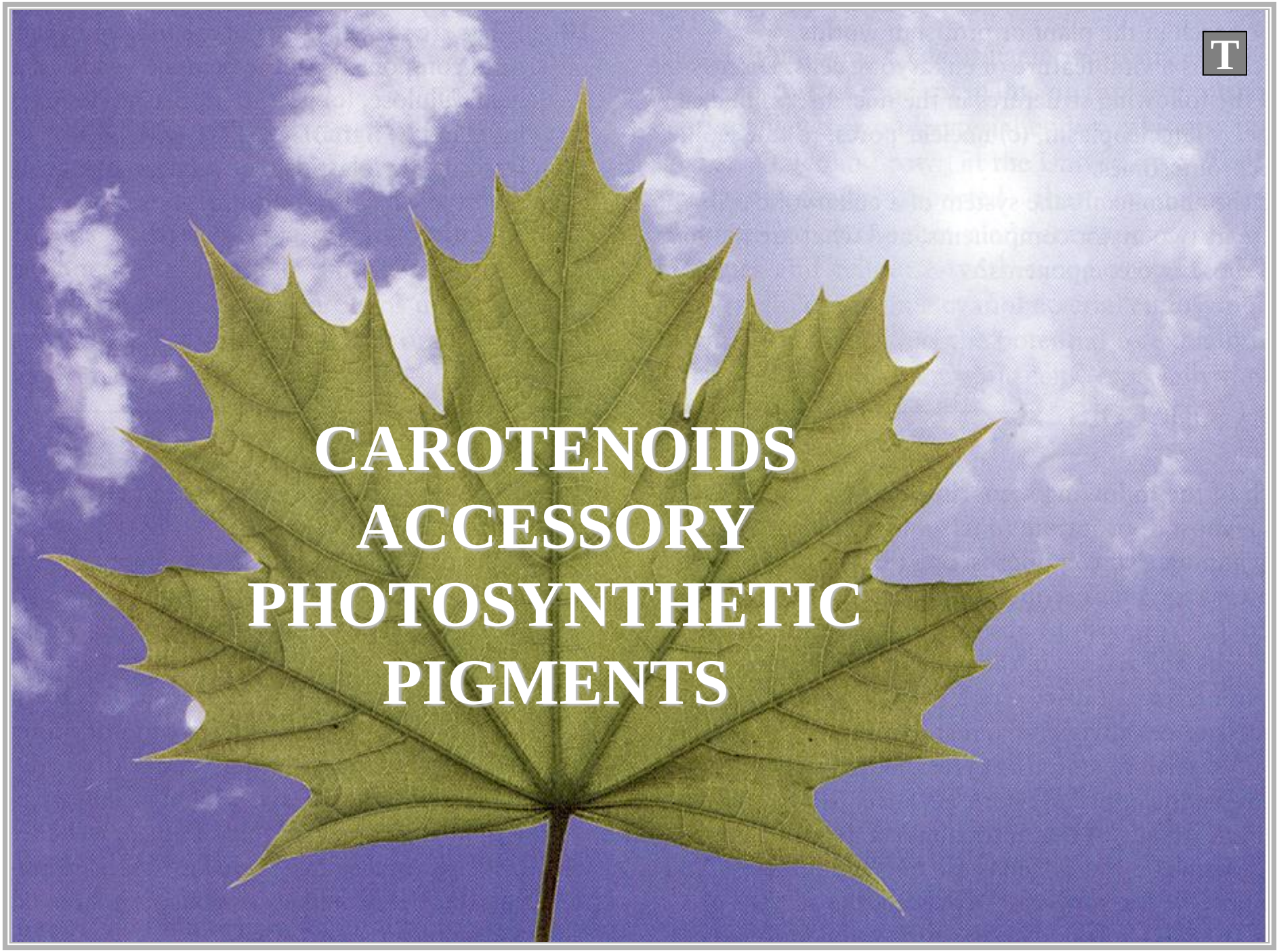
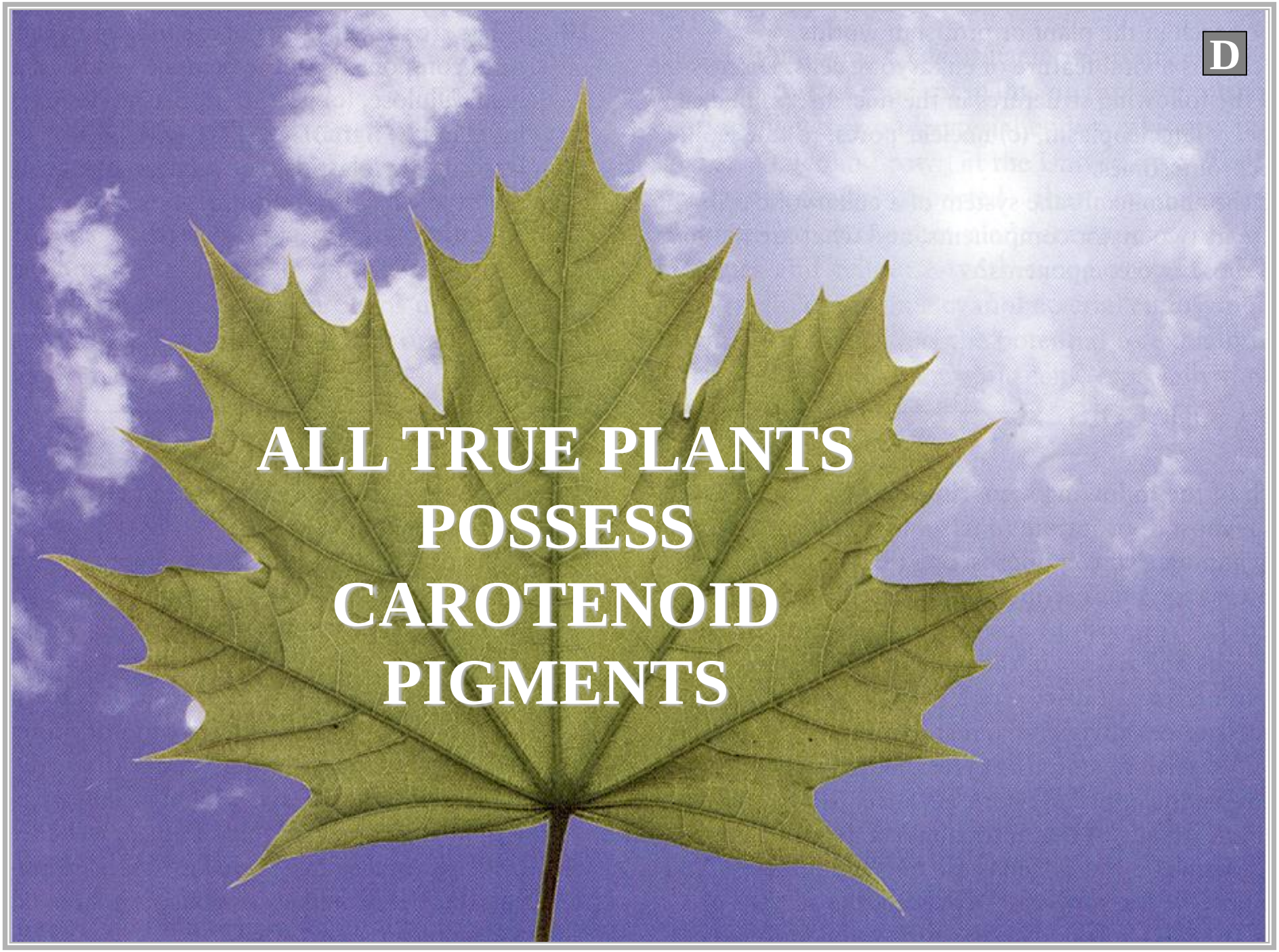
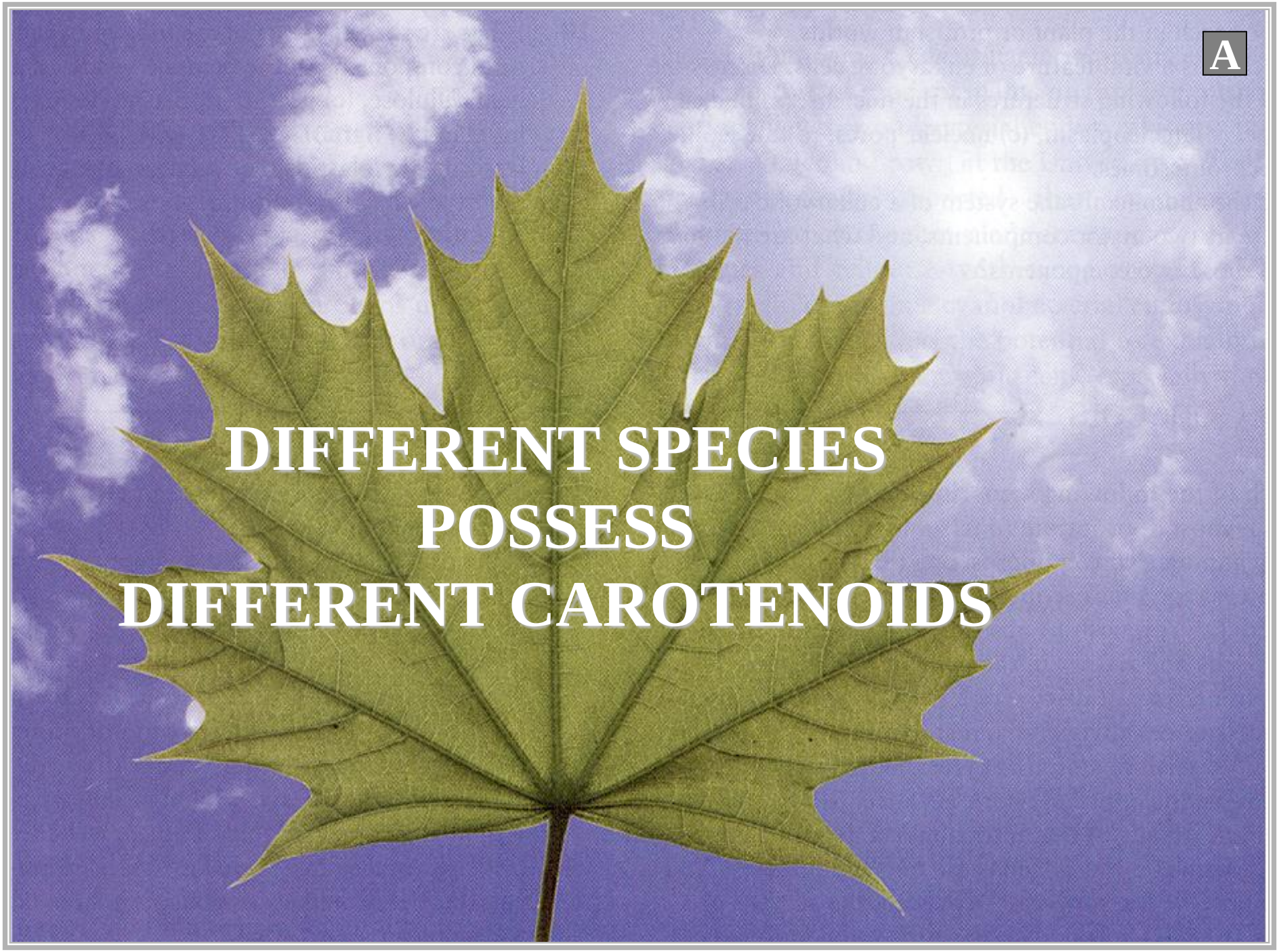
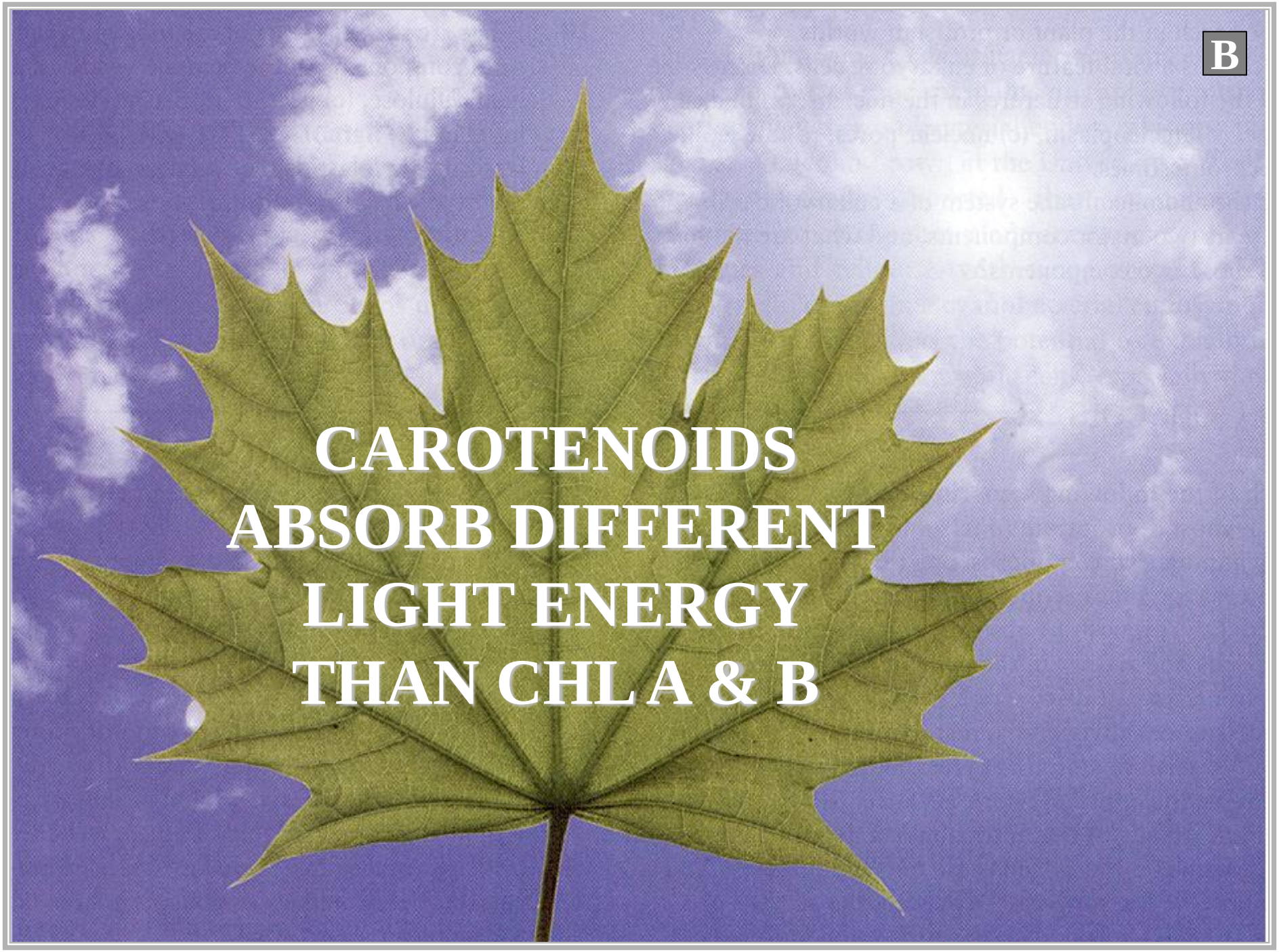
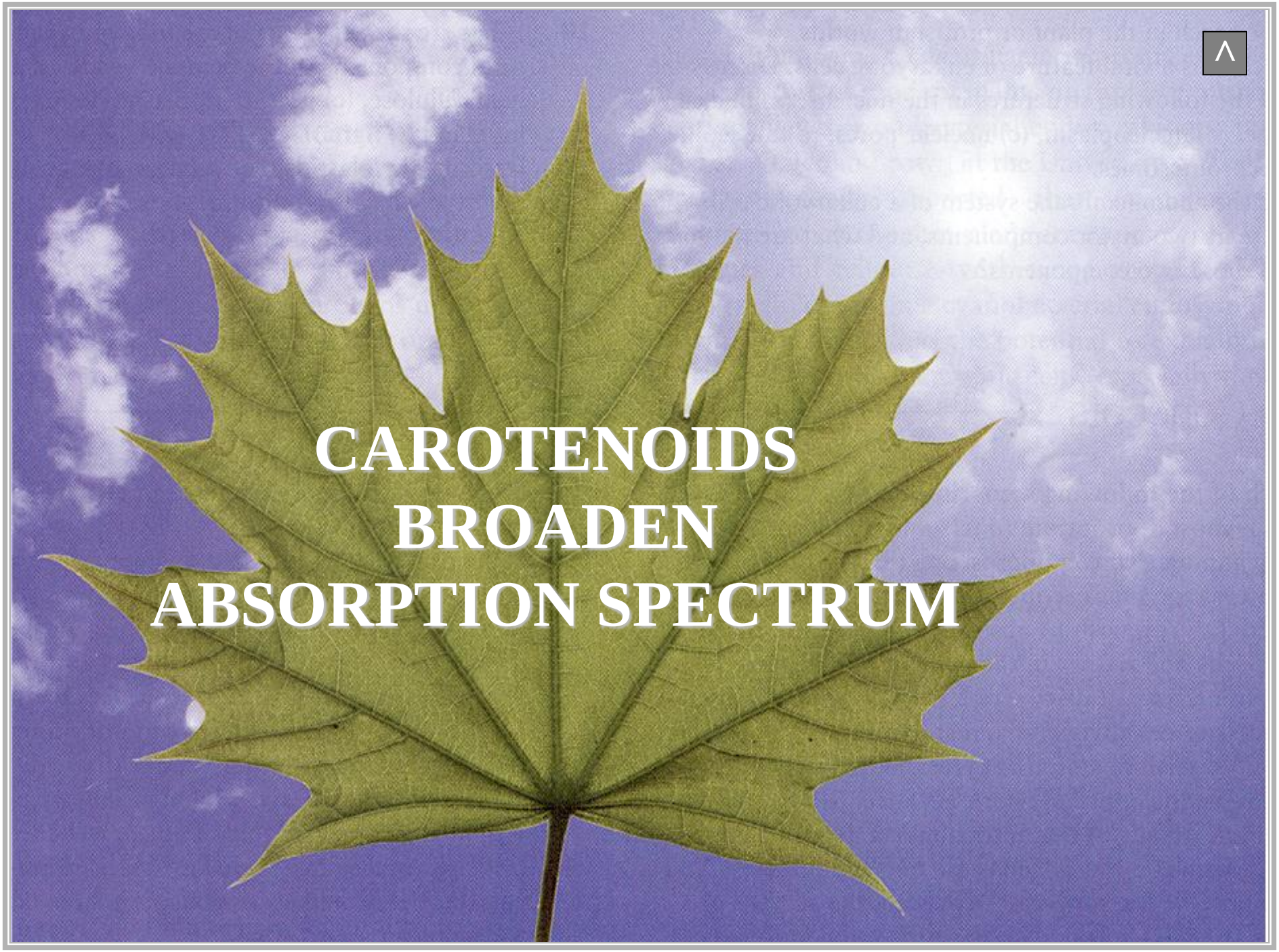

CAROTENOIDS
ACCESSORY
PHOTOSYNTHETIC
PIGMENTS


D
ALL TRUE PLANTS
POSSESS
CAROTENOID
PIGMENTS


A
DIFFERENT SPECIES
POSSESS
DIFFERENT CAROTENOIDS


B
CAROTENOIDS
ABSORB DIFFERENT
LIGHT ENERGY
THAN CHL A & B


CAROTENOIDS
BROADEN
ABSORPTION SPECTRUM

A

ABSORPTION SPECTRUM

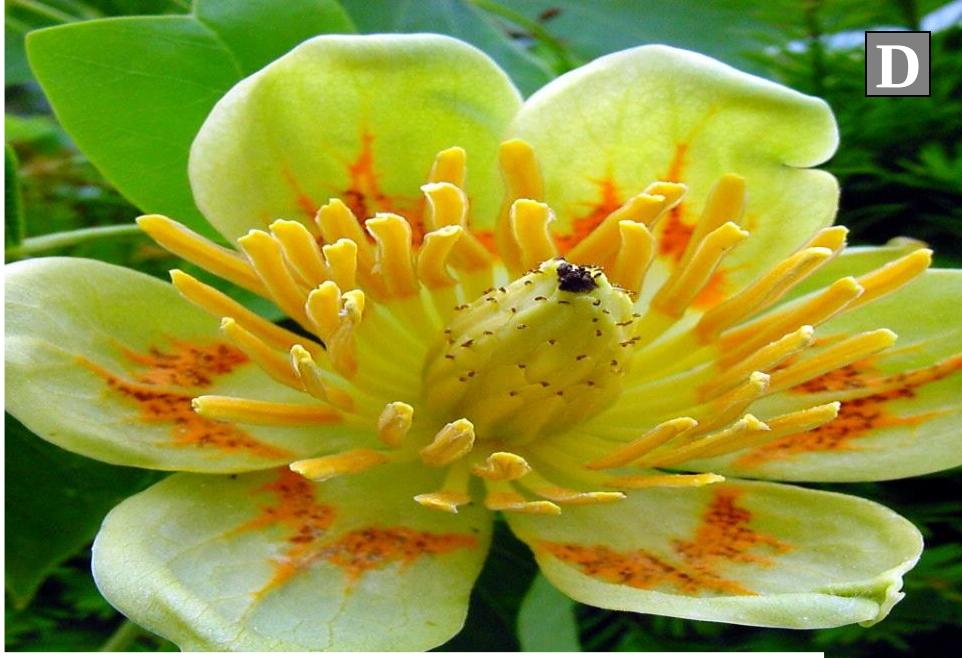
ABSORPTION SPECTRUM

ABSORPTION SPECTRUM

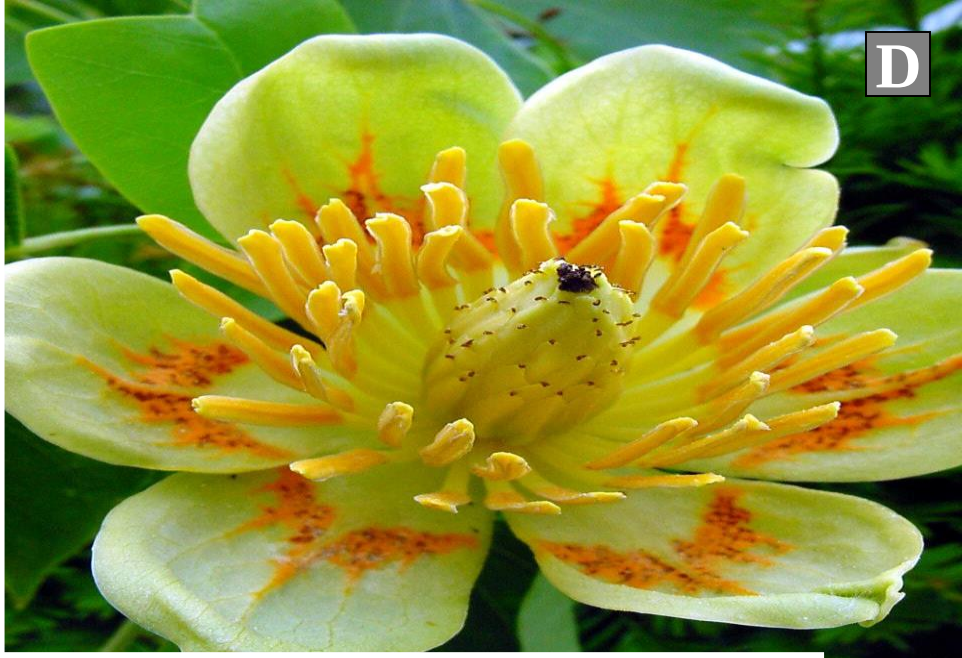
D

ALL ABSORBED PHOTOSYNTHESIS LIGHT WAVELENGHTS

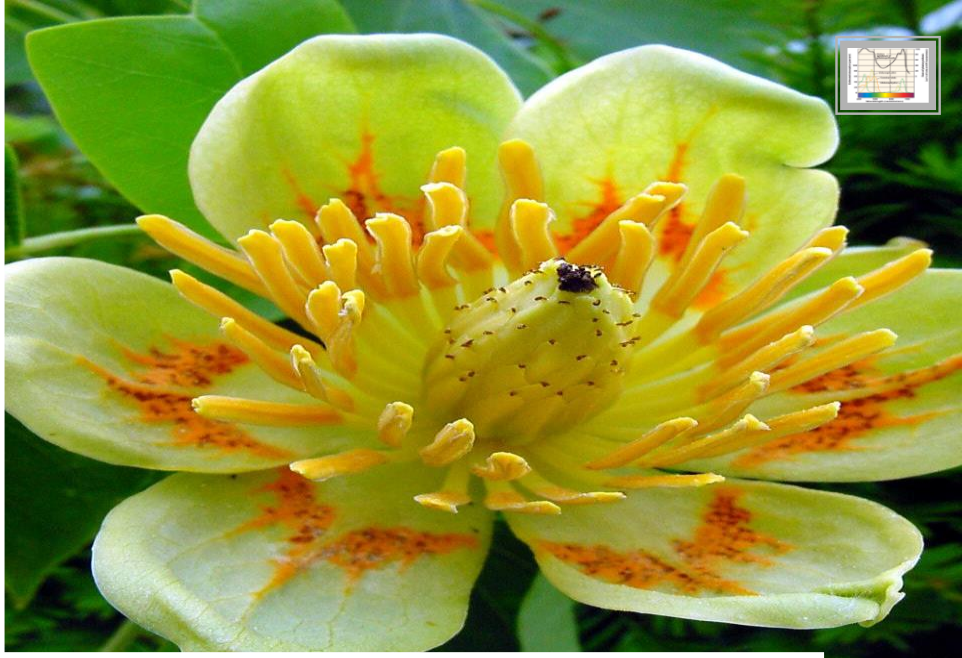
ABSORPTION SPECTRUM



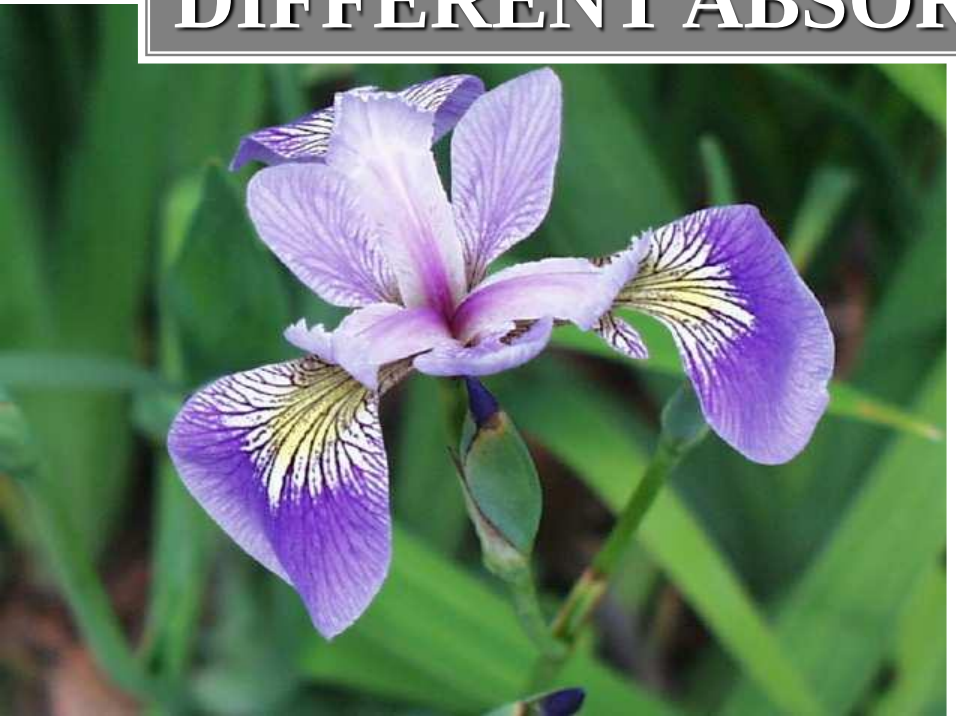
DIFFERENT SPECIES

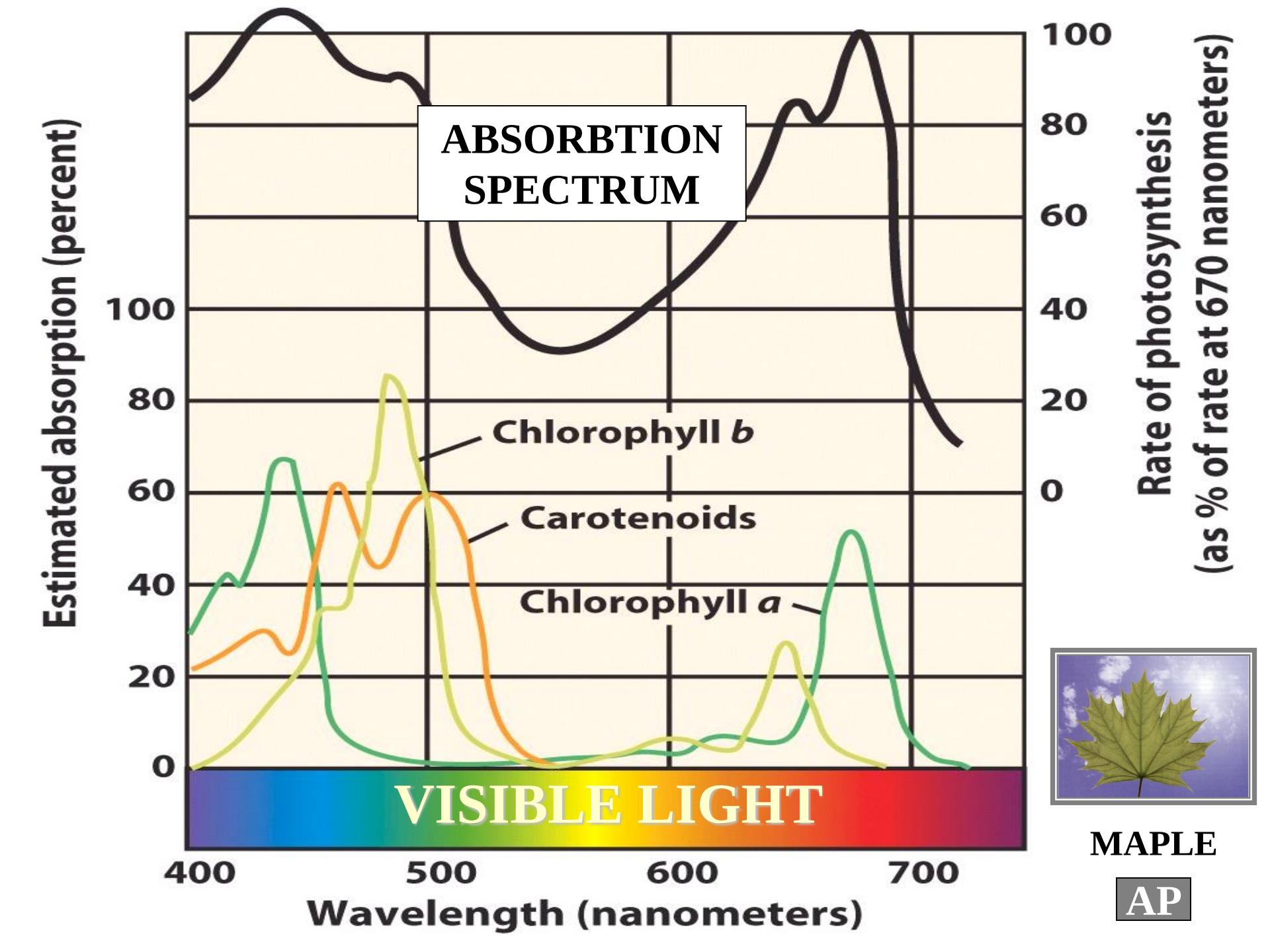


DIFFERENT CAROTENOIDS



DIFFERENT ABSORPTION SPECTRUM



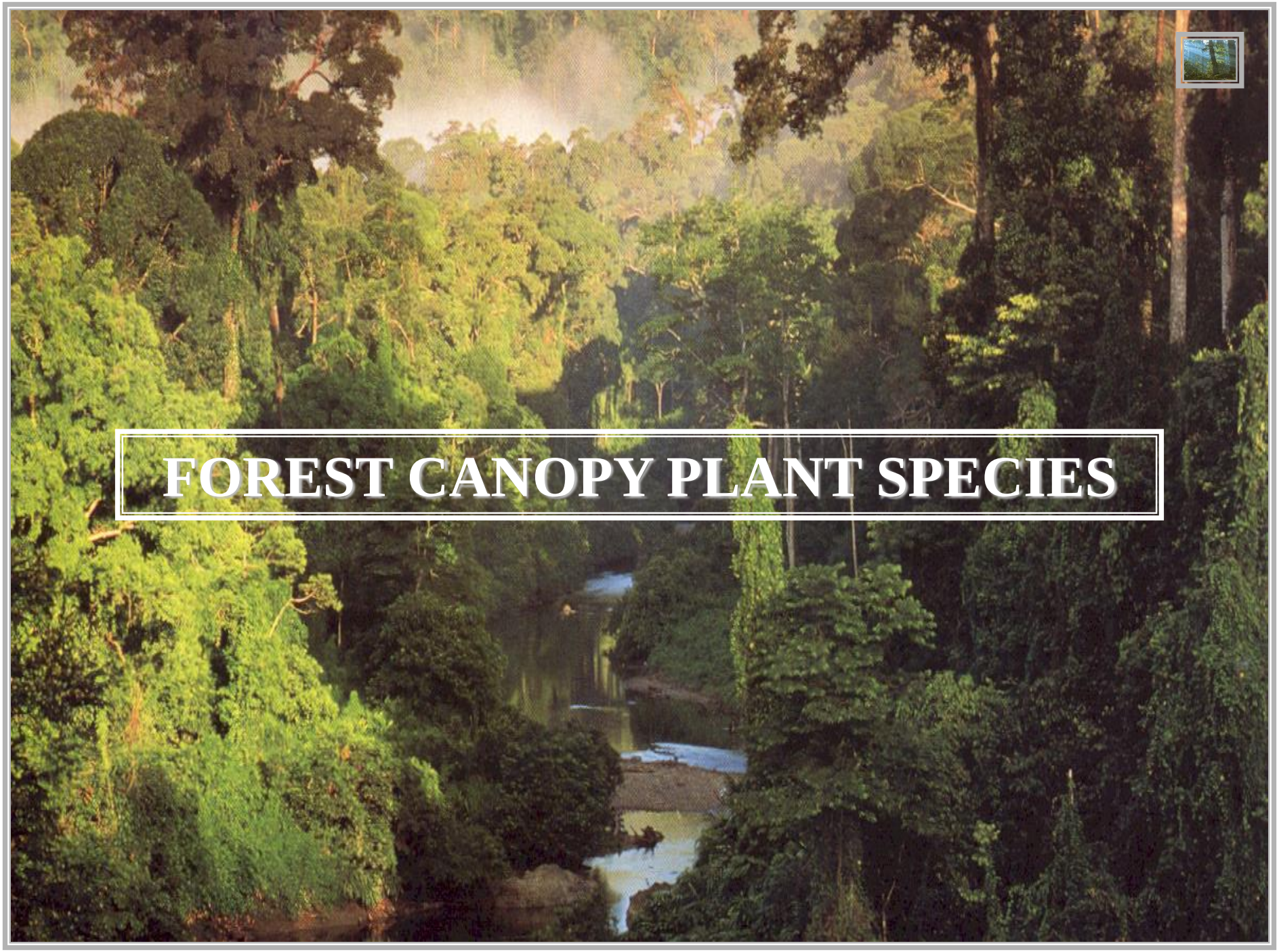

ABSORBTION SPECTRUM
Estimated absorption (percent)
Rate of photosynthesis (as % of rate at 670 nanometers)
100
80
60
40
20
0
Chlorophyll b
Carotenoids
Chlorophyll a
VISIBLE LIGHT
400
500
600
700
Wavelength (nanometers)

MAPLE

AP

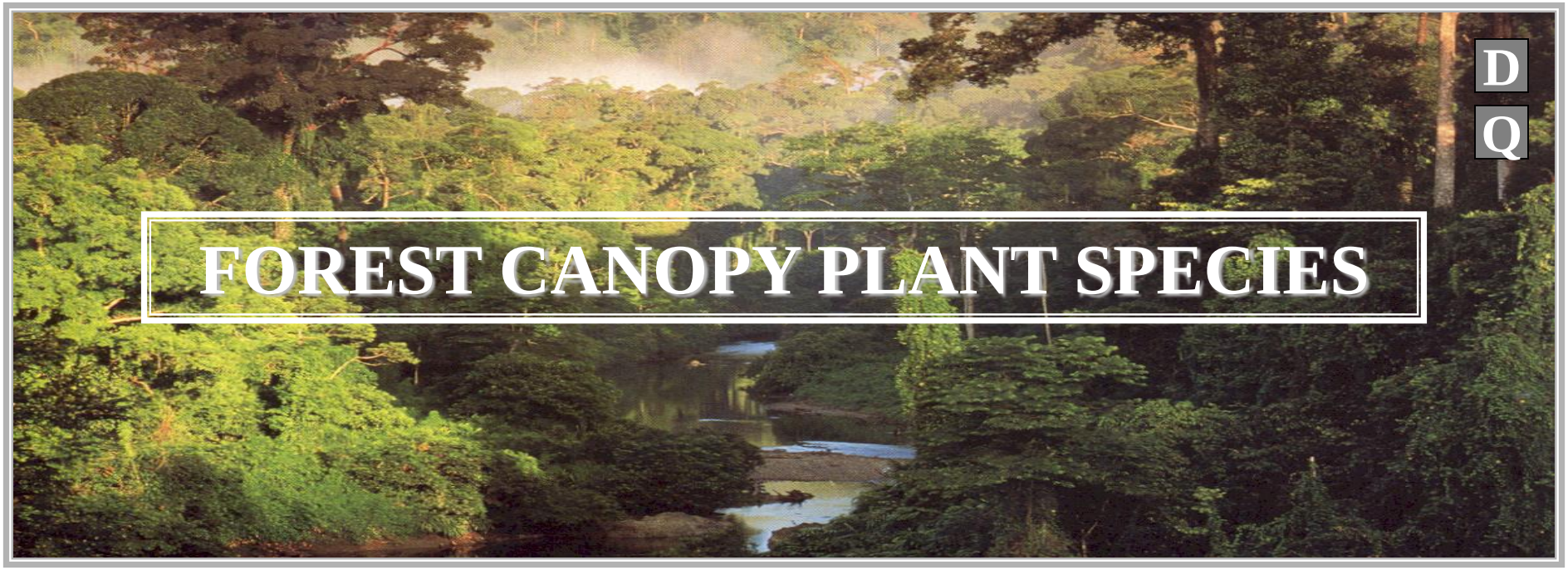
ABSORPTION SPECTRUM

APPLIED



FOREST CANOPY PLANT SPECIES

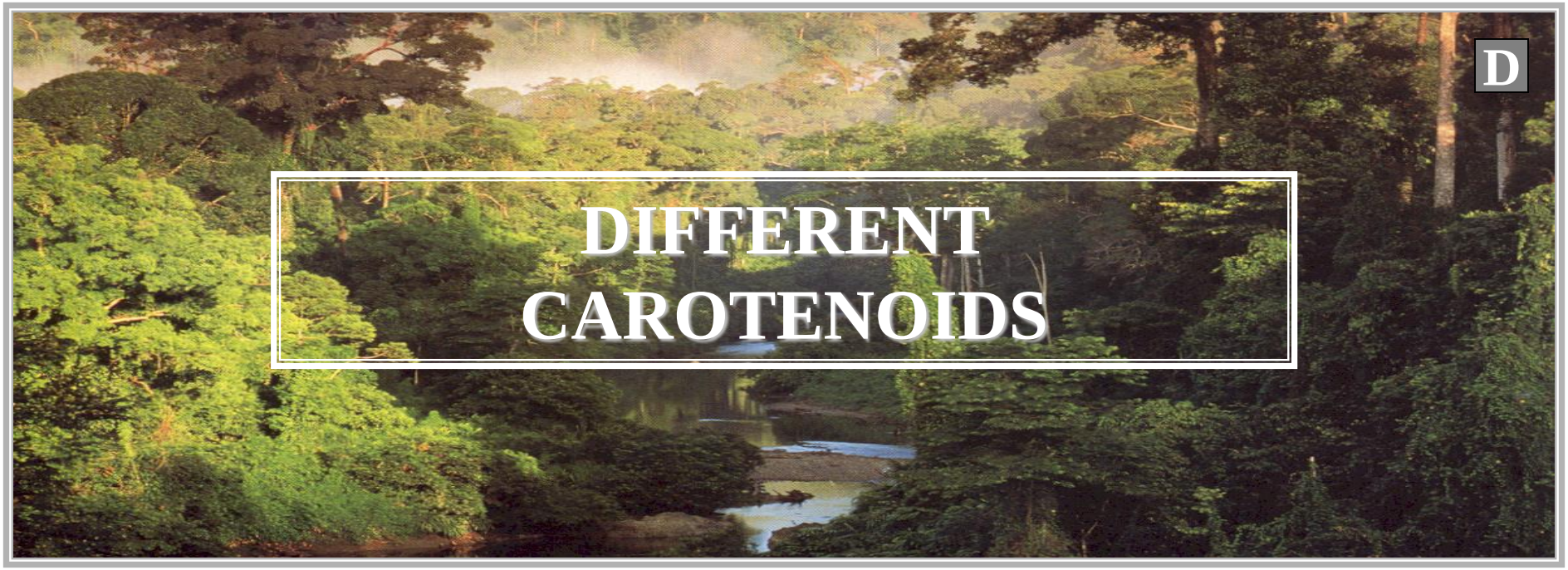
FOREST FLOOR PLANT SPECIES

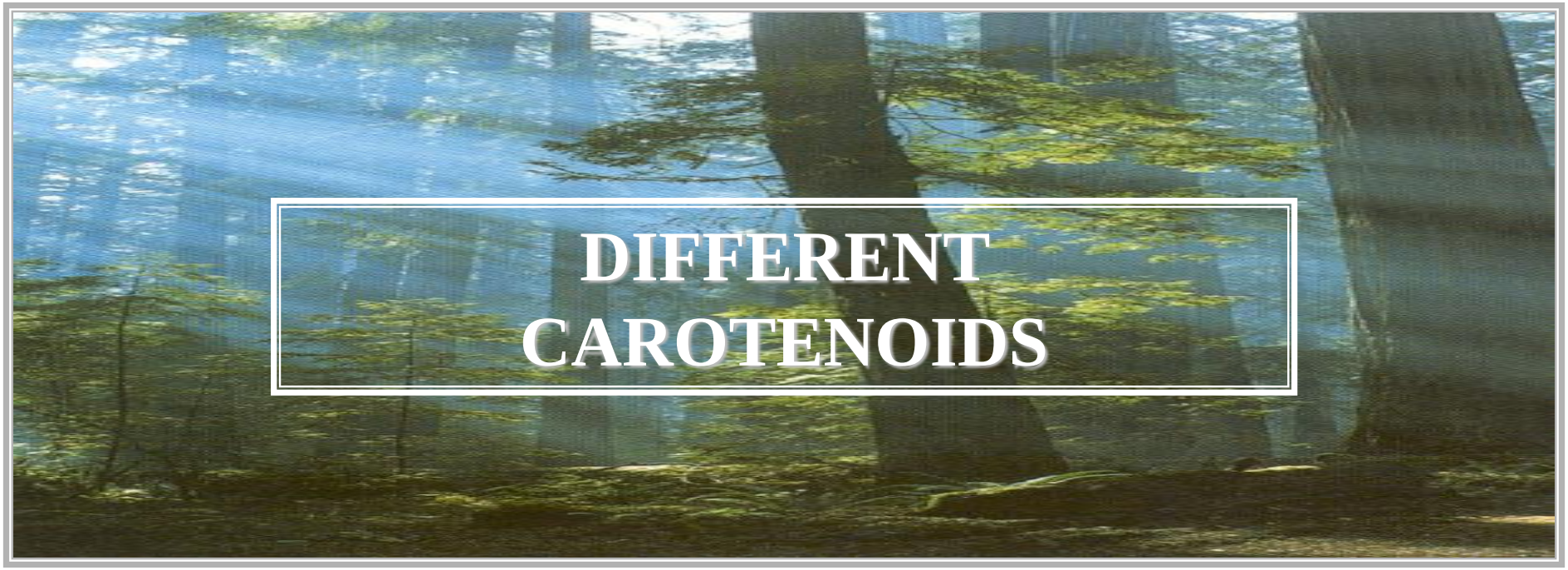

D
Q
FOREST CANOPY PLANT SPECIES


FOREST FLOOR PLANT SPECIES


D
DIFFERENT
LIGHT QUALITY


DIFFERENT
LIGHT QUALITY


D
DIFFERENT
CAROTENOIDS

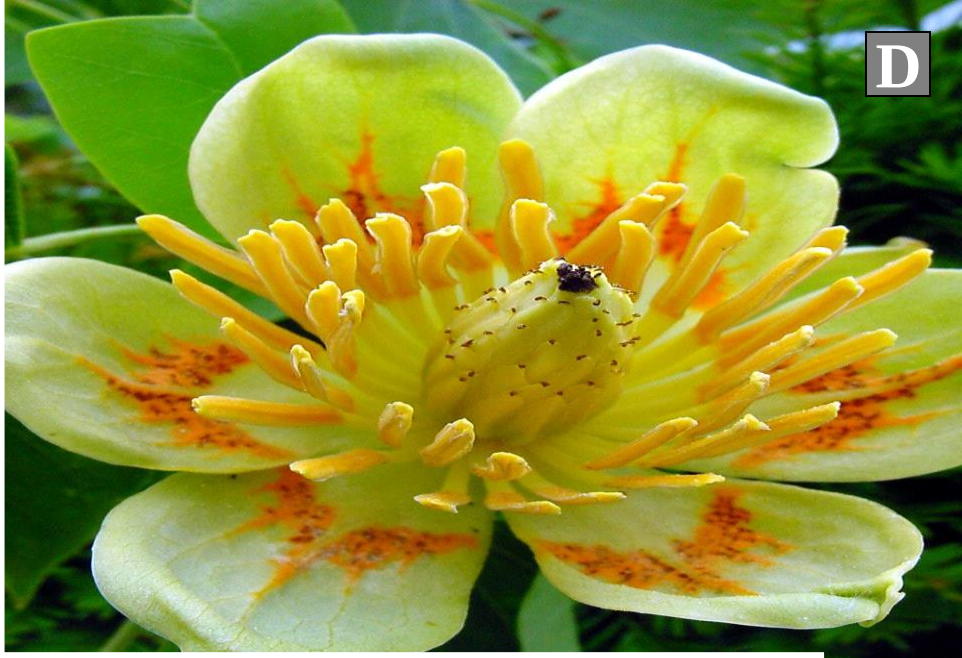

DIFFERENT
CAROTENOIDS


S
DIFFERENT
ABSORPTION SPECTRUM

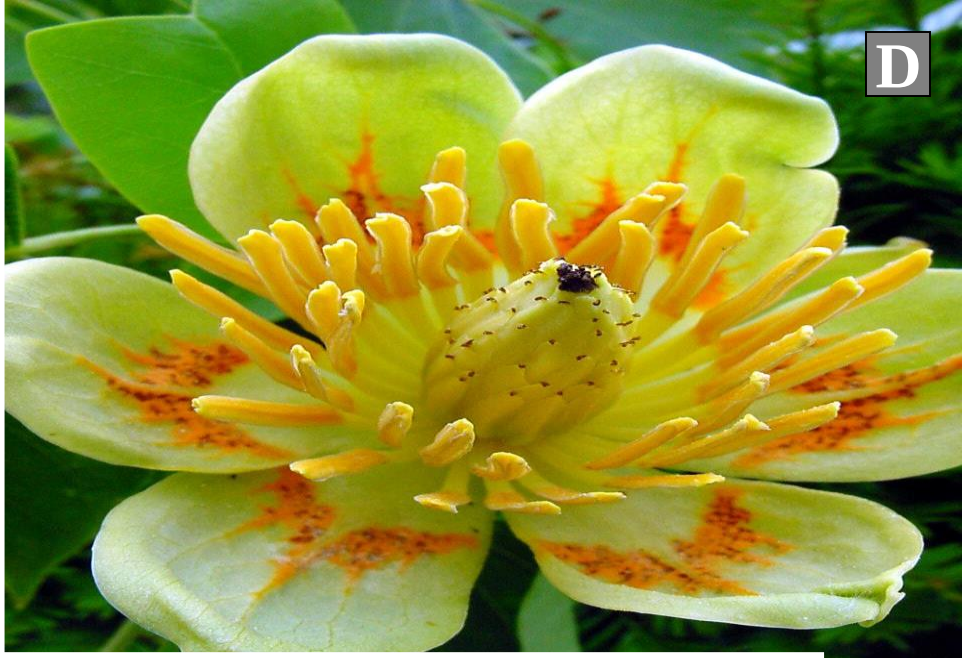

DIFFERENT
ABSORPTION SPECTRUM

ABSORPTION SPECTRUM

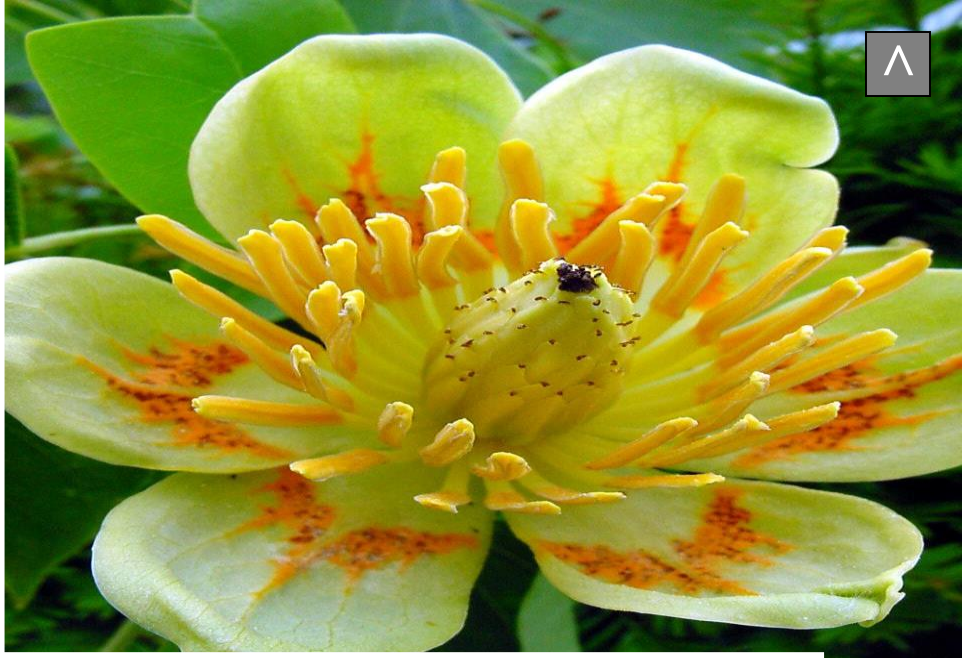
SUMMARY



DIFFERENT SPECIES



DIFFERENT CAROTENOIDS



DIFFERENT ABSORPTION SPECTRUM

WAVELENGHT EFFICIENCY

ELECTROMAGNETIC SPECTRUM

FR

SUN

ELECTROMAGNETIC SPECTRUM

HYDROGEN FUSION REACTIONS

SUN

HYDROGEN FUSION REACTIONS

E

ELECTROMAGNETIC SPECTRUM

HYDROGEN FUSION REACTIONS

SUN

HYDROGEN FUSION REACTIONS

*

ELECTROMAGNETIC SPECTRUM
PHOTONS

HIGH ENERGY

LOW ENERGY

Gamma rays | X rays | Ultraviolet | Visible | Near infrared | Infrared | Radio waves

SHORT WAVELENGTH

LONG WAVELENGTH

ELECTROMAGNETIC SPECTRUM

HYDROGEN FUSION REACTIONS

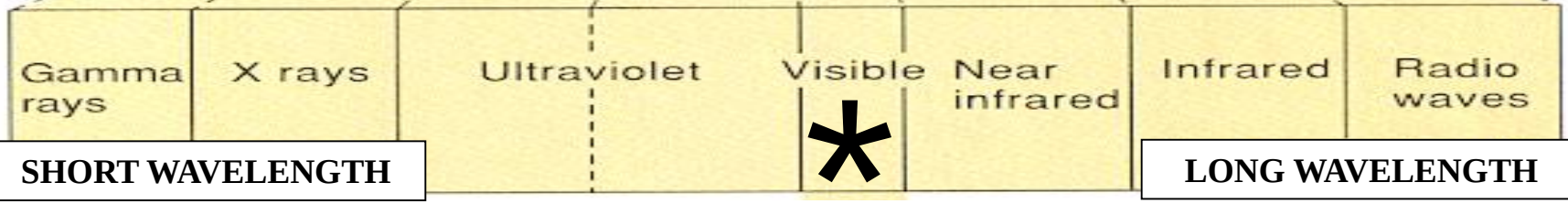
SUN

HYDROGEN FUSION REACTIONS

ELECTROMAGNETIC SPECTRUM PHOTONS

HIGH ENERGY

LOW ENERGY



SHORT WAVELENGTH

LONG WAVELENGTH

PHOTOSYNTHESIS

PHOTOSYNTHESIS

PHOTOSYNTHESIS

PHOTOSYNTHESIS

VISIBLE LIGHT

PRISM

VISIBLE LIGHT SPECTRUM

400 500 600 700

WAVELENGHT EFFICIENCY

GL

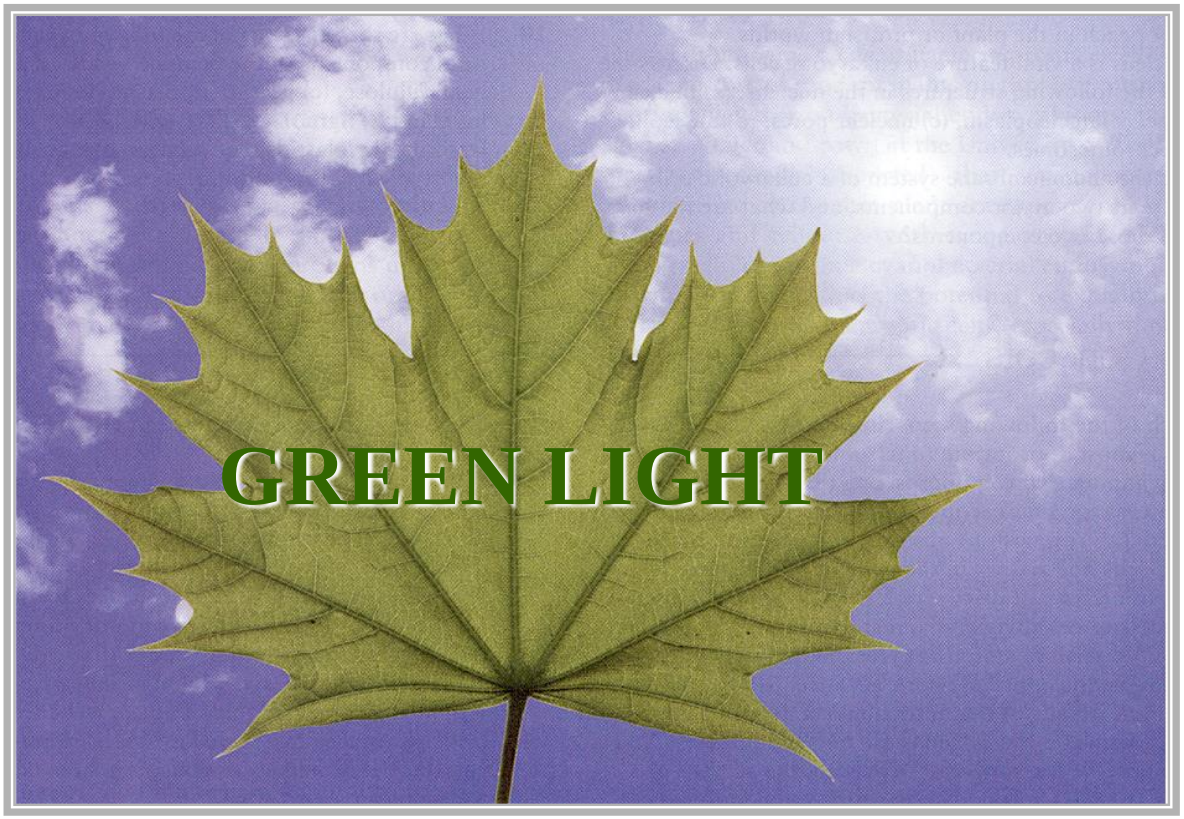
VISIBLE LIGHT →

BLUE LT
GREEN LT
YELLOW LT
ORANGE LT
RED LT

CHLOROPHYLL

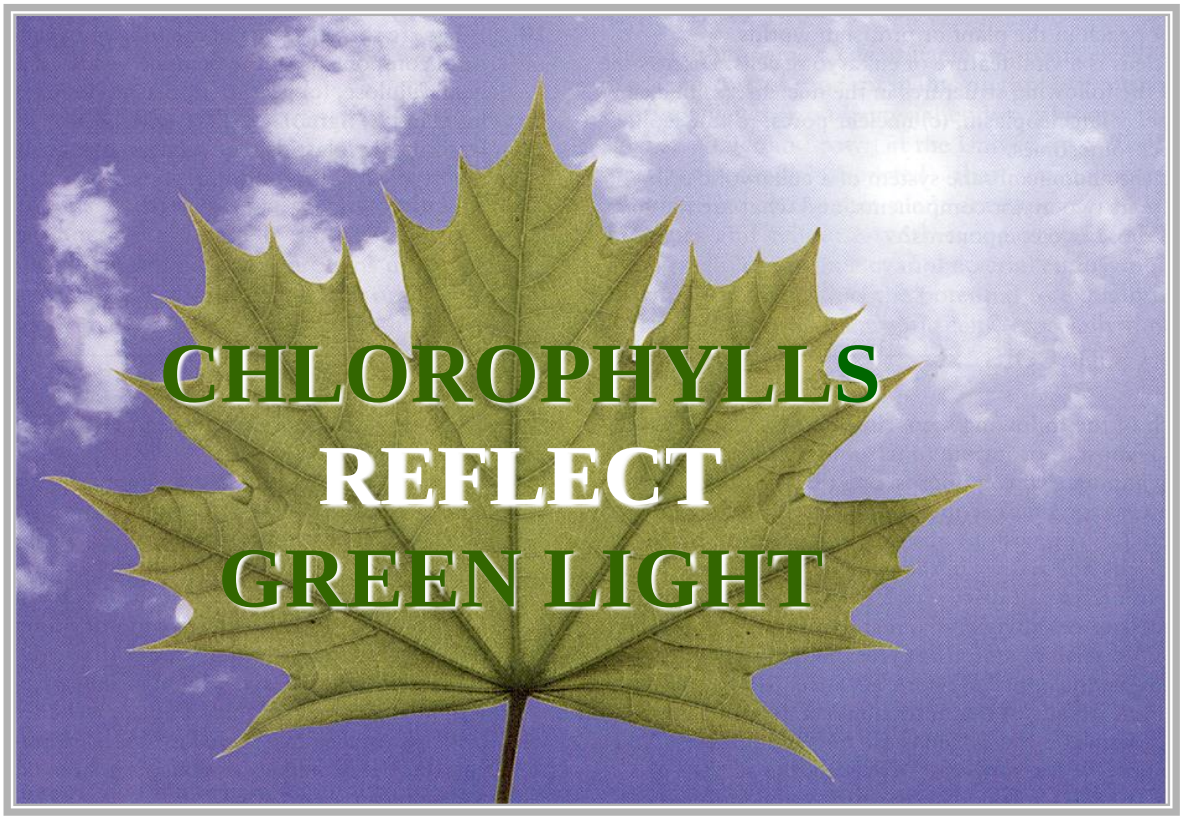
WAVELENGHT EFFICIENCY

WAVELENGHT EFFICIENCY



WAVELENGHT EFFICIENCY

VISIBLE LIGHT SPECTRUM



WAVELENGHT EFFICIENCY

PHOTOSYNTHESIS

GREEN LT

VERY

INEFFICIENT

WAVELENGHT EFFICIENCY

BLUE LT

VISIBLE LIGHT → **YELLOW LT**
ORANGE LT
RED LT

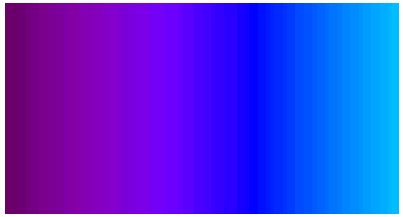
XANTHOPHYLLS

WAVELENGHT EFFICIENCY

WAVELENGHT EFFICIENCY

WAVELENGHT EFFICIENCY

WAVELENGHT EFFICIENCY



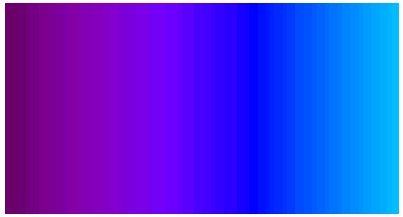
PHOTOSYNTHESIS

YELLOW LT

VERY

INEFFICIENT

WAVELENGHT EFFICIENCY



BLUE LT

VISIBLE LIGHT →

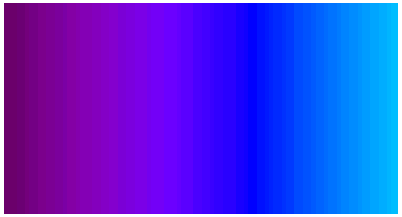
ORANGE LT

RED LT

CAROTENES

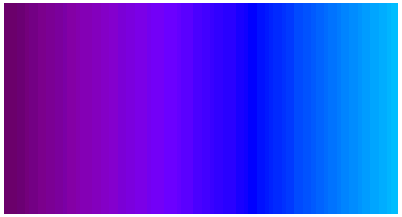
WAVELENGHT EFFICIENCY

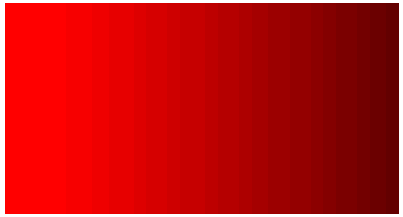
WAVELENGHT EFFICIENCY



WAVELENGHT EFFICIENCY

WAVELENGHT EFFICIENCY





PHOTOSYNTHESIS

ORANGE LT

VERY

INEFFICIENT

QUESTION

WHAT VISIBLE LT WAVELENGHTS ARE ABSORBED MOST EFFICIENTLY FOR PHOTOSYNTHESIS?

QUESTION

WAVELENGHT EFFICIENCY

BLUE LT

RED LT

WHAT VISIBLE LT WAVELENGHTS ARE ABSORBED MOST EFFICIENTLY FOR PHOTOSYNTHESIS?

WAVELENGHT EFFICIENCY

BLUE LT

RED LT

PHOTOSYNTHESIS

BLUE LT & RED LT

ABSORBED MOST EFFICIENTLY

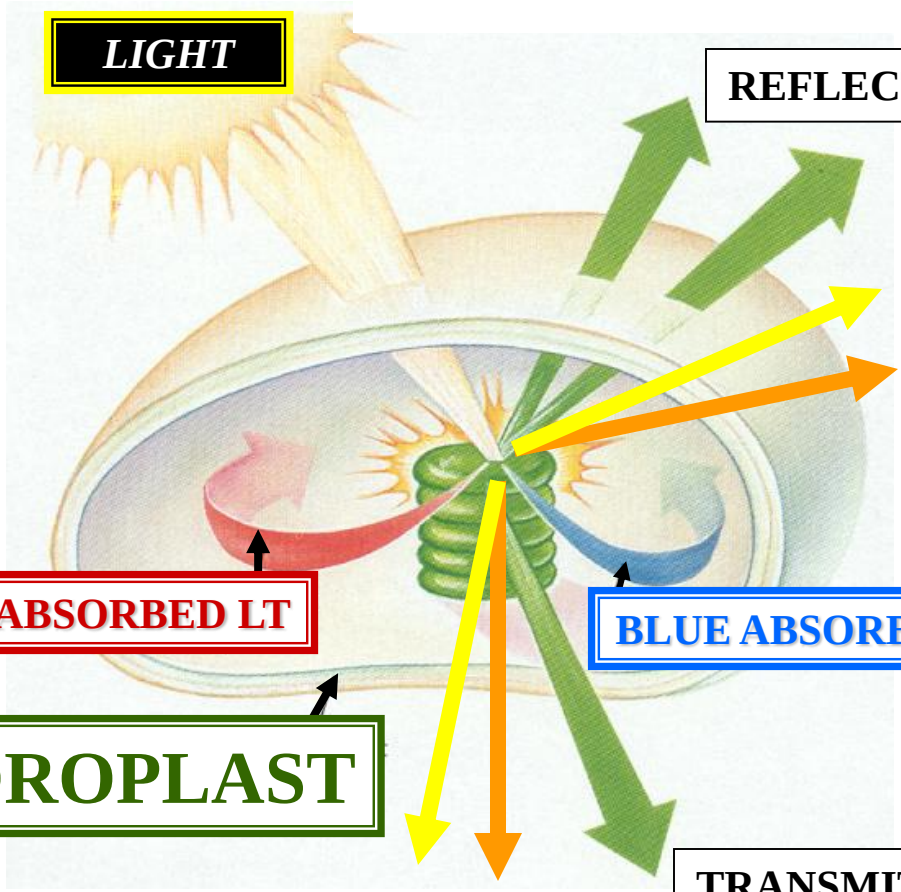
WAVELENGHT EFFICIENCY

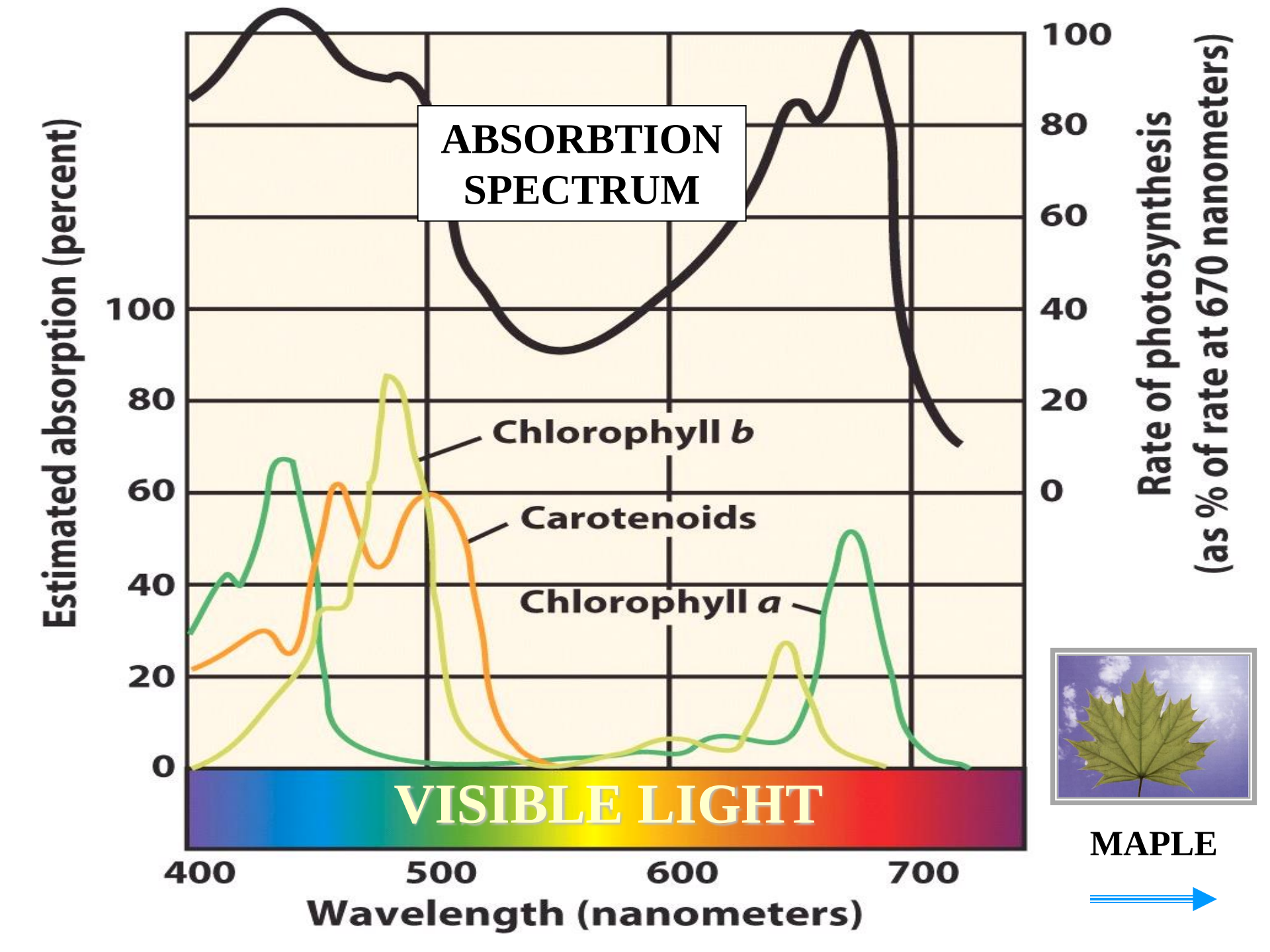
BLUE LT & RED LT MOST EFFICIENT PHOTOSYNTHESIS WAVELENGHTS

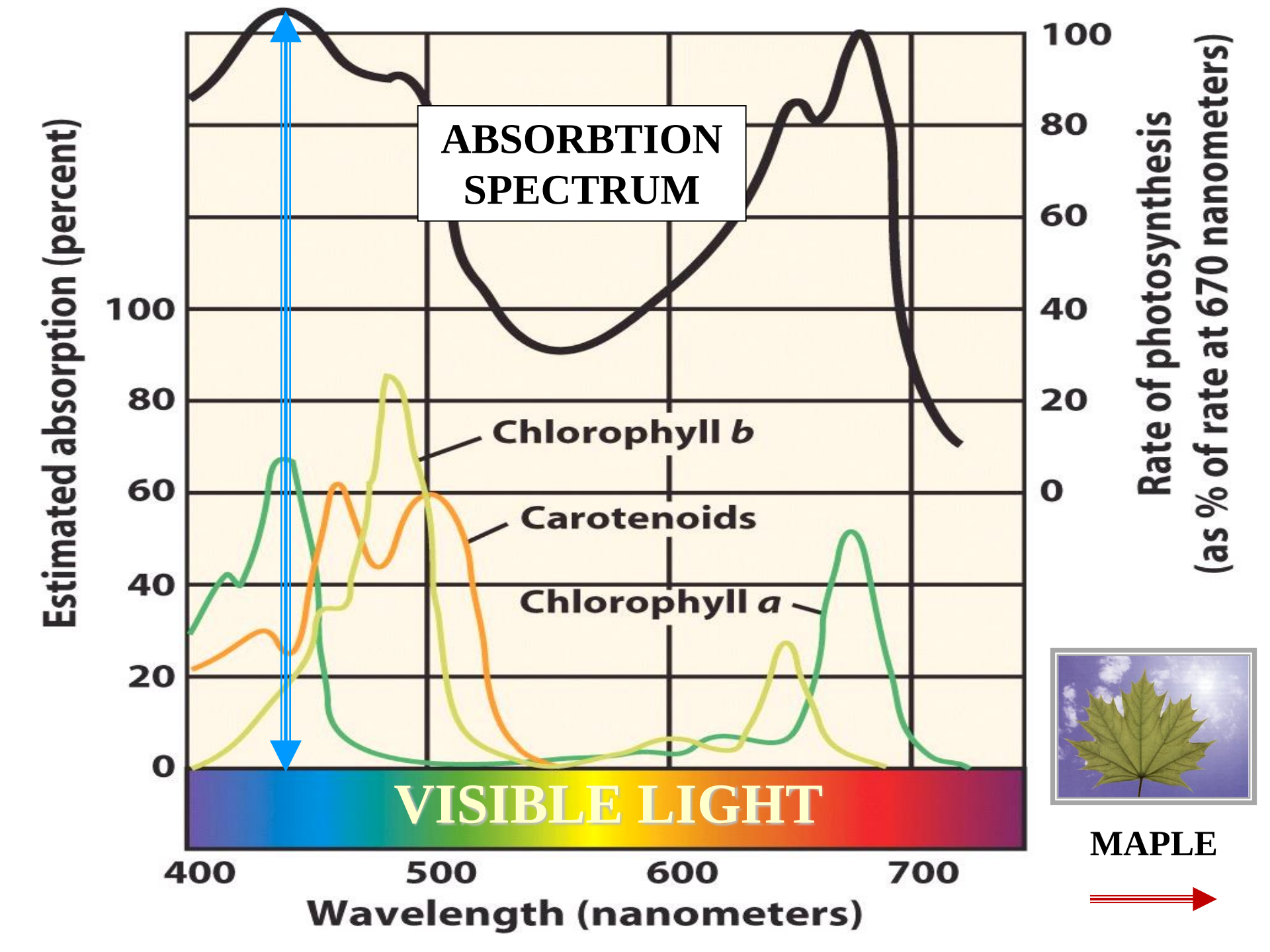
WAVELENGHT EFFICIENCY

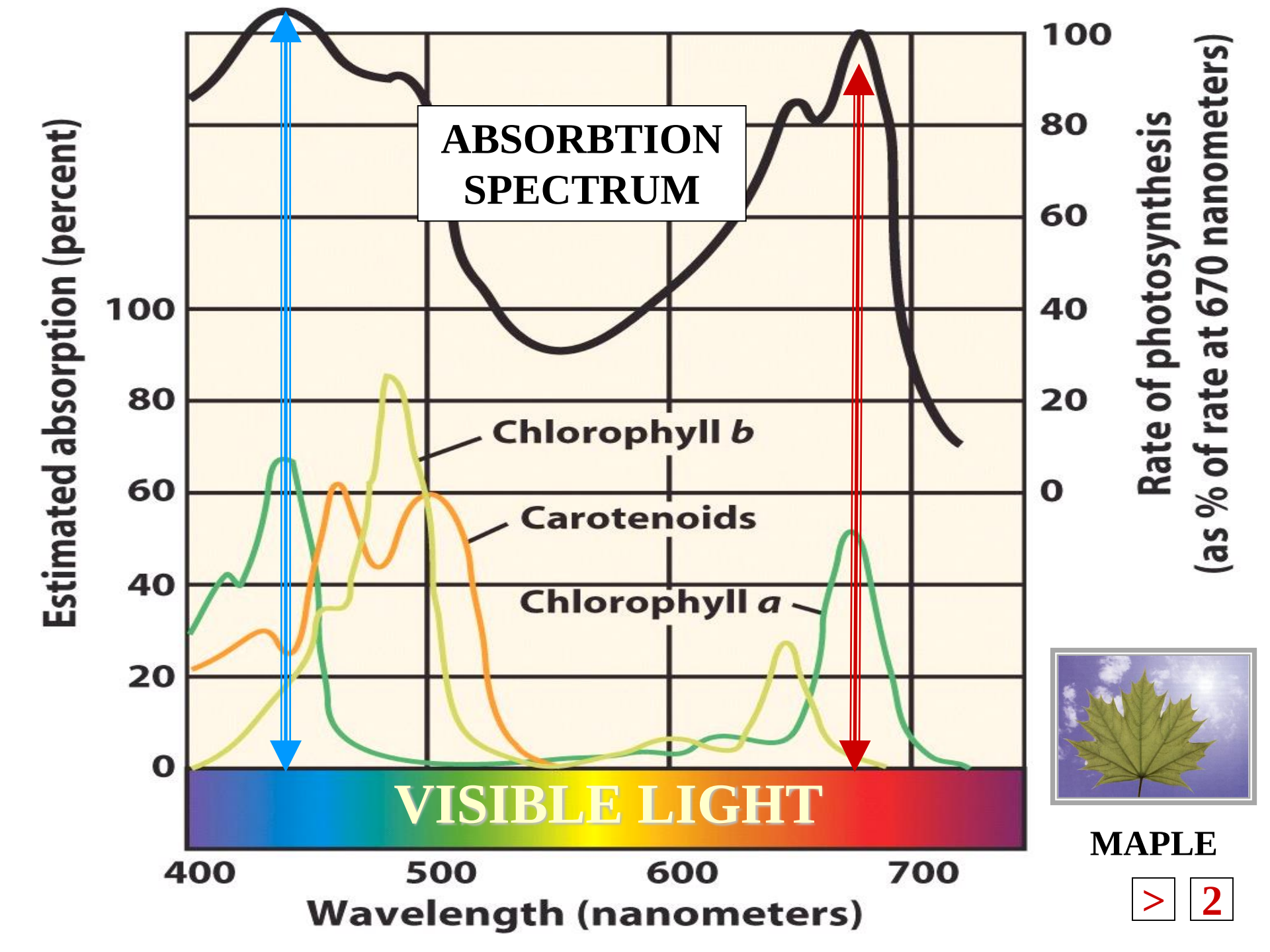
BLUE LT

RED LT

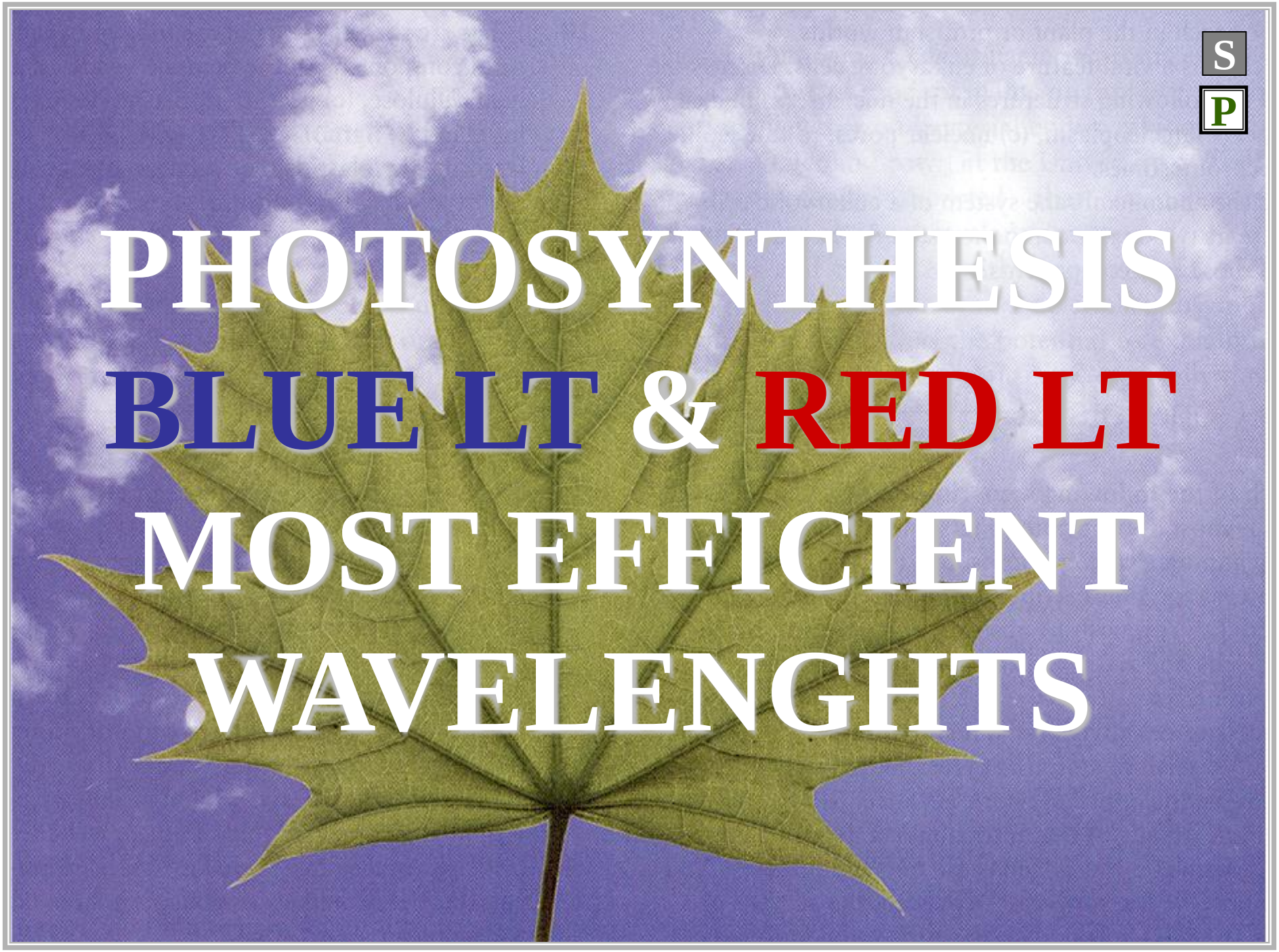


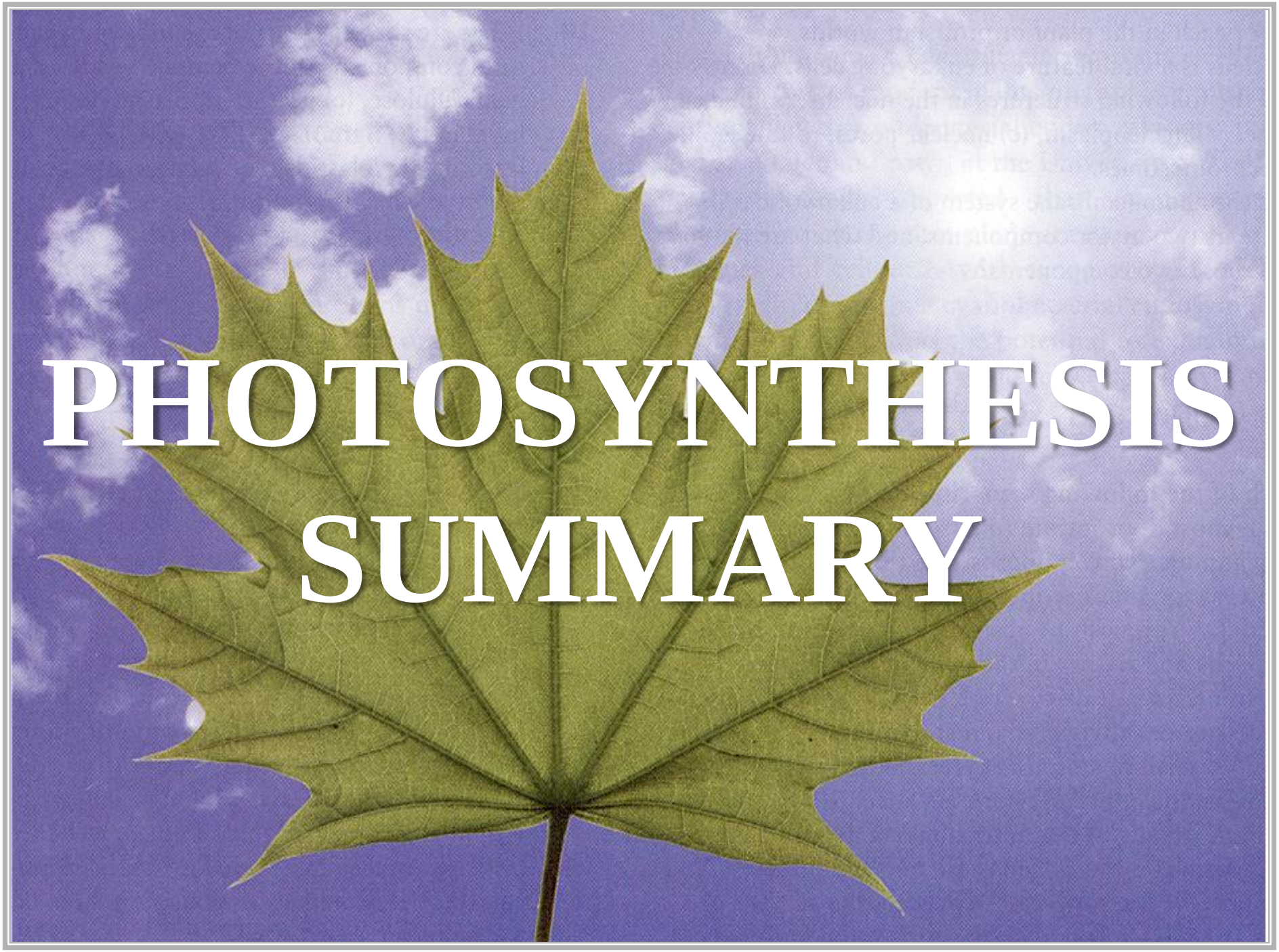

ABSORBTION SPECTRUM
Estimated absorption (percent)
Rate of photosynthesis (as % of rate at 670 nanometers)
100
80
60
40
20
0
Chlorophyll b
Carotenoids
Chlorophyll a
VISIBLE LIGHT
400
500
600
700
Wavelength (nanometers)
MAPLE


ABSORBTION SPECTRUM
Estimated absorption (percent)
100
80
60
40
20
0
Chlorophyll b
Carotenoids
Chlorophyll a
VISIBLE LIGHT
400
500
600
700
Wavelength (nanometers)
100
80
60
40
20
0
Rate of photosynthesis
(as % of rate at 670 nanometers)
MAPLE

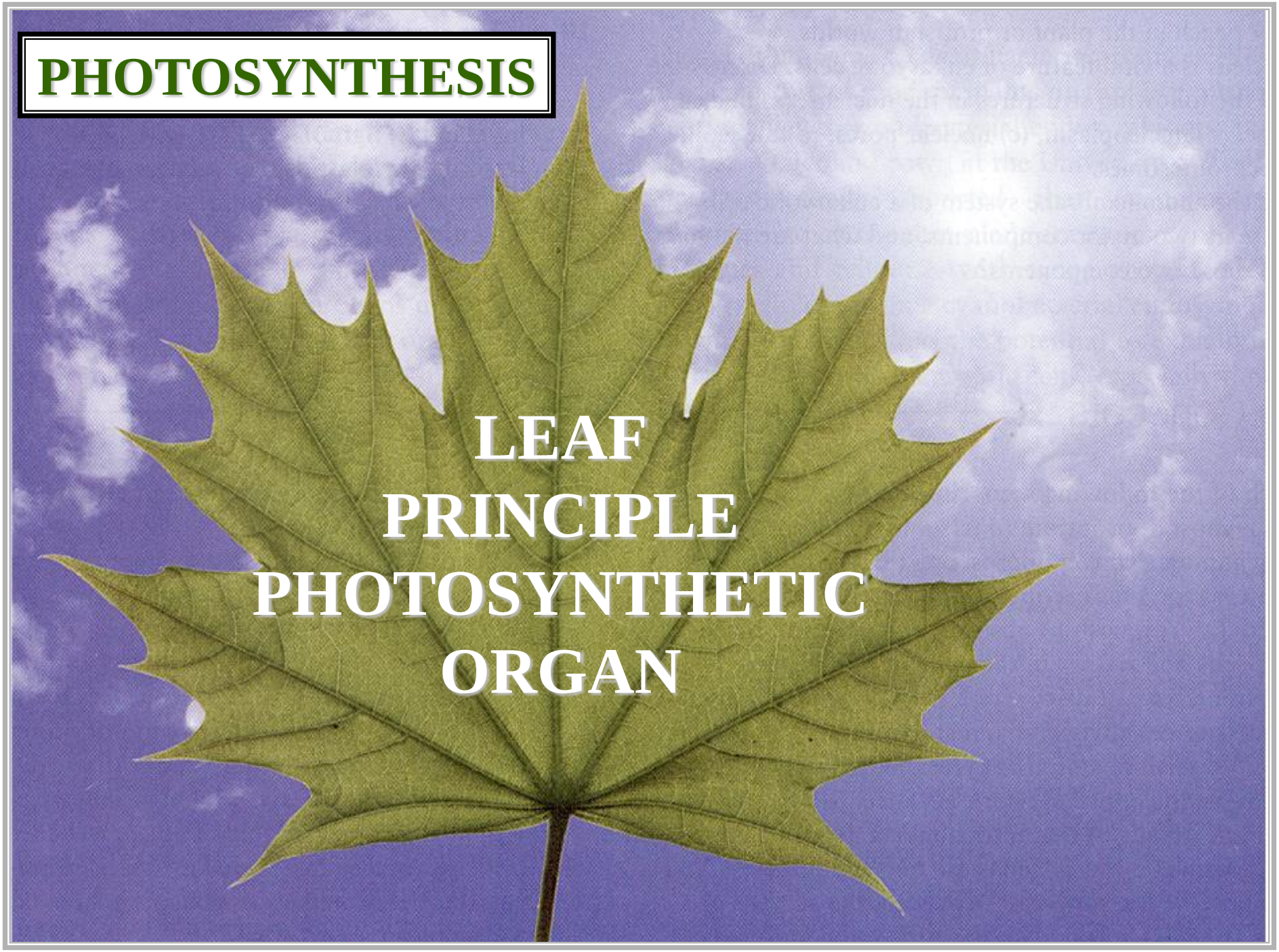

ABSORBTION SPECTRUM
Estimated absorption (percent)
Rate of photosynthesis (as % of rate at 670 nanometers)
100
80
60
40
20
0
Chlorophyll b
Carotenoids
Chlorophyll a
VISIBLE LIGHT
400
500
600
700
Wavelength (nanometers)

MAPLE


S
P
PHOTOSYNTHESIS
BLUE LT & RED LT
MOST EFFICIENT
WAVELENGHTS


PHOTOSYNTHESIS
SUMMARY

PHOTOSYNTHESIS



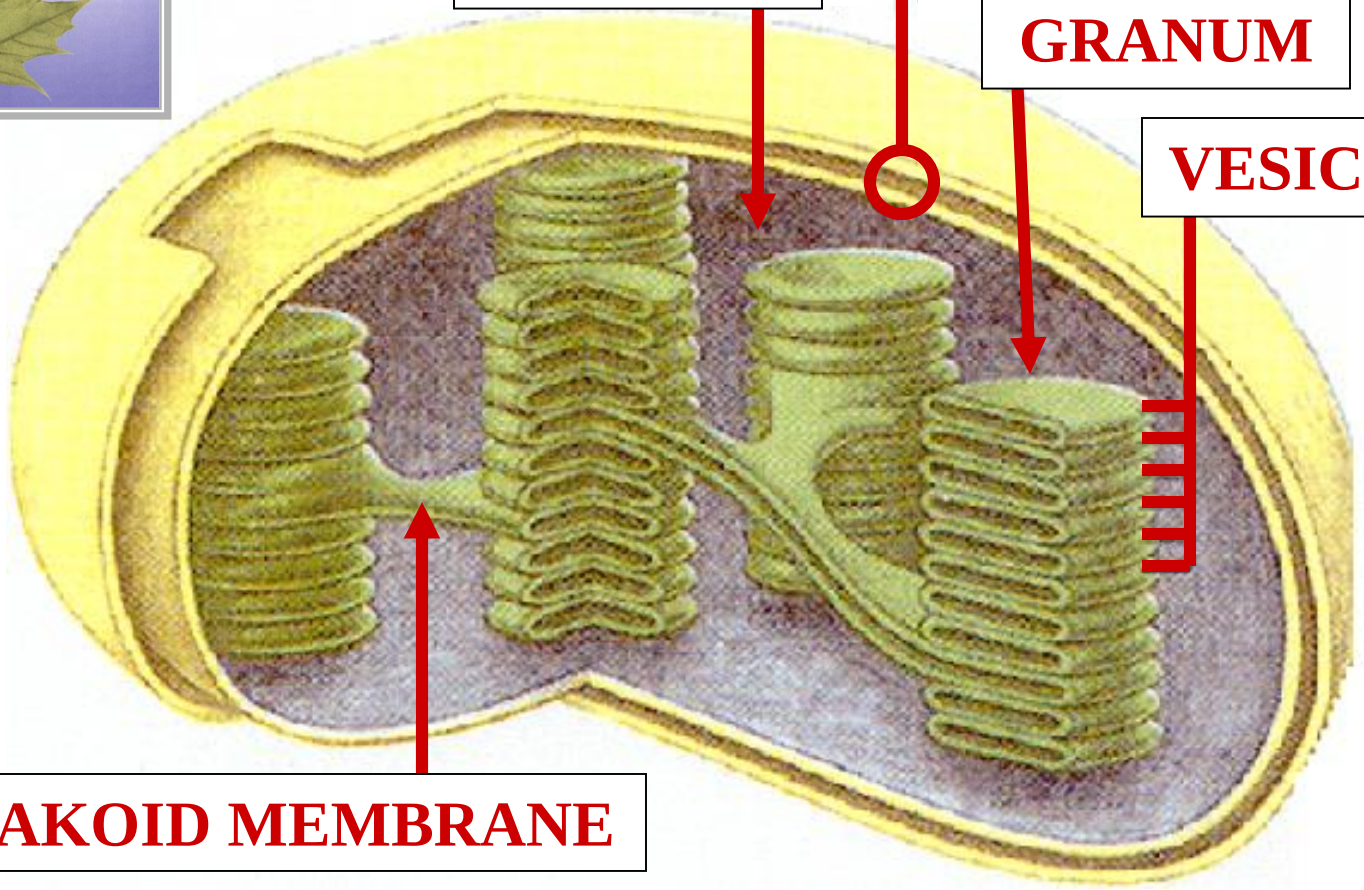
LEAF
PRINCIPLE
PHOTOSYNTHETIC
ORGAN

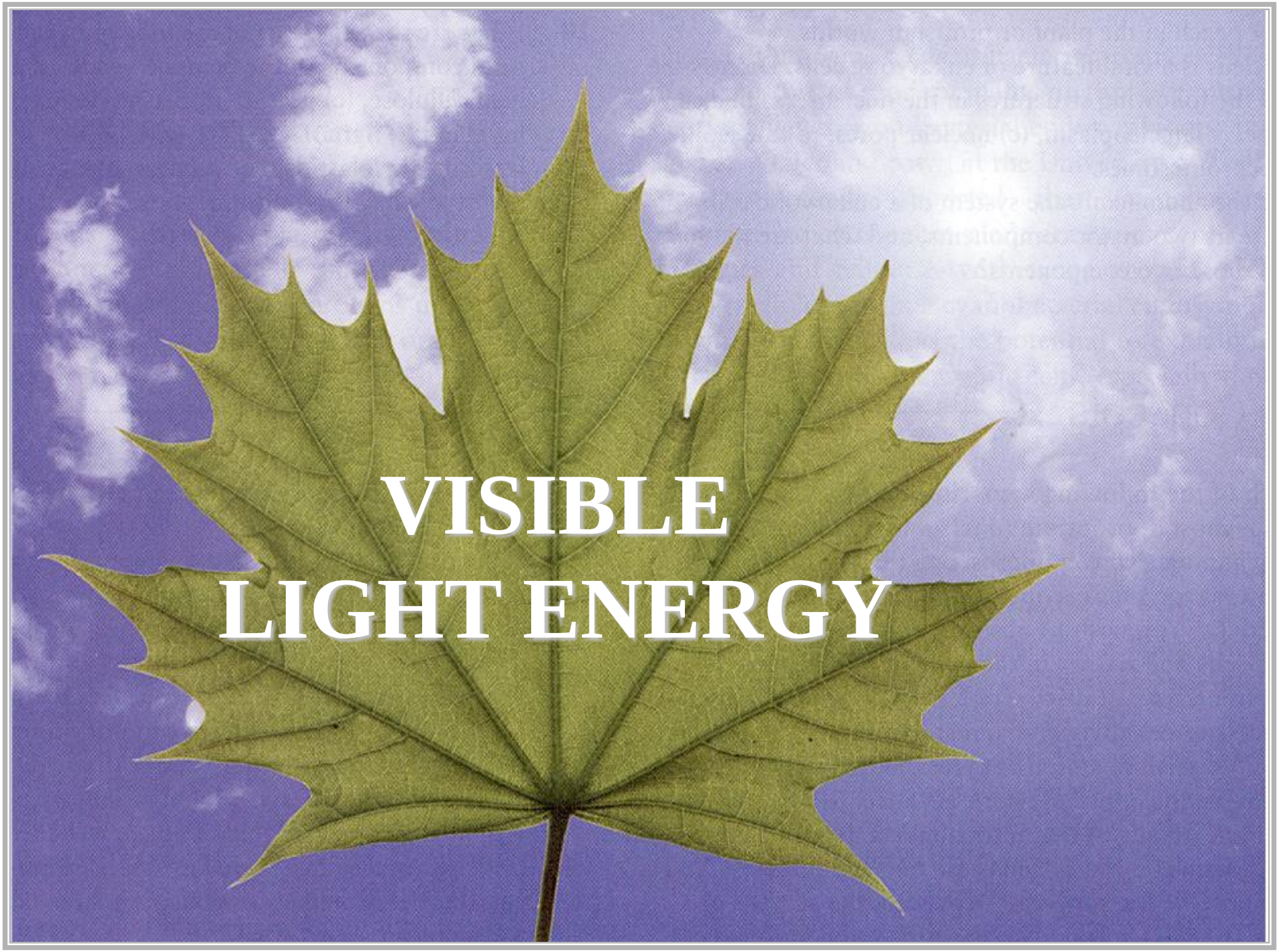
MESOPHYLL PHOTOSYNTHETIC TISSUE

LEAF

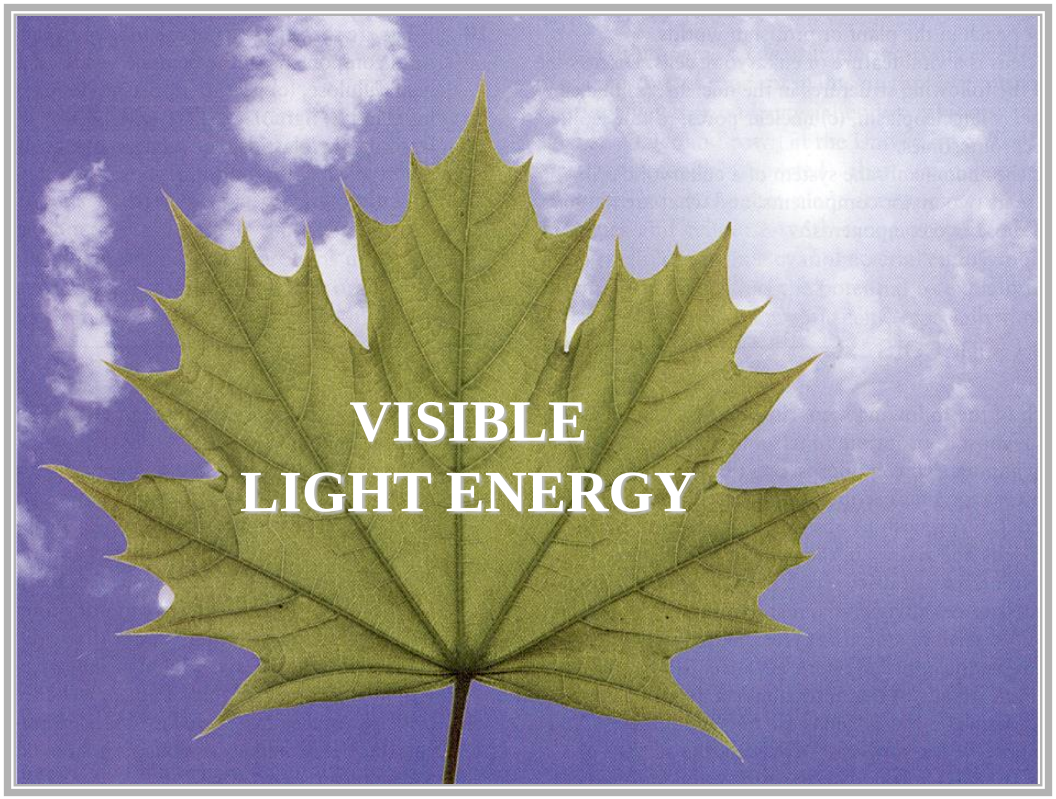
C.S.

CHLOROPLAST ULTRASTRUCTURE




VISIBLE
LIGHT ENERGY

VISIBLE LIGHT ENERGY

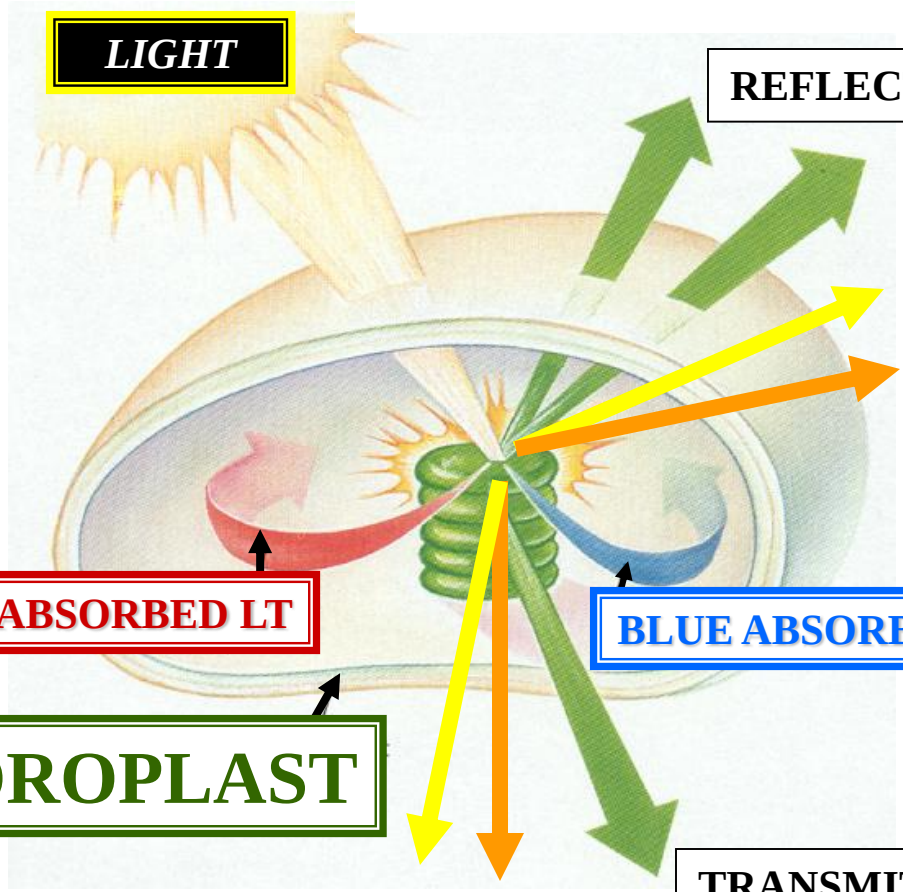


WAVELENGHT EFFICIENCY

RD

BLUE LT

RED LT



PHOTOSYNTHESIS

^

LIGHT RXT CONSISTS MOSTLY REDUCTION / OXIDATION REACTIONS

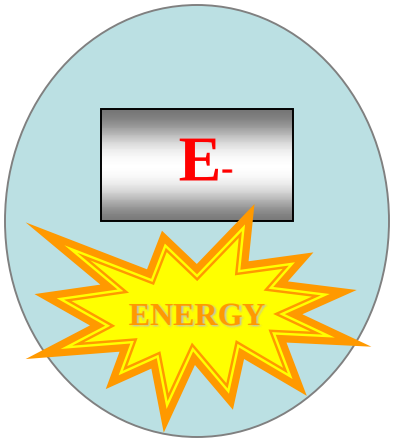
REDOX REACTION REVIEW

REDOX REACTION

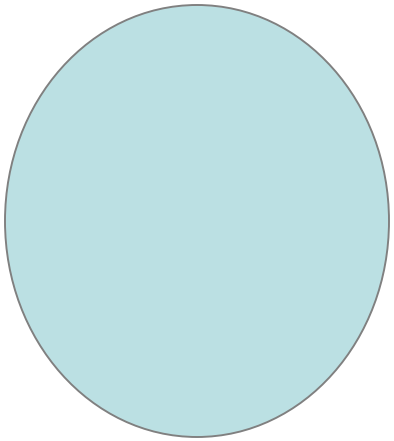
REDUCTION RXT – OXIDATION RXT

R

CMP-A



CMP-B

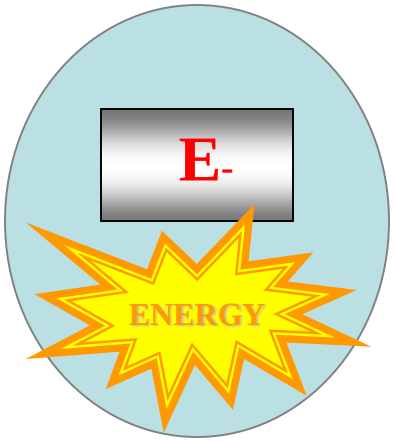


= **CHEMICAL ENERGY**

REDOX REACTION

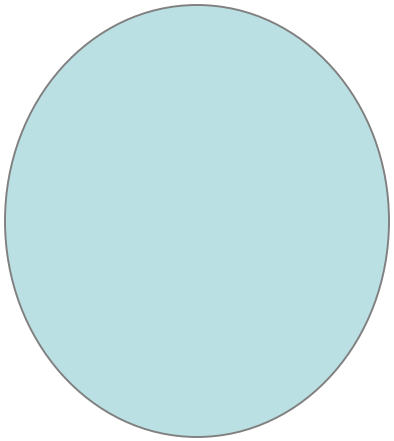
REDUCTION RXT – OXIDATION RXT

CMP-A



REDOX REACTION

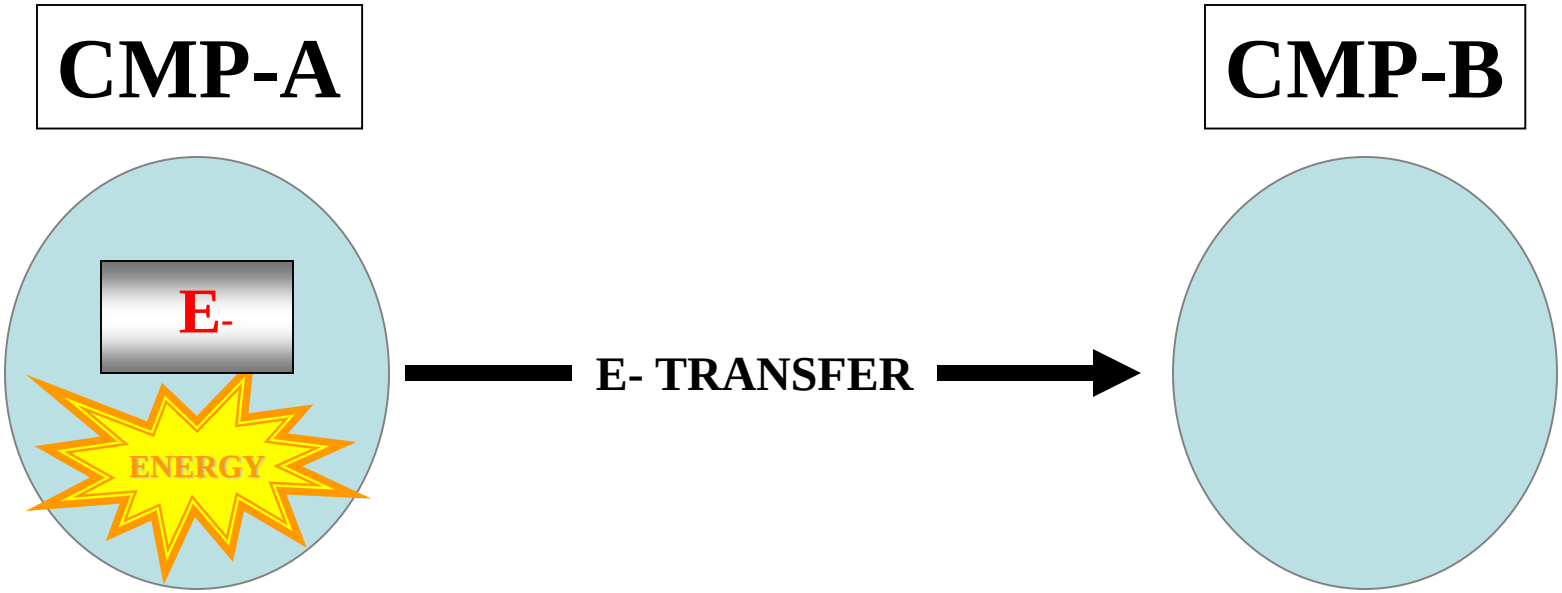
CMP-B



 = **CHEMICAL ENERGY**

REDOX REACTION

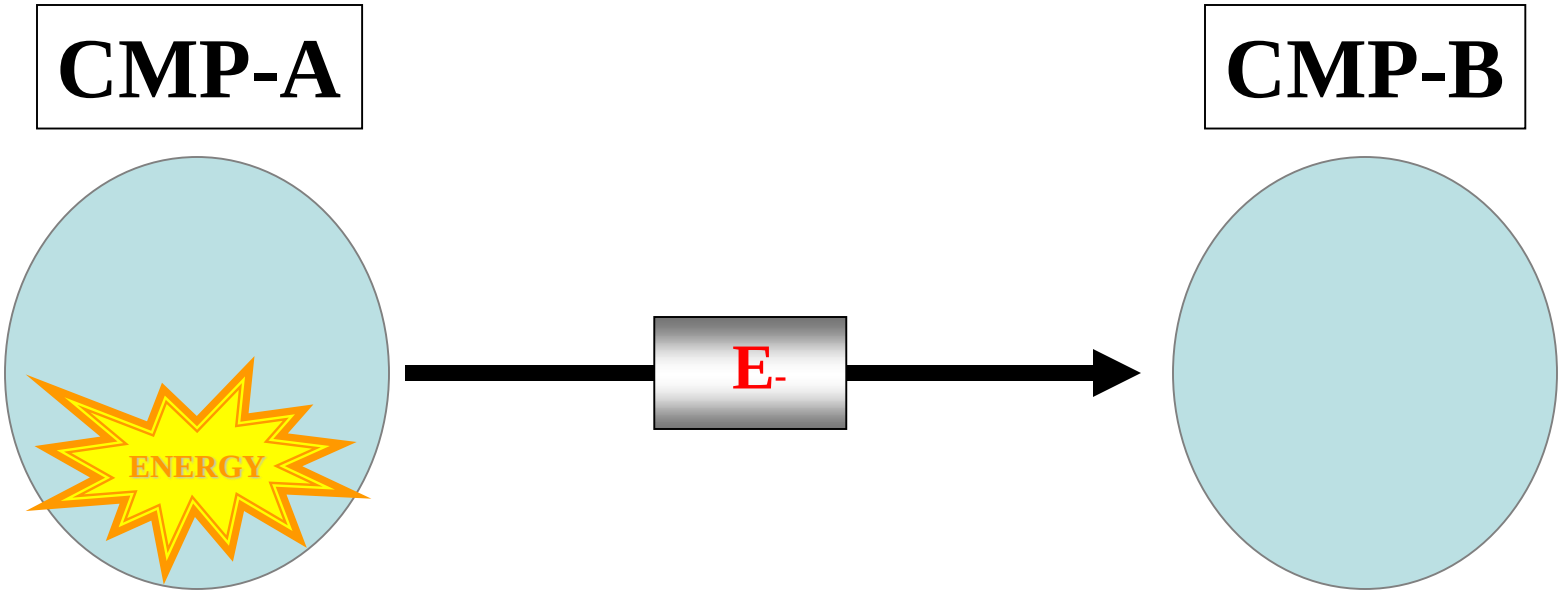
REDUCTION RXT – OXIDATION RXT



= CHEMICAL ENERGY

REDOX REACTION

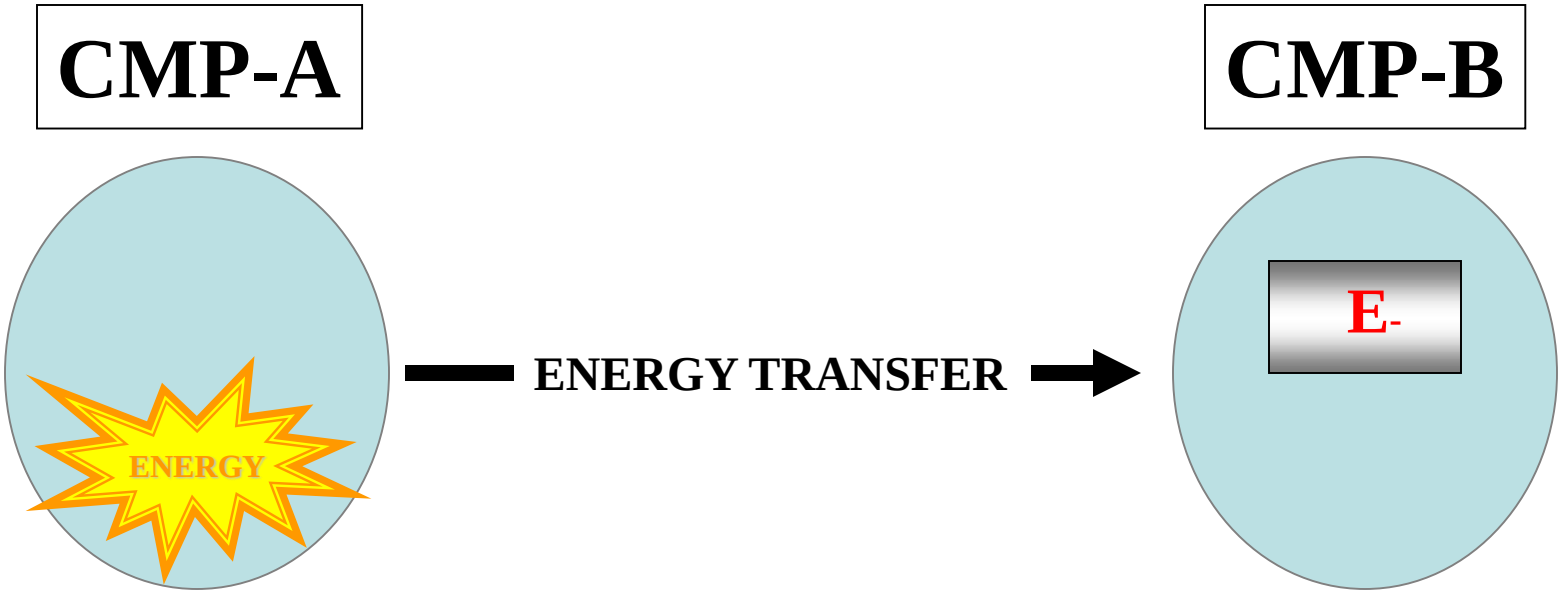
REDUCTION RXT – OXIDATION RXT



= CHEMICAL ENERGY

REDOX REACTION

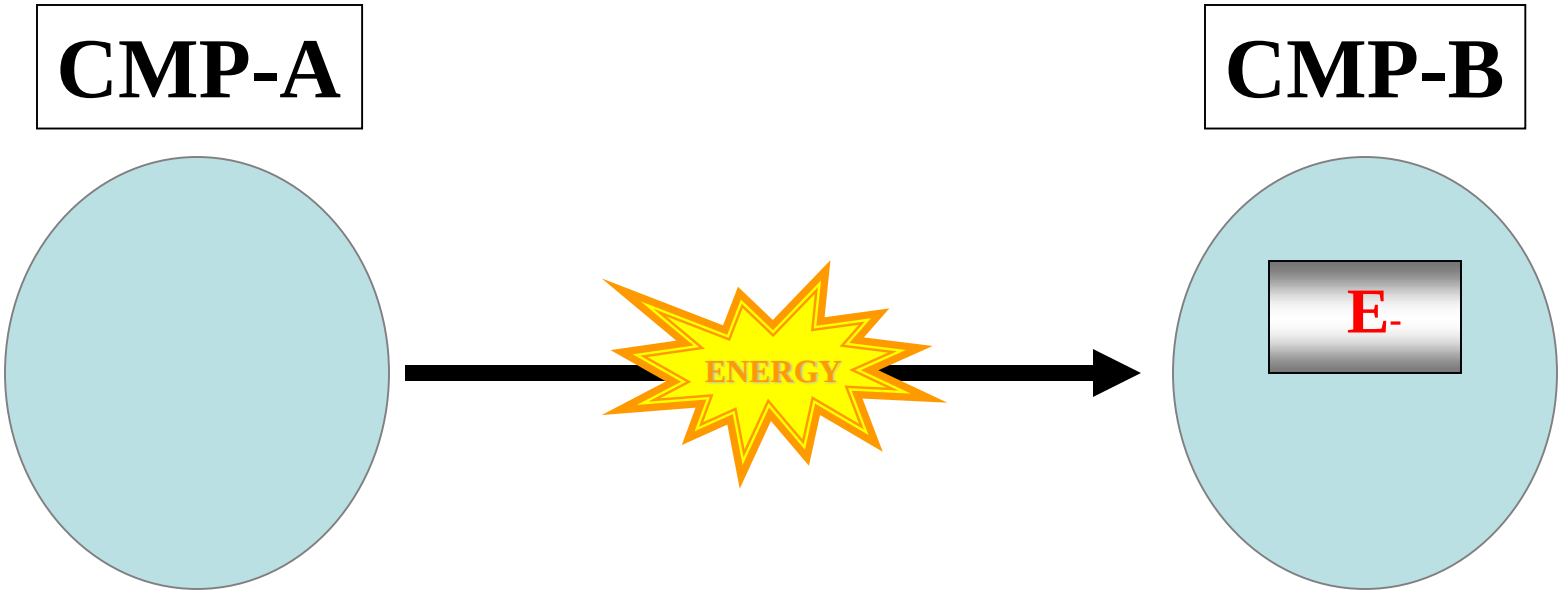
REDUCTION RXT – OXIDATION RXT



= CHEMICAL ENERGY

REDOX REACTION

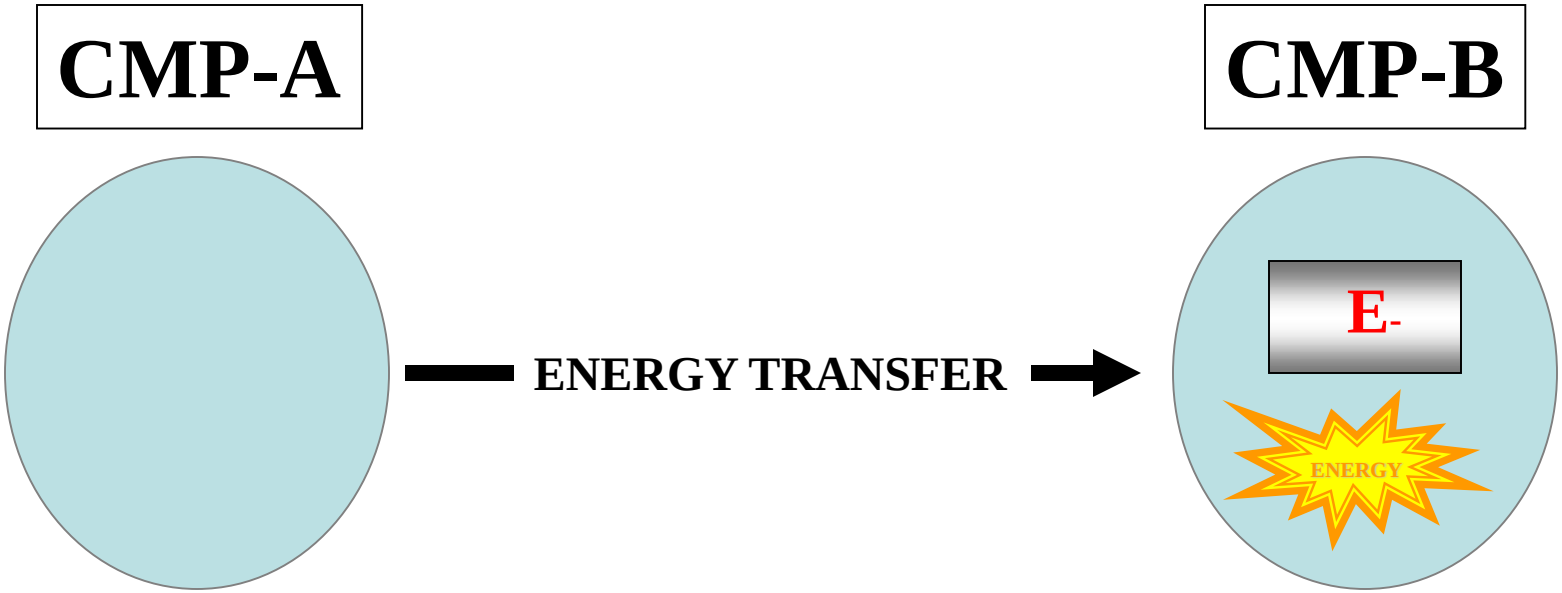
REDUCTION RXT – OXIDATION RXT



= CHEMICAL ENERGY

REDOX REACTION

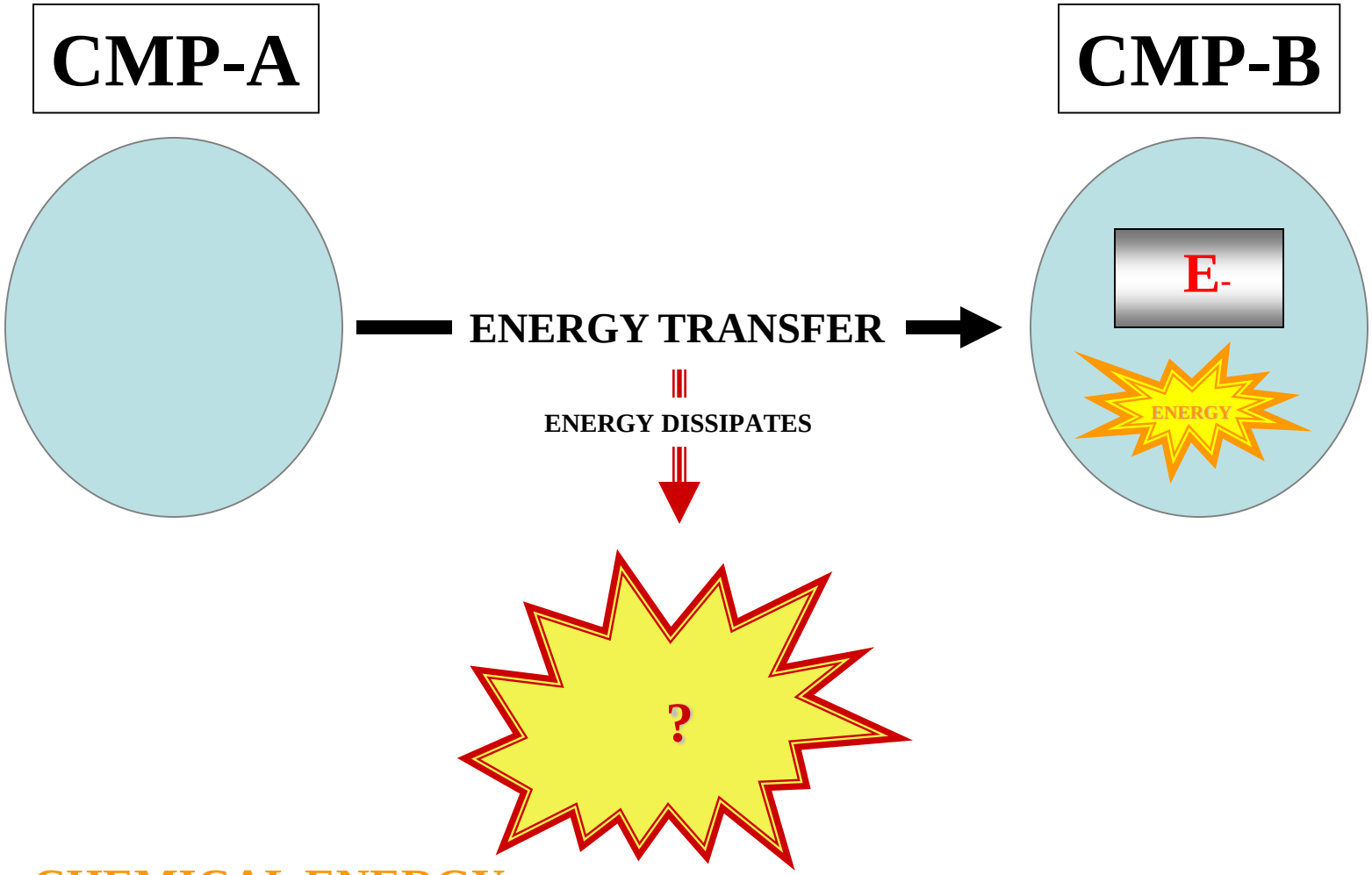
REDUCTION RXT – OXIDATION RXT



= CHEMICAL ENERGY

REDOX REACTION

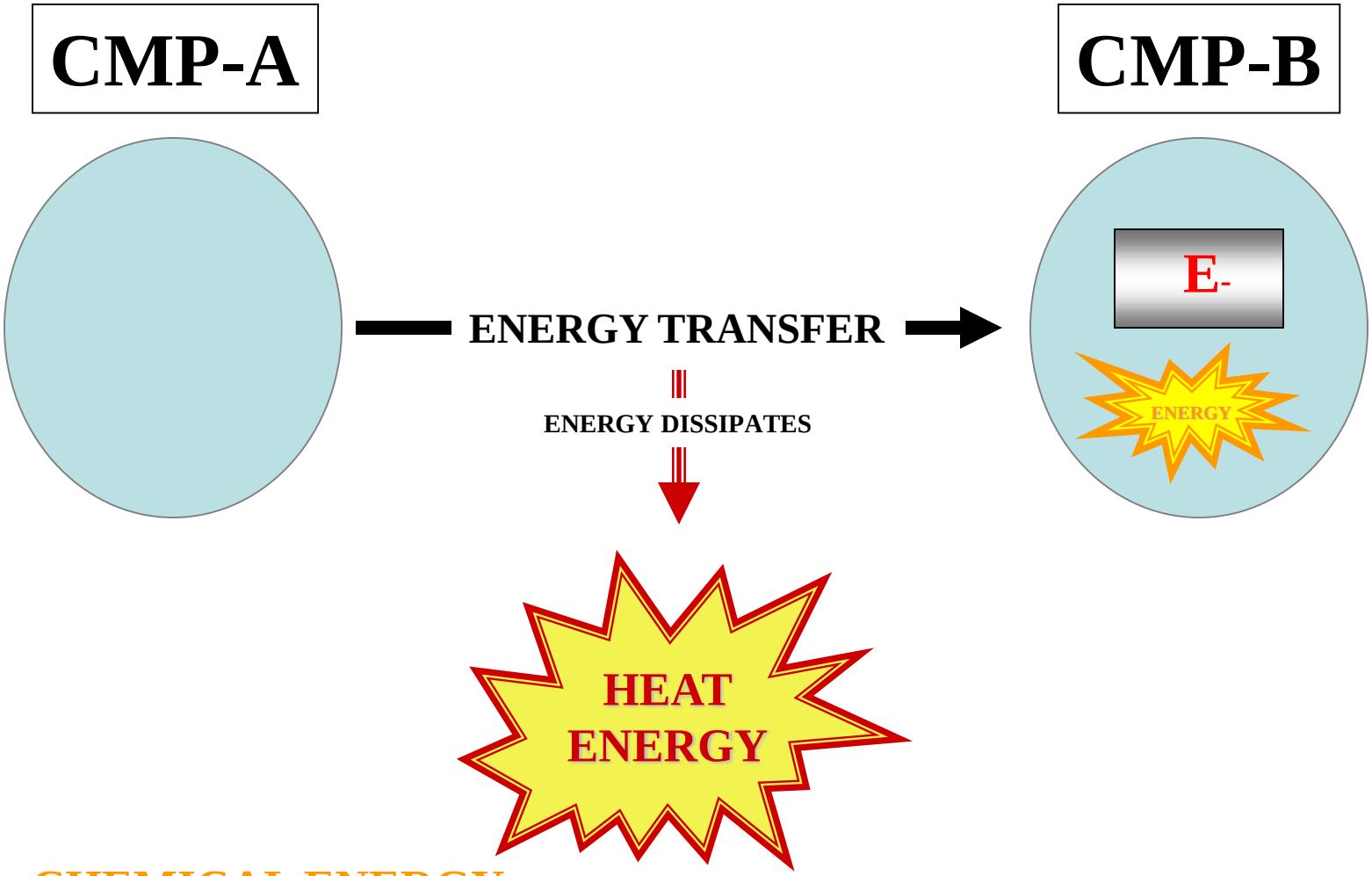
REDUCTION RXT – OXIDATION RXT



REDOX REACTION

OX

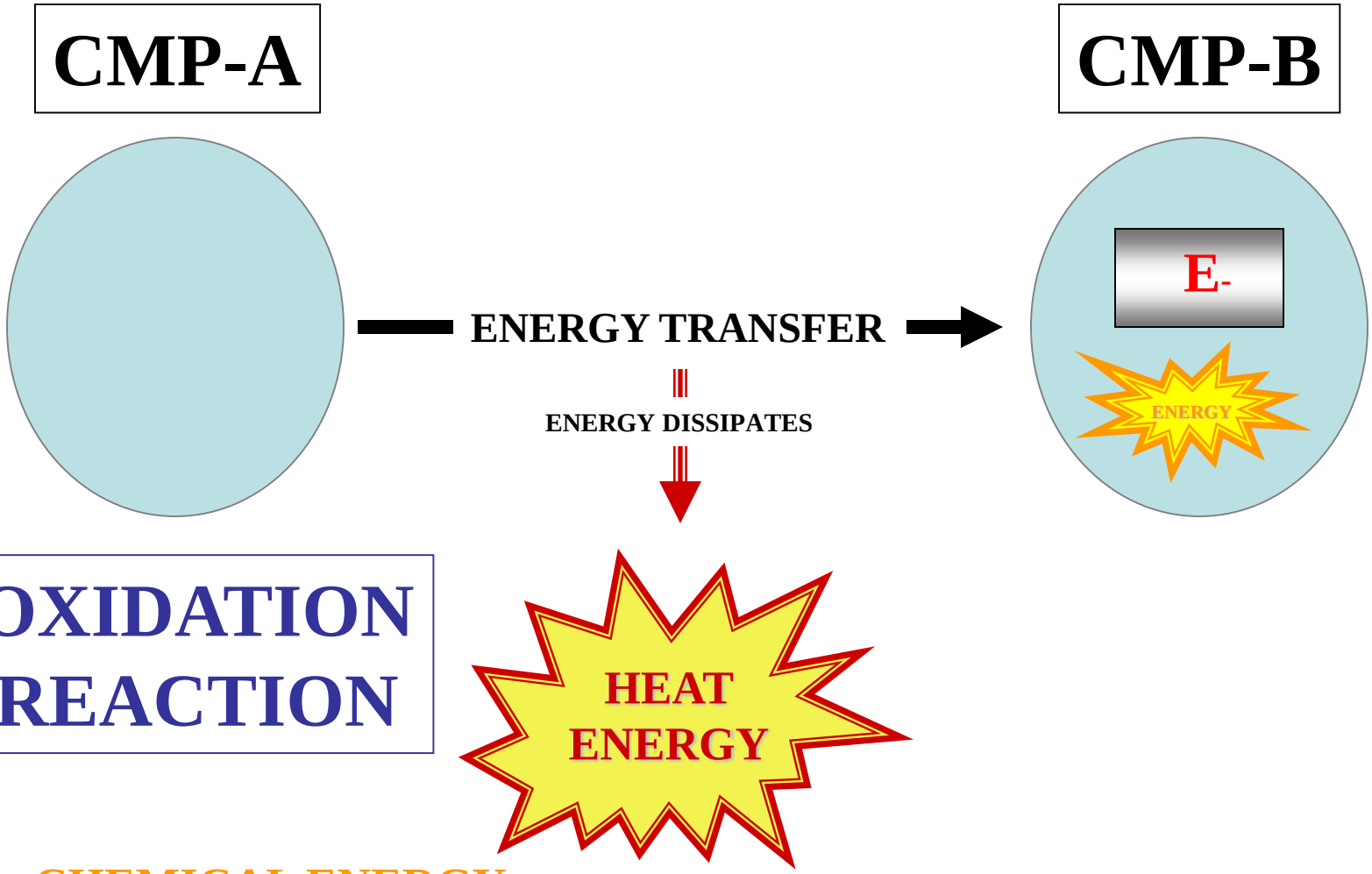
REDUCTION RXT – OXIDATION RXT



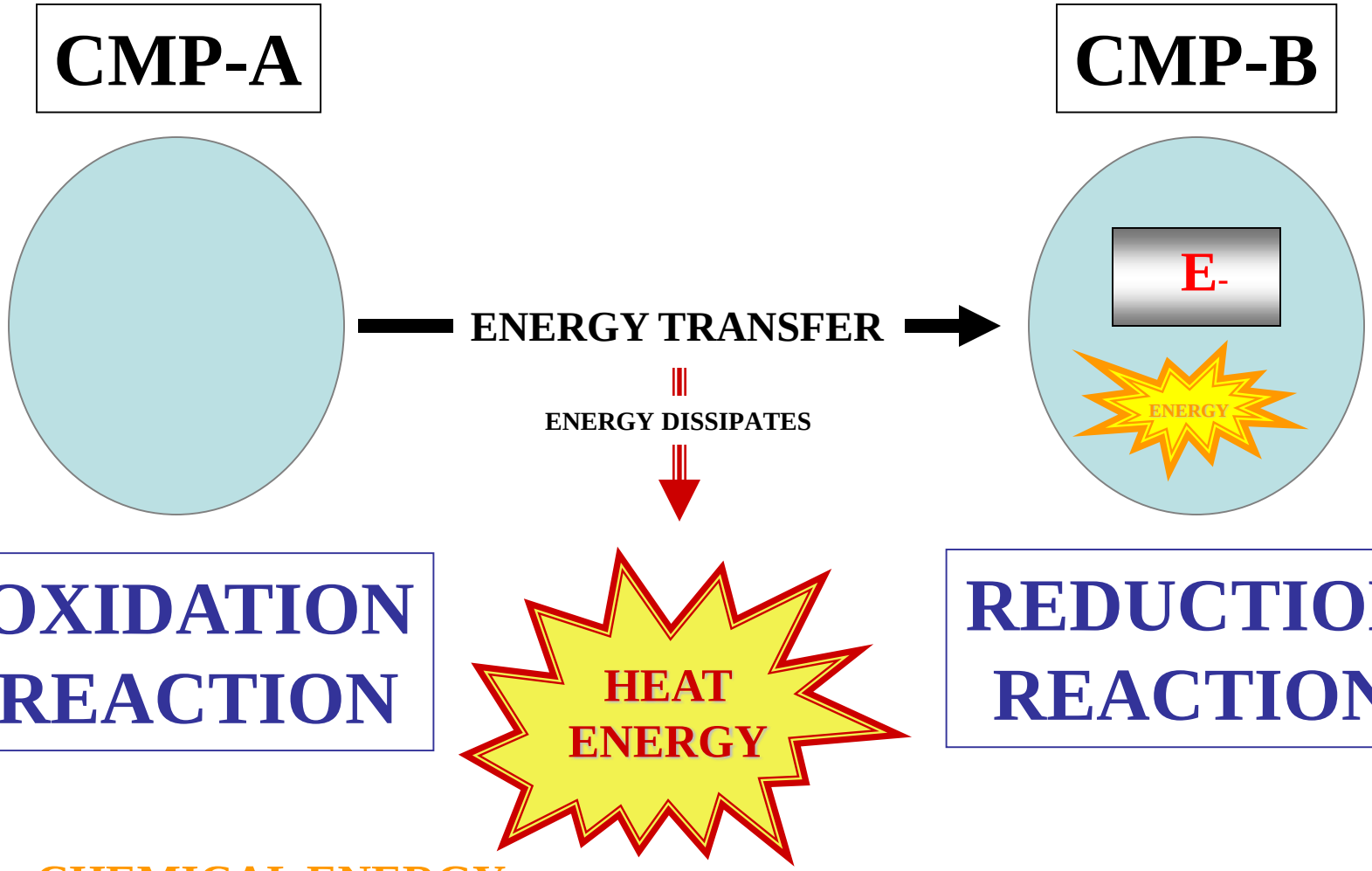
REDOX REACTION

RE

REDUCTION RXT – OXIDATION RXT



REDOX REACTION
REDUCTION RXT – OXIDATION RXT



REDOX RXTS

ESSENTIAL

PSYN

LIGHT RXTS

LIGHT REACTION TYPES

LIGHT REACTION TYPES

NON-CYCLIC PHOTO-PHOSPHORYLATION

TYPES REACTION TYPES

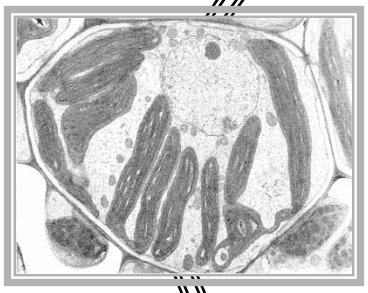
LIGHT REACTION TYPES

NON-CYCLIC PHOTO-PHOSPHORYLATION
CYCLIC PHOTO-PHOSPHORYLATION

TYPES REACTION TYPES

PHOTOSYNTHESIS

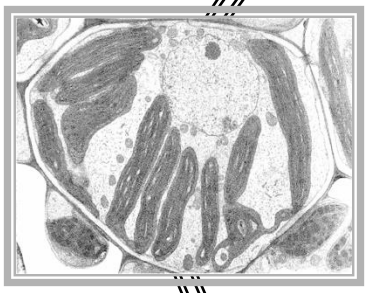
LR



CHLOROPLAST

PHOTOSYNTHESIS

LT



LT RXT

THYLAKOID GRANUM

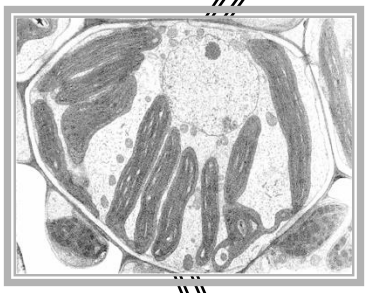
NON-CYCLIC PHOTO-PHOSPHORYLATION
&
CYCLIC PHOTO-PHOSPHORYLATION

CHLOROPLAST

PHOTOSYNTHESIS

?

LIGHT EGY



LT RXT

THYLAKOID
GRANUM

CHLOROPLAST

PHOTOSYNTHESIS

C

WATER

LIGHT EGY

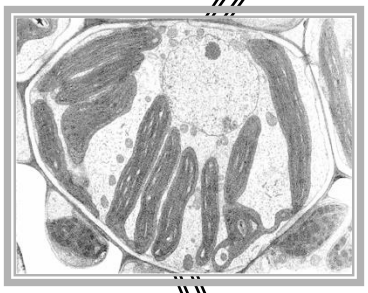
E-

PHOTOLYSIS

LT RXT

THYLAKOID
GRANUM

?



CHLOROPLAST

ATMOSPHERE

OXYGEN

PHOTOSYNTHESIS

A

WATER

LIGHT EGY

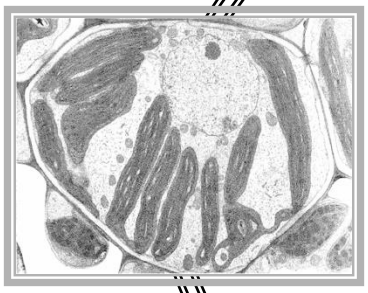
E-

PHOTOLYSIS

LT RXT

THYLAKOID GRANUM

CHEMICAL ENERGY



P + ADP

CHLOROPLAST

ATMOSPHERE

OXYGEN

CHEM EGY INPUT

PHOTOSYNTHESIS

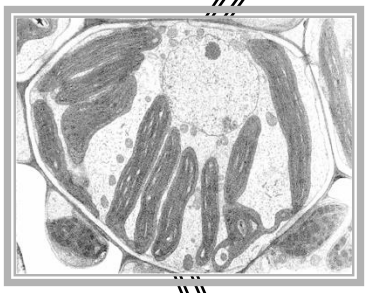
P

WATER

LIGHT EGY

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

ATP

P + ADP → ATP

CHLOROPLAST

ATMOSPHERE

OXYGEN

CHEM EGY INPUT

PHOTOSYNTHESIS

¿

LT

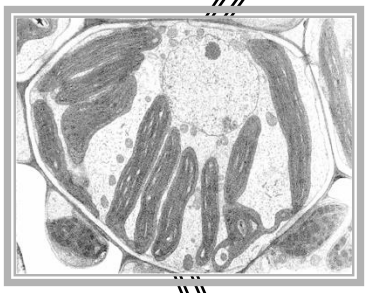
P

WATER

LIGHT EGY

E-

PHOTOLYSIS



LT RXT

THYLAKOID

GRANUM

ATP

PHOSPHORYLATION

CHLOROPLAST

ATMOSPHERE

OXYGEN

PHOTOSYNTHESIS

+

PP

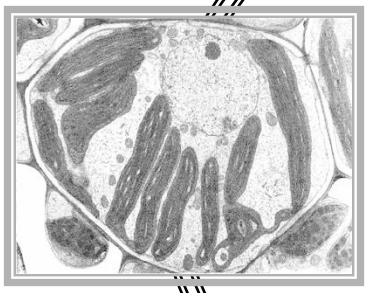
WATER

LIGHT EGY

PHOTO

E-

PHOTOLYSIS



LT RXT

THYLAKOID

GRANUM

ATP

PHOSPHORYLATION

CHLOROPLAST

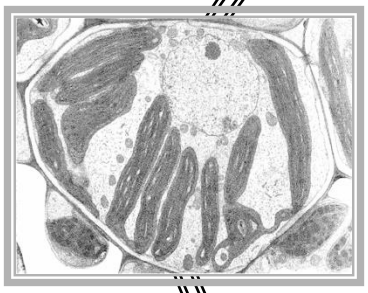
ATMOSPHERE

OXYGEN

PHOTOSYNTHESIS

^

LIGHT EGY



LT RXT

THYLAKOID GRANUM

NON-CYCLIC PHOTO-PHOSPHORYLATION
&
CYCLIC PHOTO-PHOSPHORYLATION

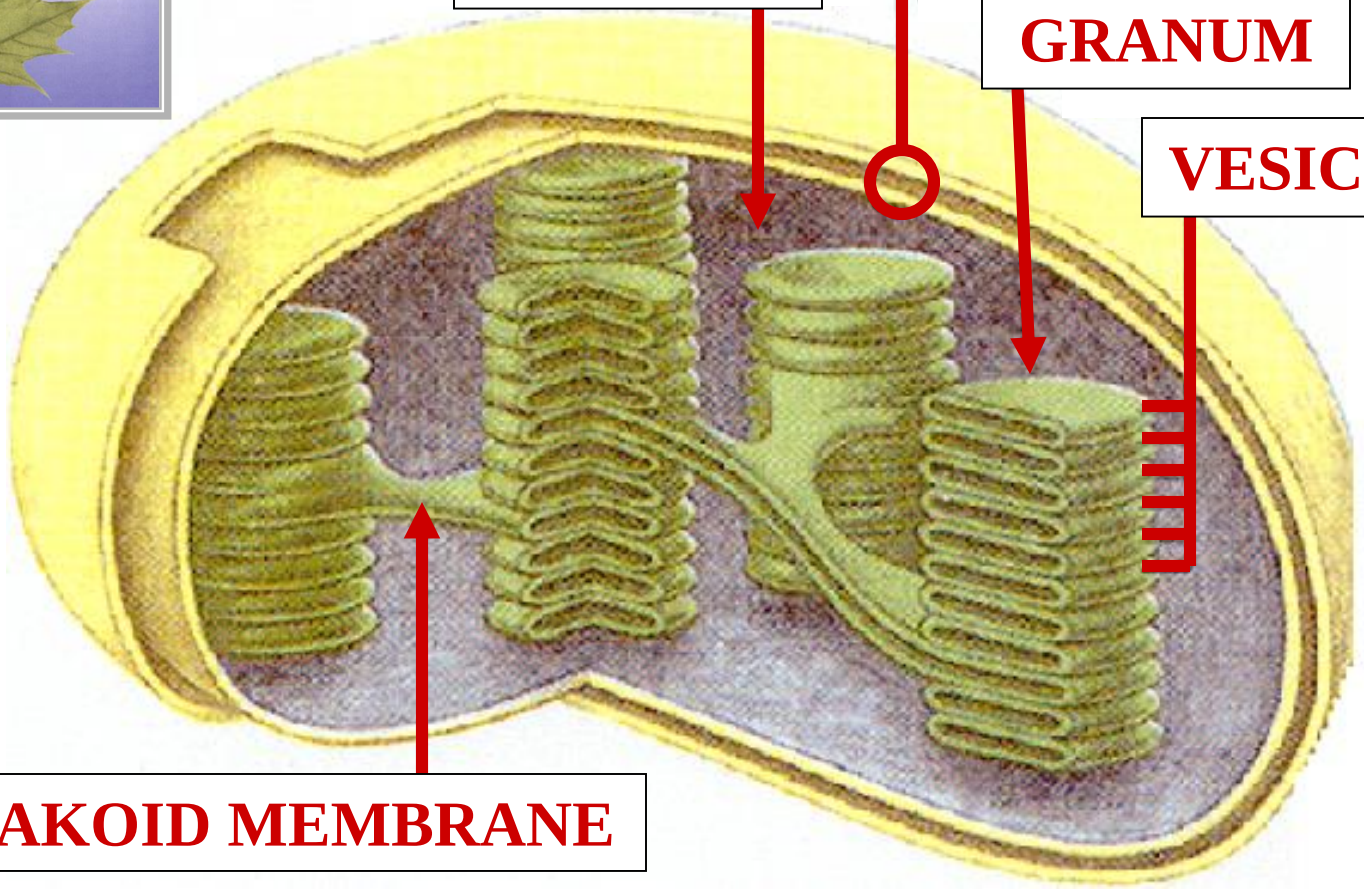
CHLOROPLAST

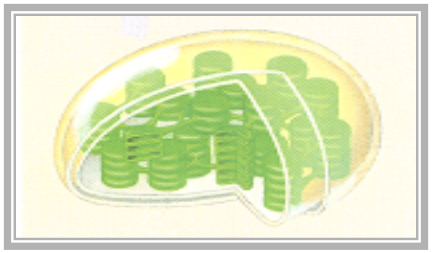
LIGHT REACTION

NON-CYCLIC

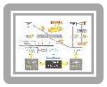
PHOTO-PHOSPHORYLATION

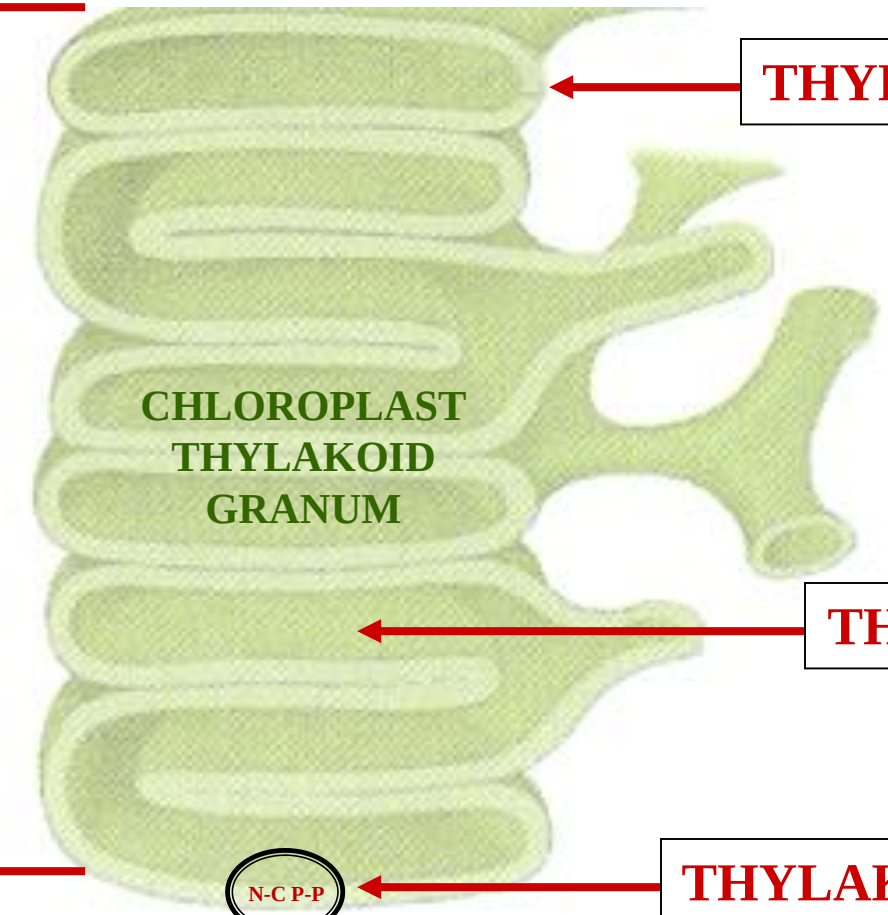
CHLOROPLAST ULTRASTRUCTURE





CHLOROPLAST THYLAKOID





THYLAKOID VESICLE

STROMA

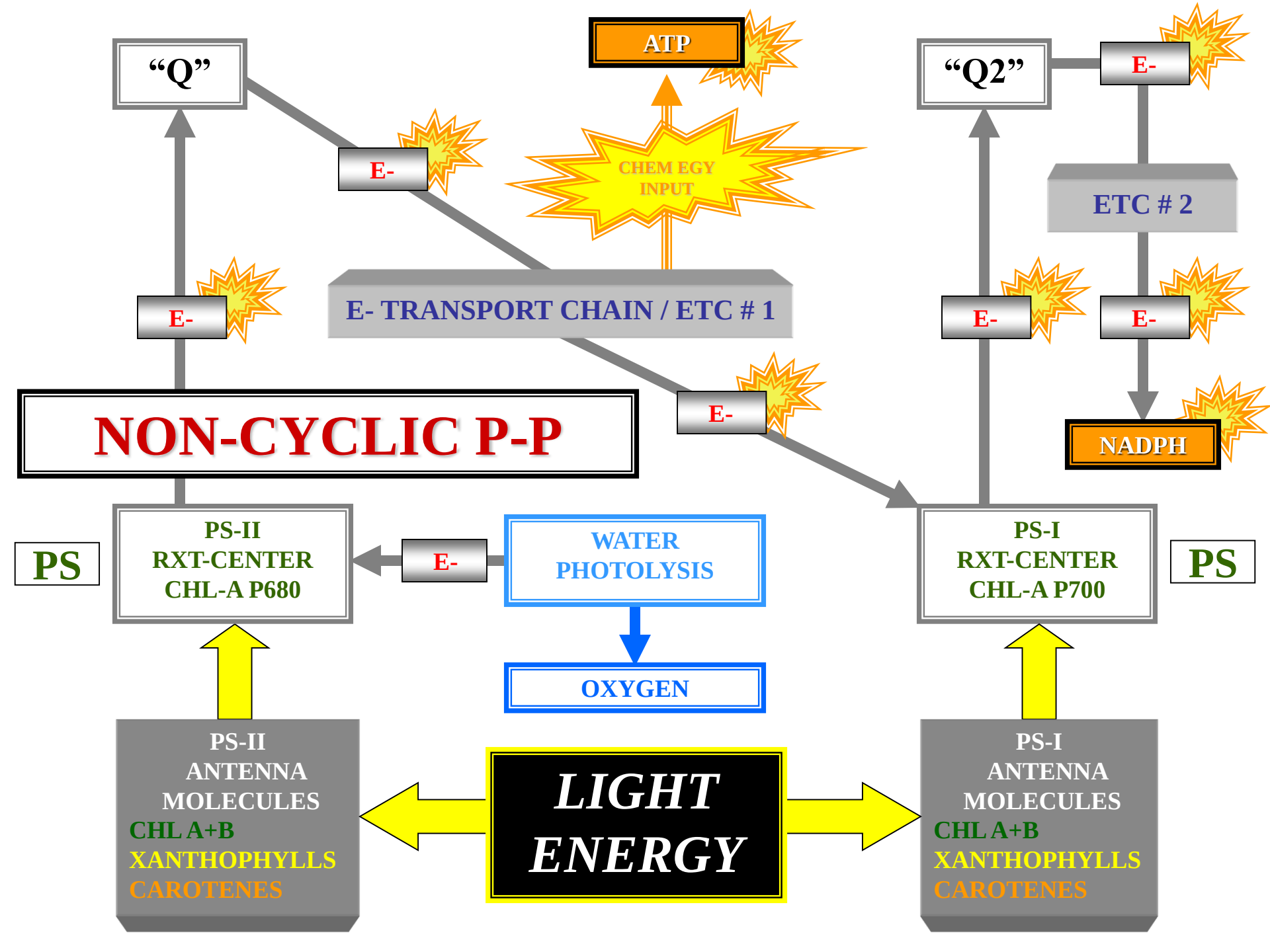
GRANUM

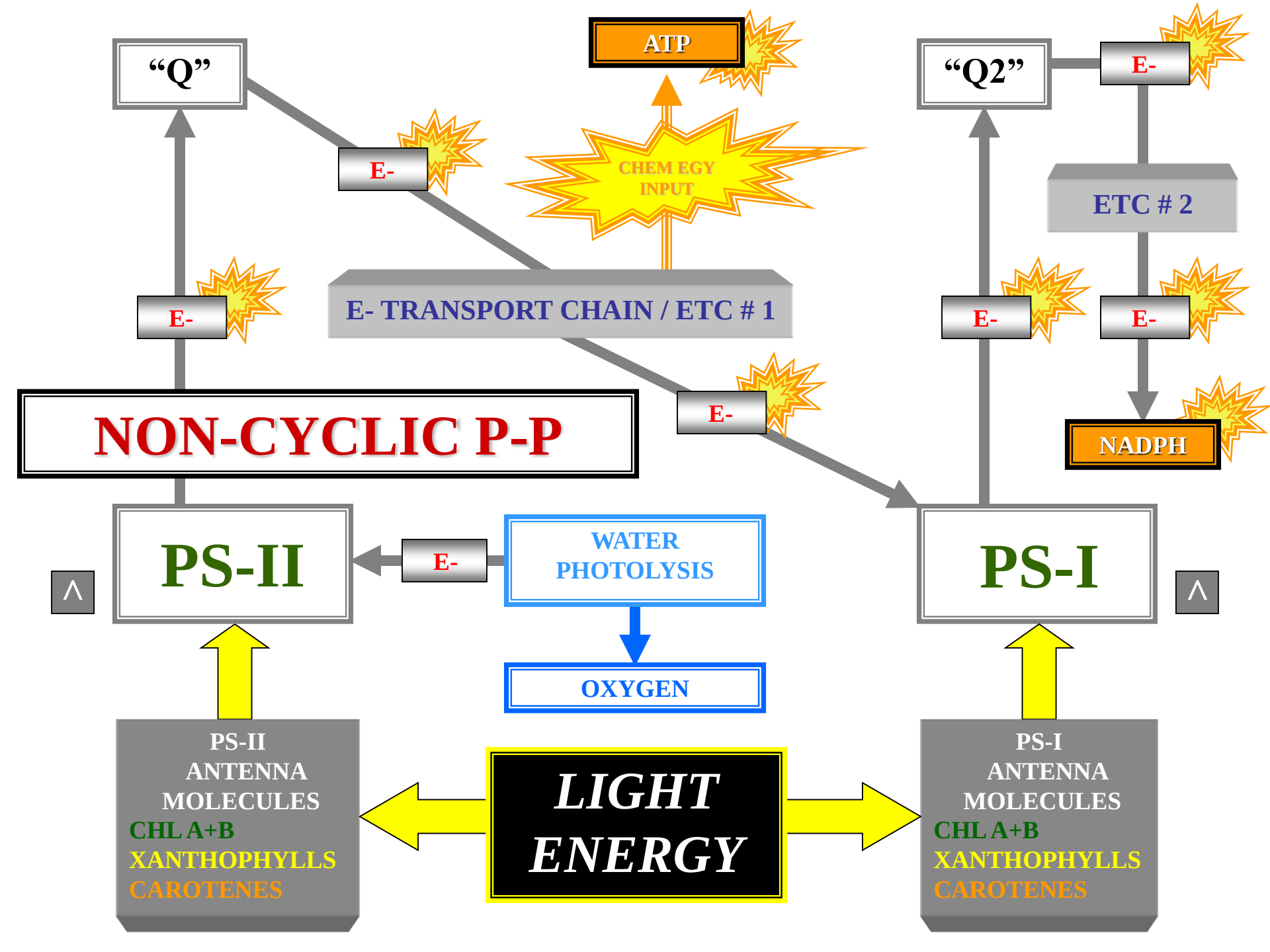
THYLAKOID SPACE

N-C P-P

THYLAKOID MEMBRANE

NON-CYCLIC P-P


"Q"
ATP
"Q2"
E-
CHEM EGY INPUT
ETC # 2
E- TRANSPORT CHAIN / ETC # 1
NON-CYCLIC P-P
NADPH
PS
PS-II RXT-CENTER CHL-A P680
WATER PHOTOLYSIS
PS-I RXT-CENTER CHL-A P700
PS
OXYGEN
PS-II ANTENNA MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES
LIGHT ENERGY
PS-I ANTENNA MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES


"Q"
ATP
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NADPH
PS-II
WATER PHOTOLYSIS
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CHL A+B
XANTHOPHYLLS
CAROTENES
LIGHT ENERGY
PS-I ANTENNA MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES

?

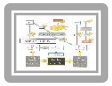
PHOTOSYSTEM II

QUESTION

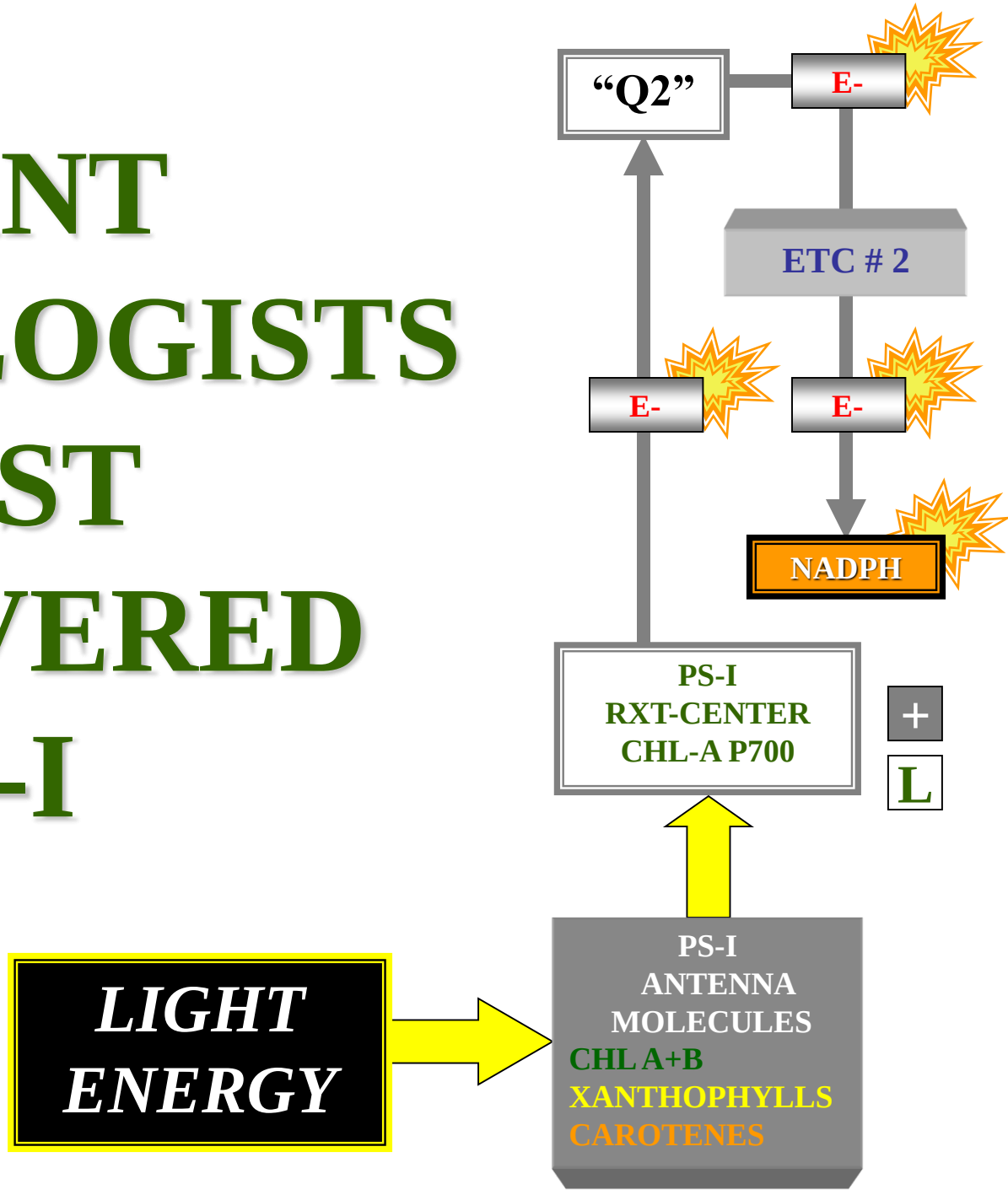
WHY ARE WE STARTING WITH PS-II AND NOT WITH PS-I?

QUESTION

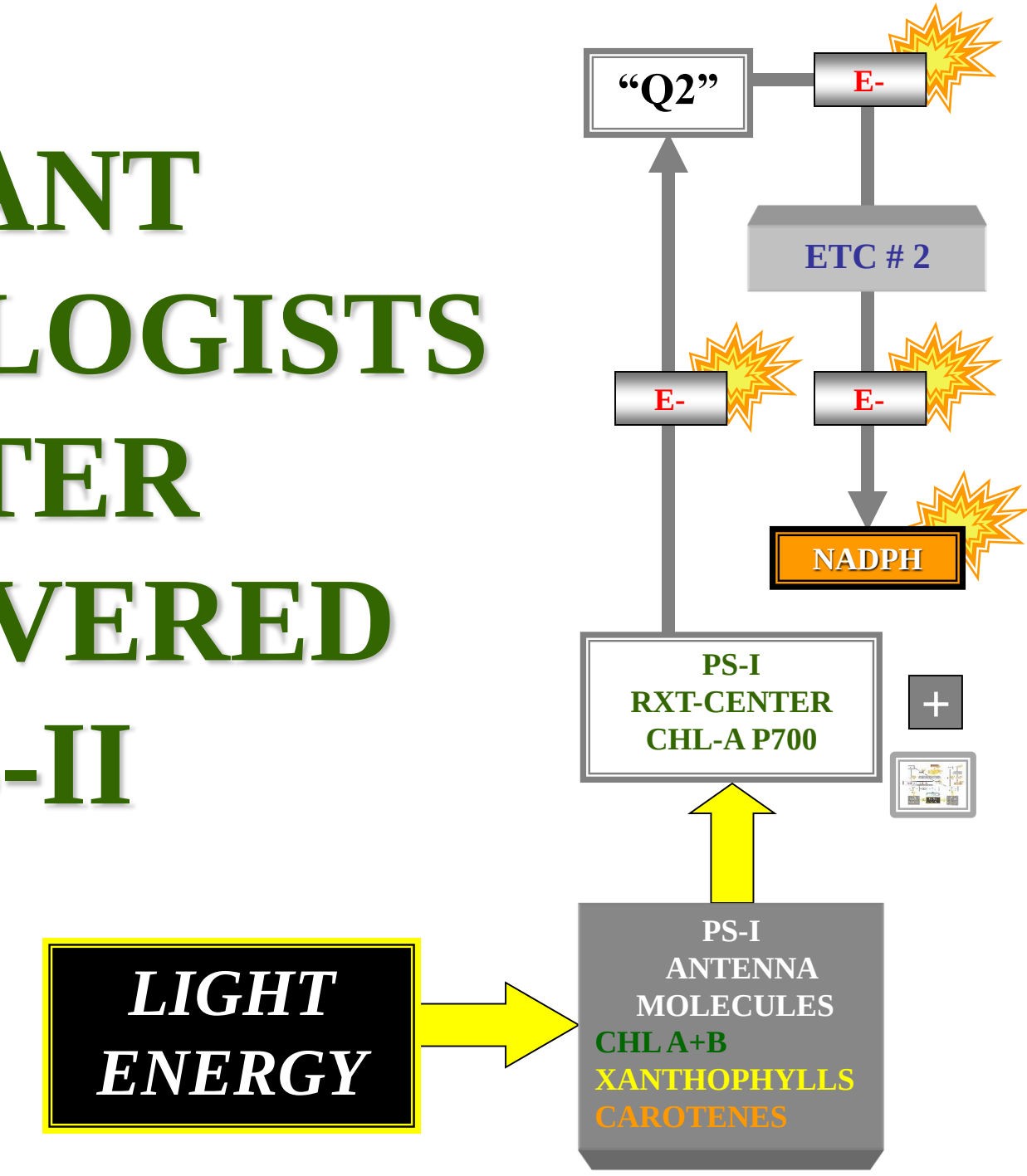
PLANT PHYSIOLOGISTS FIRST DISCOVERED PS-I

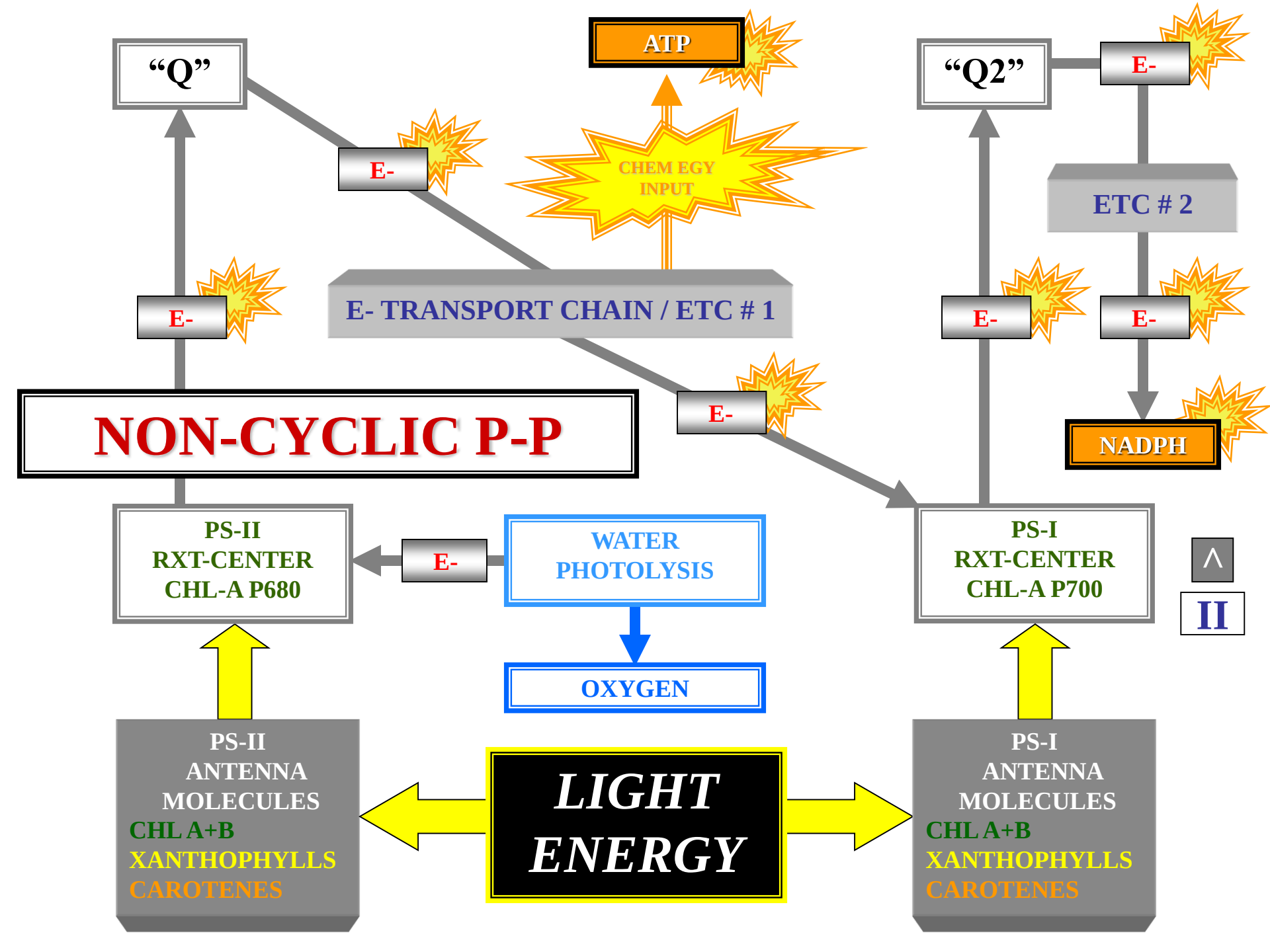


PLANT PHYSIOLOGISTS FIRST DISCOVERED PS-I



PLANT PHYSIOLOGISTS LATER DISCOVERED PS-II




"Q"
ATP
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CHEM EGY INPUT
ETC # 2
E- TRANSPORT CHAIN / ETC # 1
NON-CYCLIC P-P
NADPH
PS-II
RXT-CENTER
CHL-A P680
WATER
PHOTOLYSIS
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RXT-CENTER
CHL-A P700
OXYGEN
II
PS-II
ANTENNA
MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES
LIGHT
ENERGY
PS-I
ANTENNA
MOLECULES
CHL A+B
XANTHOPHYLLS
CAROTENES

PHOTOSYSTEM II

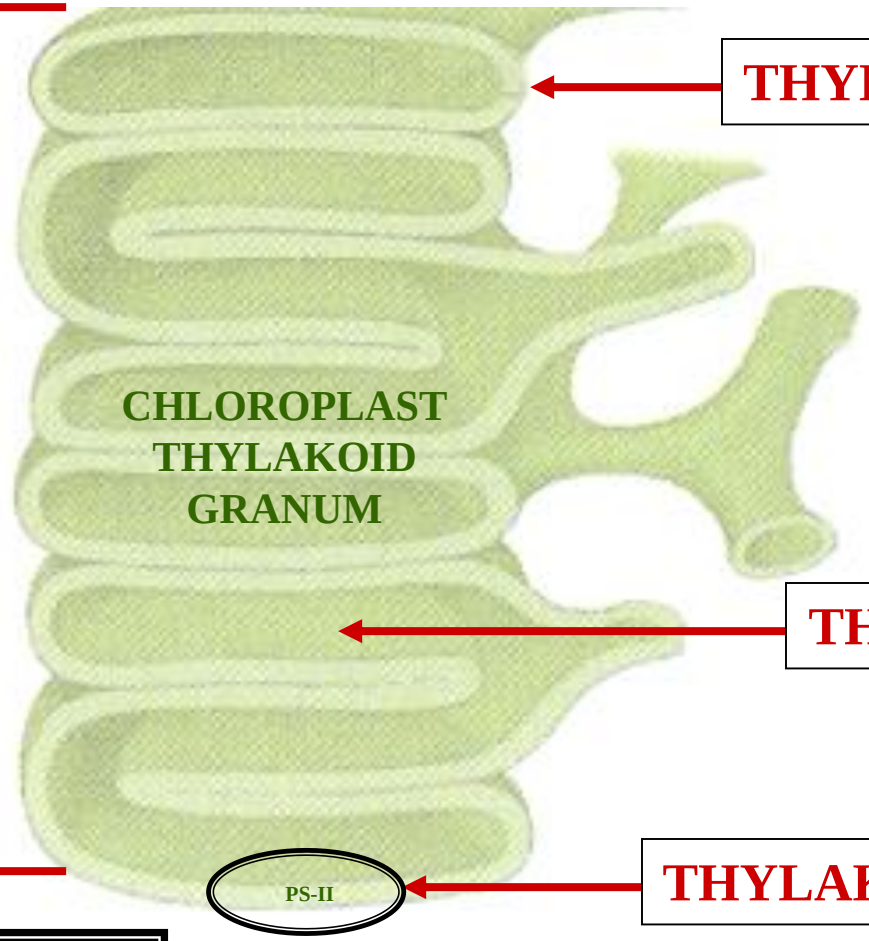
CHLOROPLAST

PS-II

THYLAKOID

+

II



THYLAKOID VESICLE

STROMA

GRANUM

THYLAKOID SPACE

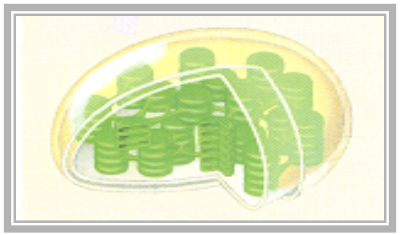
THYLAKOID MEMBRANE

NON-CYCLIC P-P

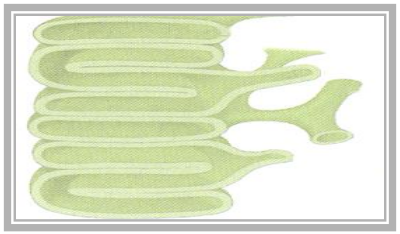
CHLOROPLAST

PS-II

THYLAKOID



PIGMENT MOLECULES

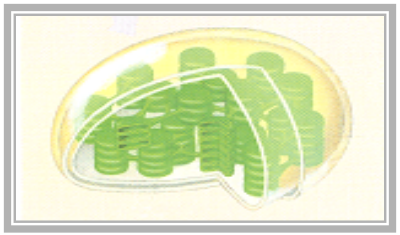


A

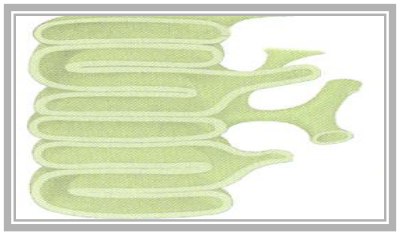
CHLOROPLAST

PS-II

THYLAKOID



ANTENNA MOLECULES



A

ANTENNA MOLECULES

ANTENNA MOLECULES

ABSORB LIGHT ENERGY

→

ANTENNA MOLECULES