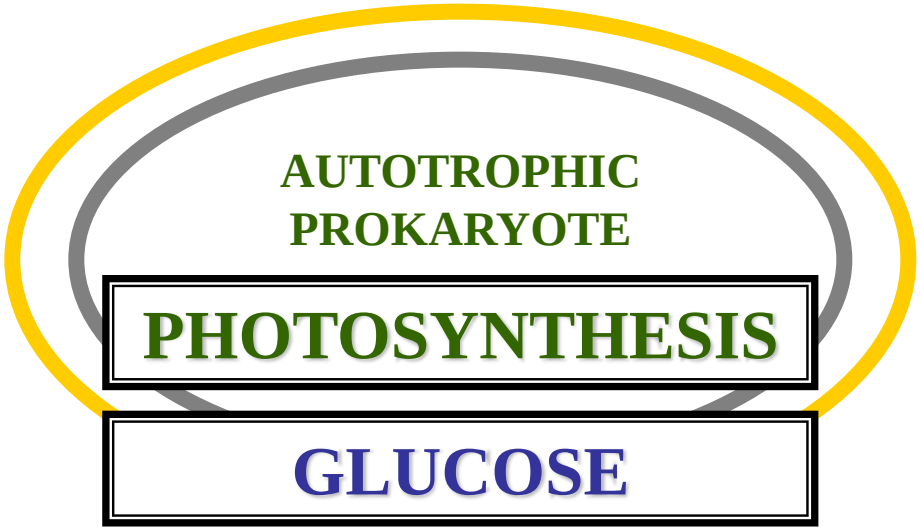
EVENTUALLY
“DAWNS ON HETEROTROPH”

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES



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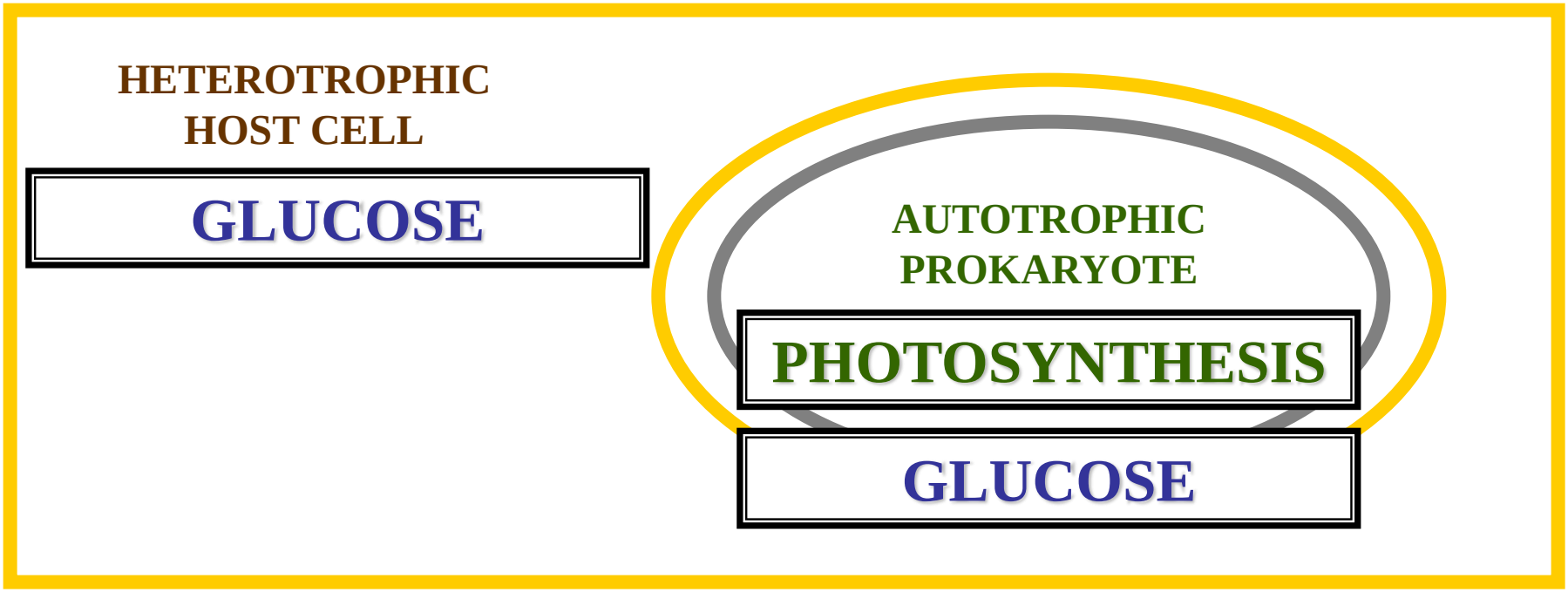
EVENTUALLY
"DAWNS ON HETEROTROPH"



AUTOTROPH LIVING WITHIN HETEROTROPH

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

2 SPECIES LIVING INTRICATE ASSOCIATION

SYMBIOSIS

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

SYMBIOSIS
ENDOSYMBIOSIS

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

SYMBIOSIS
ENDOSYMBIOSIS

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

AUTOTROPH PROVIDES HETEROTROPH WITH?

SYMBIOSIS
ENDOSYMBIOSIS

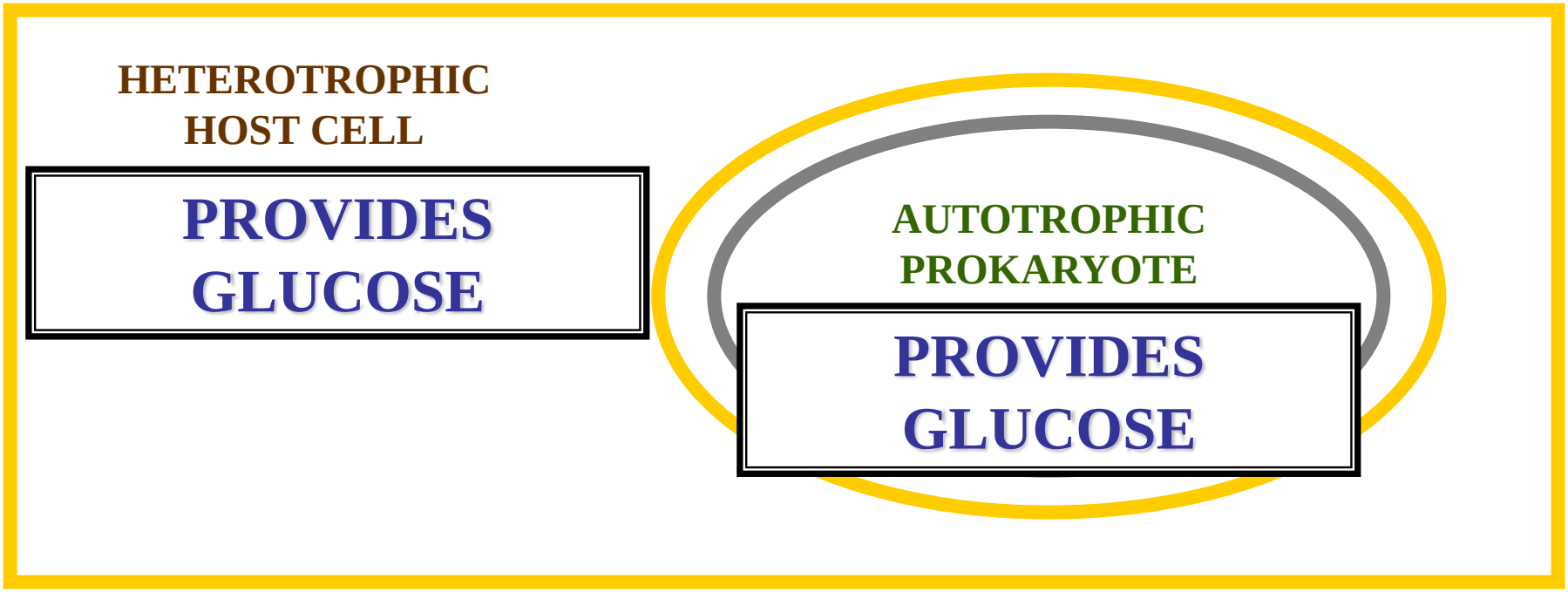
HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

AUTOTROPH PROVIDES HETEROTROPH WITH?

SYMBIOSIS
ENDOSYMBIOSIS



AUTOTROPH PROVIDES GLUCOSE

SYMBIOSIS
ENDOSYMBIOSIS

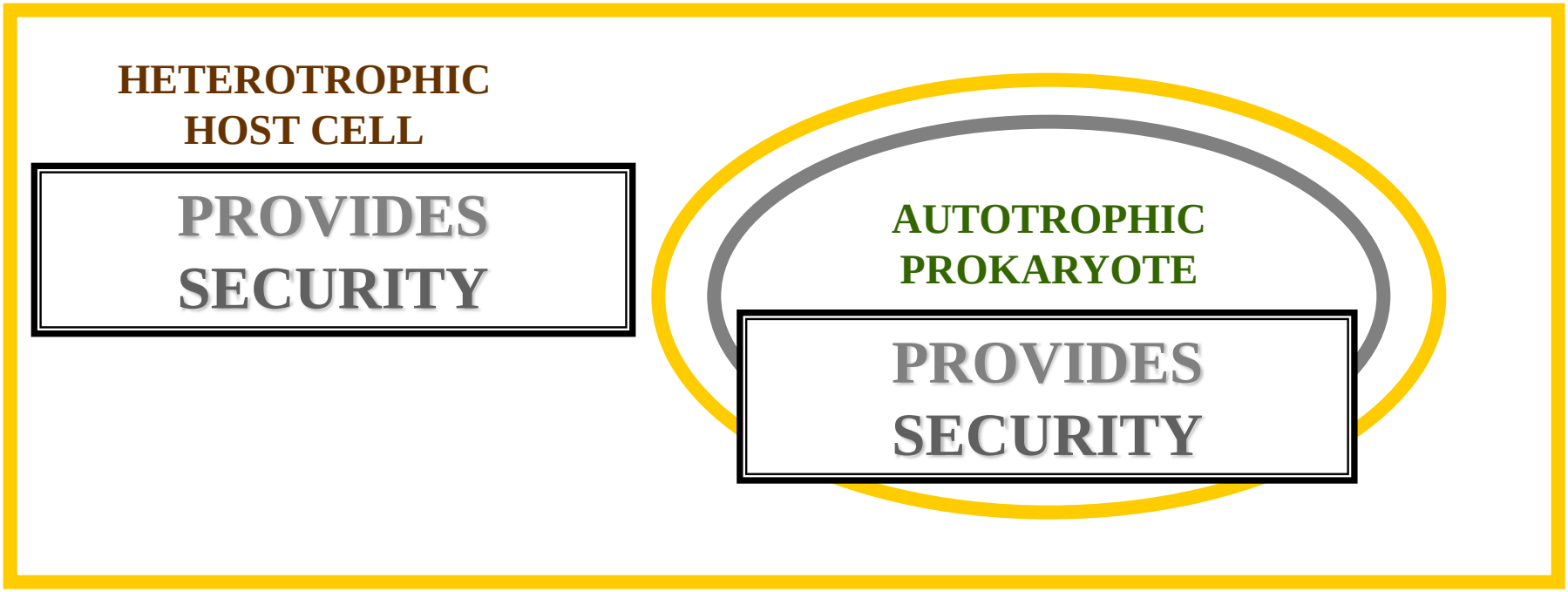
HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

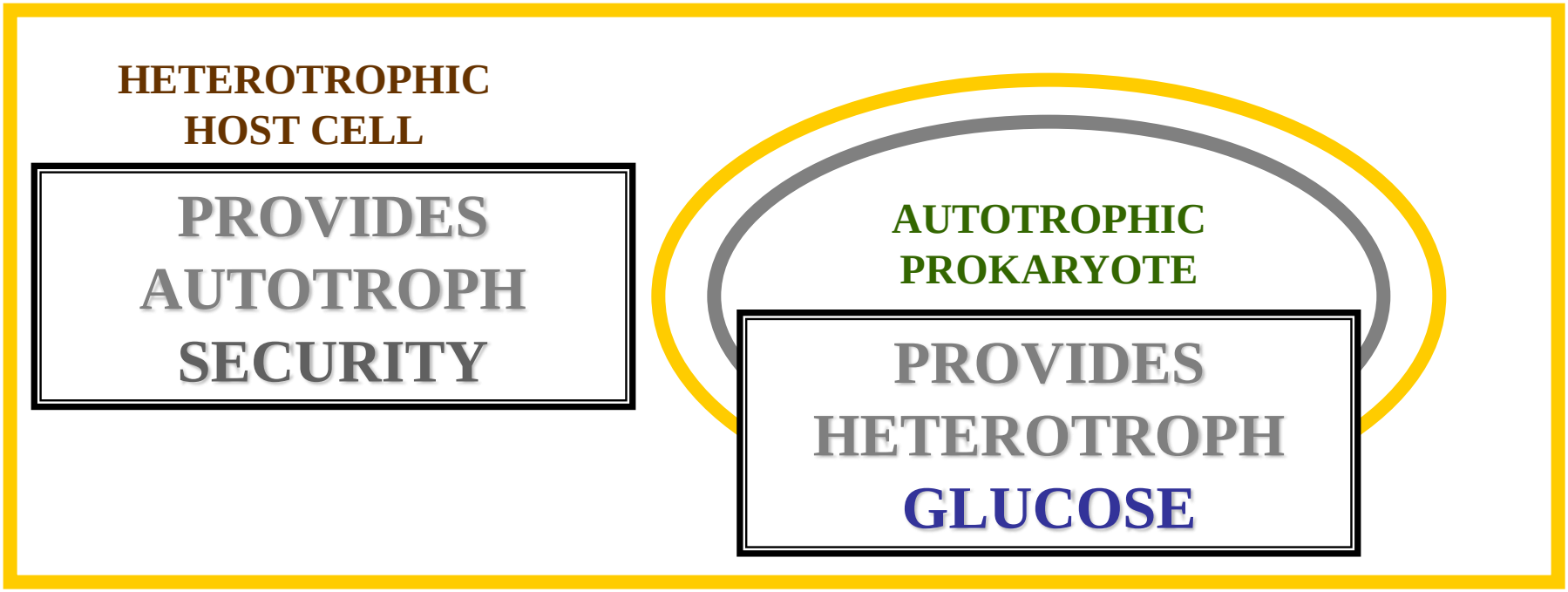
HETEROTROPH PROVIDES AUTOTROPH WITH?

SYMBIOSIS
ENDOSYMBIOSIS



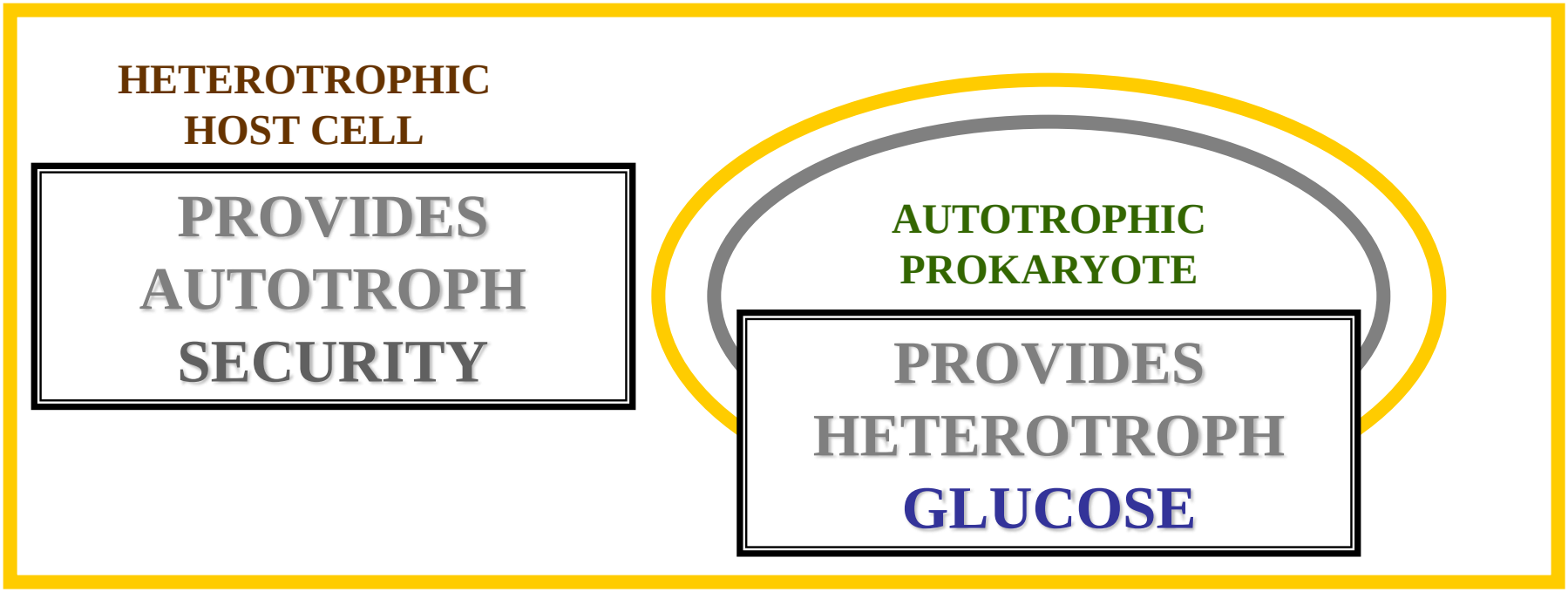
HETEROTROPH PROVIDES SECURITY

SYMBIOSIS
ENDOSYMBIOSIS



BOTH SYMBIONTS BENEFIT

SYMBIOSIS
ENDOSYMBIOSIS



MUTUALISTIC
ENDOSYMBIOSIS

MUTUALISTIC ENDOSYMBIOSIS

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

GIVEN LONG TIME PERIOD

?

OBLIGATE DEPENDENT RELATIONSHIP EVOLVES

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

SYMBIONTS CANNOT EXIST INDEPENENTLY

AUTOTROPHIC PROKARYOTE

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

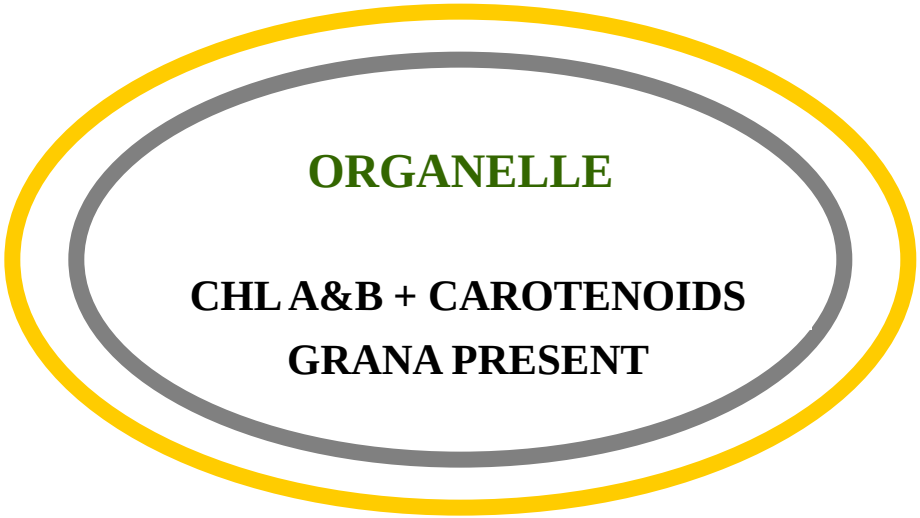
LARGE RIBOSOMES

AUTOTROPHIC ORGANELLE

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

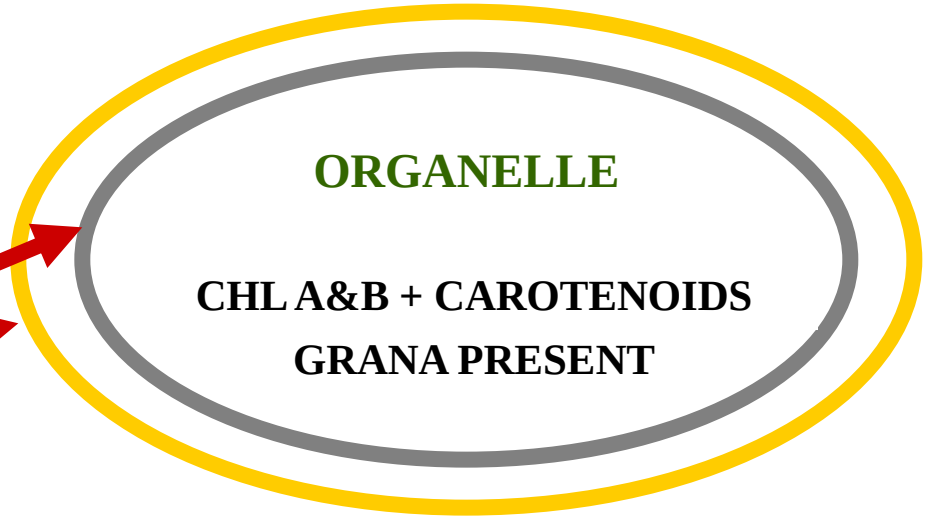


AUTOTROPHIC ORGANELLE

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

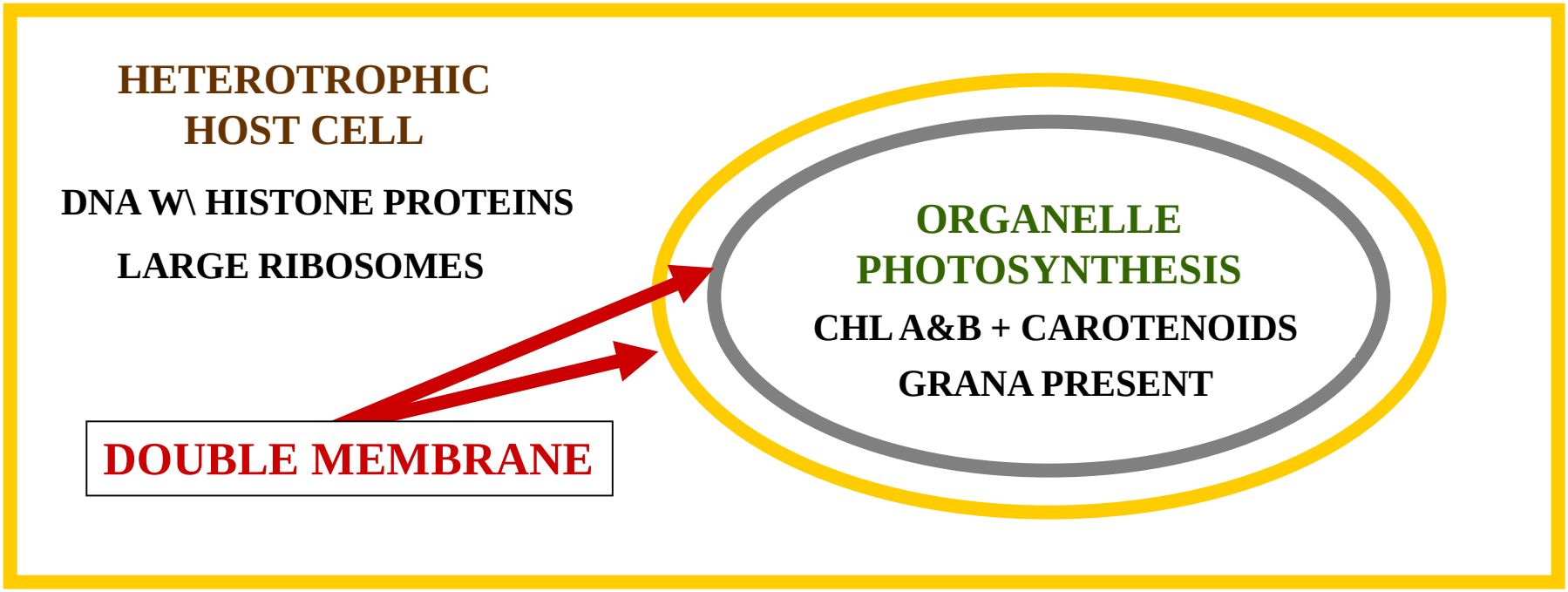
LARGE RIBOSOMES



DOUBLE MEMBRANE

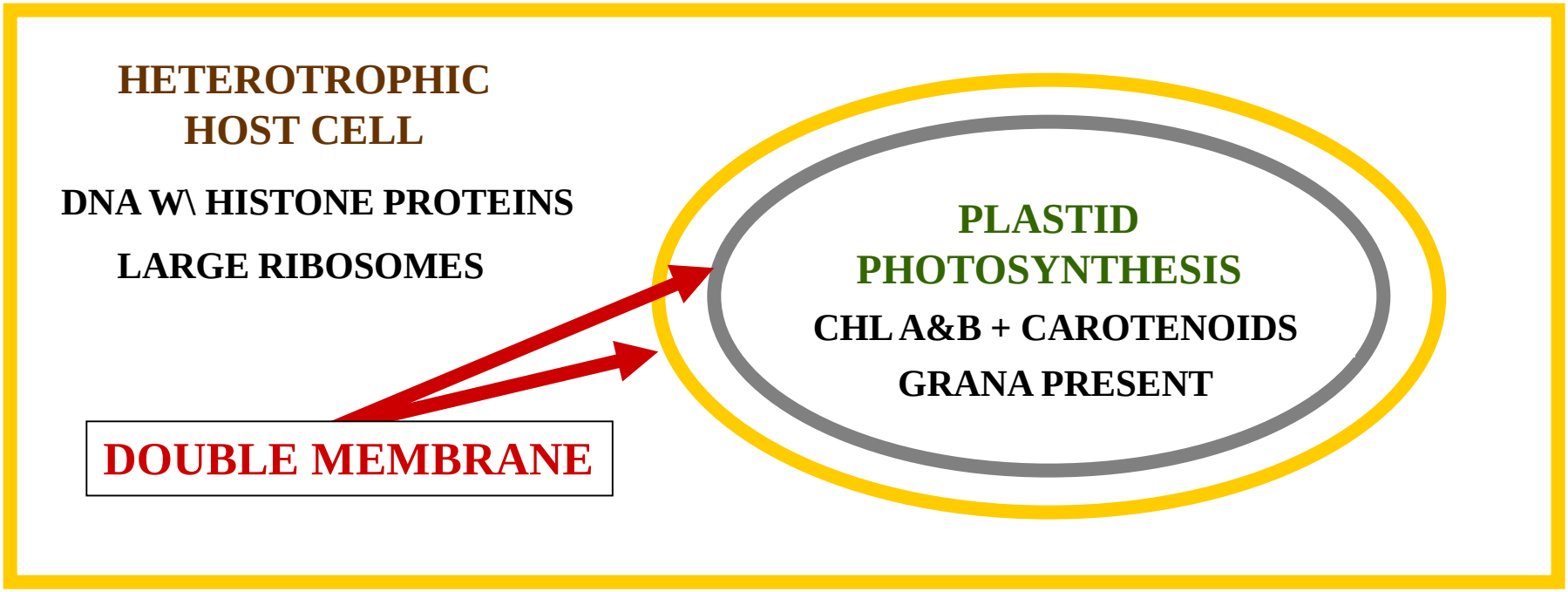
PL

AUTOTROPHIC ORGANELLE



CH

AUTOTROPHIC ORGANELLE



AUTOTROPHIC ORGANELLE

HETEROTROPHIC HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

DOUBLE MEMBRANE

A

HETEROTROPHIC HOST CELL

HETEROTROPHIC HOST CELL BECOMES ?

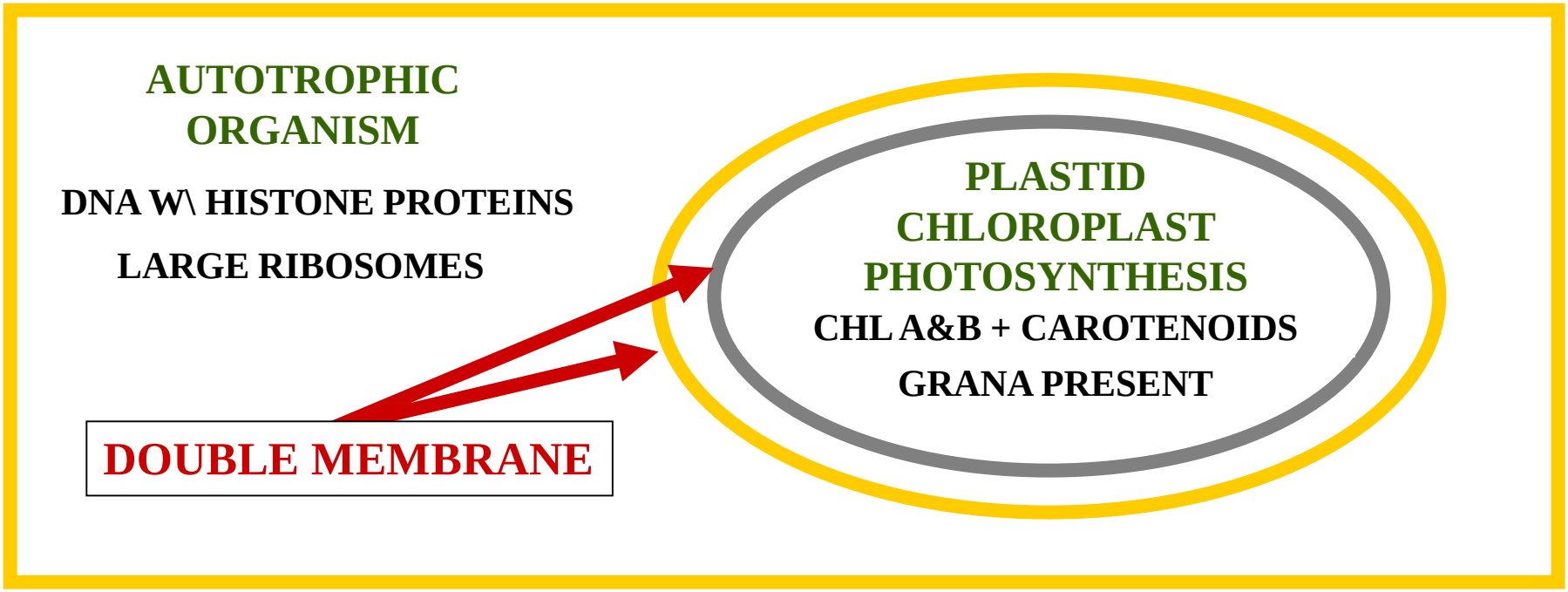
DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

DOUBLE MEMBRANE

PC

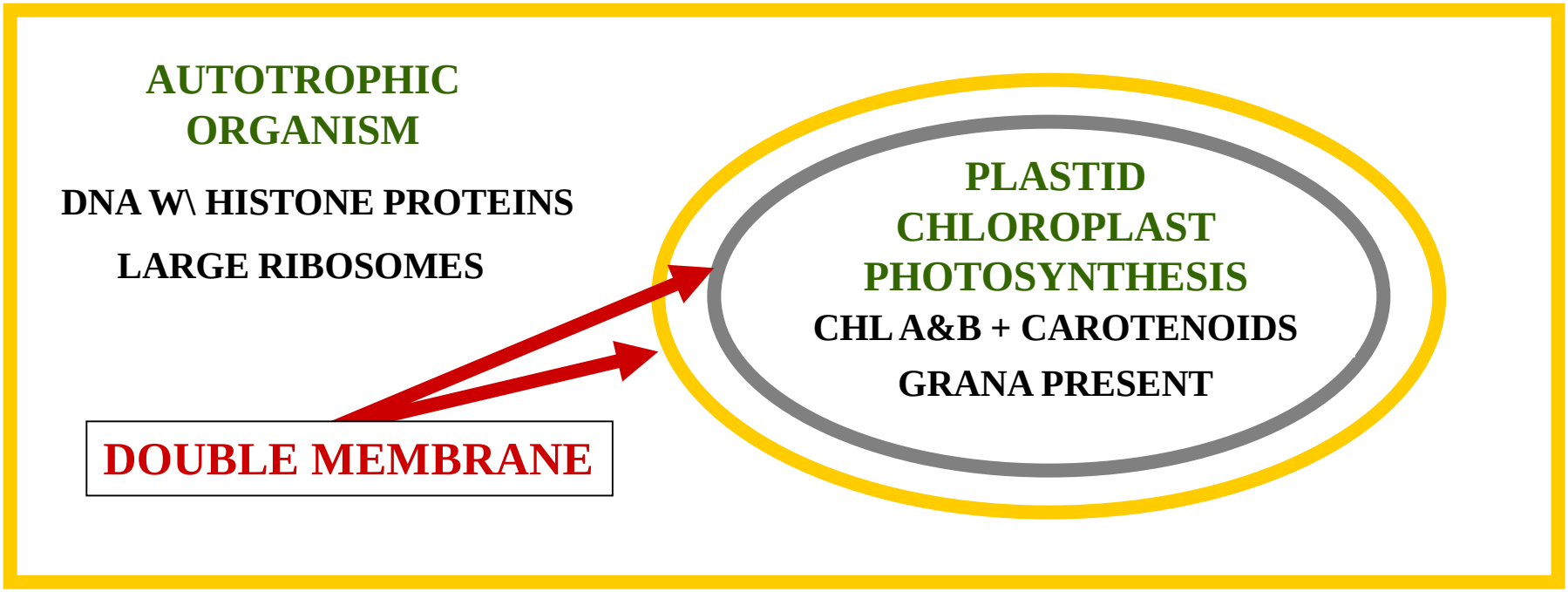
AUTOTROPHIC ORGANISM



CELL

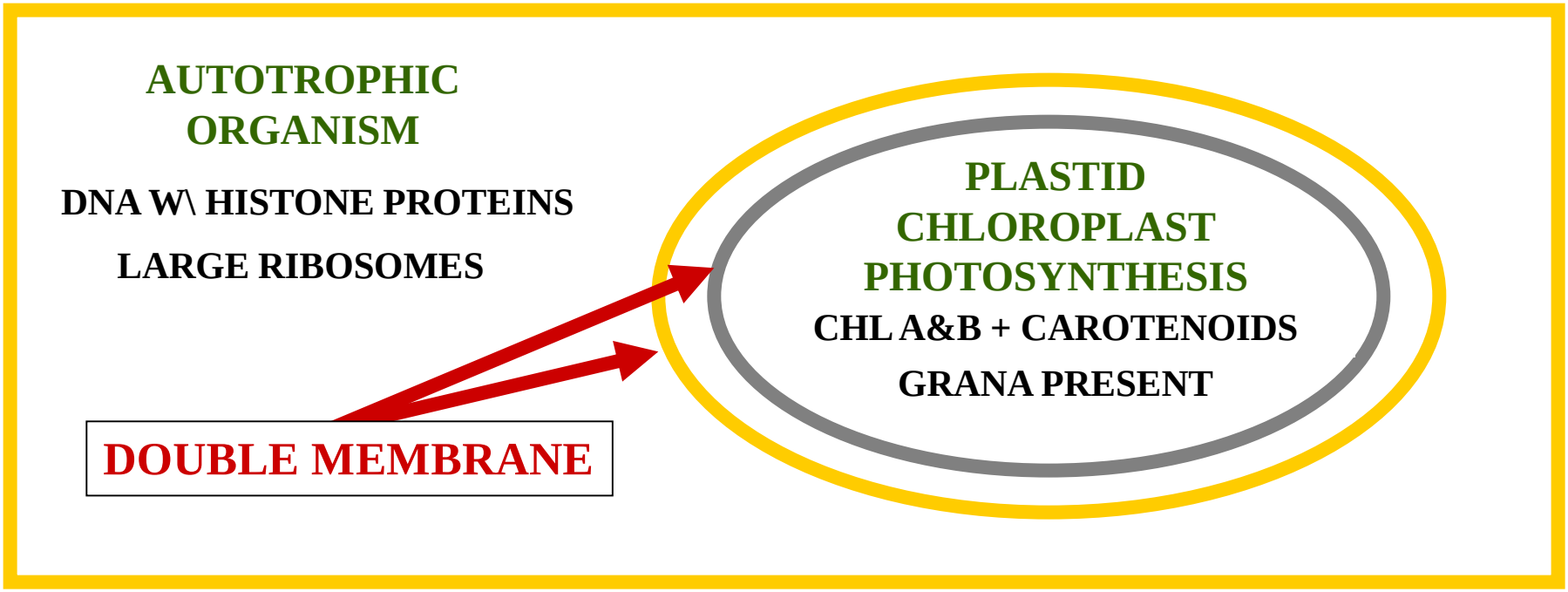
TP

AUTOTROPHIC ORGANISM



PLANT CELL

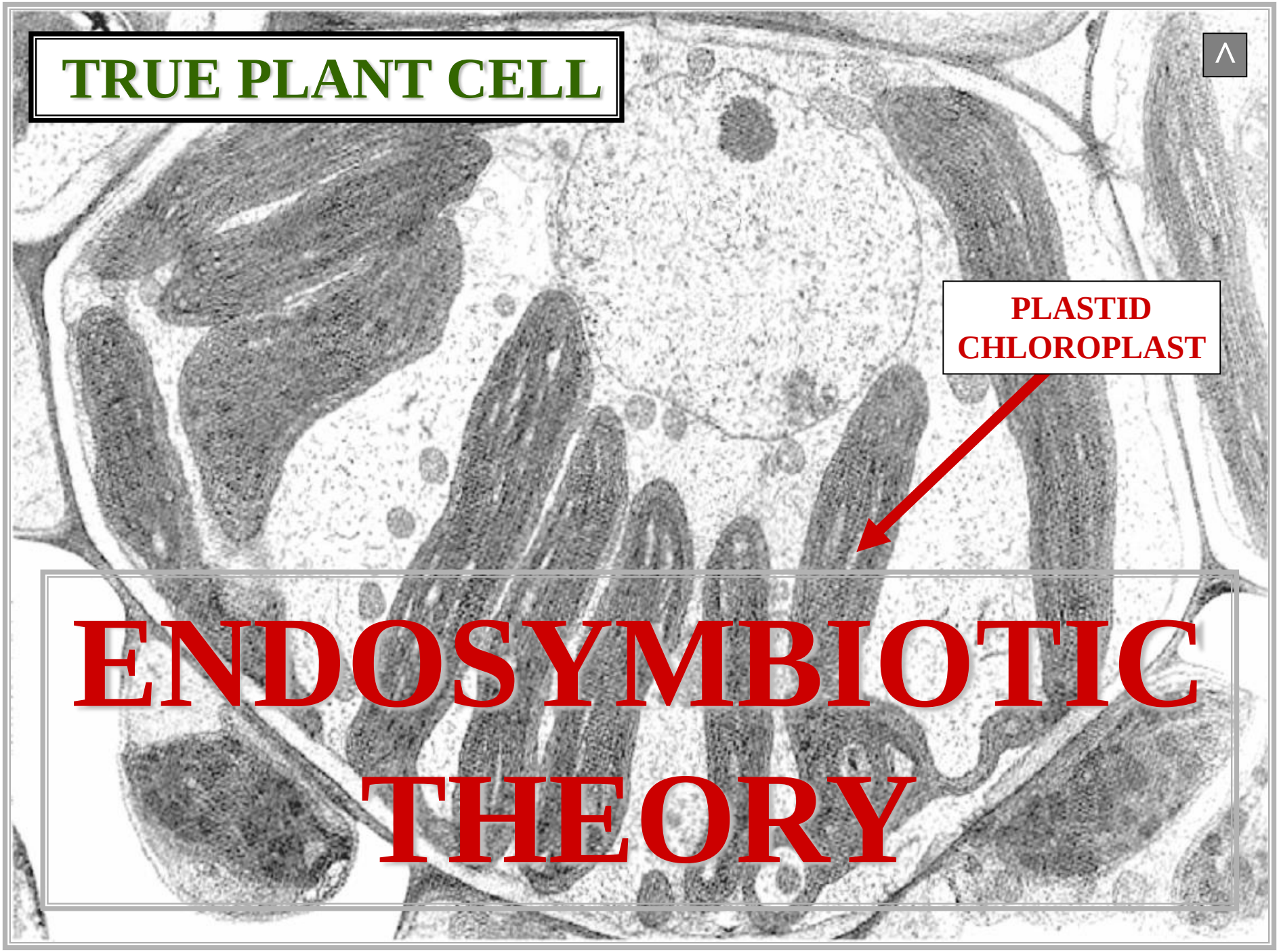
AUTOTROPHIC ORGANISM



TRUE PLANT CELL

GREEN ALGAE

TRUE PLANT CELL



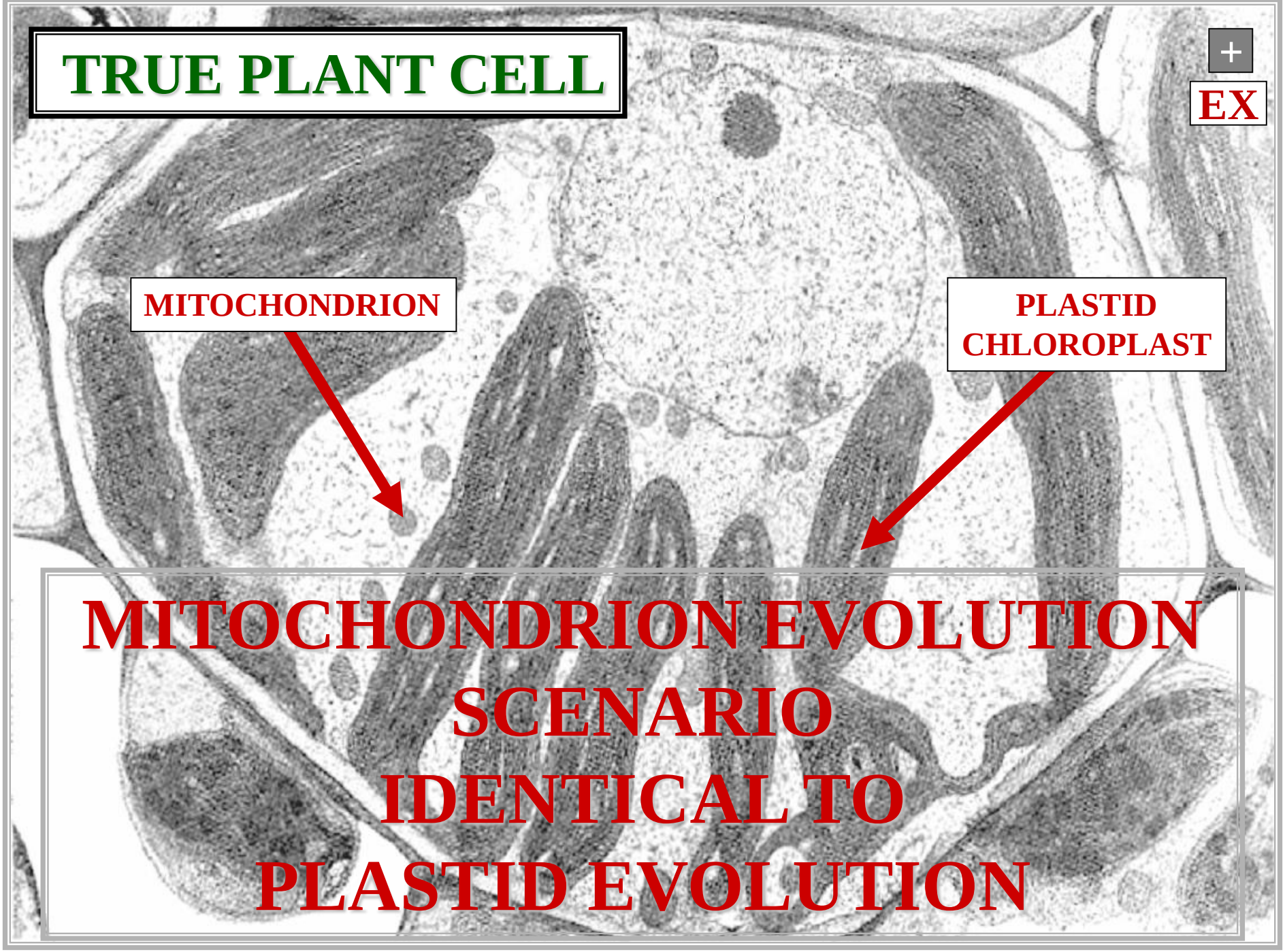
ENDOSYMBIOTIC THEORY

MITOCHONDRION EVOLUTION

I

MITOCHONDRION EVOLUTION

HYPOTHETICAL SCENARIO


TRUE PLANT CELL
+
EX
MITOCHONDRION
PLASTID
CHLOROPLAST
MITOCHONDRION EVOLUTION SCENARIO IDENTICAL TO PLASTID EVOLUTION

R

HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

AEROBIC PROKARYOTE

DNA W\OUT HISTONE PROTEINS

SMALL RIBOSOMES

EXCEPTION: AEROBIC PROKARYOTE UNDERGOES ENDOSYMBIOSIS

HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

AEROBIC PROKARYOTE

AEROBIC RESPIRATION

DNA W\OUT HISTONE PROTEINS

SMALL RIBOSOMES

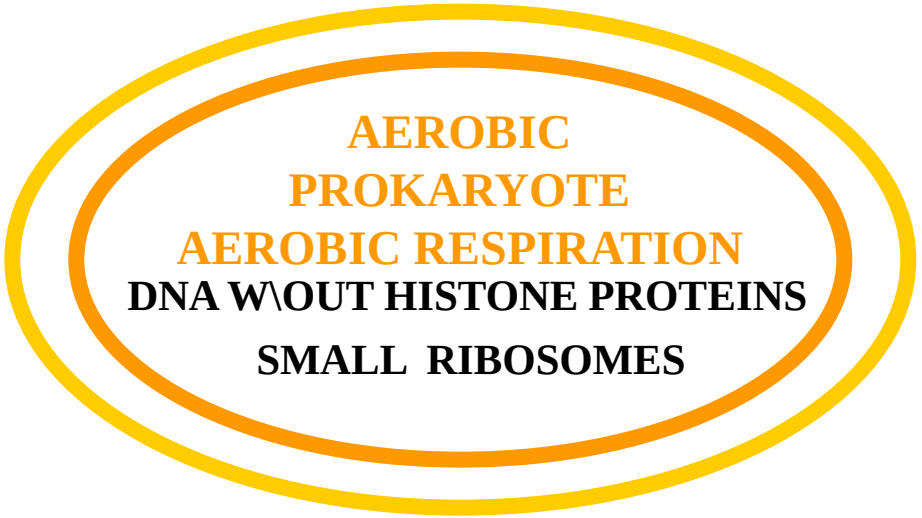
EXCEPTION: AEROBIC PROKARYOTE UNDERGOES ENDOSYMBIOSIS

MUTUALISTIC ENDOSYMBIOTIC RELATIONSHIP EVOLVES

HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES



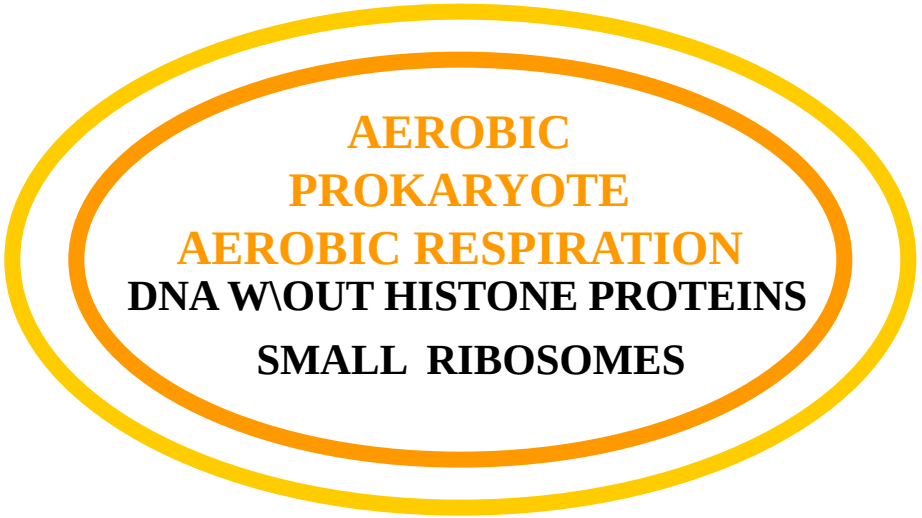
MUTUALISTIC ENDOSYMBIOTIC RELATIONSHIP EVOLVES

OBLIGATE DEPENDENT RELATIONSHIP EVOLVES

HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES



SYMBIONTS CANNOT EXIST INDEPENENTLY

MITOCHONDRION EVOLUTION

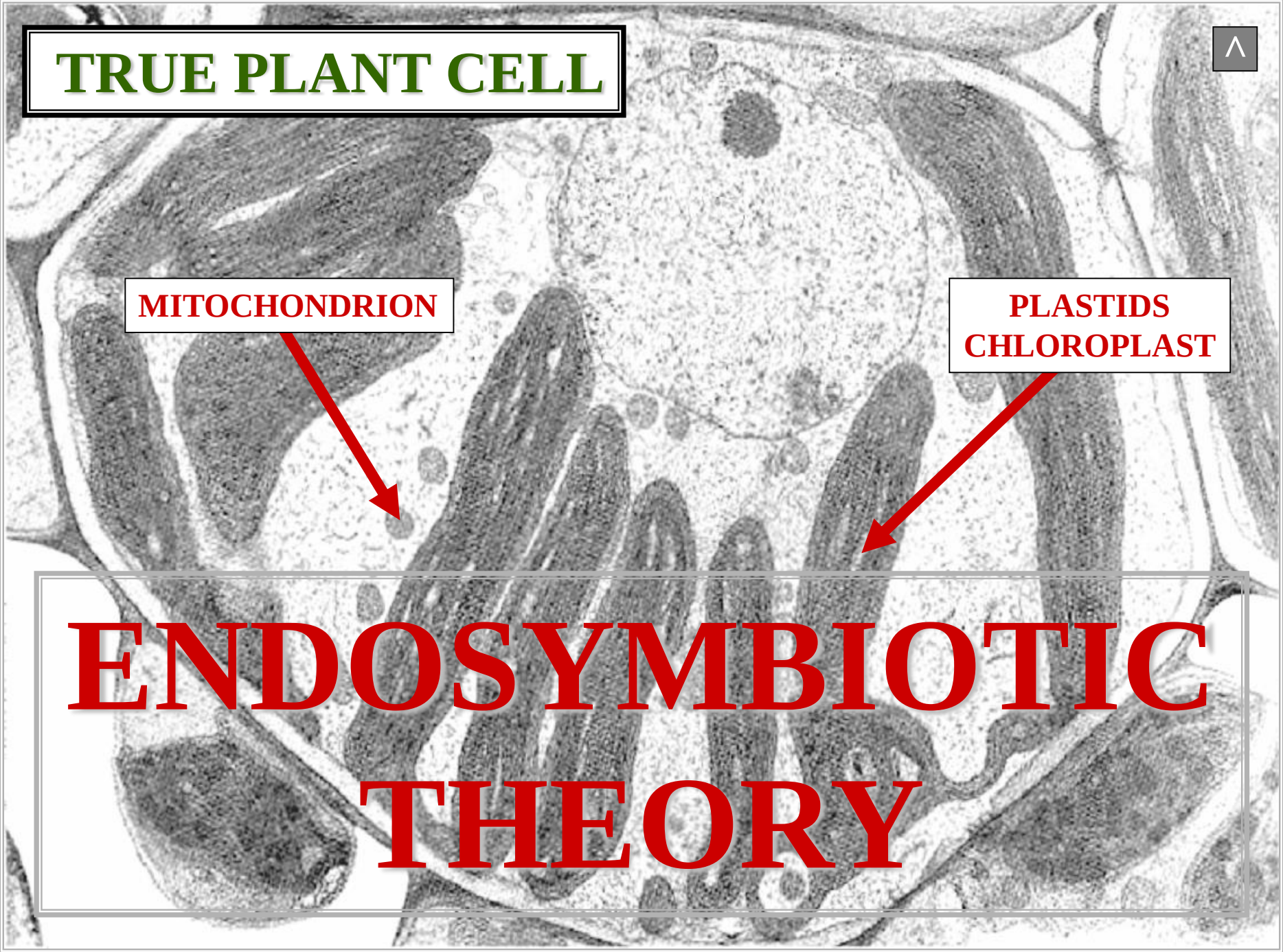
HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

MITOCHONDRION EVOLUTION

TRUE PLANT CELL



ENDOSYMBIOTIC THEORY

ENDOSYMBIOTIC THEORY SUPPORTING EVIDENCE

PROPONENT: ENDOSYMBIOTIC THEORY

LYNN MARGULIS

ELECTRON MICROSCOPE

TRUE PLANT CELL

D

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

TRUE PLANT CELL

P

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

DNA

TRUE PLANT CELL

H

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

DNA PROKARYOTE-LIKE

TRUE PLANT CELL

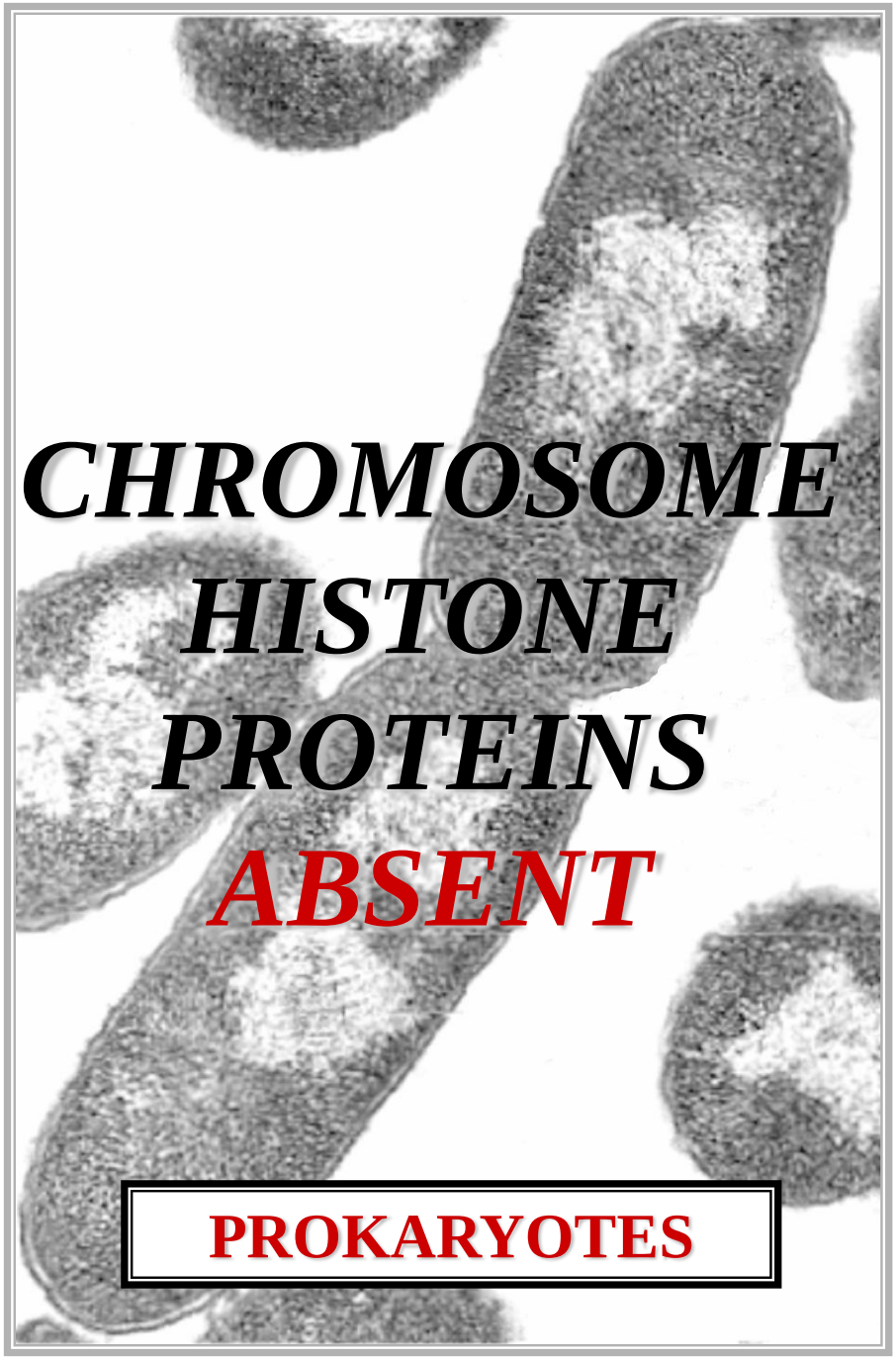
*

MITOCHONDRION

PLASTIDS

DNA PROKARYOTE-LIKE

HISTONE PROTEINS: ABSENT



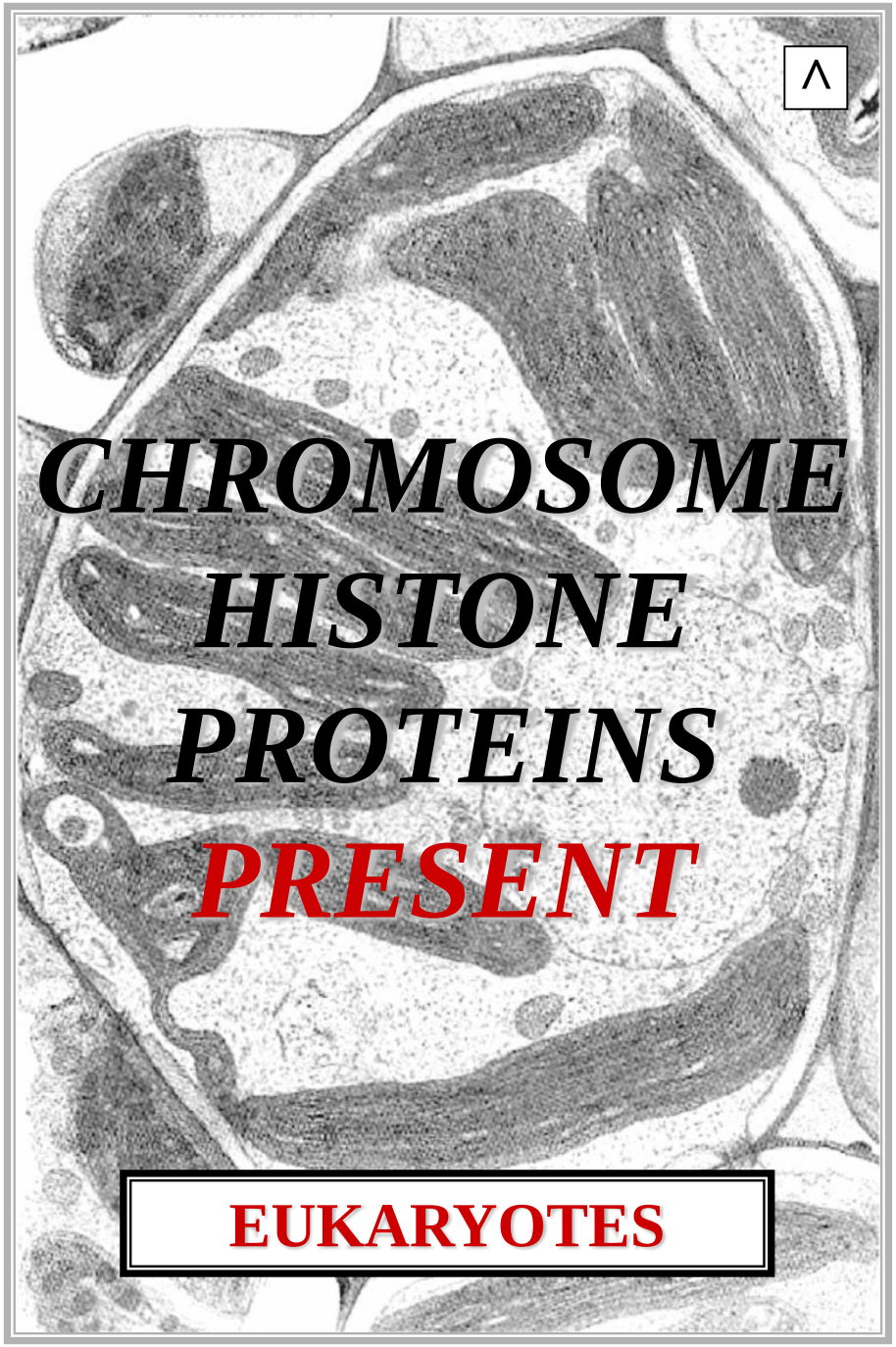
CHROMOSOME

HISTONE

PROTEINS

ABSENT

PROKARYOTES



CHROMOSOME

HISTONE

PROTEINS

PRESENT

EUKARYOTES

TRUE PLANT CELL

R

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

TRUE PLANT CELL

P

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

RIBOSOMES

TRUE PLANT CELL

S

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

RIBOSOMES PROKARYOTE-LIKE

TRUE PLANT CELL

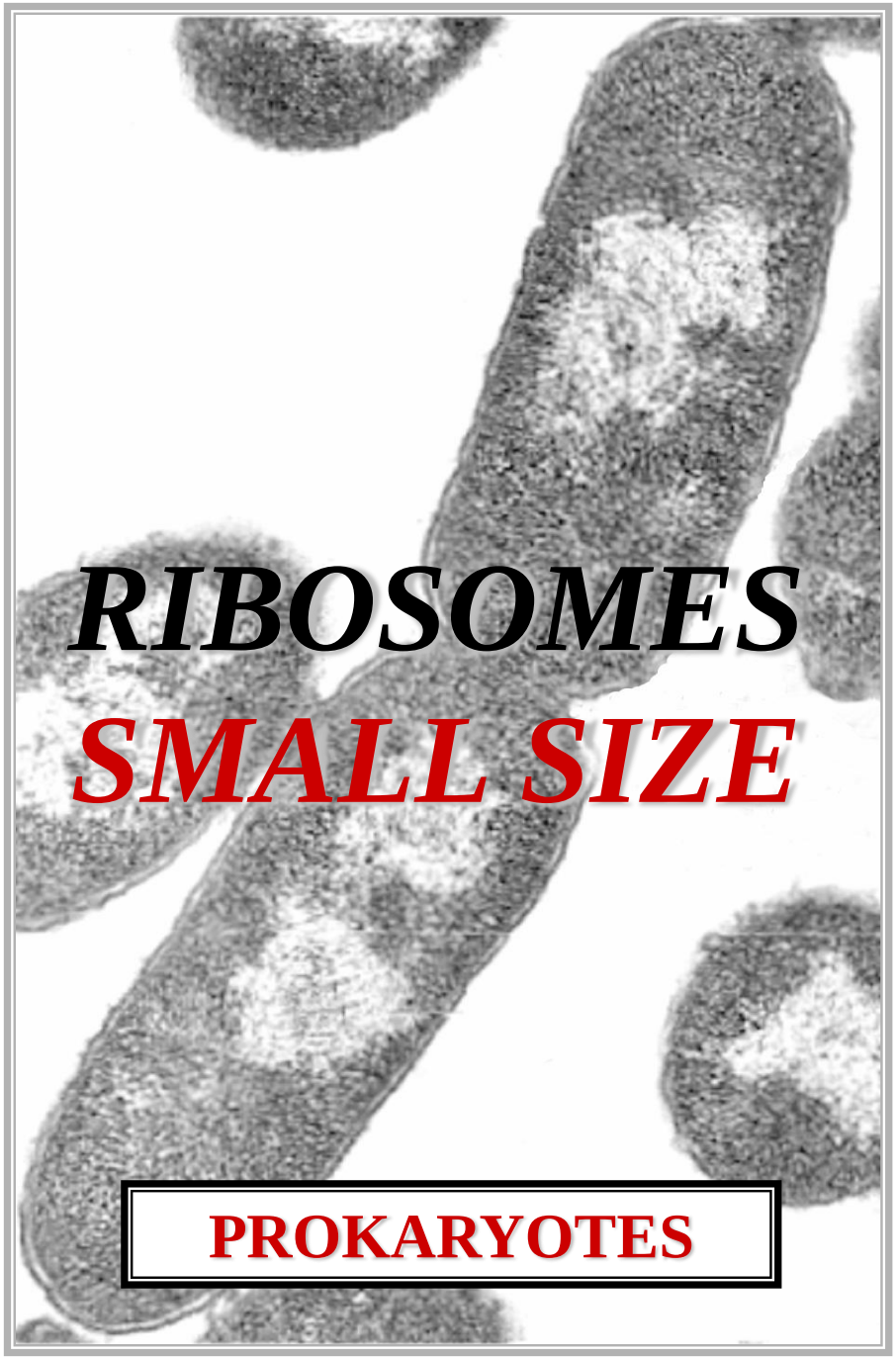
*

MITOCHONDRION

PLASTIDS

RIBOSOMES PROKARYOTE-LIKE

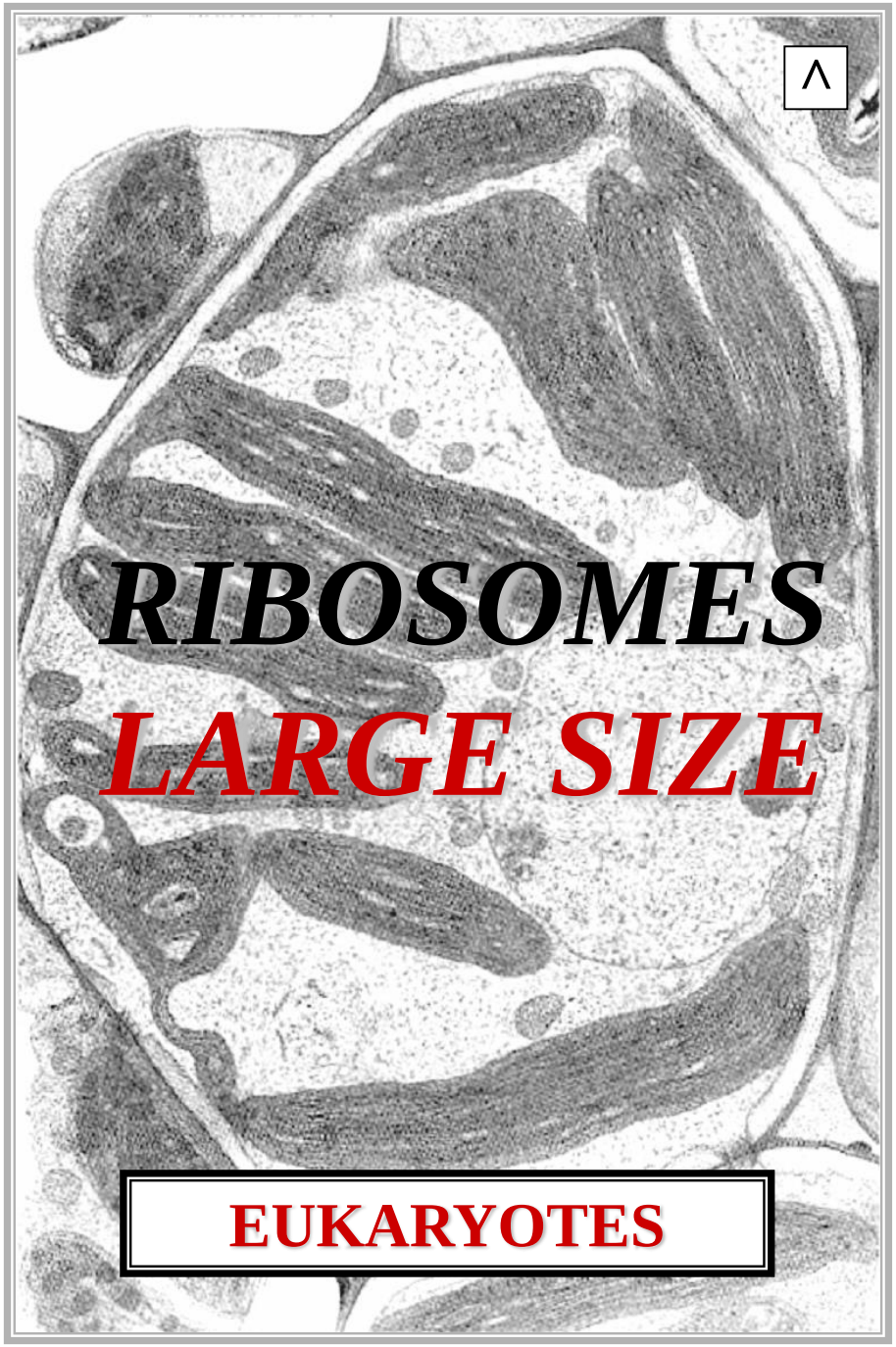
RIBOMES: SMALL



RIBOSOMES

SMALL SIZE

PROKARYOTES



RIBOSOMES

LARGE SIZE

EUKARYOTES

TRUE PLANT CELL

R

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

TRUE PLANT CELL

P

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

REPRODUCTION

TRUE PLANT CELL

B

MITOCHONDRION

PLASTIDS

MITOCHONDRION & PLASTIDS POSSESS:

REPRODUCTION PROKARYOTE-LIKE

TRUE PLANT CELL

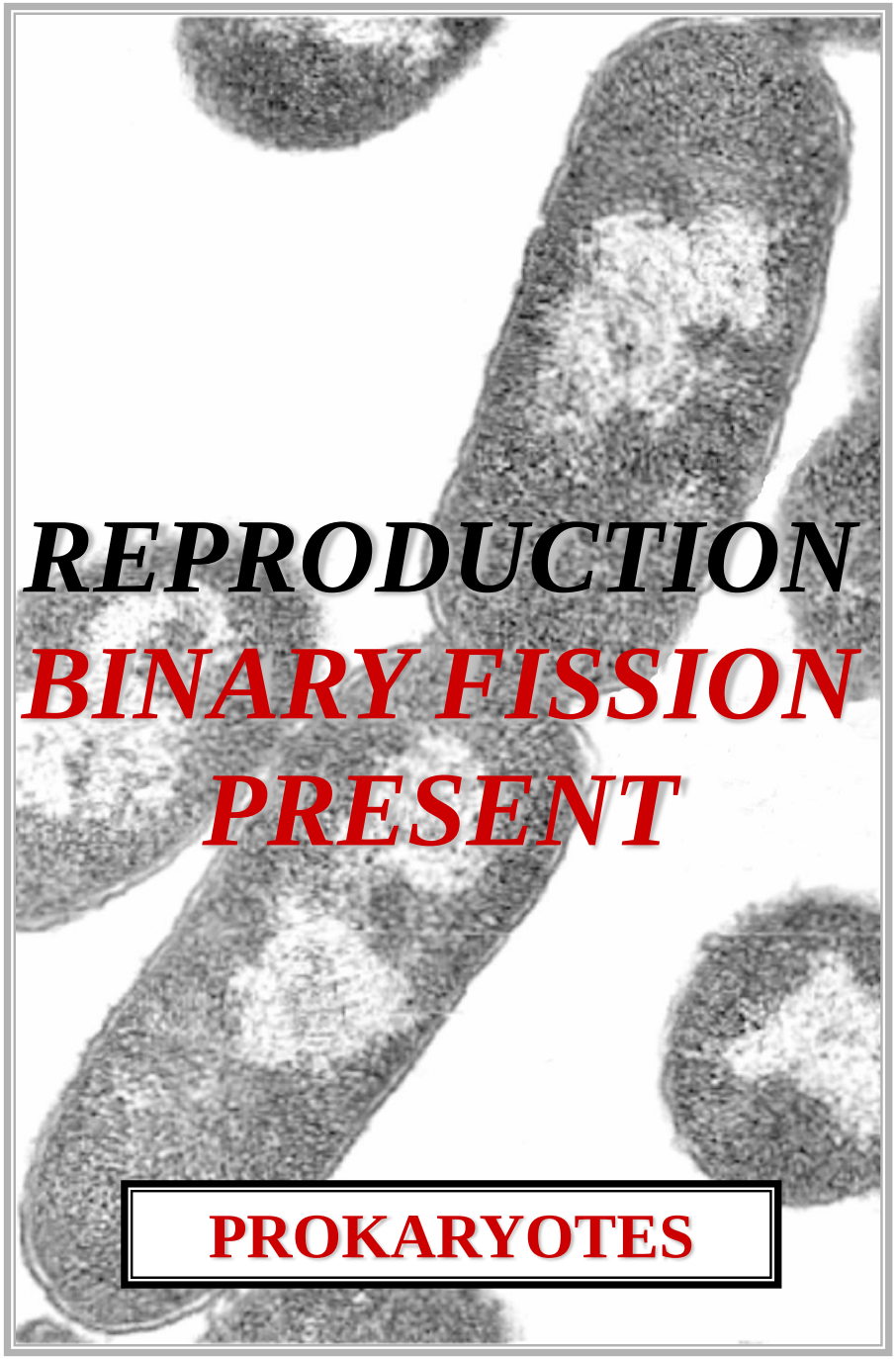
*

MITOCHONDRION

PLASTIDS

REPRODUCTION PROKARYOTE-LIKE

REPRODUCTION: BINARY FISSION

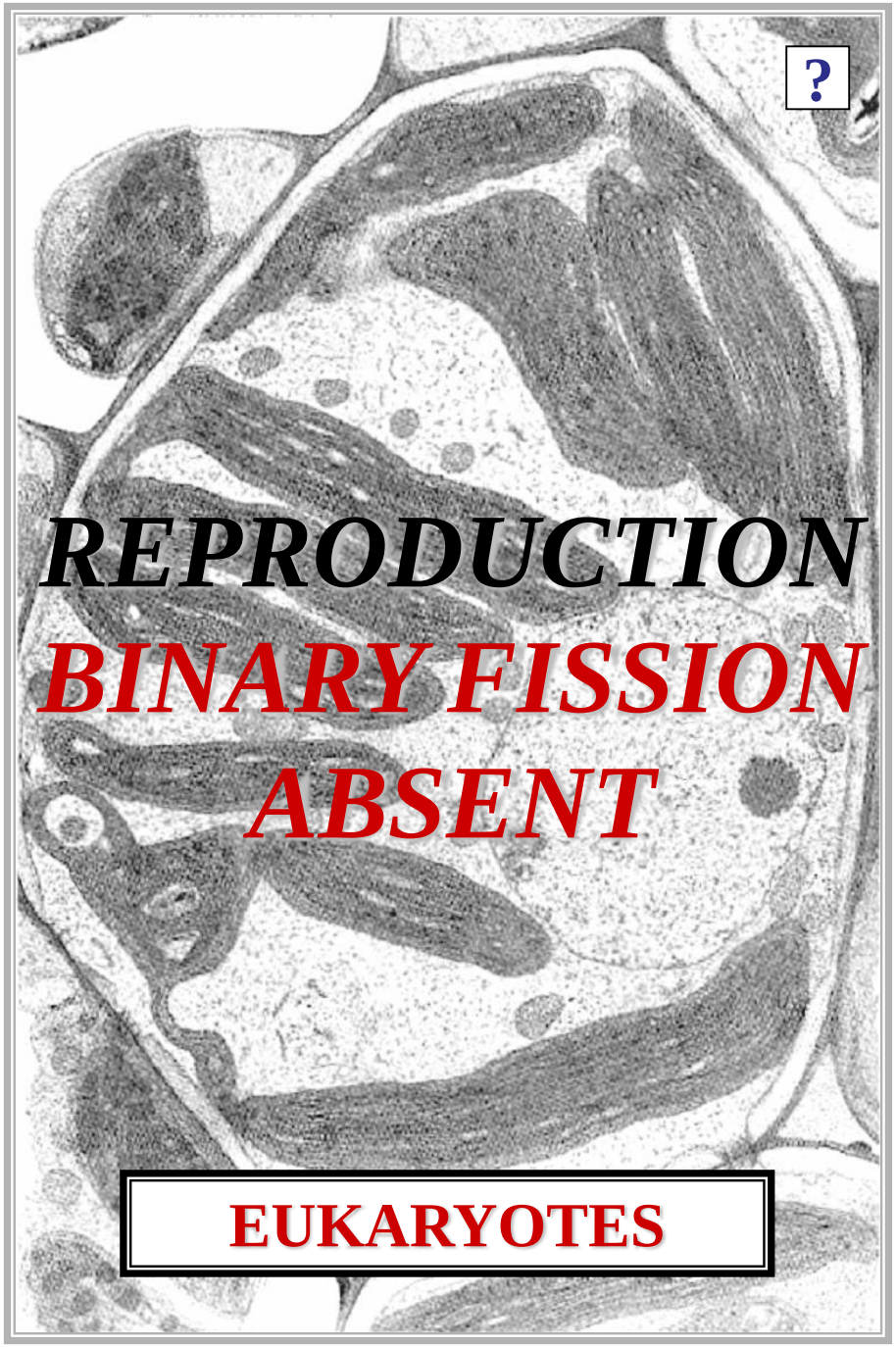


REPRODUCTION

BINARY FISSION

PRESENT

PROKARYOTES



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REPRODUCTION

BINARY FISSION

ABSENT

EUKARYOTES

QUESTION

DOES THIS EVIDENCE SUPPORT OR REFUTE THE ENDOSYMBIOTIC THEORY?

QUESTION

TRUE PLANT CELL

D+

MITOCHONDRION

PLASTIDS

TRUE PLANT CELL

R

+

MITOCHONDRION

PLASTIDS

DNA PROKARYOTE-LIKE

TRUE PLANT CELL

R +

MITOCHONDRION

PLASTIDS

DNA PROKARYOTE-LIKE

RIBOSOMES PROKARYOTE-LIKE

TRUE PLANT CELL

?

2

MITOCHONDRION

PLASTIDS

DNA PROKARYOTE-LIKE

RIBOSOMES PROKARYOTE-LIKE

REPRODUCTION PROKARYOTE-LIKE

QUESTION

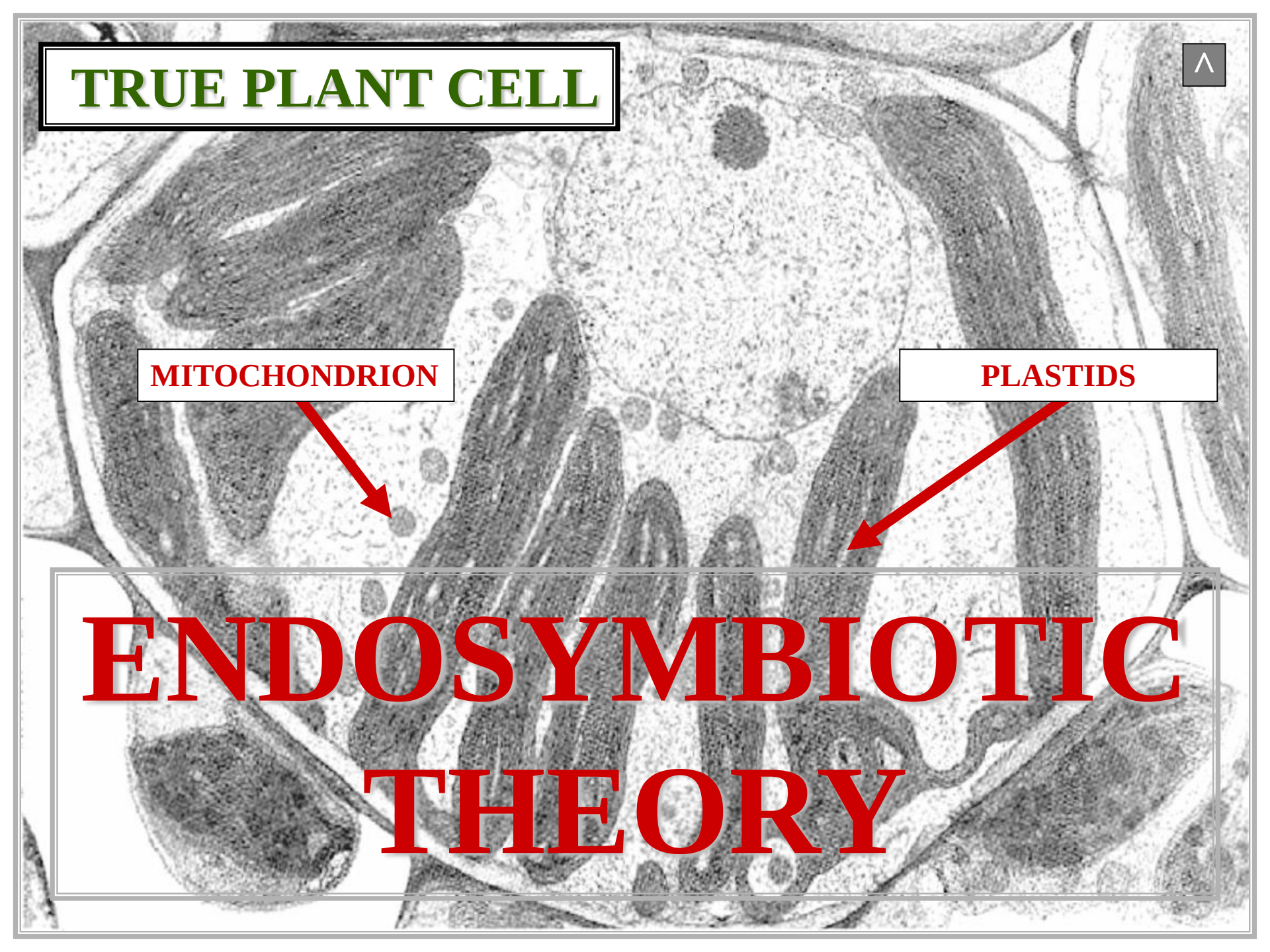
DOES THIS EVIDENCE SUPPORT OR REFUTE THE ENDOSYMBIOTIC THEORY?

QUESTION

ANSWER

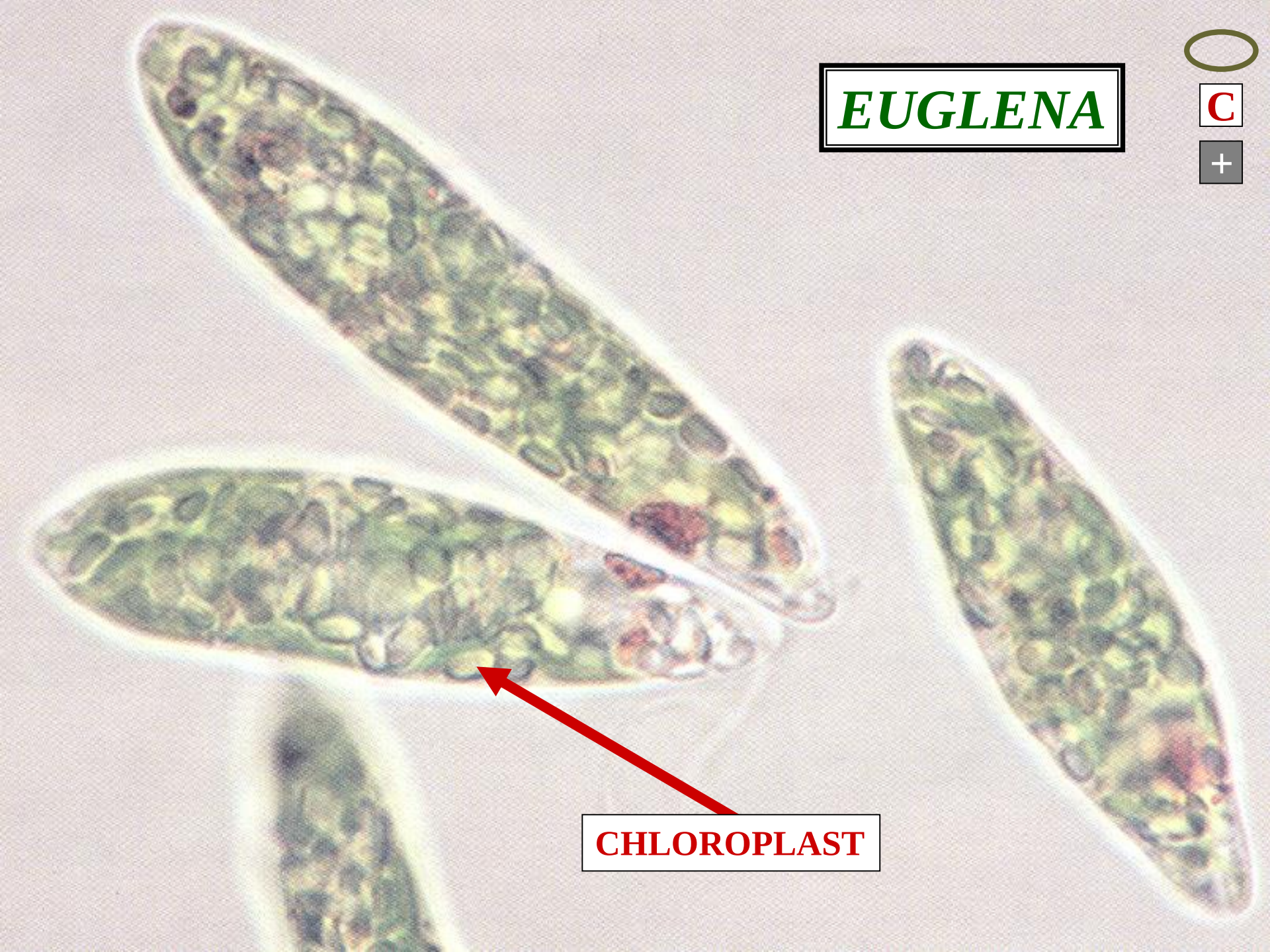
EVIDENSE SUPPORTS ENDOSYMBIOTIC THEORY

ANSWER

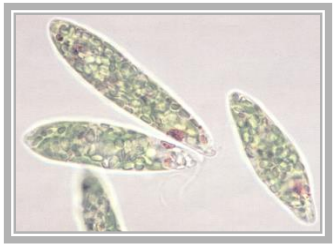

TRUE PLANT CELL
MITOCHONDRION
PLASTIDS
ENDOSYMBIOTIC THEORY

Euglena

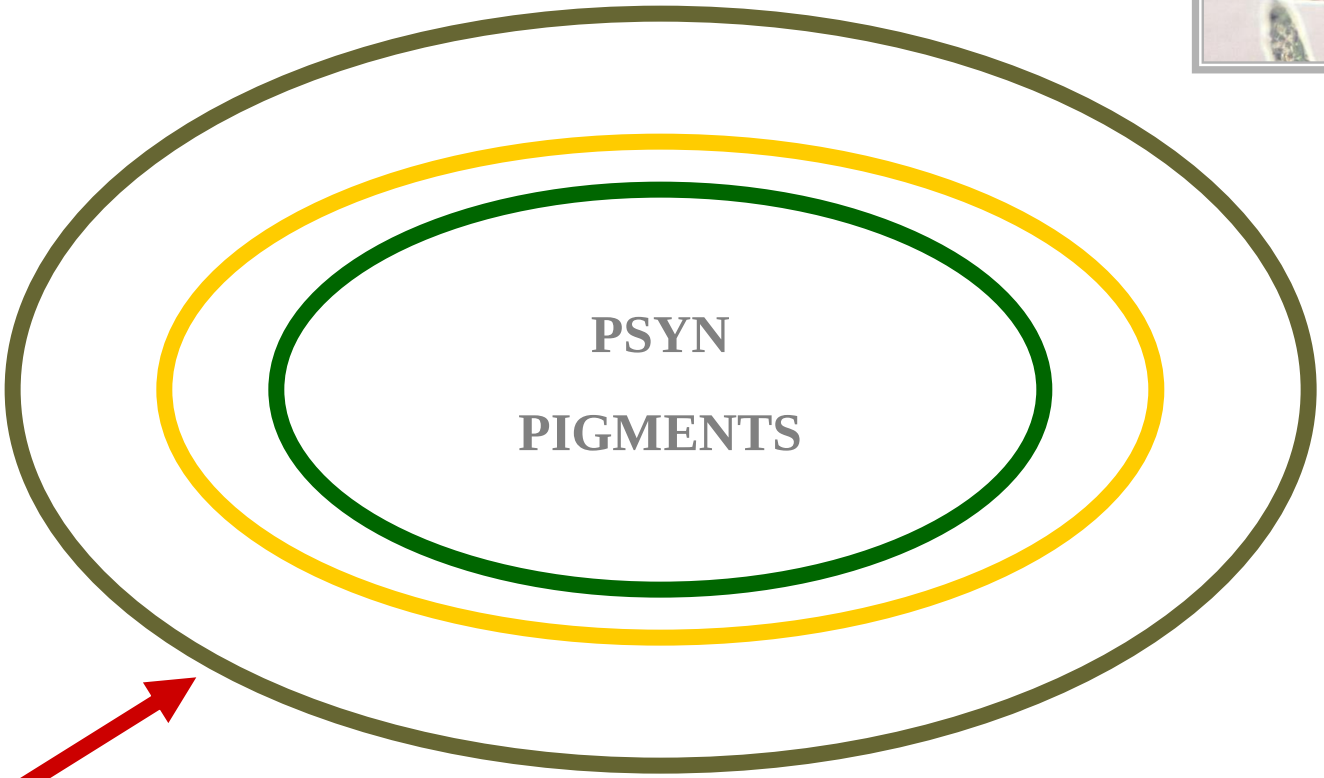
TRUE PLANT EXCLUSION


EUGLENA
C
+
CHLOROPLAST

EUGLENA

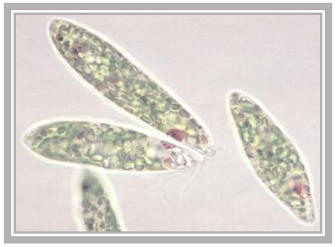


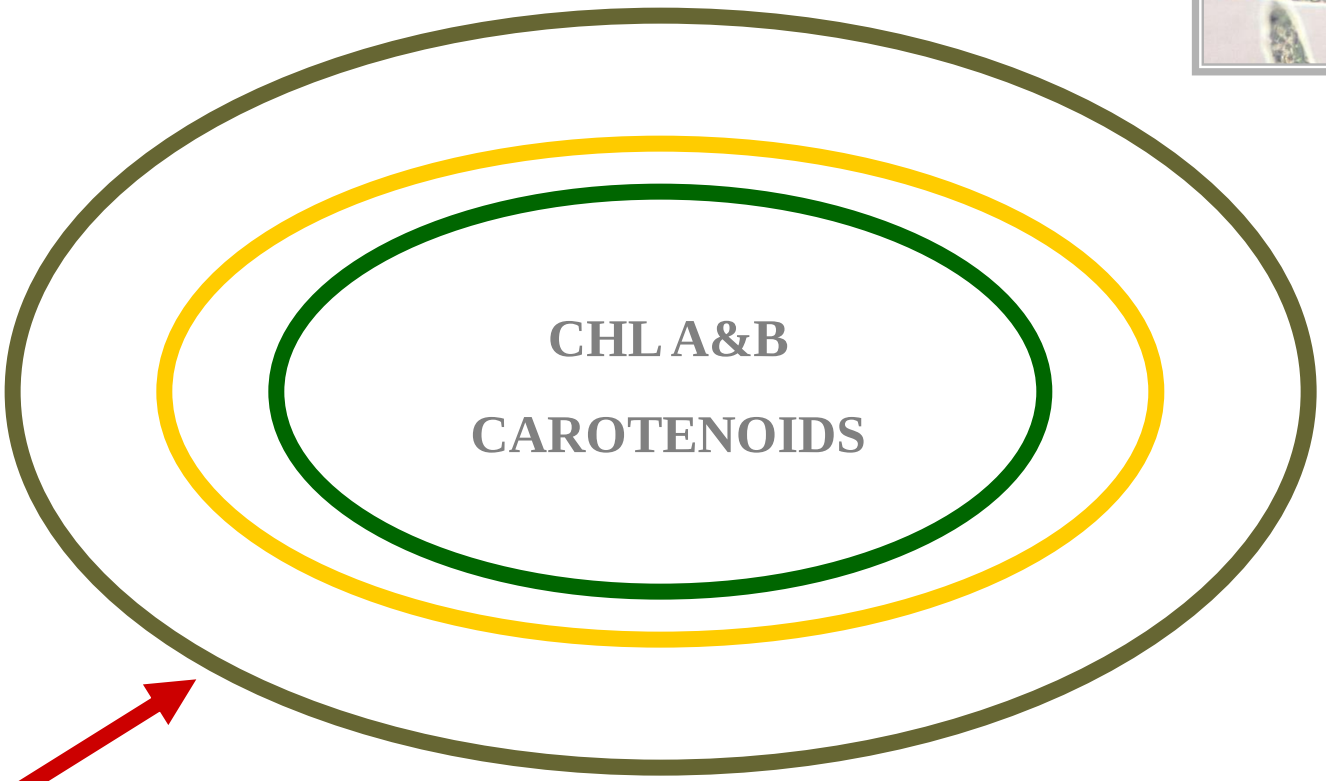
A&B



CHLOROPLAST

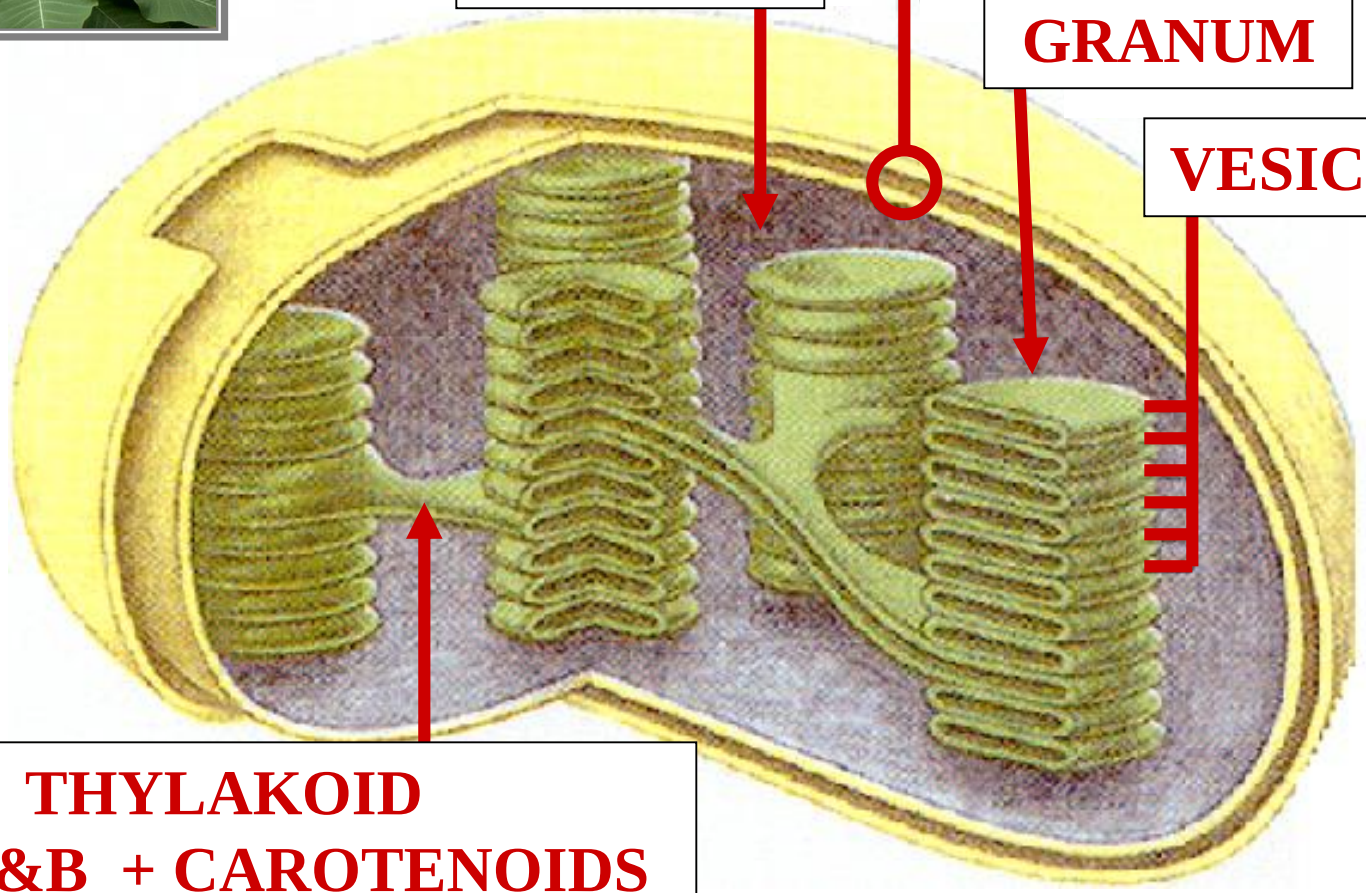
EUGLENA





CHLOROPLAST

TRUE PLANT CHLOROPLAST ULTRASTRUCTURE



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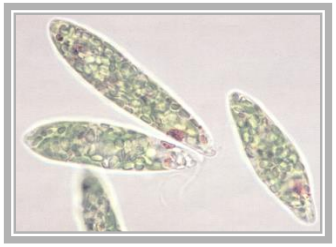


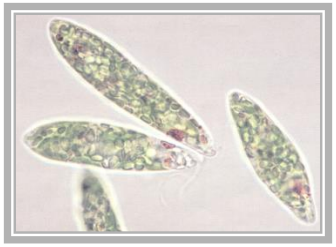
1

CHL A&B

CAROTENOIDS

CHLOROPLAST

EUGLENA



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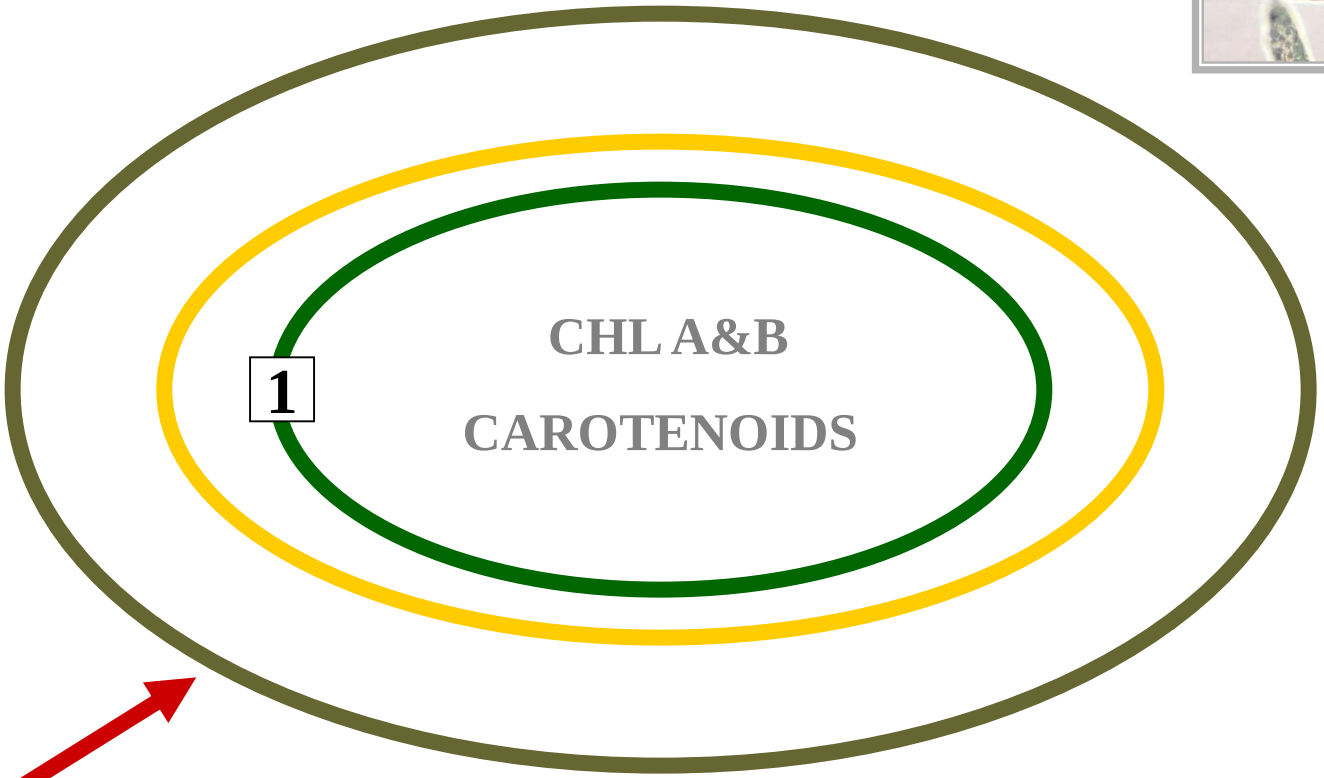
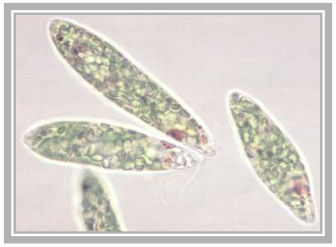


CHLOROPLAST

EUGLENA



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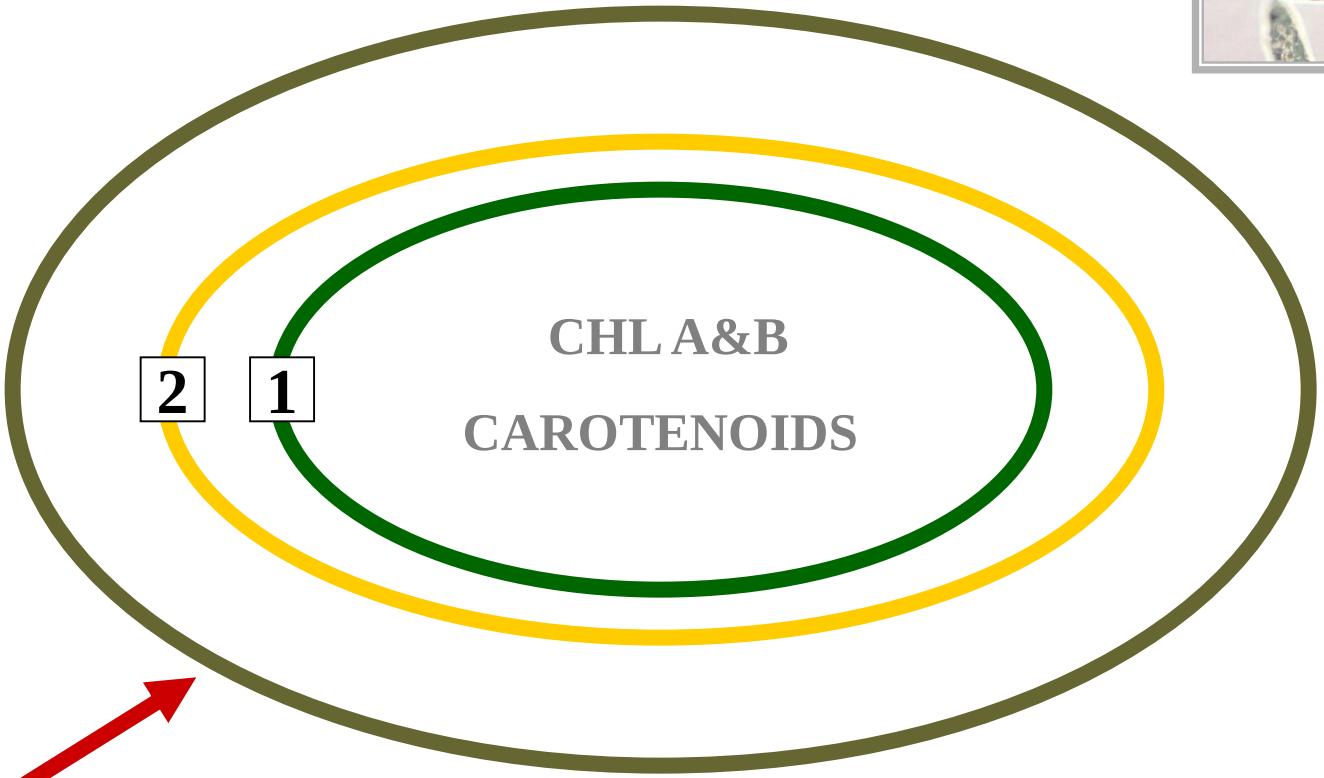
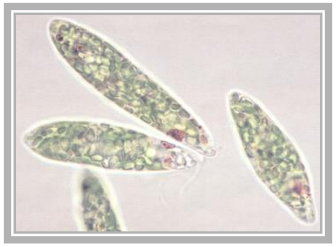


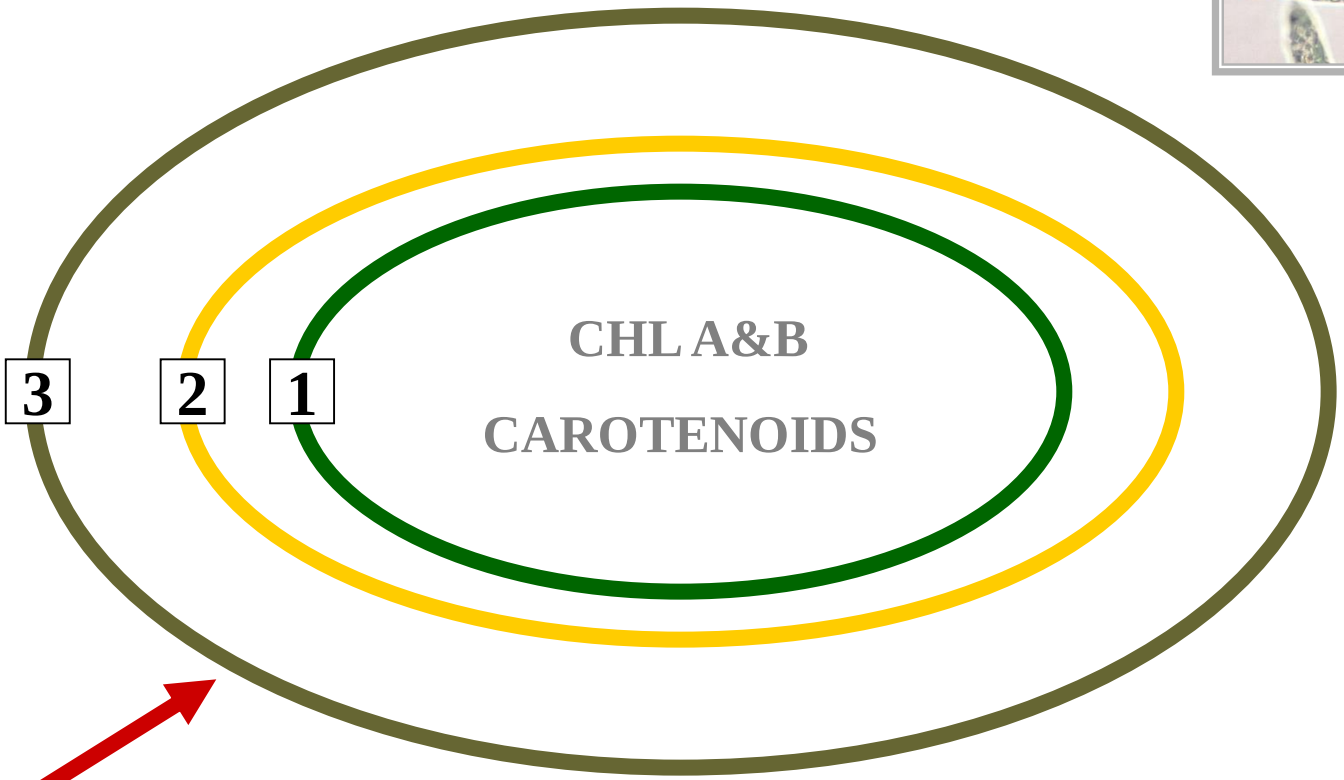
CHLOROPLAST

EUGLENA



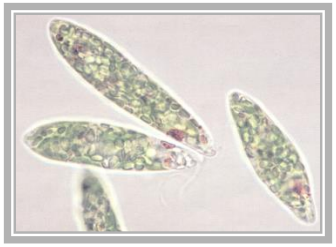
T

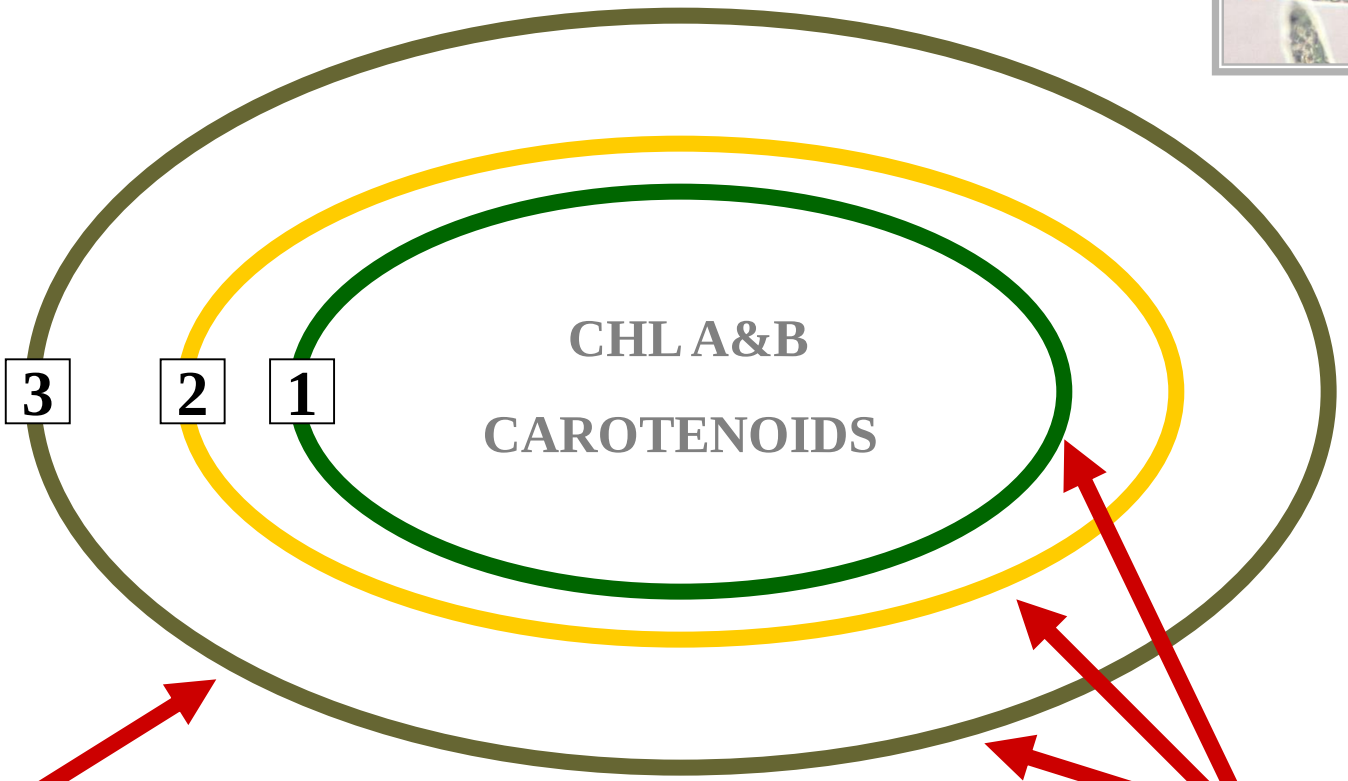
+



CHLOROPLAST

EUGLENA

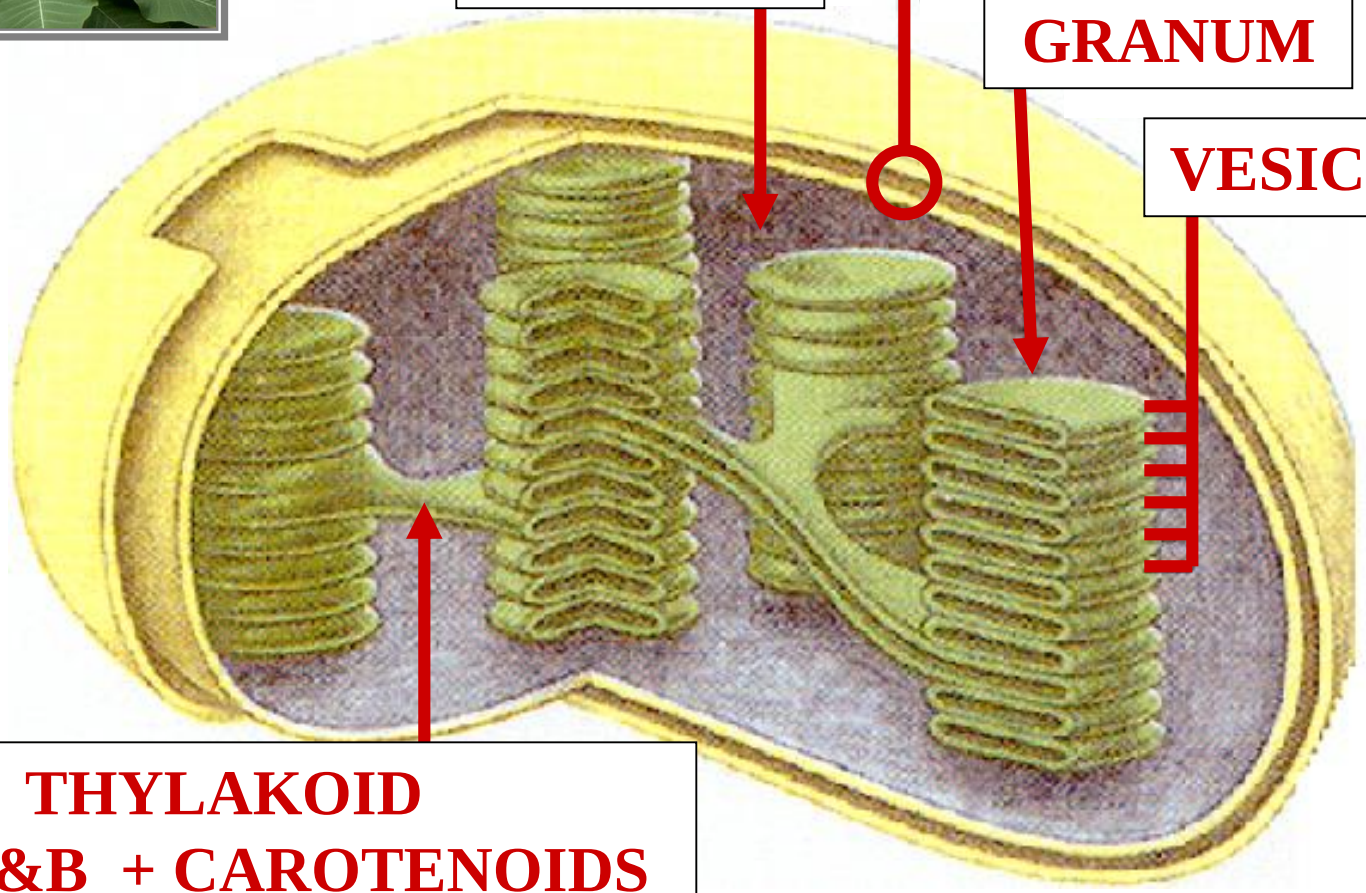




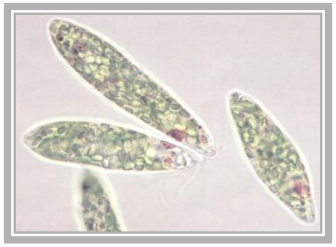
CHLOROPLAST

TRIPLE MEMBRANE

TRUE PLANT CHLOROPLAST ULTRASTRUCTURE



EUGLENA



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3 2 1

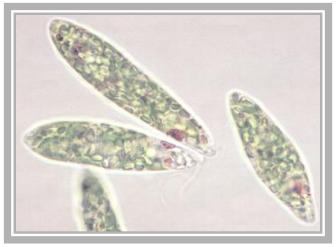
CHL A&B

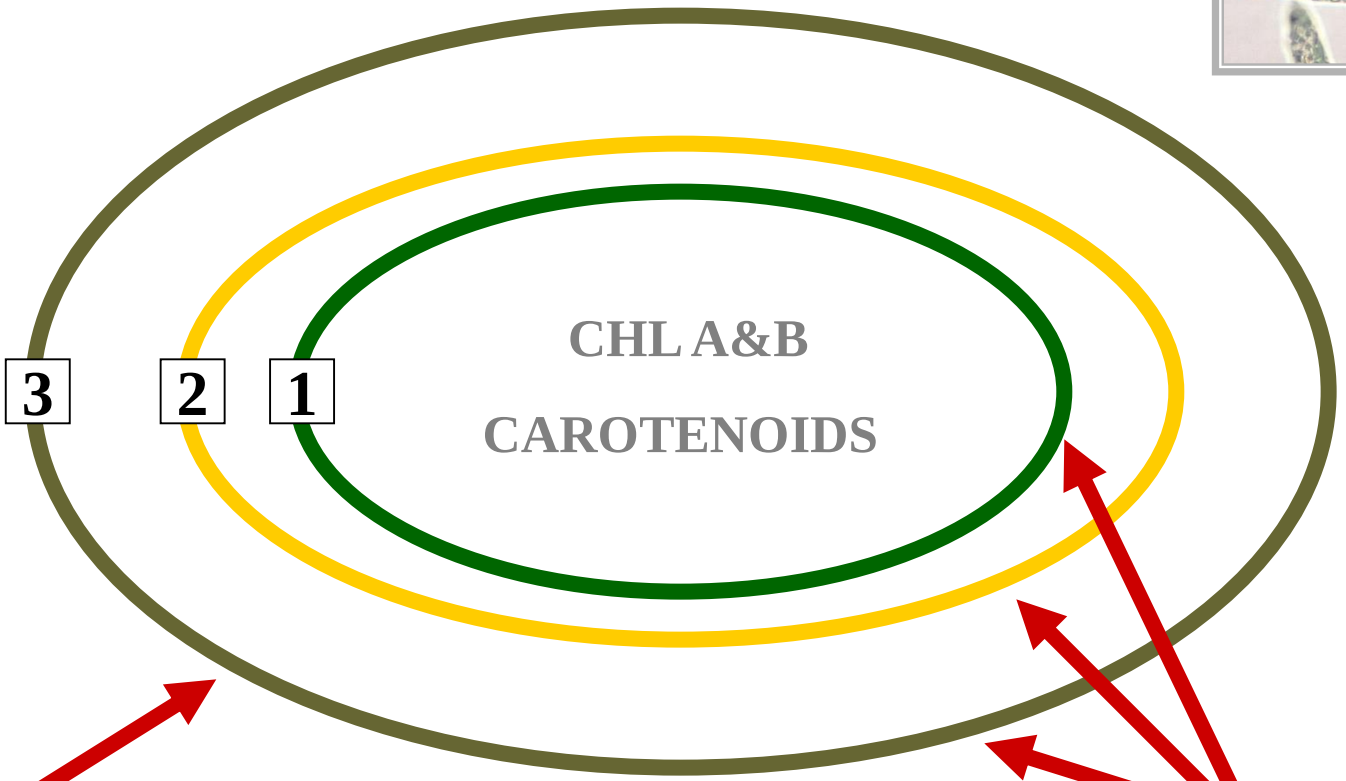
CAROTENOIDS

CHLOROPLAST

TRIPLE MEMBRANE

EUGLENA





CHLOROPLAST EVOLVED VIA SECONDARY ENDOSYMBIOSIS

TRIPLE MEMBRANE

SECONDARY ENDOSYMBIOSIS

PRIMARY ENDOSYMBIOSIS

PRIMARY ENDOSYMBIOSIS

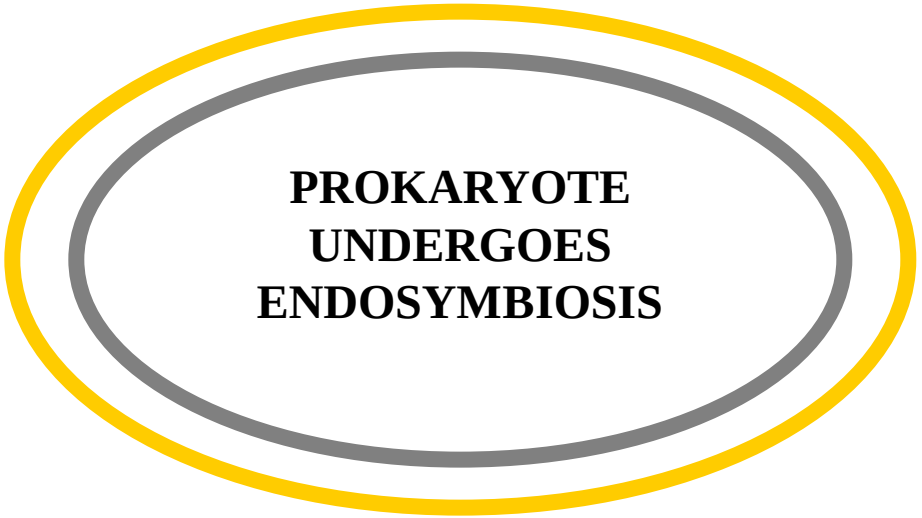
PROKARYOTE UNDERGOES ENDOSYMBIOSIS

PRIMARY ENDOSYMBIOSIS

D

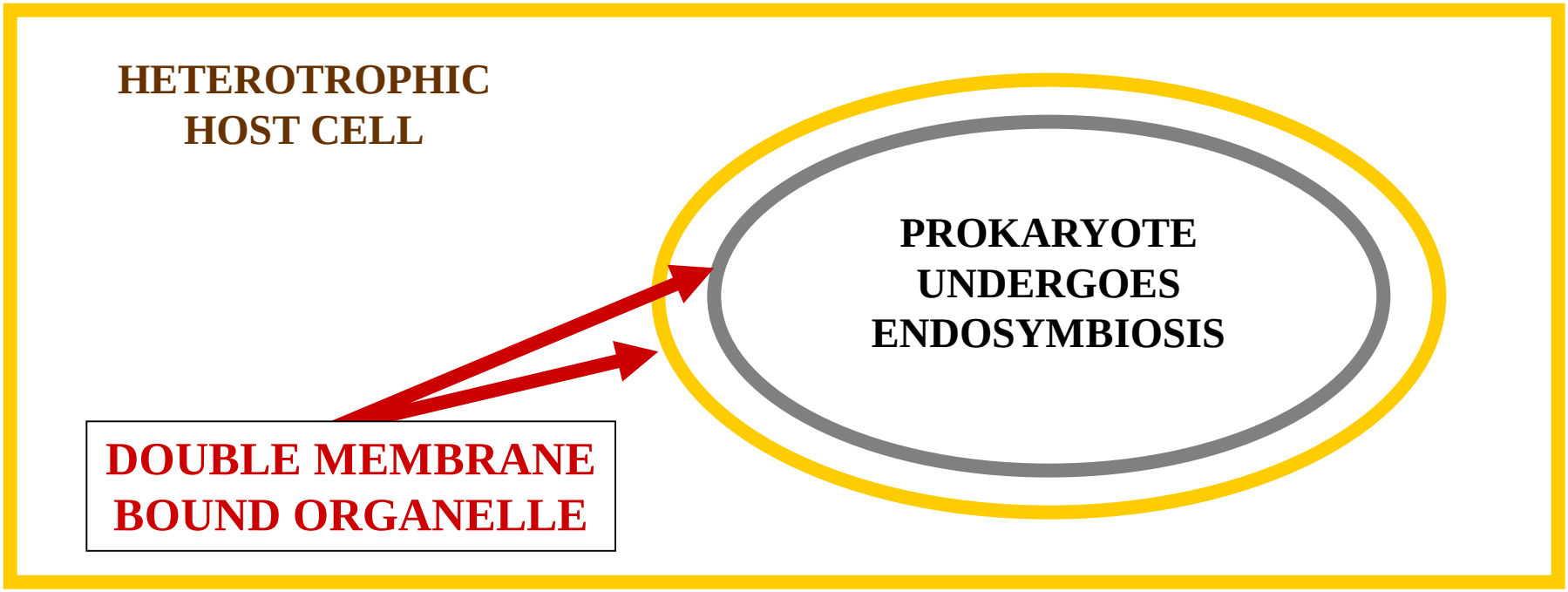
PRIMARY ENDOSYMBIOSIS

HETEROTROPHIC
HOST CELL



PRIMARY ENDOSYMBIOSIS

PRIMARY ENDOSYMBIOSIS



PRIMARY ENDOSYMBIOSIS

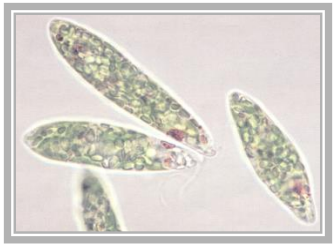
SECONDARY ENDOSYMBIOSIS

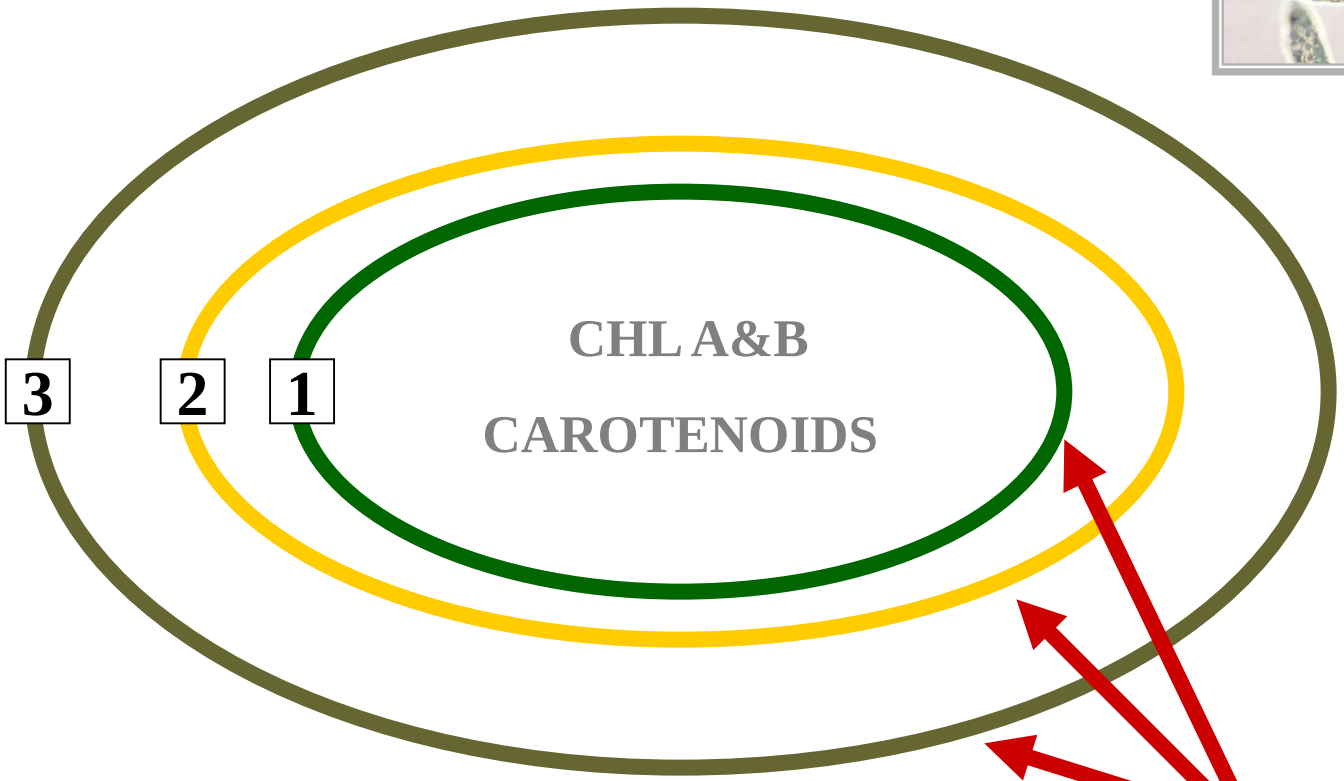
SECONDARY ENDOSYMBIOSIS

EUKARYOTE UNDERGOES ENDOSYMBIOSIS

SECONDARY ENDOCYTOSIS

EUGLENA





SECONDARY ENDOSYMBIOSIS

TRIPLE MEMBRANE BOUND ORGANELLE

Euglena
PLASTID EVOLUTION

Euglena

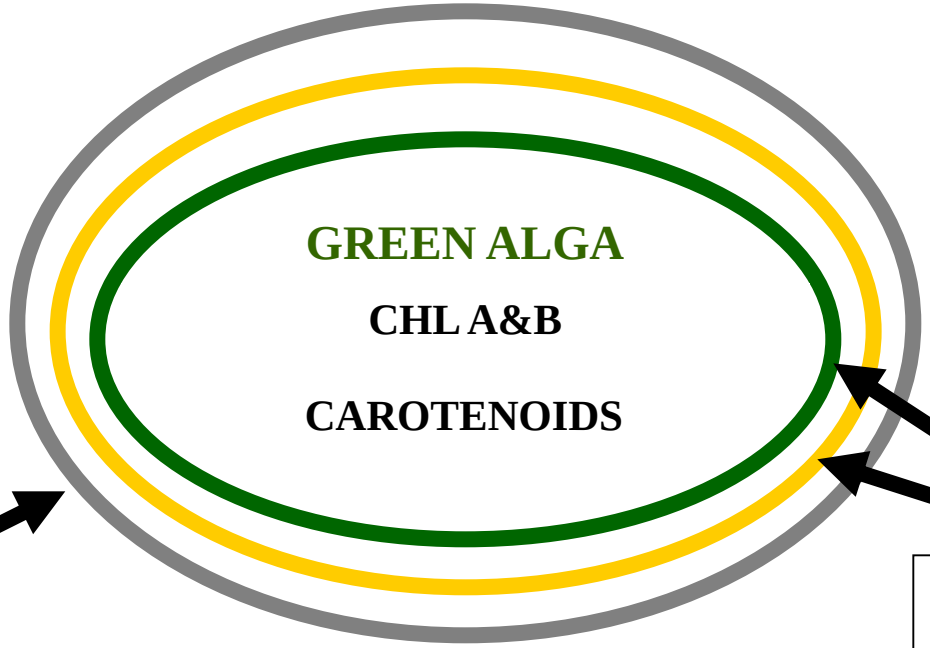
PLASTID EVOLUTION

HYPOTHETICAL SCENARIO

S

HETEROTROPHIC EUGLENOID HOST CELL

EUGLENOID MEMBRANE



CELL MEMBRANE

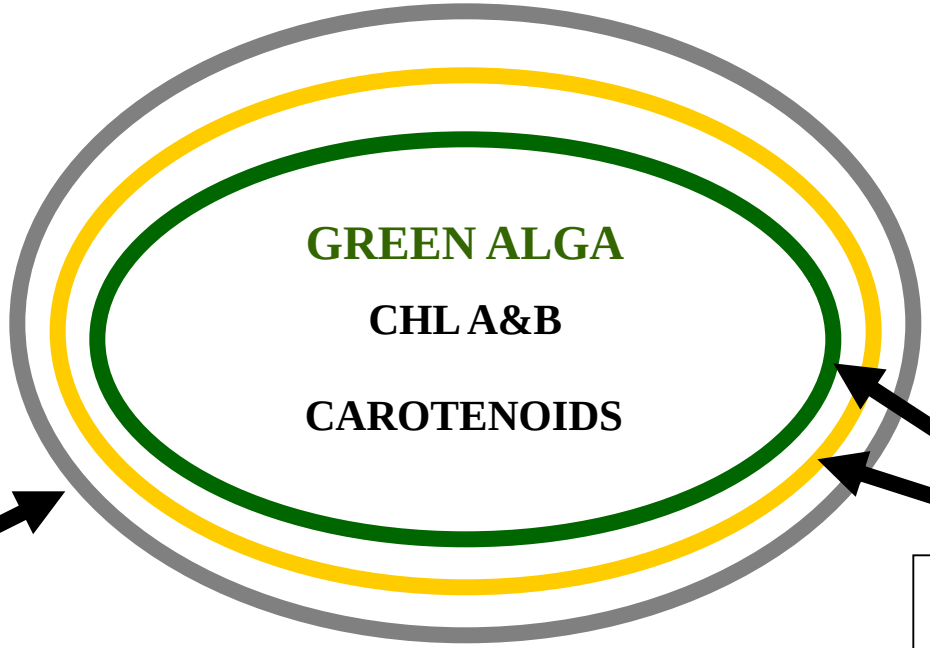
AUTOTROPHIC EUKARYOTE

CHLOROPLAST DOUBLE MEMBRANE

HETEROTROPHIC EUGLENOID HOST CELL

EUGLENOID MEMBRANE

SAME HABITAT



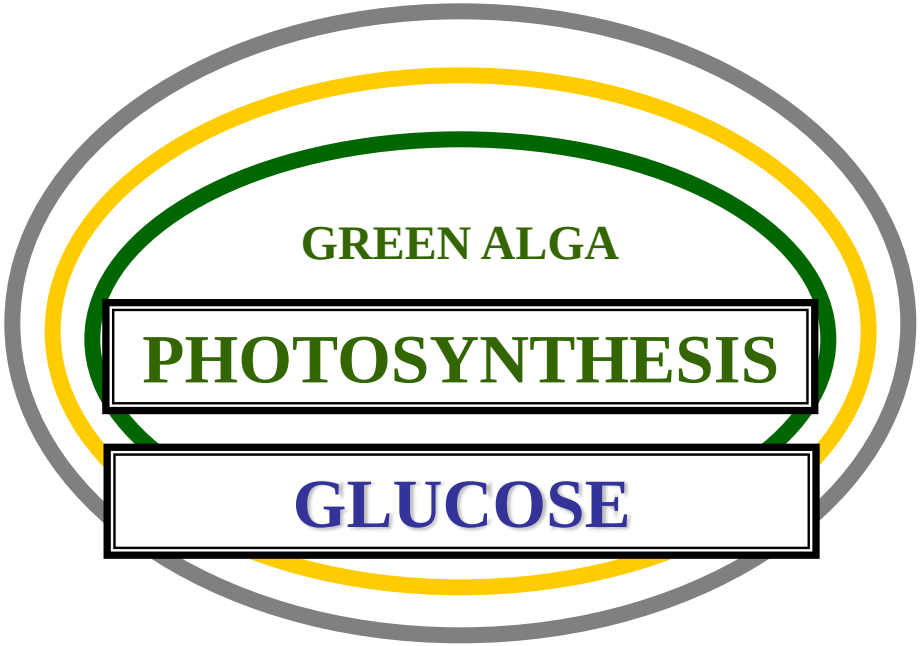
CELL MEMBRANE

AUTOTROPHIC EUKARYOTE

CHLOROPLAST DOUBLE MEMBRANE

C

HETEROTROPHIC EUGLENOID
***CANNOT DERIVE* GLUCOSE**

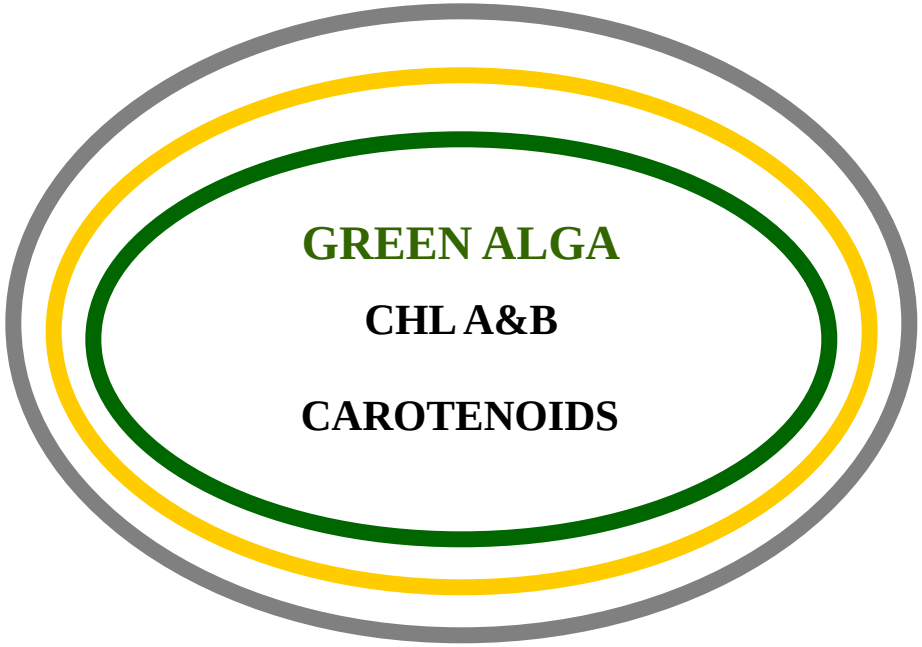


AUTOTROPHIC EUKARYOTE

E

HETEROTROPHIC EUGLENOID

CONSUMES AUTOTROPHIC GREEN ALGA



AUTOTROPHIC EUKARYOTE

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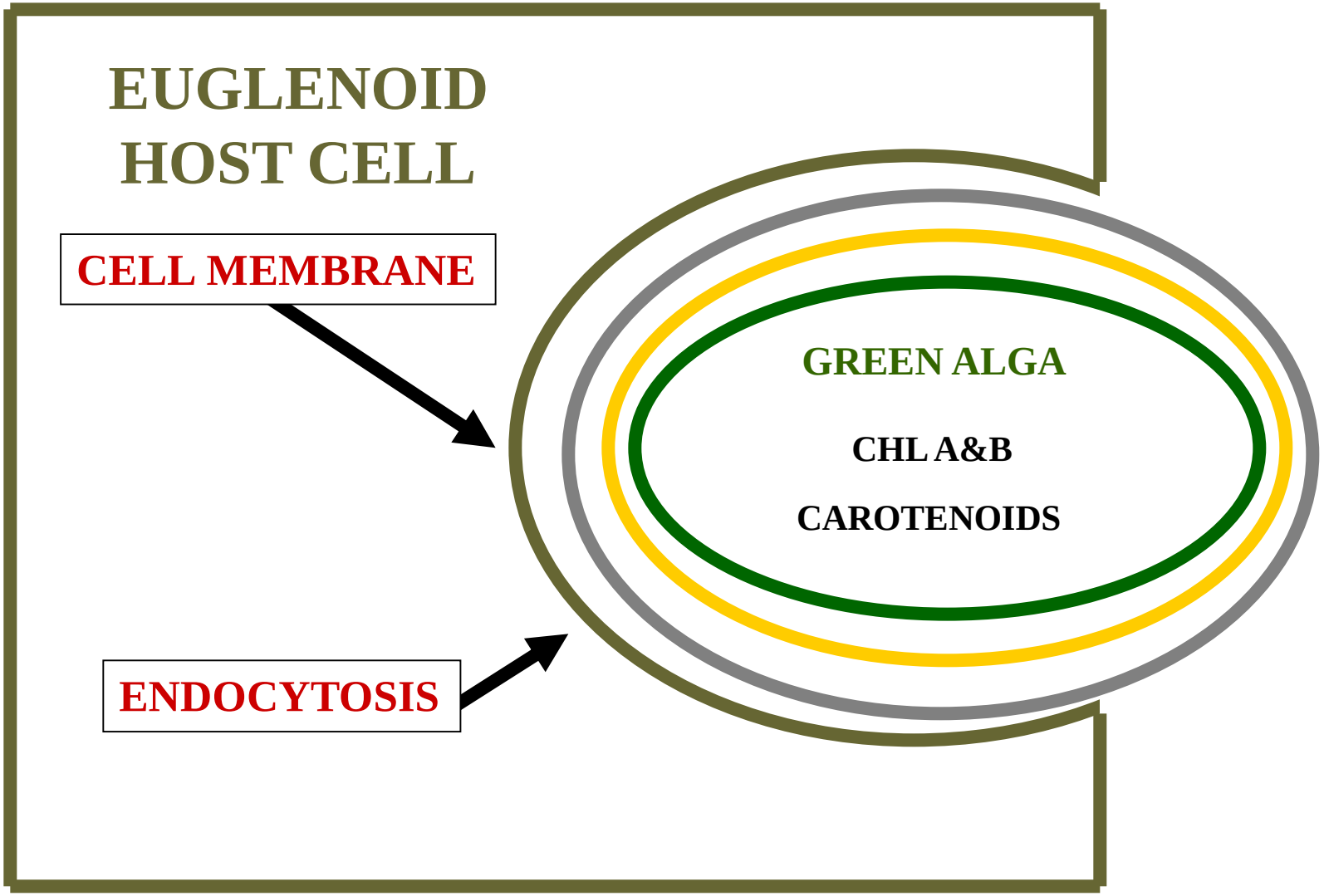
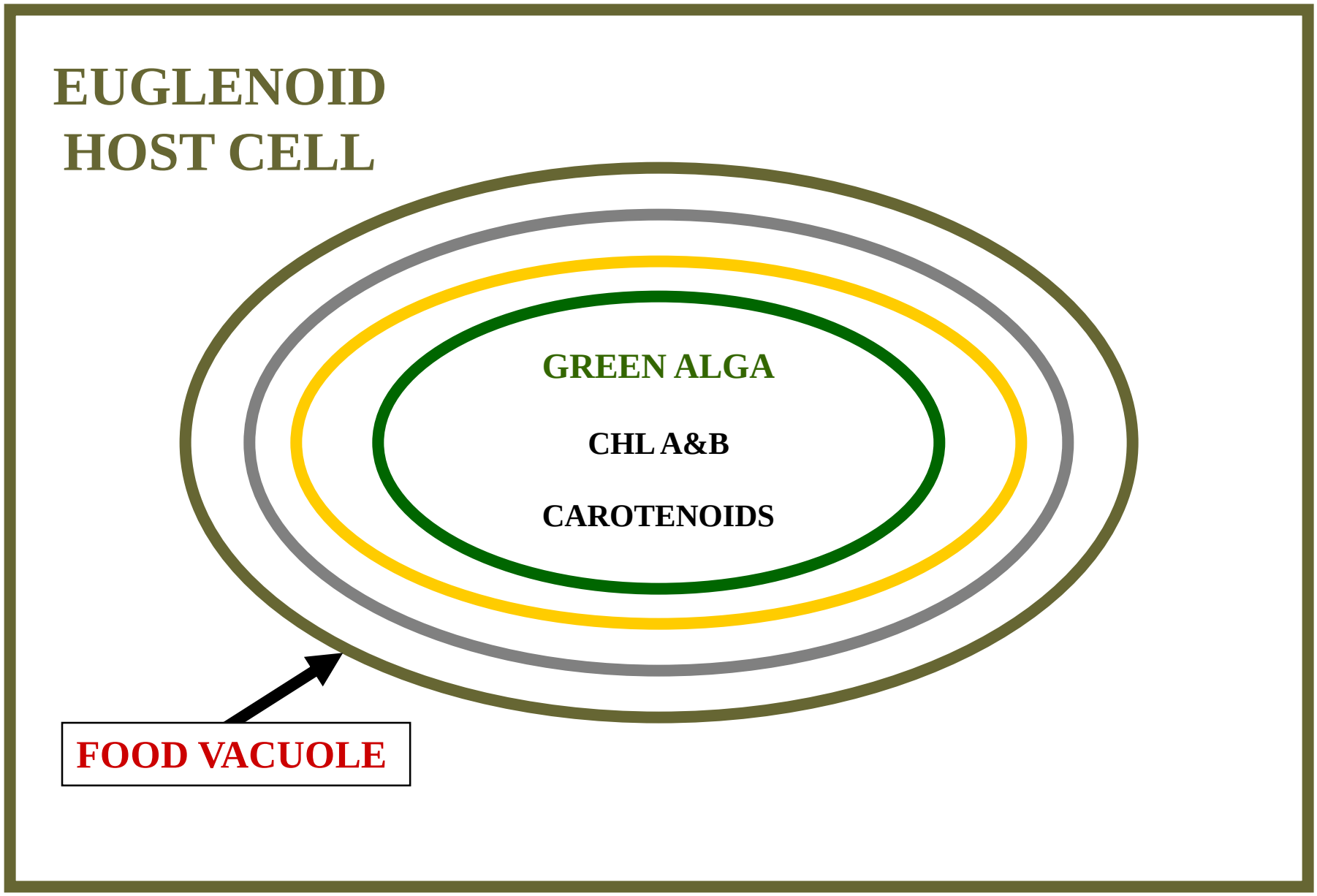
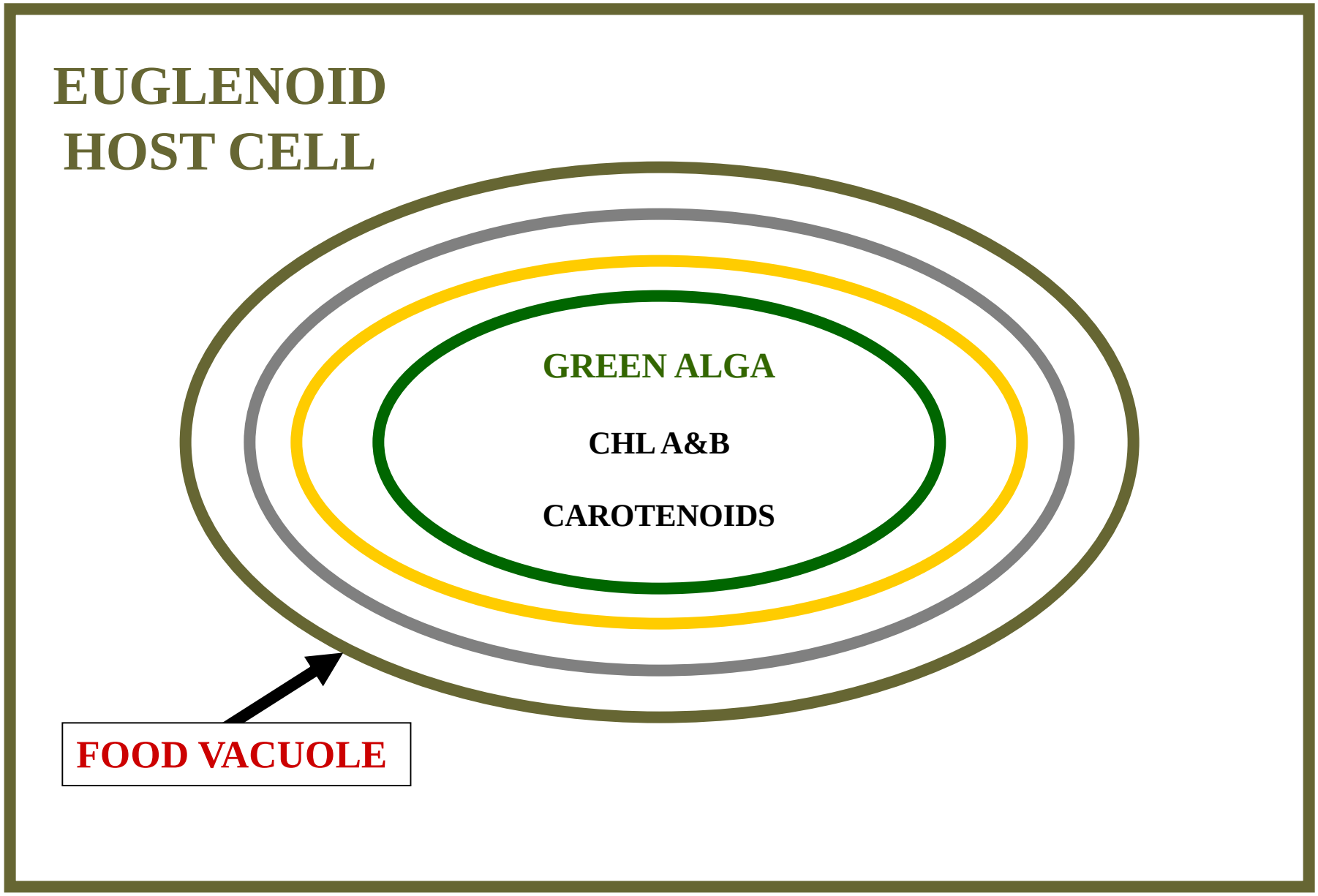

EUGLENOID
HOST CELL
CELL MEMBRANE
GREEN ALGA
CHL A&B
CAROTENOIDS
ENDOCYTOSIS

GREEN ALGA WITHIN FOOD VACUOLE

I



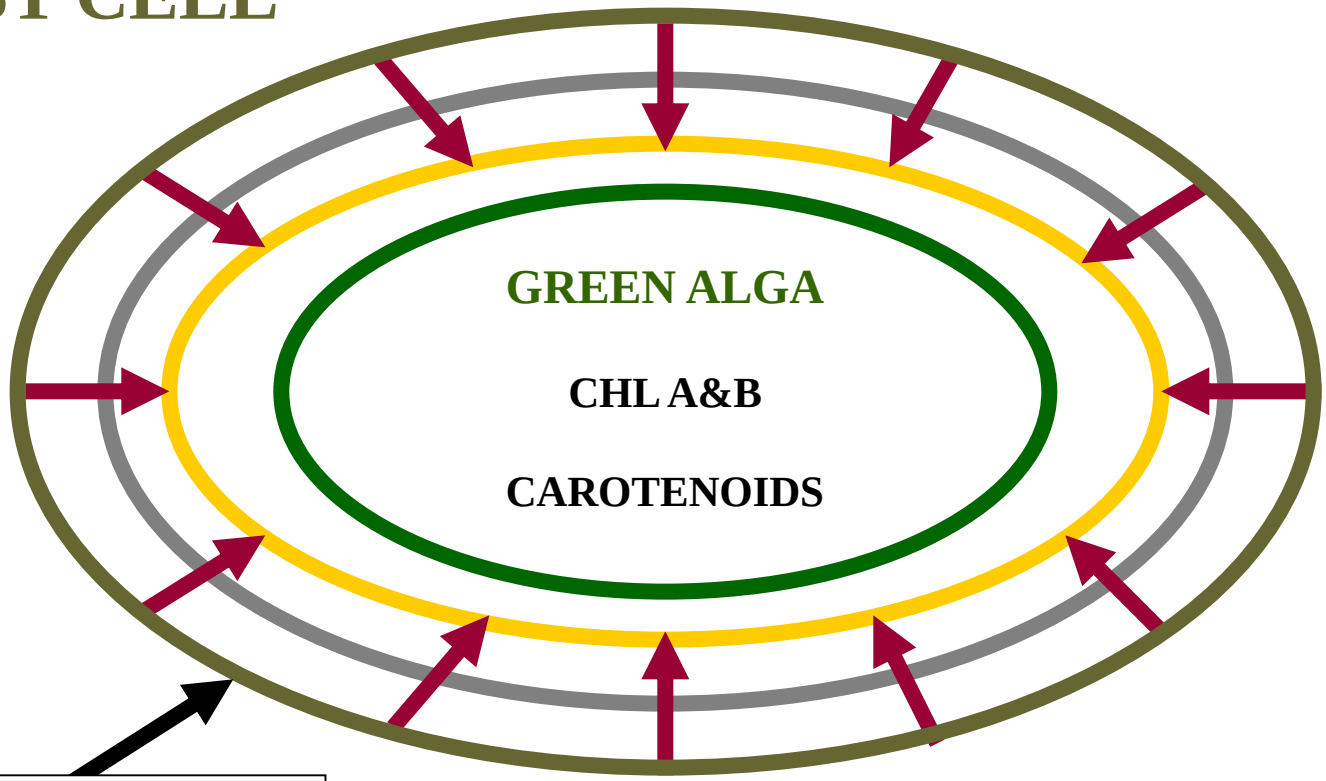
INITIALLY EUGLENOID DIGESTS GREEN ALGA



INITIALLY EUGLENOID DIGESTS GREEN ALGA

P

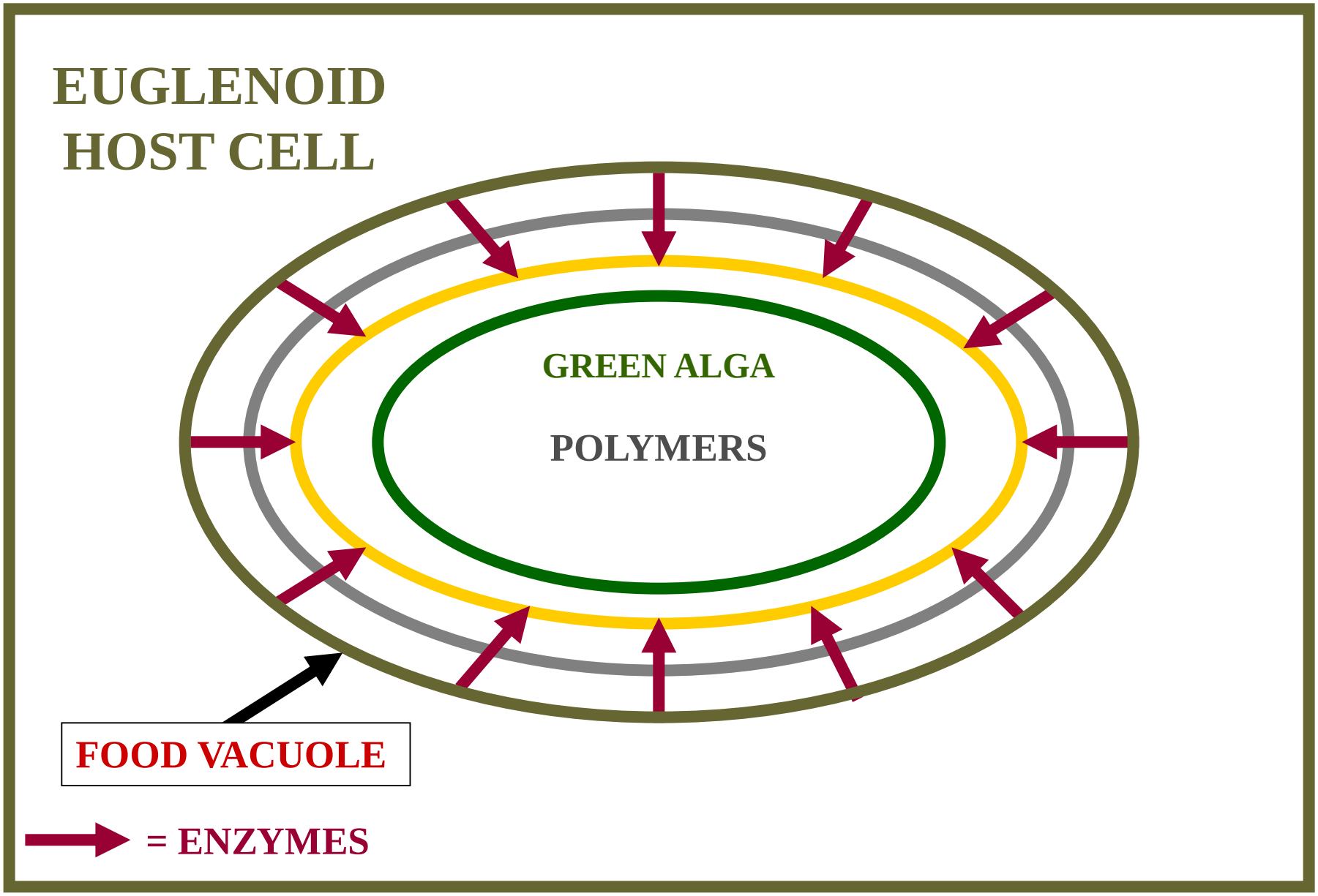
EUGLENOID HOST CELL



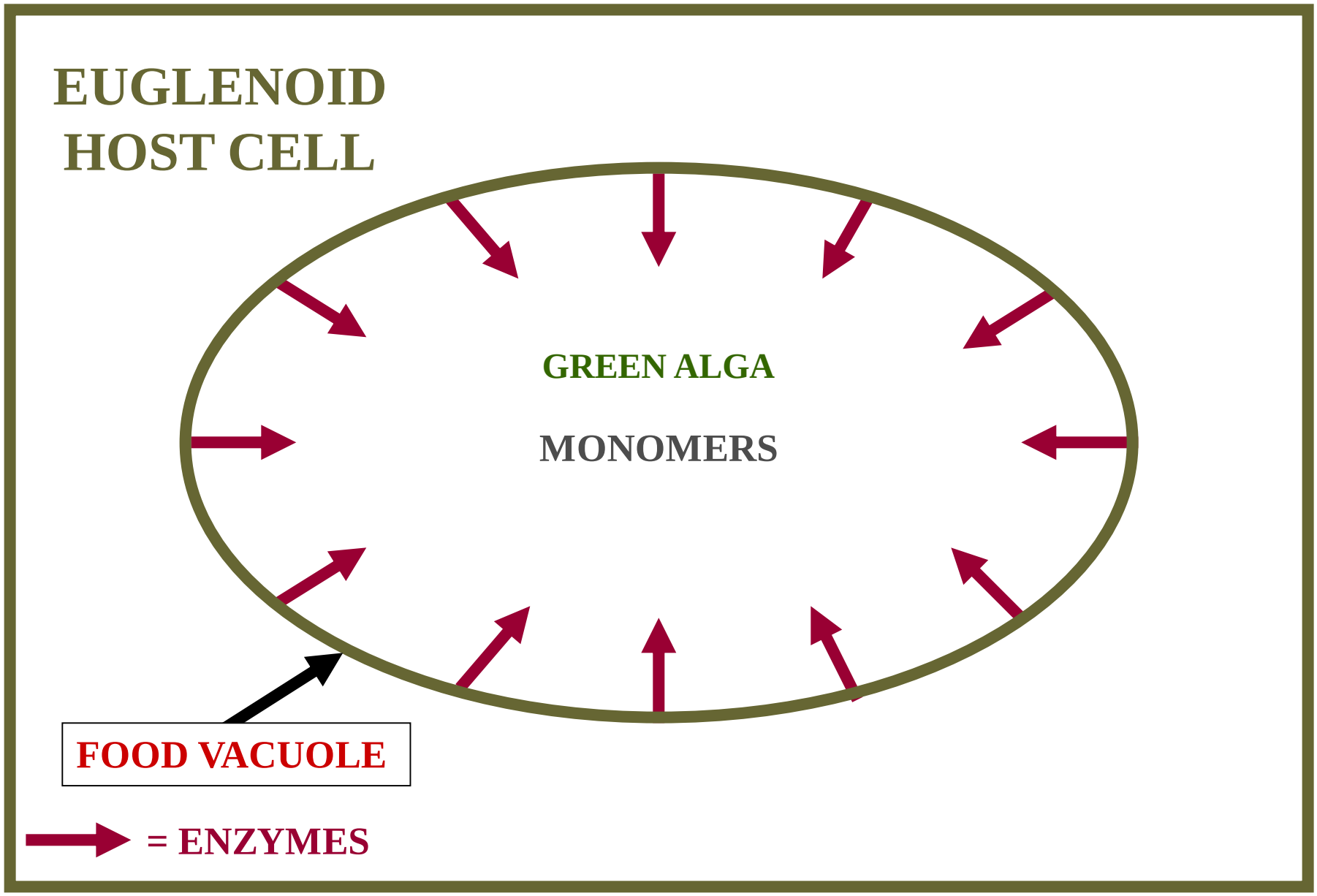
FOOD VACUOLE

= ENZYMES

INITIALLY EUGLENOID DIGESTS GREEN ALGA

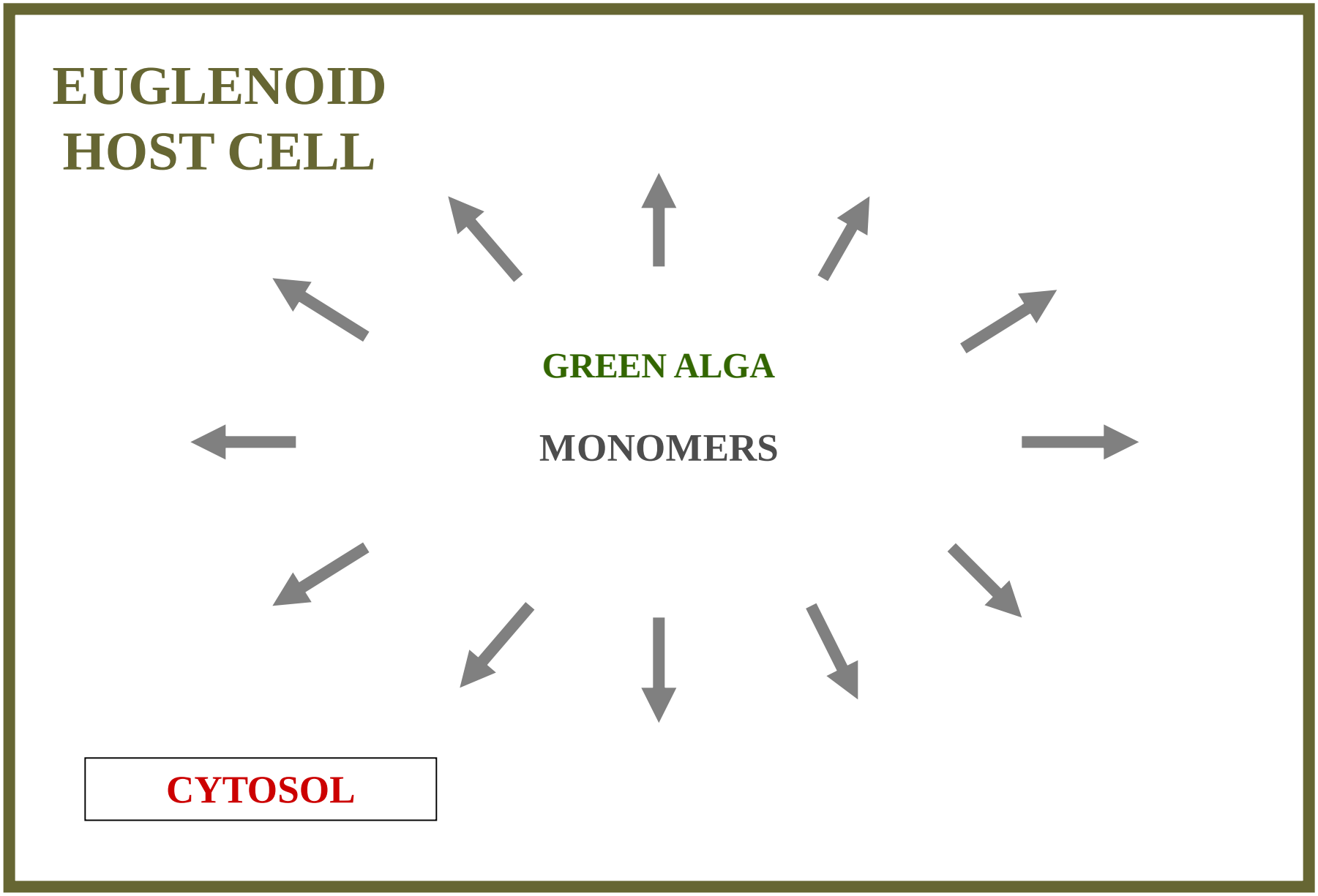


INITIALLY EUGLENOID DIGESTS GREEN ALGA

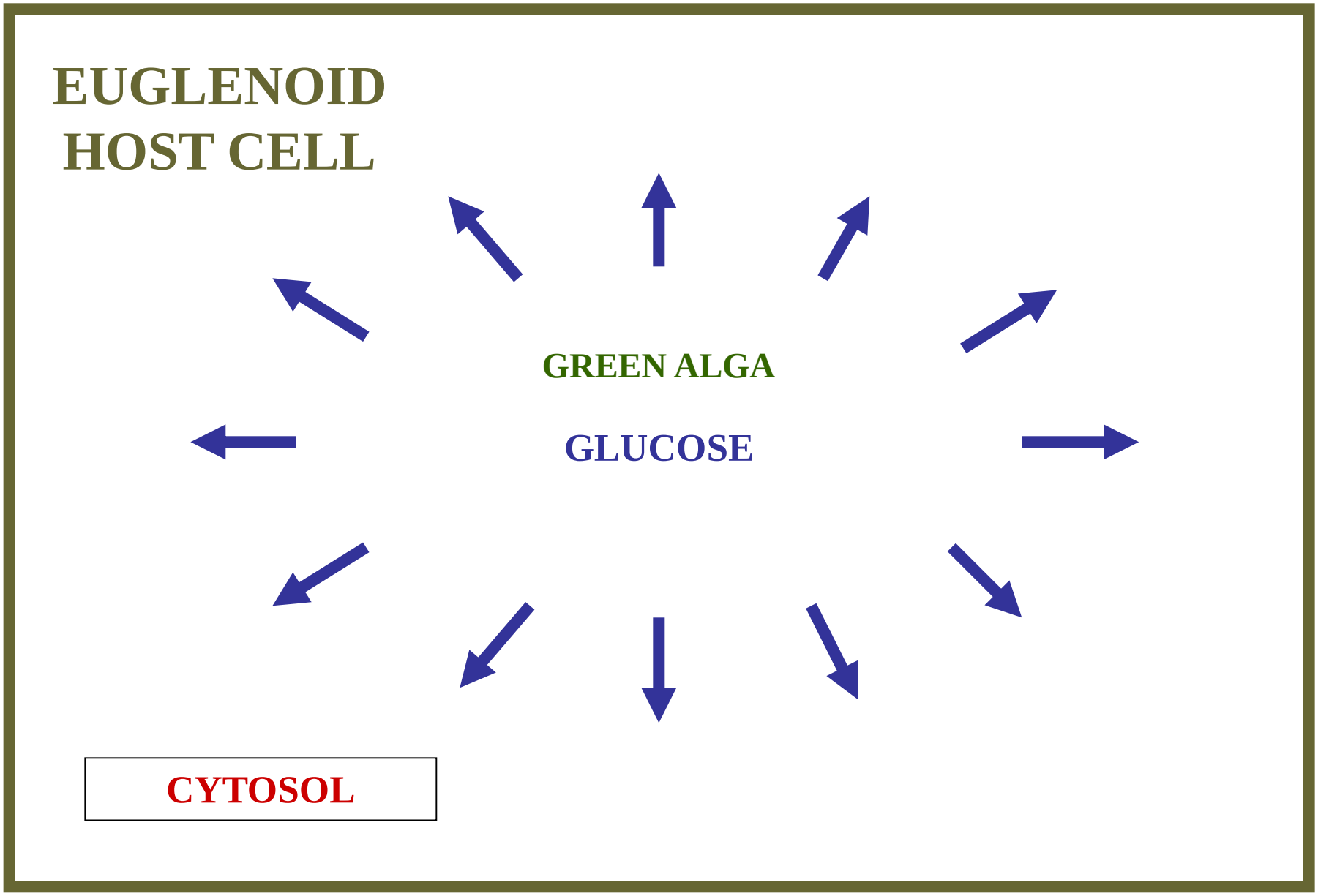


INITIALLY EUGLENOID DIGESTS GREEN ALGA

G



INITIALLY EUGLENOID DIGESTS GREEN ALGA



INITIALLY EUGLENOID DIGESTS GREEN ALGA

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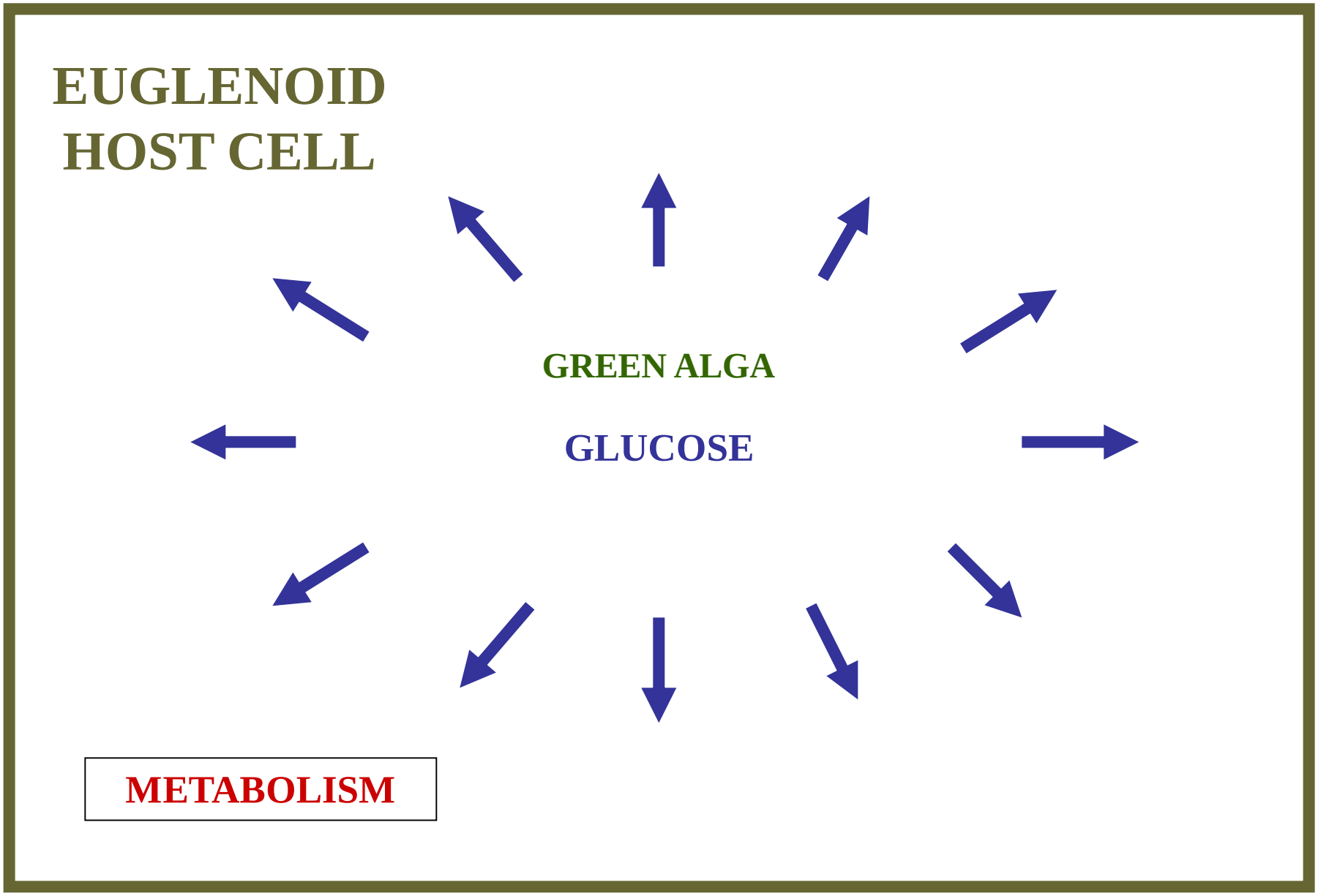
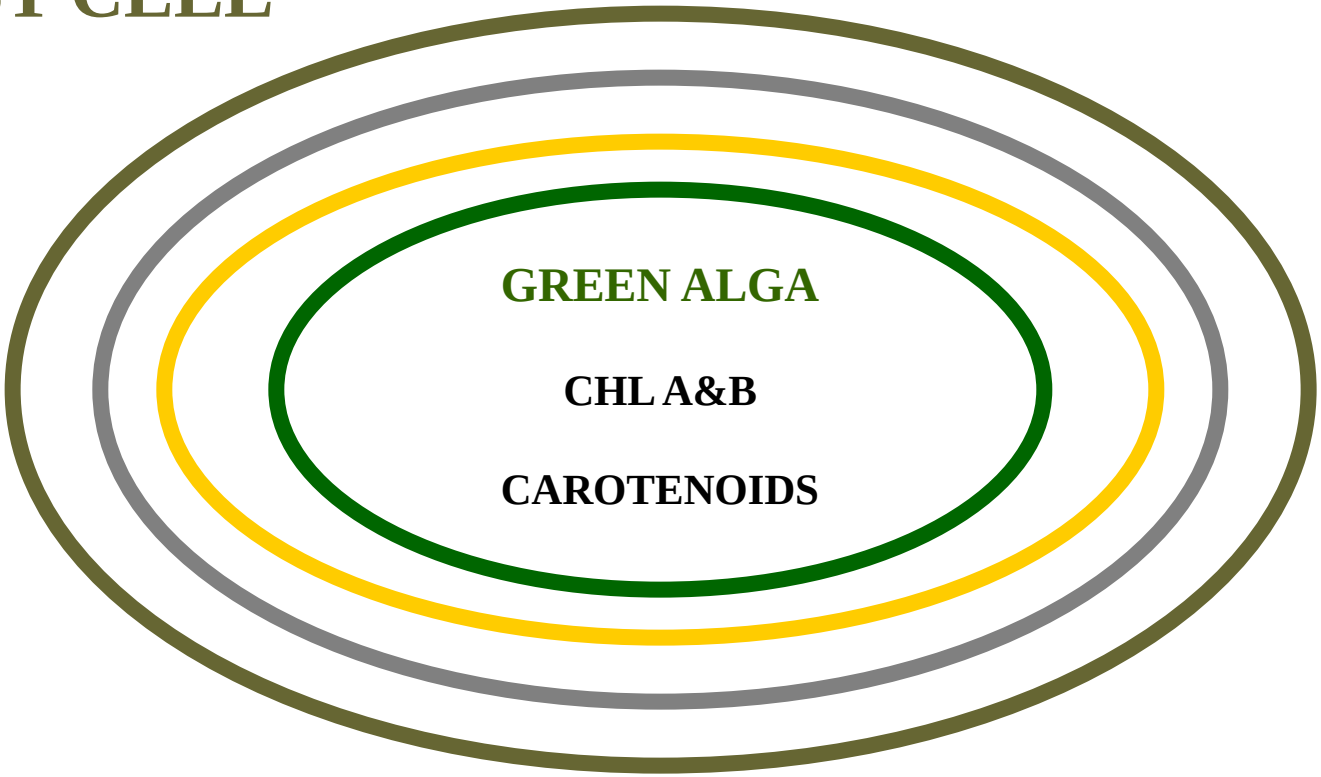


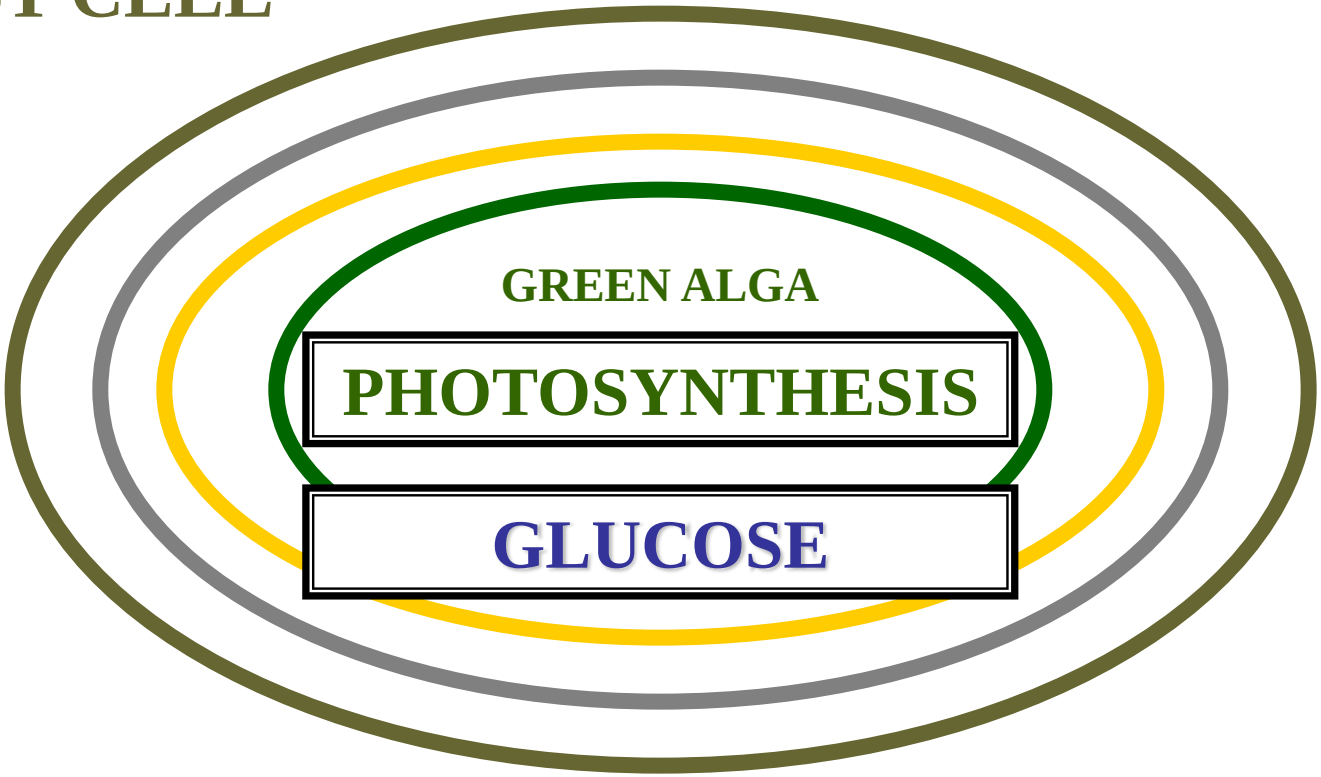
EUGLENOID HOST CELL



“DAWNS ON EUGLENOID”

G

EUGLENOID HOST CELL

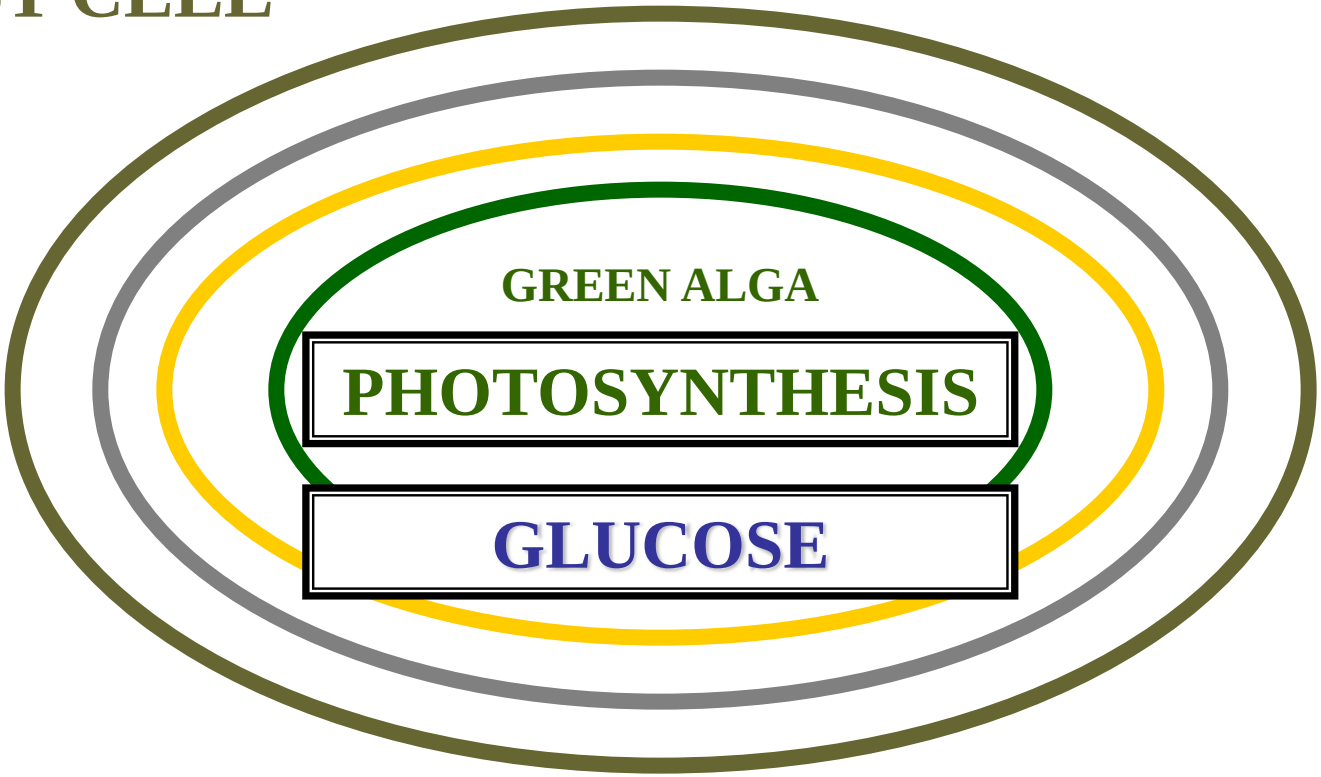


“DAWNS ON EUGLENOID”

G

EUGLENOID HOST CELL

GLUCOSE



“DAWNS ON EUGLENOID”