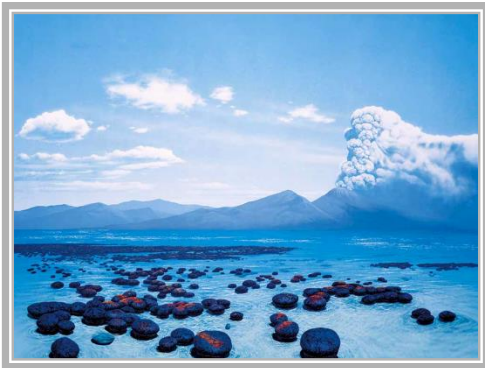


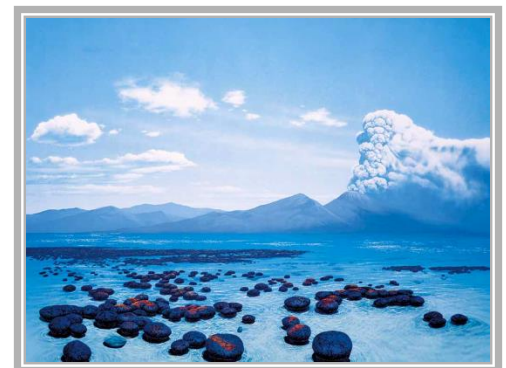
**HETEROTROPHIC  
HOST CELL  
DNA W\ HISTONE PROTEINS  
LARGE RIBOSOMES**



**AUTOTROPHIC  
PROKARYOTE**

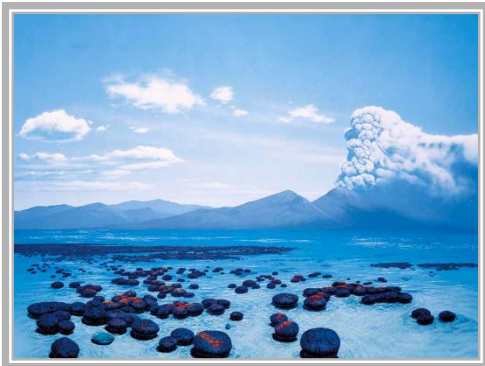
**PHOTOSYNTHESIS**

**GLUCOSE**



**HETEROTROPHIC  
HOST CELL**

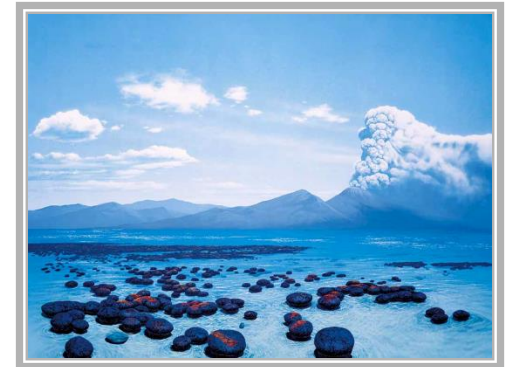
**CONSUMES OTHER ORGANISMS  
CONSUMES AUTOTROPH**



**AUTOTROPHIC  
PROKARYOTE**

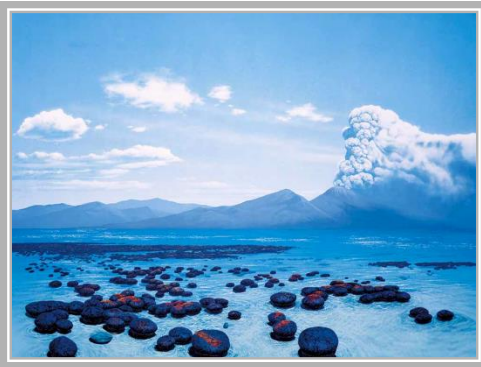
**PHOTOSYNTHESIS**

**GLUCOSE**



**HETEROTROPHIC  
HOST CELL**

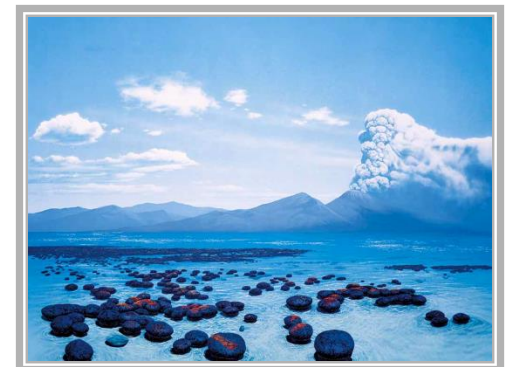
**CONSUMES OTHER ORGANISMS  
CONSUMES AUTOTROPH  
VIA ENDOCYTOSIS**



**AUTOTROPHIC  
PROKARYOTE**

**PHOTOSYNTHESIS**

**GLUCOSE**



# HETEROTROPH CONSUMES AUTOTROPH

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

**ENDOCYTOSIS**





# ENDOCYTOSIS



# **ENDOCYTOSIS**

**CELL MEMBRANE  
ENGULFMENT  
INTO HOST CELL**

**ENDOCYTOSIS**

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

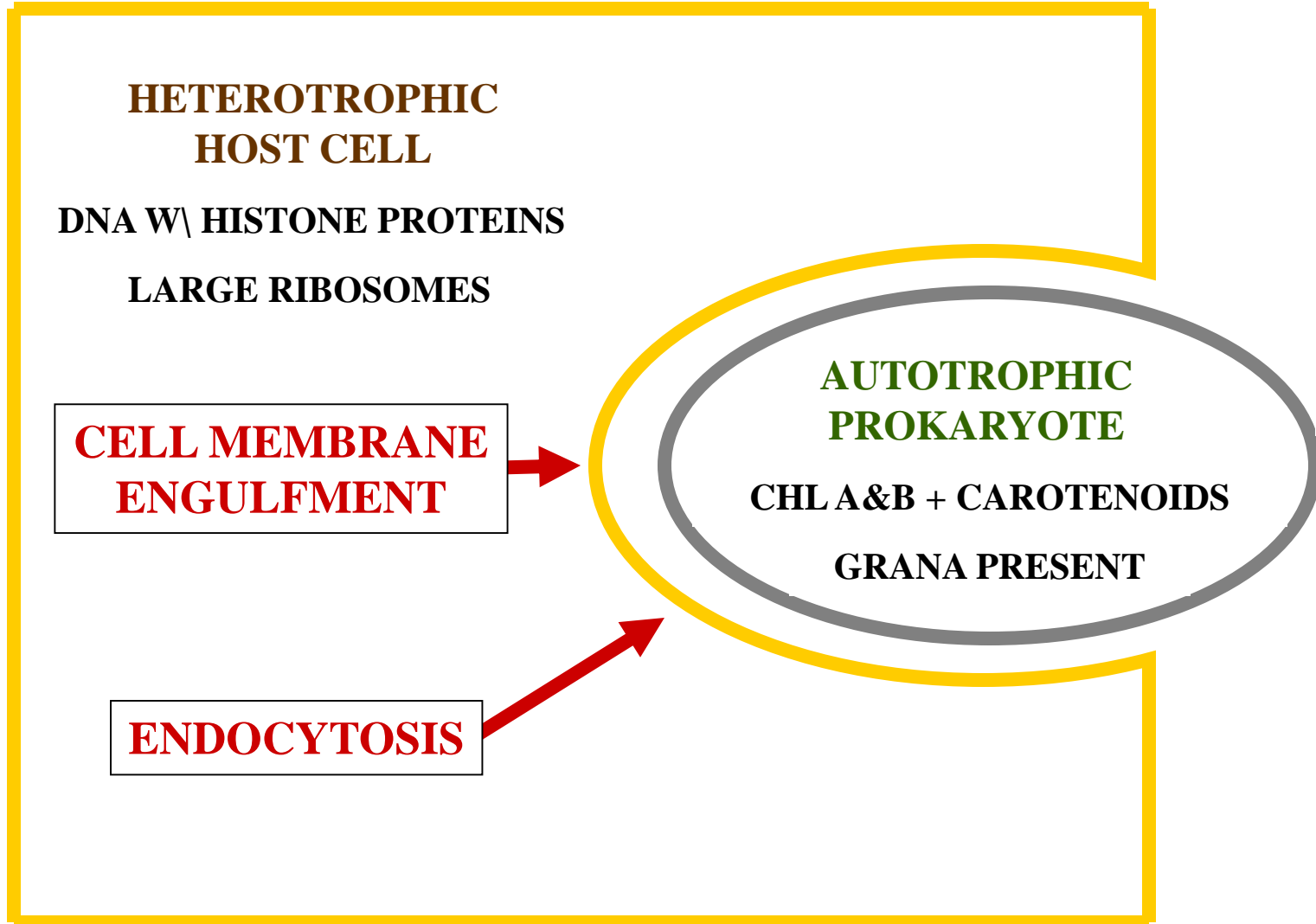
**CELL MEMBRANE  
ENGULFMENT**

**ENDOCYTOSIS**

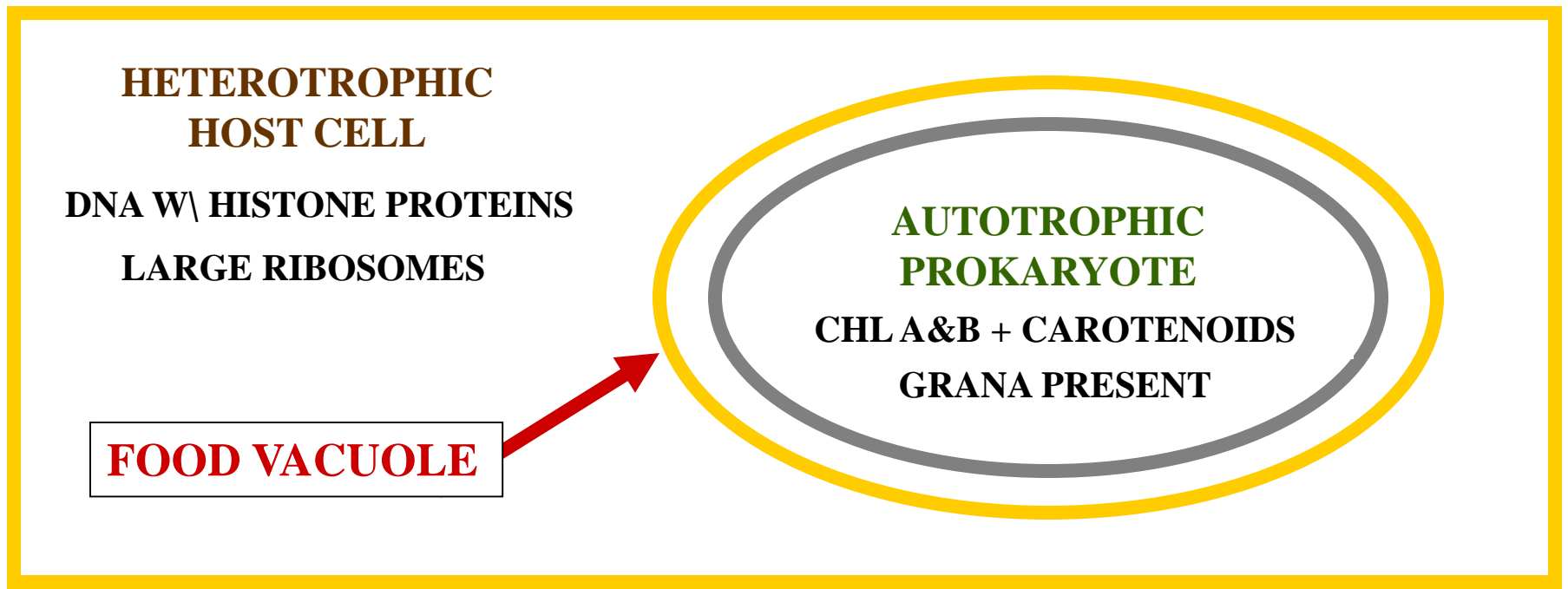
**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

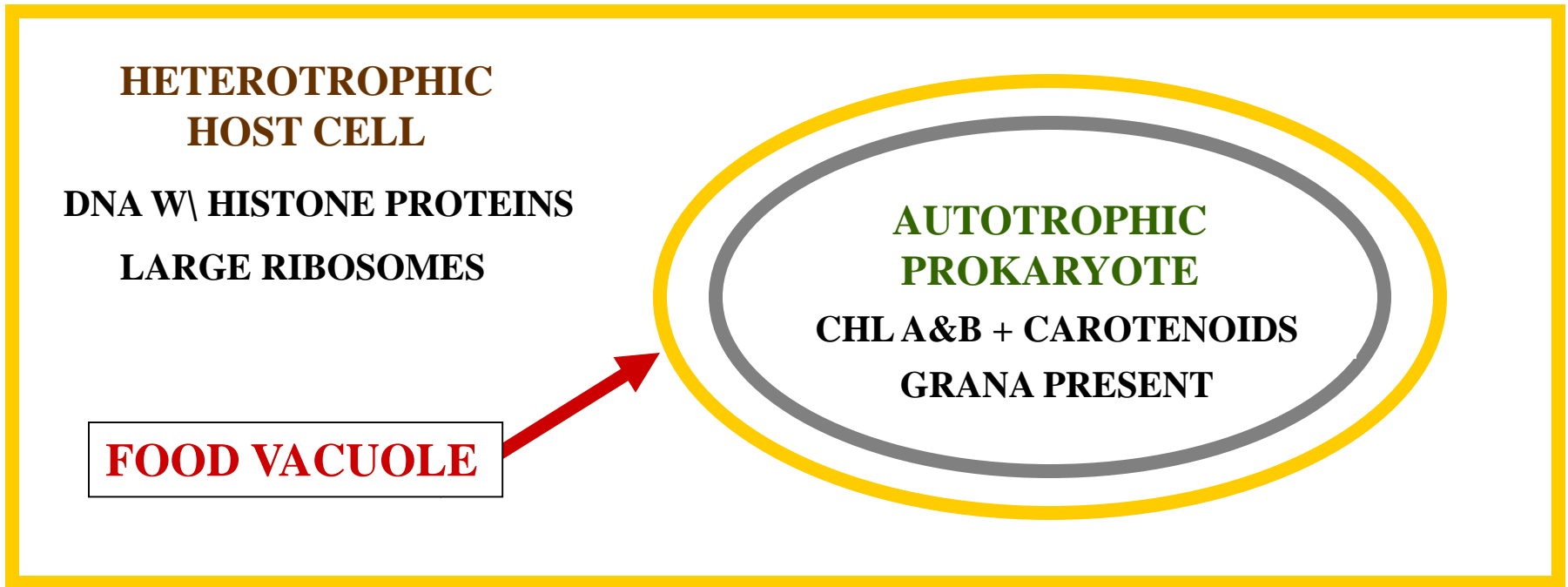


# AUTOTROPH WITHIN HETEROTROPH FOOD VACUOLE

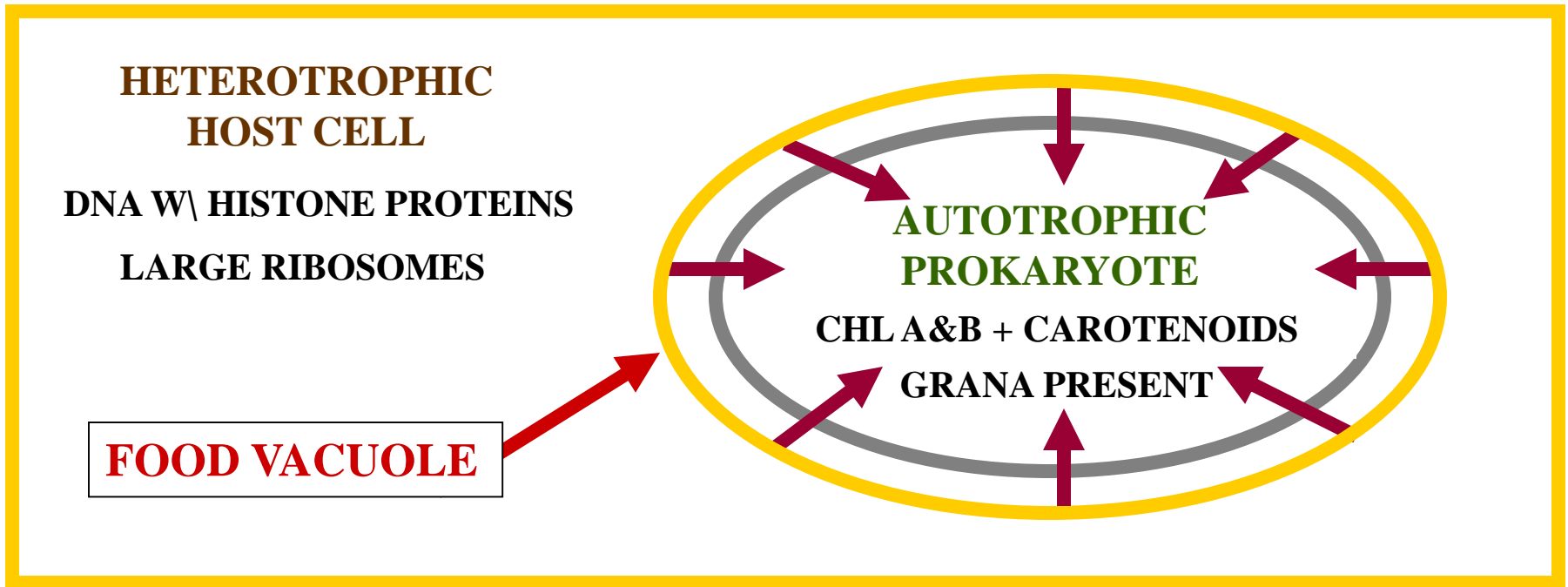




# INITIALLY HETEROTROPH DIGESTS AUTOTROPH

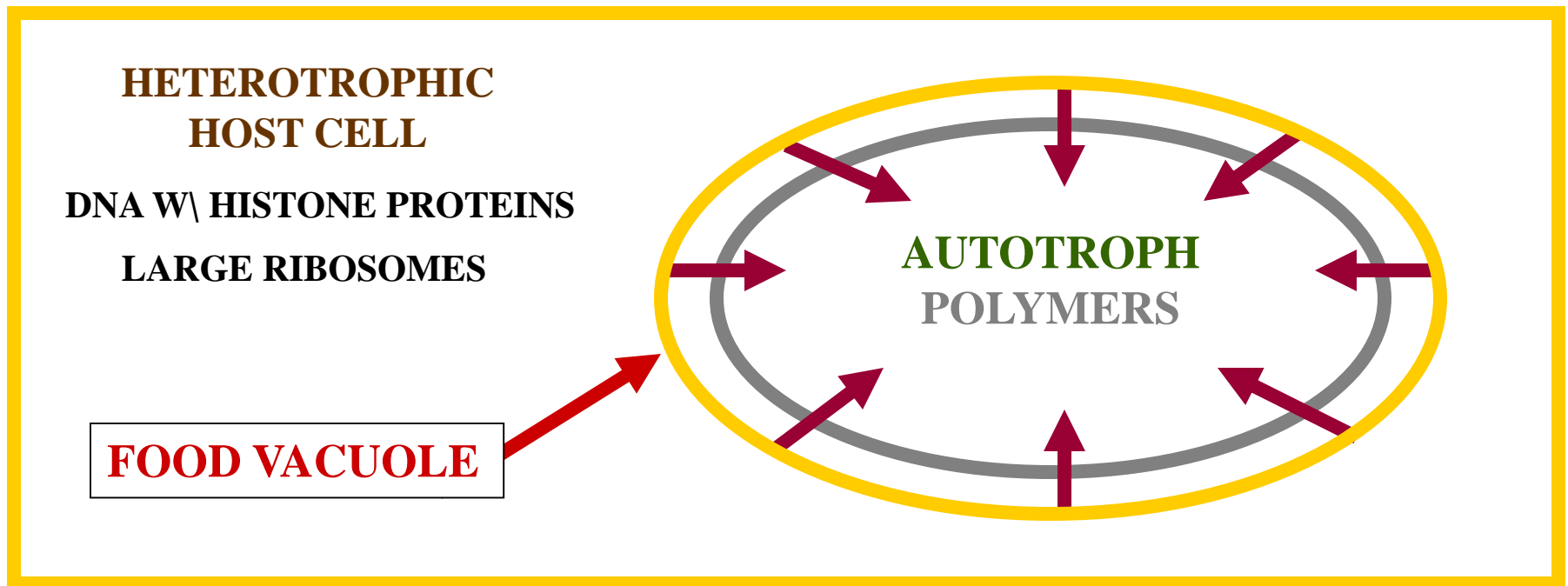


# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



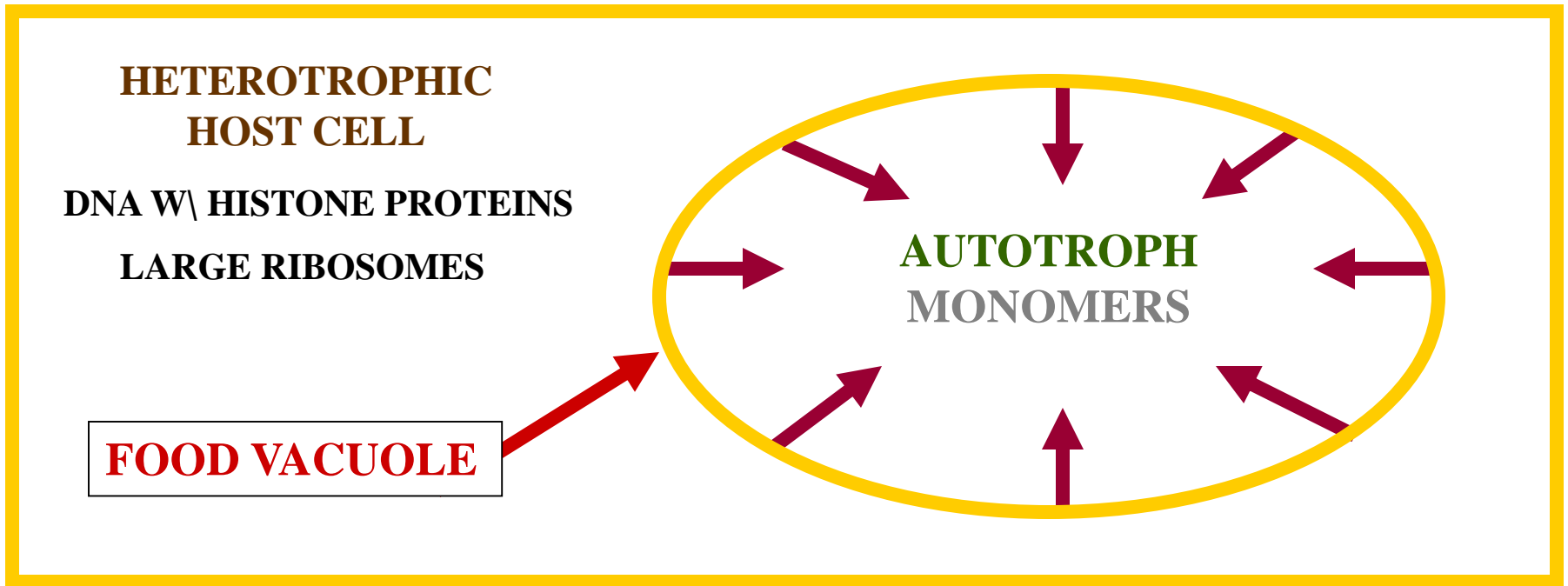
➔ = ENZYMES

# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



➔ = ENZYMES

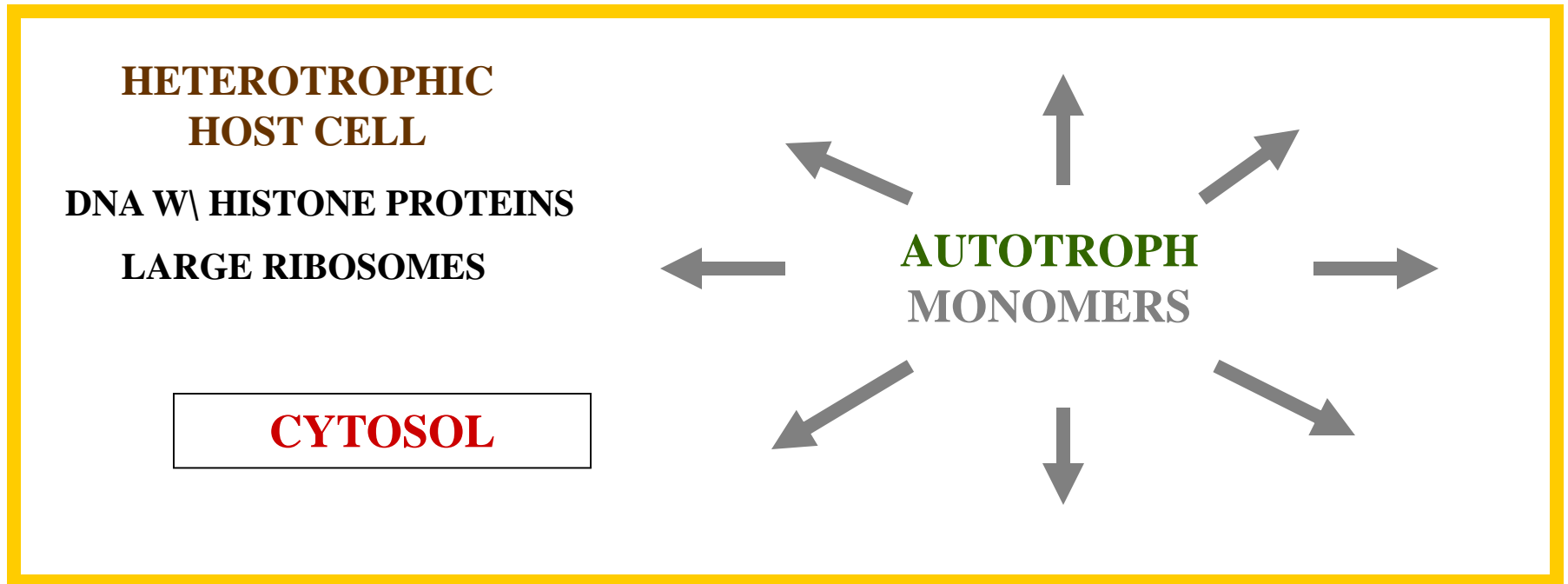
# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



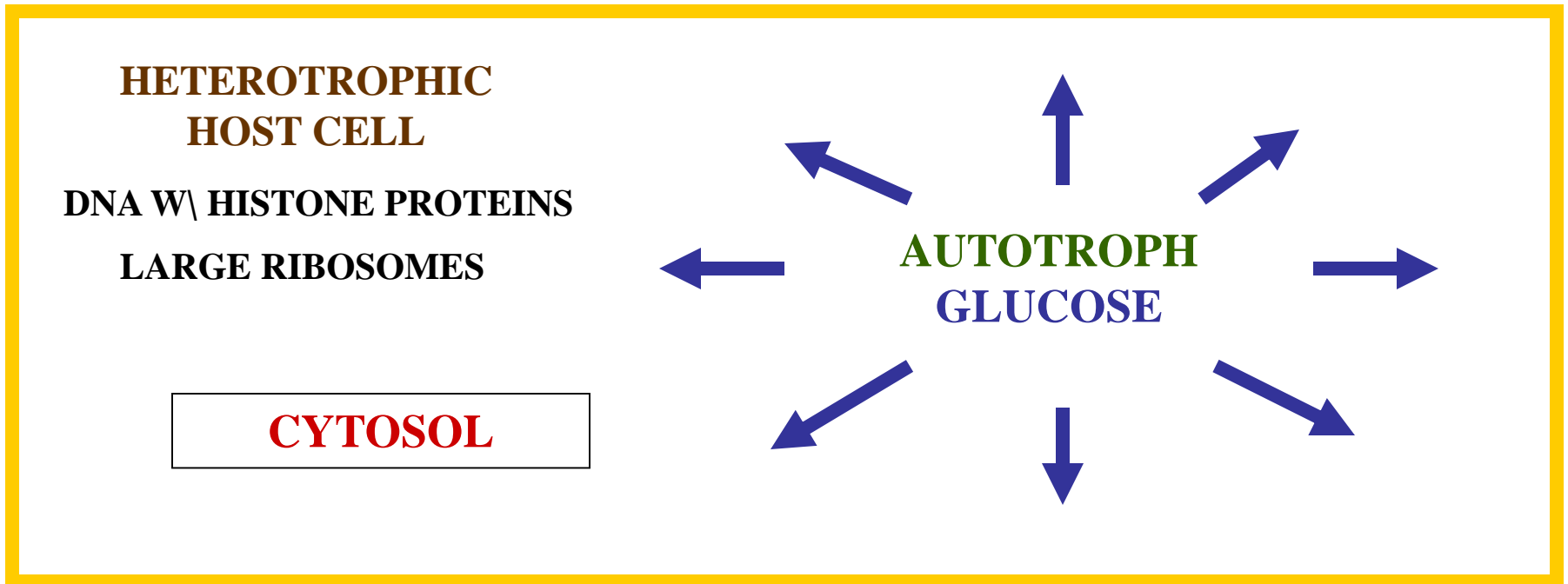
➔ = ENZYMES



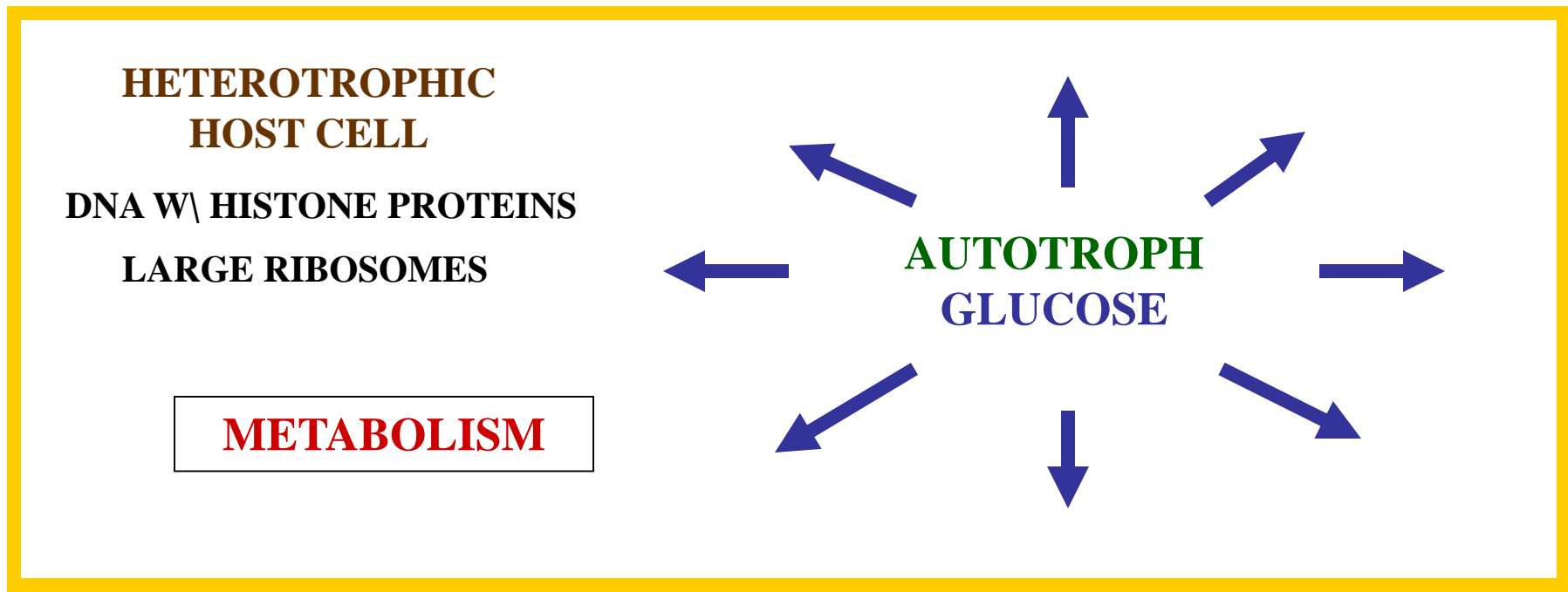
# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



# EVENTUALLY “DAWNS ON HETEROTROPH”

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

# EVENTUALLY “DAWNS ON HETEROTROPH”

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**PHOTOSYNTHESIS**

# EVENTUALLY “DAWNS ON HETEROTROPH”

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

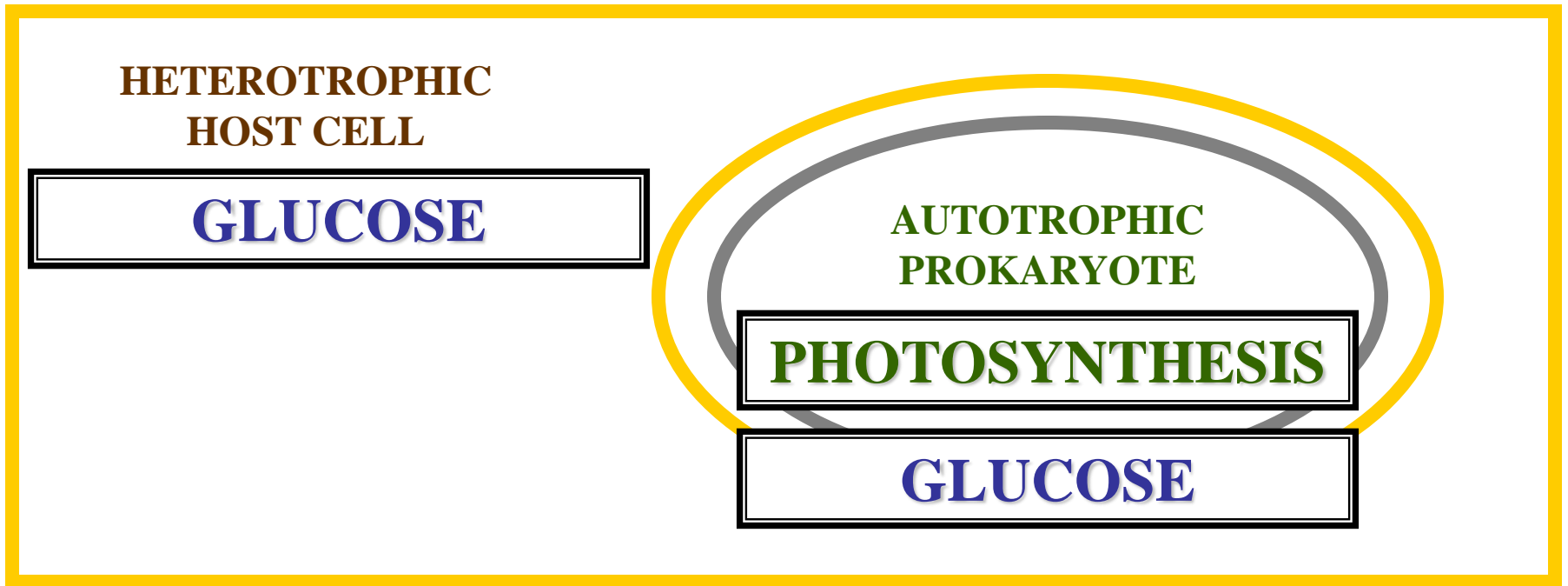
**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**PHOTOSYNTHESIS**

**GLUCOSE**

# EVENTUALLY “DAWNS ON HETEROTROPH”



# **AUTOTROPH LIVING WITHIN HETEROTROPH**



**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS  
LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS  
GRANA PRESENT**

**2 SPECIES LIVING  
INTRICATE ASSOCIATION**



# SYMBIOSIS



**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**



# **SYMBIOSIS**

## **ENDOSYMBIOSIS**

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

# SYMBIOSIS

## ENDOSYMBIOSIS

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

**AUTOTROPH PROVIDES  
HETEROTROPH WITH?**

# SYMBIOSIS

## ENDOSYMBIOSIS

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

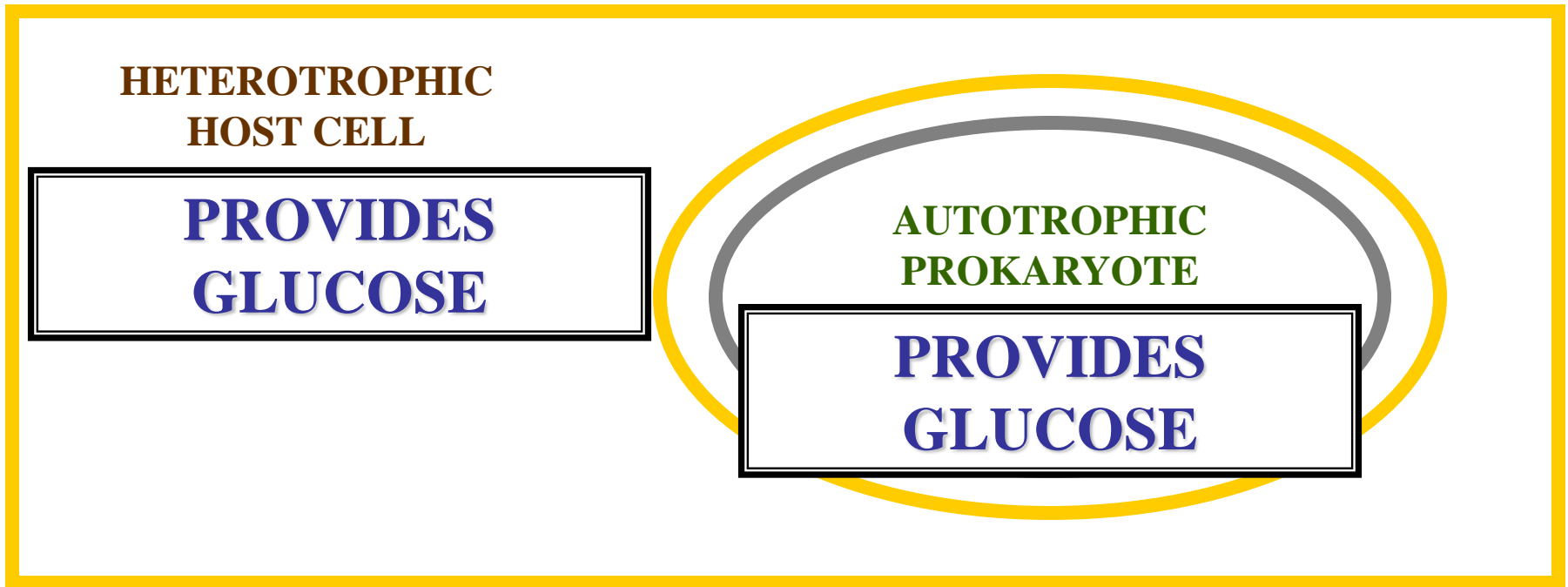
**AUTOTROPHIC  
PROKARYOTE**

**PHOTOSYNTHESIS**

**AUTOTROPH PROVIDES  
HETEROTROPH WITH?**

# SYMBIOSIS

## ENDOSYMBIOSIS



**AUTOTROPH PROVIDES  
GLUCOSE**

# SYMBIOSIS

## ENDOSYMBIOSIS

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

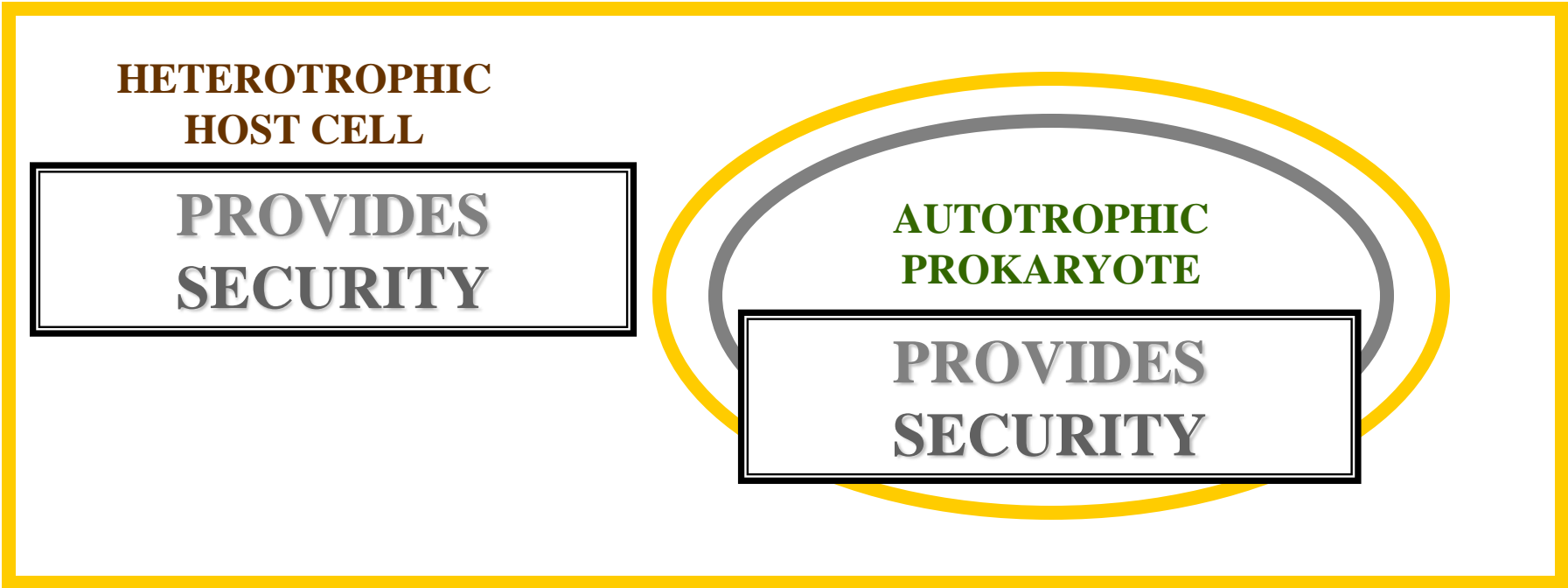
**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

**HETEROTROPH PROVIDES  
AUTOTROPH WITH?**

# SYMBIOSIS

## ENDOSYMBIOSIS



**HETEROTROPH PROVIDES SECURITY**

# SYMBIOSIS

## ENDOSYMBIOSIS

**HETEROTROPHIC  
HOST CELL**

**PROVIDES  
AUTOTROPH  
SECURITY**

**AUTOTROPHIC  
PROKARYOTE**

**PROVIDES  
HETEROTROPH  
GLUCOSE**

**BOTH SYMBIONTS  
BENEFIT**



# SYMBIOSIS

## ENDOSYMBIOSIS

**HETEROTROPHIC  
HOST CELL**

**PROVIDES  
AUTOTROPH  
SECURITY**

**AUTOTROPHIC  
PROKARYOTE**

**PROVIDES  
HETEROTROPH  
GLUCOSE**

# MUTUALISTIC

## ENDOSYMBIOSIS

# MUTUALISTIC ENDOSYMBIOSIS

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

**GIVEN LONG TIME PERIOD**



# OBLIGATE DEPENDENT RELATIONSHIP EVOLVES



**SYMBIONTS CANNOT  
EXIST INDEPENDENTLY**

# AUTOTROPHIC PROKARYOTE

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AUTOTROPHIC  
BECOMES ?**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

# AUTOTROPHIC ORGANELLE

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

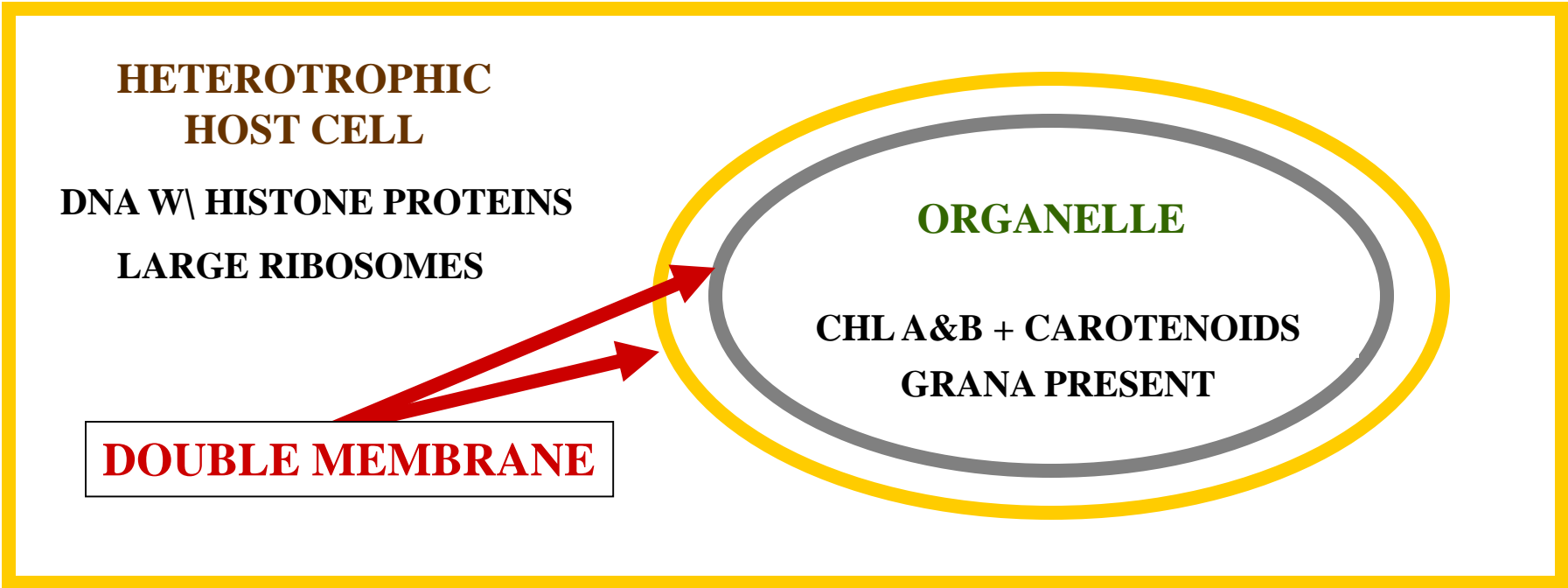
**LARGE RIBOSOMES**

**ORGANELLE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

# AUTOTROPHIC ORGANELLE



# AUTOTROPHIC ORGANELLE

**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**DOUBLE MEMBRANE**

**ORGANELLE**  
**PHOTOSYNTHESIS**  
**CHL A&B + CAROTENOIDS**  
**GRANA PRESENT**



# AUTOTROPHIC ORGANELLE

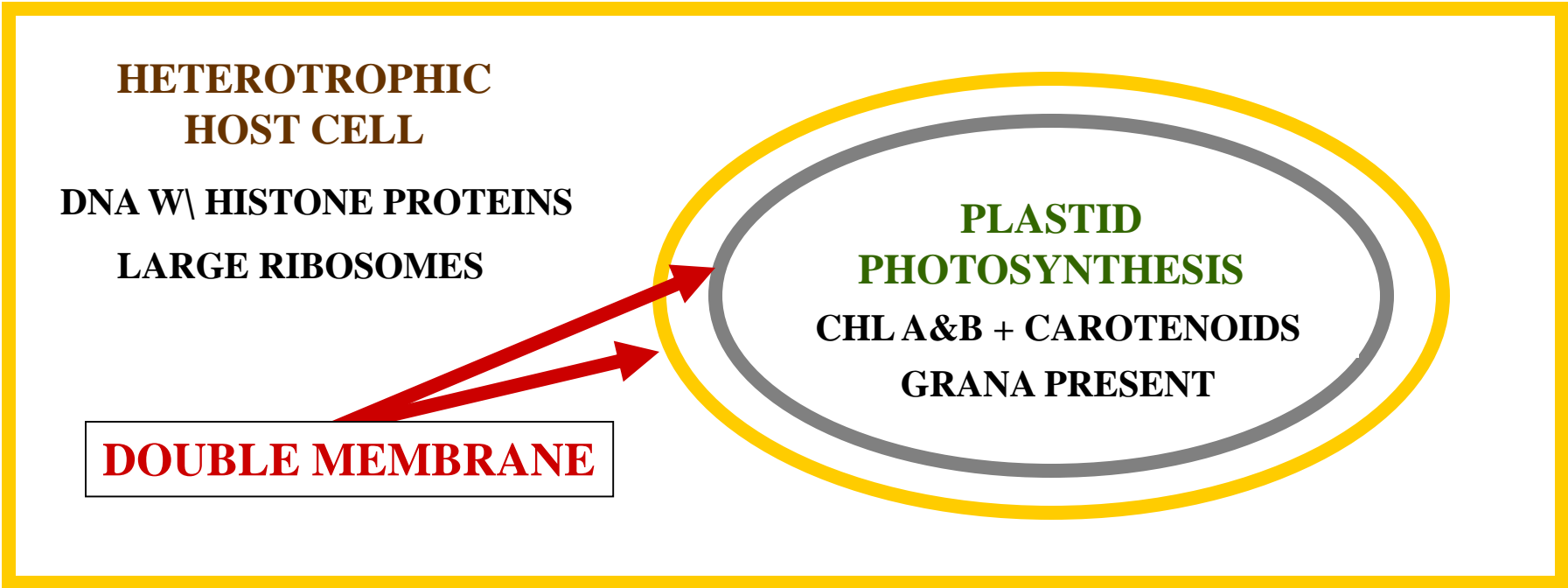
**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**DOUBLE MEMBRANE**

**PLASTID  
PHOTOSYNTHESIS  
CHL A&B + CAROTENOIDS  
GRANA PRESENT**





# AUTOTROPHIC ORGANELLE



**HETEROTROPHIC  
HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**DOUBLE MEMBRANE**

**PLASTID  
CHLOROPLAST**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**



# HETEROTROPHIC HOST CELL

**HETEROTROPHIC HOST CELL  
BECOMES ?**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**DOUBLE MEMBRANE**

**PLASTID  
CHLOROPLAST  
PHOTOSYNTHESIS  
CHL A&B + CAROTENOIDS  
GRANA PRESENT**

# AUTOTROPHIC ORGANISM

## AUTOTROPHIC ORGANISM

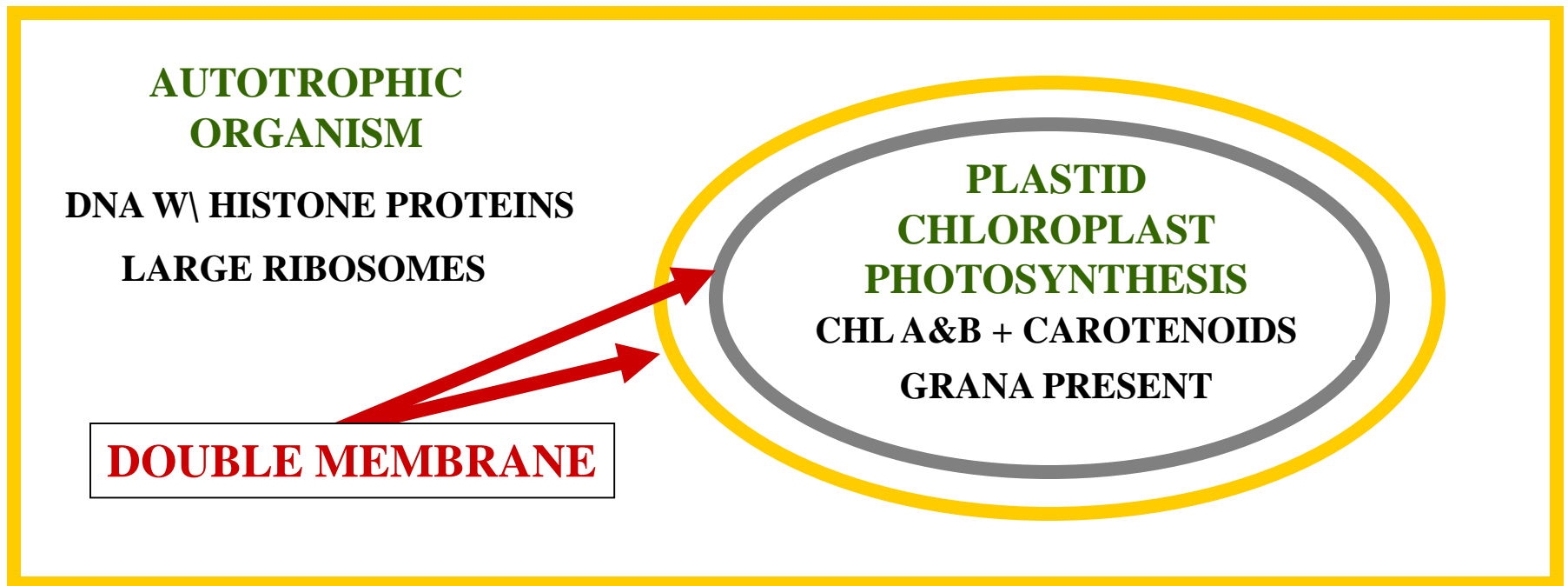
DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

**DOUBLE MEMBRANE**

PLASTID  
CHLOROPLAST  
PHOTOSYNTHESIS  
CHL A&B + CAROTENOIDS  
GRANA PRESENT

# AUTOTROPHIC ORGANISM



## PLANT CELL

# AUTOTROPHIC ORGANISM



**AUTOTROPHIC ORGANISM**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**DOUBLE MEMBRANE**

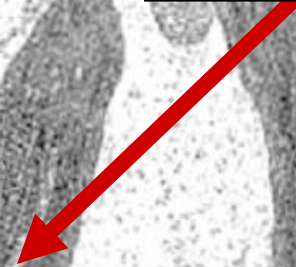
**PLASTID  
CHLOROPLAST  
PHOTOSYNTHESIS  
CHL A&B + CAROTENOIDS  
GRANA PRESENT**

**TRUE PLANT CELL**

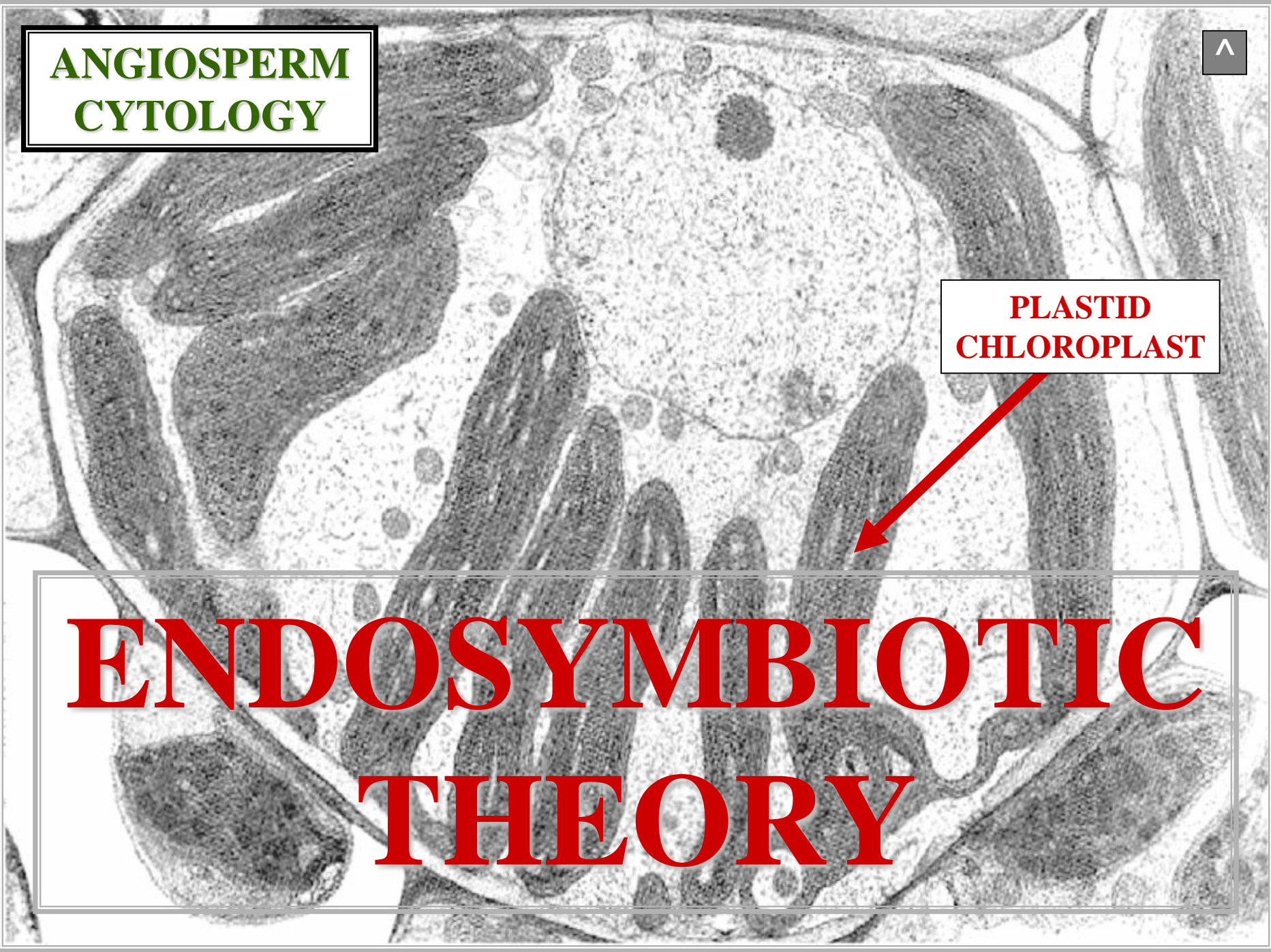
**ANGIOSPERM  
CYTOLOGY**



**PLASTID  
CHLOROPLAST**



**ENDOSYMBIOTIC  
THEORY**





I

# MITOCHONDRION EVOLUTION



# ANGIOSPERM CYTOLOGY

MITOCHONDRION

PLASTID  
CHLOROPLAST

MITOCHONDRION EVOLUTION  
SCENARIO  
IDENTICAL TO  
PLASTID EVOLUTION





**HOST CELL**  
**DNA W\ HISTONE PROTEINS**  
**LARGE RIBOSOMES**

**AEROBIC**  
**PROKARYOTE**  
**AEROBIC RESPIRATION**  
**DNA W\OUT HISTONE PROTEINS**  
**SMALL RIBOSOMES**

**AEROBIC PROKARYOTE UNDERGOES ENDOSYMBIOSIS**

# MUTUALISTIC ENDOSYMBIOSIC RELATIONSHIP

**HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**AEROBIC**

**PROKARYOTE**

**AEROBIC RESPIRATION**

**DNA W\OUT HISTONE PROTEINS**

**SMALL RIBOSOMES**

# MUTUALISTIC ENDOSYMBIOSIC RELATIONSHIP

# OBLIGATE DEPENDENT RELATIONSHIP EVOLVES

HOST CELL

DNA W\ HISTONE PROTEINS

LARGE RIBOSOMES

AEROBIC

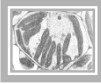
PROKARYOTE

AEROBIC RESPIRATION

DNA W\OUT HISTONE PROTEINS

SMALL RIBOSOMES

# OBLIGATE DEPENDENT RELATIONSHIP EVOLVES



# MITOCHONDRION EVOLUTION

**HOST CELL**

**DNA W\ HISTONE PROTEINS**

**LARGE RIBOSOMES**

**MITOCHONDRION**

**DNA W\OUT HISTONE PROTEINS**

**SMALL RIBOSOMES**

# MITOCHONDRION EVOLUTION

An electron micrograph showing a cross-section of a plant cell. The cell contains several large, dark, oval-shaped chloroplasts with visible internal membranes (grana). A red arrow points from a label to a smaller, bean-shaped organelle with internal folds, identified as a mitochondrion. The cytoplasm is filled with various organelles and a network of membranes.

## ANGIOSPERM CYTOLOGY

MITOCHONDRION

# ENDOSYMBIOTIC THEORY



# ENDOSYMBIOTIC THEORY SUPPORTING EVIDENCE





**PROPONENT: ENDOSYMBIOTIC THEORY**

**LYNN MARGULIS**

# ELECTRON MICROSCOPE



M





# ANGIOSPERM CYTOLOGY

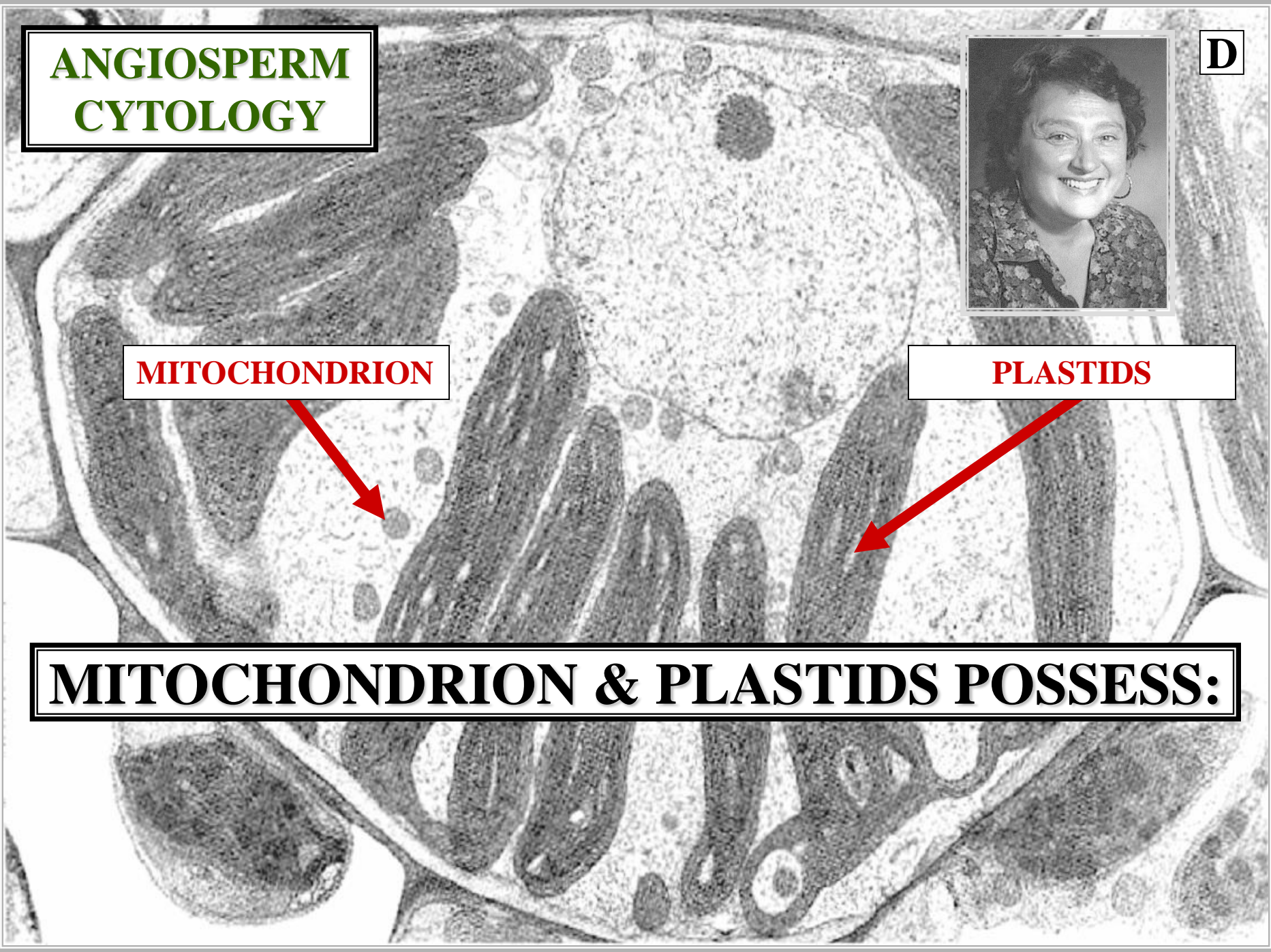
D



MITOCHONDRION

PLASTIDS

**MITOCHONDRION & PLASTIDS POSSESS:**





# ANGIOSPERM CYTOLOGY

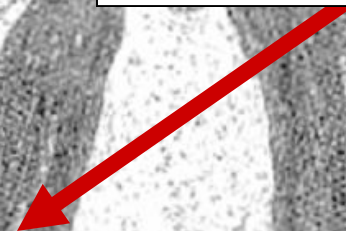
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**MITOCHONDRION**



**PLASTIDS**



**MITOCHONDRION & PLASTIDS POSSESS:**

**DNA**

# ANGIOSPERM CYTOLOGY

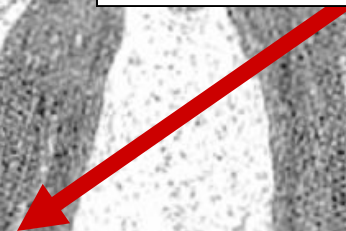
H



**MITOCHONDRION**



**PLASTIDS**



**MITOCHONDRION & PLASTIDS POSSESS:**

**DNA PROKARYOTE-LIKE**



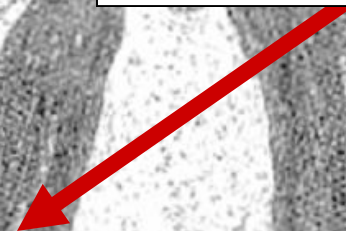
# ANGIOSPERM CYTOLOGY



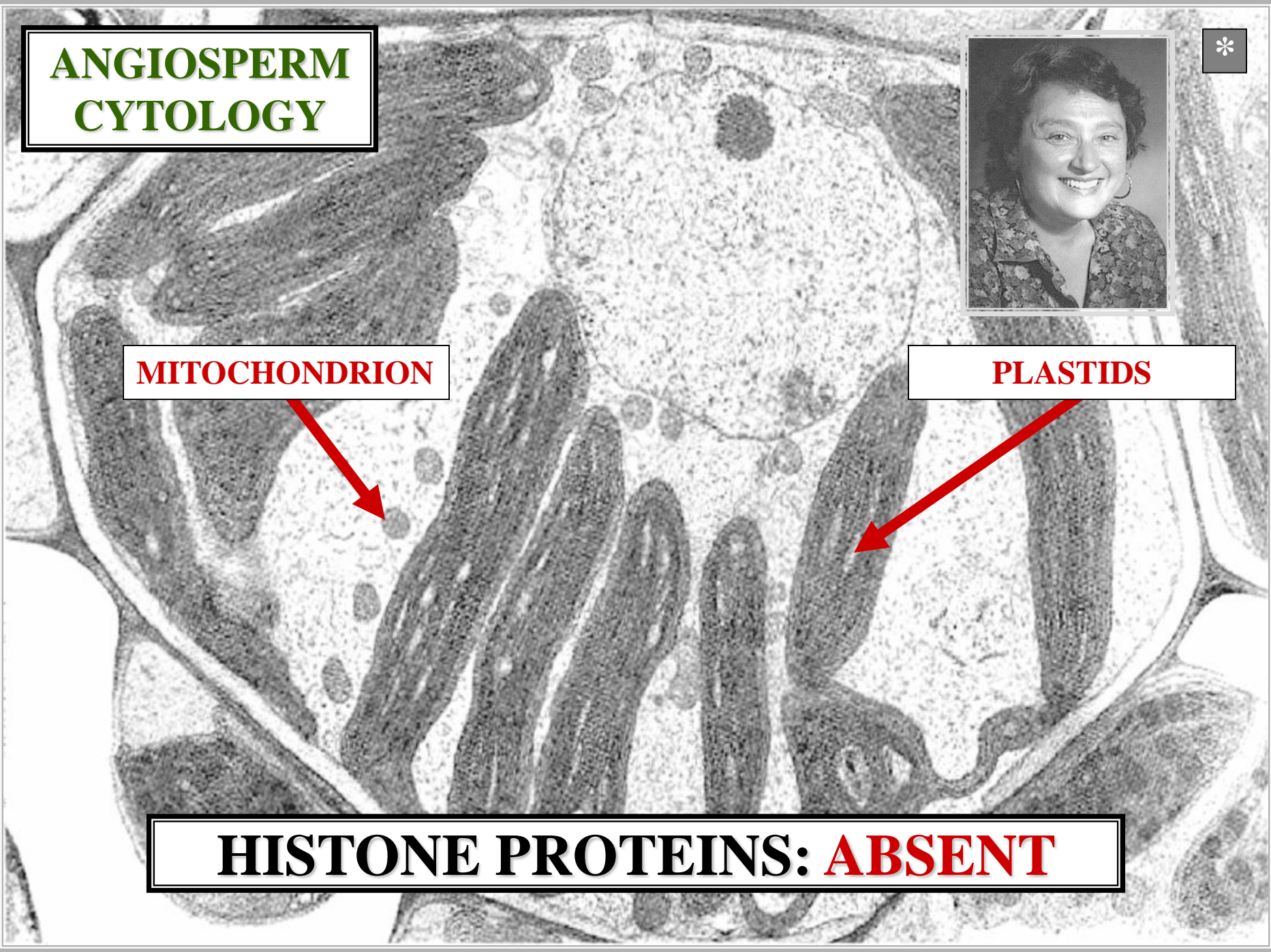
**MITOCHONDRION**



**PLASTIDS**



**HISTONE PROTEINS: ABSENT**

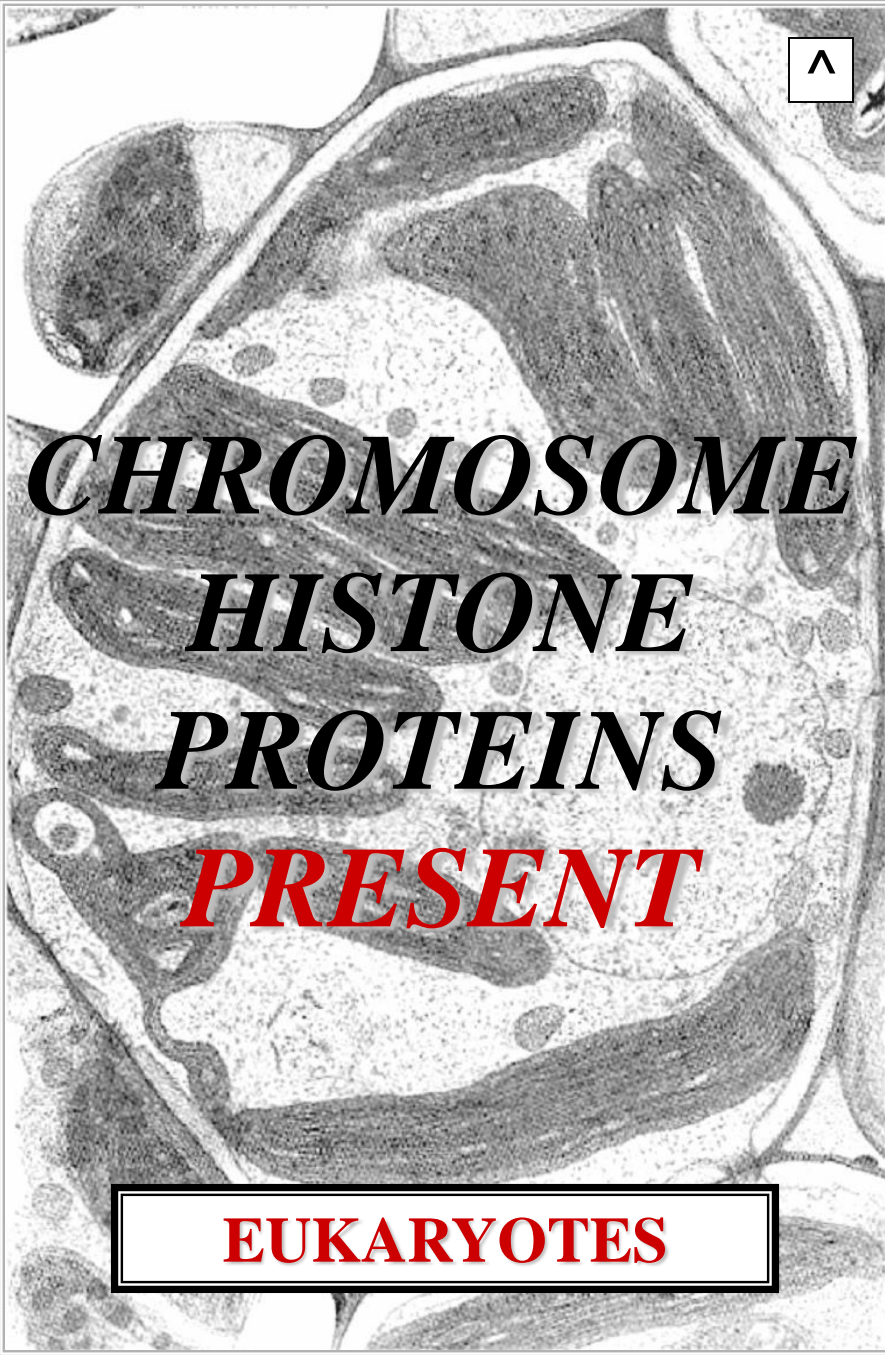






***CHROMOSOME***  
***HISTONE***  
***PROTEINS***  
***ABSENT***

**PROKARYOTES**



***CHROMOSOME***  
***HISTONE***  
***PROTEINS***  
***PRESENT***

**EUKARYOTES**



# ANGIOSPERM CYTOLOGY

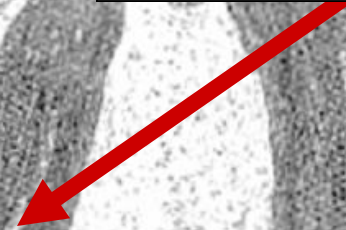
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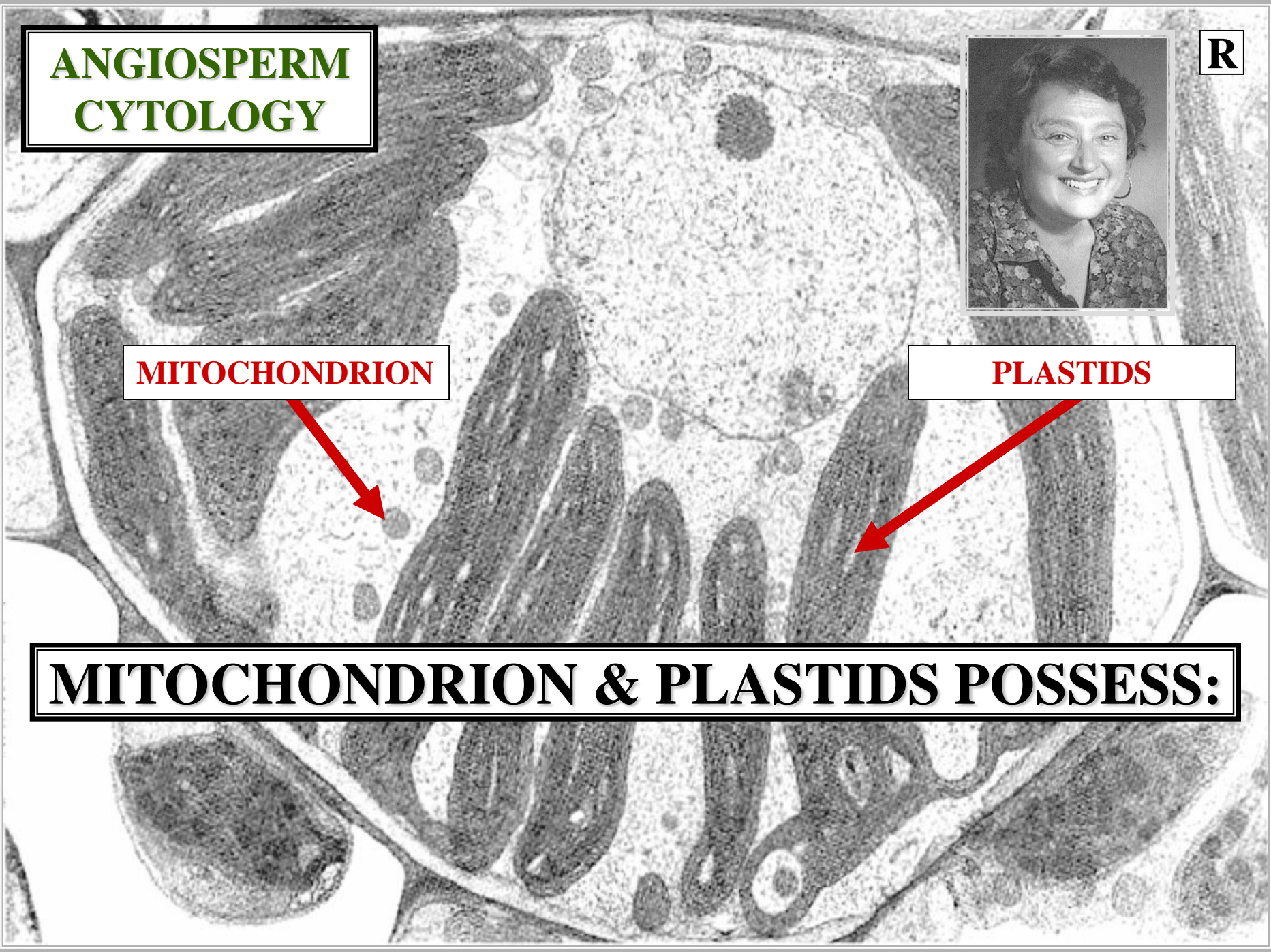
**MITOCHONDRION**



**PLASTIDS**



**MITOCHONDRION & PLASTIDS POSSESS:**





# ANGIOSPERM CYTOLOGY

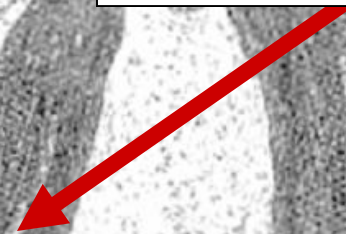
P



**MITOCHONDRION**



**PLASTIDS**



**MITOCHONDRION & PLASTIDS POSSESS:**

**RIBOSOMES**

# ANGIOSPERM CYTOLOGY

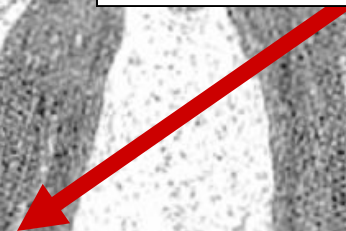
S



**MITOCHONDRION**



**PLASTIDS**



**MITOCHONDRION & PLASTIDS POSSESS:**

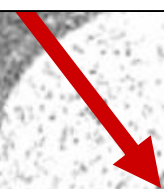
**RIBOSOMES PROKARYOTE-LIKE**



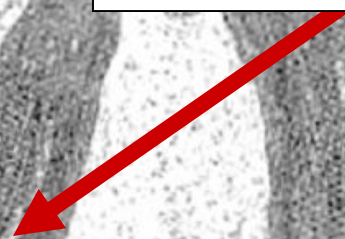
# ANGIOSPERM CYTOLOGY



**MITOCHONDRION**

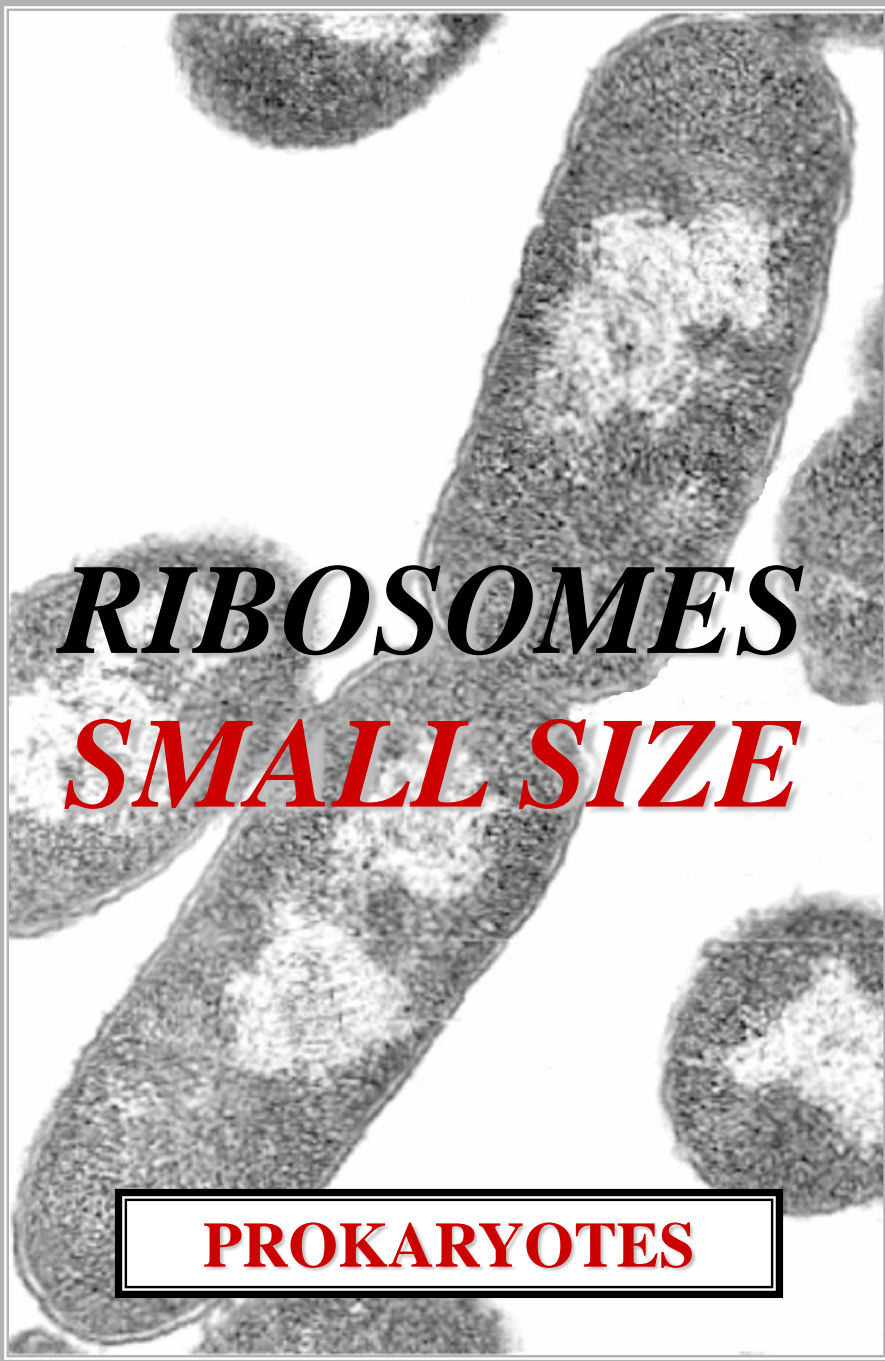


**PLASTIDS**



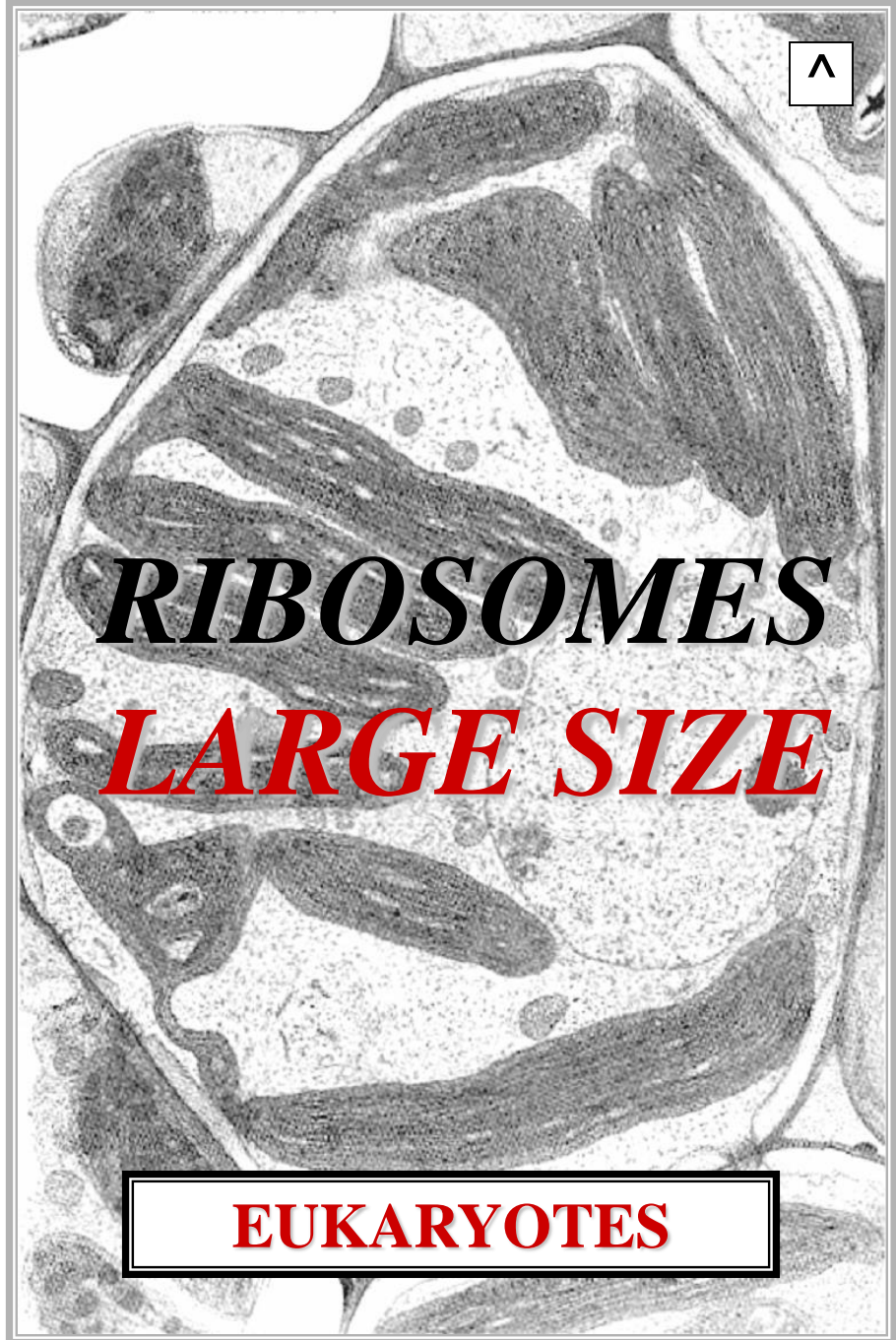
**RIBOMES: SMALL**





***RIBOSOMES***  
***SMALL SIZE***

**PROKARYOTES**



***RIBOSOMES***  
***LARGE SIZE***

**EUKARYOTES**



# ANGIOSPERM CYTOLOGY

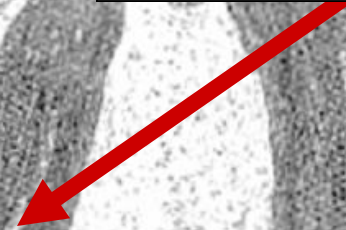
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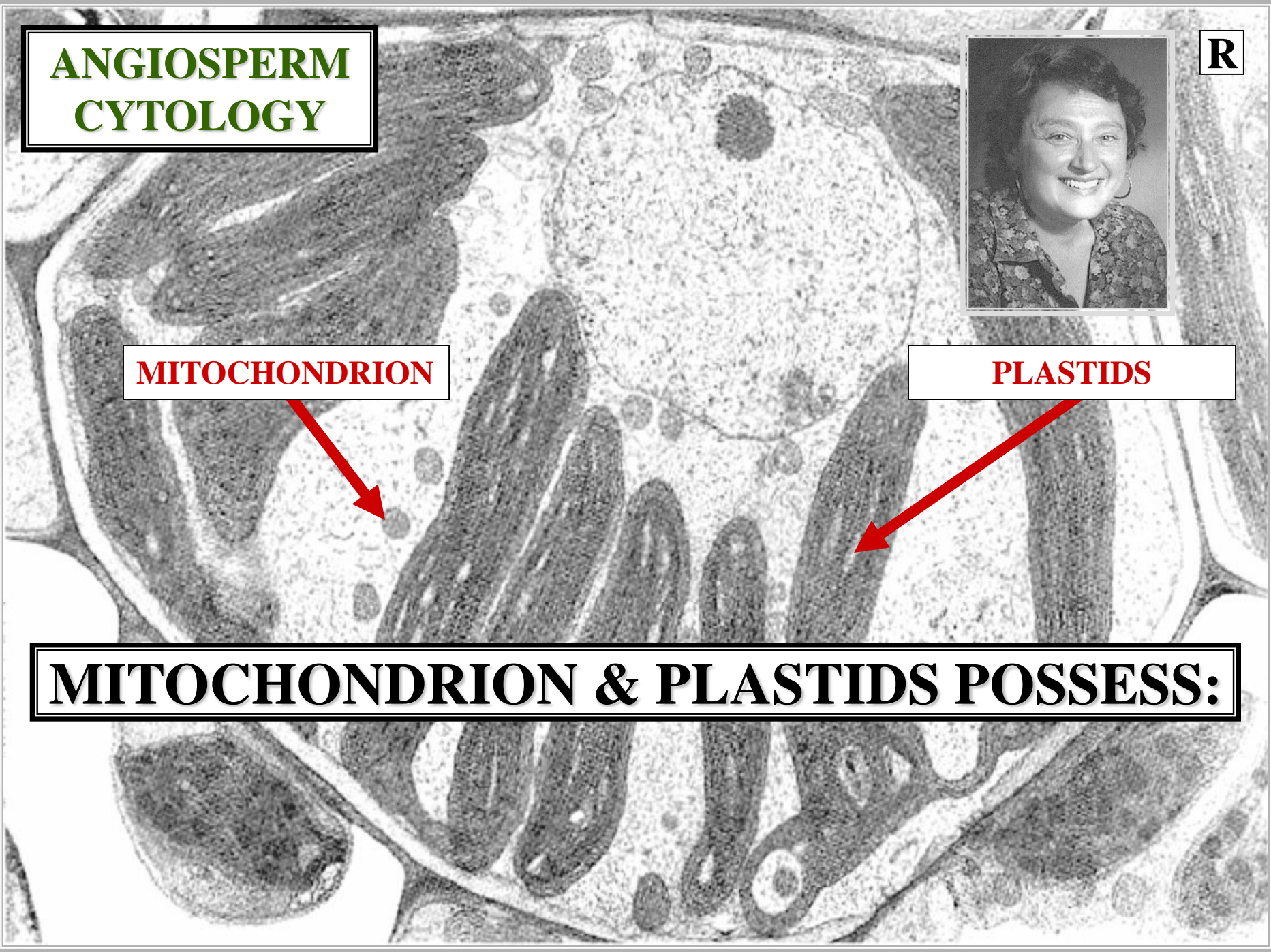
**MITOCHONDRION**



**PLASTIDS**



**MITOCHONDRION & PLASTIDS POSSESS:**





# ANGIOSPERM CYTOLOGY

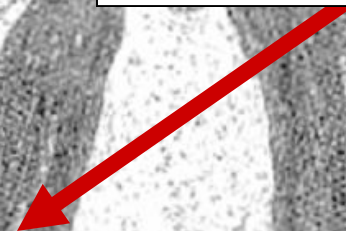
P



**MITOCHONDRION**



**PLASTIDS**



**MITOCHONDRION & PLASTIDS POSSESS:**

**REPRODUCTION**

# ANGIOSPERM CYTOLOGY

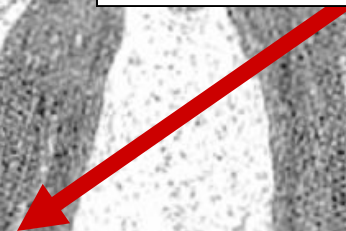
B



MITOCHONDRION



PLASTIDS



**MITOCHONDRION & PLASTIDS POSSESS:**

**REPRODUCTION PROKARYOTE-LIKE**



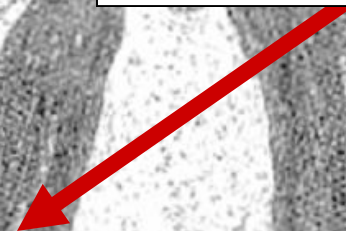
# ANGIOSPERM CYTOLOGY



**MITOCHONDRION**



**PLASTIDS**



**REPRODUCTION: BINARY FISSION**



Electron micrograph showing several rod-shaped prokaryotic cells. The cells have a thick, textured outer layer and a granular interior. One cell in the center is elongated and shows a distinct internal structure.

***REPRODUCTION  
BINARY FISSION  
PRESENT***

**PROKARYOTES**

Electron micrograph showing a cross-section of a eukaryotic cell. The cell is large and contains various organelles, including a nucleus with a nucleolus, mitochondria with cristae, and endoplasmic reticulum. A small box with a question mark is in the top right corner.

***REPRODUCTION  
BINARY FISSION  
ABSENT***

**EUKARYOTES**

# QUESTION

DOES THIS EVIDENCE  
SUPPORT OR REFUTE  
THE  
ENDOSYMBIOTIC  
THEORY?

# QUESTION



# ANGIOSPERM CYTOLOGY

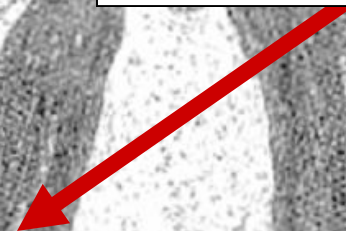
R



**MITOCHONDRION**



**PLASTIDS**



**DNA PROKARYOTE-LIKE**



# ANGIOSPERM CYTOLOGY

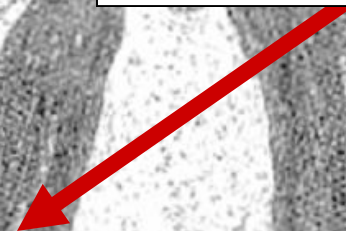
R



**MITOCHONDRION**



**PLASTIDS**



**RIBOSOMES PROKARYOTE-LIKE**



# ANGIOSPERM CYTOLOGY



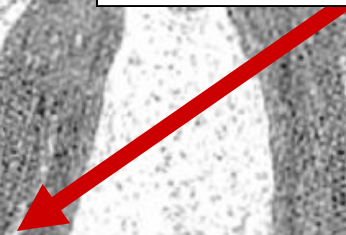
A

>

**MITOCHONDRION**



**PLASTIDS**



**REPRODUCTION PROKARYOTE-LIKE**



**ANSWER**

**EVIDENCE SUPPORTS  
ENDOSYMBIOTIC  
THEORY**

**ANSWER**



# DMBO EVOLUTION SUMMARY

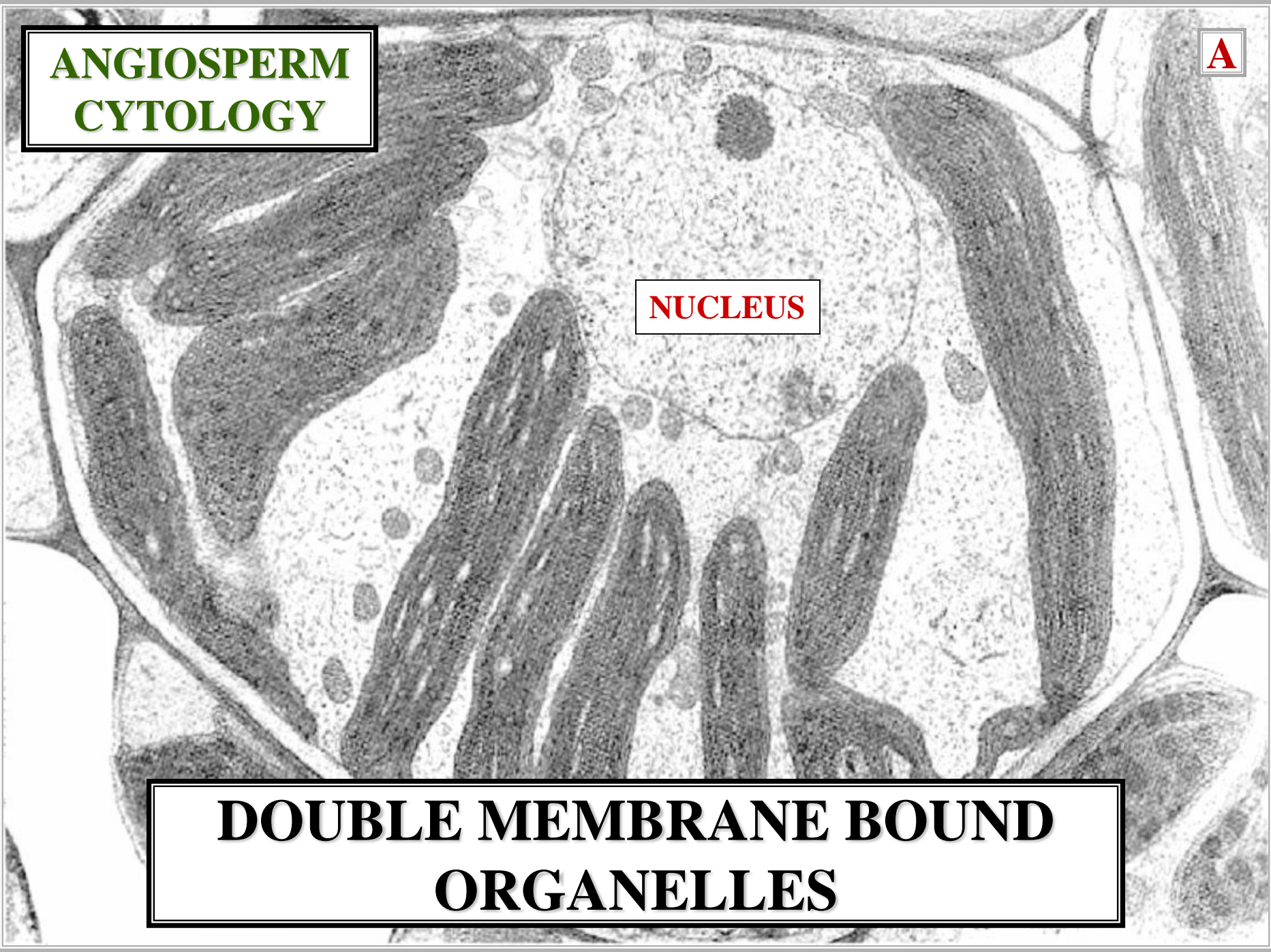


**ANGIOSPERM  
CYTOLOGY**

**A**

**NUCLEUS**

**DOUBLE MEMBRANE BOUND  
ORGANELLES**



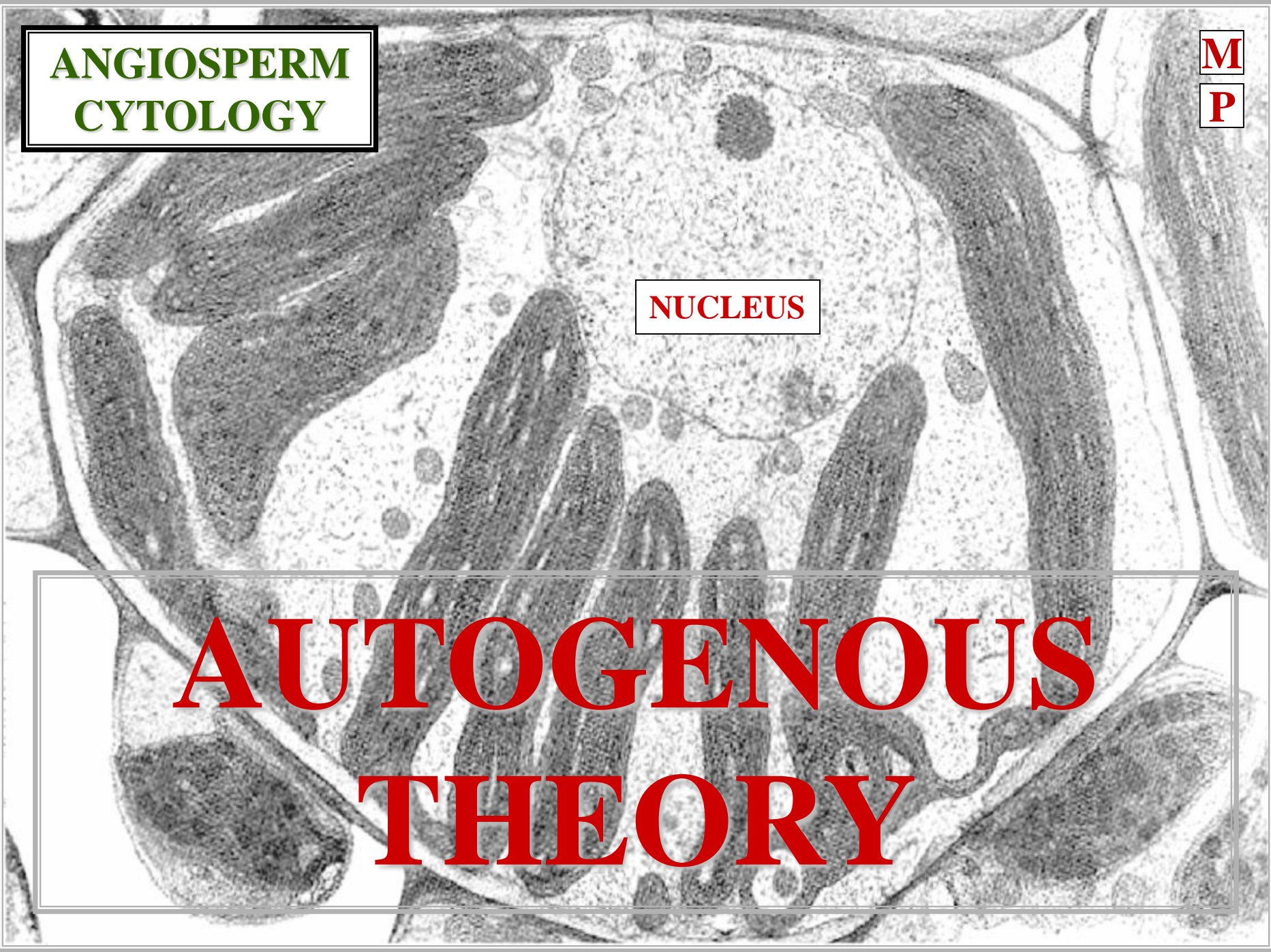


**ANGIOSPERM  
CYTOLOGY**

**M  
P**

**NUCLEUS**

**AUTOGENOUS  
THEORY**



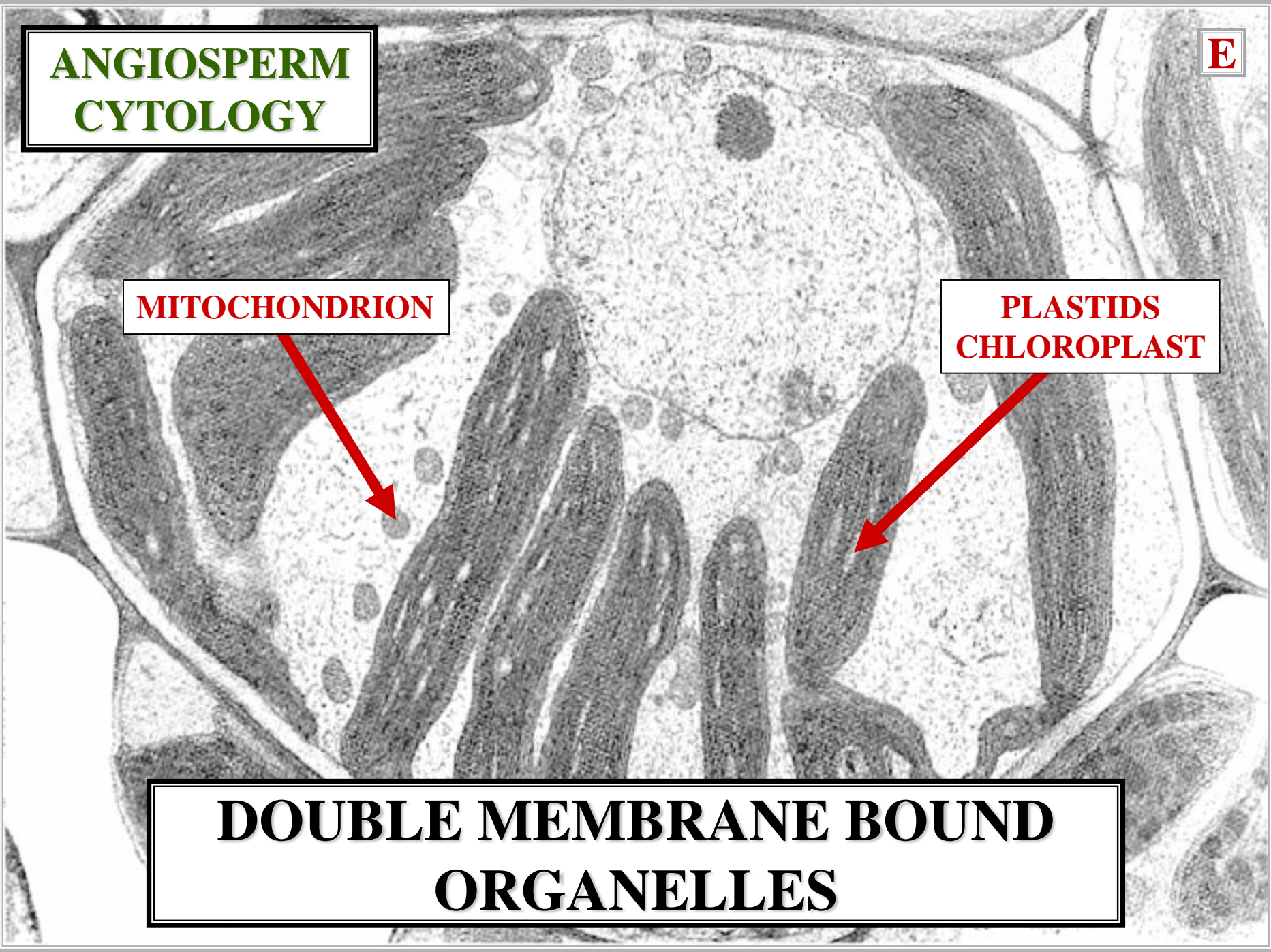
**ANGIOSPERM  
CYTOLOGY**

**E**

**MITOCHONDRION**

**PLASTIDS  
CHLOROPLAST**

**DOUBLE MEMBRANE BOUND  
ORGANELLES**





# ANGIOSPERM CYTOLOGY

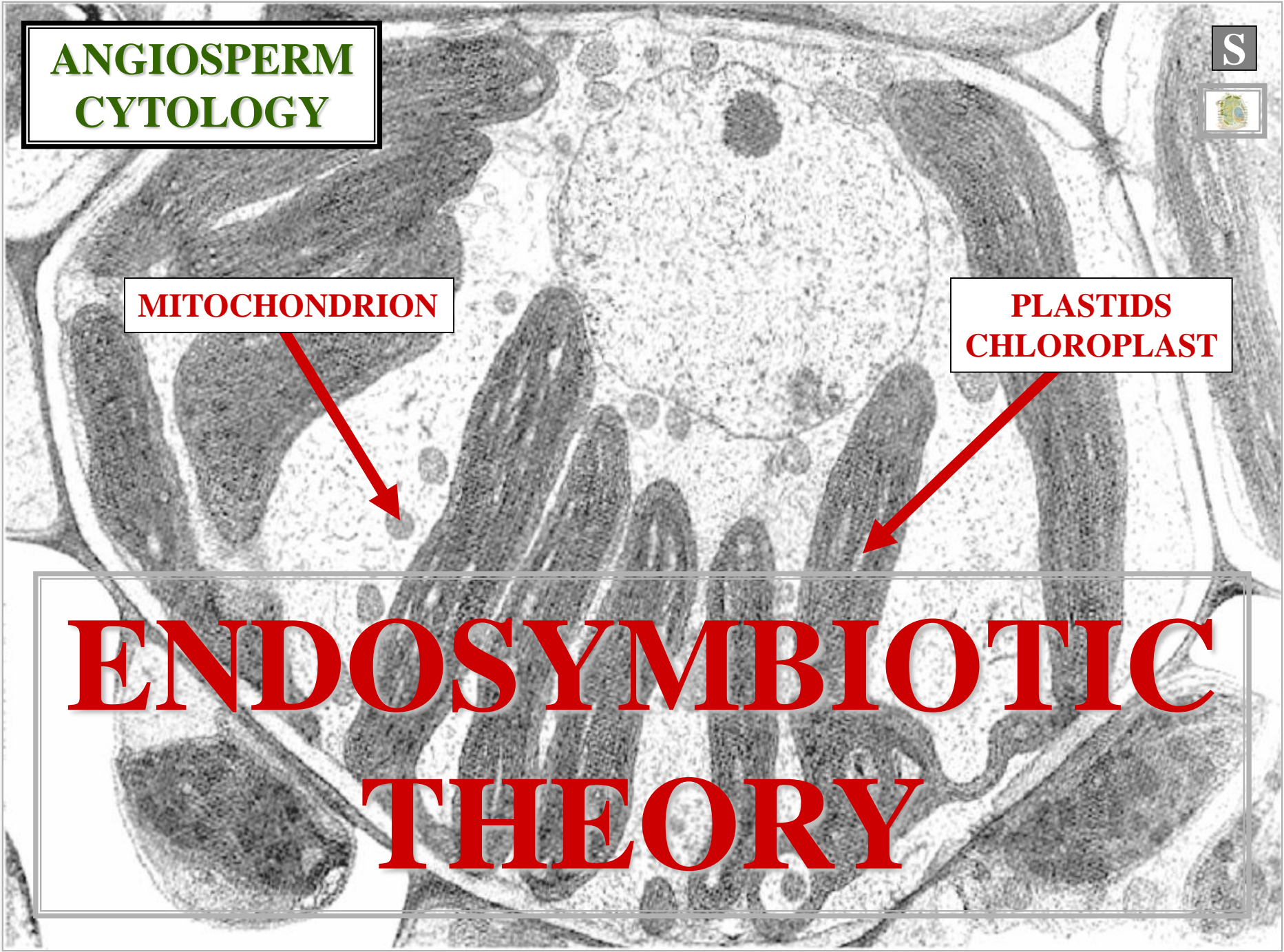
S



MITOCHONDRION

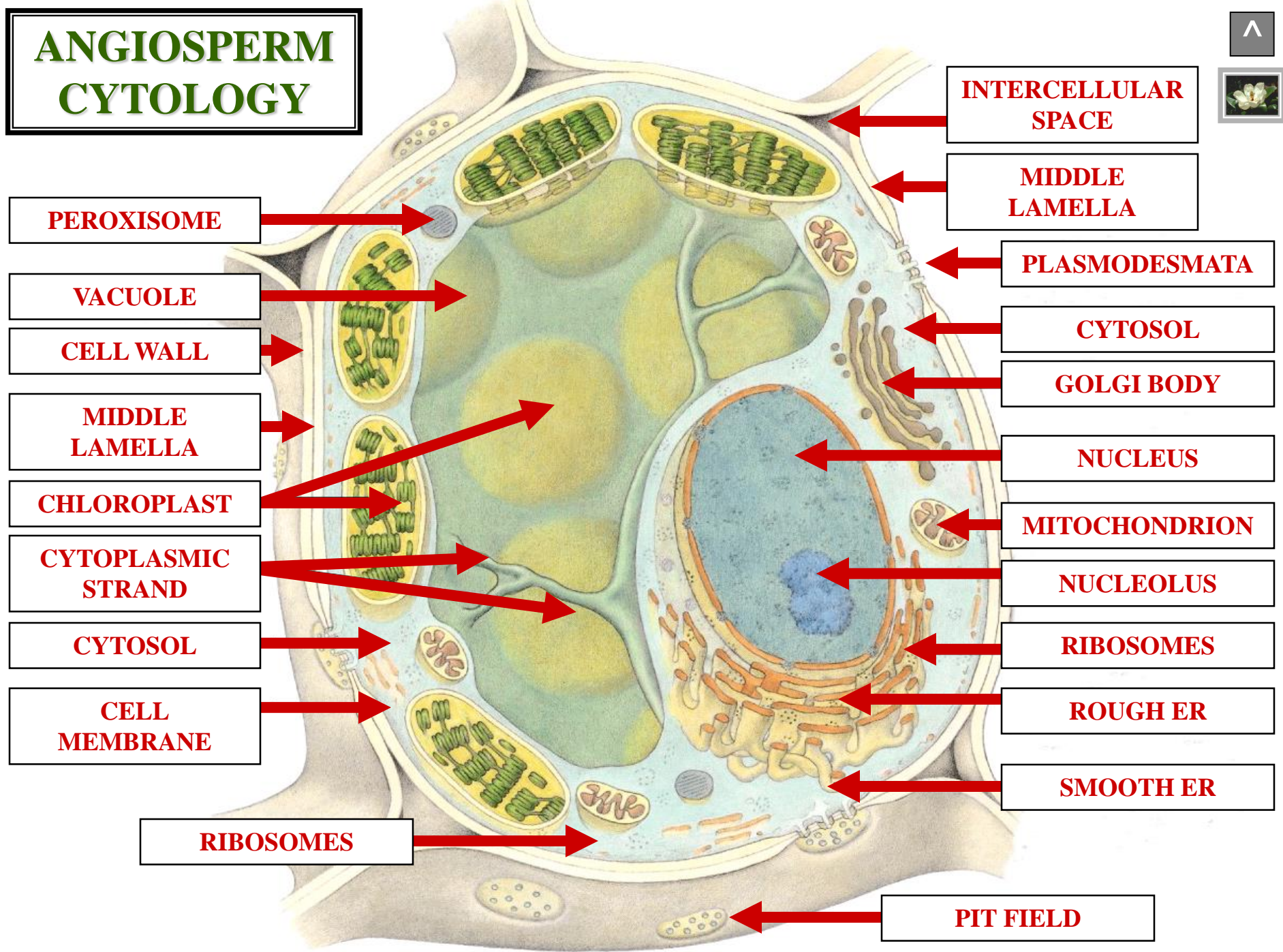
PLASTIDS  
CHLOROPLAST

# ENDOSYMBIOTIC THEORY





# ANGIOSPERM CYTOLOGY



**PEROXISOME**

**VACUOLE**

**CELL WALL**

**MIDDLE LAMELLA**

**CHLOROPLAST**

**CYTOPLASMIC STRAND**

**CYTOSOL**

**CELL MEMBRANE**

**RIBOSOMES**

**INTERCELLULAR SPACE**

**MIDDLE LAMELLA**

**PLASMODESMATA**

**CYTOSOL**

**GOLGI BODY**

**NUCLEUS**

**MITOCHONDRION**

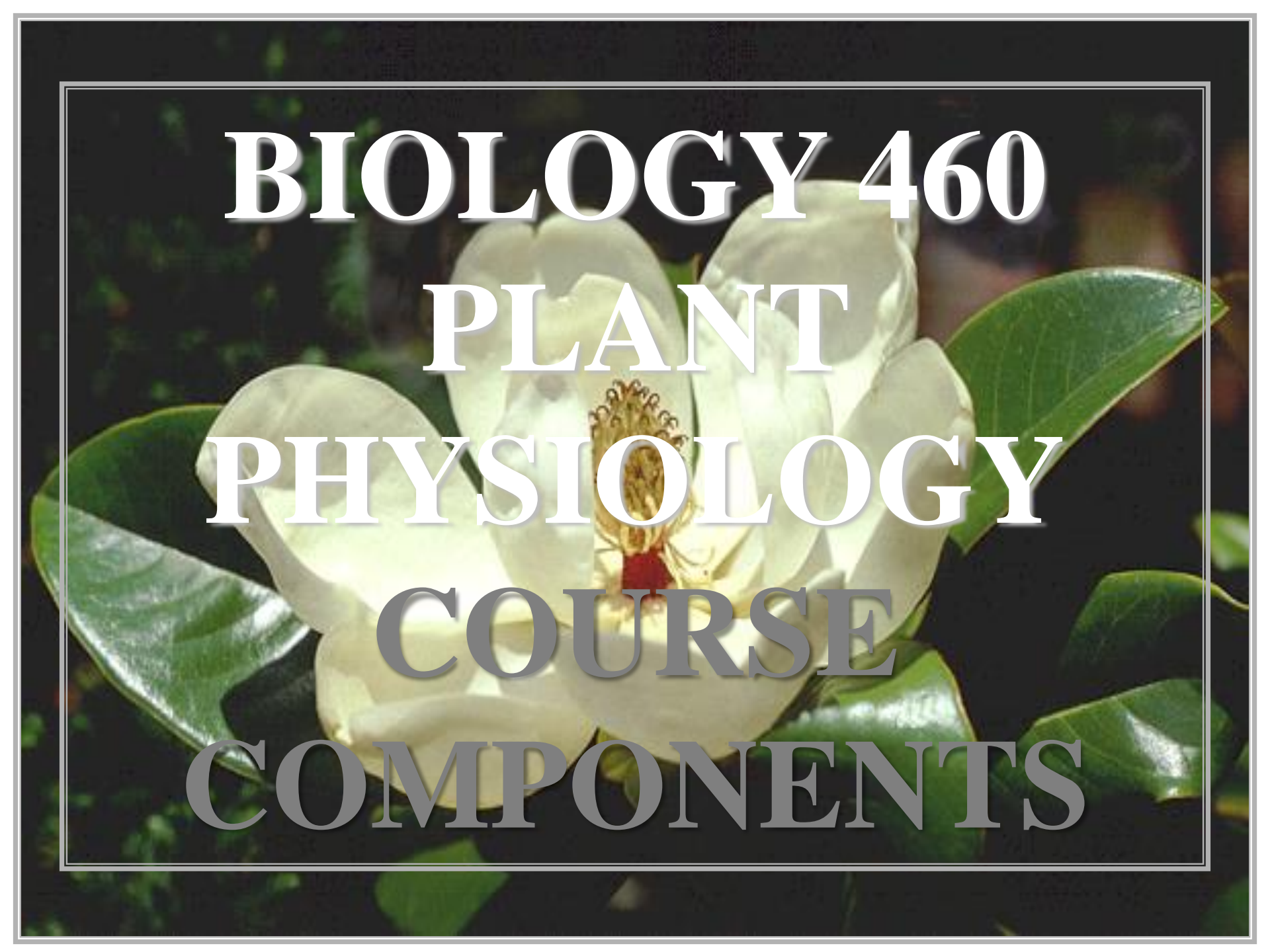
**NUCLEOLUS**

**RIBOSOMES**

**ROUGH ER**


**SMOOTH ER**

**PIT FIELD**



**BIOLOGY 460**  
**PLANT**  
**PHYSIOLOGY**  
**COURSE**  
**COMPONENTS**





ANGIOSPERM  
MORPHOLOGY  
&  
ANGIOSPERM  
ANATOMY



**ANGIOSPERM  
CYTOLOGY**



# ANGIOSPERM PHYSIOLOGY





# ANGIOSPERM PHYSIOLOGY



# **METABOLISM**

# **METABOLISM**

**METABOLISM**



**CELL  
BIOCHEMISTRY**

**METABOLISM**



***CELL  
METABOLISM  
=  
CELL  
BIOCHEMISTRY***



**MONOMERS**  
**VS**  
**POLYMERS**

**MONOMER**

**MONOMER**

**POLYMER SUBUNIT**

**MONOMER**

**POLYMER**



**POLYMER**

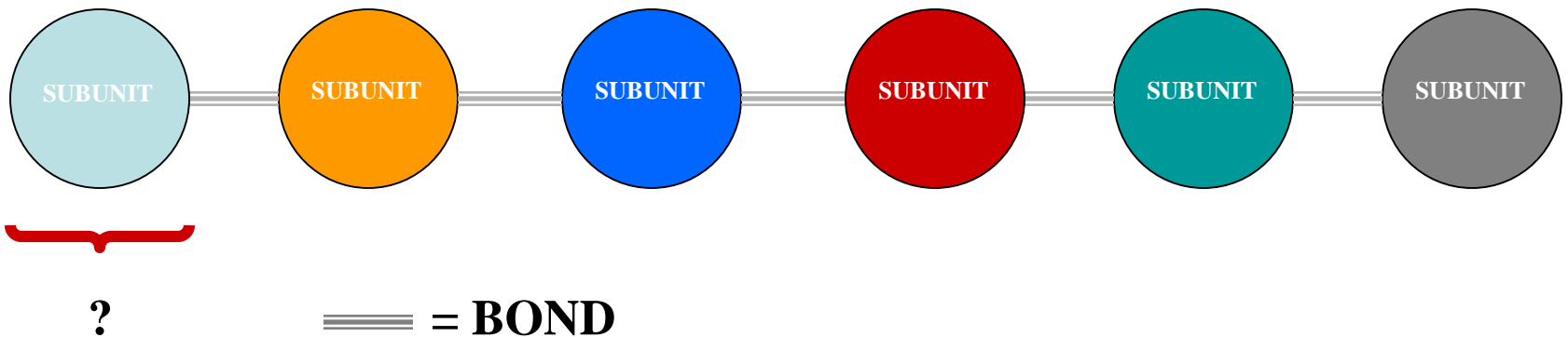
**MONOMER ASSEMBLAGE**

**POLYMER**



# **MONOMERS VS POLYMERS APPLIED**

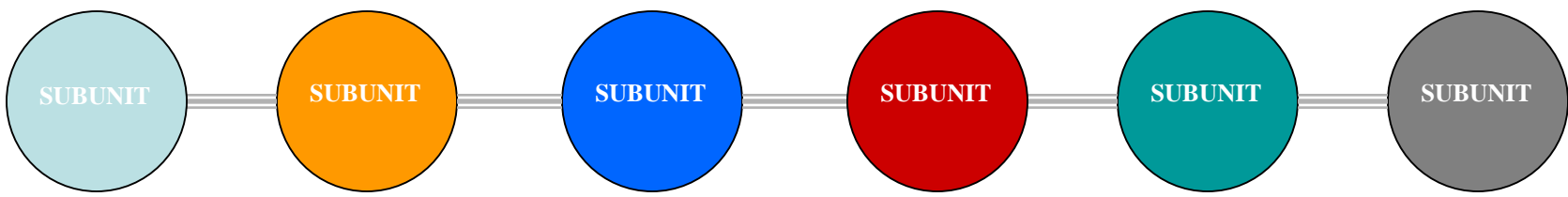
# MACROMOLECULE MONOMER VS POLYMER



**MACROMOLECULE**



# MACROMOLECULE MONOMER VS POLYMER



**MONOMER**

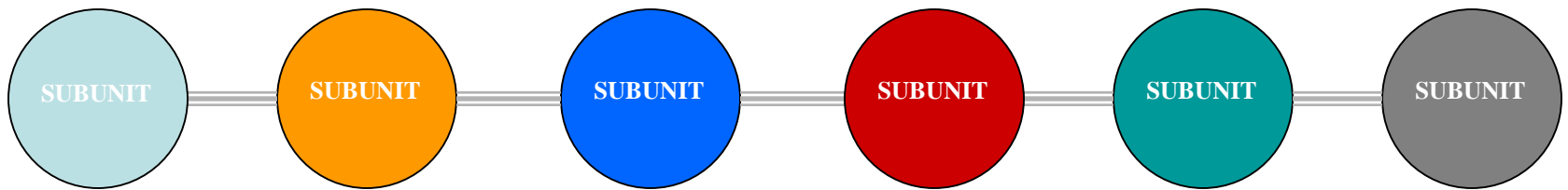
**== = BOND**



**MACROMOLECULE**



# MACROMOLECULE MONOMER VS POLYMER



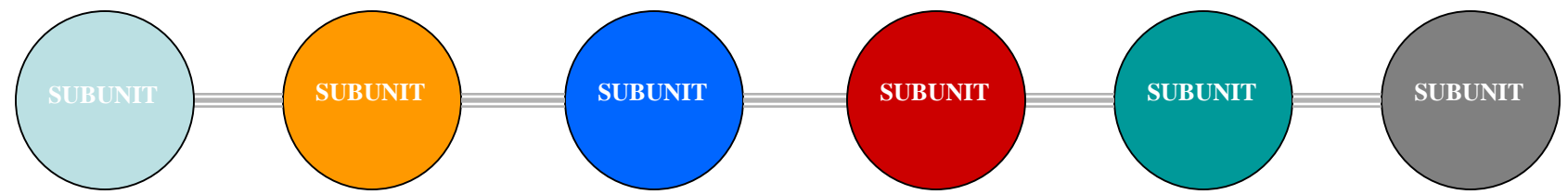
**MONOMER**

**== = BOND**

A large red curly bracket spans the width of the entire polymer chain shown above. Below the center of this bracket is a large black question mark, suggesting a question about the nature of the whole chain.

**?**

# MACROMOLECULE MONOMER VS POLYMER



**MONOMER**     **==** = **BOND**



**POLYMER**



**CONDENSATION  
REACTION  
VS  
HYDROLYSIS  
REACTION**

# CONDENSATION REACTION

# CONDENSATION REACTION