

THYLAKOID VESICLES



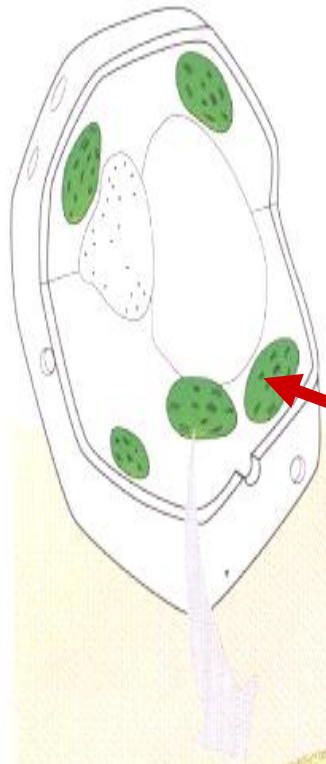
THYLAKOID VESICLES

COMPRISE

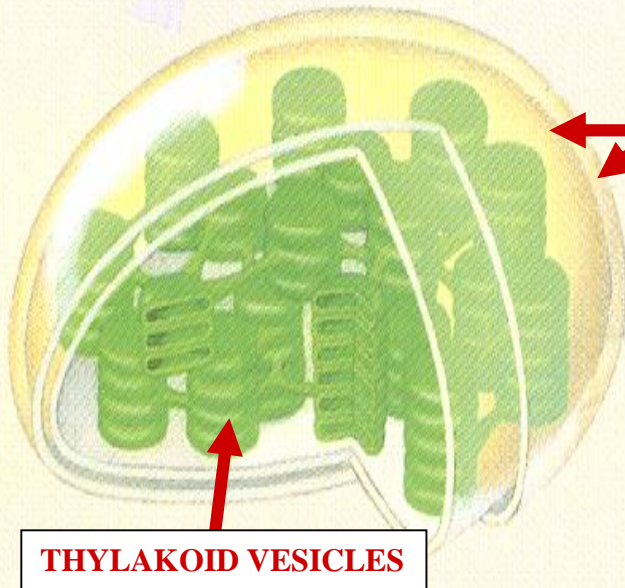
THYLAKOID MEMBRANE

THYLAKOID VESICLES

CHLOROPLAST ULTRASTRUCTURE

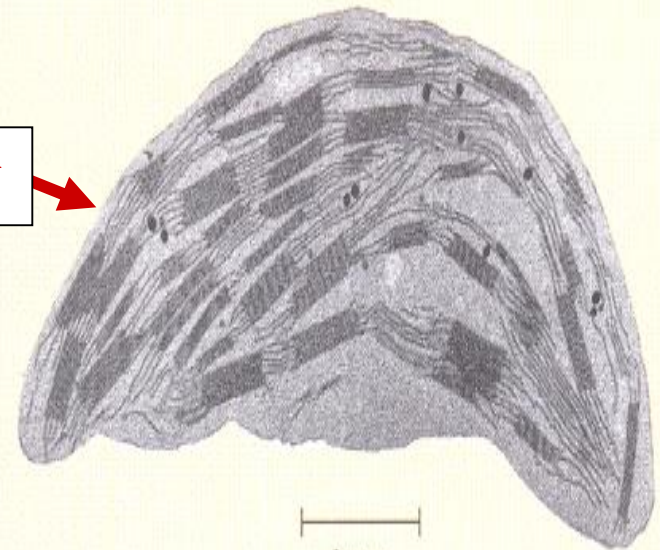


CHLOROPLAST



THYLAKOID VESICLES

OUTER & INNER
MEMBRANE



1 μ m

THYLAKOID
GRANUM / GRANA

THYLAKOID GRANUM



STACKED

THYLAKOID VESICLES

THYLAKOID GRANUM

THYLAKOID GRANUM



STACKED

THYLAKOID VESICLES

SITE: LIGHT RXT

THYLAKOID GRANUM

THYLAKOID GRANUM



STACKED

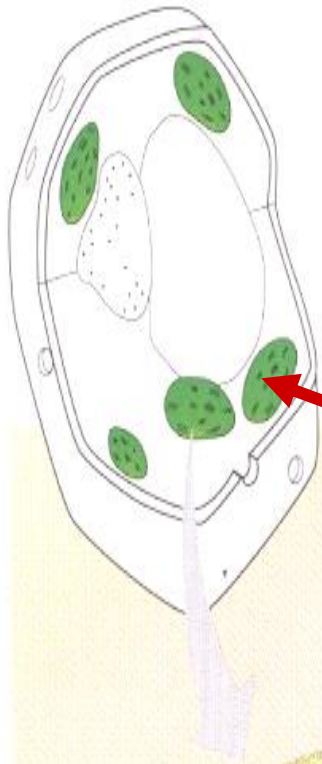
THYLAKOID VESICLES

SITE: LIGHT RXT

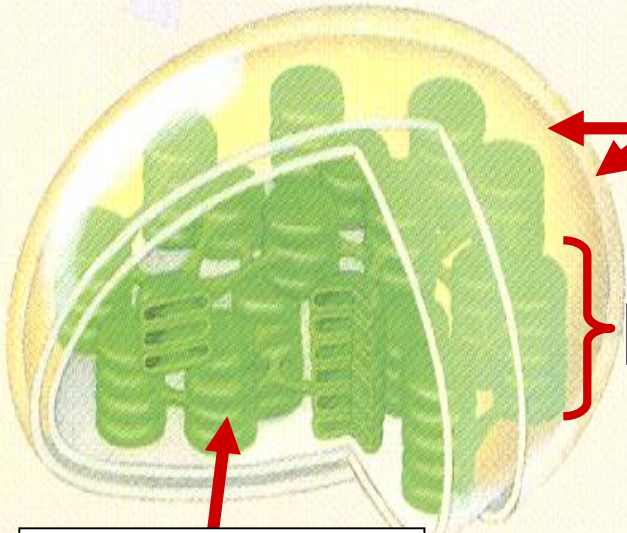
DERIVES ATP

THYLAKOID GRANUM

CHLOROPLAST ULTRASTRUCTURE



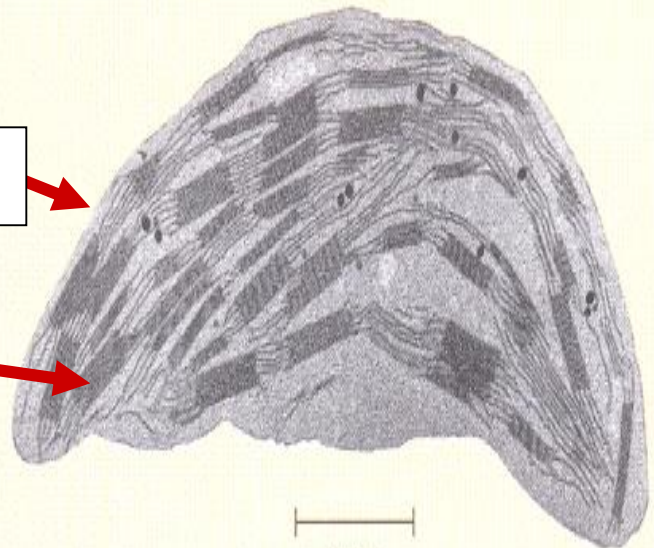
CHLOROPLAST



OUTER & INNER
MEMBRANE

GRANUM

THYLAKOID VESICLES



1 μ m



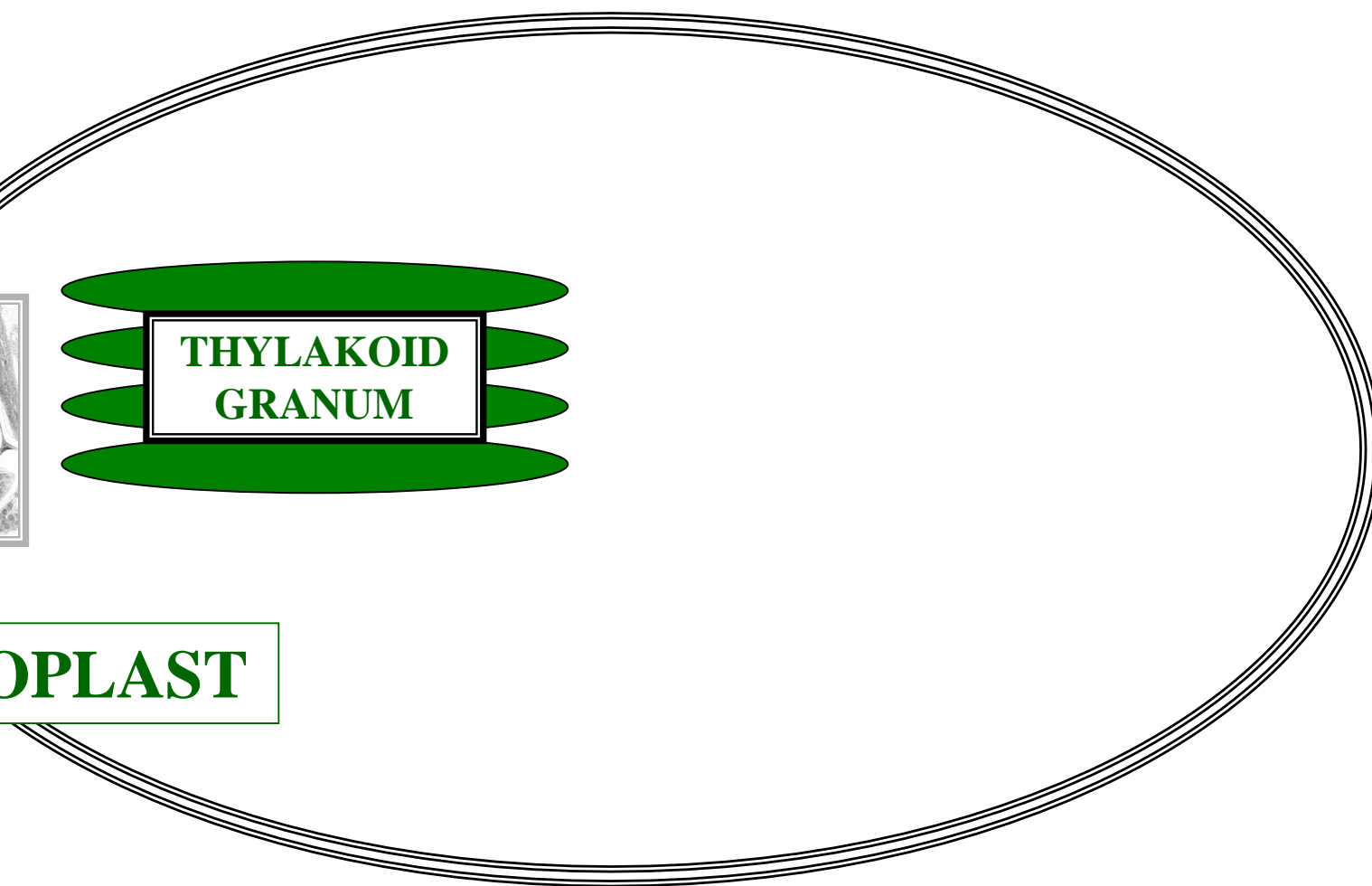
LIGHT REACTION

PHOTOSYNTHESIS

LR

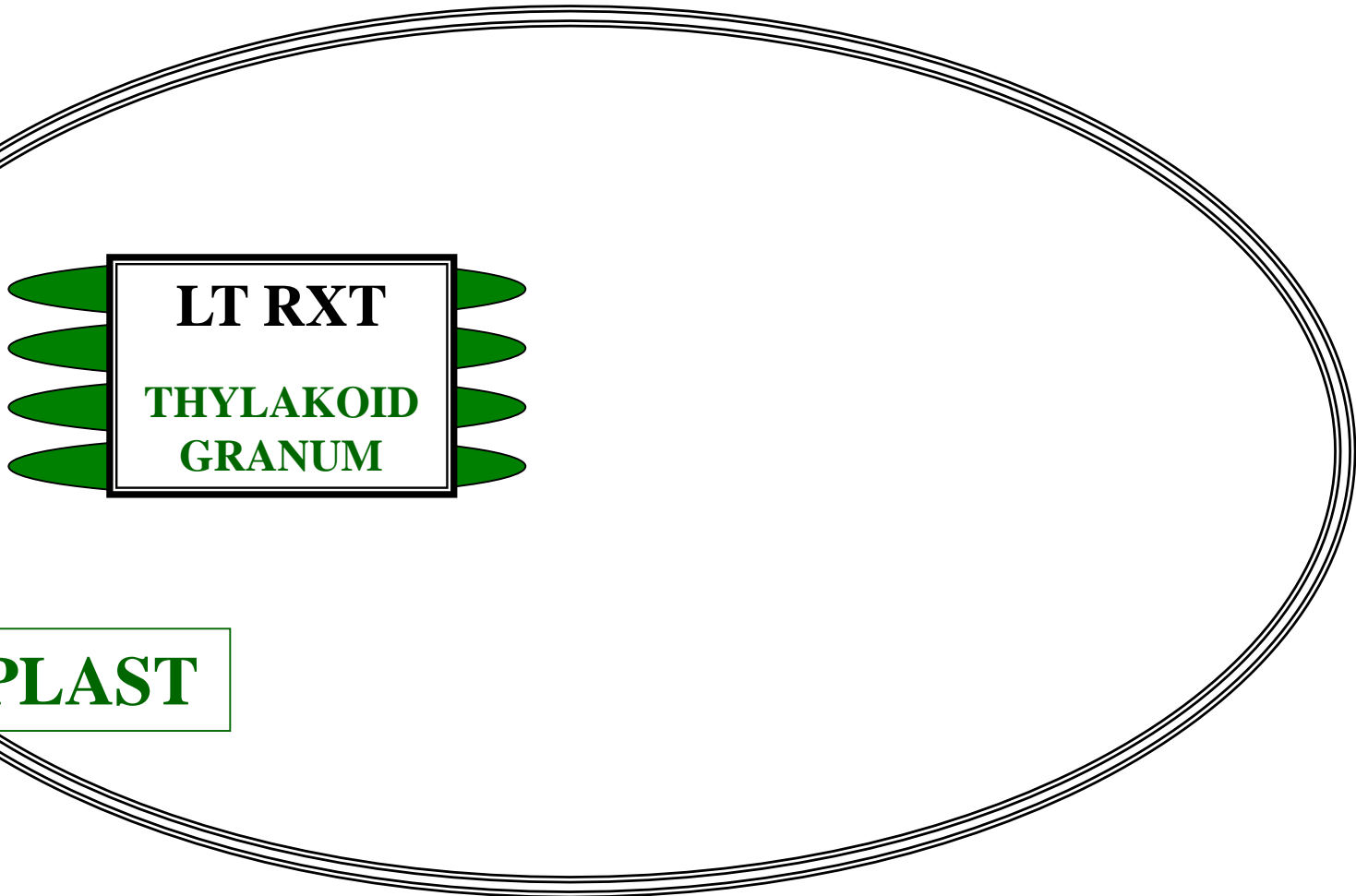


CHLOROPLAST



PHOTOSYNTHESIS

LT



LT RXT
**THYLAKOID
GRANUM**

CHLOROPLAST

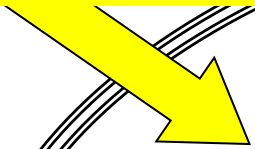
PHOTOSYNTHESIS



C



LIGHT ENERGY



LTRXT
THYLAKOID
GRANUM

CHLOROPLAST



PHOTOSYNTHESIS

P



WATER

LIGHT ENERGY

E-

PHOTOLYSIS

LT RXT

THYLAKOID
GRANUM

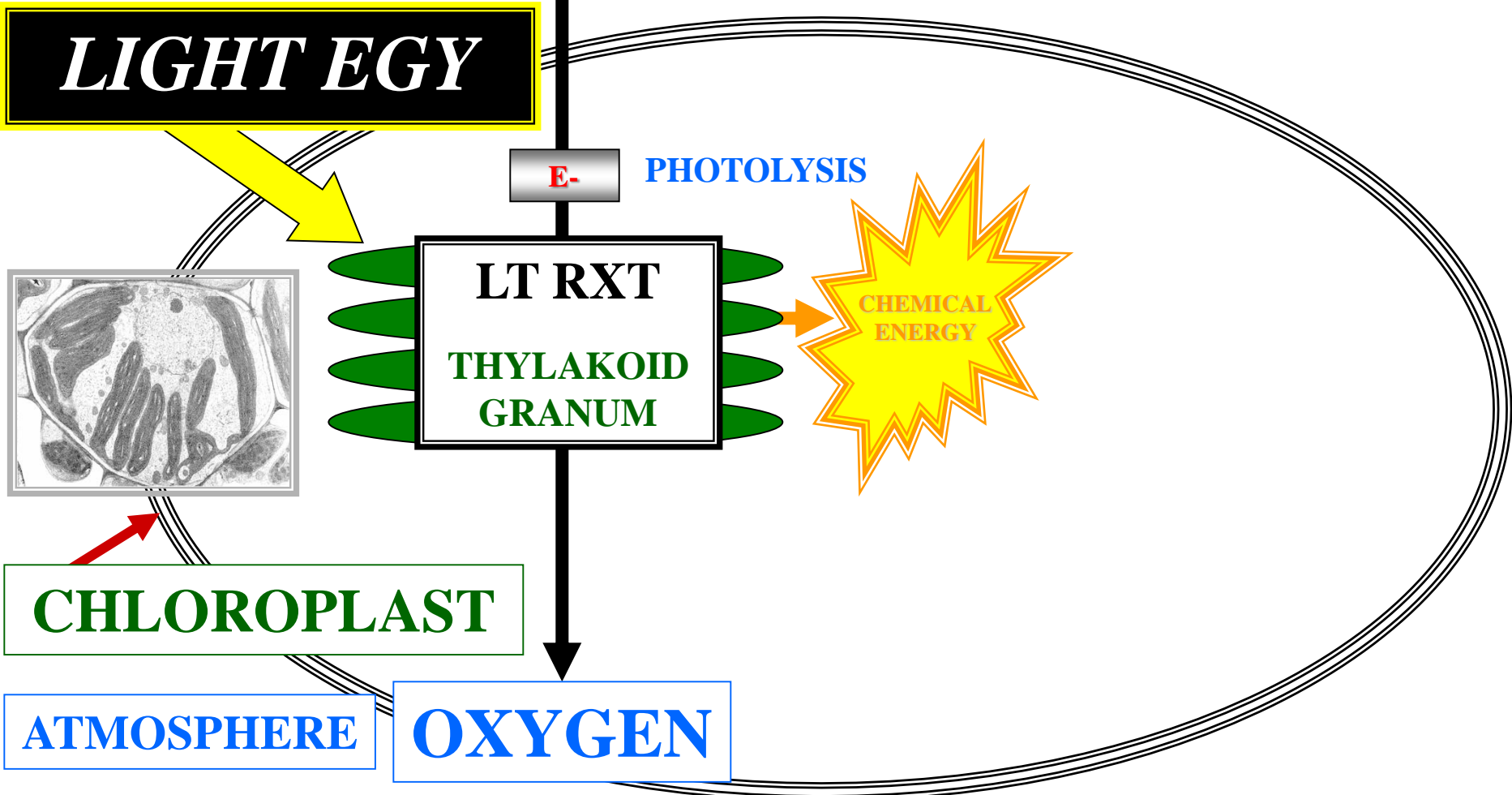
CHEMICAL
ENERGY



CHLOROPLAST

ATMOSPHERE

OXYGEN



PHOTOSYNTHESIS



WATER

LIGHT ENERGY

E-

PHOTOLYSIS

LT RXT

THYLAKOID
GRANUM

CHEMICAL
ENERGY

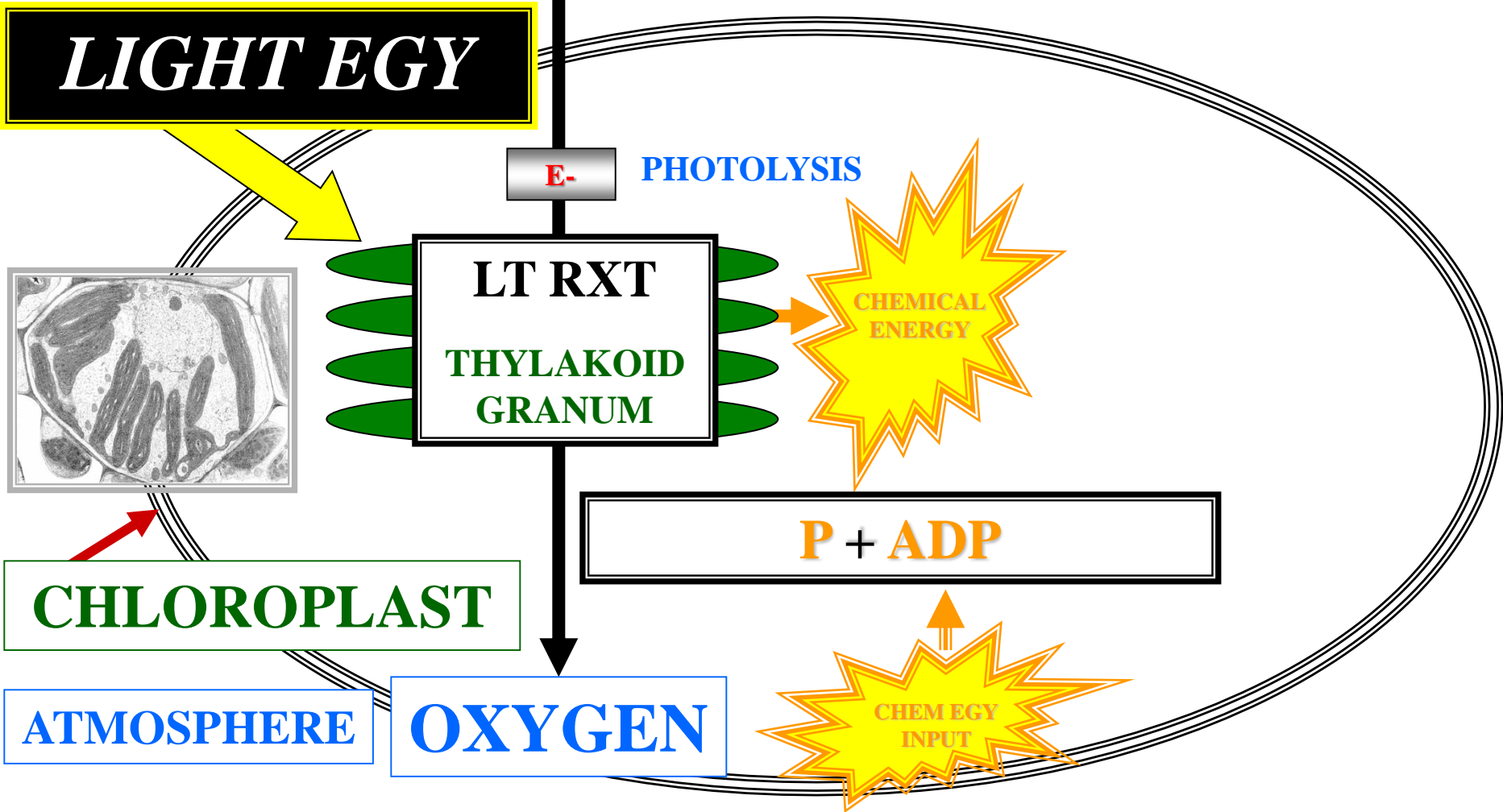
P + ADP

CHLOROPLAST

ATMOSPHERE

OXYGEN

CHEMICAL
INPUT



PHOTOSYNTHESIS

P



WATER

LIGHT ENERGY

E-

PHOTOLYSIS

LT RXT

THYLAKOID
GRANUM

ATP

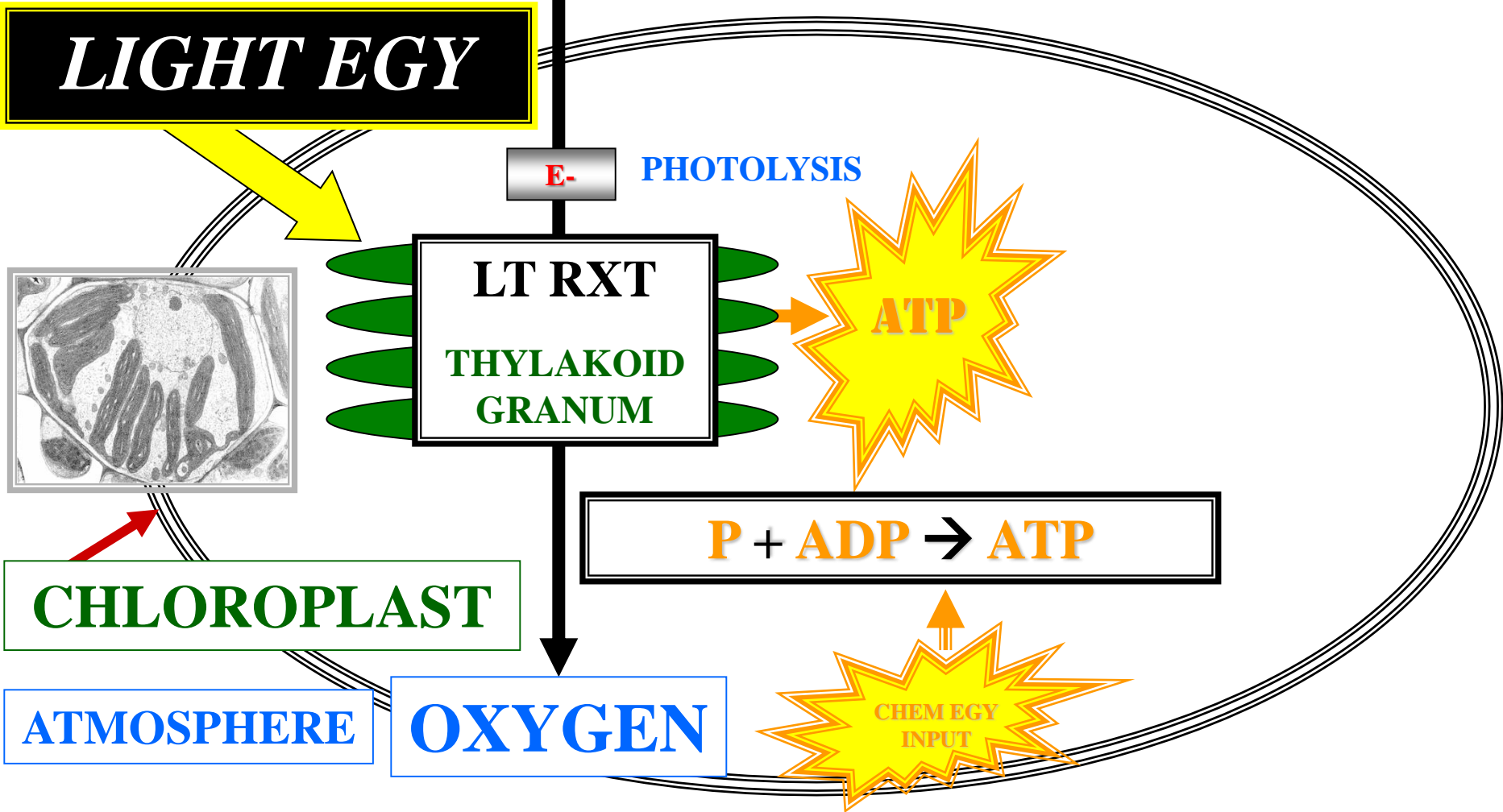
$P + ADP \rightarrow ATP$

CHLOROPLAST

ATMOSPHERE

OXYGEN

CHEMICAL
INPUT



PHOTOSYNTHESIS



WATER

LIGHT ENERGY

E-

PHOTOLYSIS

LT RXT

THYLAKOID
GRANUM

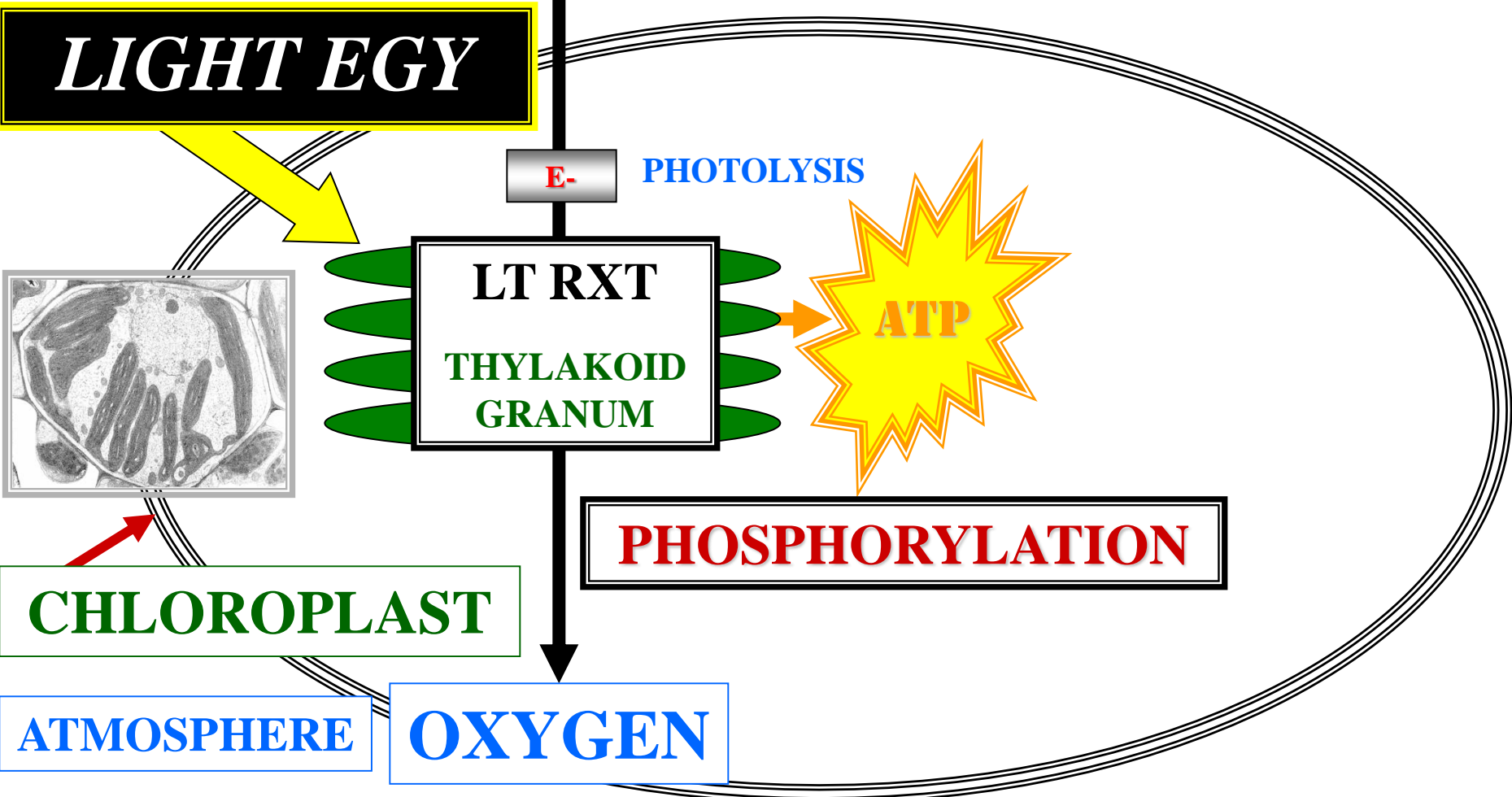
ATP

PHOSPHORYLATION

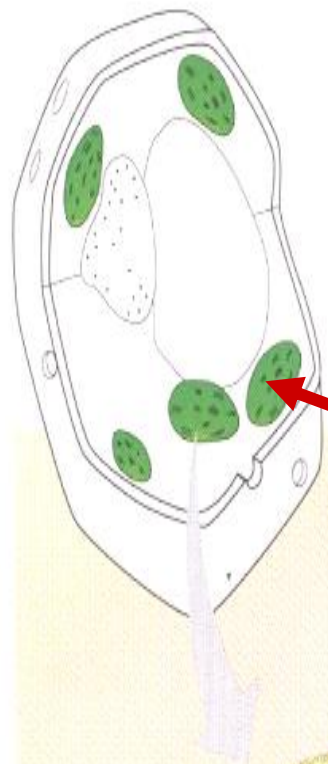
CHLOROPLAST

ATMOSPHERE

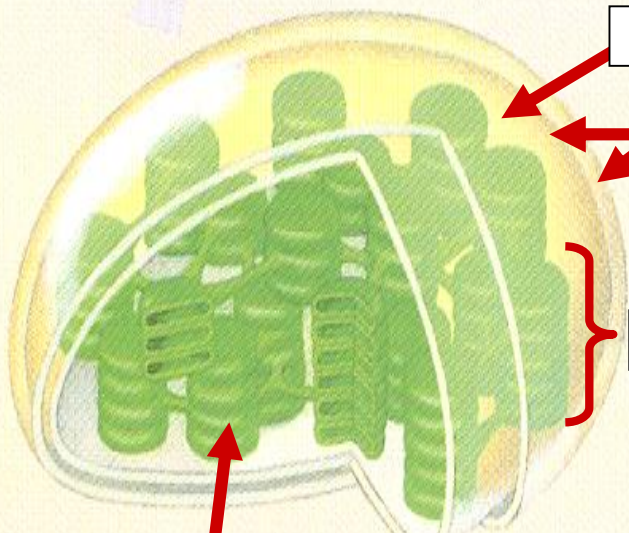
OXYGEN



CHLOROPLAST ULTRASTRUCTURE



CHLOROPLAST

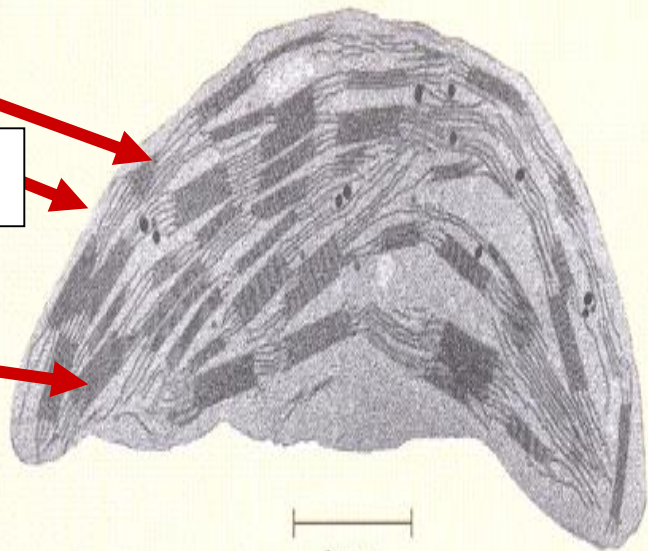


FLUID

OUTER & INNER
MEMBRANE

GRANUM

THYLAKOID MEMBRANE



1 μ m

STROMA



STROMA

**CHLOROPLAST
FLUID MATRIX**

STROMA



STROMA

**CHLOROPLAST
FLUID MATRIX**

SITE: DARK RXT

STROMA



STROMA

CHLOROPLAST

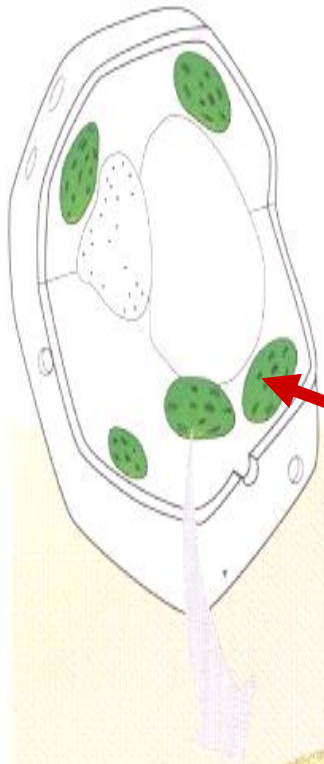
FLUID MATRIX

SITE: DARK RXT

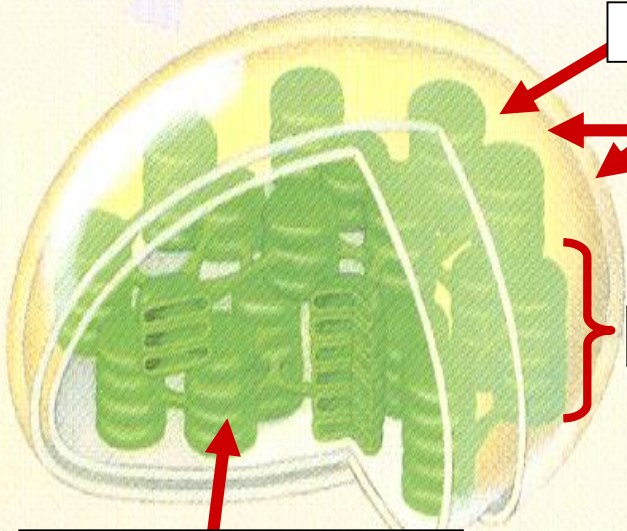
DERIVES GLUCOSE

STROMA

CHLOROPLAST ULTRASTRUCTURE



CHLOROPLAST

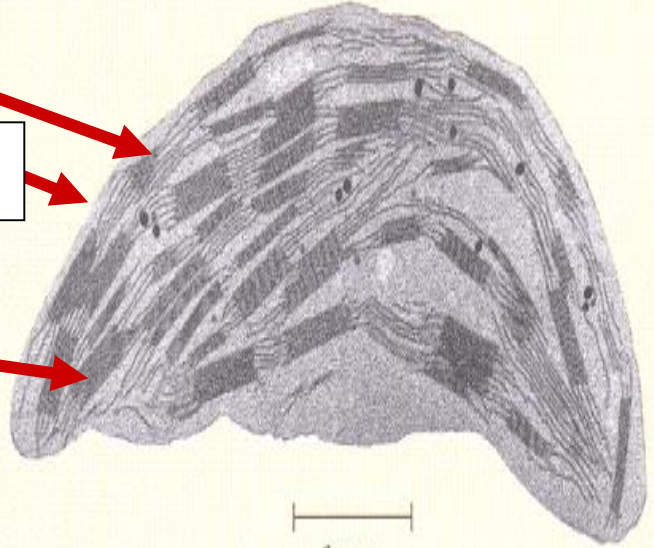


THYLAKOID MEMBRANE

STROMA

OUTER & INNER
MEMBRANE

GRANUM



1 μm



DARK REACTION

PHOTOSYNTHESIS

DR



WATER

LIGHT ENERGY

E-

PHOTOLYSIS

LT RXT

THYLAKOID

ATP

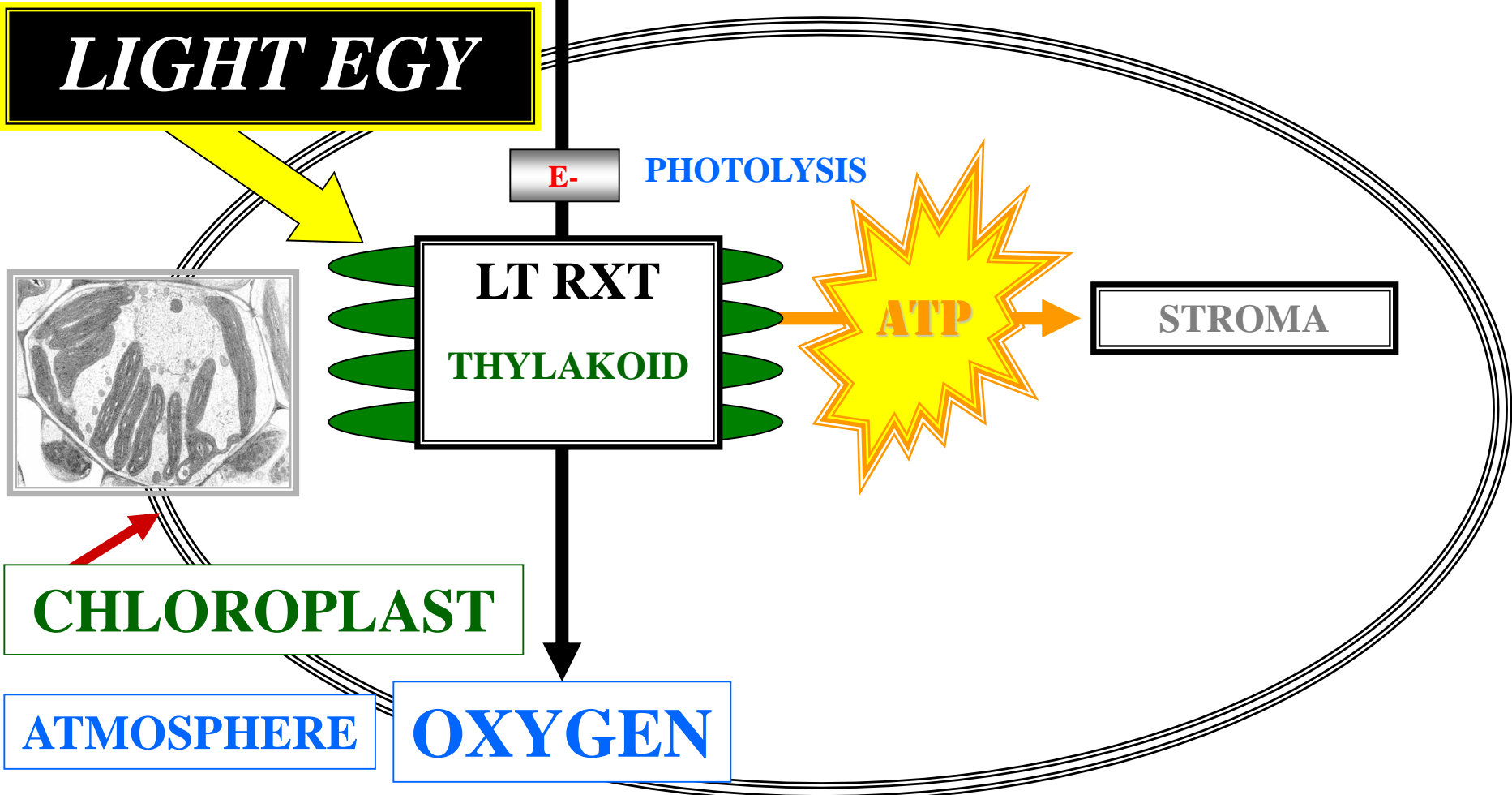
STROMA



CHLOROPLAST

ATMOSPHERE

OXYGEN



PHOTOSYNTHESIS



?

C

WATER

LIGHT ENERGY

E-

PHOTOLYSIS

LT RXT

THYLAKOID

ATP

DK RXT

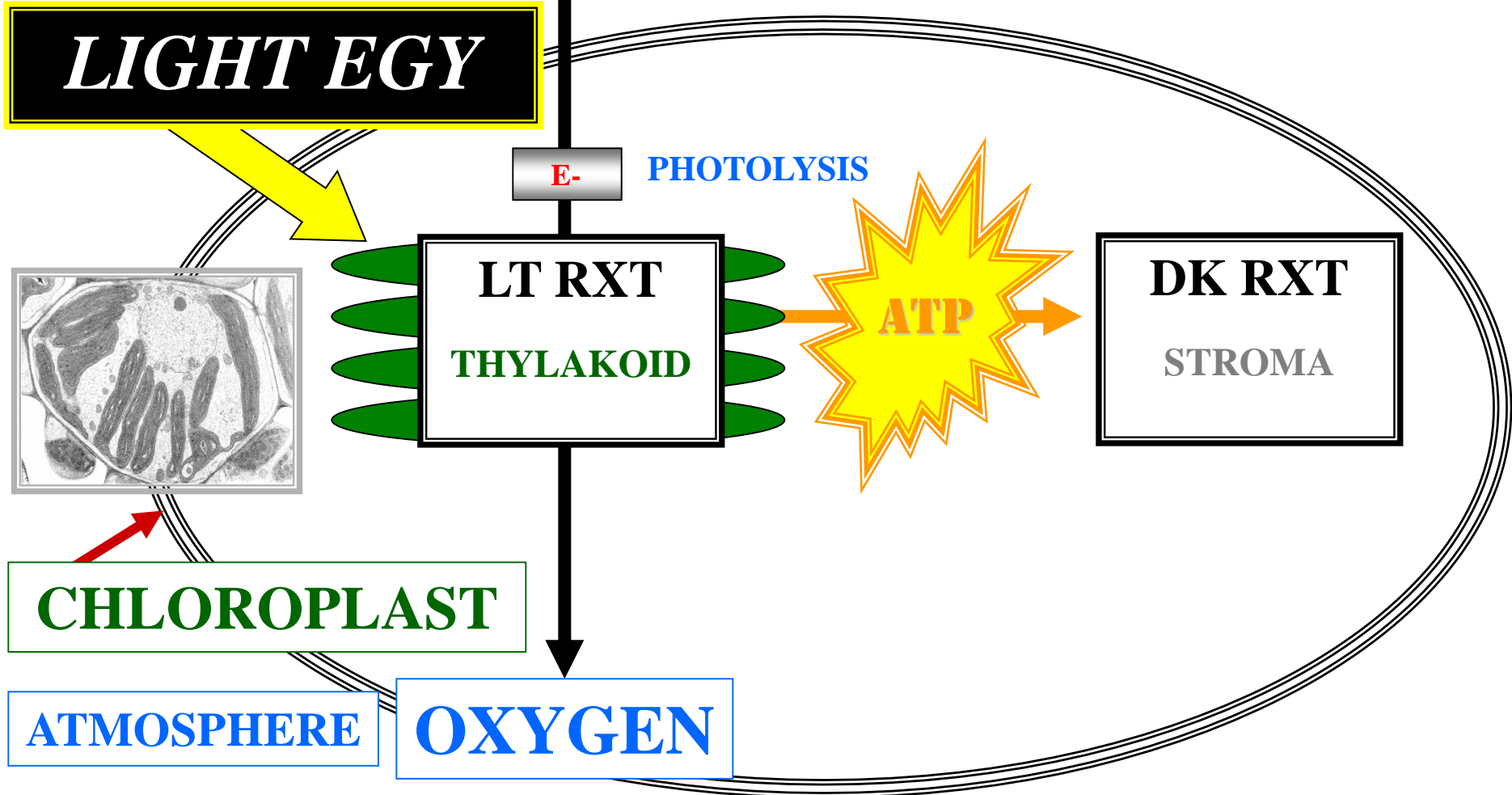
STROMA



CHLOROPLAST

ATMOSPHERE

OXYGEN



PHOTOSYNTHESIS

C



LIGHT ENERGY



CHLOROPLAST

ATMOSPHERE

WATER

?

ATMOSPHERE

E-

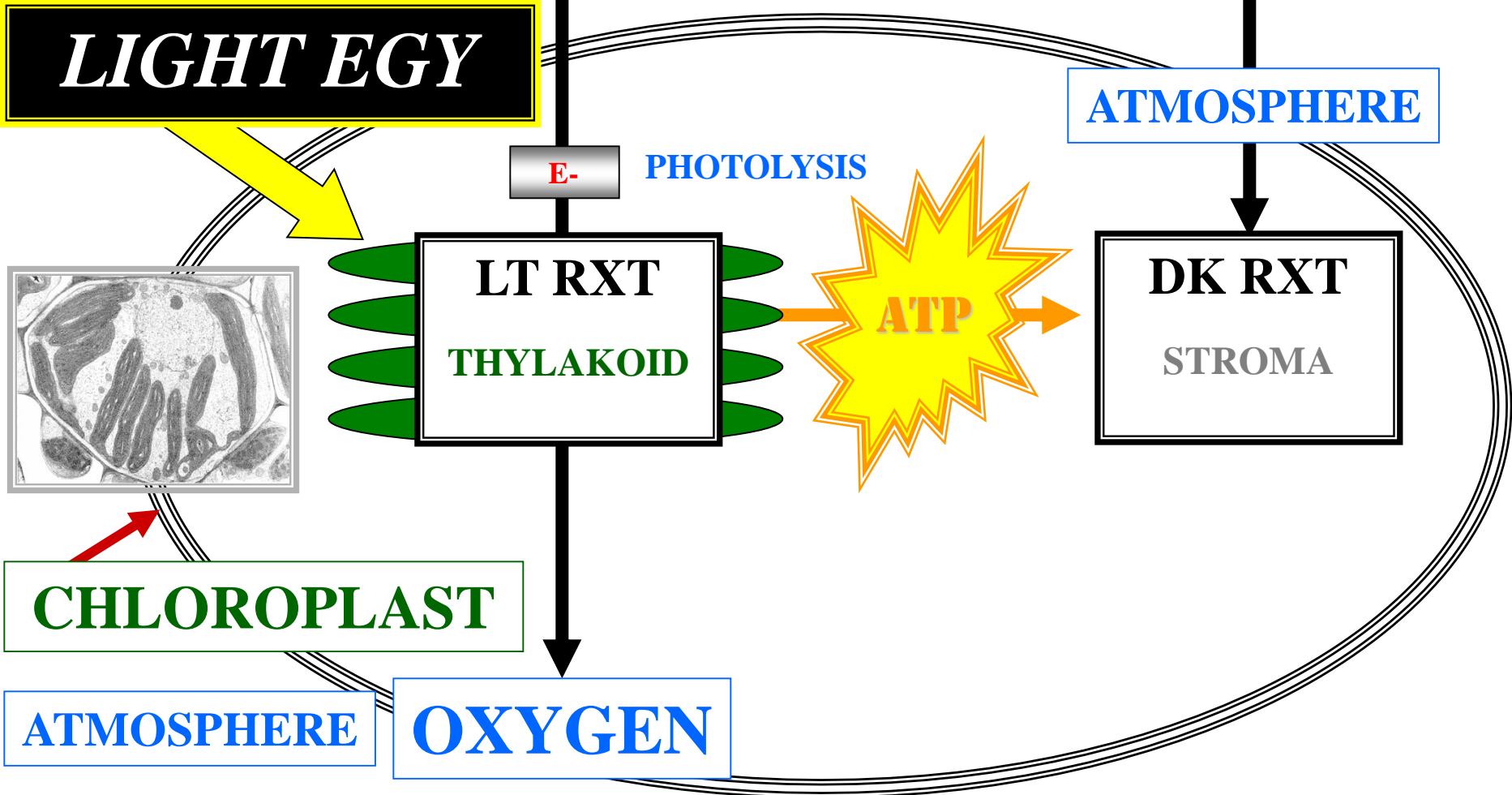
PHOTOLYSIS

LT RXT
THYLAKOID



DK RXT
STROMA

OXYGEN



PHOTOSYNTHESIS



WATER

CO₂

LIGHT ENERGY

ATMOSPHERE

E⁻

PHOTOLYSIS

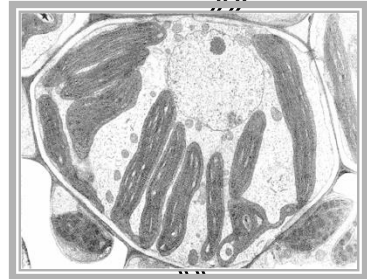
LT RXT

THYLAKOID

CHEMICAL ENERGY

DK RXT

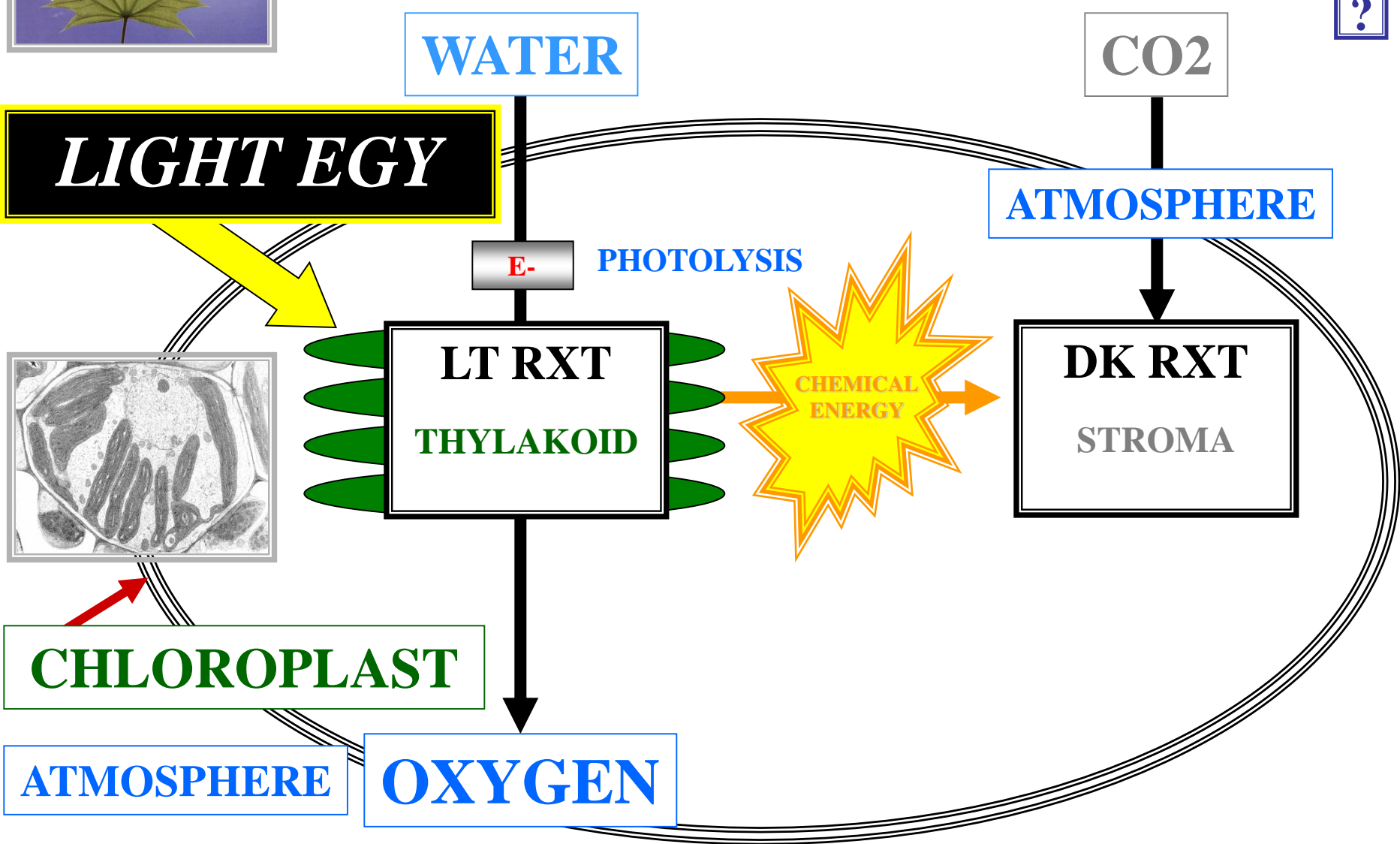
STROMA



CHLOROPLAST

ATMOSPHERE

OXYGEN



PHOTOSYNTHESIS

G



WATER

CO₂

LIGHT ENERGY

ATMOSPHERE

E-

PHOTOLYSIS

LT RXT

THYLAKOID

CHEMICAL ENERGY

DK RXT

STROMA

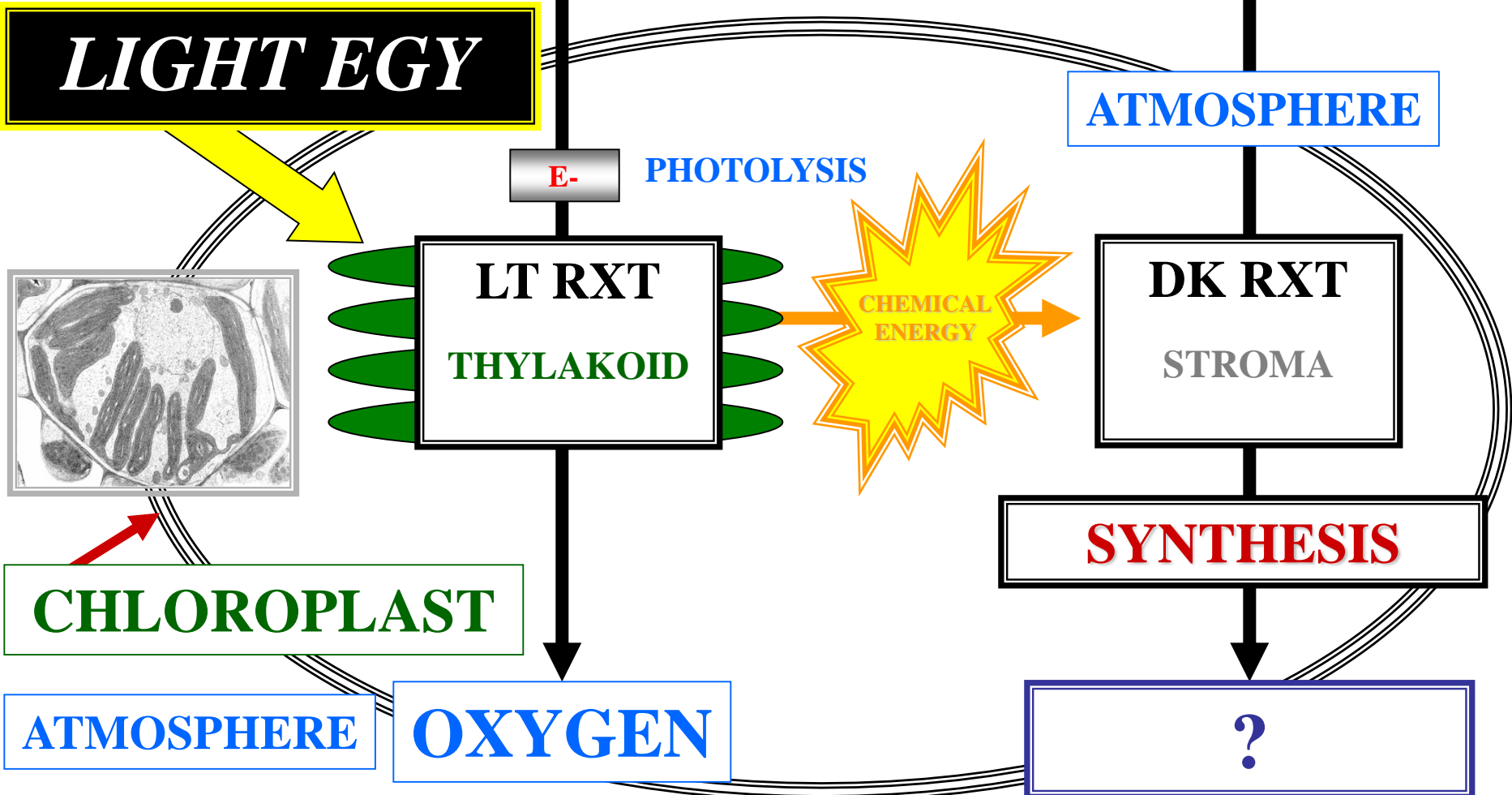
SYNTHESIS

CHLOROPLAST

ATMOSPHERE

OXYGEN

?



PHOTOSYNTHESIS



WATER

CO₂

LIGHT ENERGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS

LT RXT

THYLAKOID

ATP

DK RXT

STROMA

SYNTHESIS

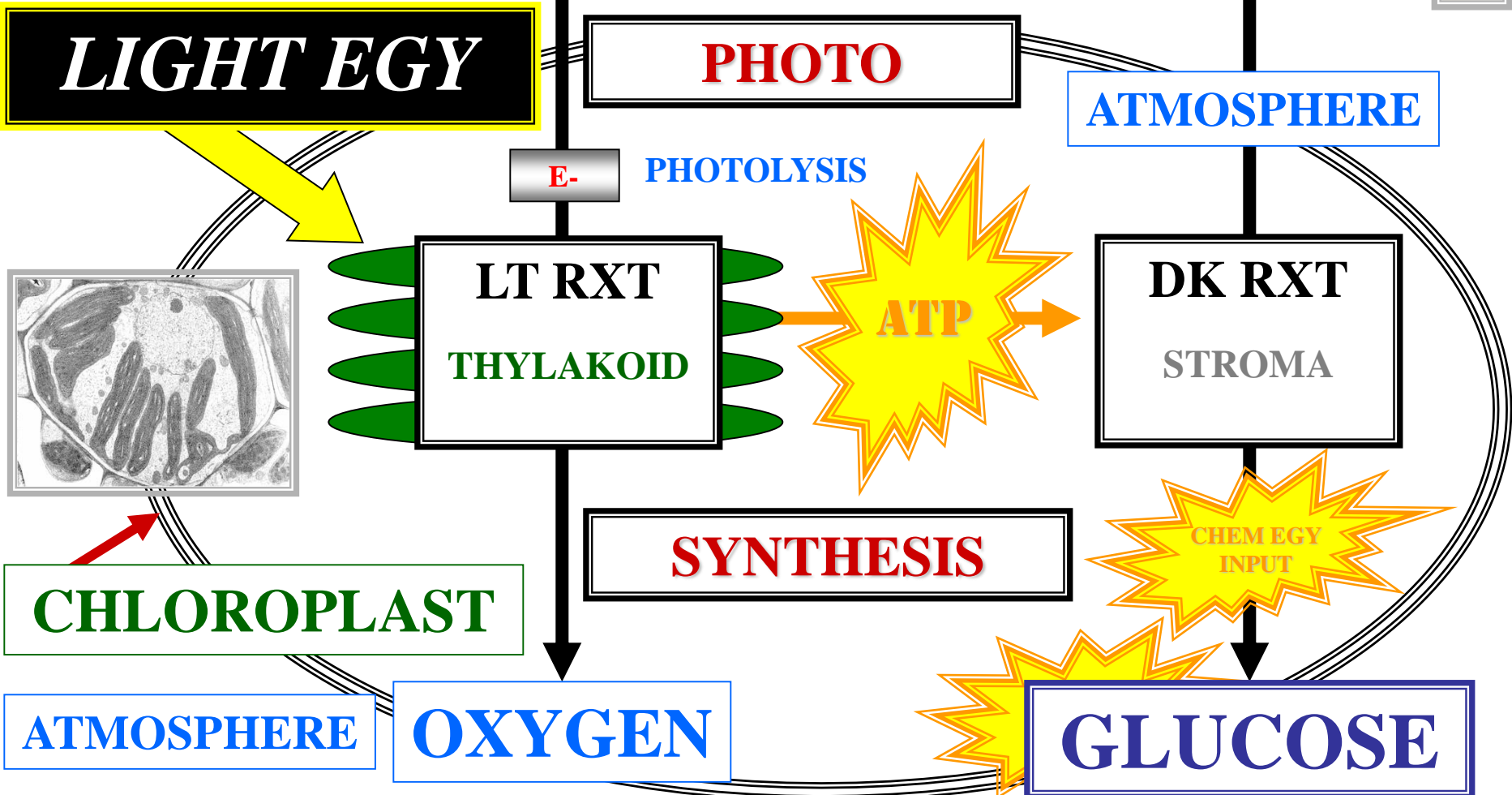
CHEMICAL INPUT

CHLOROPLAST

ATMOSPHERE

OXYGEN

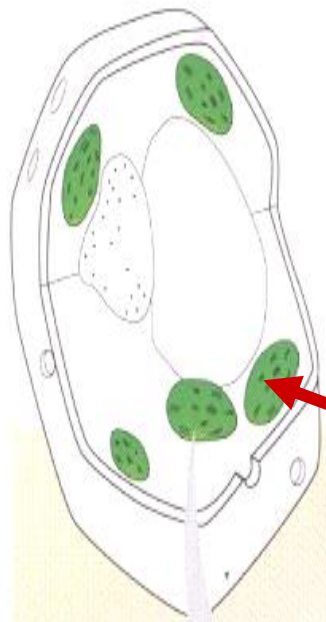
GLUCOSE



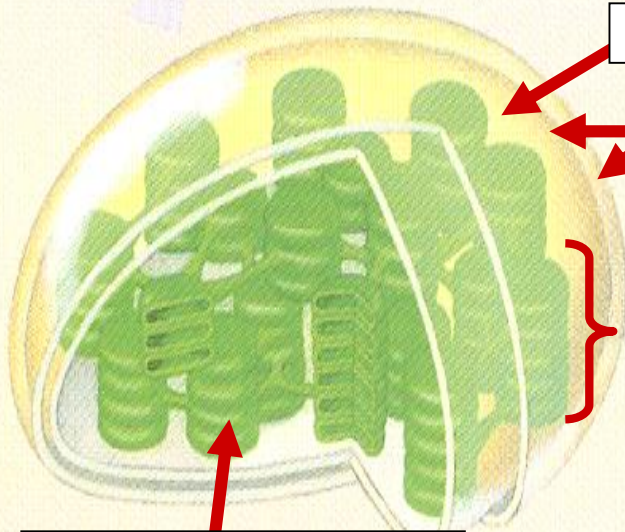


D

CHLOROPLAST ULTRASTRUCTURE



CHLOROPLAST

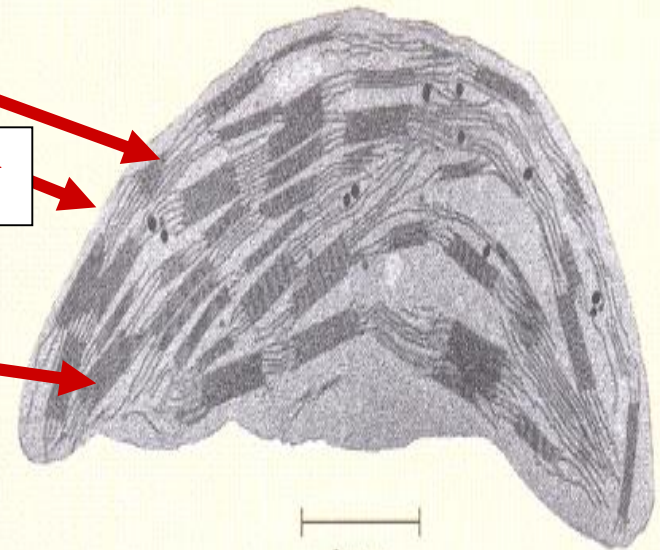


STROMA

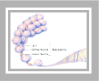
**OUTER & INNER
MEMBRANE**

GRANUM

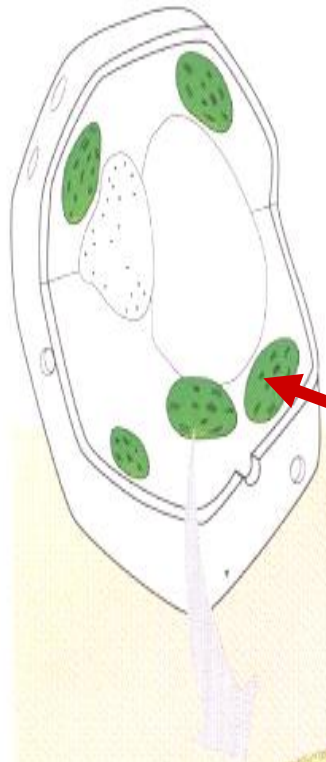
THYLAKOID MEMBRANE



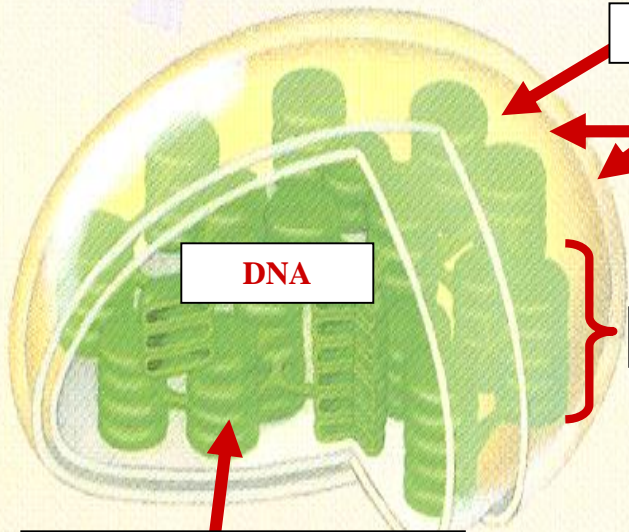
1 μ m



CHLOROPLAST ULTRASTRUCTURE



CHLOROPLAST

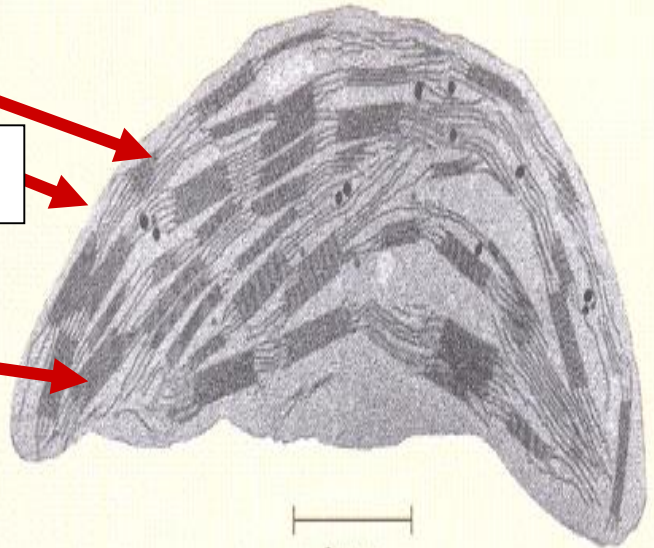


THYLAKOID MEMBRANE

STROMA

OUTER & INNER
MEMBRANE

GRANUM

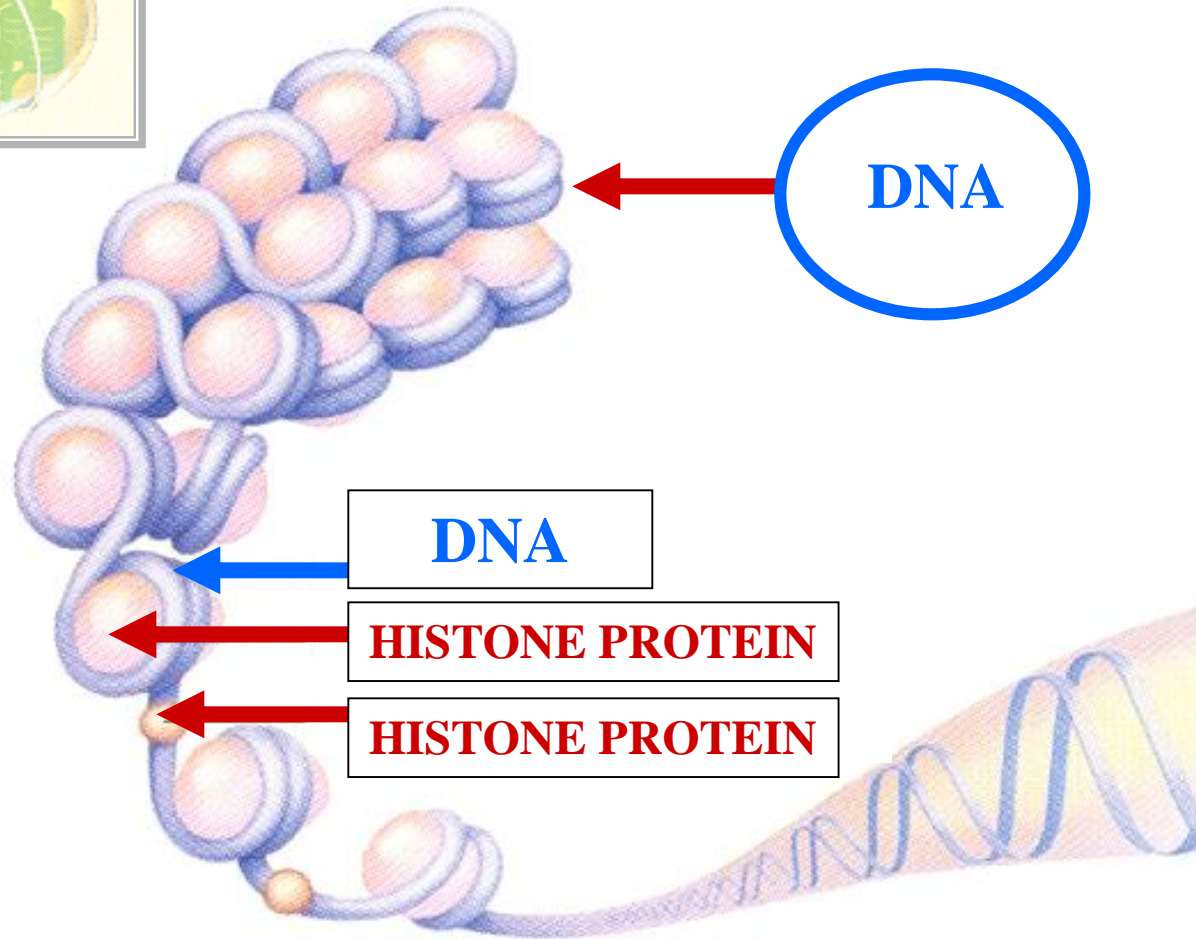


1 μm

CHLOROPLAST DNA

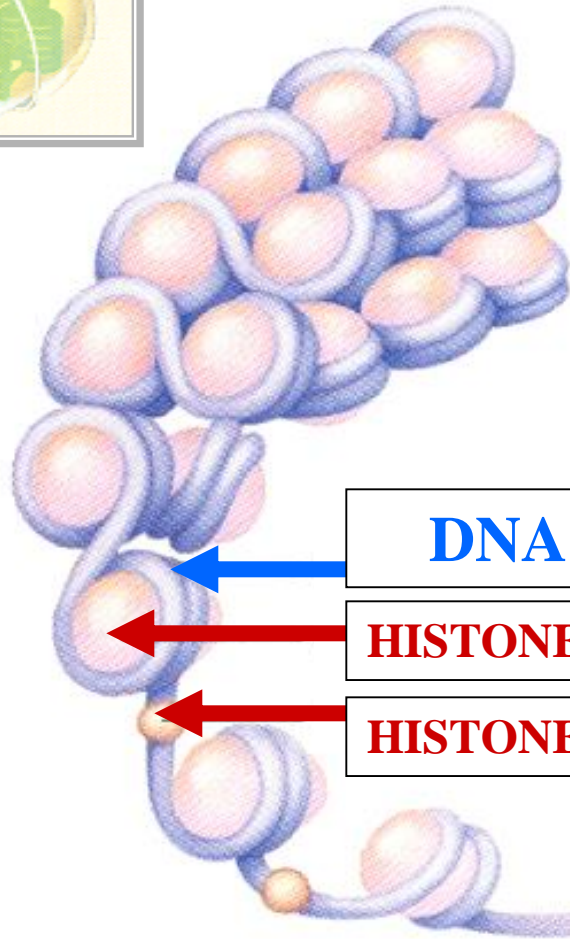


P



CHLOROPLAST DNA: HISTONE PROTEINS ABSENT

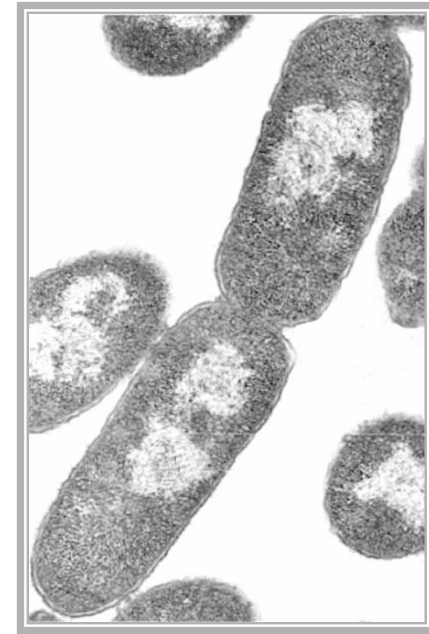
CHLOROPLAST DNA



DNA

HISTONE PROTEIN

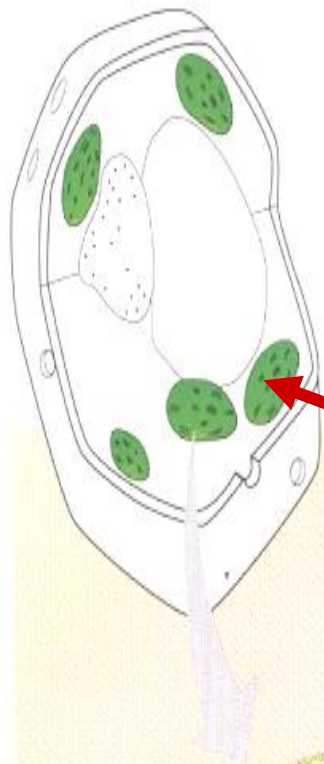
HISTONE PROTEIN



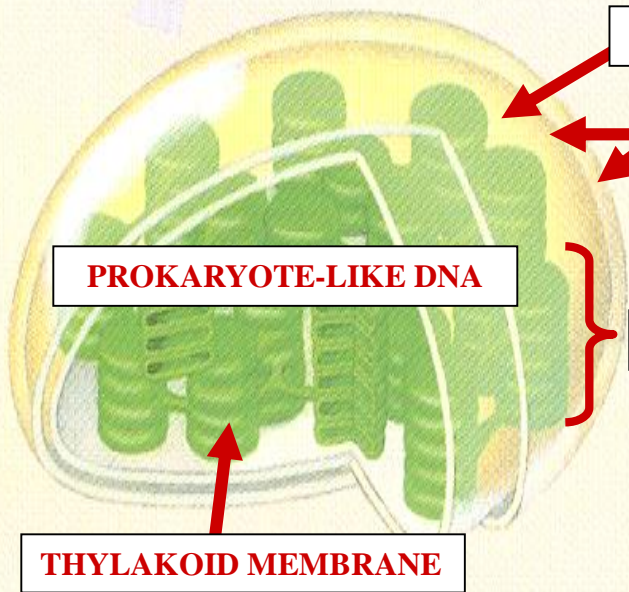
PROKARYOTE-LIKE

CHLOROPLAST DNA: HISTONE PROTEINS ABSENT

CHLOROPLAST ULTRASTRUCTURE



CHLOROPLAST



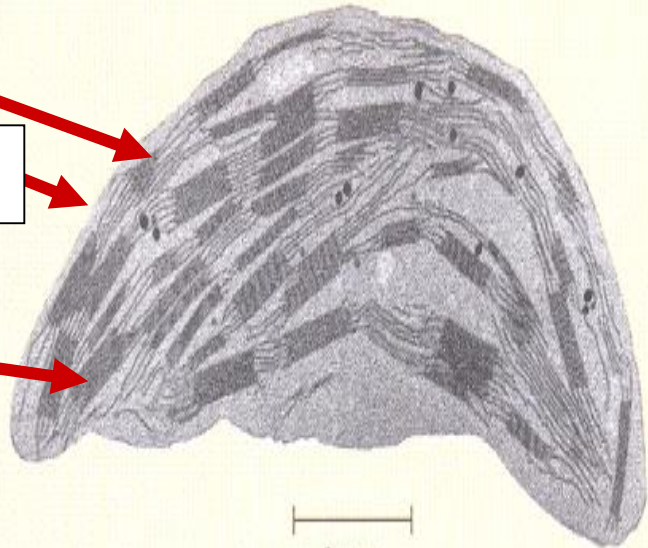
STROMA

OUTER & INNER
MEMBRANE

PROKARYOTE-LIKE DNA

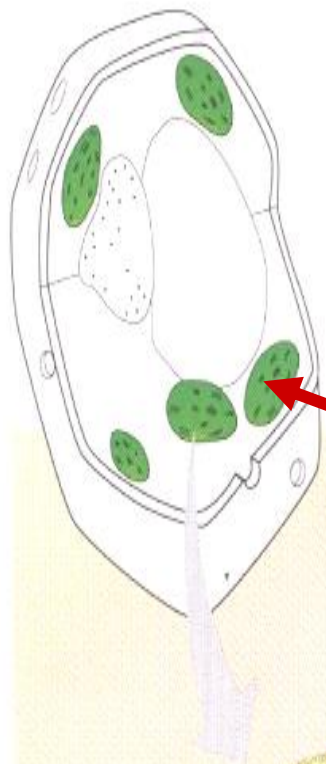
GRANUM

THYLAKOID MEMBRANE

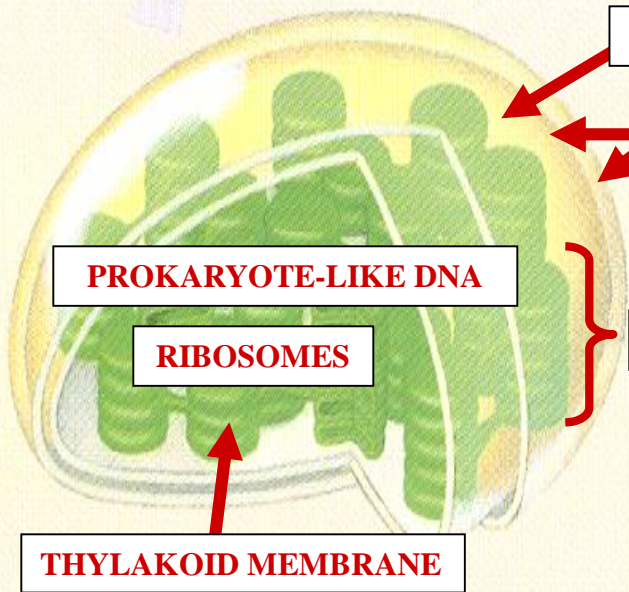


1 μ m

CHLOROPLAST ULTRASTRUCTURE



CHLOROPLAST



STROMA

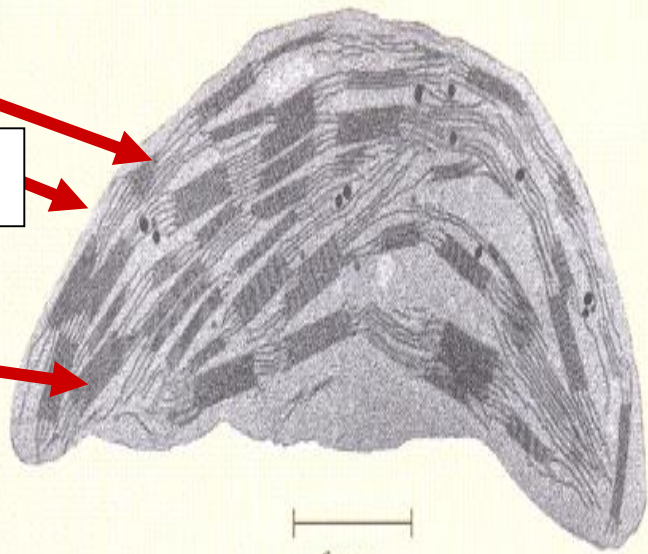
OUTER & INNER
MEMBRANE

PROKARYOTE-LIKE DNA

RIBOSOMES

GRANUM

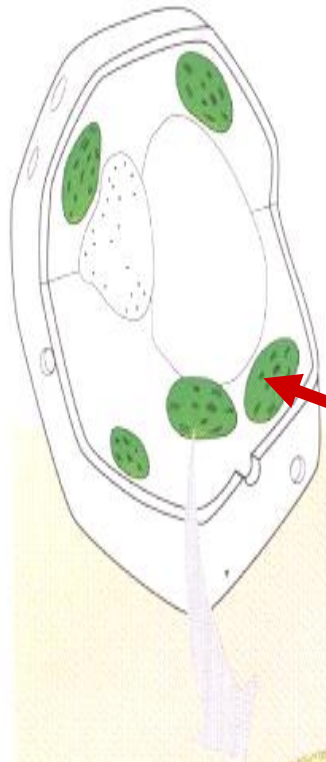
THYLAKOID MEMBRANE



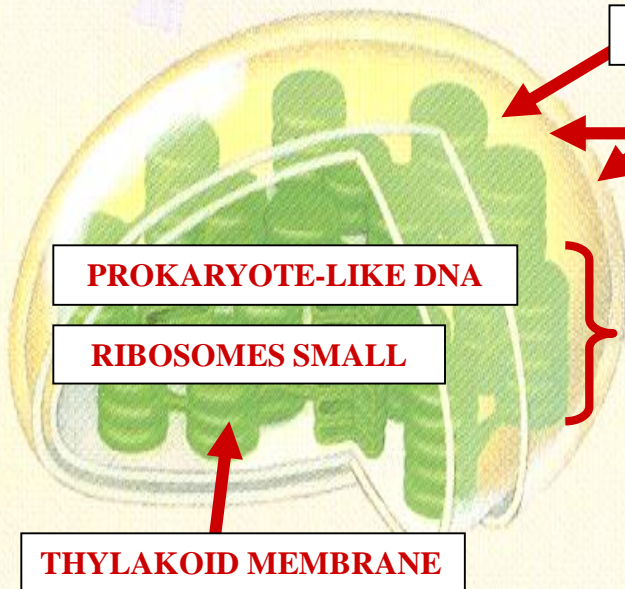
1 μ m



CHLOROPLAST ULTRASTRUCTURE



CHLOROPLAST



STROMA

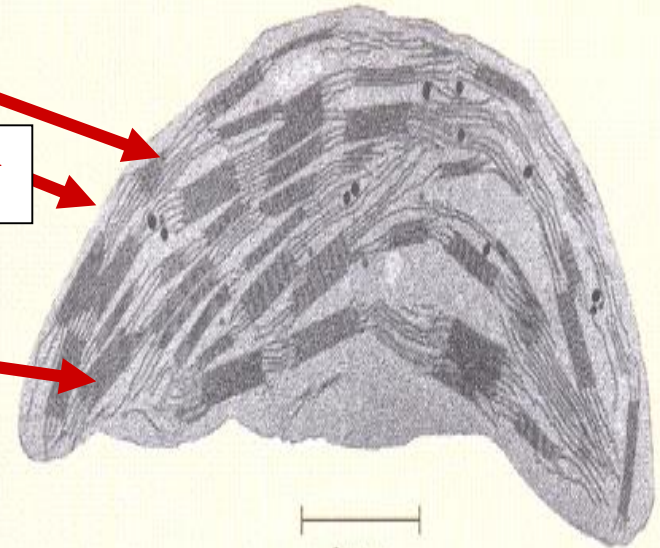
OUTER & INNER
MEMBRANE

PROKARYOTE-LIKE DNA

RIBOSOMES SMALL

THYLAKOID MEMBRANE

GRANUM



1 μ m

CHLOROPLAST RIBOSOME SMALL



3 RNAs & 54 PROTEINS

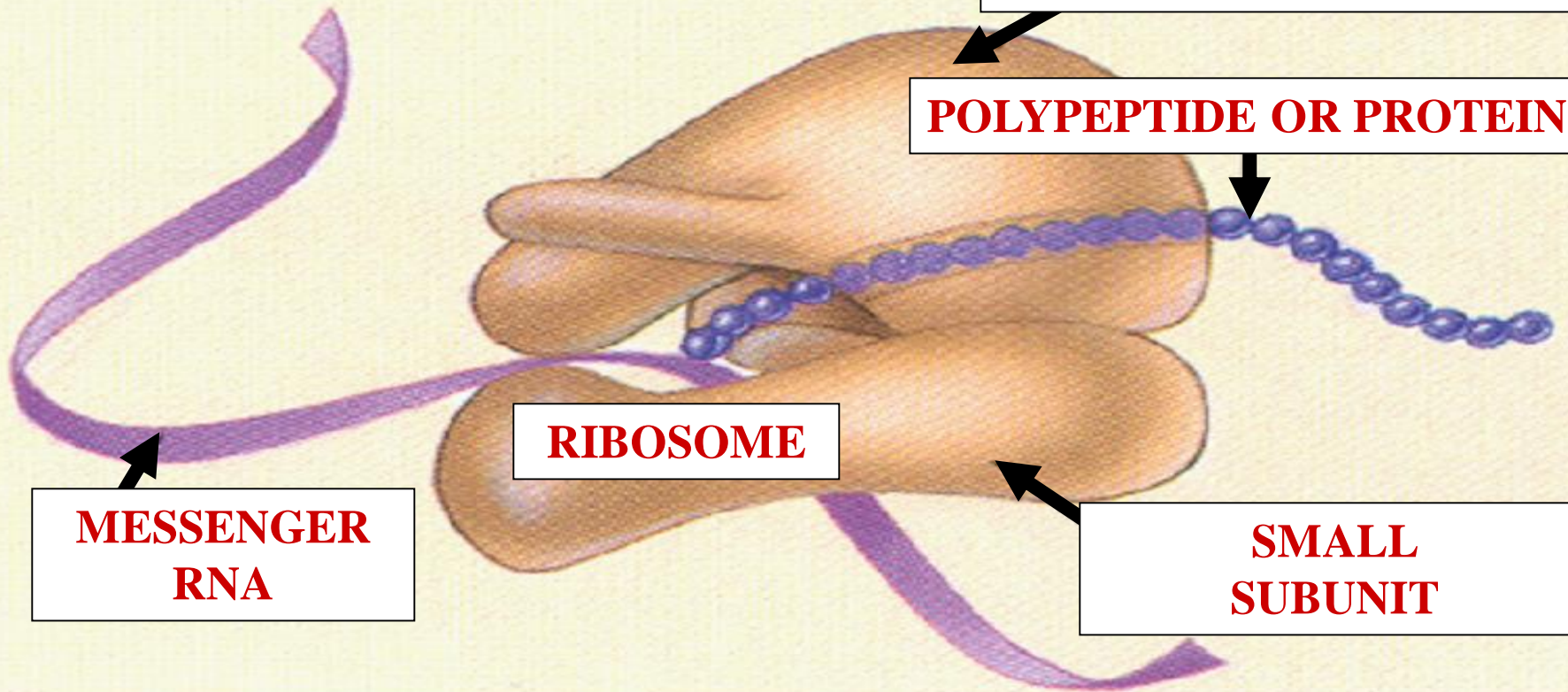
**LARGE
SUBUNIT**

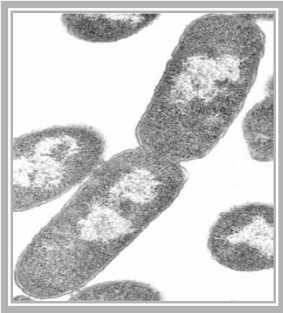
POLYPEPTIDE OR PROTEIN

RIBOSOME

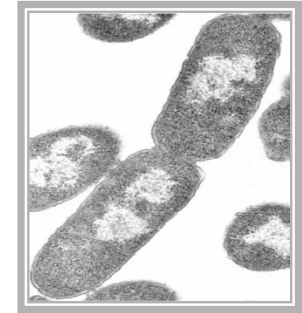
**MESSENGER
RNA**

**SMALL
SUBUNIT**





CHLOROPLAST RIBOSOME SMALL



S
+

PROKARYOTE-LIKE

PROKARYOTE-LIKE

3 RNAs & 54 PROTEINS

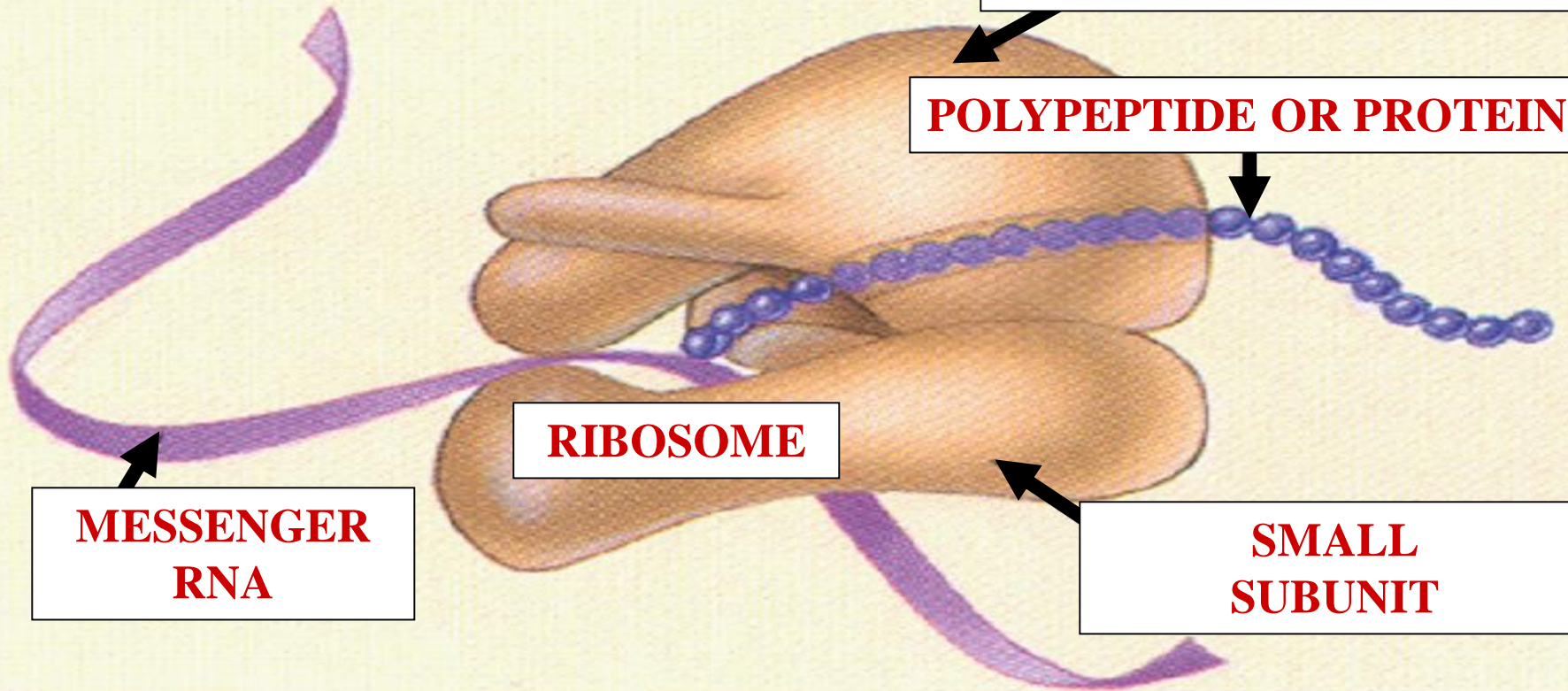
**LARGE
SUBUNIT**

POLYPEPTIDE OR PROTEIN

RIBOSOME

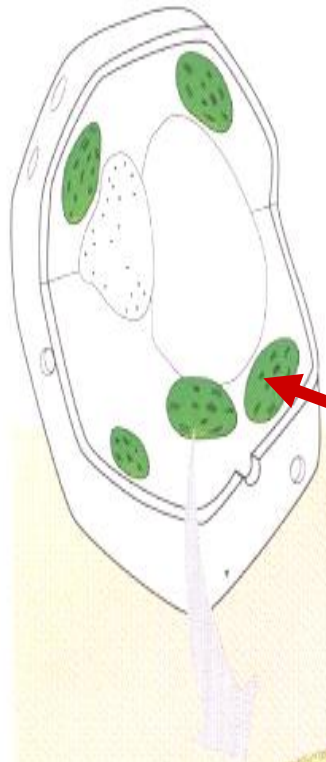
**MESSENGER
RNA**

**SMALL
SUBUNIT**

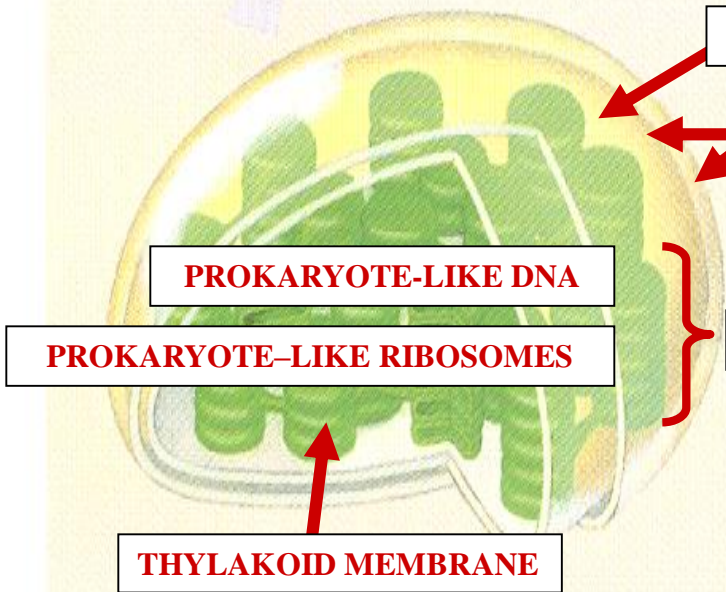




CHLOROPLAST ULTRASTRUCTURE



CHLOROPLAST



STROMA

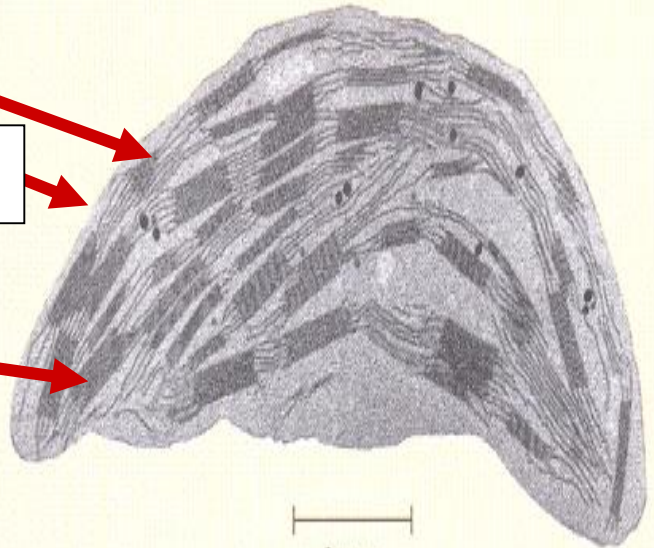
OUTER & INNER
MEMBRANE

PROKARYOTE-LIKE DNA

PROKARYOTE-LIKE RIBOSOMES

THYLAKOID MEMBRANE

GRANUM



1 μ m



CHLOROPLAST EVOLUTION

**TRUE PLANT
CYTOLOGY**

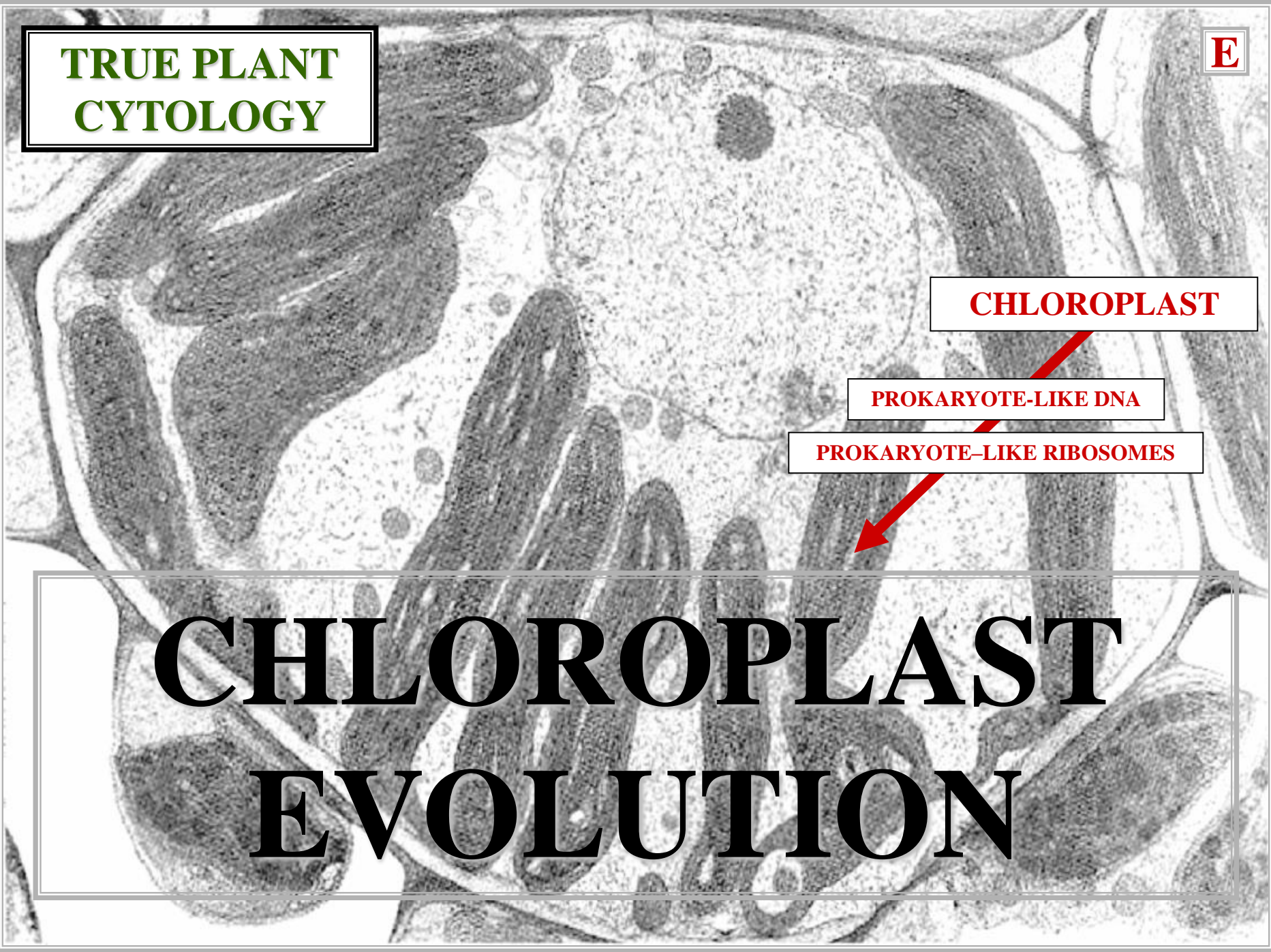
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CHLOROPLAST

PROKARYOTE-LIKE DNA

PROKARYOTE-LIKE RIBOSOMES

**CHLOROPLAST
EVOLUTION**



TRUE PLANT CYTOLOGY

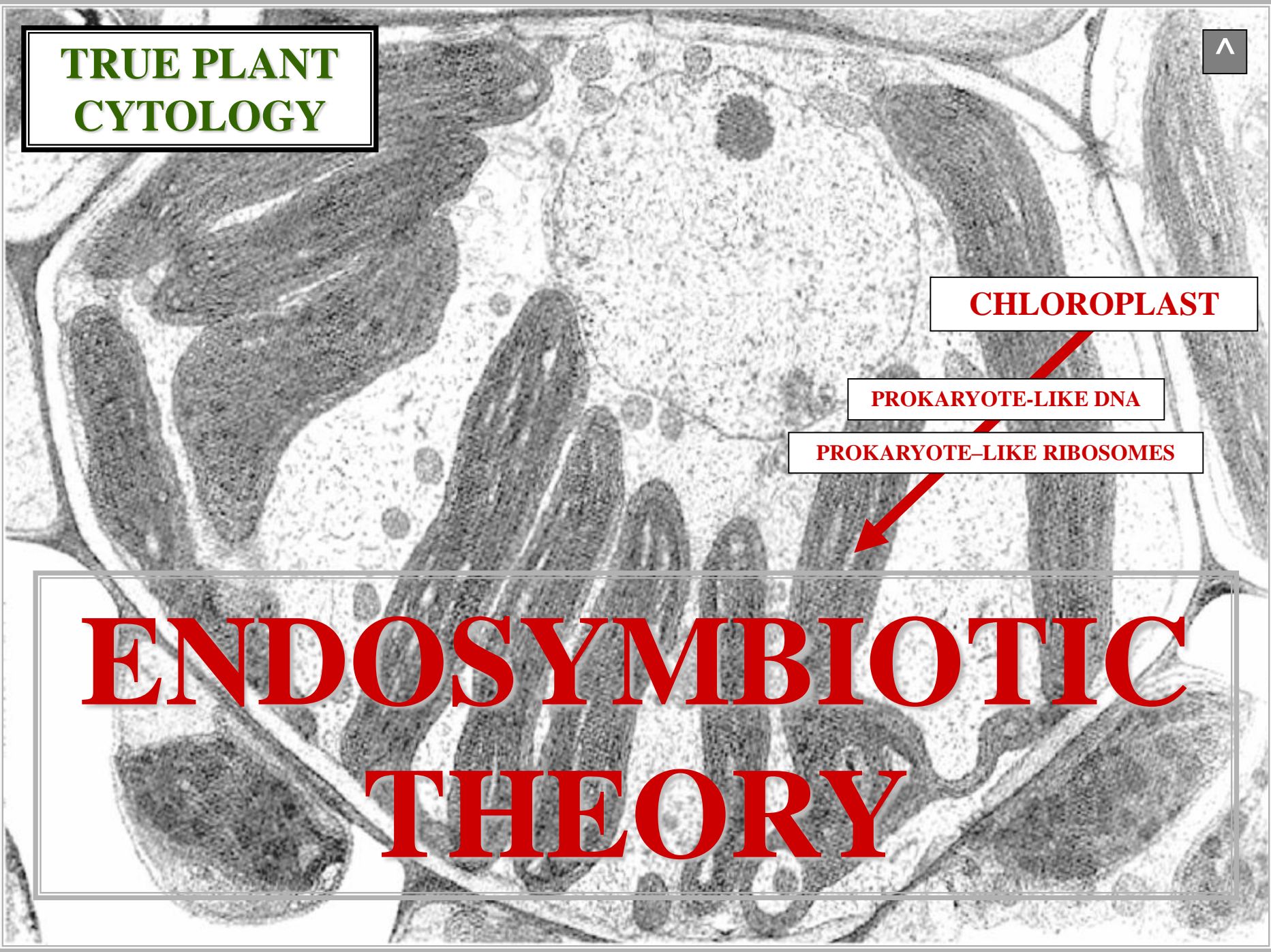


CHLOROPLAST

PROKARYOTE-LIKE DNA

PROKARYOTE-LIKE RIBOSOMES

ENDOSYMBIOTIC THEORY



MITOCHONDRION

MITOCHONDRION



MITOCHONDRION

**KNOWN ALL
EUKARYOTE CELLS**

MITOCHONDRION



MITOCHONDRION

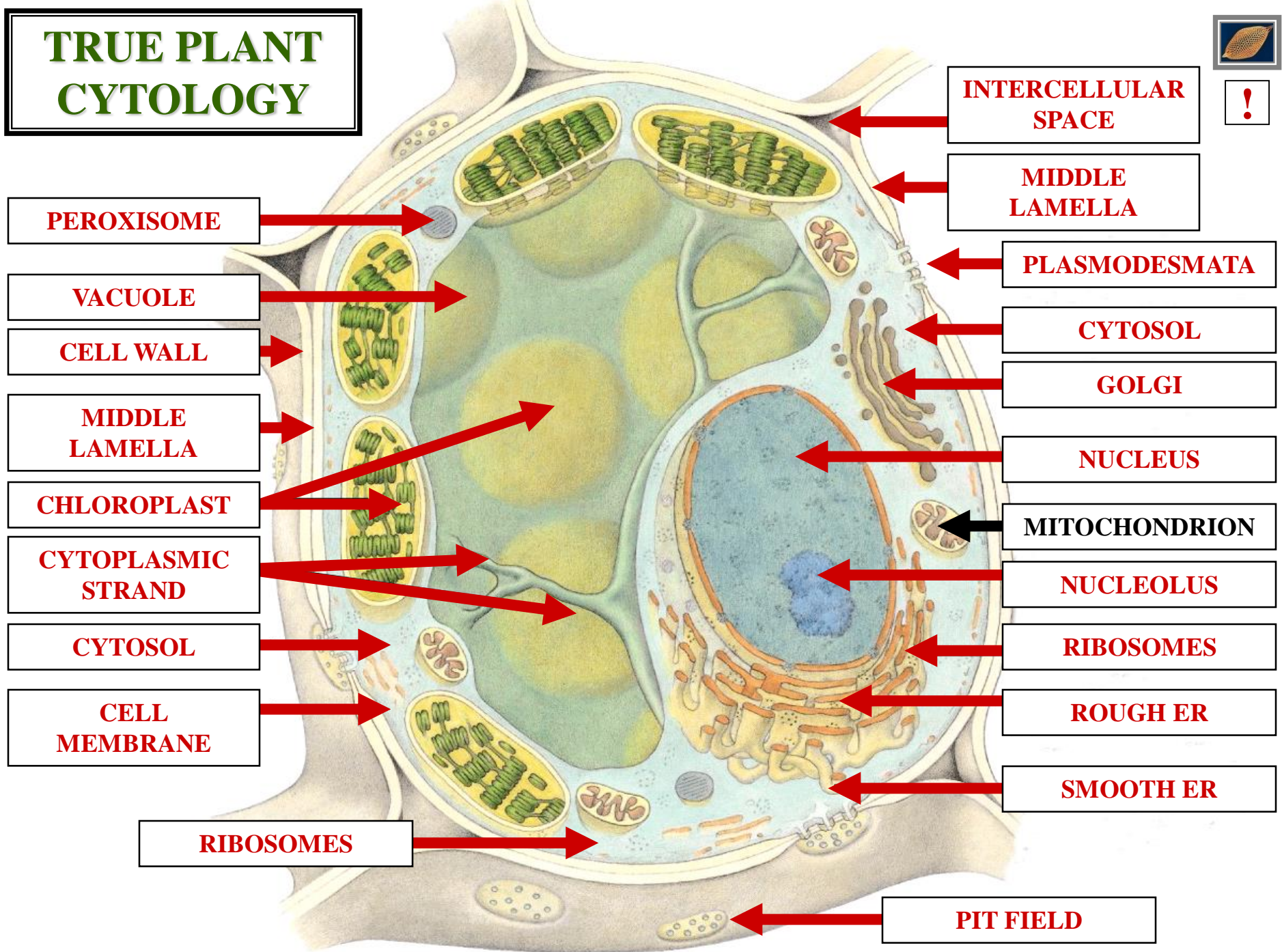
**KNOWN ALL
EUKARYOTE CELLS**

SITE

AEROBIC RESPIRATION

MITOCHONDRION

TRUE PLANT CYTOLOGY



PEROXISOME

VACUOLE

CELL WALL

MIDDLE LAMELLA

CHLOROPLAST

CYTOPLASMIC STRAND

CYTOSOL

CELL MEMBRANE

RIBOSOMES

INTERCELLULAR SPACE

MIDDLE LAMELLA

PLASMODESMATA

CYTOSOL

GOLGI

NUCLEUS

MITOCHONDRION

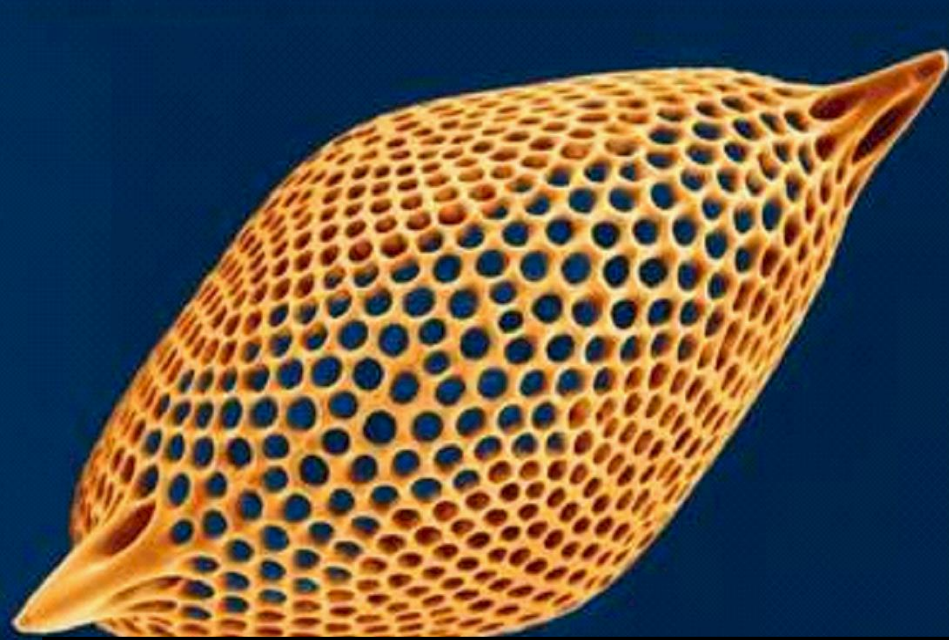
NUCLEOLUS

RIBOSOMES

ROUGH ER

SMOOTH ER

PIT FIELD

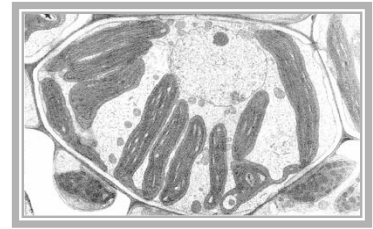


KNOWN ALL EUKARYOTES





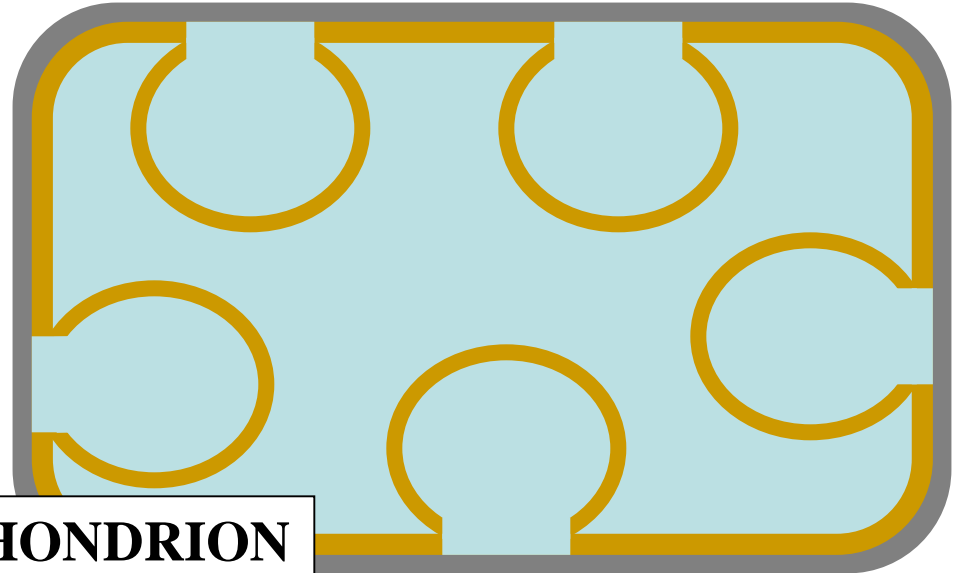
AEROBIC RESPIRATION



G

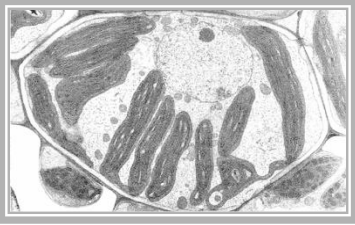


CYTOSOL

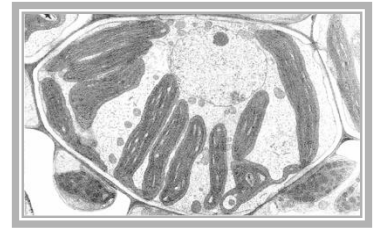


MITOCHONDRION

CELL



AEROBIC RESPIRATION



K

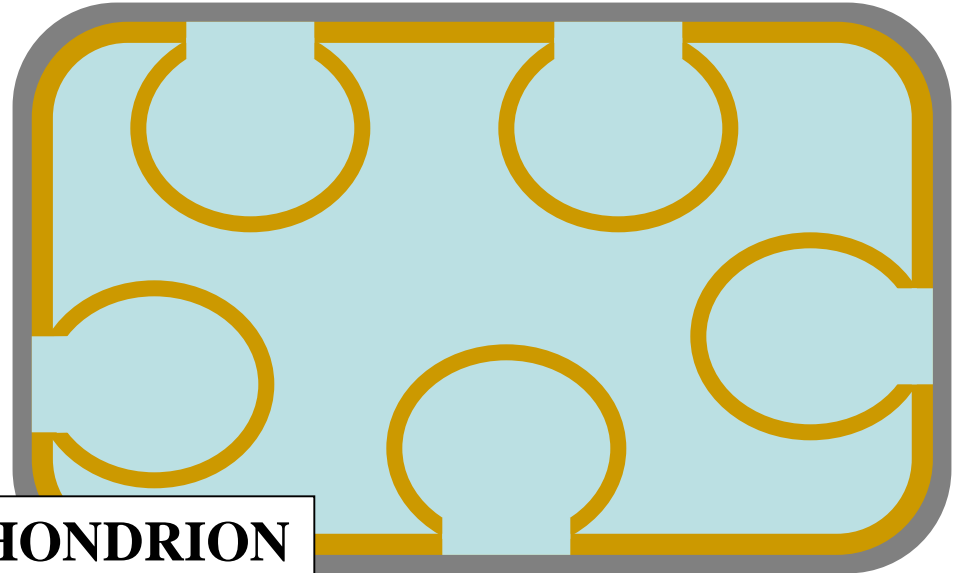
GLYCOLYSIS

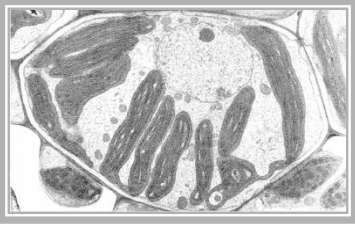


CYTOSOL

MITOCHONDRION

CELL





AEROBIC RESPIRATION



E

GLYCOLYSIS



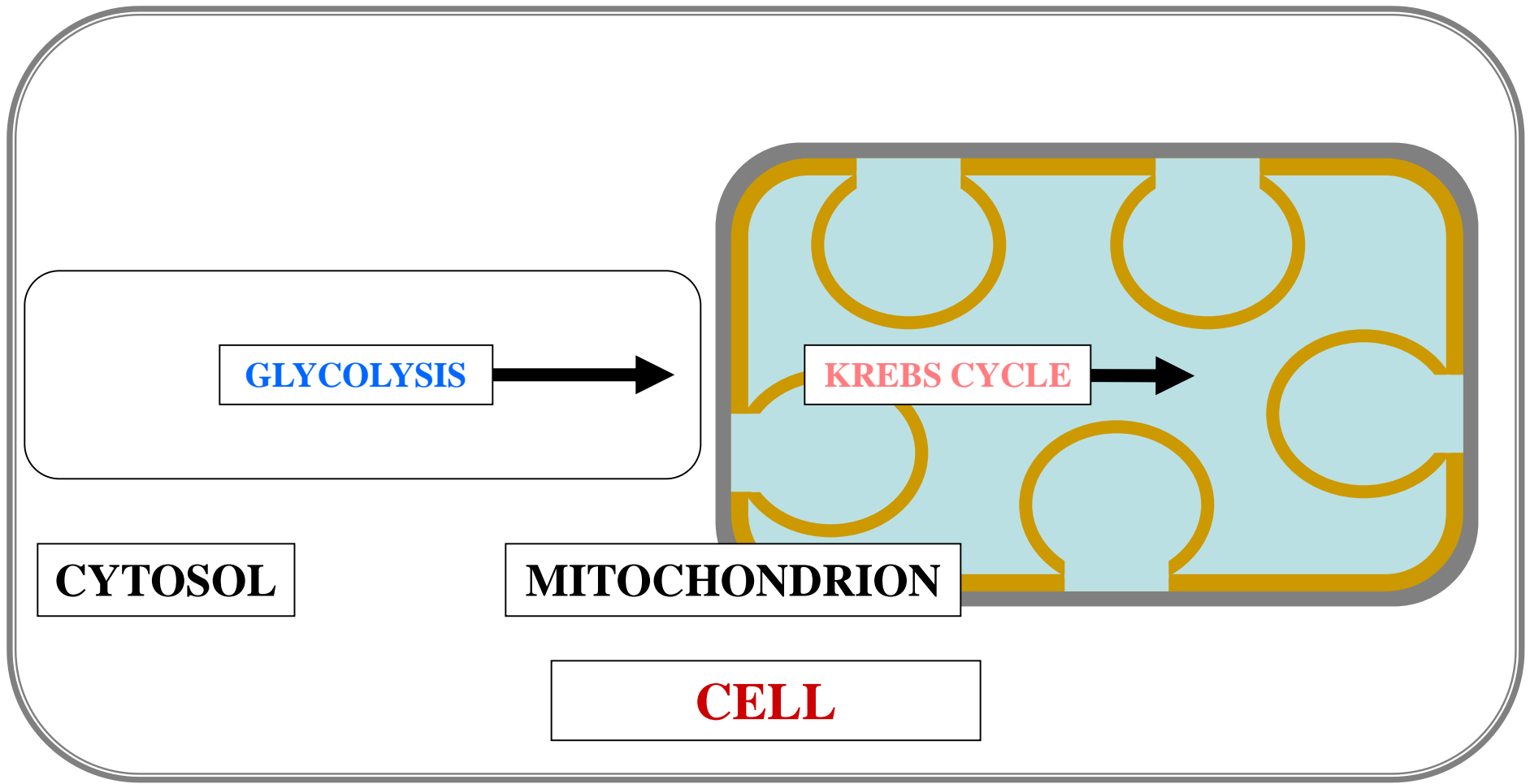
KREBS CYCLE



CYTOSOL

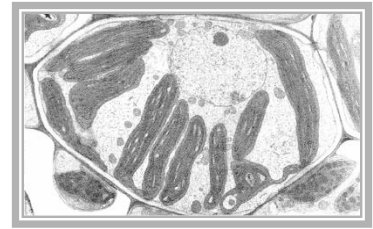
MITOCHONDRION

CELL





AEROBIC RESPIRATION



GLYCOLYSIS



KREBS CYCLE

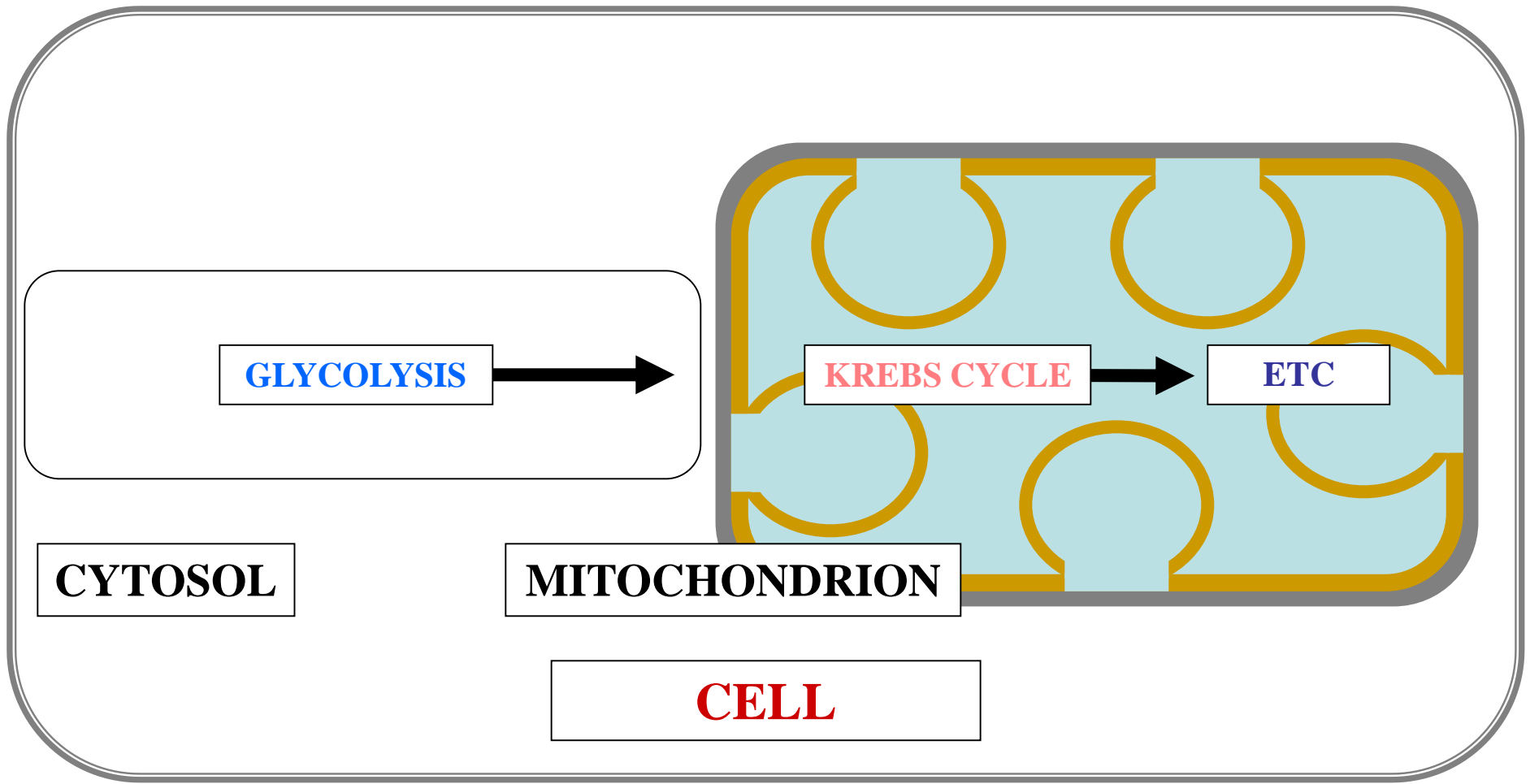


ETC

CYTOSOL

MITOCHONDRION

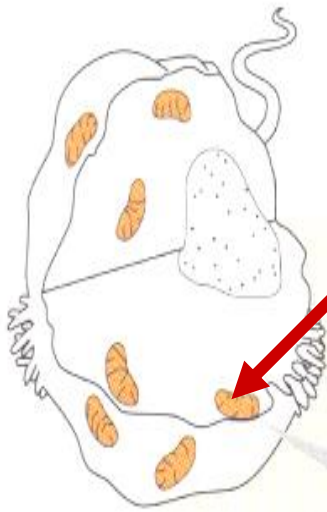
CELL



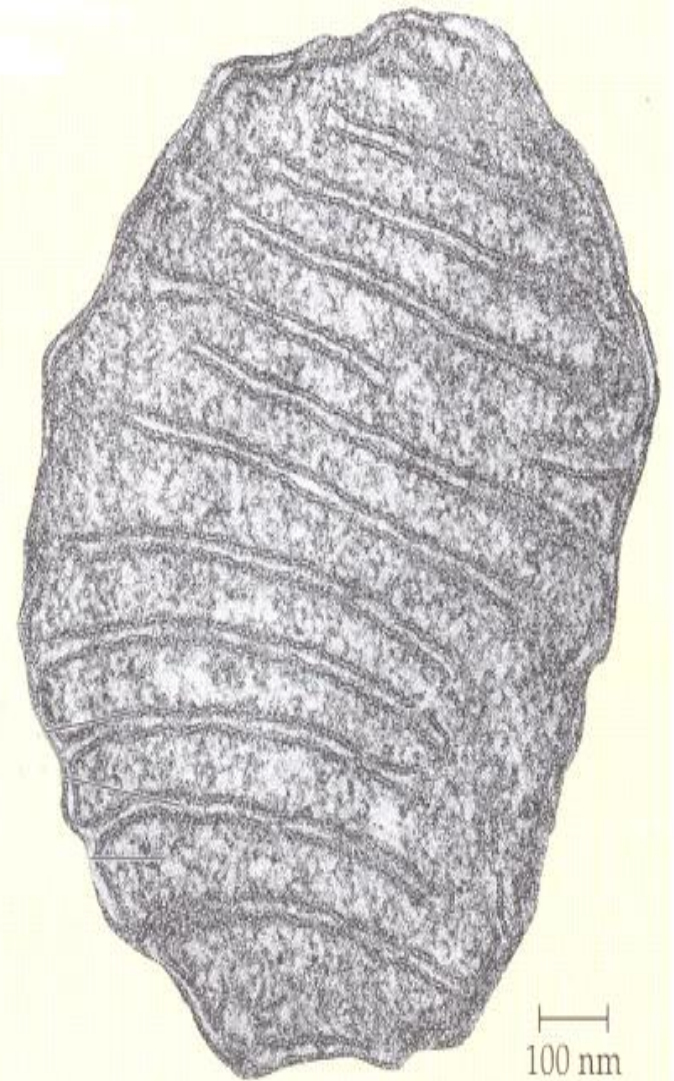
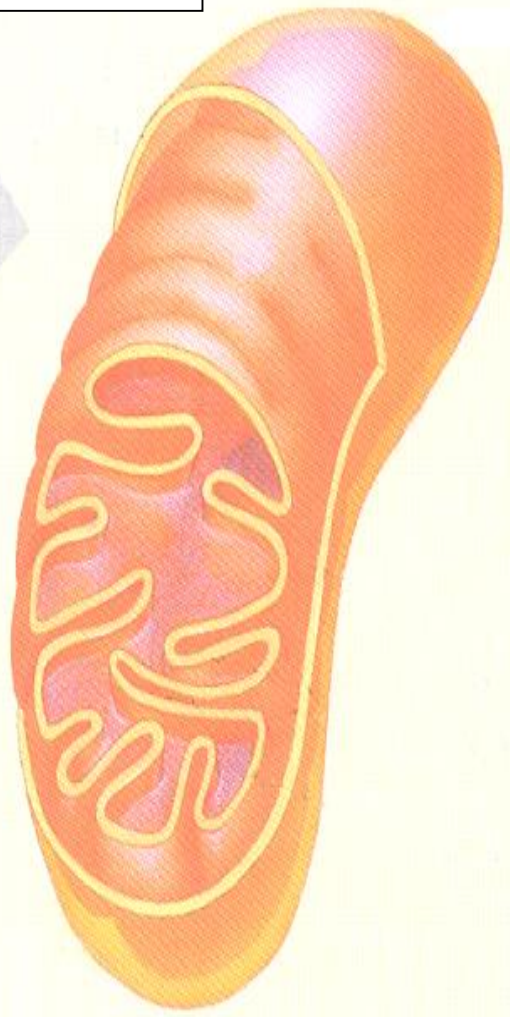


MITOCHONDRION ULTRASTRUCTURE

MITOCHONDRION ULTRASTRUCTURE

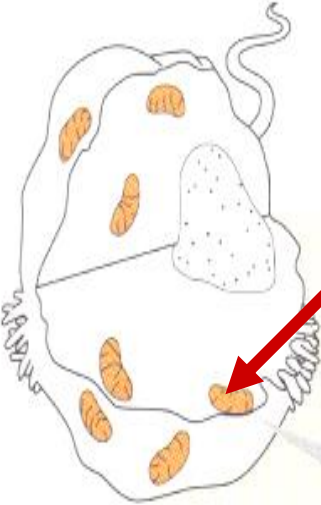


MITOCHONDRION



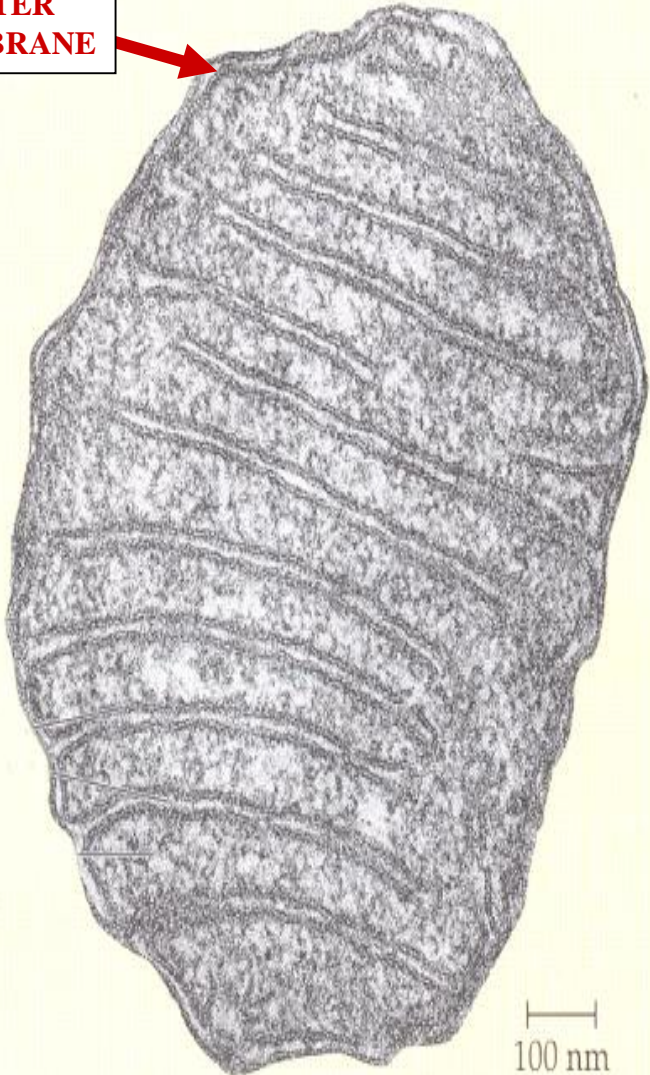
100 nm

MITOCHONDRION ULTRASTRUCTURE



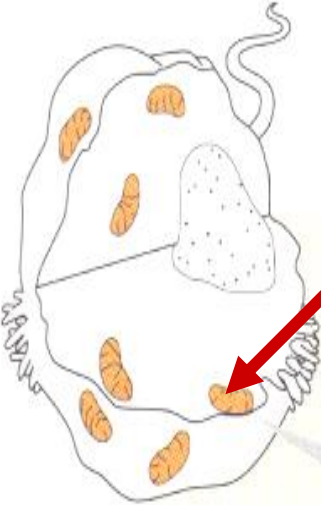
MITOCHONDRION

OUTER
MEMBRANE



100 nm

MITOCHONDRION ULTRASTRUCTURE

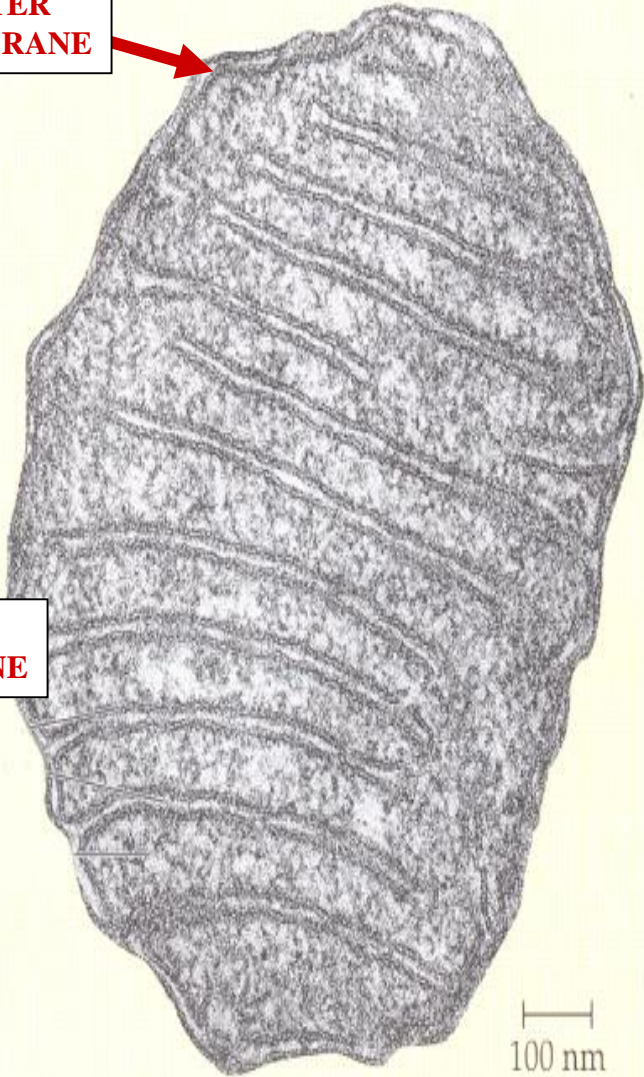
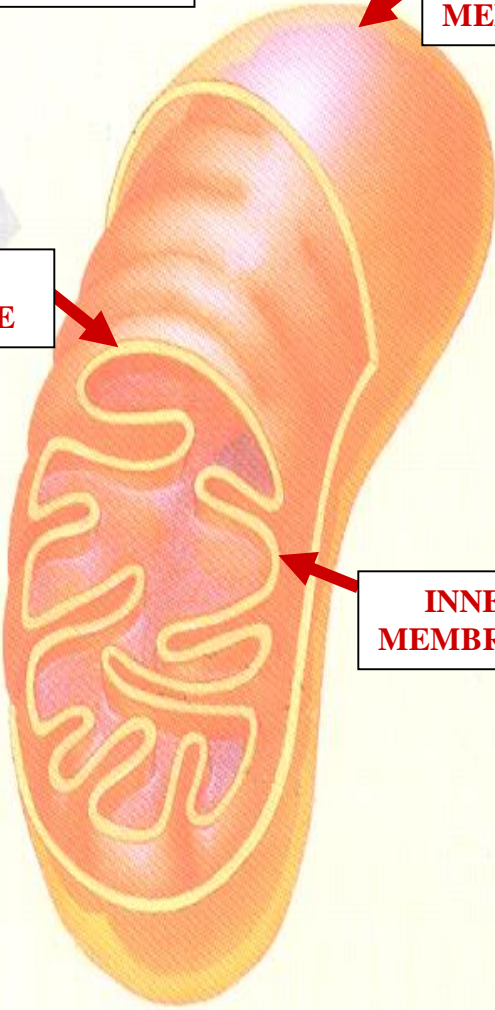


MITOCHONDRION

OUTER
MEMBRANE

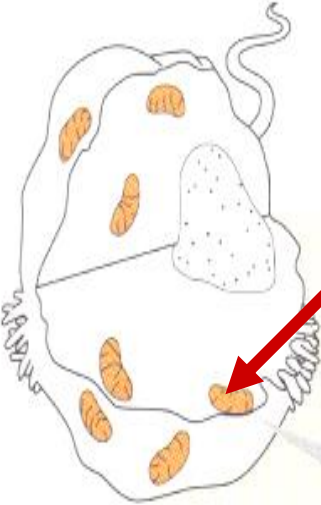
INNER
MEMBRANE

INNER
MEMBRANE



100 nm

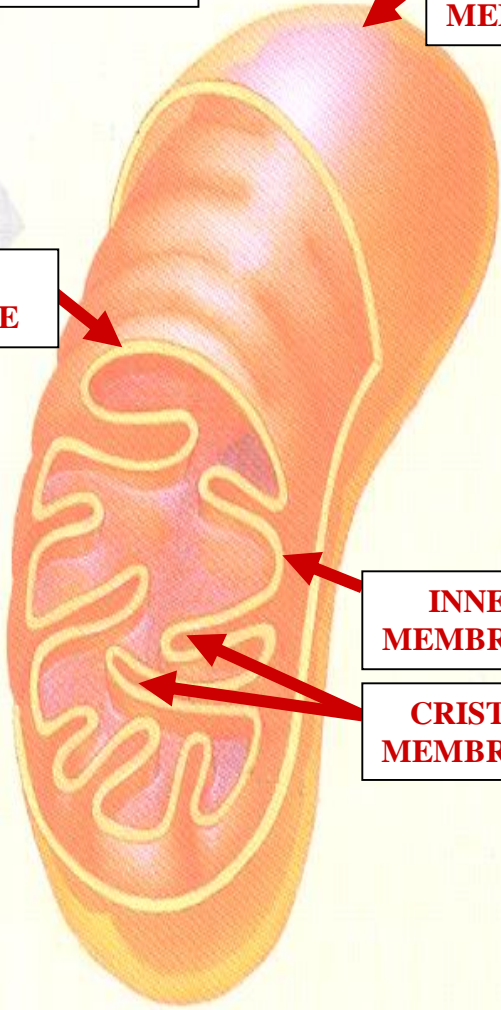
MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

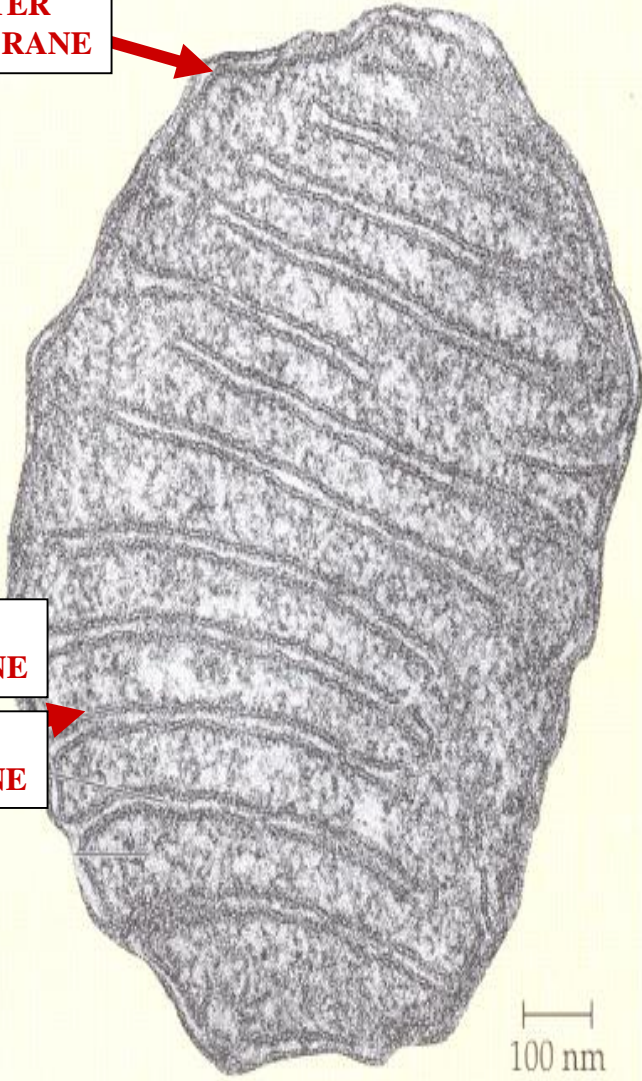
**OUTER
MEMBRANE**

**INNER
MEMBRANE**



**INNER
MEMBRANE**

**CRISTAE
MEMBRANE**



100 nm

INNER

MEMBRANE

SYNONYMOUS

CRISTAE

MEMBRANE

CRISTAE MEMBRANE



CRISTAE MEMBRANE

**MITOCHONDRION
INNER MEMBRANE**

CRISTAE MEMBRANE



CRISTAE
MEMBRANE
MITOCHONDRION
INNER MEMBRANE

SITE: ETC

CRISTAE
MEMBRANE

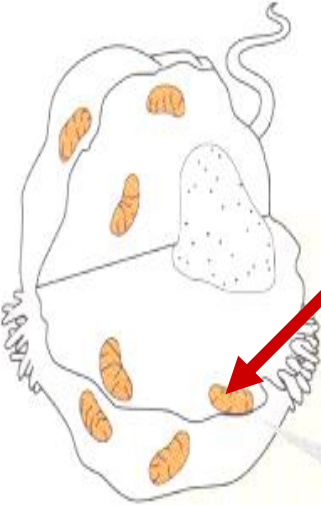


CRISTAE
MEMBRANE
MITOCHONDRION
INNER MEMBRANE

SITE: ETC
DERIVES ATP
CRISTAE
MEMBRANE

MITOCHONDRION ULTRASTRUCTURE

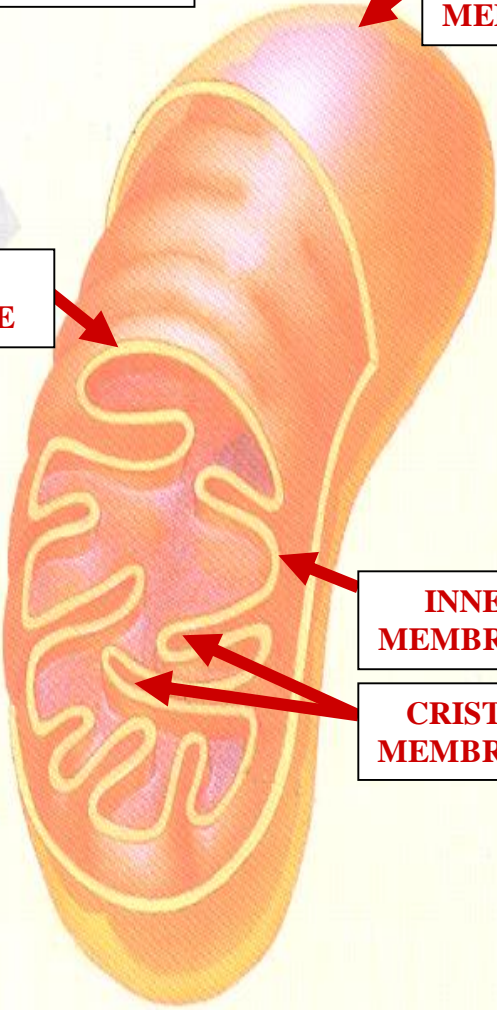
ETC



MITOCHONDRION

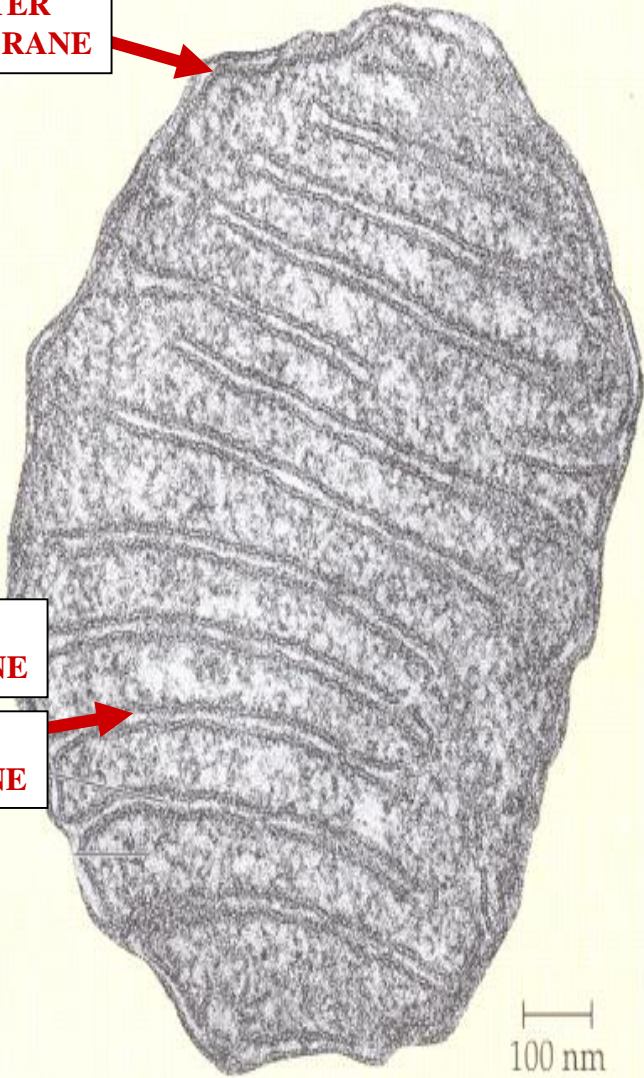
OUTER
MEMBRANE

INNER
MEMBRANE



INNER
MEMBRANE

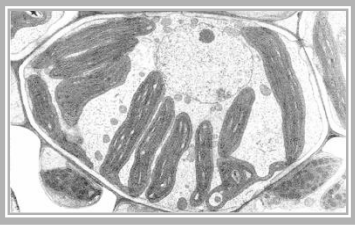
CRISTAE
MEMBRANE



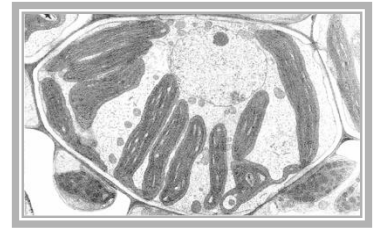
100 nm



ELECTRON TRANSPORT CHAIN



AEROBIC RESPIRATION



P

CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

ETC

CRISTAE

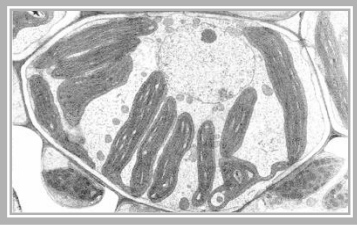
**CHEM EGY
INPUT**

P + ADP → ATP

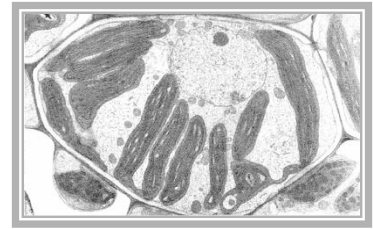
ATP

EGY





AEROBIC RESPIRATION



F

CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

ETC

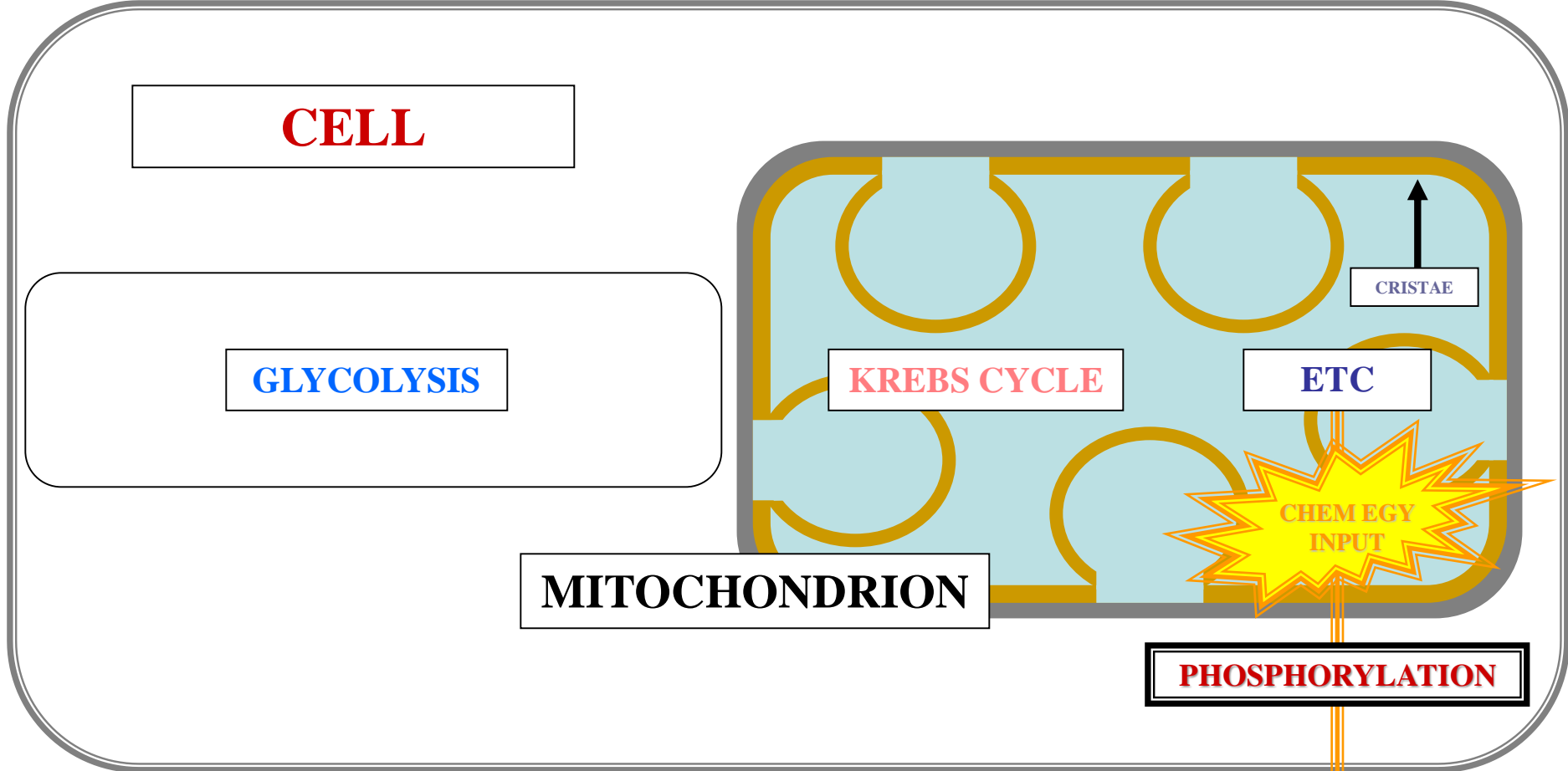
CRISTAE

**CHEM EGY
INPUT**

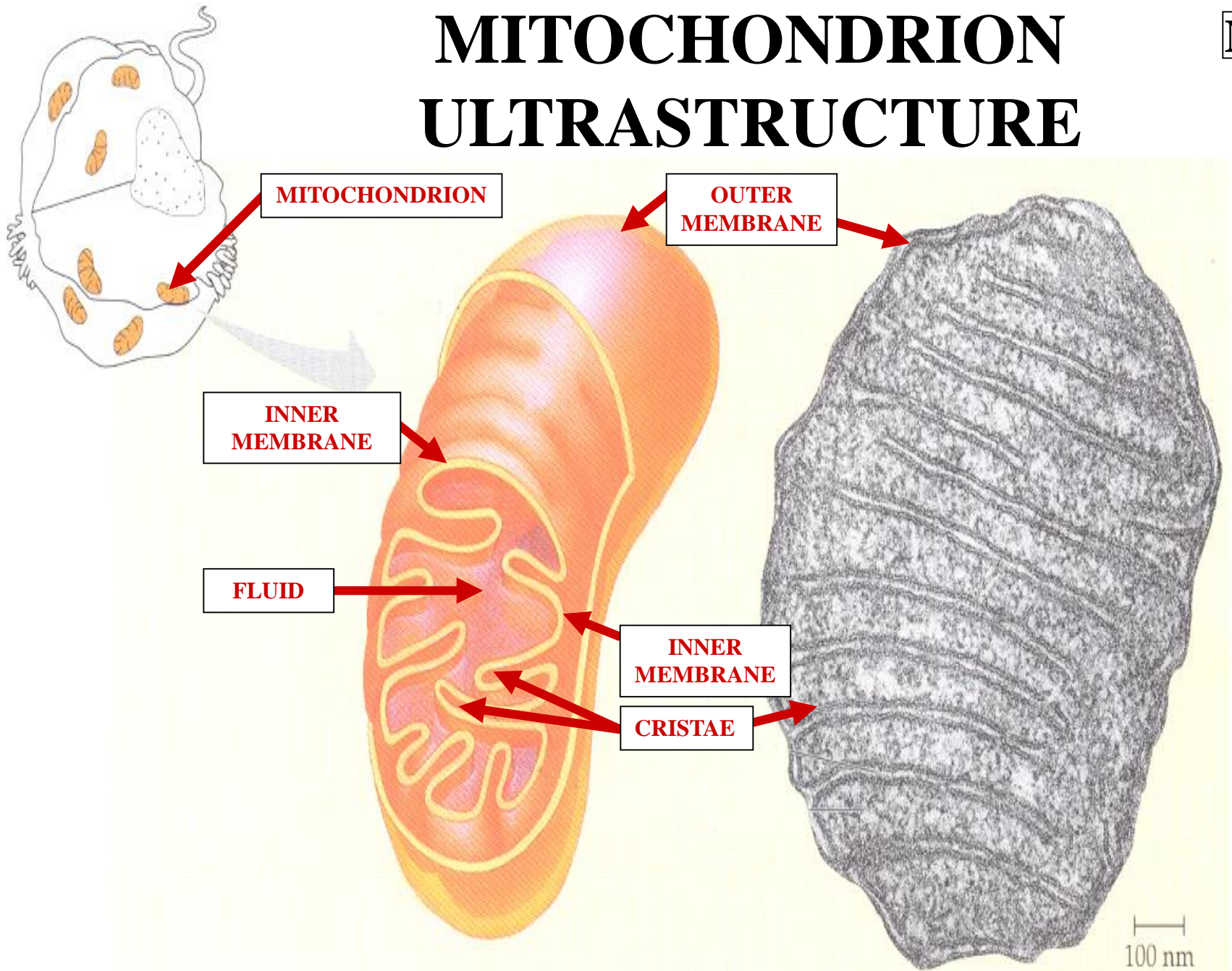
PHOSPHORYLATION

ATP

EGY



MITOCHONDRION ULTRASTRUCTURE



MATRIX



MATRIX

**MITOCHONDRION
INNER FLUID**

MATRIX



MATRIX

**MITOCHONDRION
INNER FLUID**

SITE: KREBS CYCLE

MATRIX



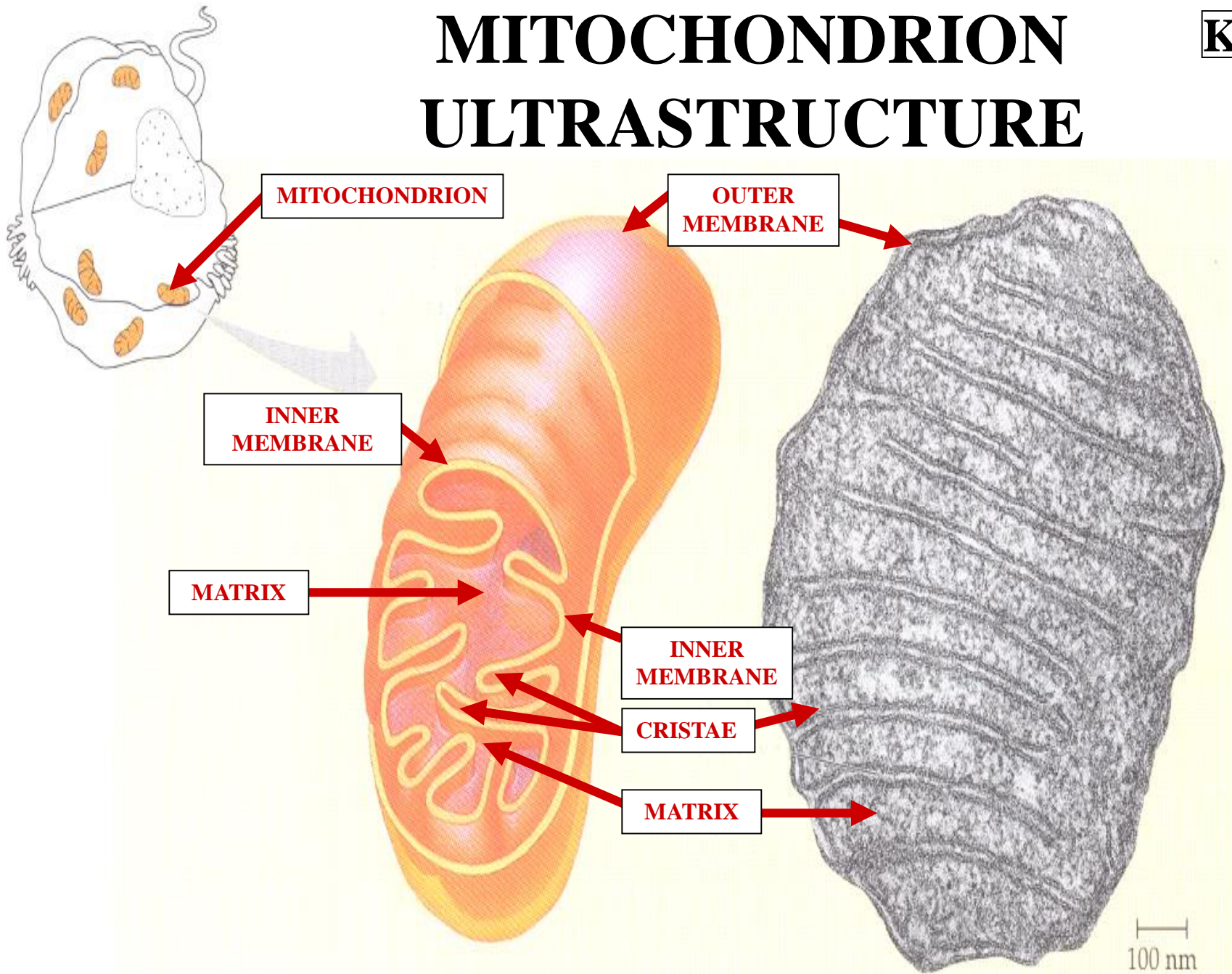
MATRIX

**MITOCHONDRION
INNER FLUID**

**SITE: KREBS CYCLE
DERIVES ATP**

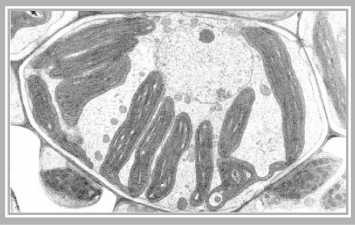
MATRIX

MITOCHONDRION ULTRASTRUCTURE

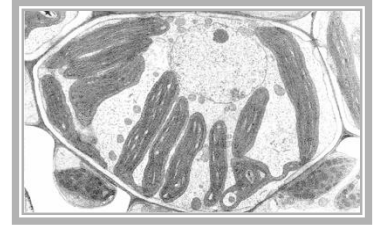




KREBS CYCLE



AEROBIC RESPIRATION

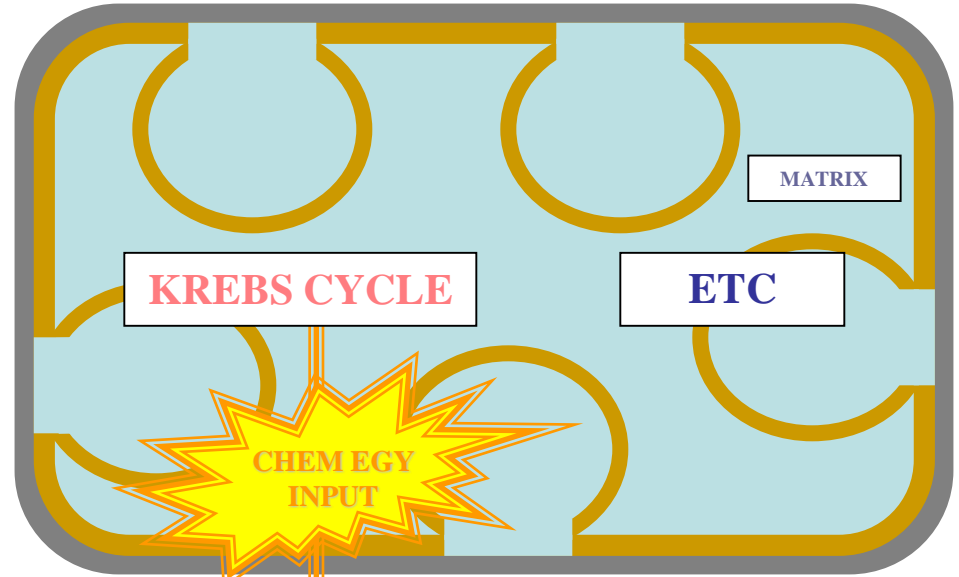


P

CELL

GLYCOLYSIS

MITOCHONDRION

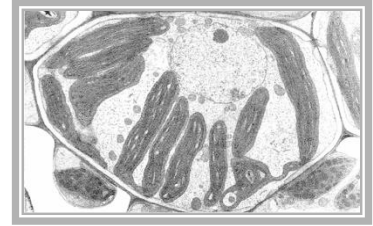


ATP

EGY



AEROBIC RESPIRATION



CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

ETC

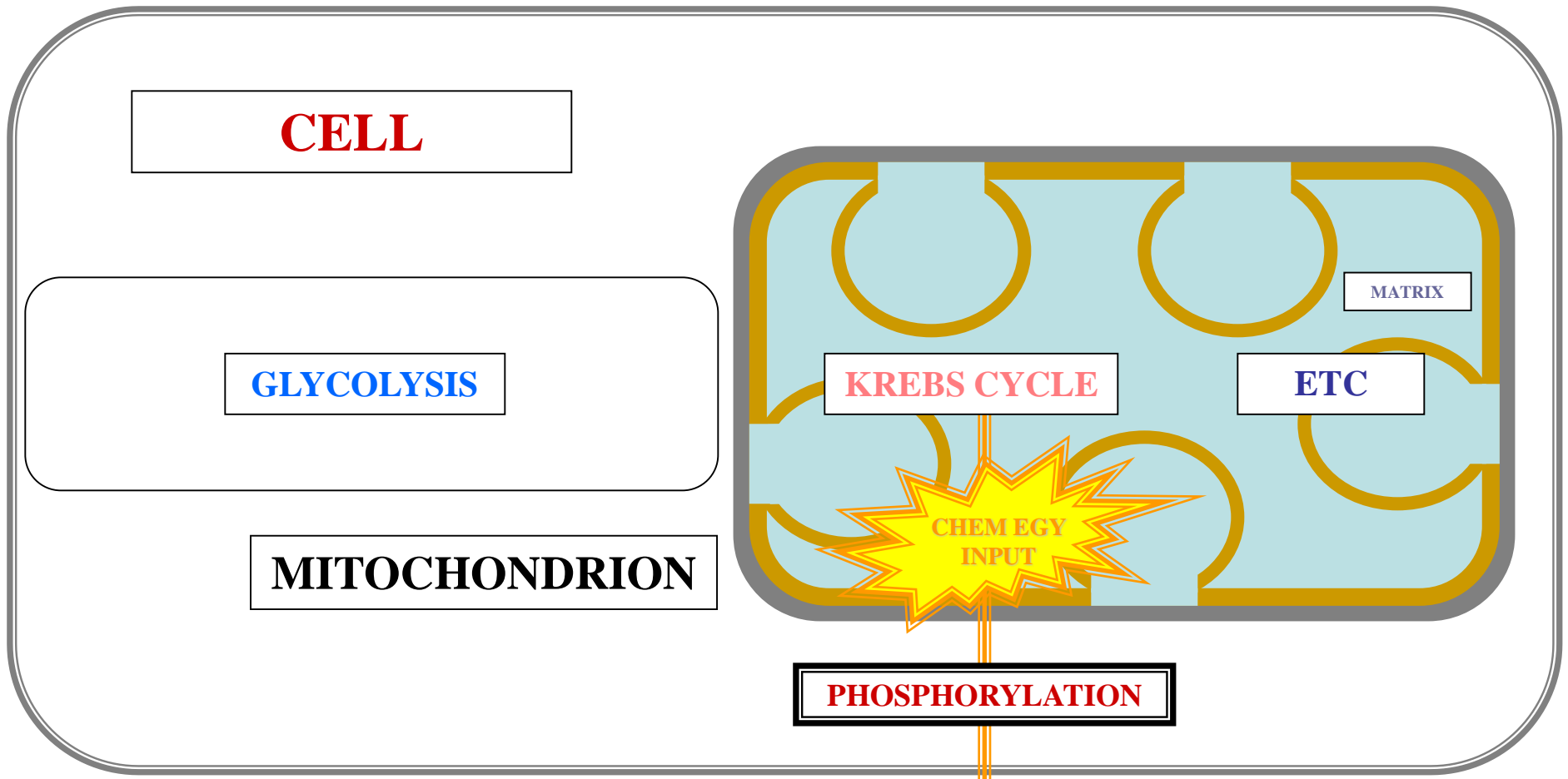
MATRIX

**CHEM EGY
INPUT**

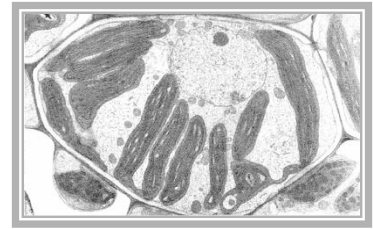
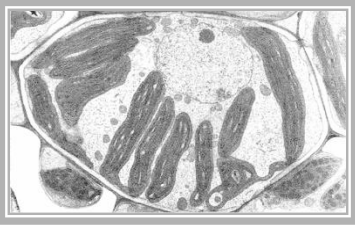
PHOSPHORYLATION

ATP

EGY



AEROBIC RESPIRATION



CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

ETC

PHOSPHORYLATION

ATP

ATP

EGY



CELL METABOLISM

C

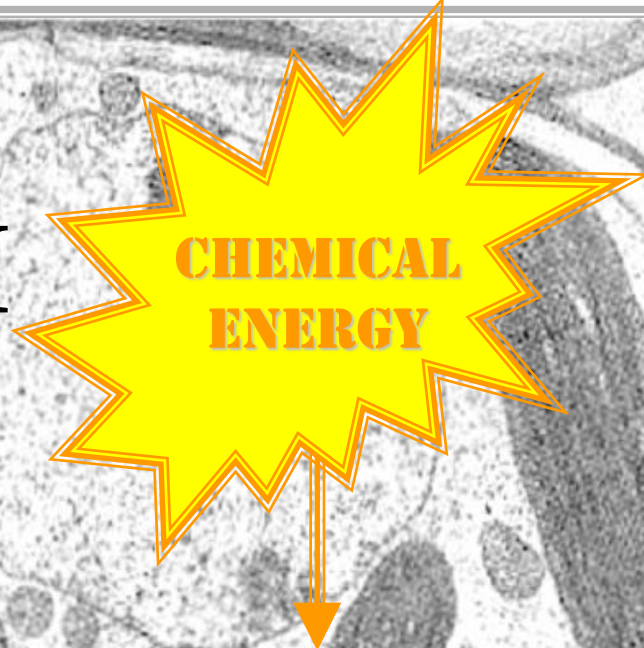


ATP



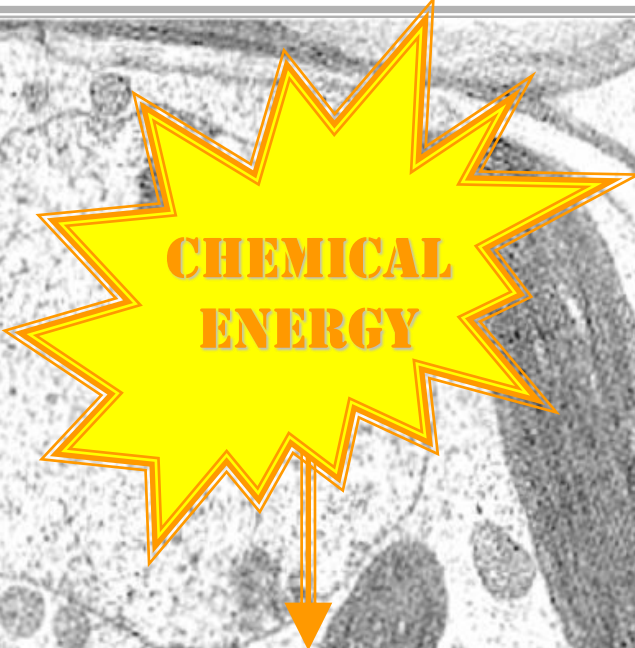
BIOCHEMICAL REACTION

CELL METABOLISM



BIOCHEMICAL REACTION

CELL METABOLISM



**CHEMICAL
ENERGY**



**ENDERGONIC
BIOCHEMICAL REACTION**

CELL METABOLISM

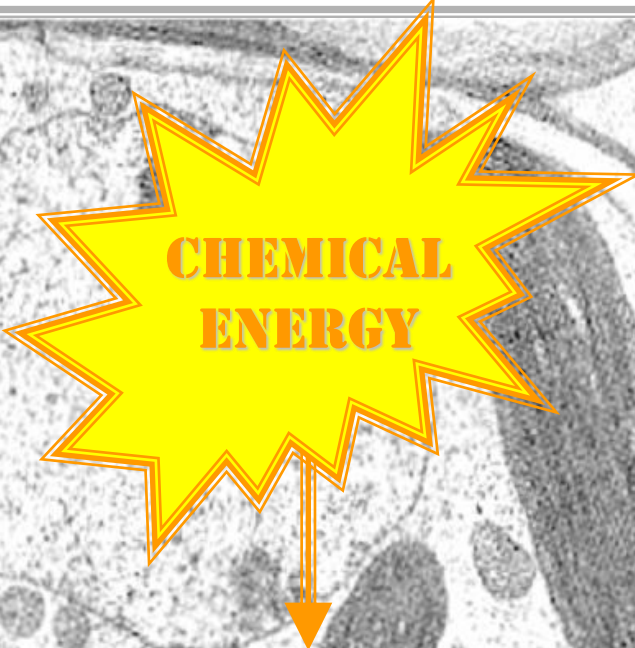


ATP

CMP-A + CMP-B → CMP-C

**ATP DELIVERS CHEM-EGY
TO DRIVE
ENDERGONIC
BIOCHEMICAL REACTIONS**

CELL METABOLISM



**CHEMICAL
ENERGY**

CMP-A + CMP-B → CMP-C

**ATP DELIVERS CHEM-EGY
TO DRIVE ENDERGONIC
BIOCHEMICAL REACTIONS
TO A PRODUCT**

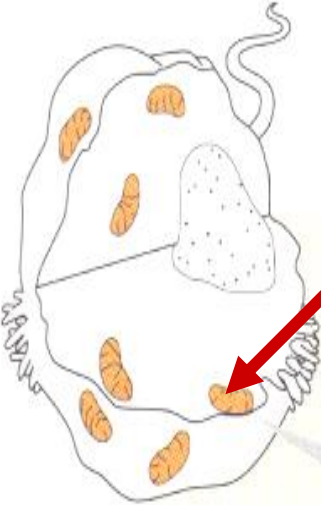
***EFFICIENT
CELL
METABOLISM***



HOMEOSTASIS



MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

INNER
MEMBRANE



?

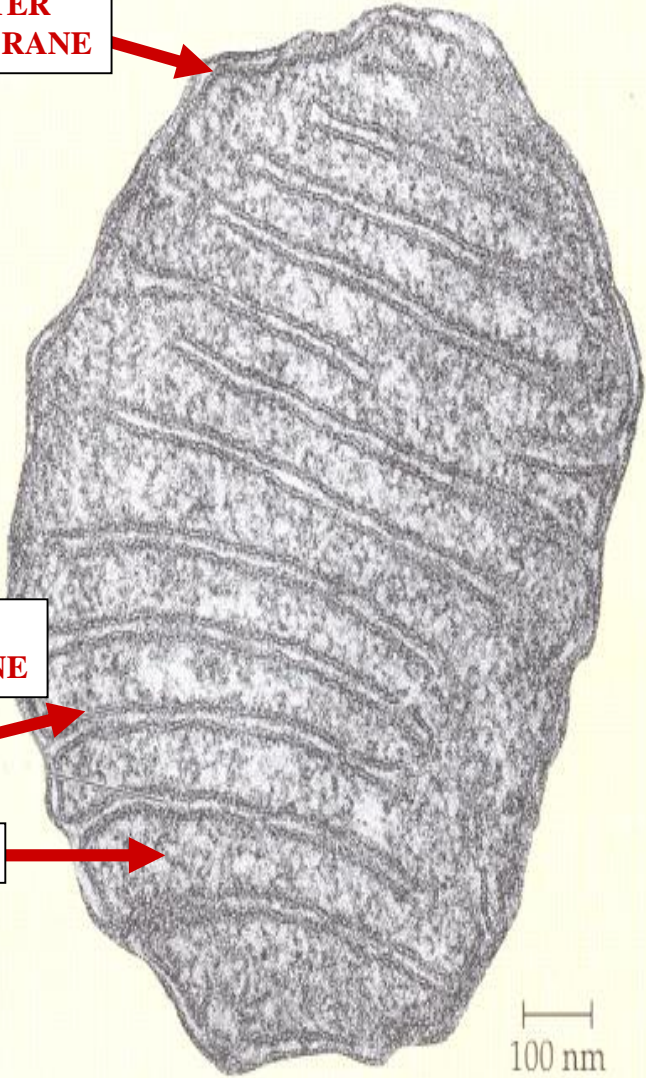
INNER
MEMBRANE

CRISTAE

MATRIX



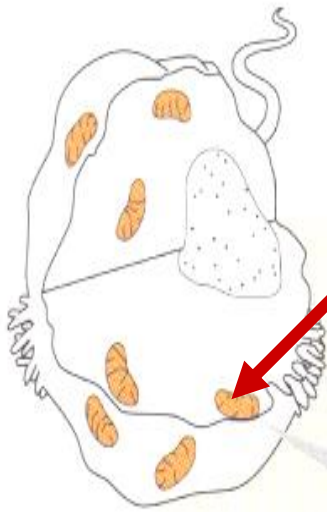
= BIO ENERGY
MOLECULE



100 nm

MITOCHONDRION ULTRASTRUCTURE

^
D



MITOCHONDRION

OUTER
MEMBRANE

INNER
MEMBRANE



INNER
MEMBRANE

CRISTAE

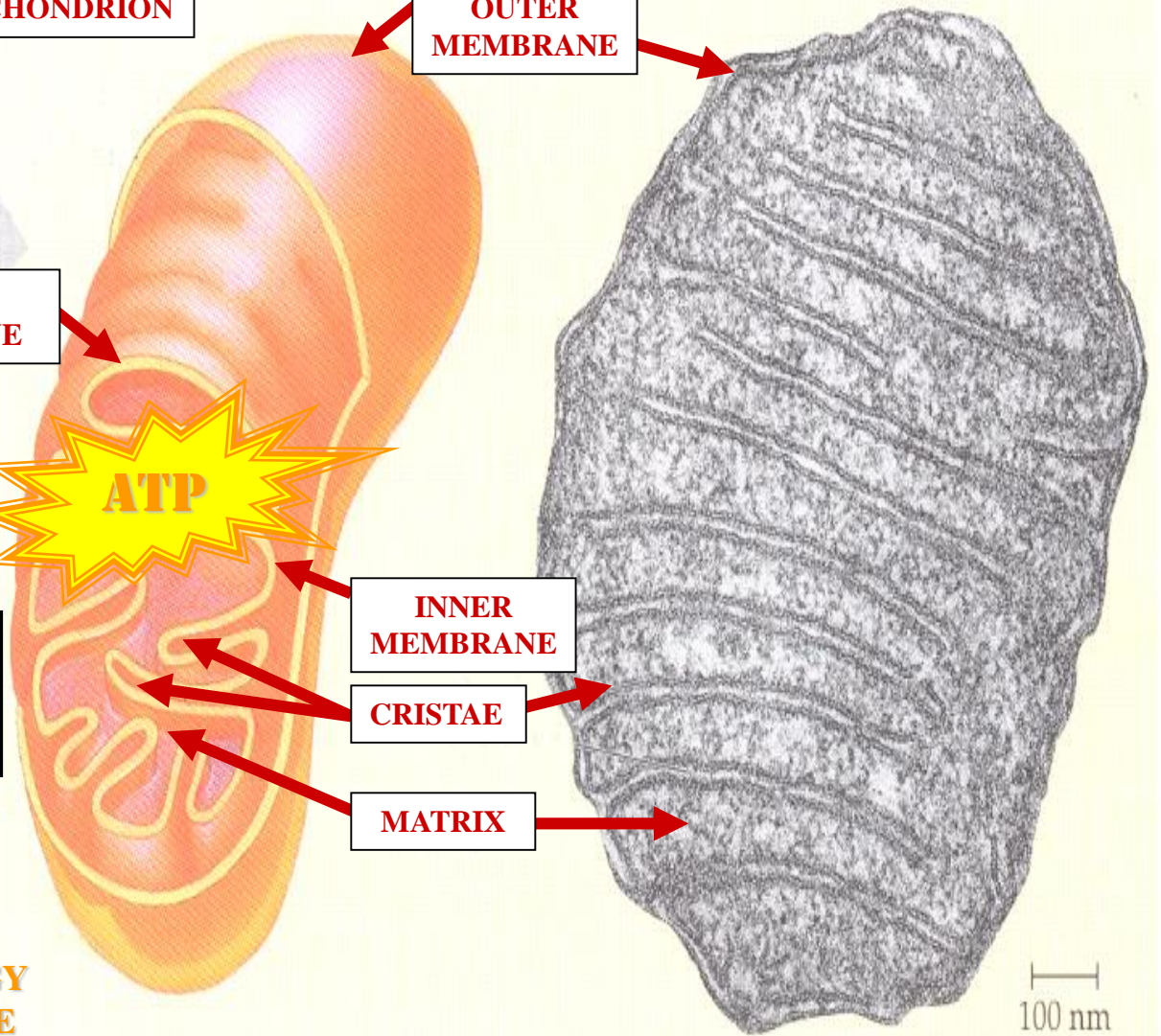
MATRIX

CELL
"POWER-HOUSE"

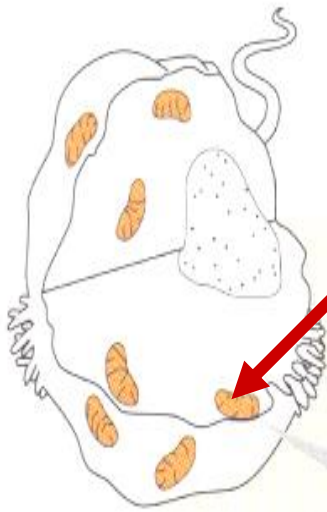
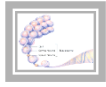


= BIO ENERGY
MOLECULE

100 nm



MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

INNER
MEMBRANE

DNA



**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

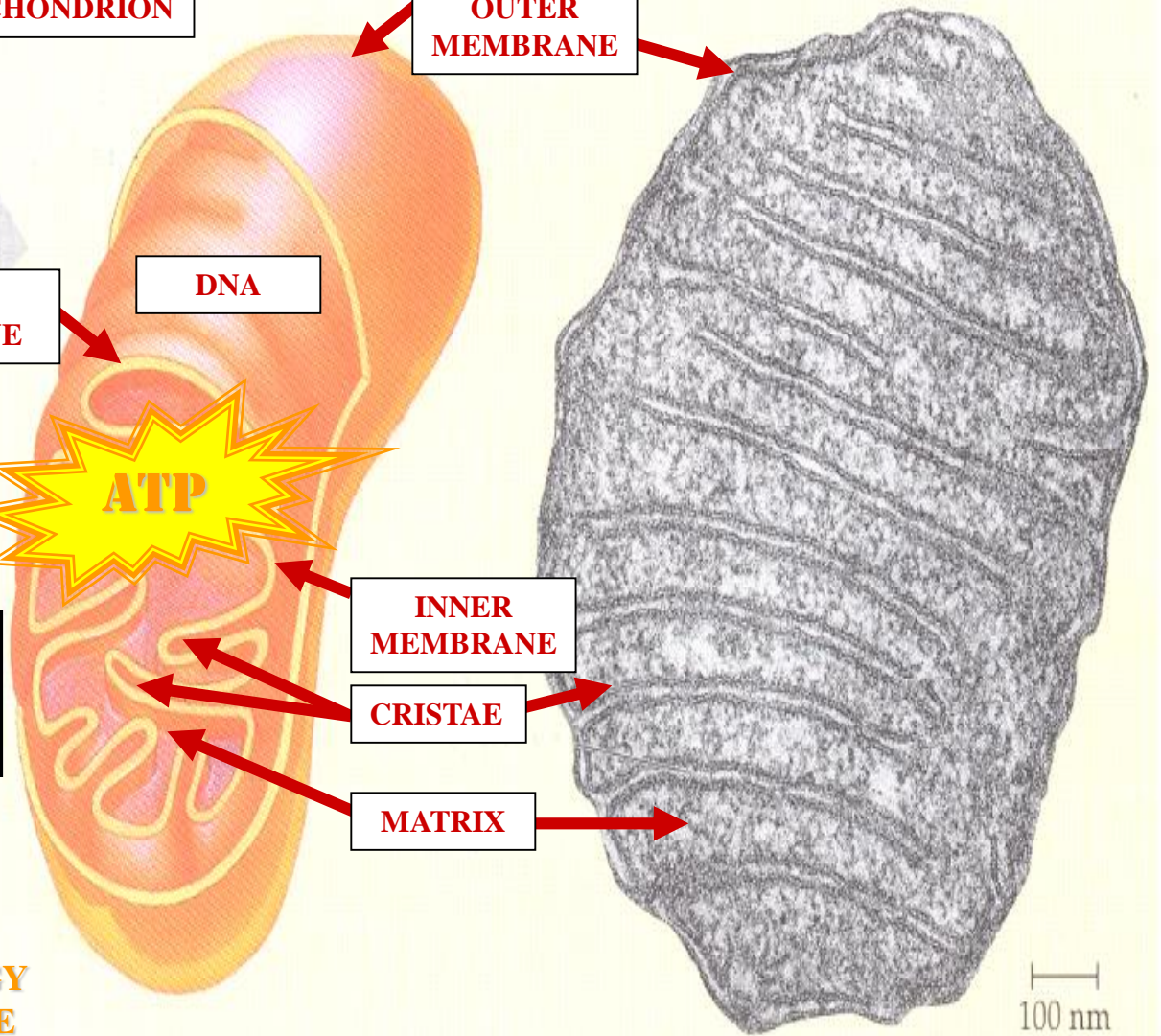
CRISTAE

MATRIX



= BIO ENERGY
MOLECULE

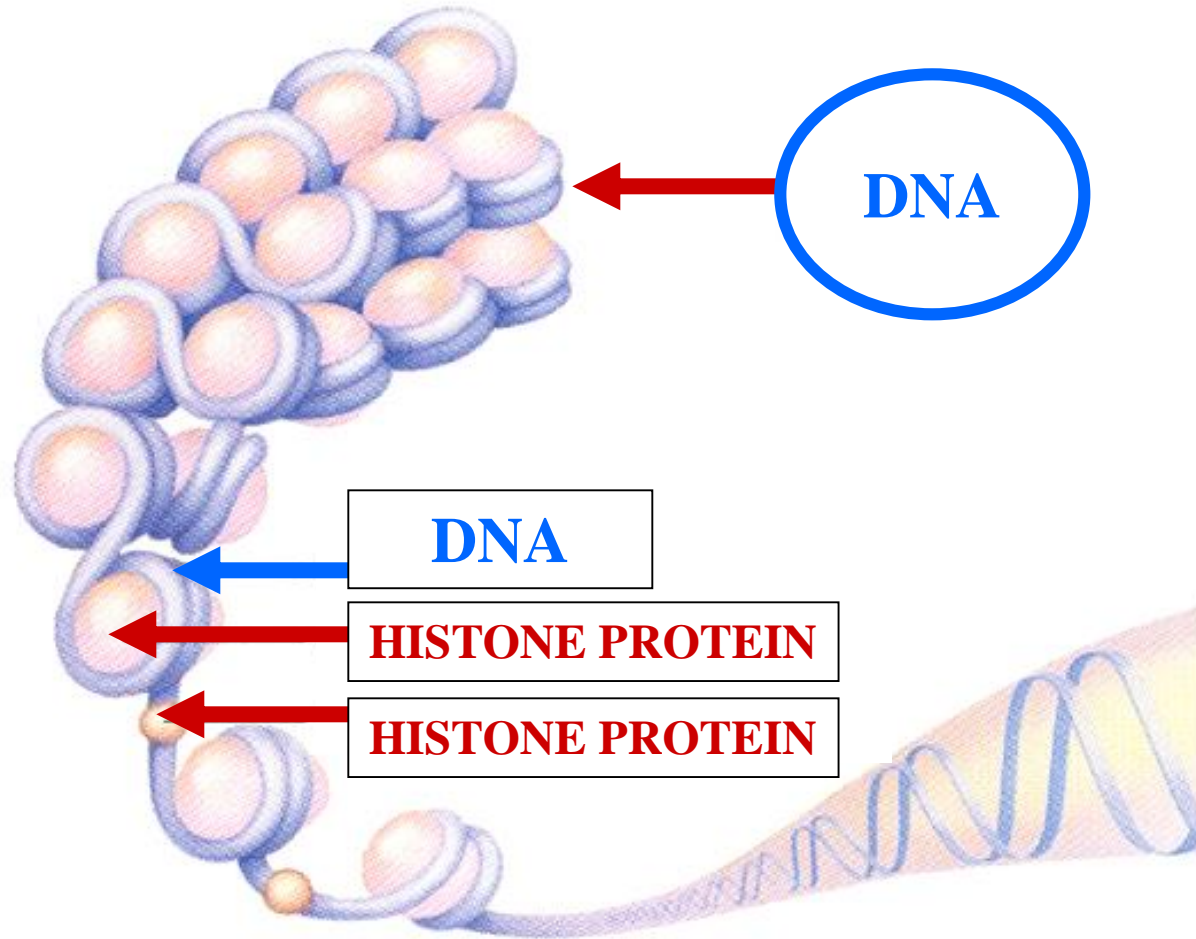
100 nm



MITOCHONDRION DNA

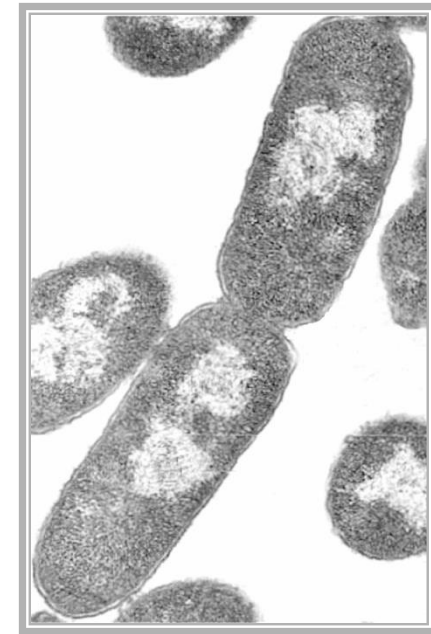
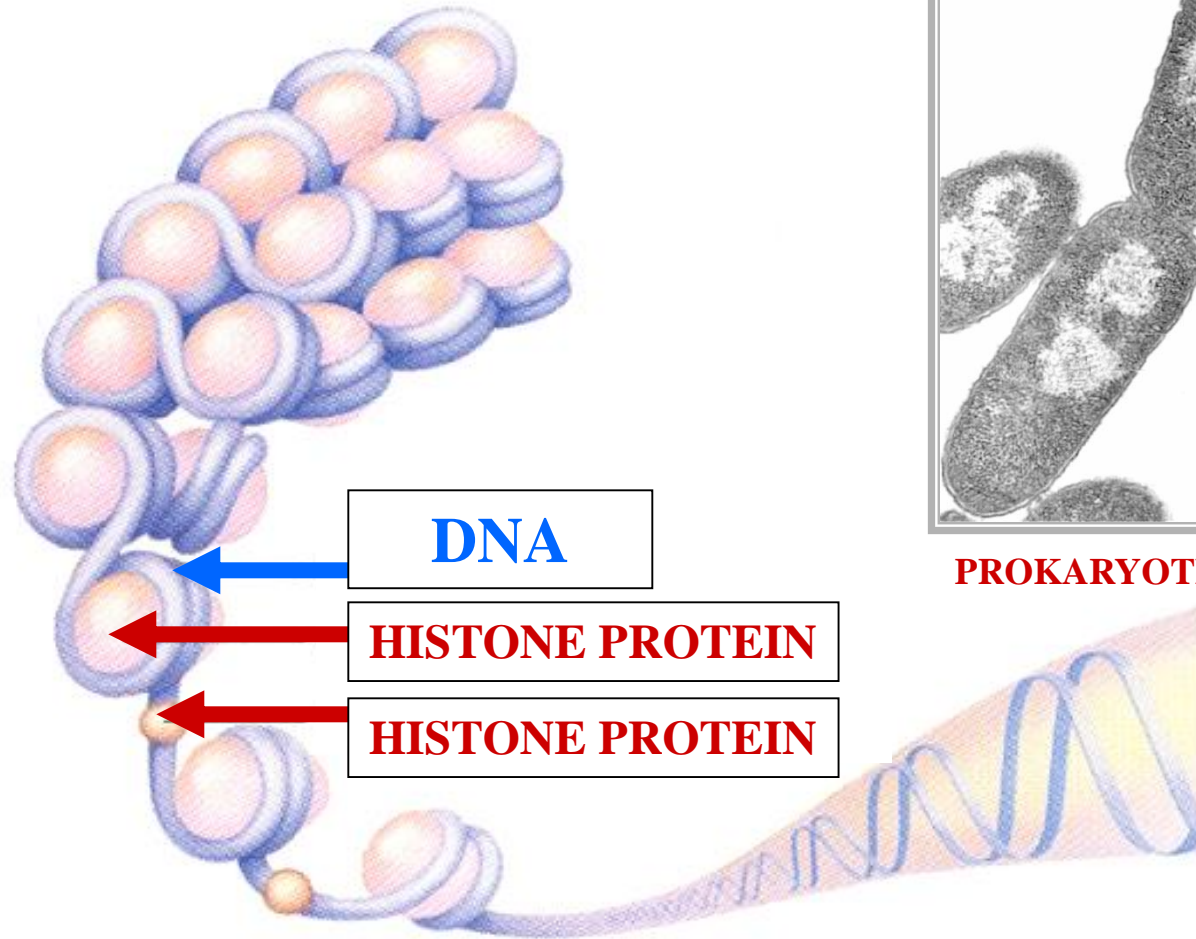


P



MITOCHONDRION DNA: HISTONE PROTEINS ABSENT

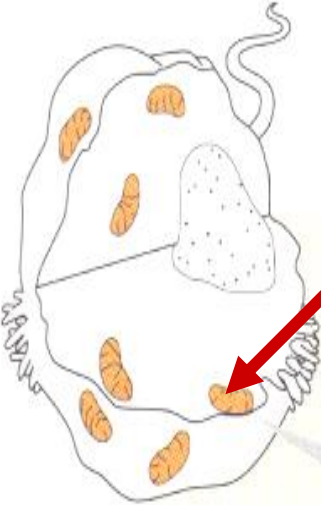
MITOCHONDRION DNA



PROKARYOTE-LIKE

MITOCHONDRION DNA: HISTONE PROTEINS ABSENT

MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

PROKARYOTE-LIKE DNA

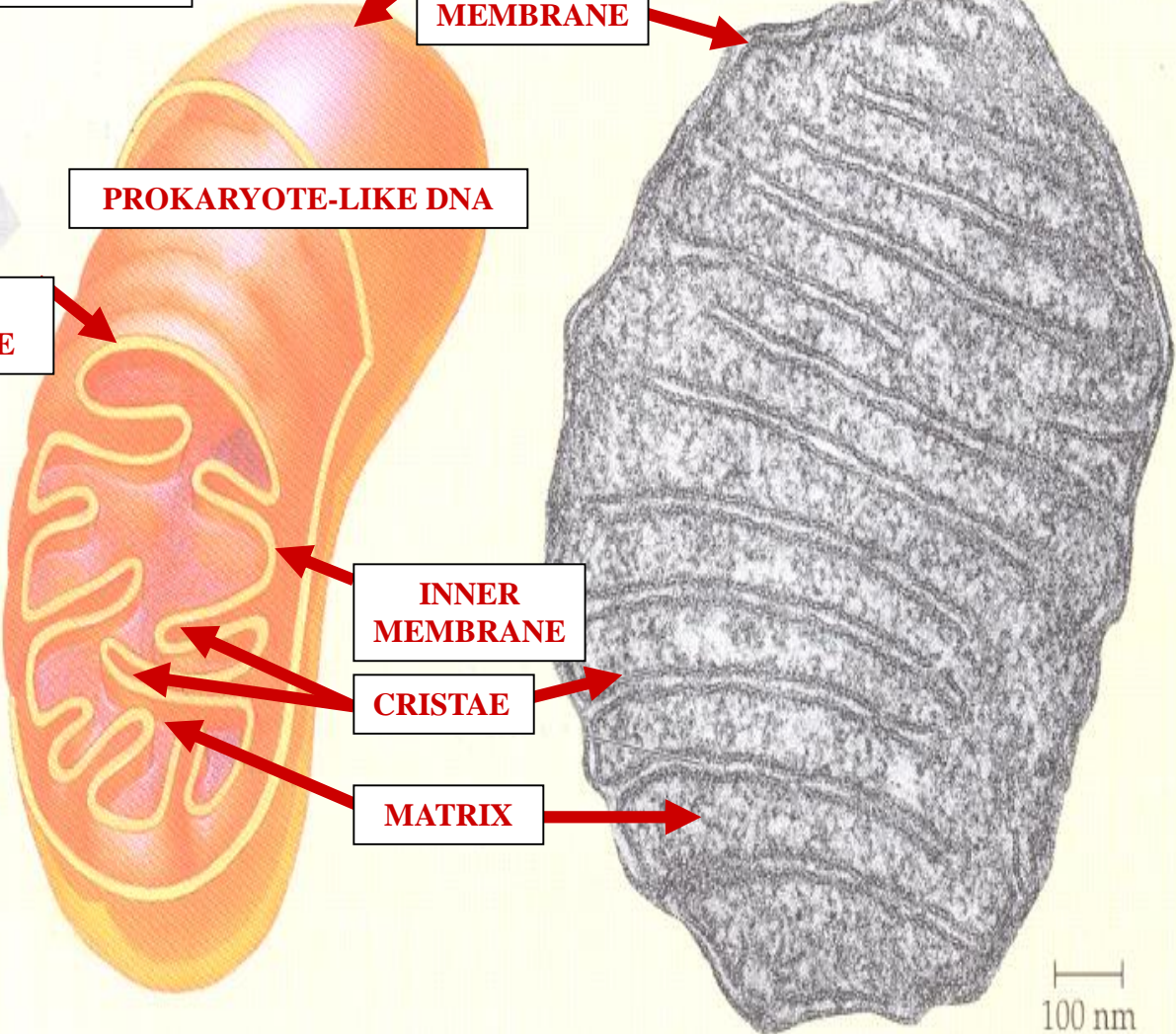
INNER
MEMBRANE

**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

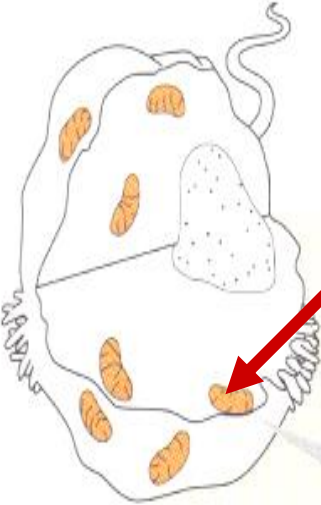
CRISTAE

MATRIX



100 nm

MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

PROKARYOTE-LIKE DNA

INNER
MEMBRANE

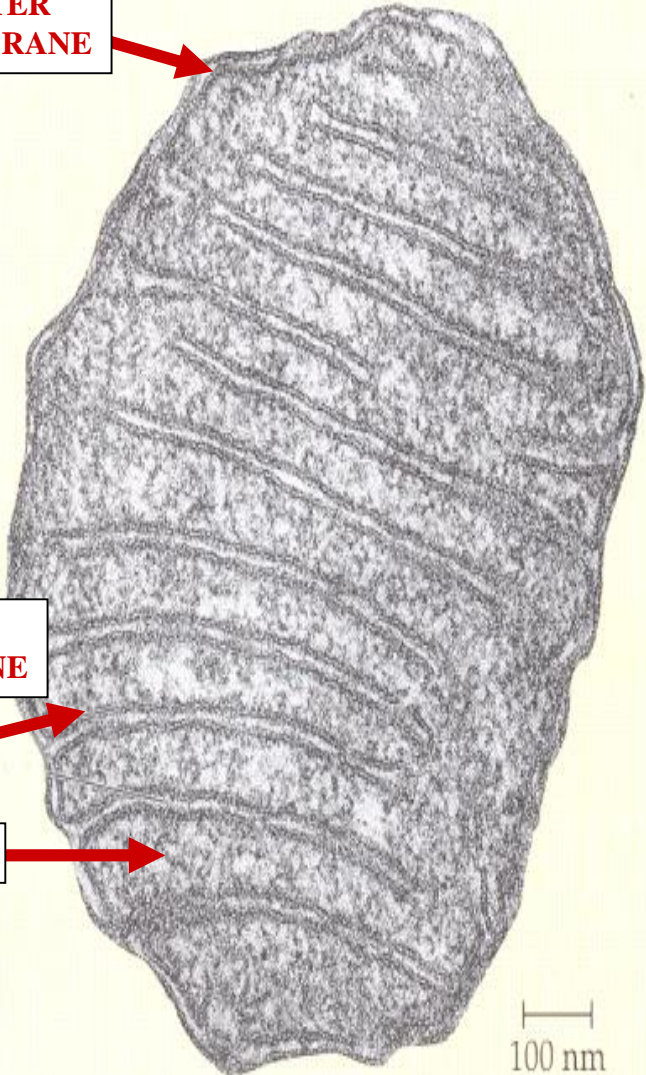
RIBOSOMES

**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

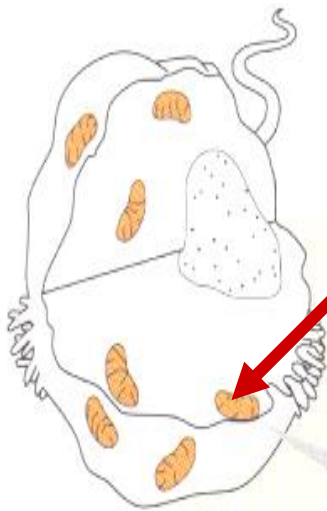
CRISTAE

MATRIX



100 nm

MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

PROKARYOTE-LIKE DNA

INNER
MEMBRANE

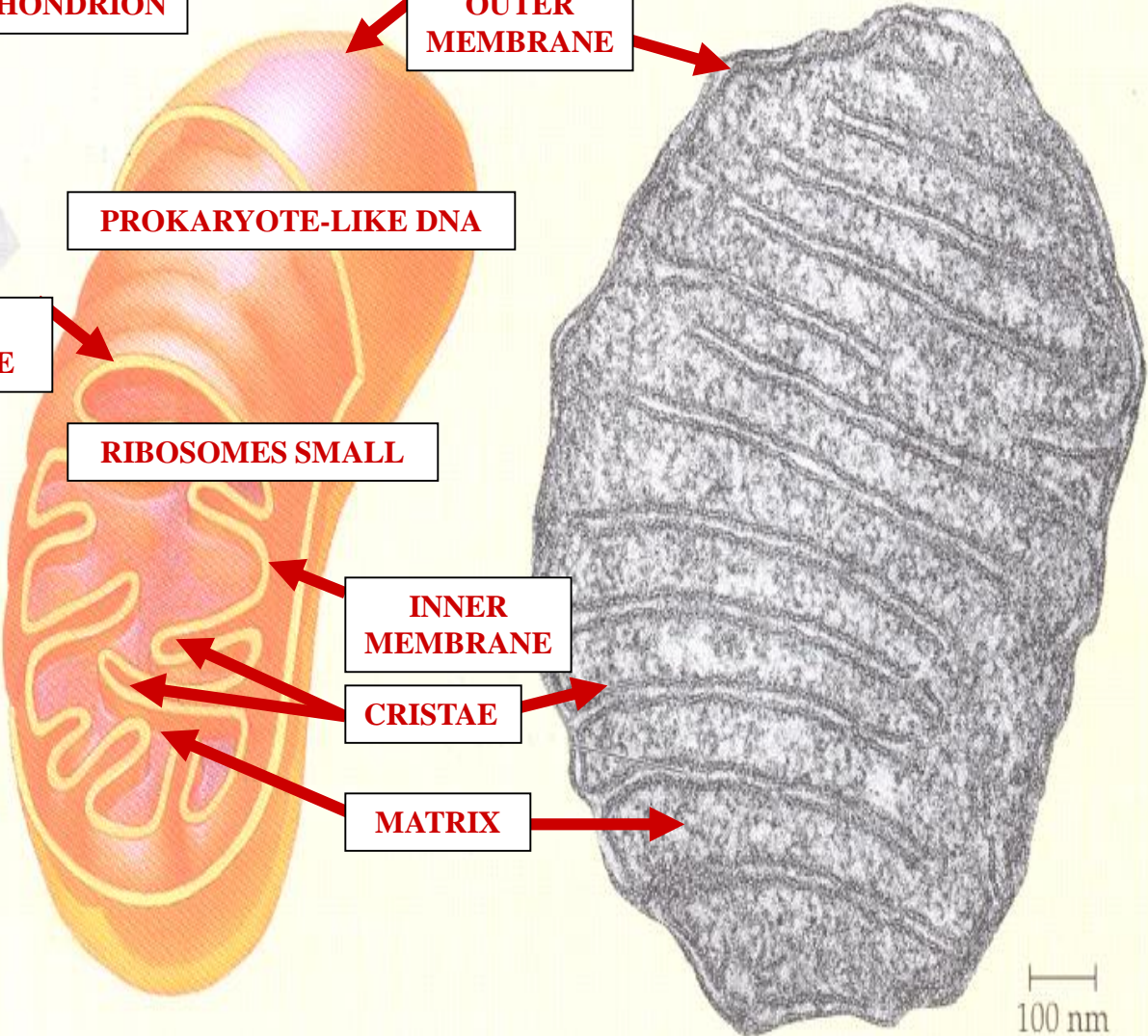
RIBOSOMES SMALL

**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

CRISTAE

MATRIX



100 nm

MITOCHONDRION RIBOSOME SMALL



P

3 RNAs & 54 PROTEINS

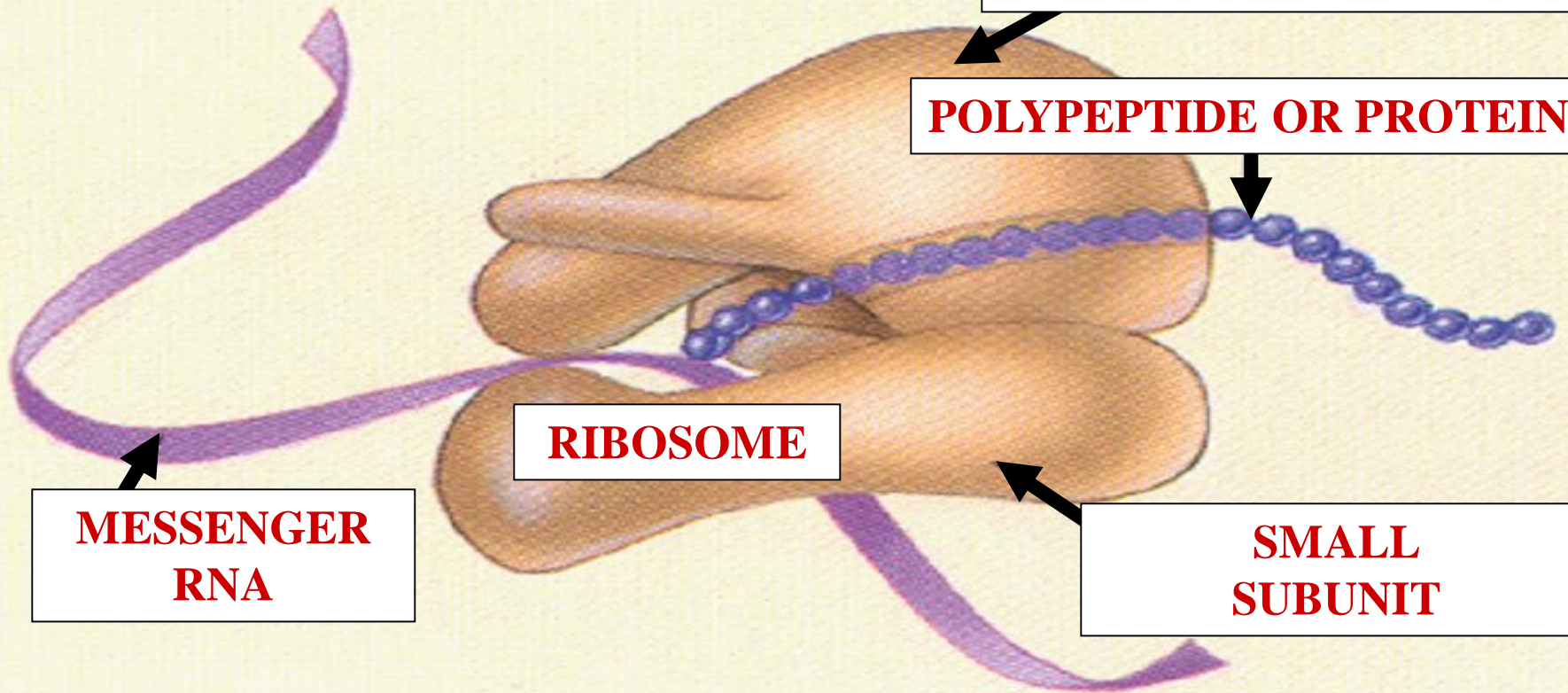
**LARGE
SUBUNIT**

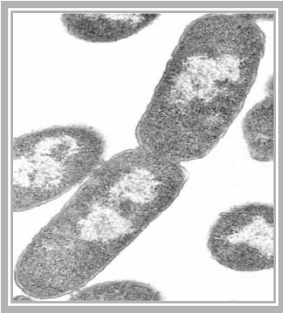
POLYPEPTIDE OR PROTEIN

RIBOSOME

**MESSENGER
RNA**

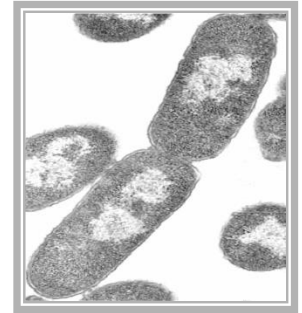
**SMALL
SUBUNIT**





PROKARYOTE-LIKE

MITOCHONDRION RIBOSOME SMALL



PROKARYOTE-LIKE

S
+

3 RNAs & 54 PROTEINS

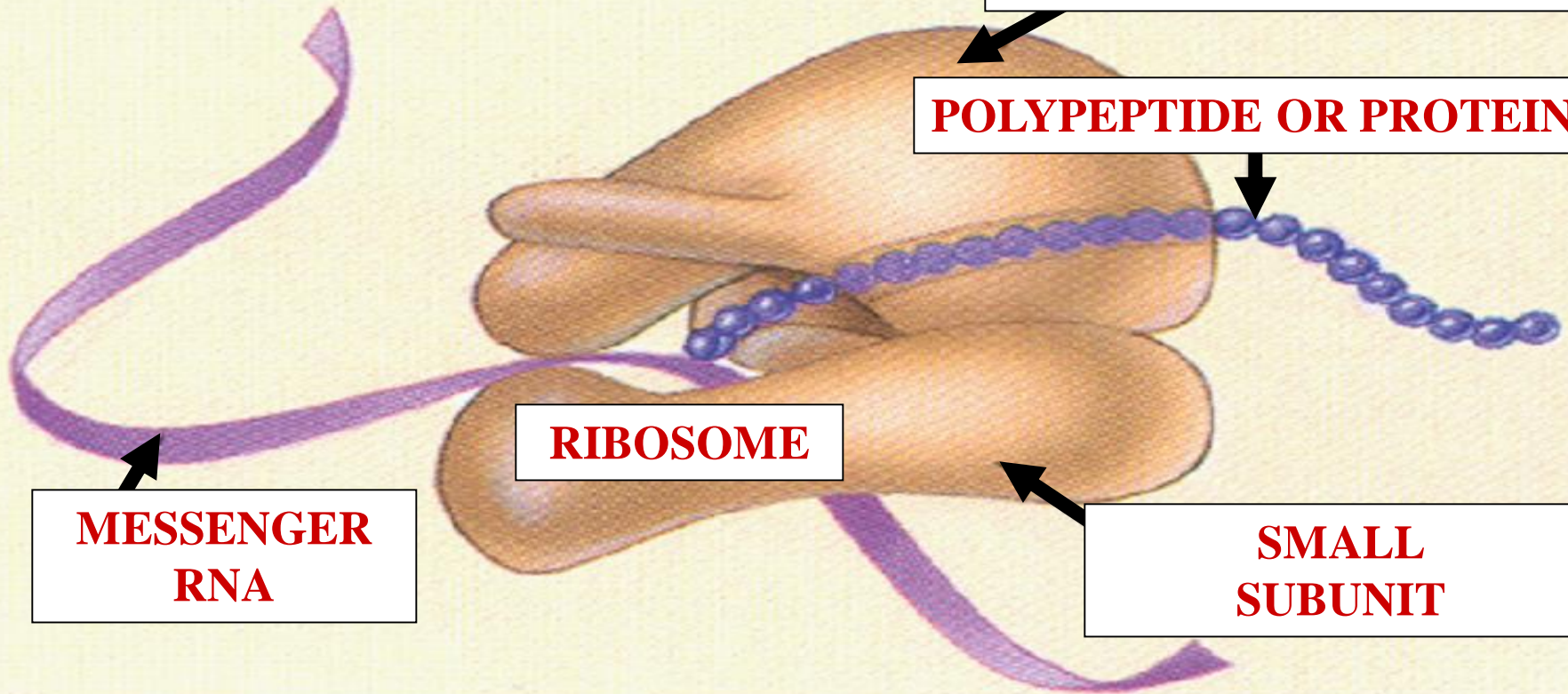
**LARGE
SUBUNIT**

POLYPEPTIDE OR PROTEIN

RIBOSOME

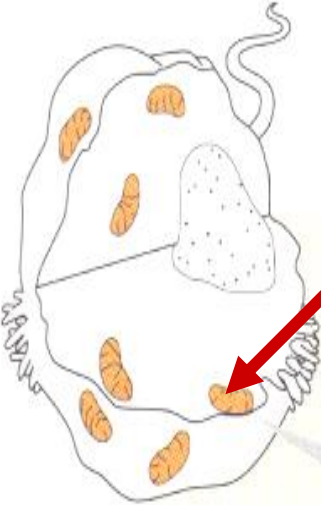
**MESSENGER
RNA**

**SMALL
SUBUNIT**





MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

PROKARYOTE-LIKE DNA

INNER
MEMBRANE

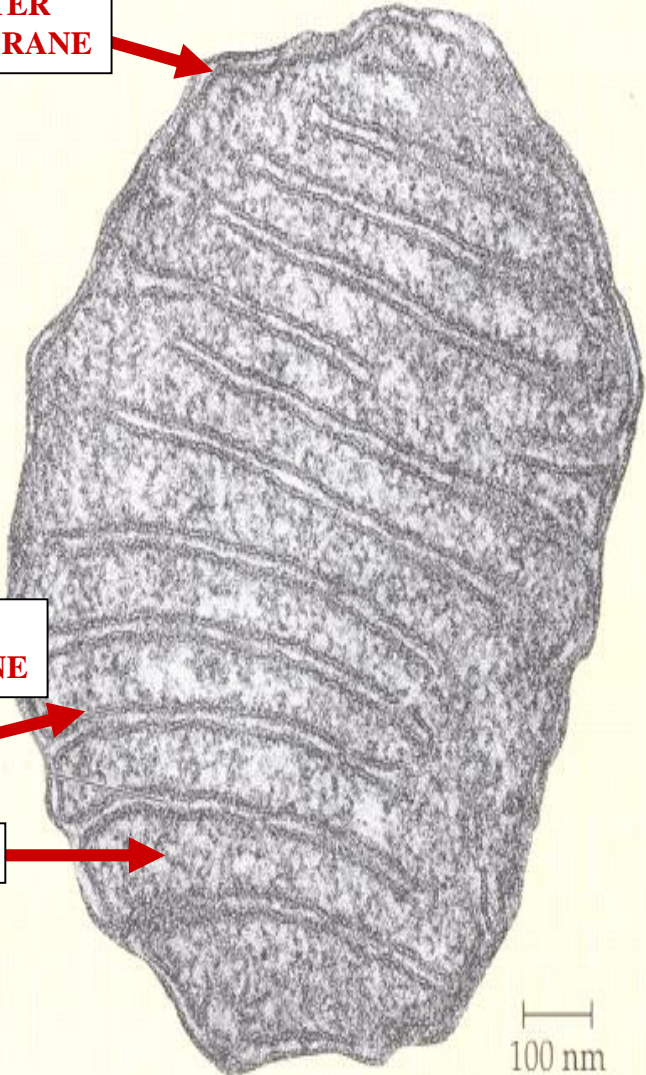
PROKARYOTE-LIKE RIBOSOMES

**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

CRISTAE

MATRIX



100 nm



MITOCHONDRION EVOLUTION

TRUE PLANT CYTOLOGY

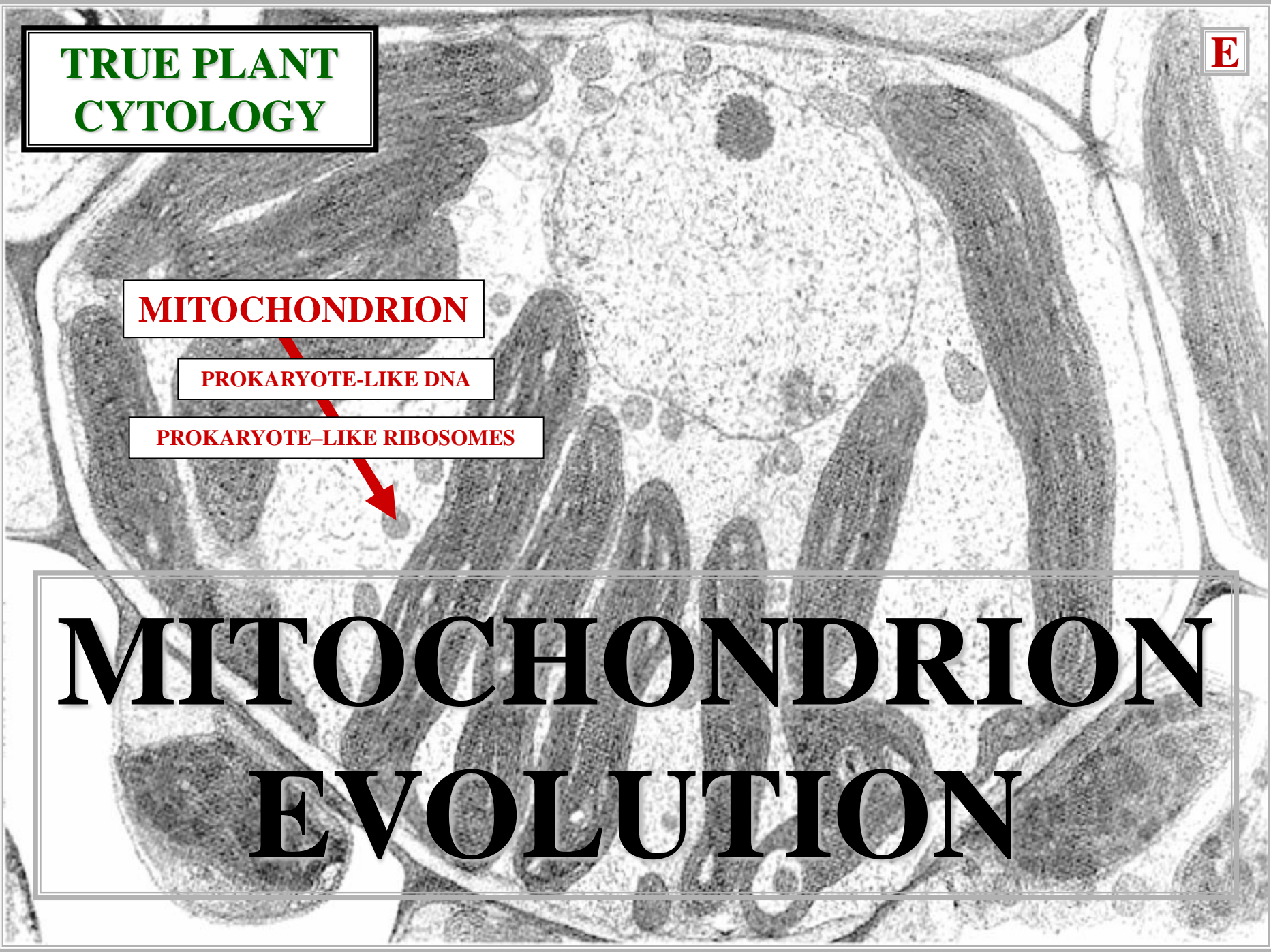
E

MITOCHONDRION

PROKARYOTE-LIKE DNA

PROKARYOTE-LIKE RIBOSOMES

MITOCHONDRION EVOLUTION



An electron micrograph of a plant cell. A large chloroplast is visible in the upper left, showing stacked thylakoids. A mitochondrion is located in the lower right, showing internal cristae. A central nucleus is also present. A red arrow points from the labels to a specific region within the mitochondrion.

TRUE PLANT CYTOLOGY

MITOCHONDRION

PROKARYOTE-LIKE DNA

PROKARYOTE-LIKE RIBOSOMES

ENDOSYMBIOTIC THEORY

NUCLEUS

NUCLEUS



NUCLEUS

KNOWN MOST EUKARYOTES

NUCLEUS