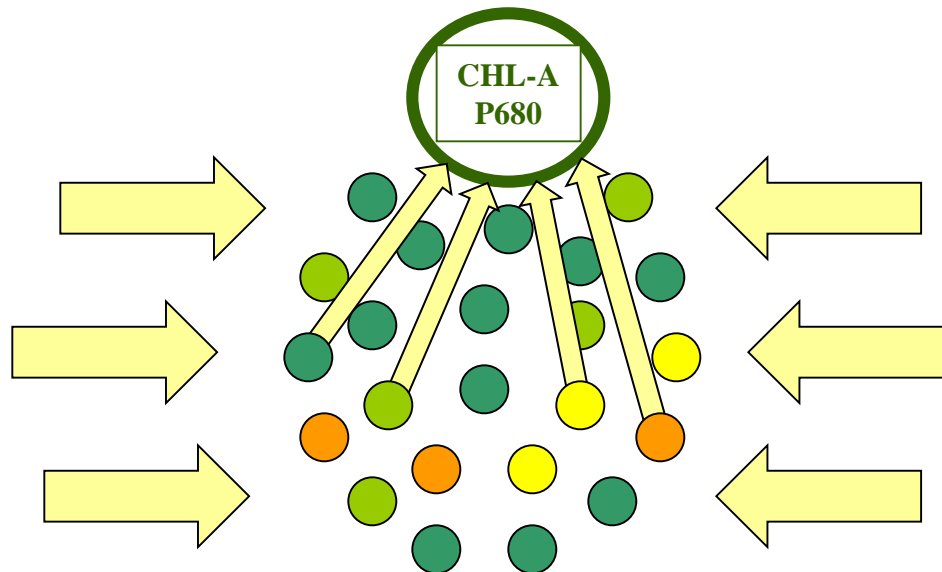
**Mg**

**REACTION CENTER**



**LTEGY**

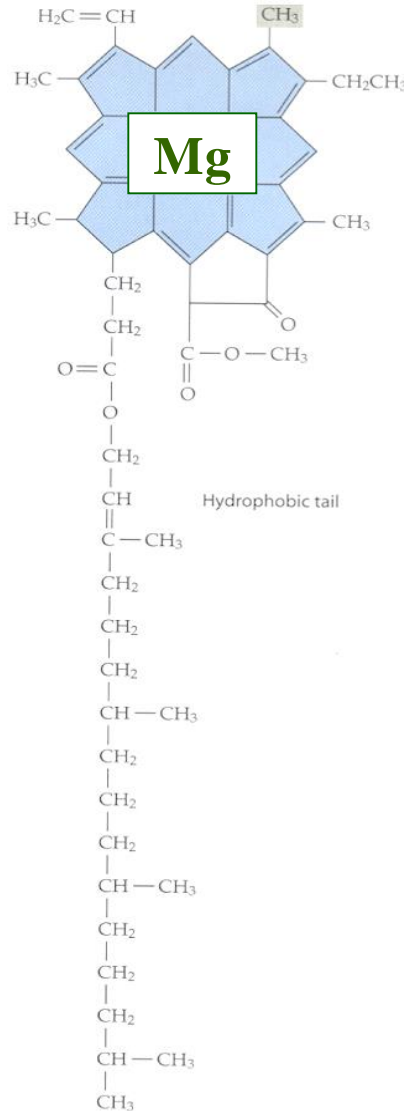
**LTEGY**



# RXT CENTER

## CHL-A / PROTEIN COMPLEX = P680

### Mg E- ENERGIZED



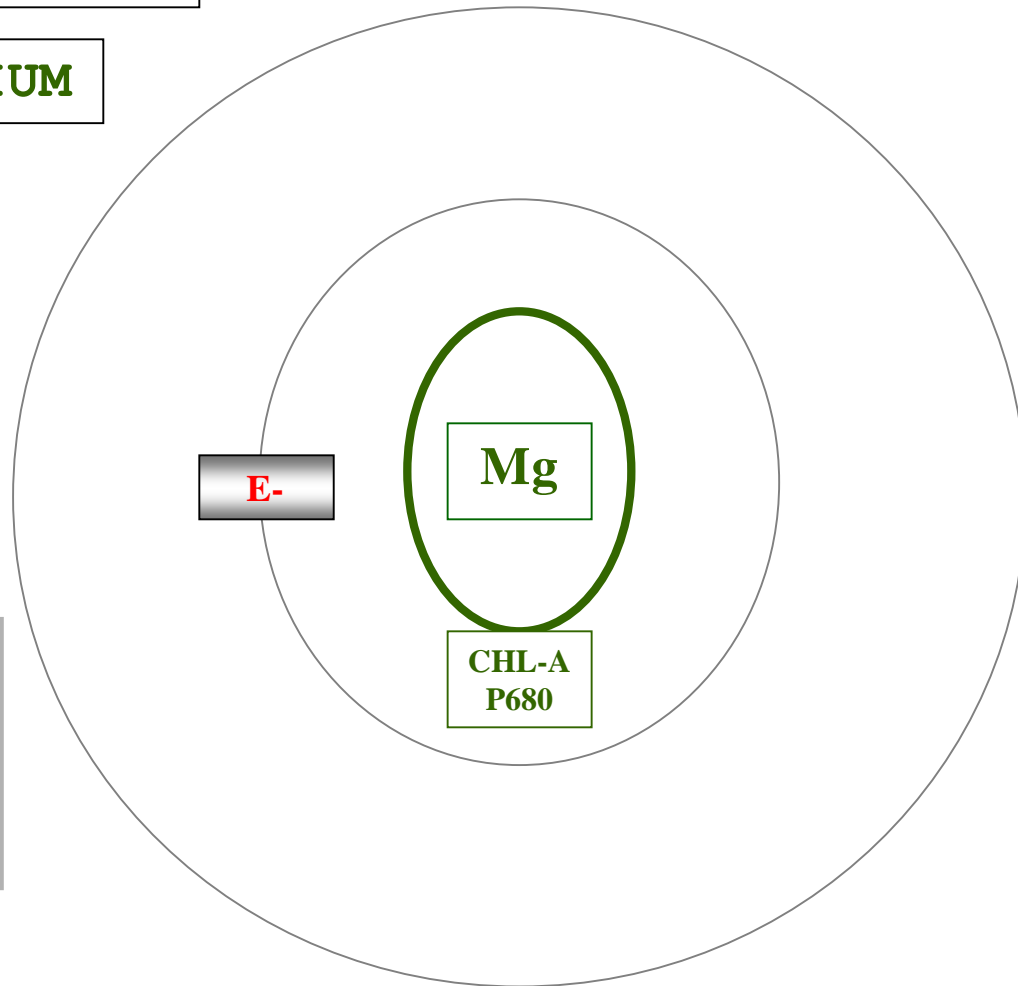
**Mg = MAGNESIUM**



# REACTION CENTER



Mg = MAGNESIUM



## ANTENNA MOLECULES



CHL-A



CHL-B



CAROTENES



XANTHOPHYLLS

# REACTION CENTER

Mg = MAGNESIUM



**L T E G Y**

**L T E G Y**

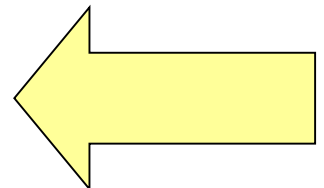
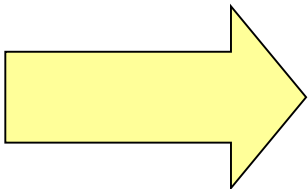
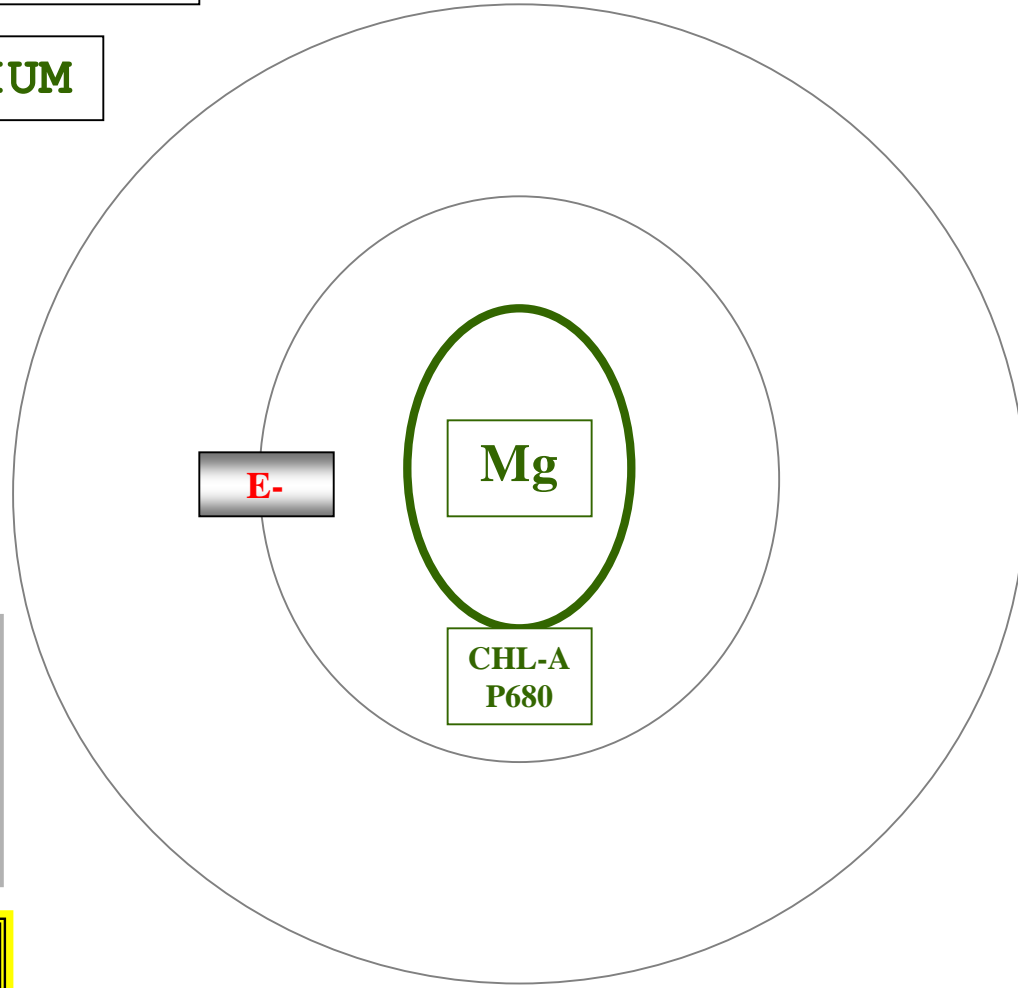
## ANTENNA MOLECULES

CHL-A

CHL-B

CAROTENES

XANTHOPHYLLS



# REACTION CENTER

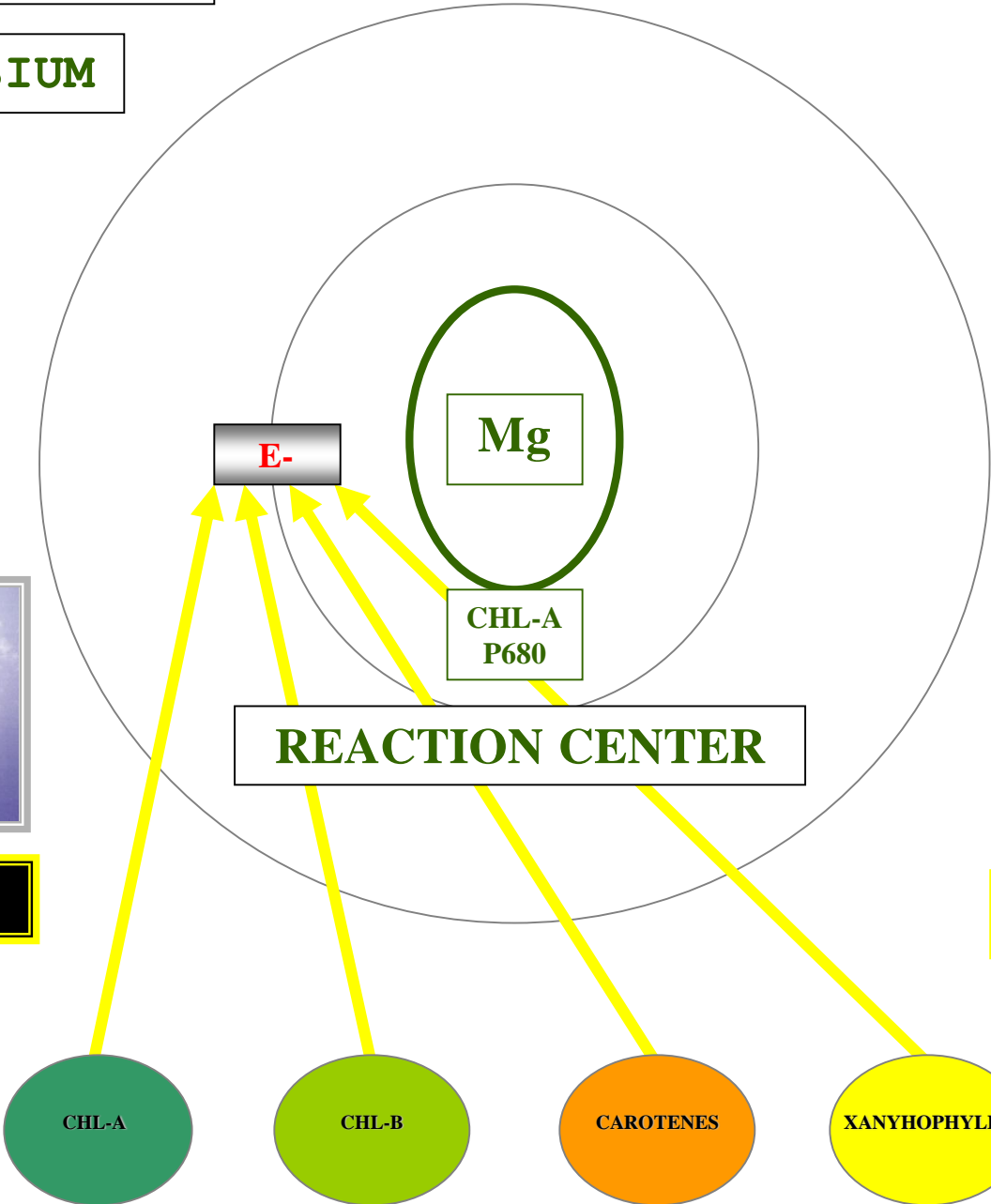
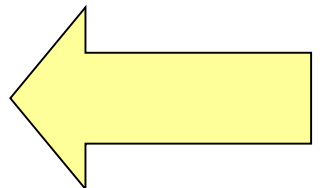
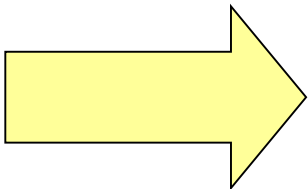
Mg = MAGNESIUM

E-



**L T E G Y**

**L T E G Y**



# REACTION CENTER

CHL-A

CHL-B

CAROTENES

XANTHOPHYLLS

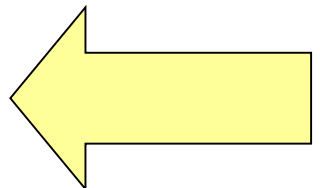
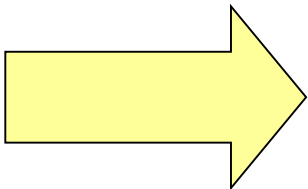
Mg

CHL-A  
P680

E-

**L T E G Y**

**L T E G Y**



**REACTION CENTER**

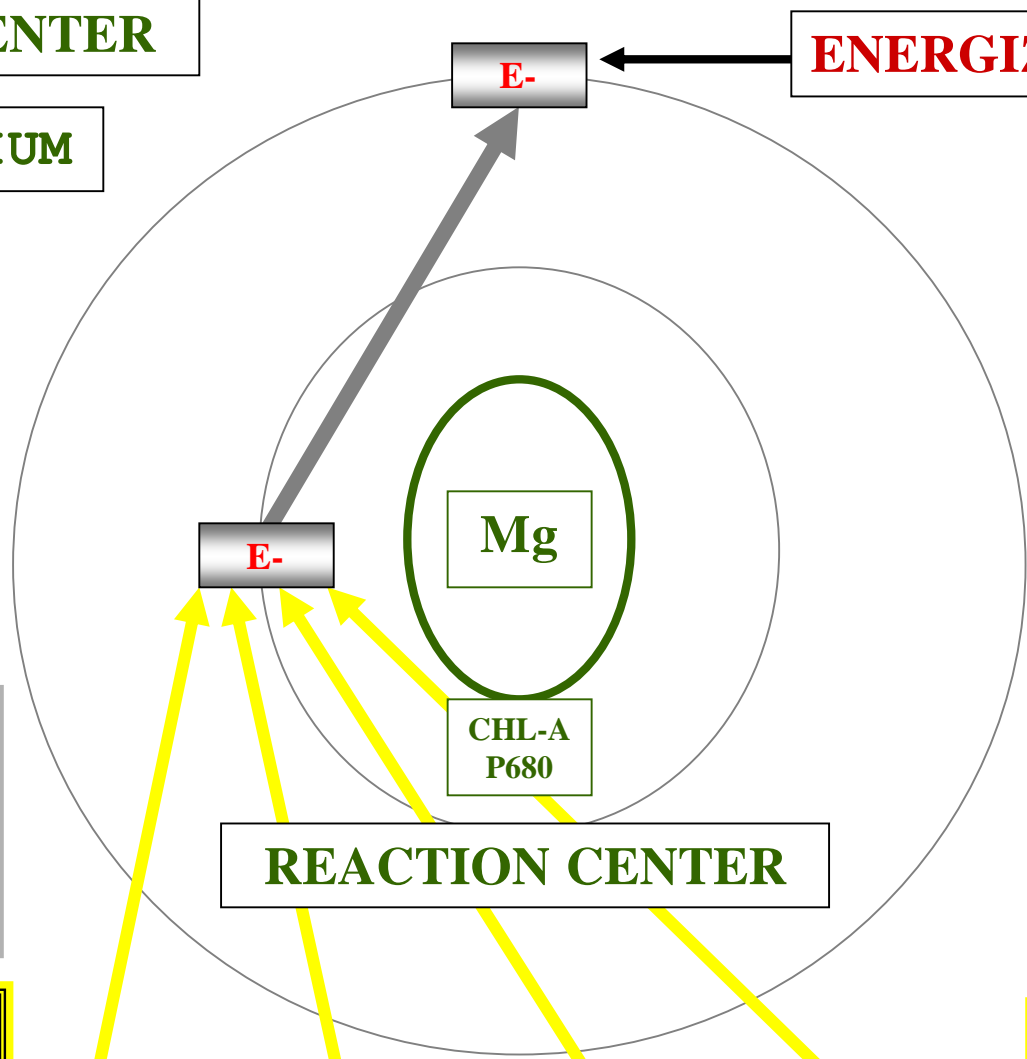
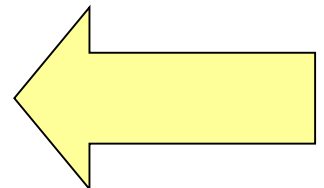
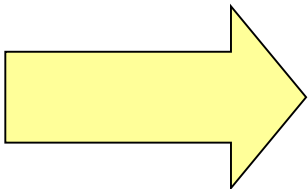
**Mg = MAGNESIUM**

**ENERGIZED E-**



**LTEGY**

**LTEGY**



**REACTION CENTER**

**Mg**

**CHL-A  
P680**

**E-**

**E-**

**CHL-A**

**CHL-B**

**CAROTENES**

**XANTHOPHYLLS**