LEAF
STOMATE

C

X

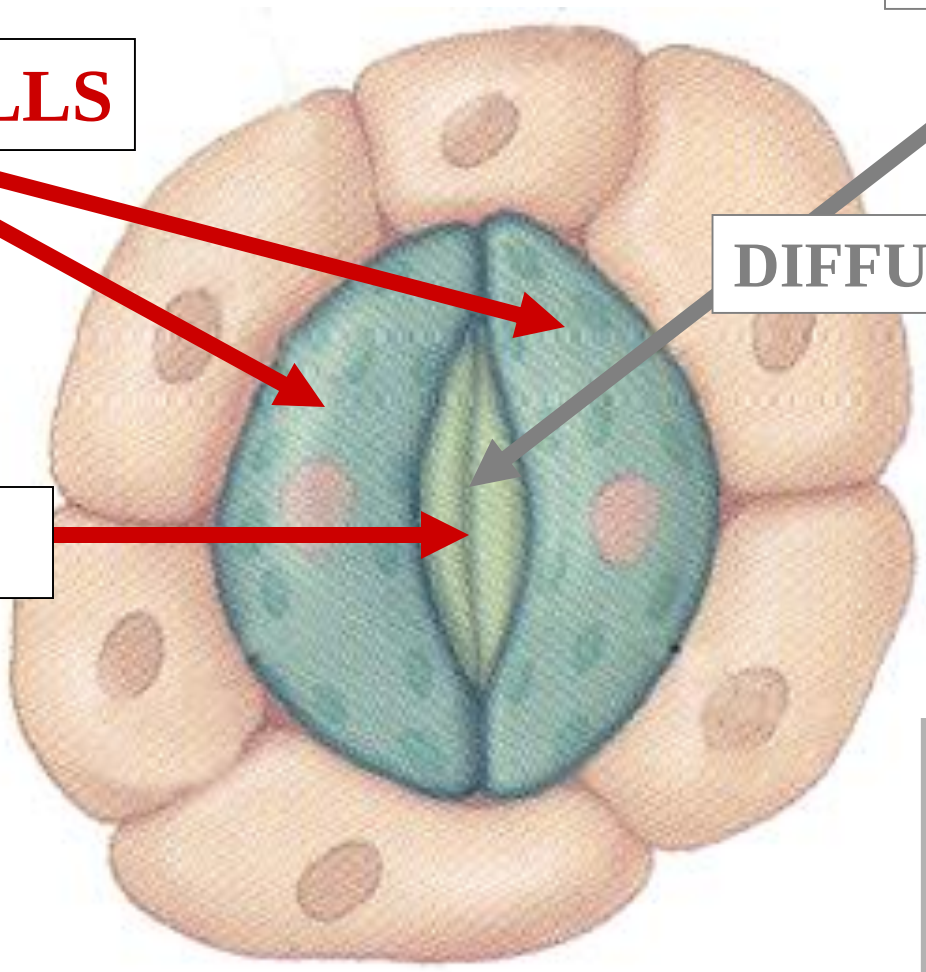
ATMOSPHERE

GUARD CELLS

CO2

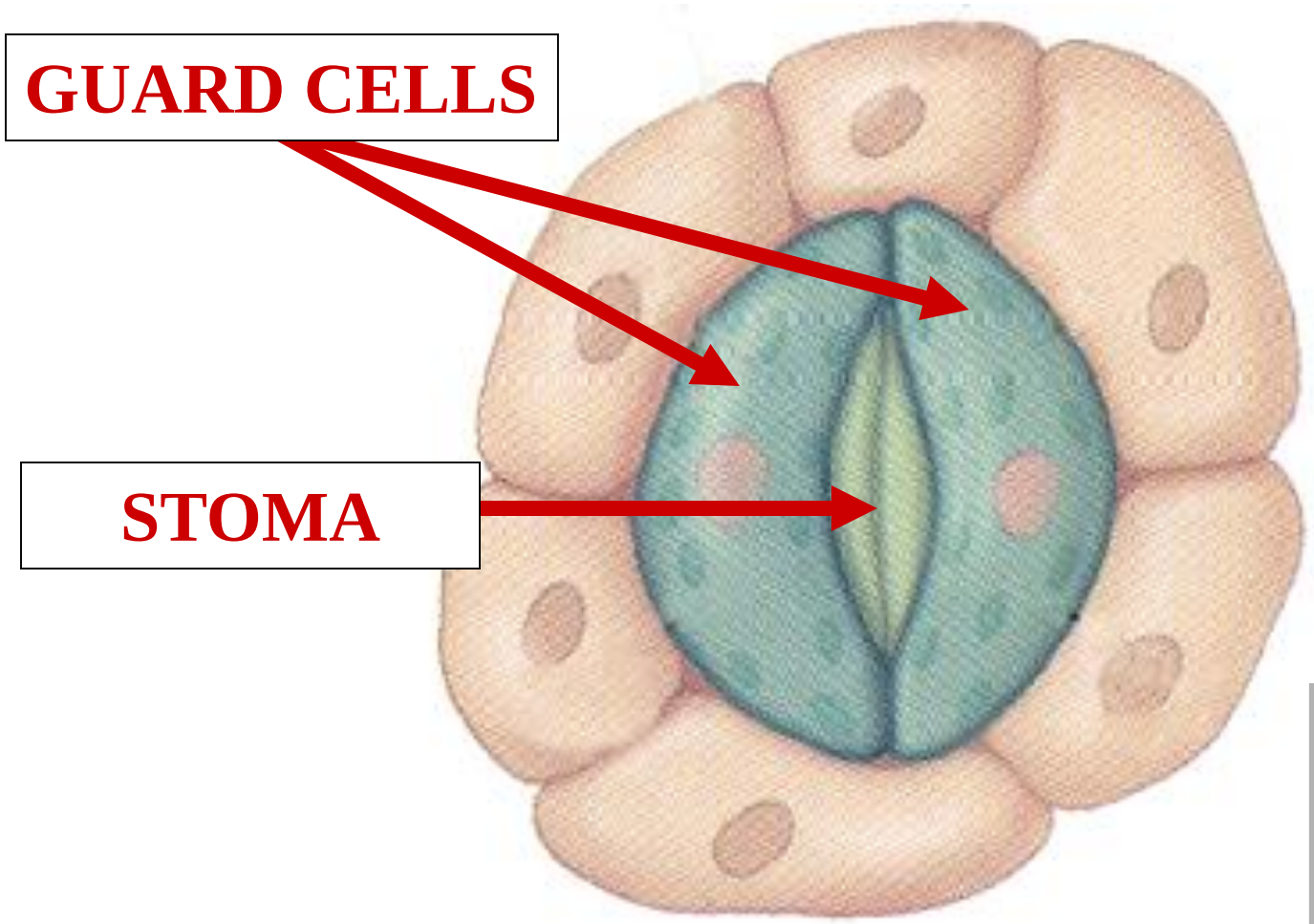
DIFFUSION

STOMA



STOMA CLOSED

LEAF
STOMATE

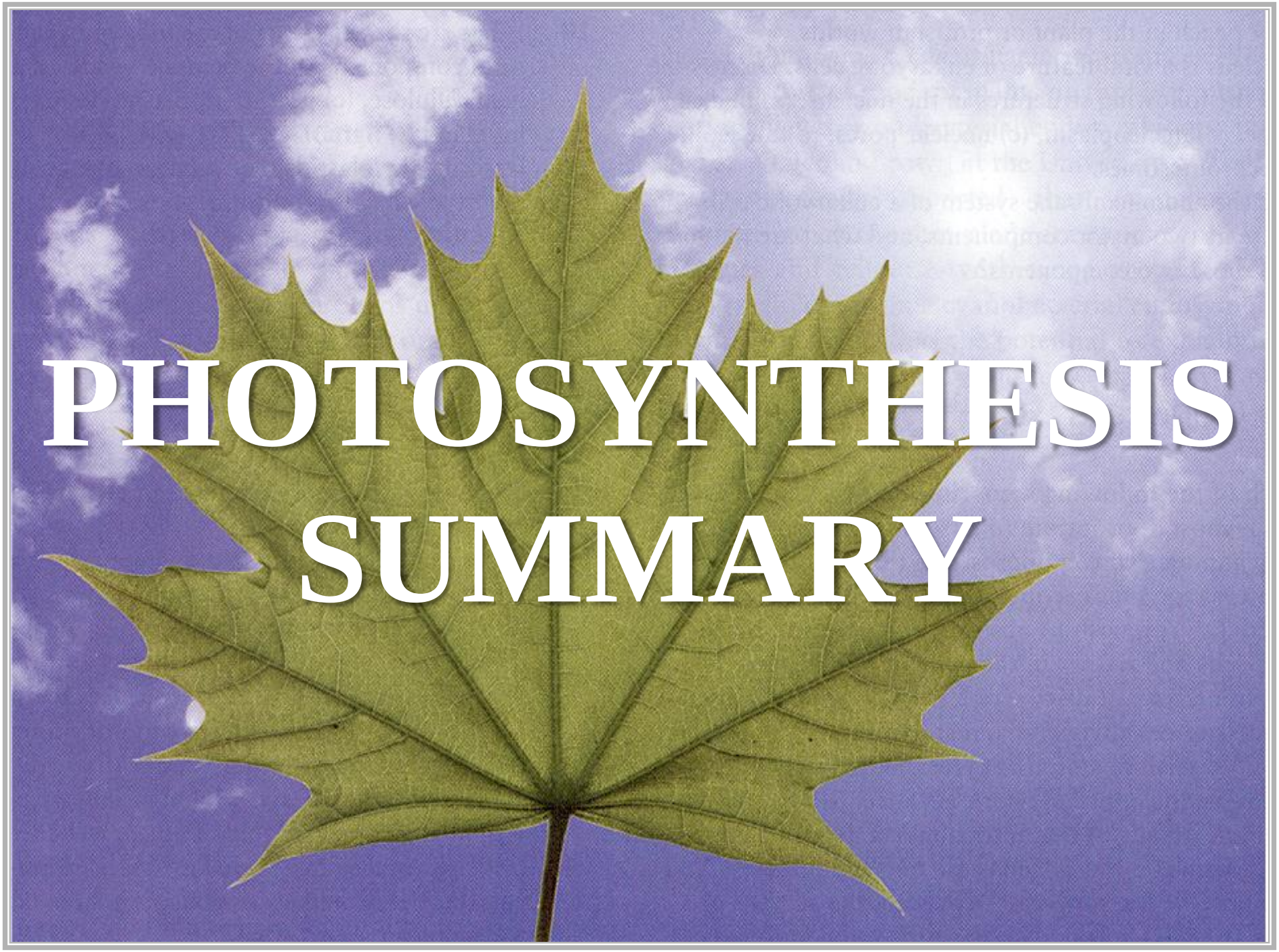


STOMA CLOSED

PHOTOSYNTHESIS TRADE-OFF BETWEEN SUGAR SYNTHESIS AND WATER RETENTION

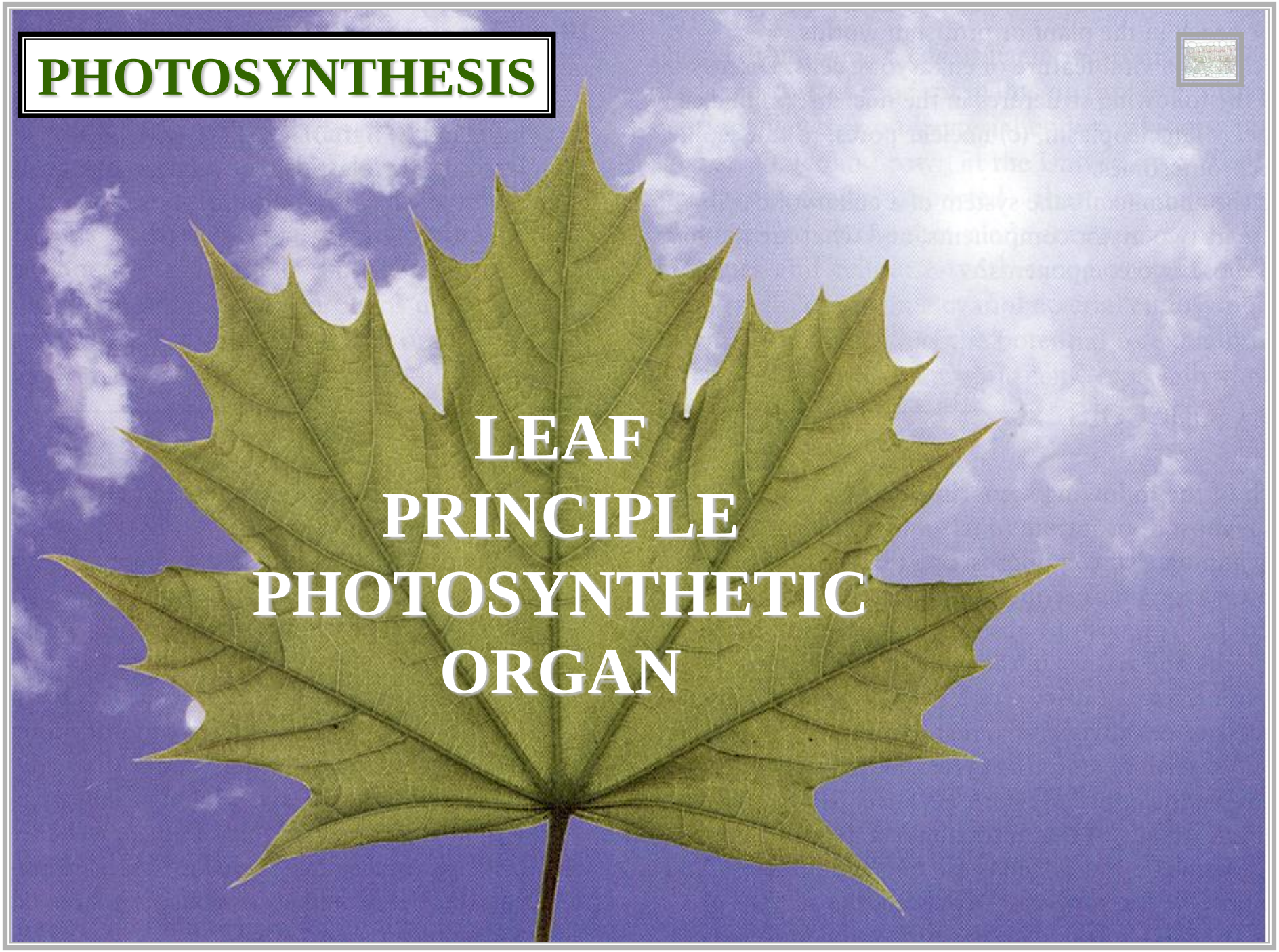
S

P



PHOTOSYNTHESIS SUMMARY

PHOTOSYNTHESIS



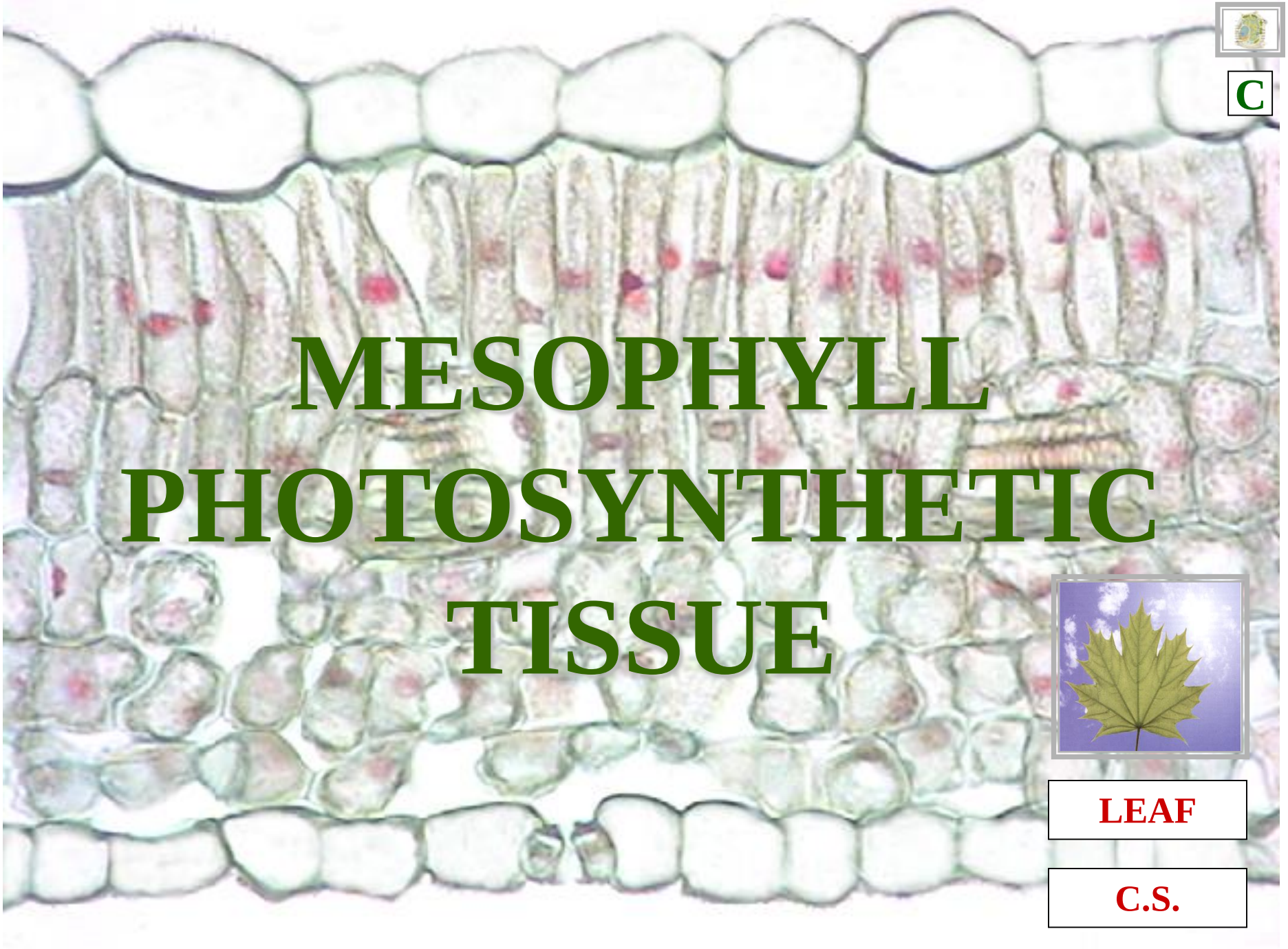
LEAF
PRINCIPLE
PHOTOSYNTHETIC
ORGAN

M

PHOTOSYNTHETIC TISSUE

LEAF

C.S.



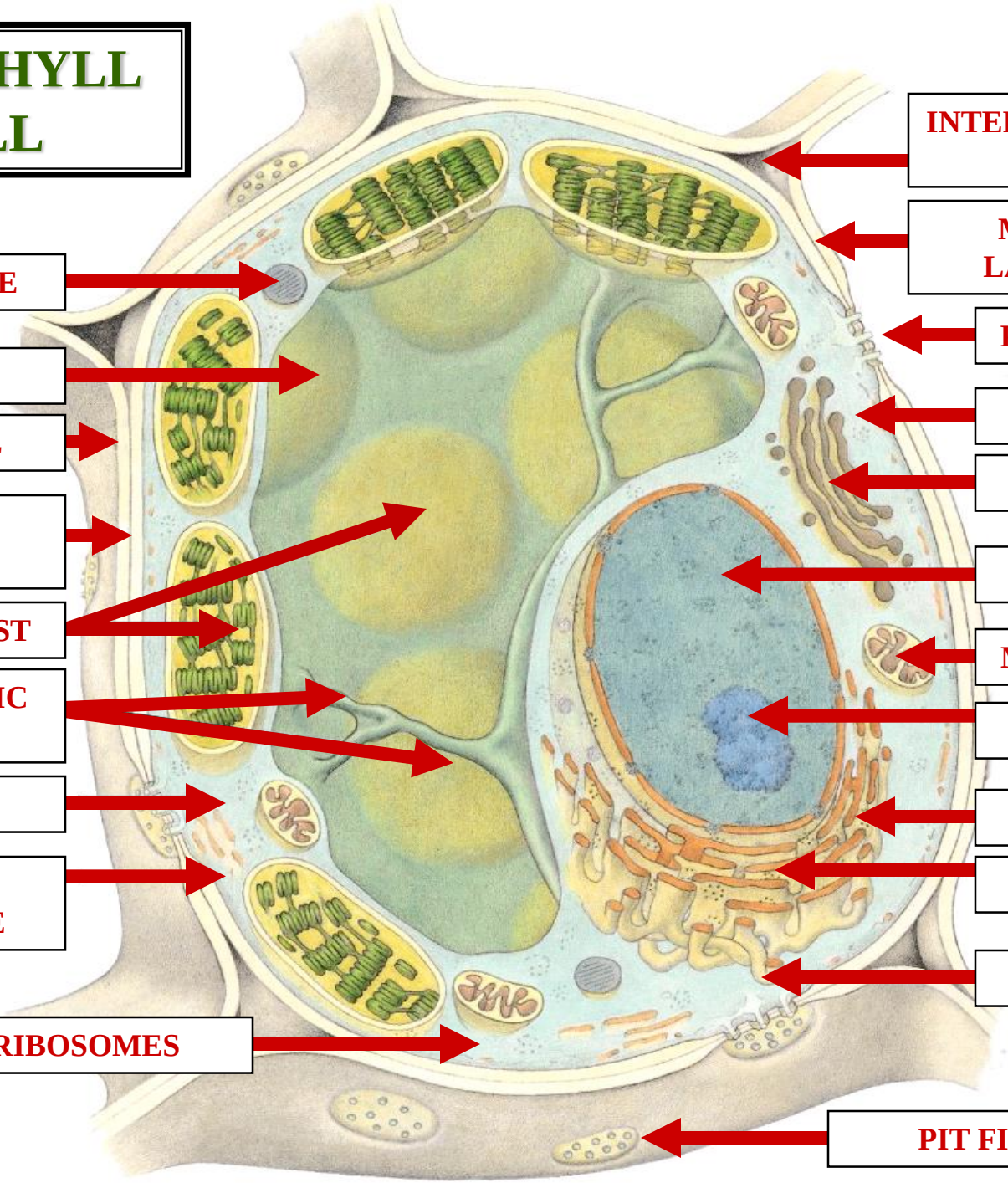
C

MESOPHYLL PHOTOSYNTHETIC TISSUE

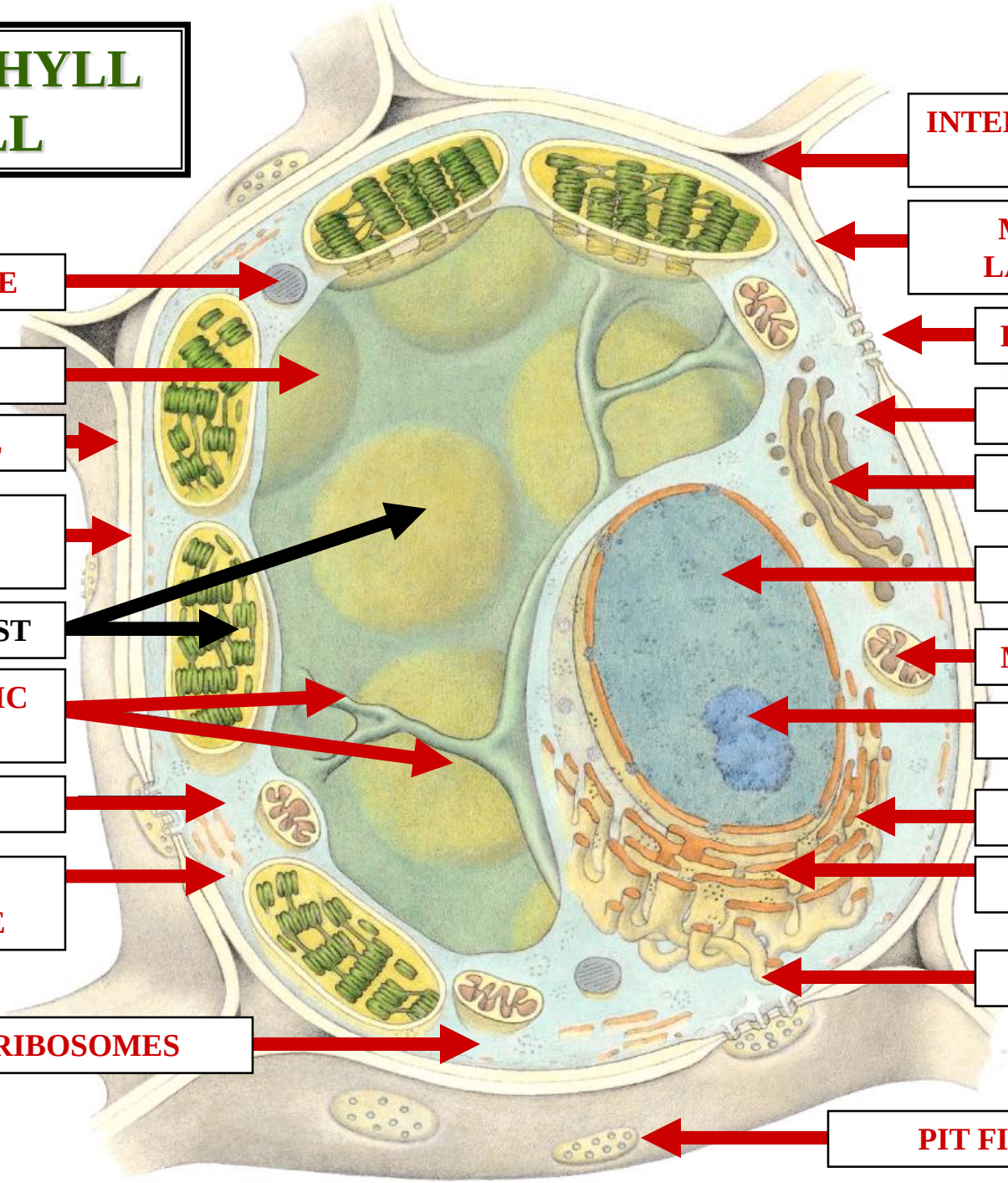
LEAF

C.S.

MESOPHYLL CELL



MESOPHYLL CELL



C

CHLOROPLAST

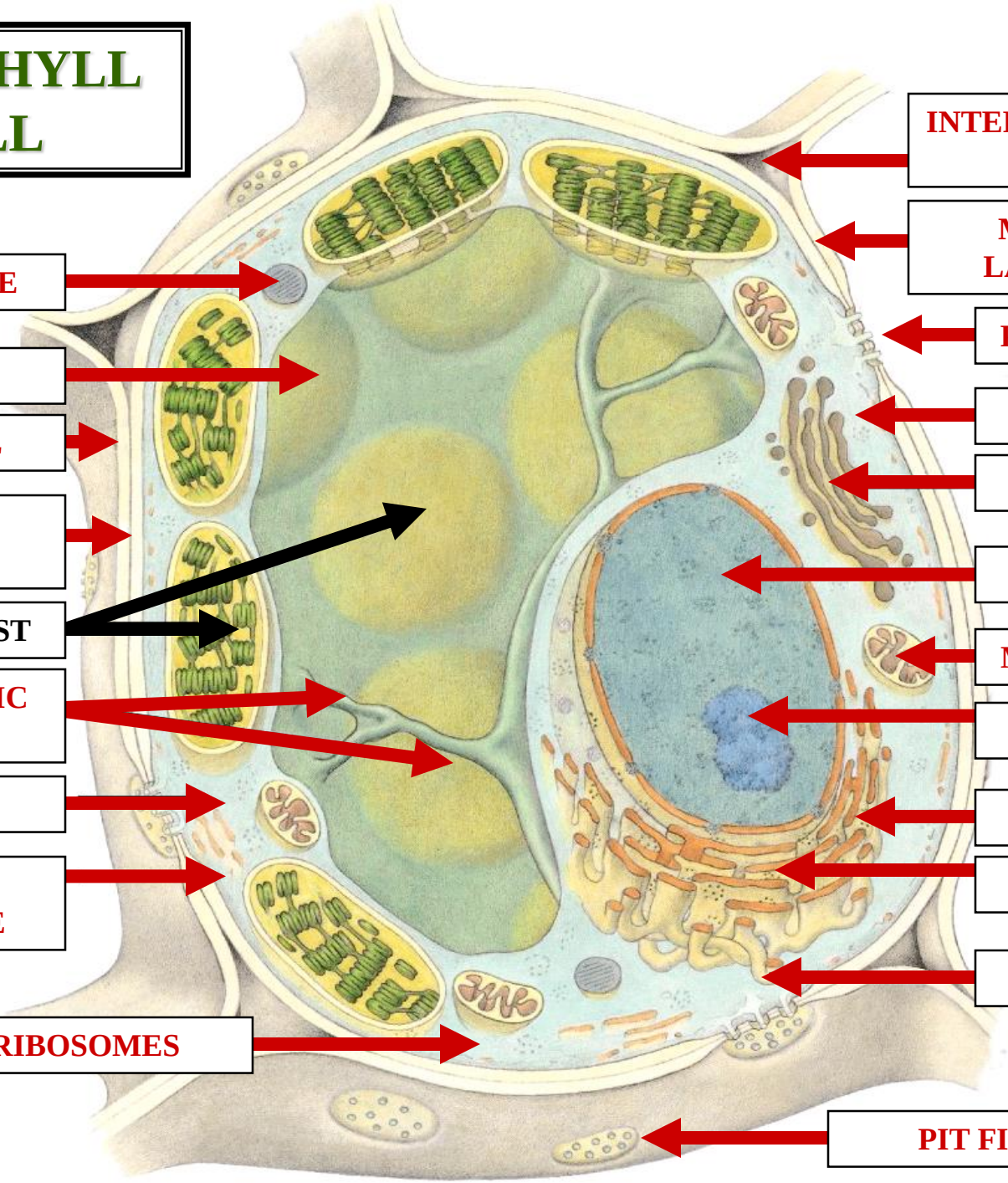
CHLOROPLAST

CHLOROPLAST

SITE: PHOTOSYNTHESIS

CHLOROPLAST

MESOPHYLL CELL



PHOTOSYNTHESIS

WATER

CO2

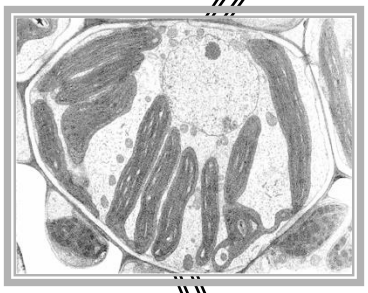
LIGHT EGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

ATP

DK RXT

STROMA ENZYMES

SYNTHESIS

CHEM EGY INPUT

CHLOROPLAST

ATMOSPHERE

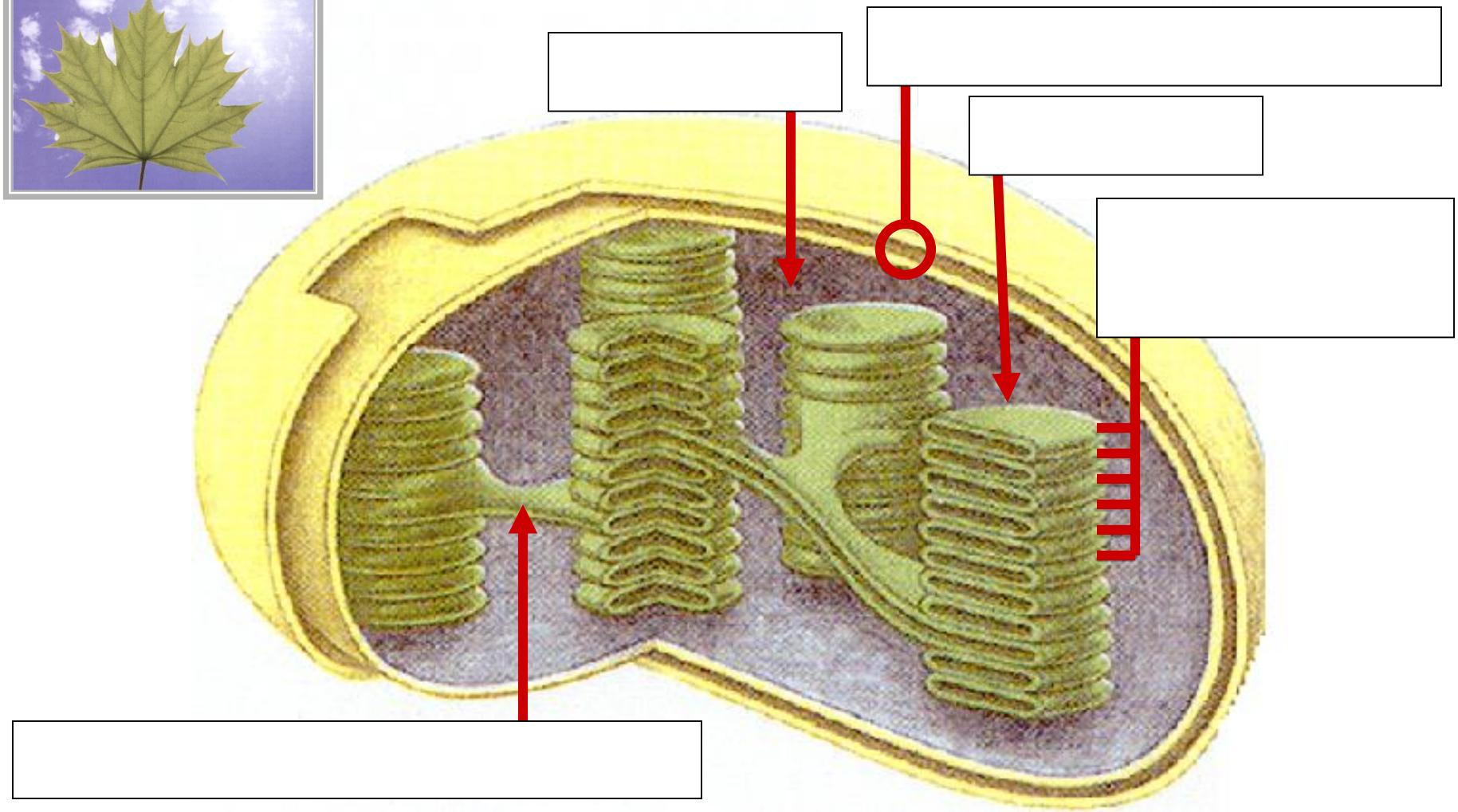
OXYGEN

GLUCOSE

CHLOROPLAST ULTRASTRUCTURE

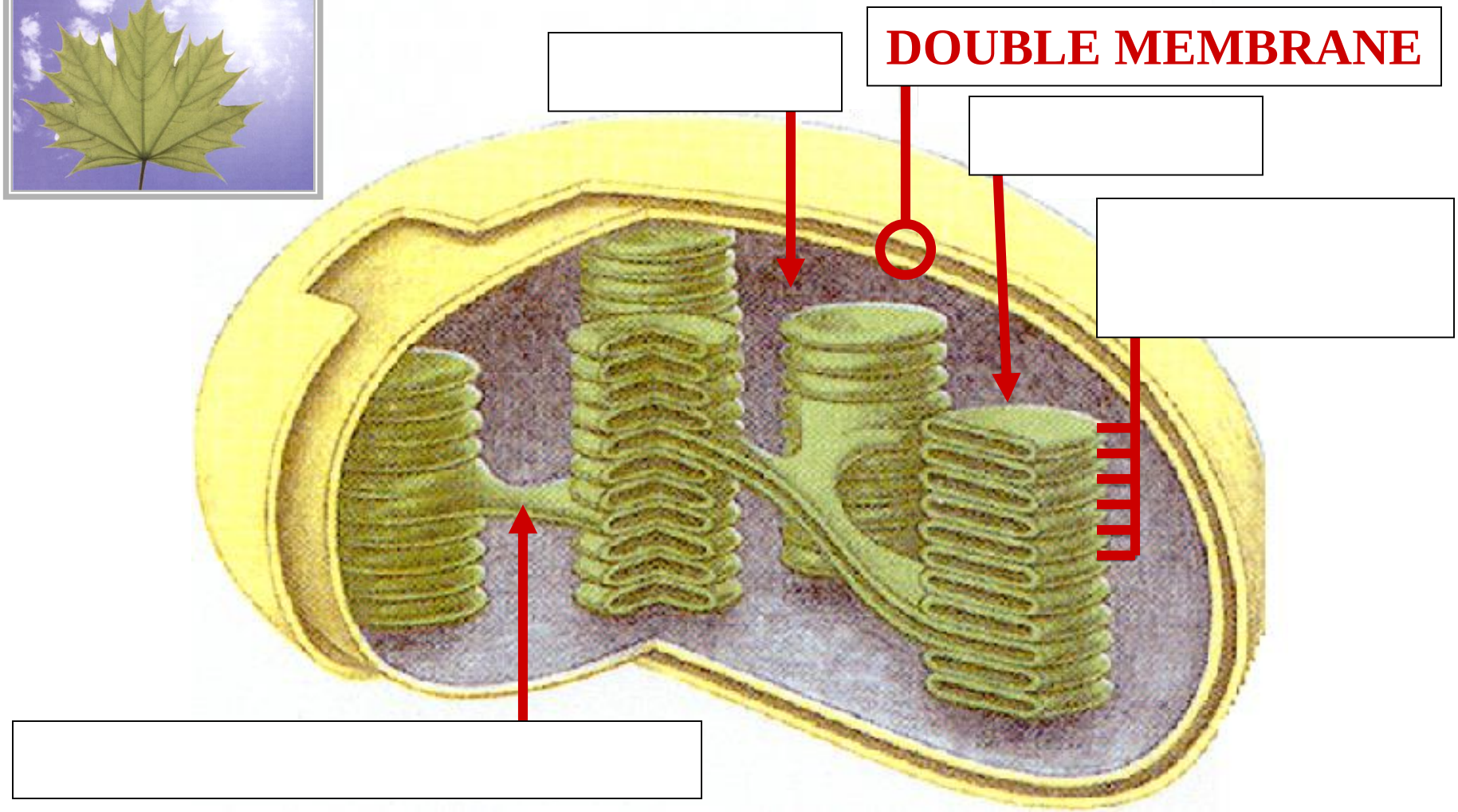
D

CHLOROPLAST ULTRASTRUCTURE



T

CHLOROPLAST ULTRASTRUCTURE



THYLAKOID MEMBRANE

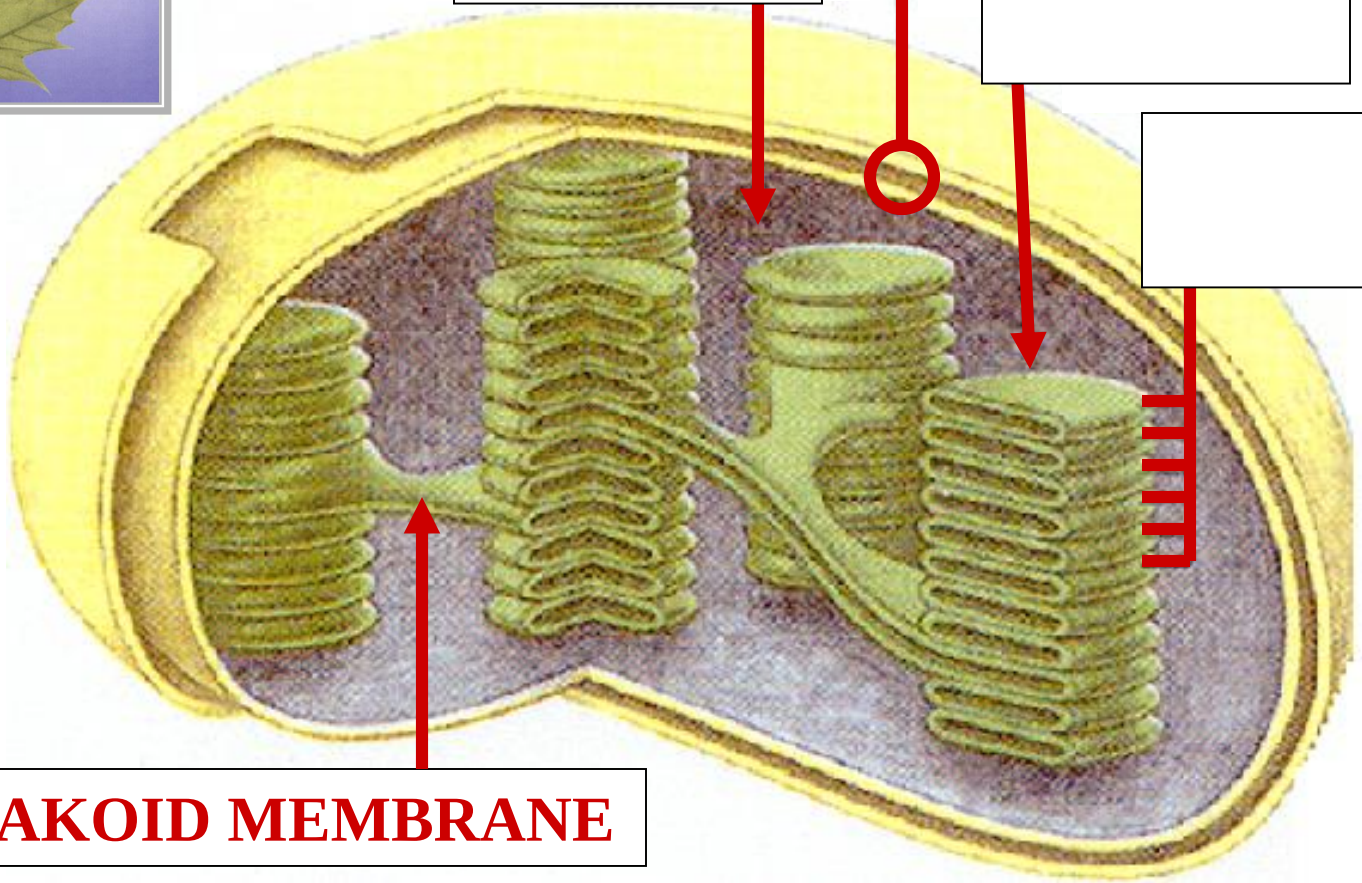
THYLAKOID MEMBRANE

CHLOROPLAST PIGMENTED INNERMOST MEMBRANE

THYLAKOID MEMBRANE

T

CHLOROPLAST ULTRASTRUCTURE



THYLAKOID VESICLES

THYLAKOID VESICLES

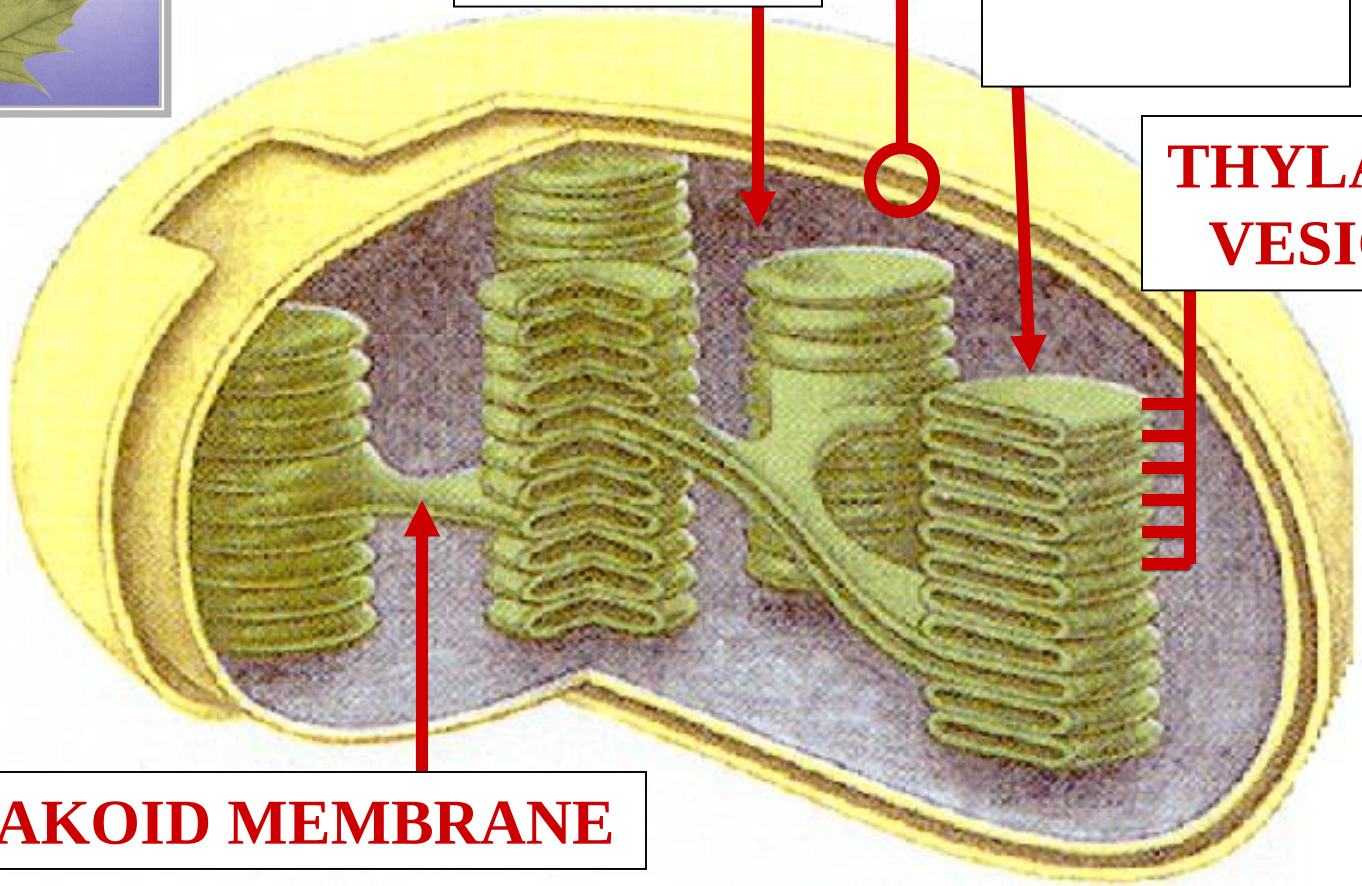
COMPRISE

THYLAKOID MEMBRANE

THYLAKOID VESICLES

G

CHLOROPLAST ULTRASTRUCTURE



THYLAKOID GRANUM / GRANA

THYLAKOID GRANUM

STACKED THYLAKOID VESICLES

THYLAKOID GRANUM

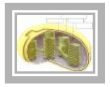
THYLAKOID GRANUM

STACKED
THYLAKOID VESICLES

SITE: LIGHT RXT

THYLAKOID GRANUM

THYLAKOID GRANUM



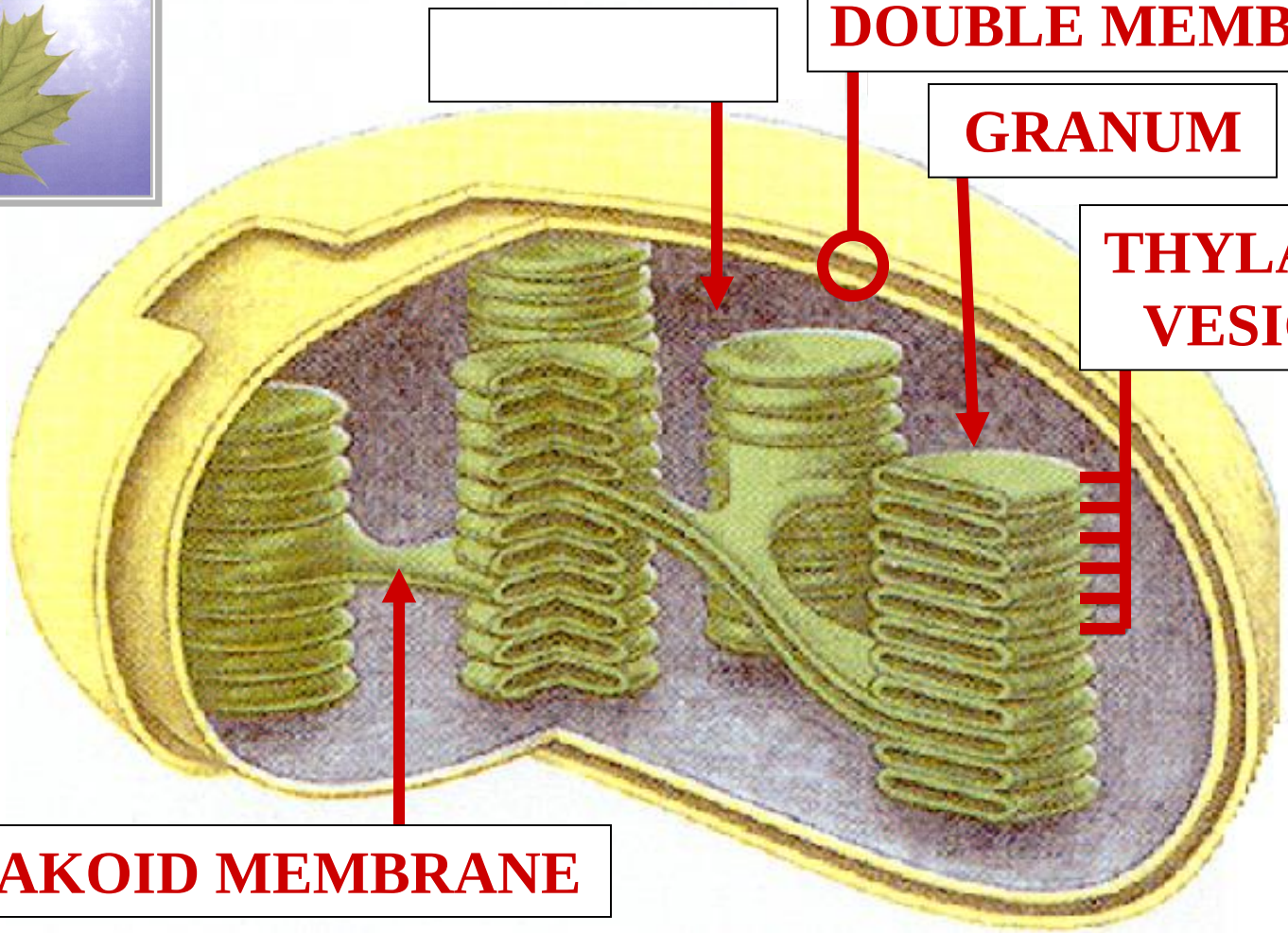
STACKED
THYLAKOID VESICLES

SITE: LIGHT RXT
DERIVES ATP

THYLAKOID GRANUM

LR

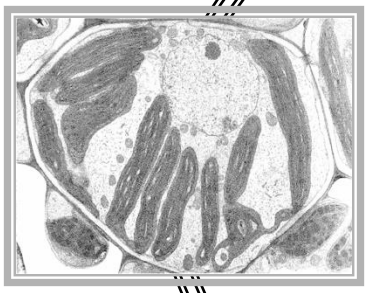
CHLOROPLAST ULTRASTRUCTURE



LIGHT REACTION

PHOTOSYNTHESIS

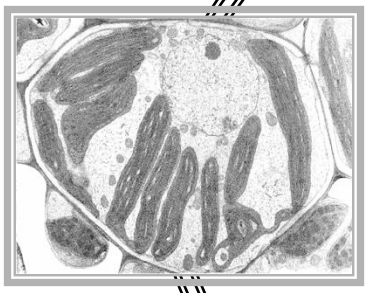
LR



CHLOROPLAST

PHOTOSYNTHESIS

LT



LT RXT

THYLAKOID
GRANUM

CHLOROPLAST

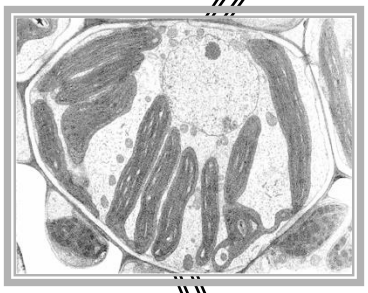
PHOTOSYNTHESIS

?

LIGHT EGY

LT RXT

THYLAKOID
GRANUM



CHLOROPLAST

PHOTOSYNTHESIS

C

WATER

LIGHT EGY

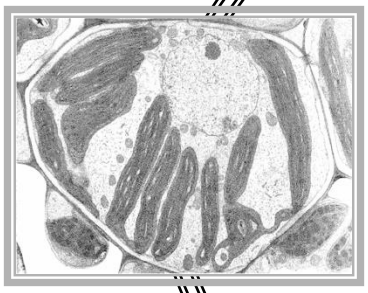
E-

PHOTOLYSIS

LT RXT

THYLAKOID
GRANUM

?



CHLOROPLAST

ATMOSPHERE

OXYGEN

PHOTOSYNTHESIS

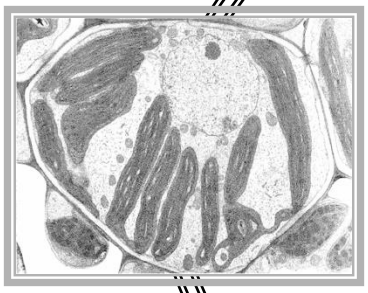
A

WATER

LIGHT EGY

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

CHEMICAL ENERGY

P + ADP

CHLOROPLAST

ATMOSPHERE

OXYGEN

CHEMICAL ENERGY INPUT

PHOTOSYNTHESIS

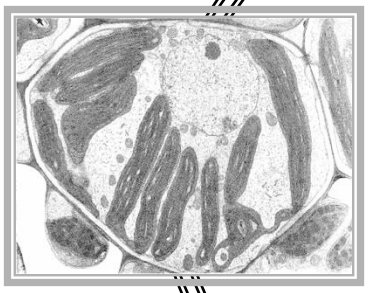
P

WATER

LIGHT EGY

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

CHEMICAL ENERGY

P + ADP → ATP

CHLOROPLAST

ATMOSPHERE

OXYGEN

CHEMICAL ENERGY INPUT

PHOTOSYNTHESIS

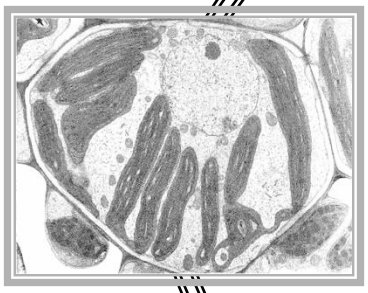
F

WATER

LIGHT EGY

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

ATP

PHOSPHORYLATION

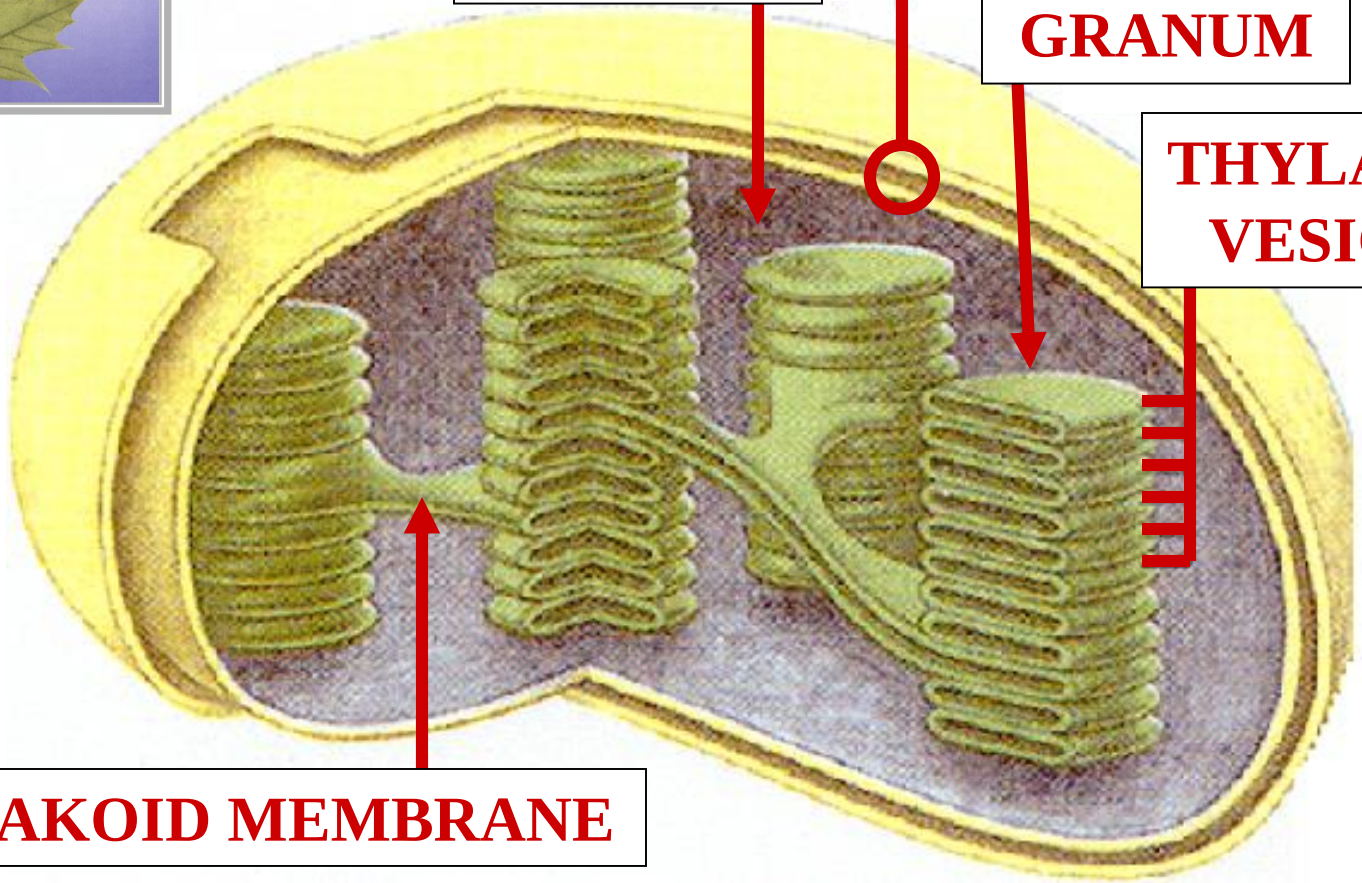
CHLOROPLAST

ATMOSPHERE

OXYGEN

S

CHLOROPLAST ULTRASTRUCTURE



STROMA

STROMA

CHLOROPLAST FLUID MATRIX

STROMA

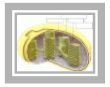
STROMA

CHLOROPLAST FLUID MATRIX

SITE: DARK RXT

STROMA

STROMA



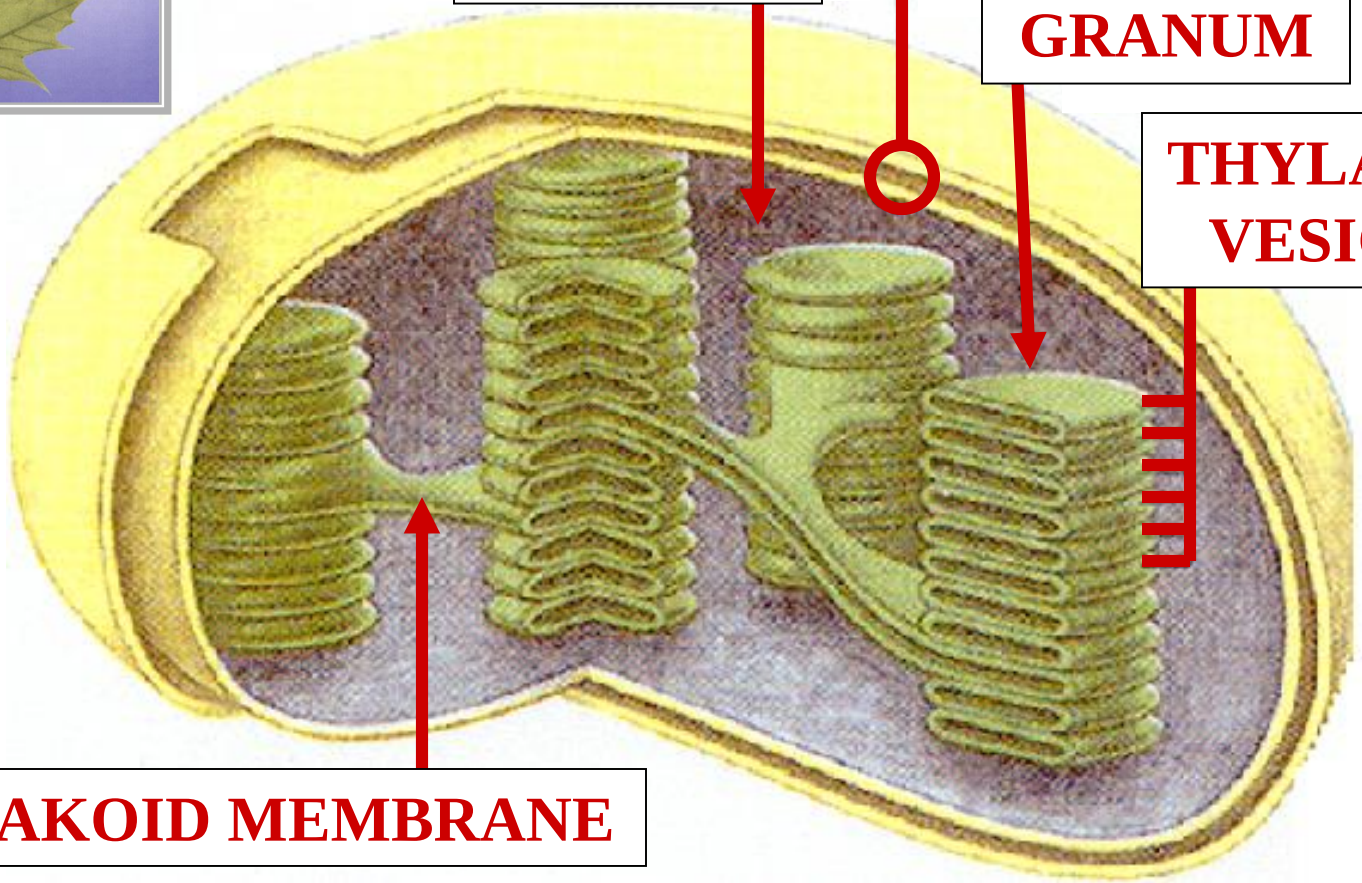
CHLOROPLAST FLUID MATRIX

SITE: DARK RXT DERIVES GLUCOSE

STROMA

CHLOROPLAST ULTRASTRUCTURE

DR



DARK REACTION

PHOTOSYNTHESIS

DK

WATER

LIGHT EGY

E-

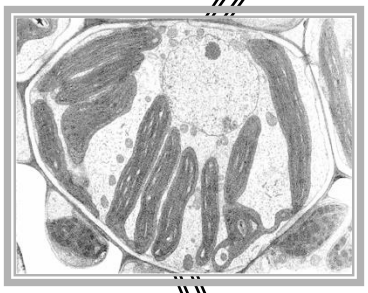
PHOTOLYSIS

LT RXT

THYLAKOID GRANUM

ATP

STROMA



CHLOROPLAST

ATMOSPHERE

OXYGEN

PHOTOSYNTHESIS

?

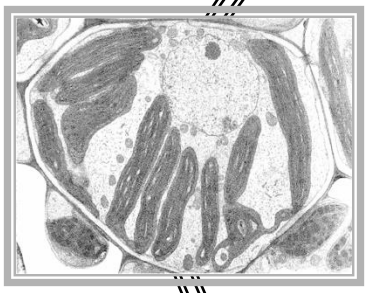
C

WATER

LIGHT EGY

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

ATP

DK RXT

STROMA

ENZYMES

CHLOROPLAST

ATMOSPHERE

OXYGEN

PHOTOSYNTHESIS

C

WATER

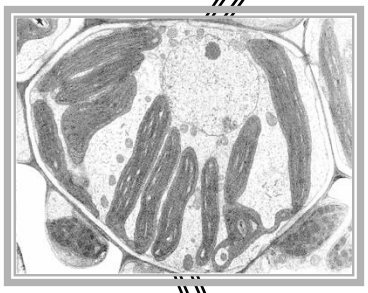
?

LIGHT EGY

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

ATP

DK RXT

STROMA

ENZYMES

CHLOROPLAST

ATMOSPHERE

OXYGEN

PHOTOSYNTHESIS

?

S

WATER

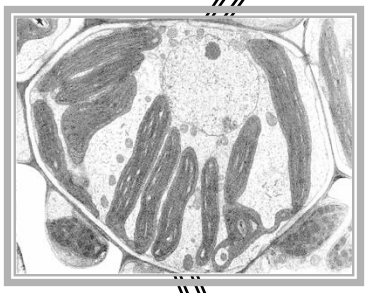
CO2

LIGHT EGY

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

ATP

DK RXT

STROMA

ENZYMES

CHLOROPLAST

ATMOSPHERE

OXYGEN

PHOTOSYNTHESIS

G

WATER

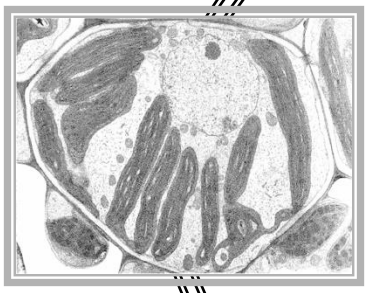
CO2

LIGHT EGY

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT

THYLAKOID GRANUM

CHEMICAL ENERGY

DK RXT

STROMA ENZYMES

SYNTHESIS

CHLOROPLAST

ATMOSPHERE

OXYGEN

?

PHOTOSYNTHESIS

LT

¿

WATER

CO2

LIGHT EGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS

LT RXT

THYLAKOID GRANUM

CHEMICAL ENERGY

DK RXT

STROMA ENZYMES

SYNTHESIS

CHEMICAL ENERGY INPUT

CHLOROPLAST

ATMOSPHERE

OXYGEN

GLUCOSE

PHOTOSYNTHESIS

PHOTOSYNTHESIS

LIGHT ENERGY

INITIAL ENERGY SOURCE

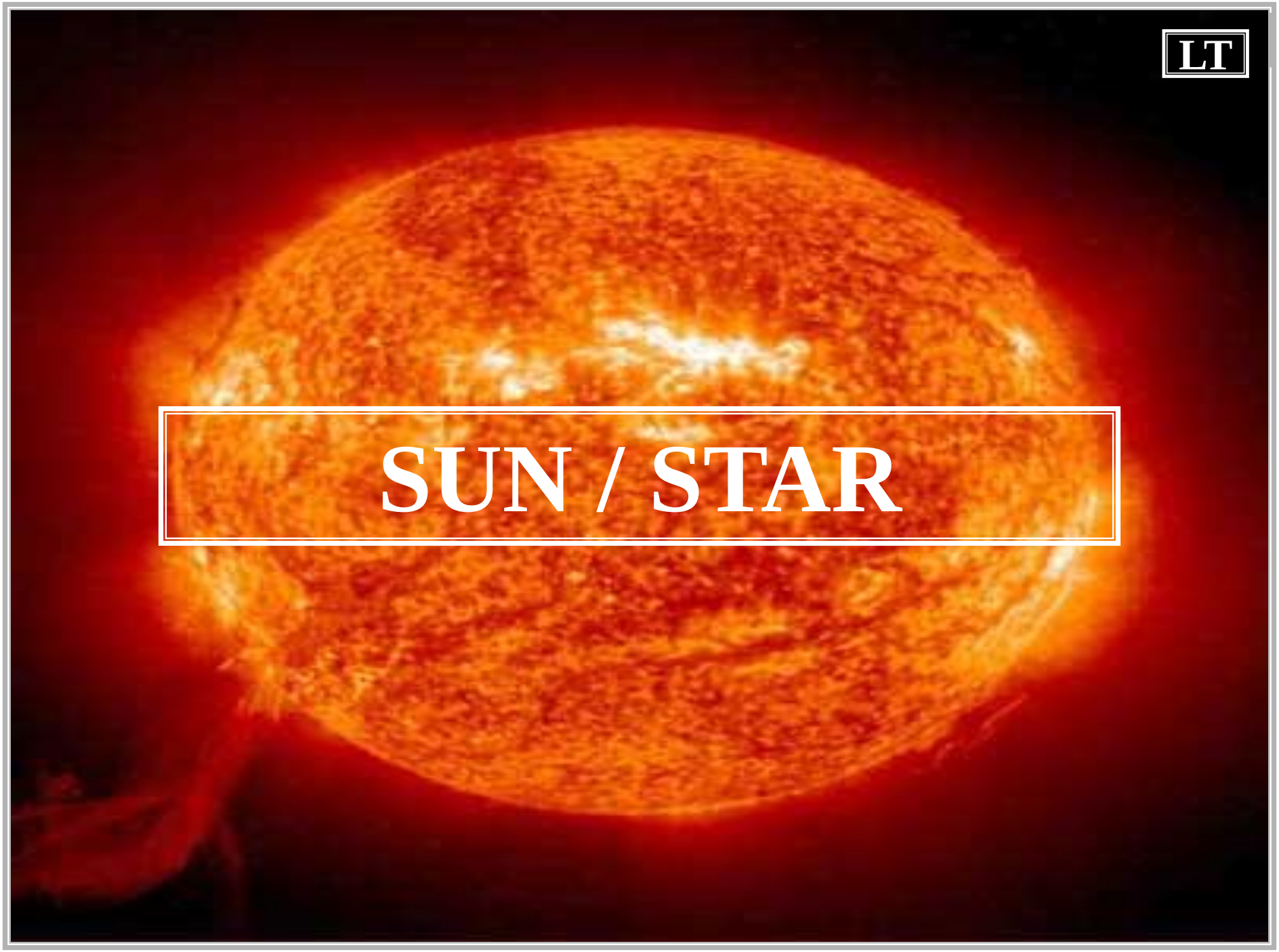
?

LIGHT ENERGY

QUESTION

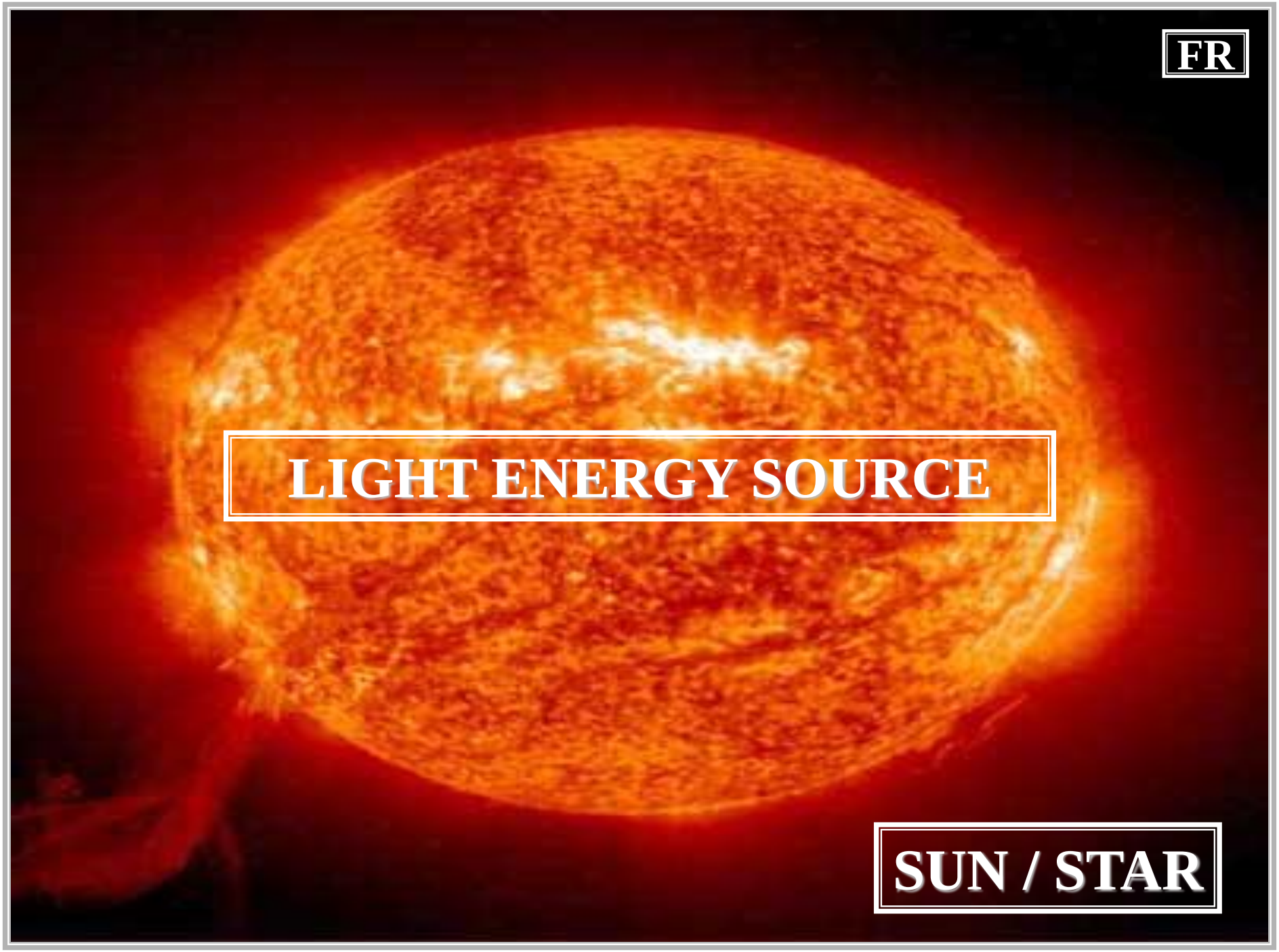
WHAT IS THE SOURCE OF THE LIGHT ENERGY?

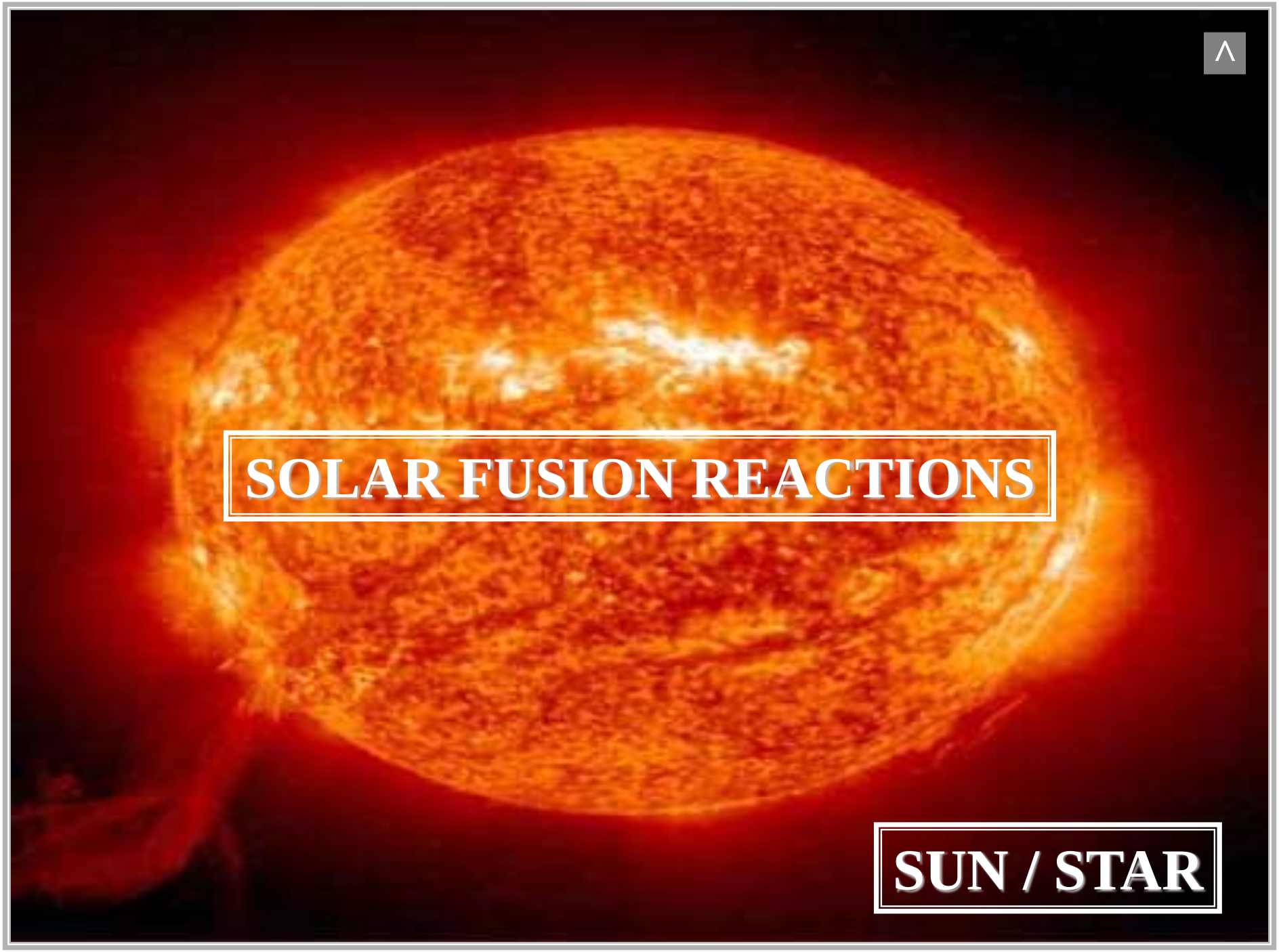
QUESTION



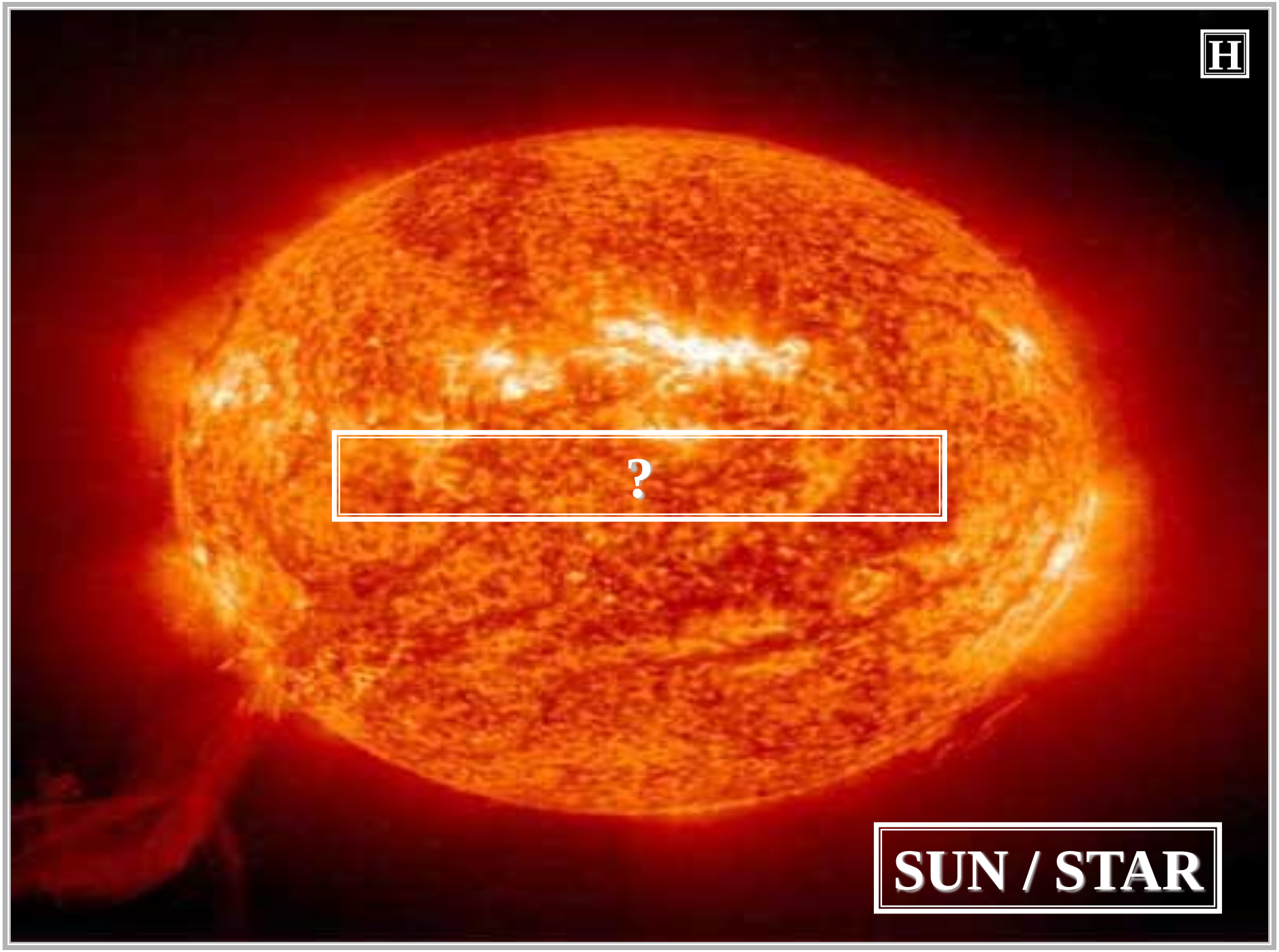
LT

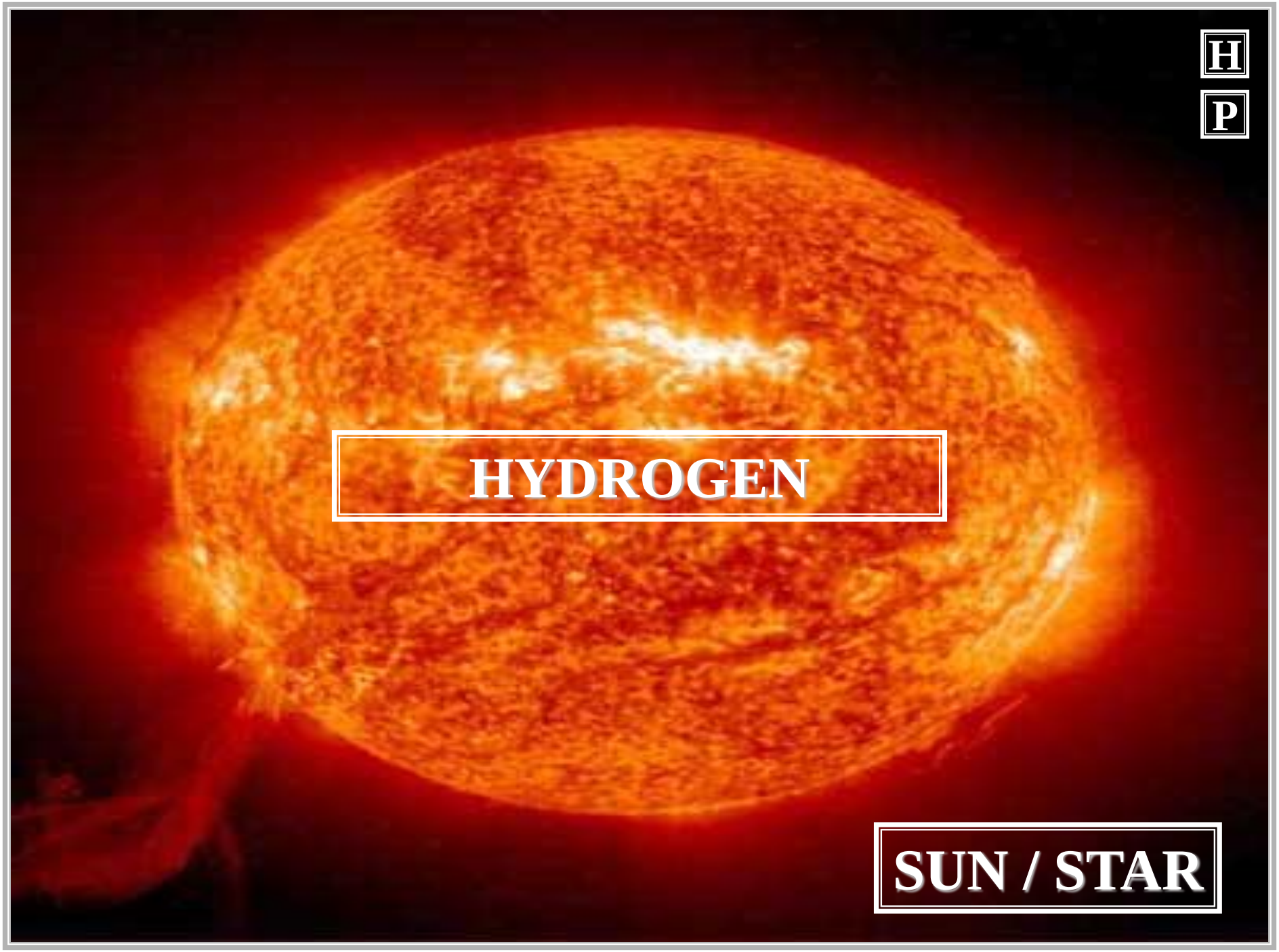
SUN / STAR

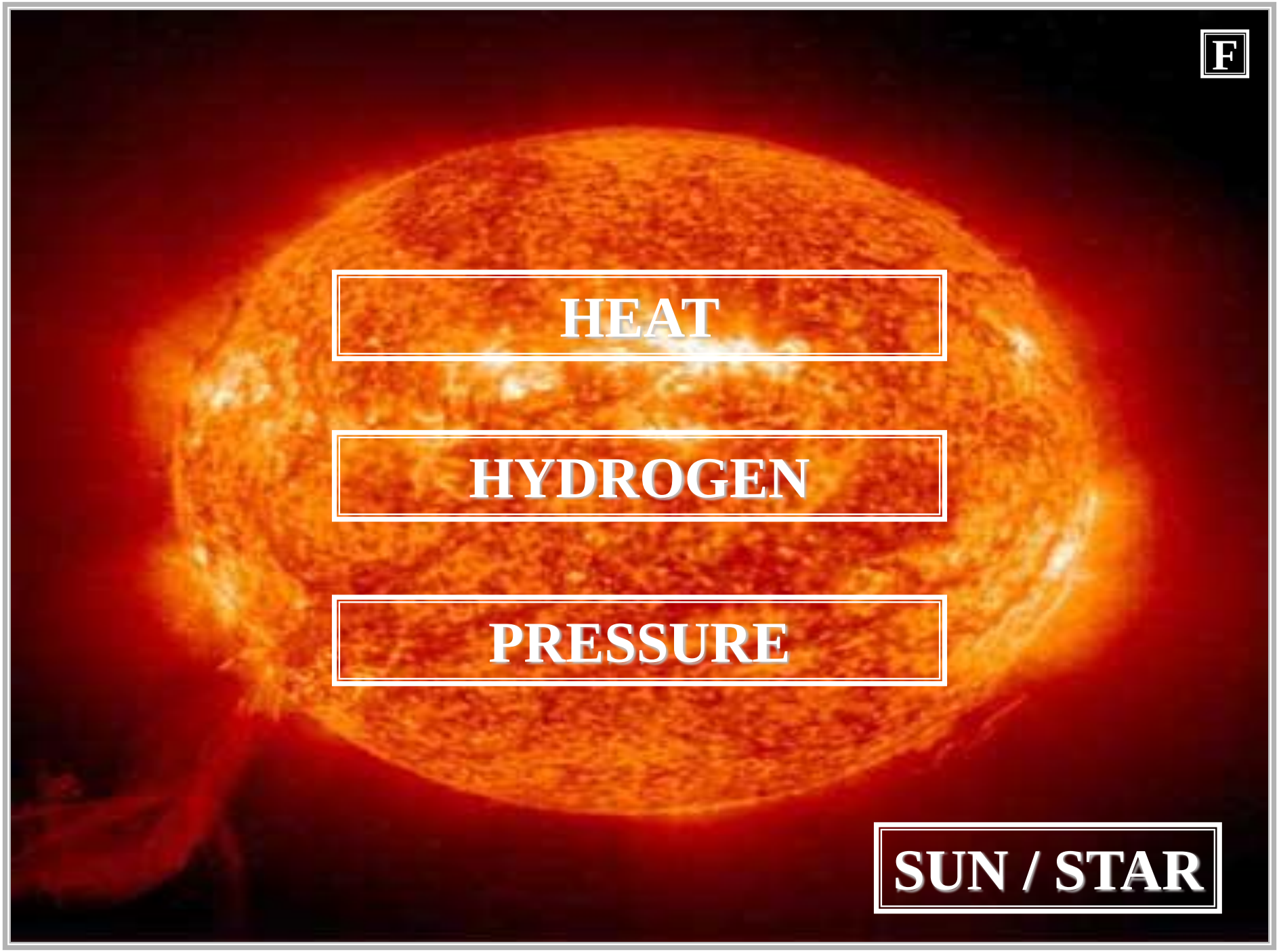

FR
LIGHT ENERGY SOURCE
SUN / STAR

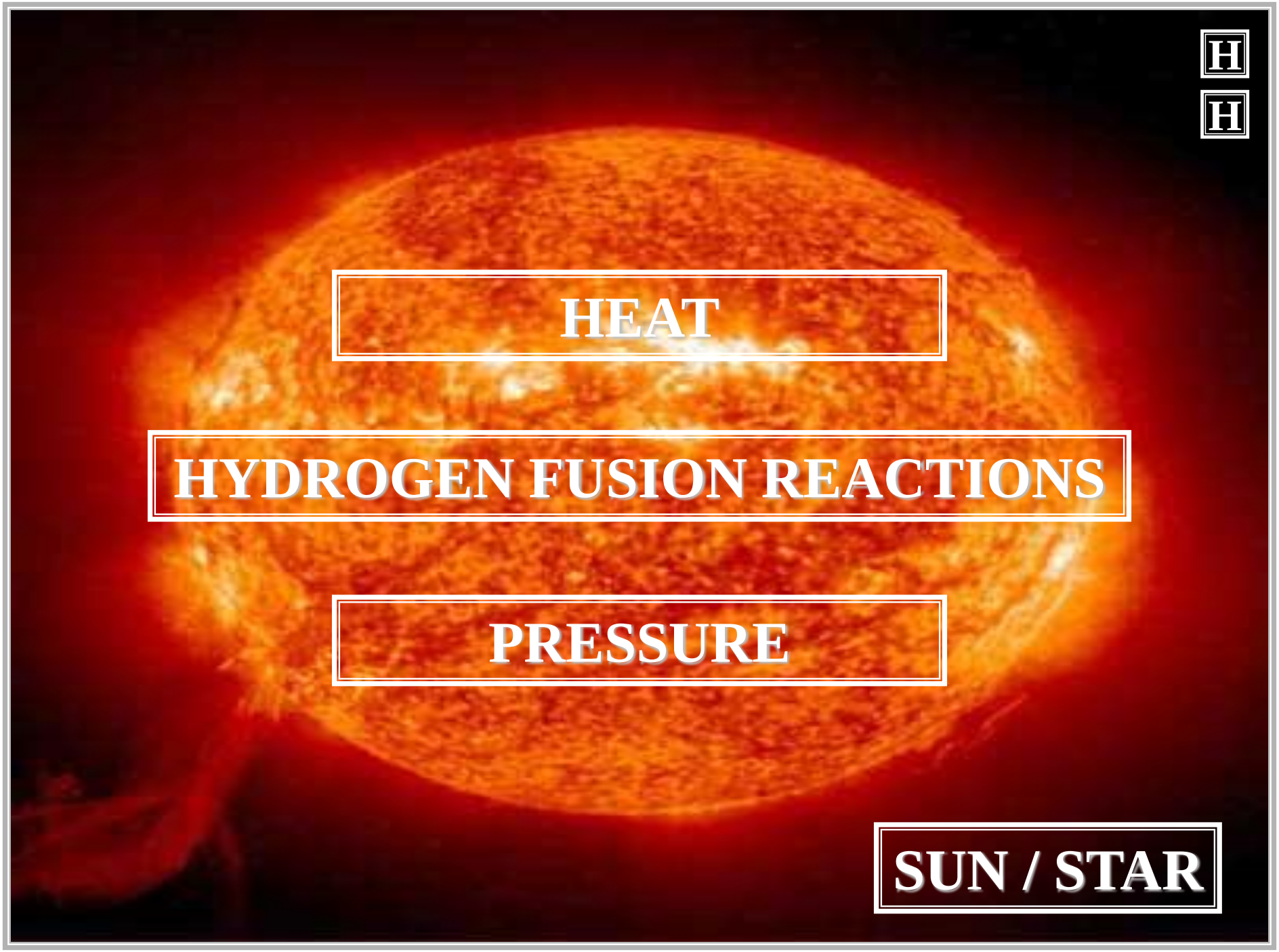

SOLAR FUSION REACTIONS
SUN / STAR

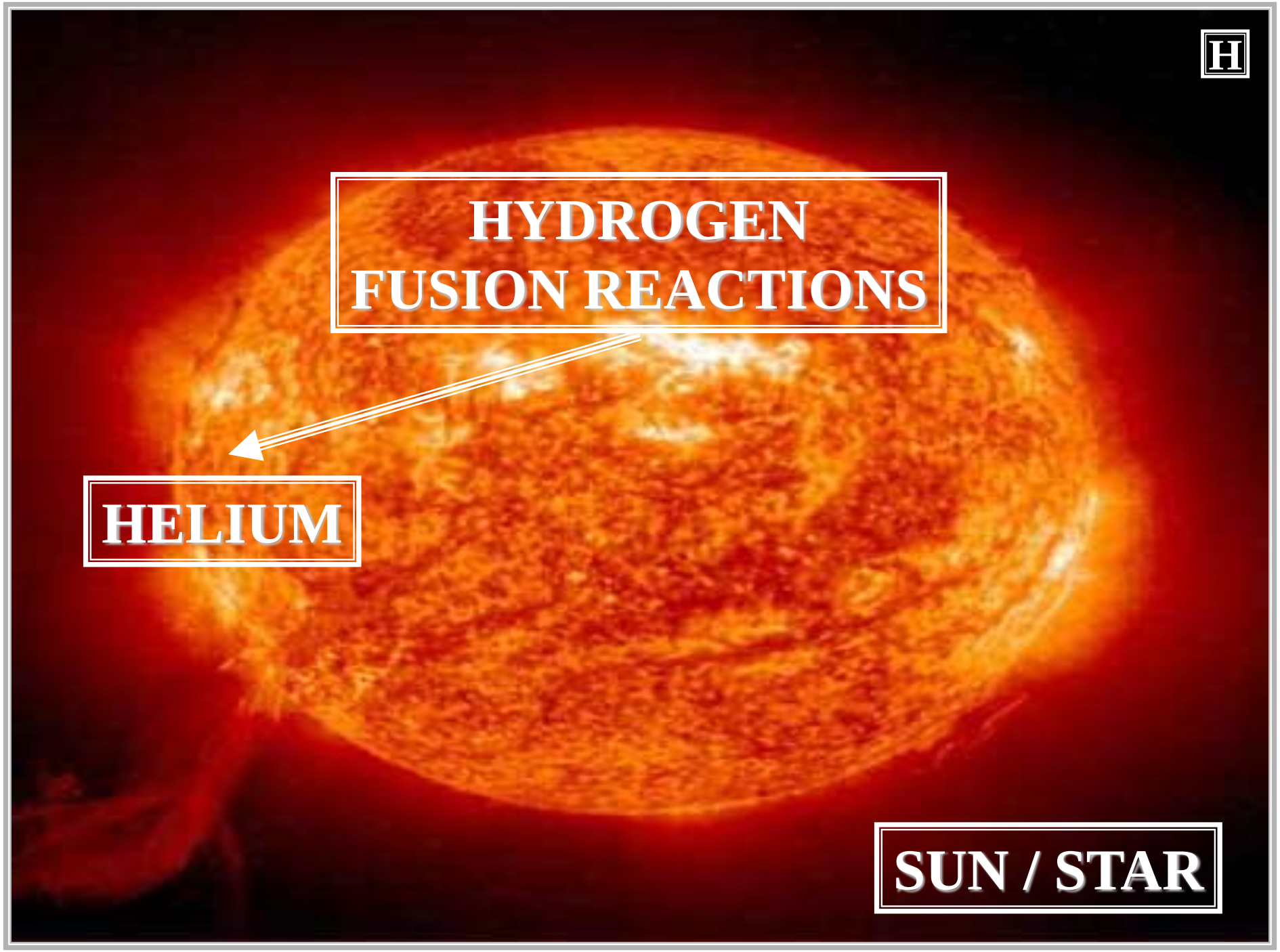
SOLAR FUSION REACTIONS

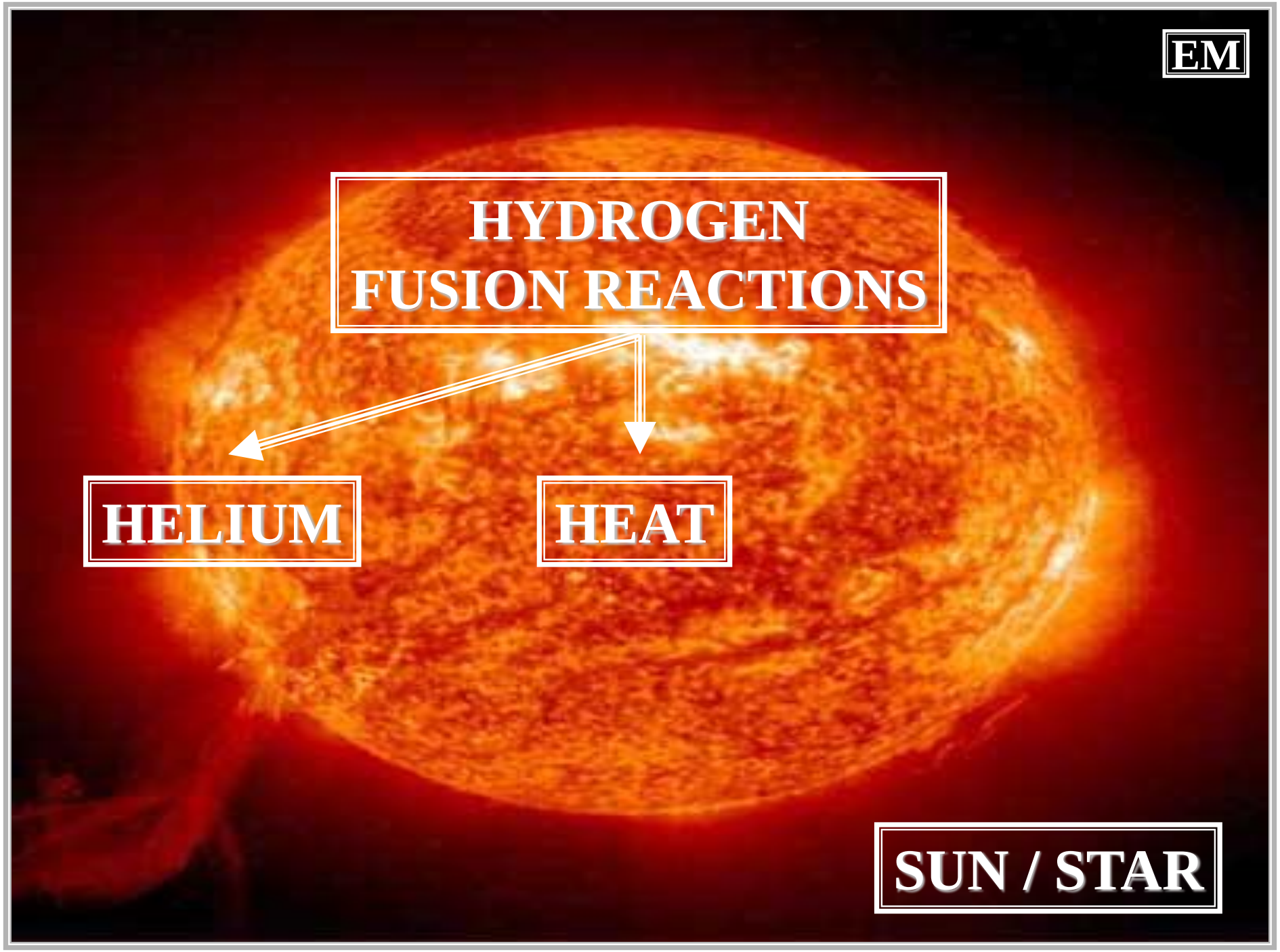

H
?
SUN / STAR

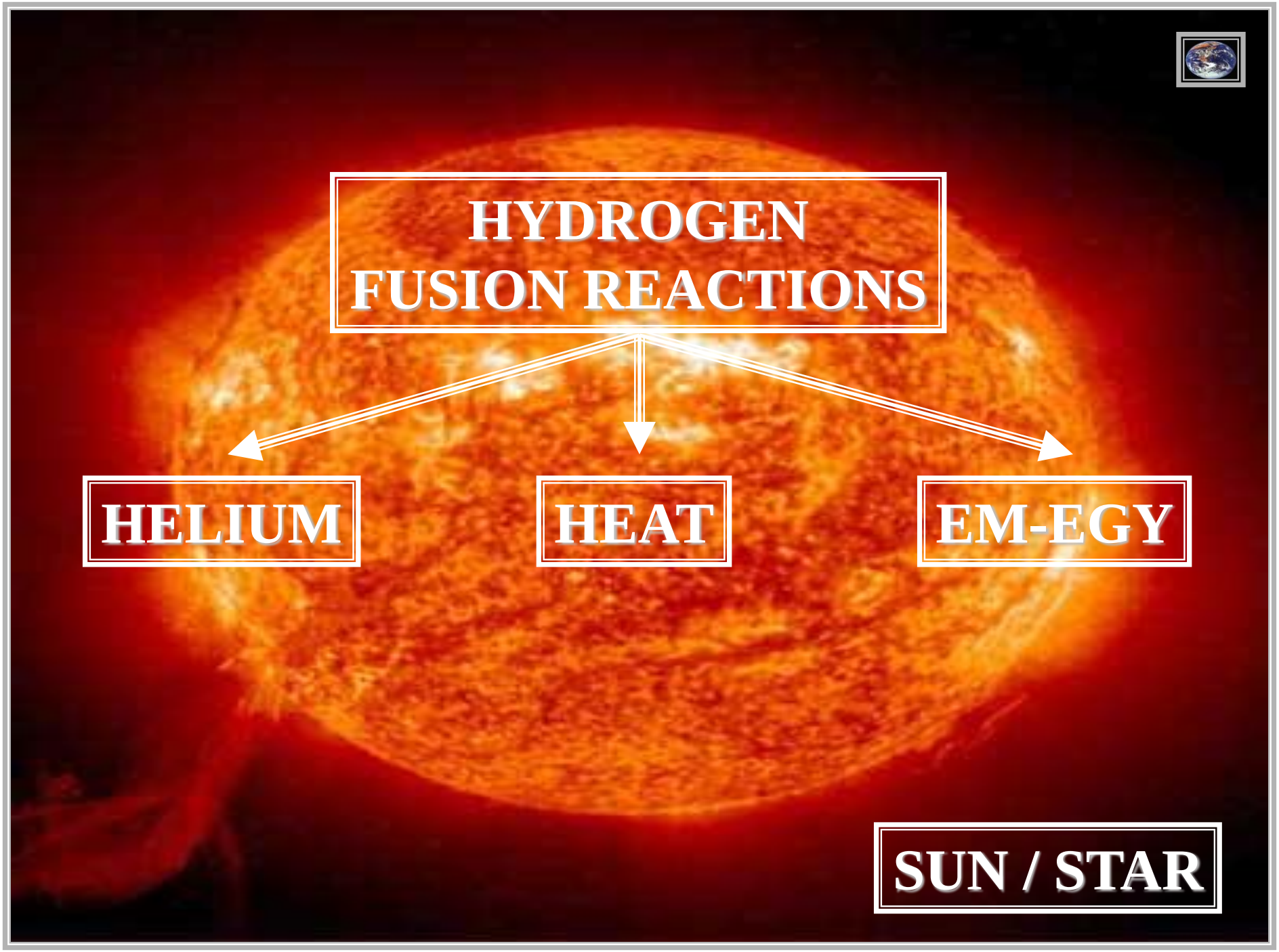

H
P
HYDROGEN
SUN / STAR


F
HEAT
HYDROGEN
PRESSURE
SUN / STAR


H
H
HEAT
HYDROGEN FUSION REACTIONS
PRESSURE
SUN / STAR


H
HYDROGEN
FUSION REACTIONS
HELIUM
SUN / STAR


EM
HYDROGEN
FUSION REACTIONS
HELIUM
HEAT
SUN / STAR


HYDROGEN
FUSION REACTIONS
HELIUM
HEAT
EM-EGY
SUN / STAR

D

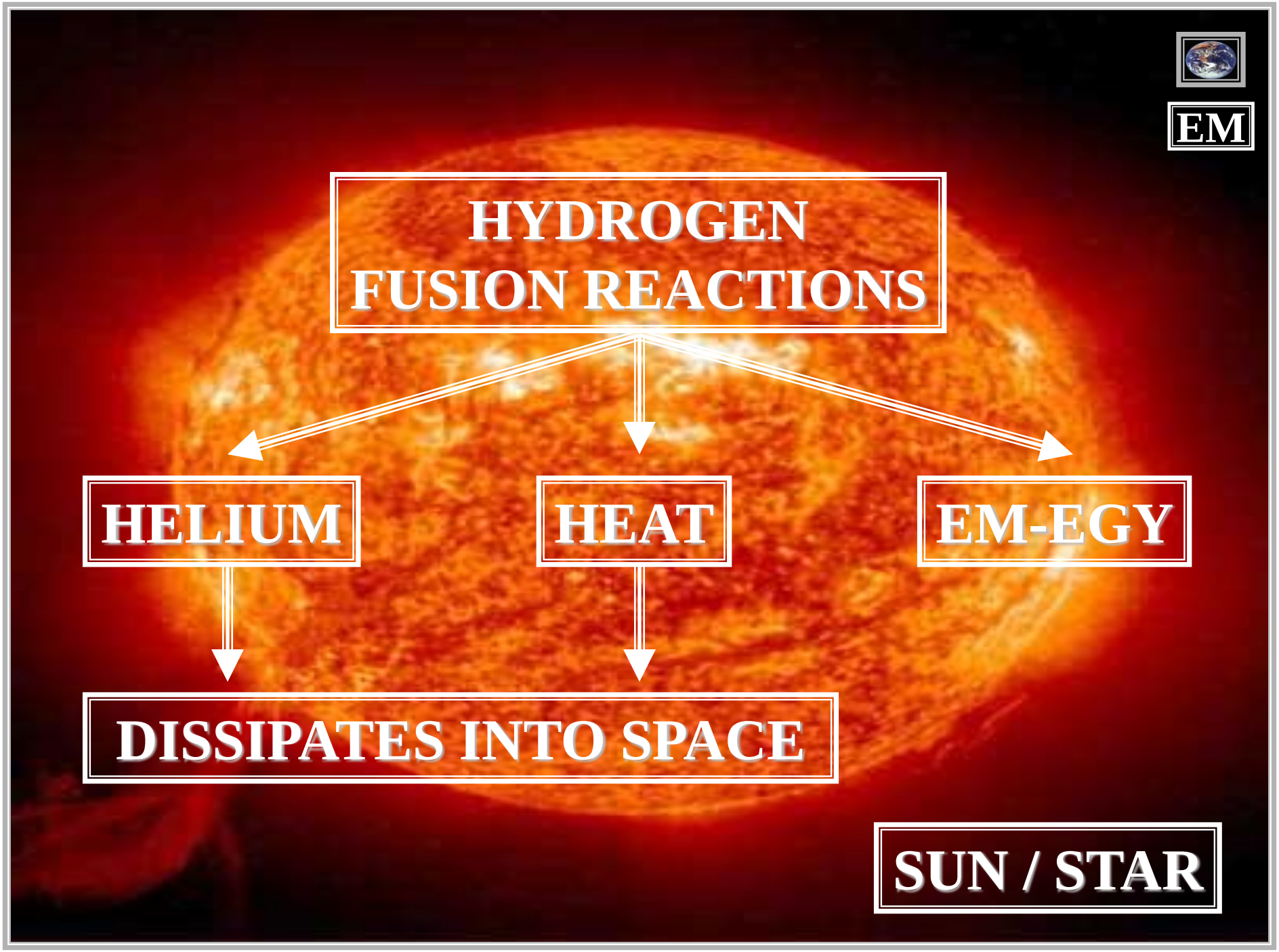
HYDROGEN FUSION REACTIONS

HELIUM

HEAT

EM-EGY

SUN / STAR


EM
HYDROGEN FUSION REACTIONS
HELIUM
HEAT
EM-EGY
DISSIPATES INTO SPACE
SUN / STAR

E

HYDROGEN FUSION REACTIONS

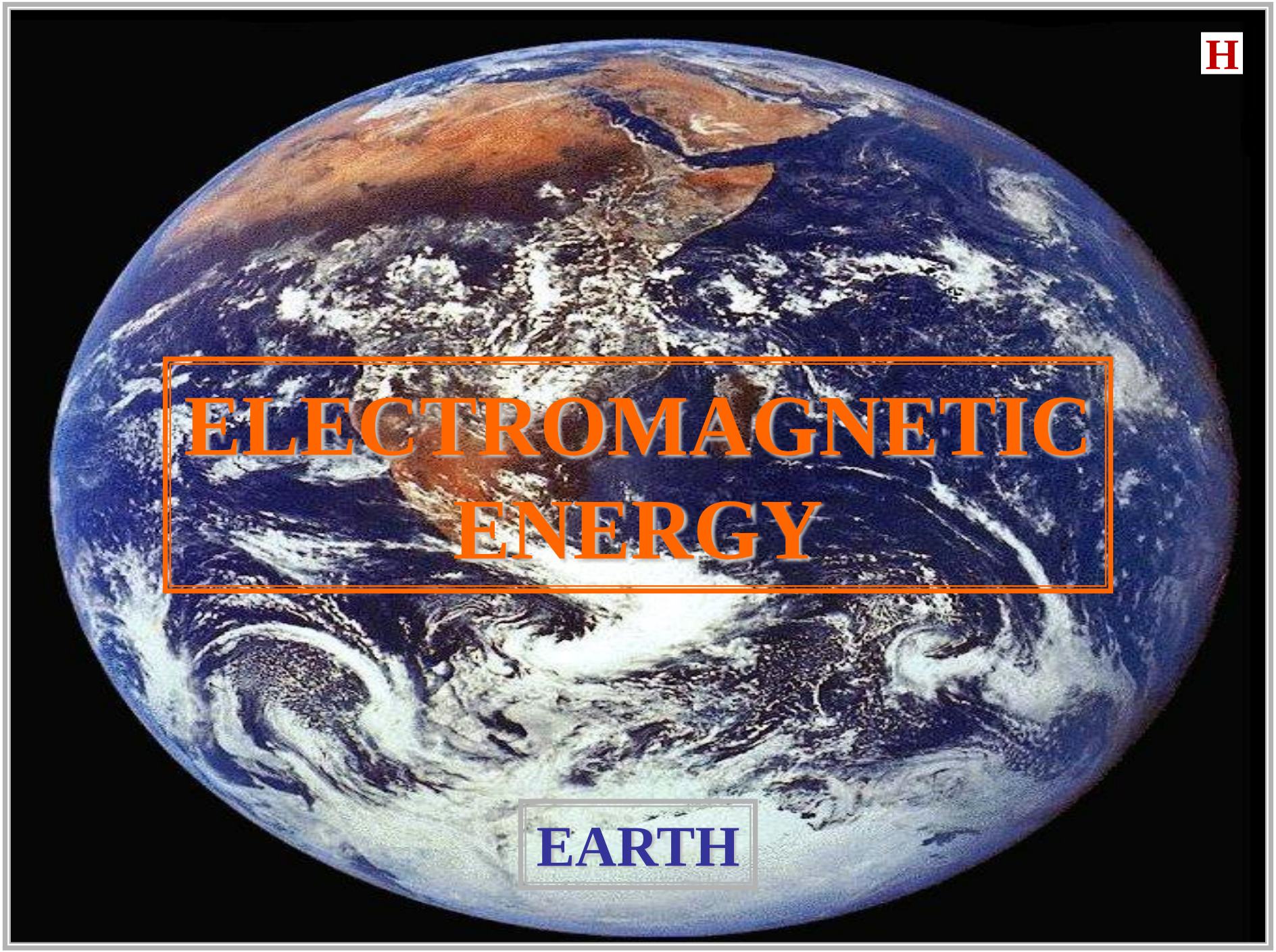
HELIUM

HEAT

EM-EGY

DISSIPATES INTO SPACE

EARTH


H
ELECTROMAGNETIC ENERGY
EARTH

HEAT ENERGY

EARTH

EM

HYDROGEN FUSION REACTIONS

HELIUM

HEAT

EM-EGY

DISSIPATES INTO SPACE

EARTH

E

ELECTROMAGNETIC ENERGY

ELECTROMAGNETIC ENERGY (RADIATION)

ELECTROMAGNETIC RADIATION

P

CONSISTS PHOTONS

ELECTROMAGNETIC RADIATION

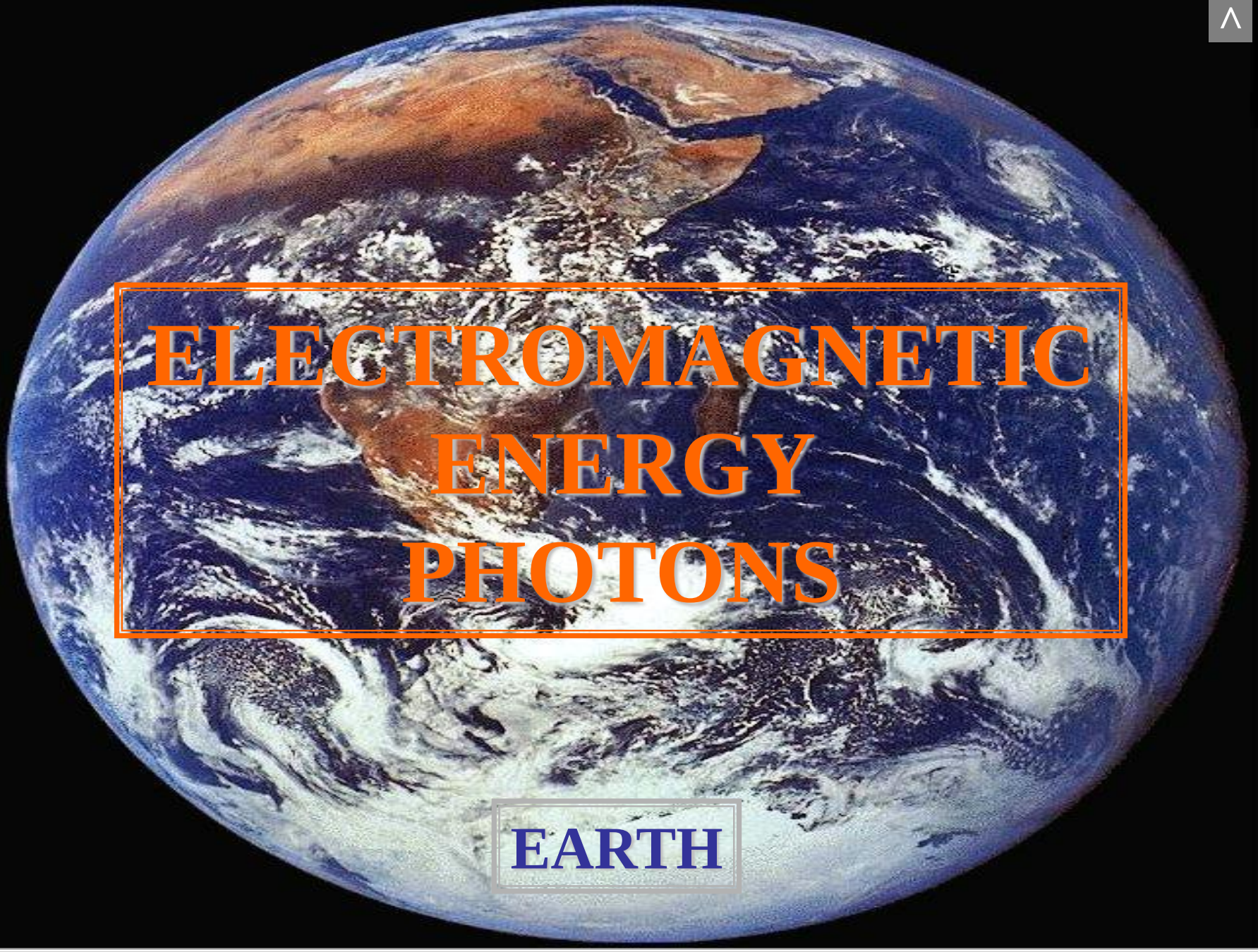
PHOTON

PHOTON

P

UNIT ELECTROMAGNETIC ENERGY

PHOTON


ELECTROMAGNETIC
ENERGY
PHOTONS
EARTH

ELECTROMAGNETIC ENERGY SPECTRUM

ELECTROMAGNETIC SPECTRUM

FR

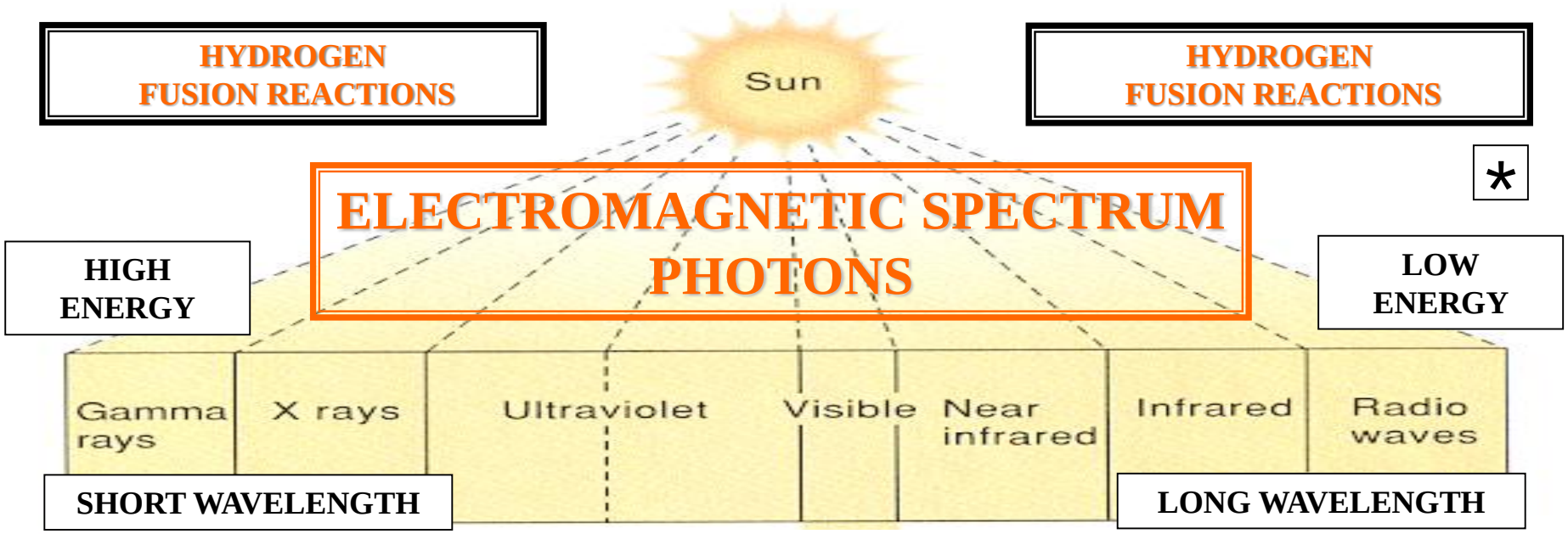
ELECTROMAGNETIC SPECTRUM

HYDROGEN FUSION REACTIONS

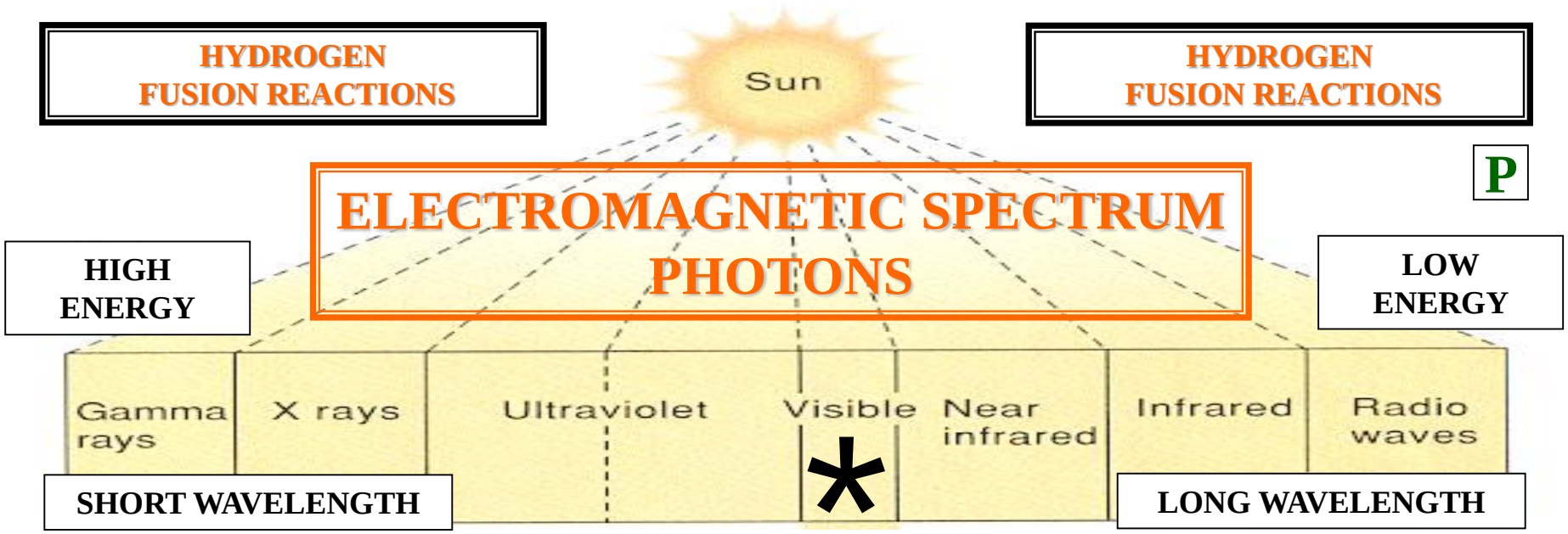
HYDROGEN FUSION REACTIONS

E

ELECTROMAGNETIC SPECTRUM



ELECTROMAGNETIC SPECTRUM



ELECTROMAGNETIC SPECTRUM

HYDROGEN FUSION REACTIONS

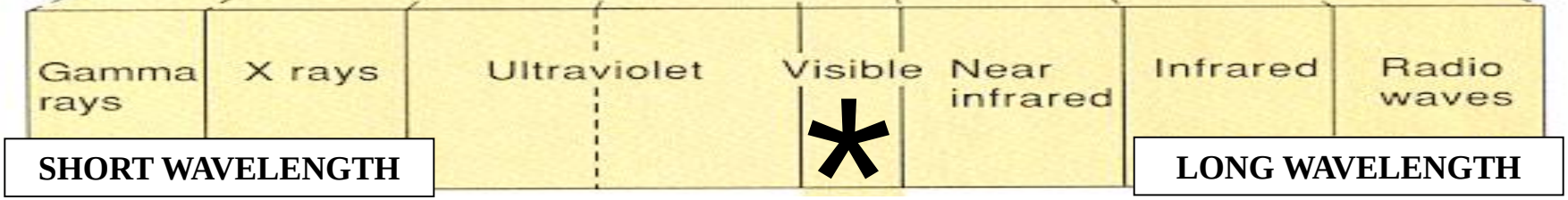
HYDROGEN FUSION REACTIONS

>

ELECTROMAGNETIC SPECTRUM PHOTONS

HIGH ENERGY

LOW ENERGY



SHORT WAVELENGTH

LONG WAVELENGTH

PHOTOSYNTHESIS

PHOTOSYNTHESIS

PHOTOSYNTHESIS

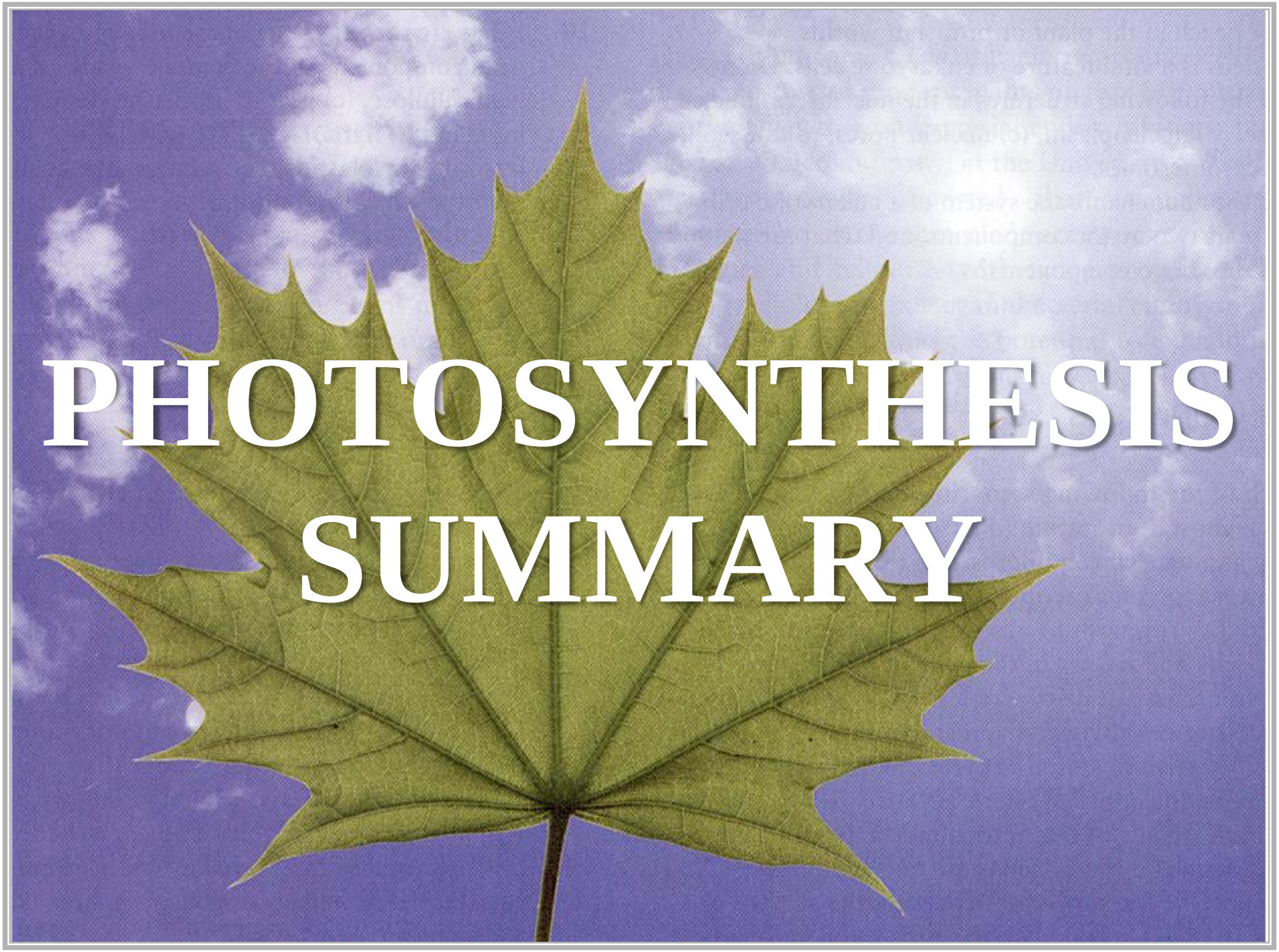
PHOTOSYNTHESIS

PHOTOSYNTHESIS

S

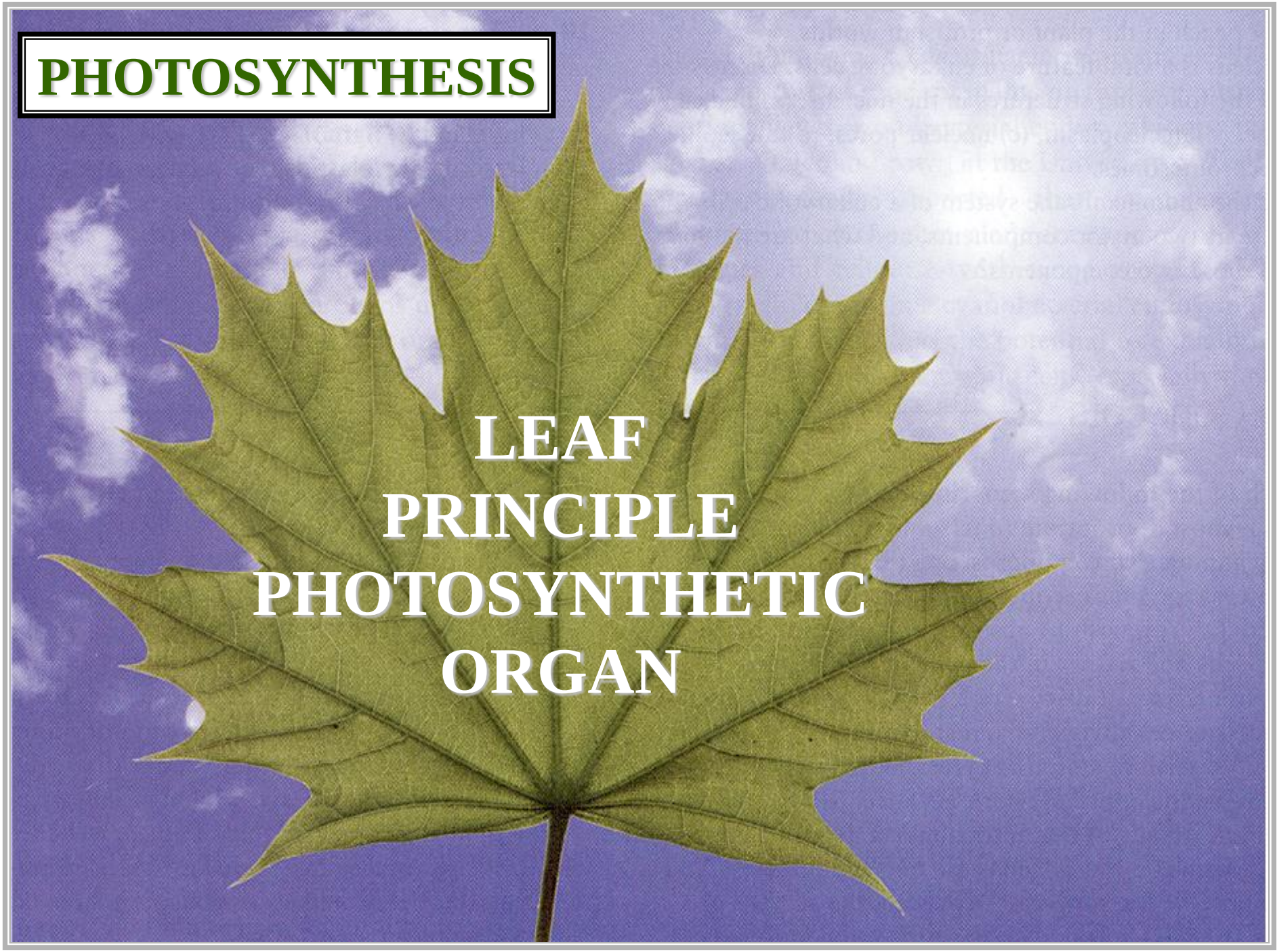
P

PLANTS CONVERT VISIBLE LT EGY → CHEM EGY VIA PHOTOSYNTHESIS



PHOTOSYNTHESIS SUMMARY

PHOTOSYNTHESIS



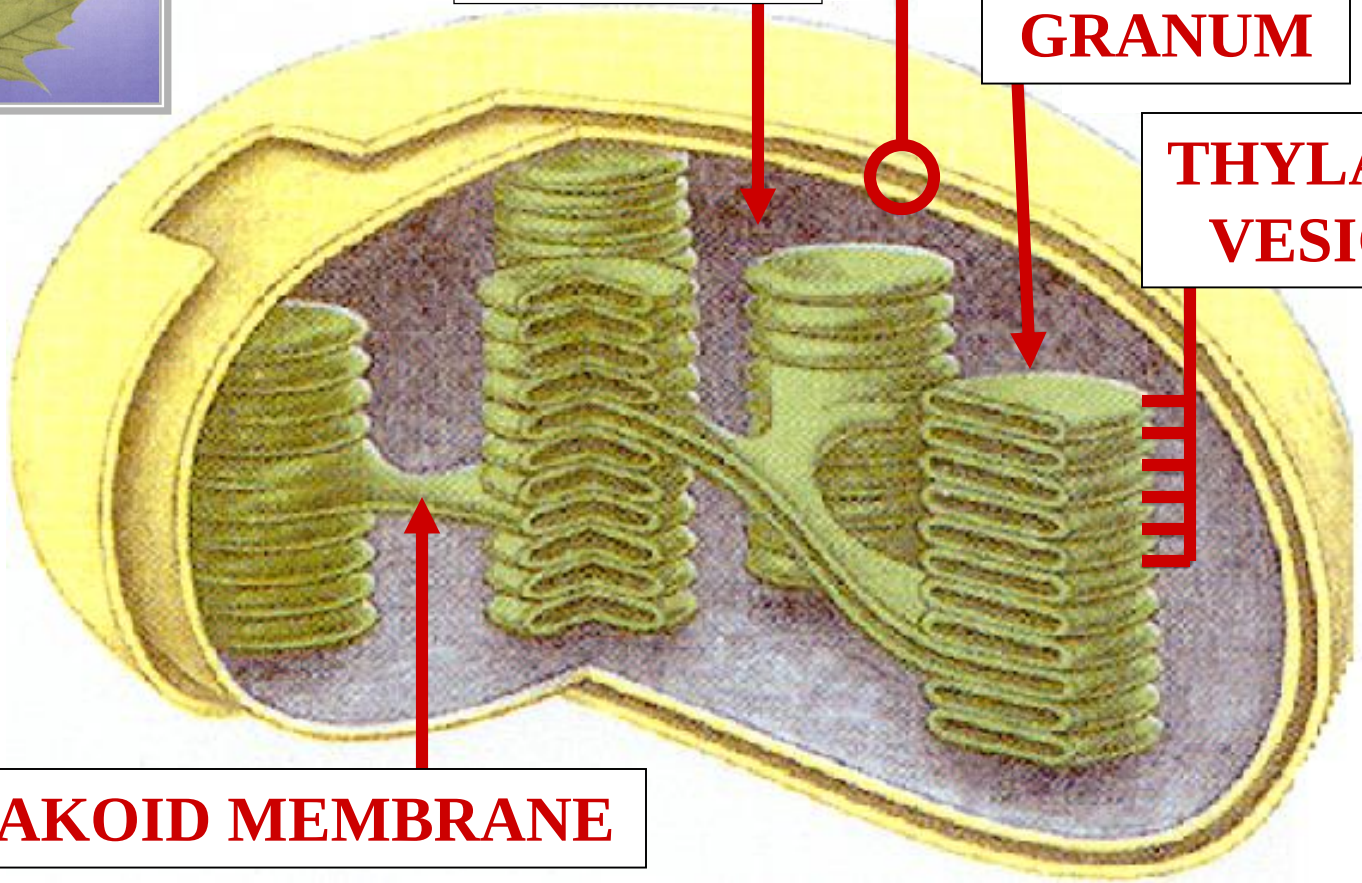
LEAF
PRINCIPLE
PHOTOSYNTHETIC
ORGAN

MESOPHYLL PHOTOSYNTHETIC TISSUE

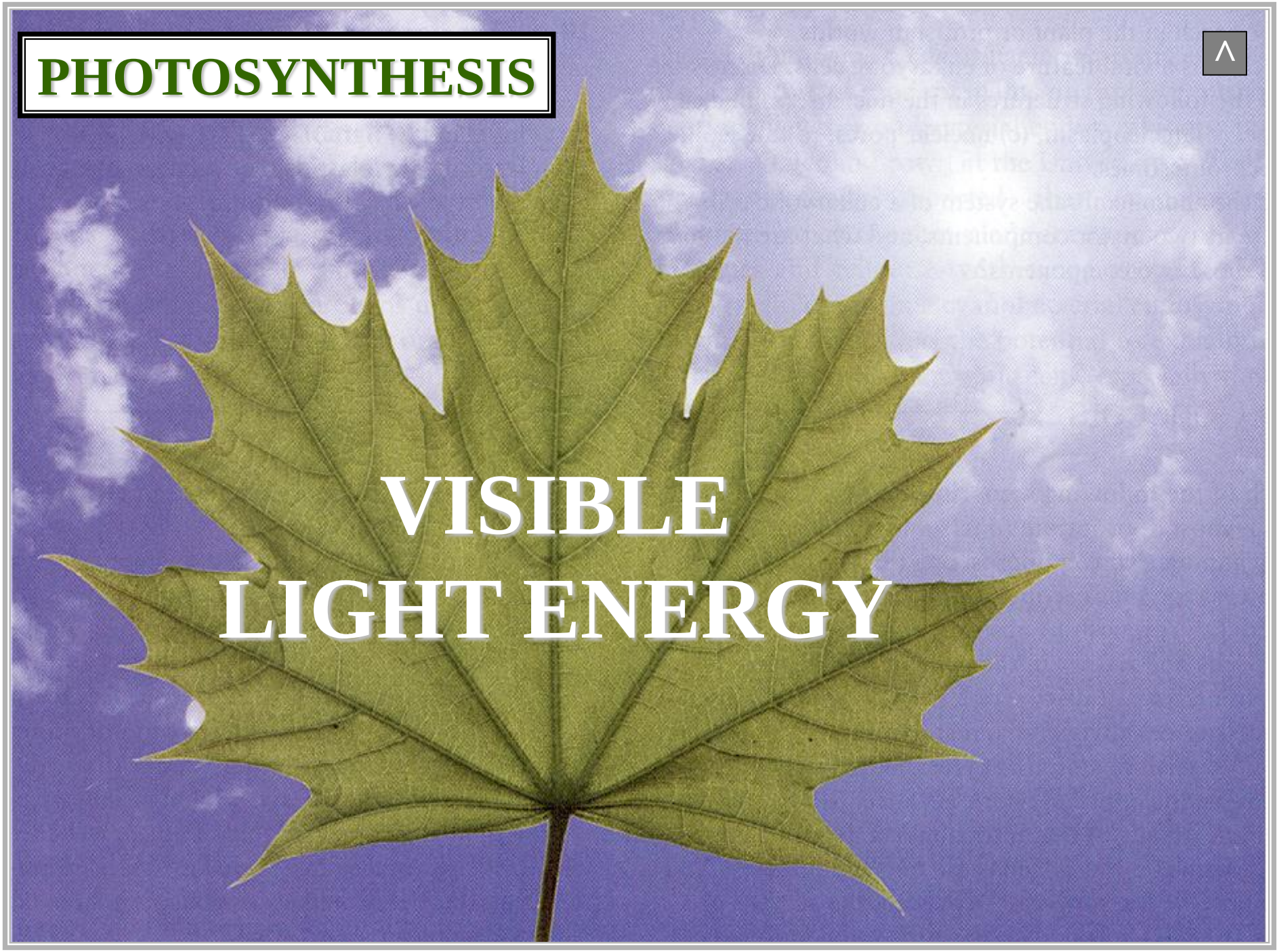
LEAF

C.S.

CHLOROPLAST ULTRASTRUCTURE



PHOTOSYNTHESIS



PHOTOSYNTHESIS CHEMISTRY

PHOTOSYNTHESIS EQUATION

PHOTOSYNTHESIS EQUATION

C

PHOTOSYNTHESIS EQUATION

PHOTOSYNTHESIS EQUATION

H

$6CO_2$

PHOTOSYNTHESIS EQUATION

PHOTOSYNTHESIS EQUATION

$6CO_2 + 12H_2O$

PHOTOSYNTHESIS EQUATION

PHOTOSYNTHESIS EQUATION

G

$6CO_2 + 12H_2O \longrightarrow$

PHOTOSYNTHESIS EQUATION

PHOTOSYNTHESIS EQUATION

O

$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6$

CHEM EGY INPUT

PHOTOSYNTHESIS EQUATION

PHOTOSYNTHESIS EQUATION

$6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$

CHEM EGY INPUT

PHOTOSYNTHESIS EQUATION

PHOTOSYNTHESIS

LR

WATER

CO2

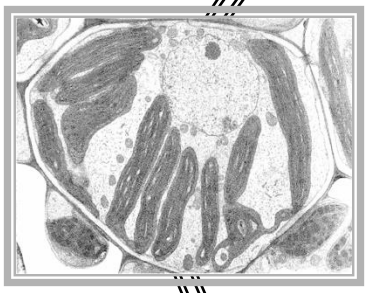
LIGHT EGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS



?

ATP

?

SYNTHESIS

CHEMICAL ENERGY INPUT

CHLOROPLAST

ATMOSPHERE

OXYGEN

GLUCOSE

PHOTOSYNTHESIS

DK

WATER

CO2

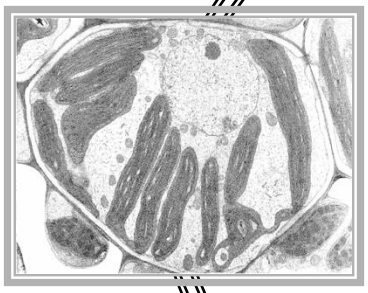
LIGHT EGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT

THYLAKOID

ATP

?

SYNTHESIS

CHEMICAL ENERGY INPUT

CHLOROPLAST

ATMOSPHERE

OXYGEN

GLUCOSE

PHOTOSYNTHESIS

WATER

CO2

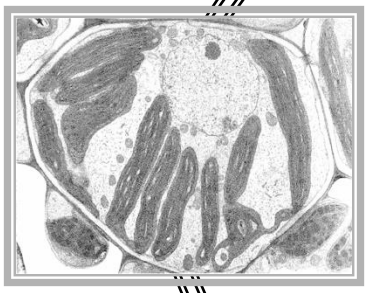
LIGHT EGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT

THYLAKOID

ATP

DK RXT

STROMA

SYNTHESIS

CHEMICAL ENERGY INPUT

CHLOROPLAST

ATMOSPHERE

OXYGEN

GLUCOSE

LIGHT REACTION & DARK REACTION

LIGHT REACTION OVERVIEW