



**ANSWER**

**NO**

**---**

**PLASTIDS**

**ABSENT**

**ANSWER**

**QUESTION**

**WHY ARE WE  
STUDYING  
CYANOBACTERIA  
GREEN BACTERIA?**

**QUESTION**



# ANSWER

SOME UNKNOWN  
CYANOBACTERIUM  
WITH POSSIBLE  
GREEN BACTERIA  
CHARACTERS  
EVOLVED TRUE PLANT  
CHLOROPLASTS

# ANSWER

**QUESTION**

**WHAT THEORY  
GAVE RISE TO  
TRUE PLANT  
CHLOROPLAST?**

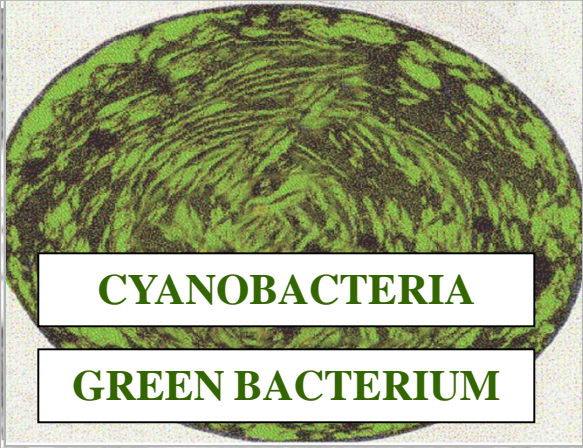
**QUESTION**

**ANSWER**



**ENDOSYMBIOTIC  
THEORY**

**ANSWER**



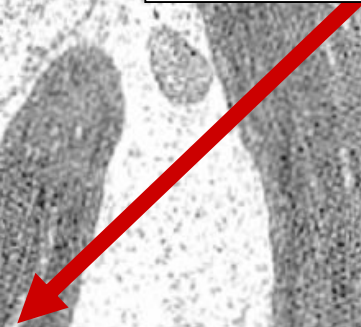
**CYANOBACTERIA**

**GREEN BACTERIUM**

SE

+

**CHLOROPLAST**



***ENDOSYMBIOTIC THEORY***

**TRUE PLANT CELL**



**ENDOSYMBIOTIC  
THEORY  
CYANOBACTERIUM  
SUPPORTING  
EVIDENCE**

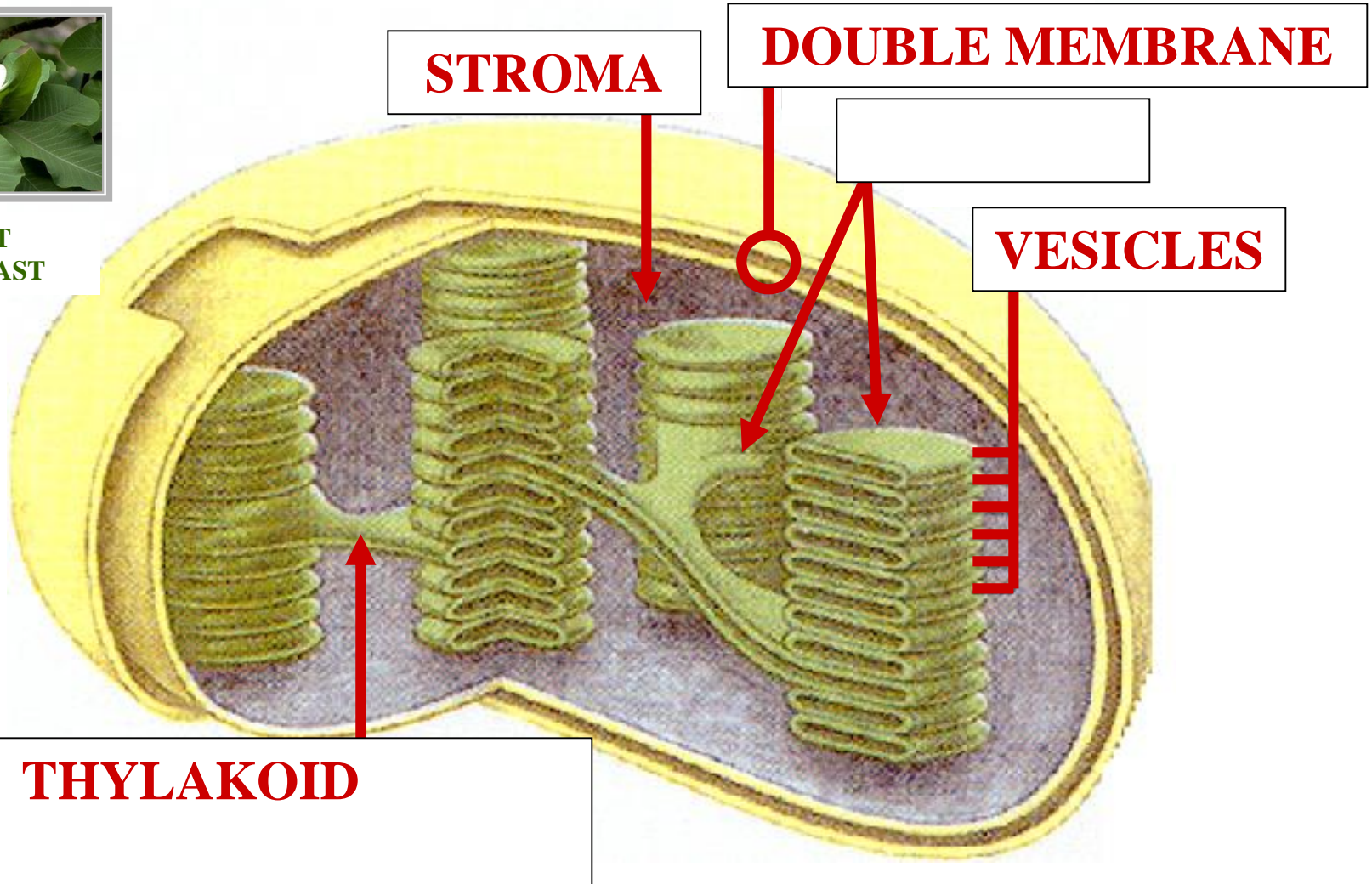
CYANOBACTERIUM  
GREEN BACTERIUM



TRUE PLANT  
CHLOROPLAST

# TRUE PLANT CHLOROPLAST ULTRASTRUCTURE

G





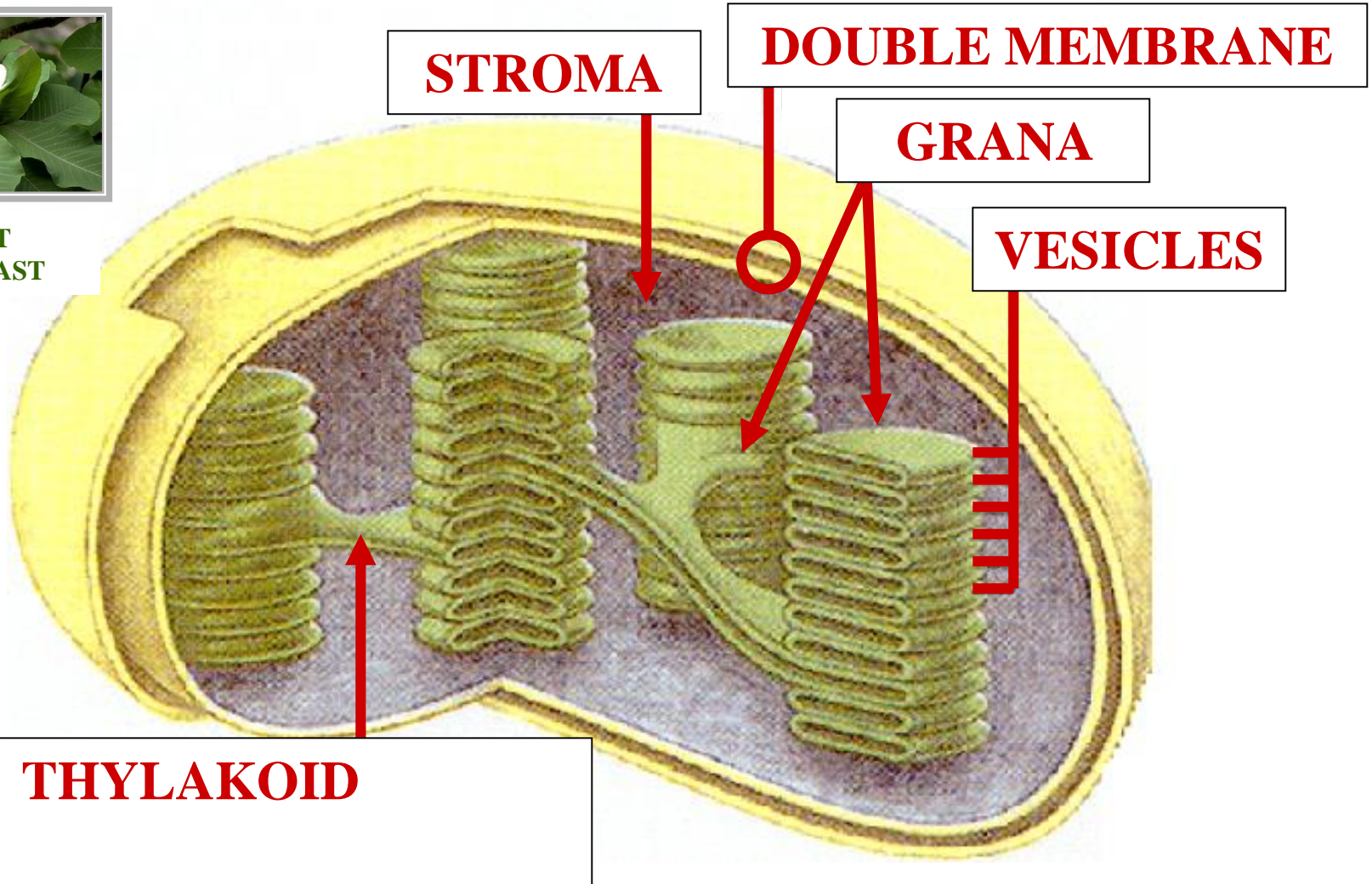
CYANOBACTERIUM  
GREEN BACTERIUM



TRUE PLANT  
CHLOROPLAST

# TRUE PLANT CHLOROPLAST ULTRASTRUCTURE

A  
B



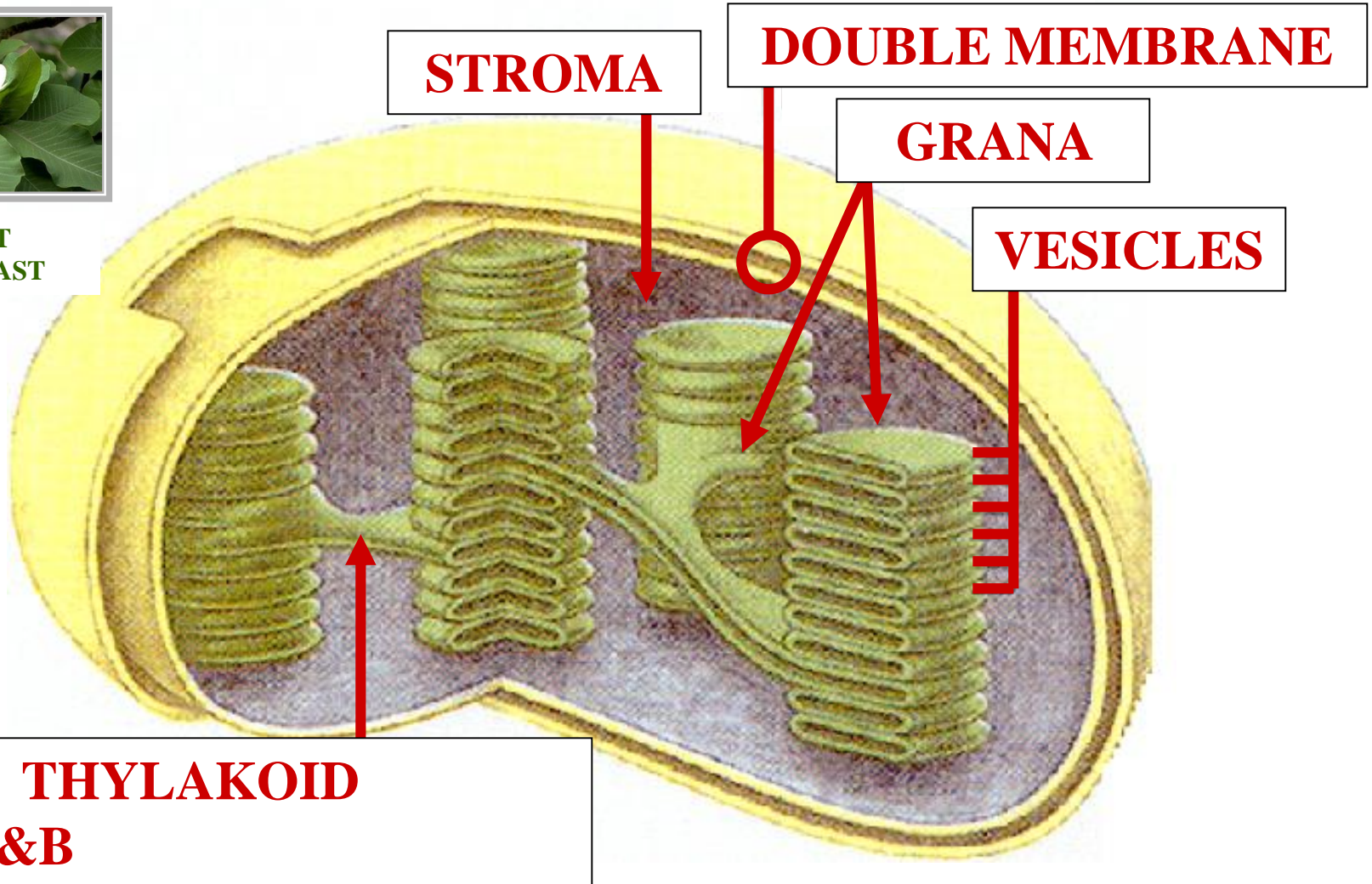
CYANOBACTERIUM  
GREEN BACTERIUM



TRUE PLANT  
CHLOROPLAST

# TRUE PLANT CHLOROPLAST ULTRASTRUCTURE

C

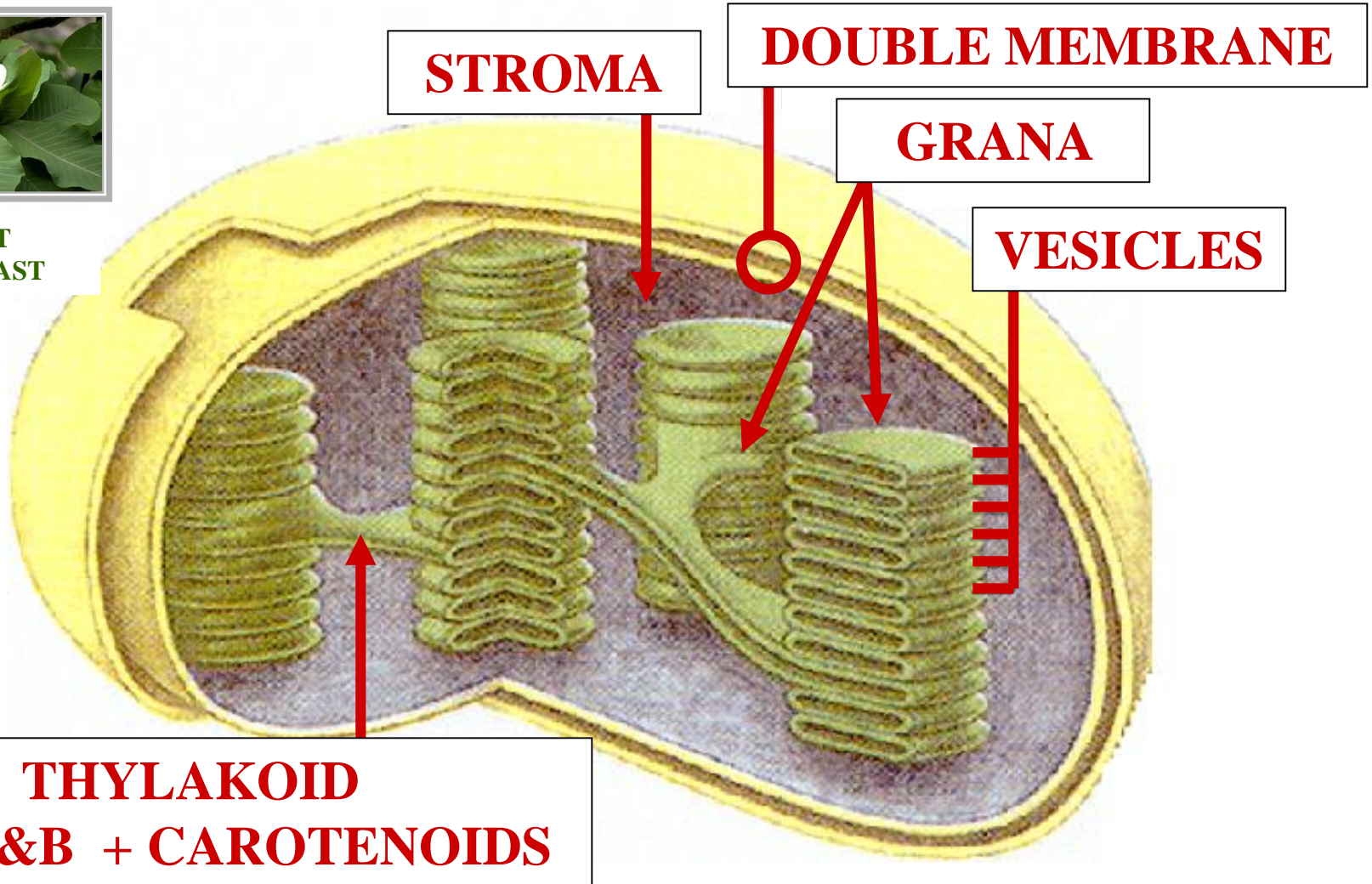


CYANOBACTERIUM  
GREEN BACTERIUM



TRUE PLANT  
CHLOROPLAST

# TRUE PLANT CHLOROPLAST ULTRASTRUCTURE



# VASCULAR PLANT EVOLUTION



**2.1 – 1.8**  
**BILLION YEARS**

A high-resolution satellite image of Earth from space, showing the curvature of the planet, blue oceans, white clouds, and brown and green landmasses. The image is framed by a thin white border.

**UNICELLULAR  
EUKARYOTES  
EVOLVE**

**EARTH**

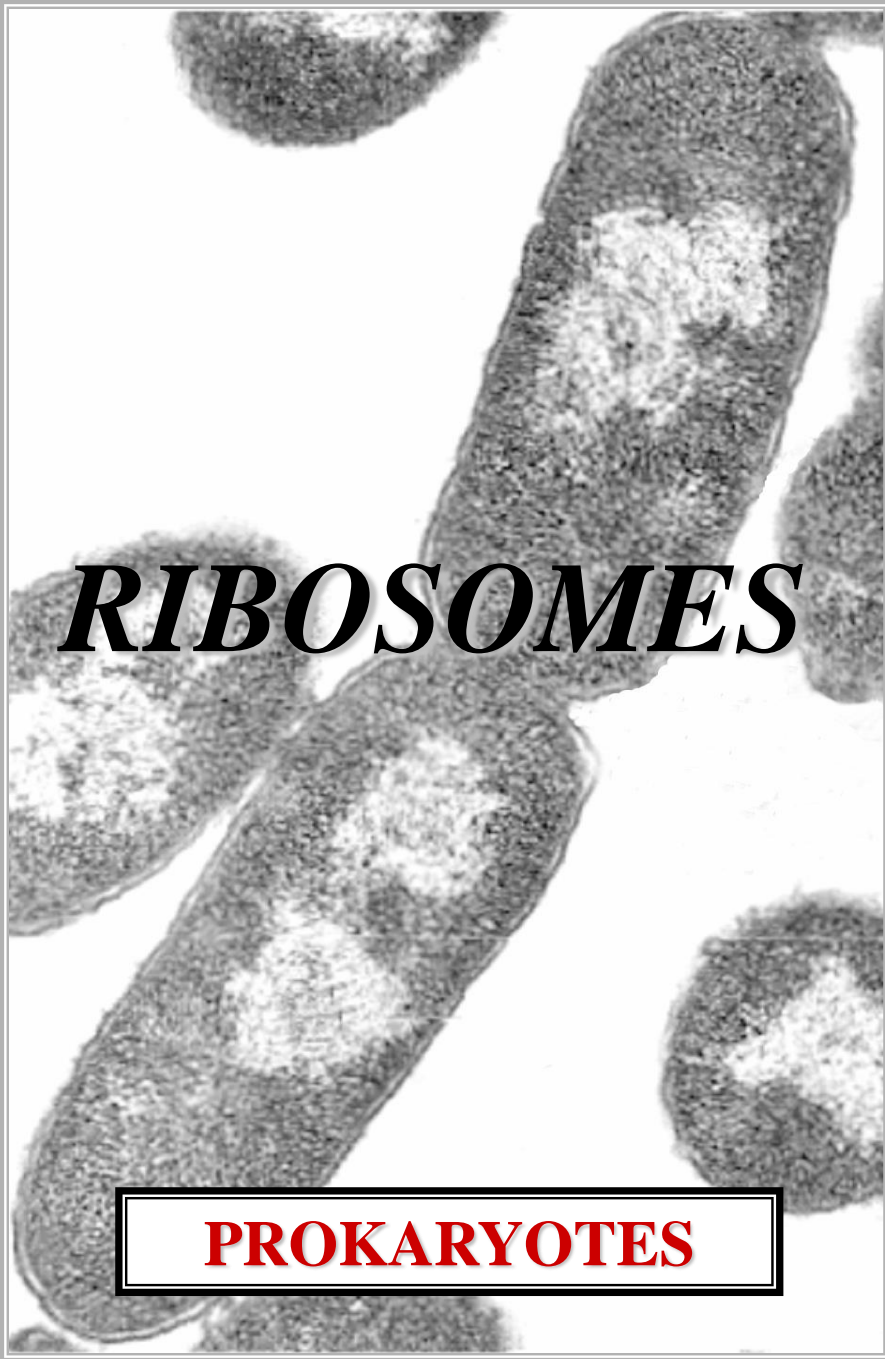


# INTRODUCTION EUKARYOTES



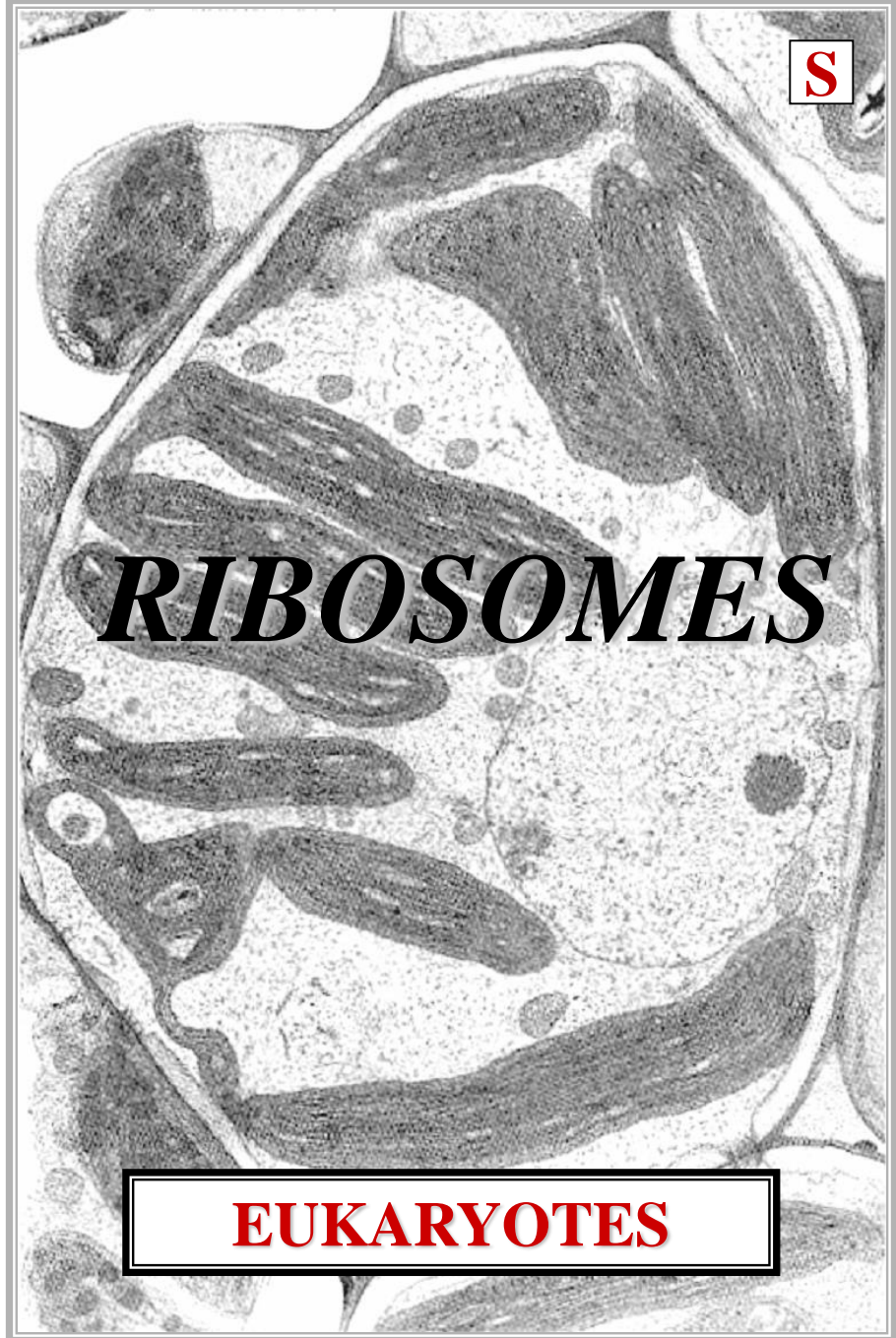
# EUKARYOTE CHARACTERS





***RIBOSOMES***

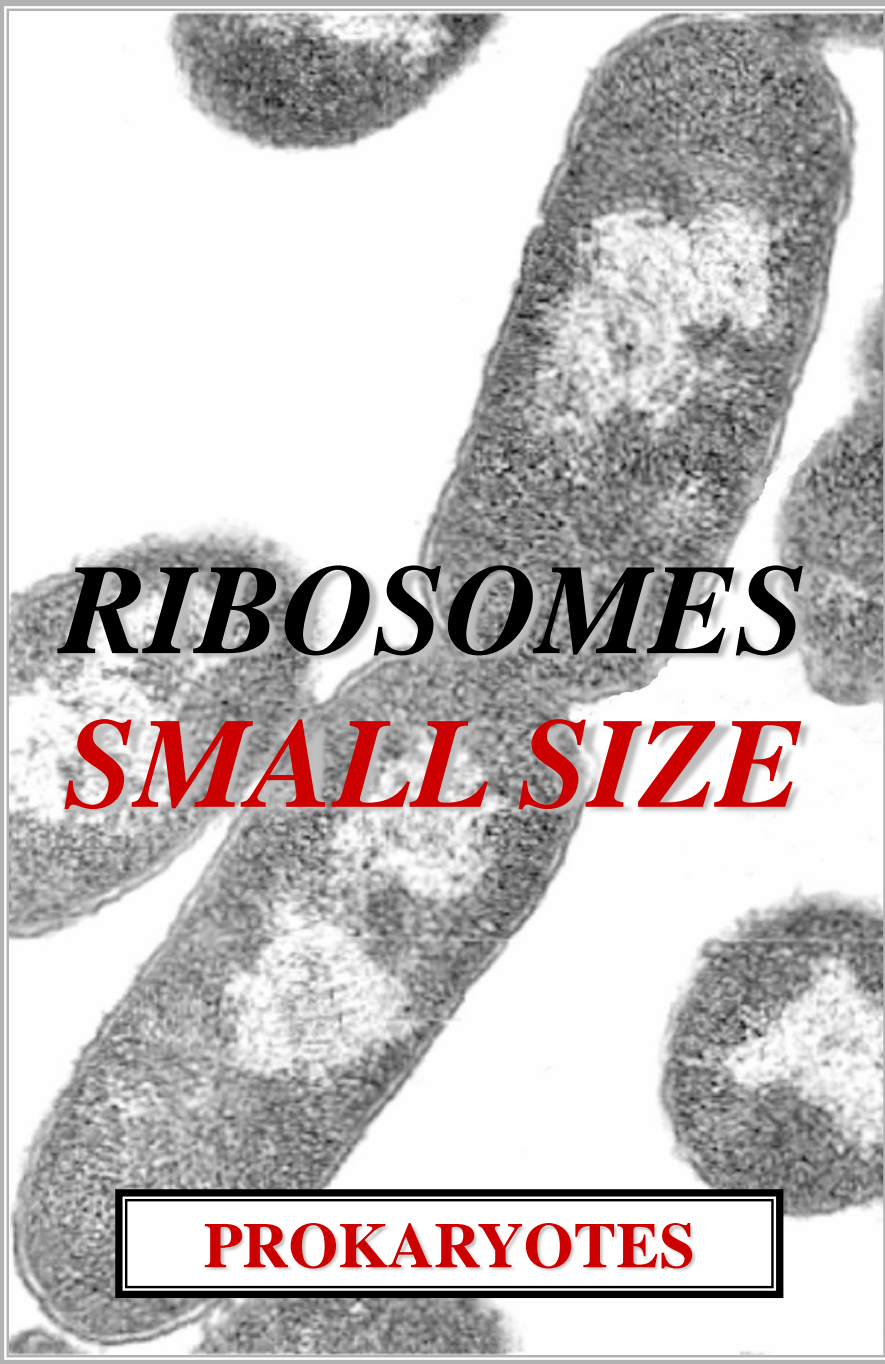
**PROKARYOTES**



**S**

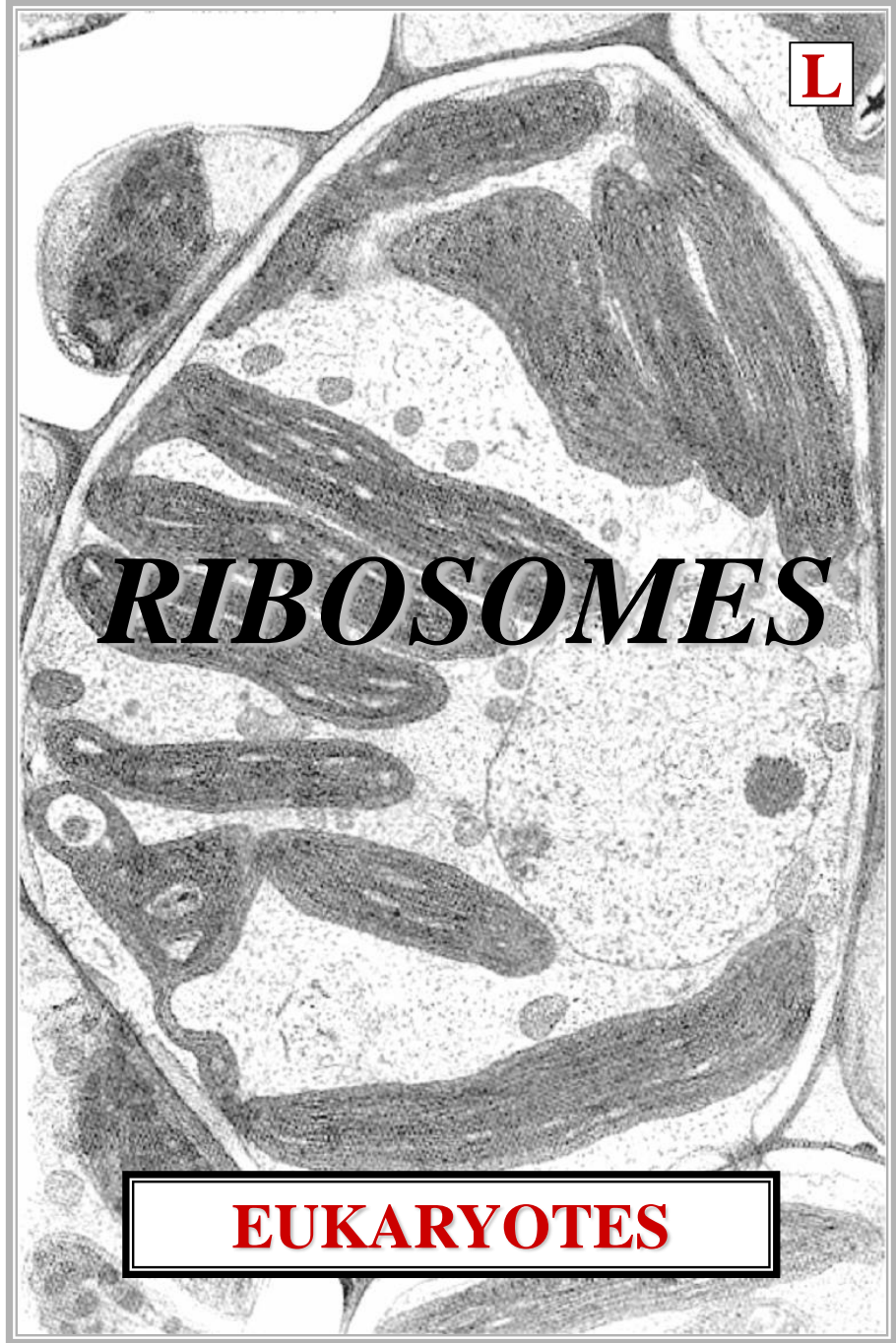
***RIBOSOMES***

**EUKARYOTES**



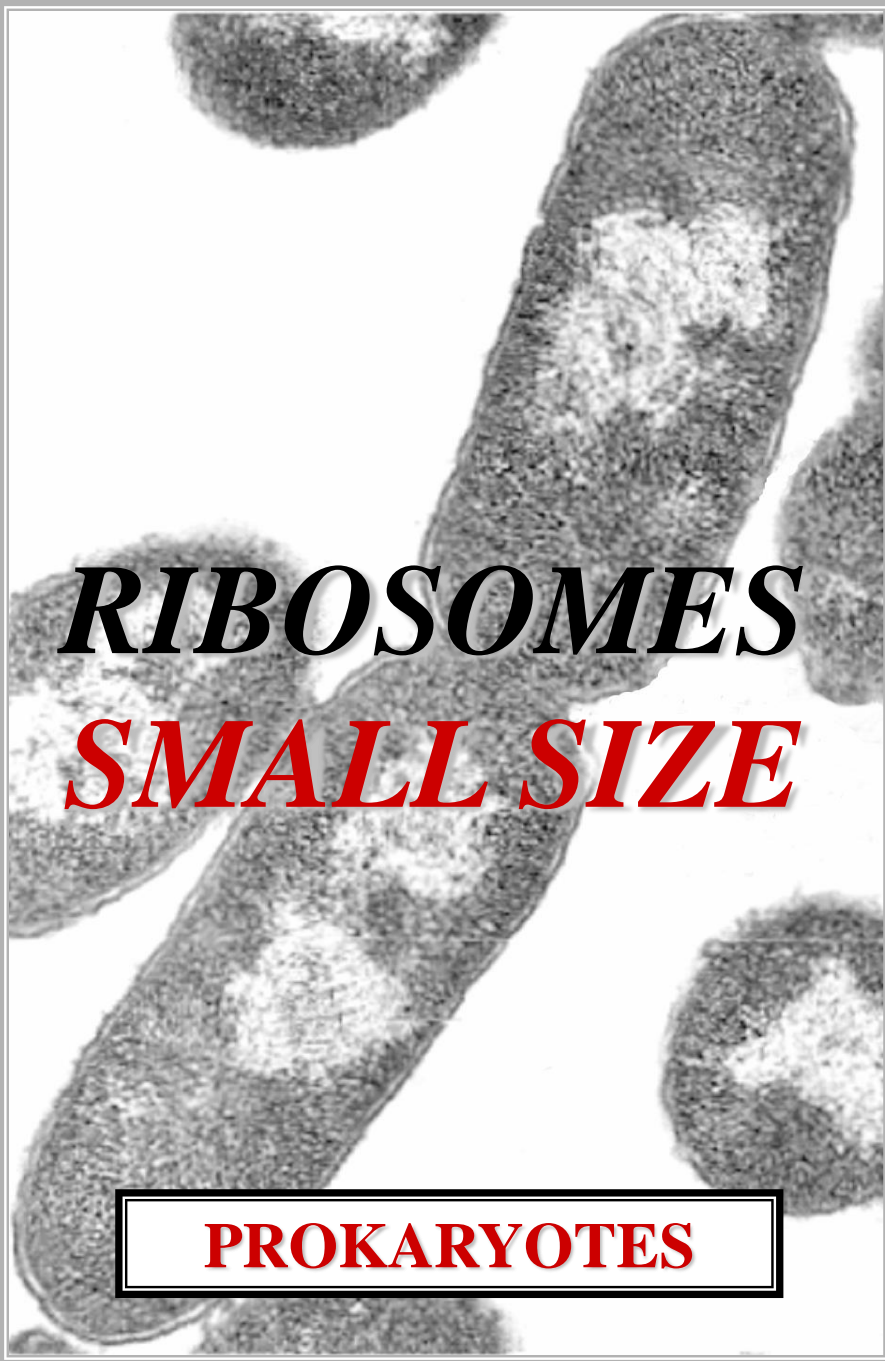
***RIBOSOMES***  
***SMALL SIZE***

**PROKARYOTES**



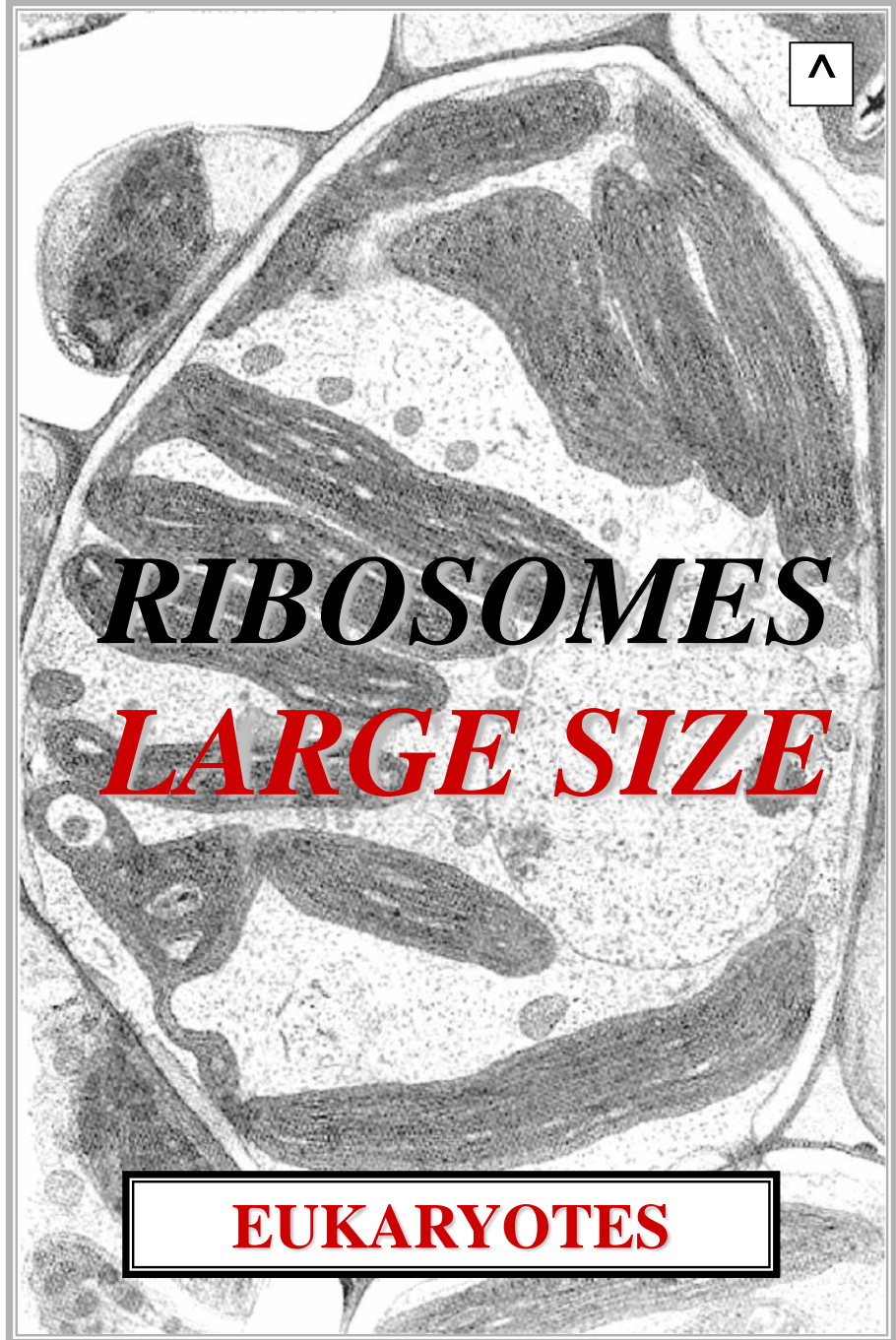
***RIBOSOMES***

**EUKARYOTES**



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

**PROKARYOTES**



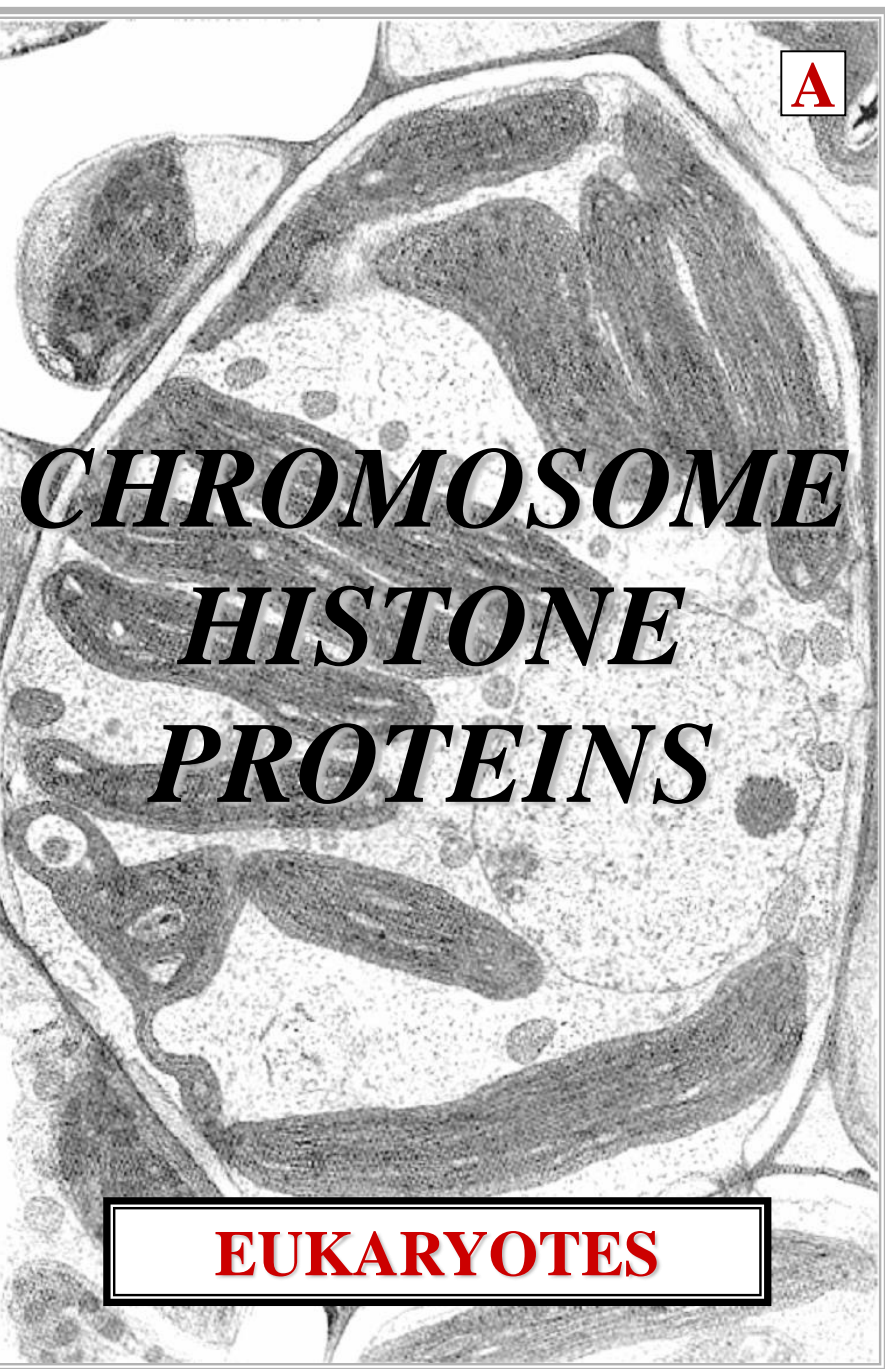
***RIBOSOMES***  
***LARGE SIZE***

**EUKARYOTES**

An electron micrograph showing a single, large, circular chromosome from a prokaryote. The chromosome is a dense, dark, fibrous structure with a mottled appearance, indicating its complex, condensed state. It is surrounded by a lighter, granular matrix.

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

**PROKARYOTES**

An electron micrograph showing multiple, smaller, X-shaped chromosomes from a eukaryote. The chromosomes are dark, fibrous structures with a distinct X-shape, indicating they are in a condensed state. They are surrounded by a lighter, granular matrix. A small red 'A' in a white box is located in the top right corner of the image.

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

**EUKARYOTES**



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

**PROKARYOTES**



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

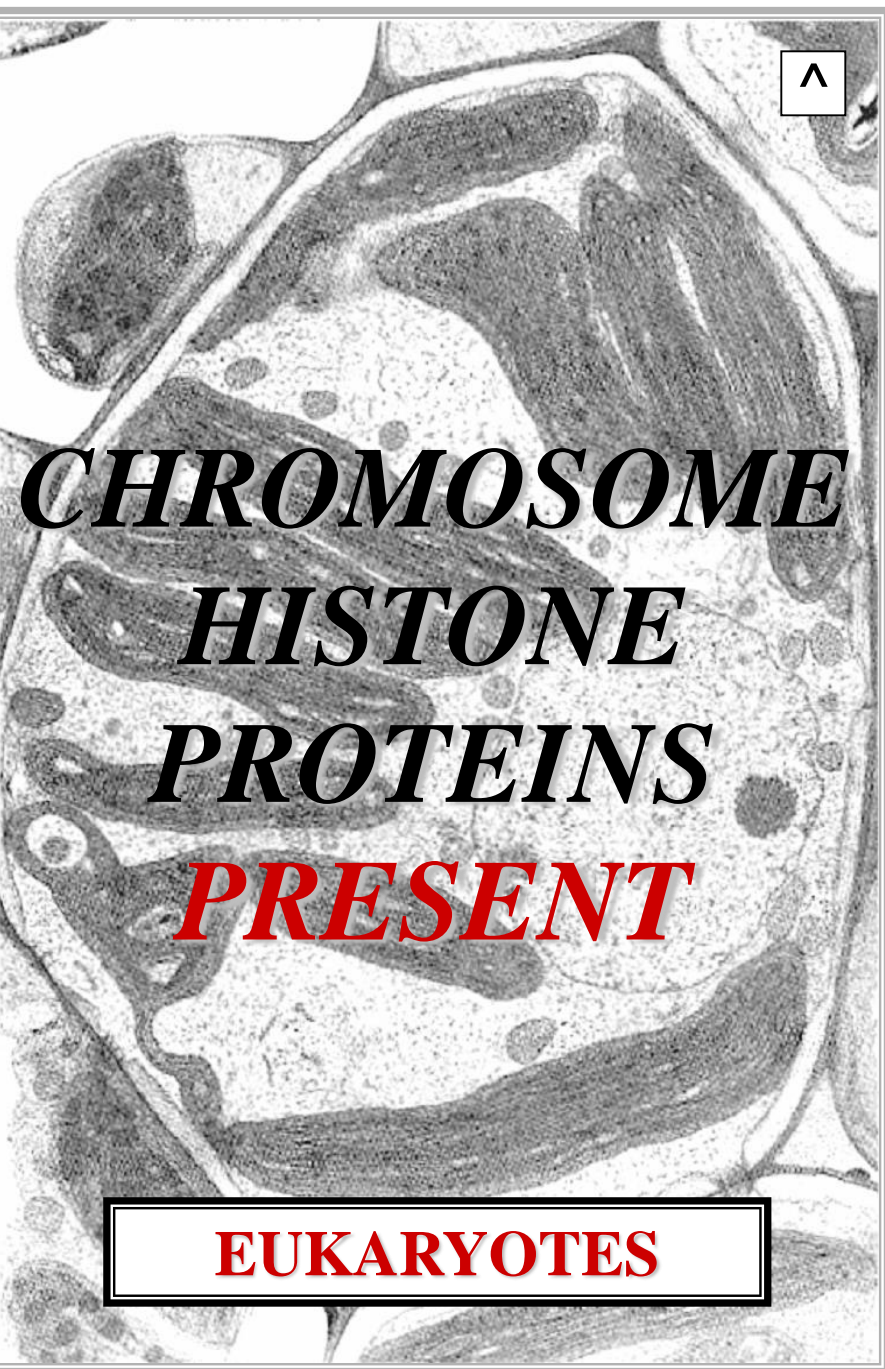
**EUKARYOTES**

**P**



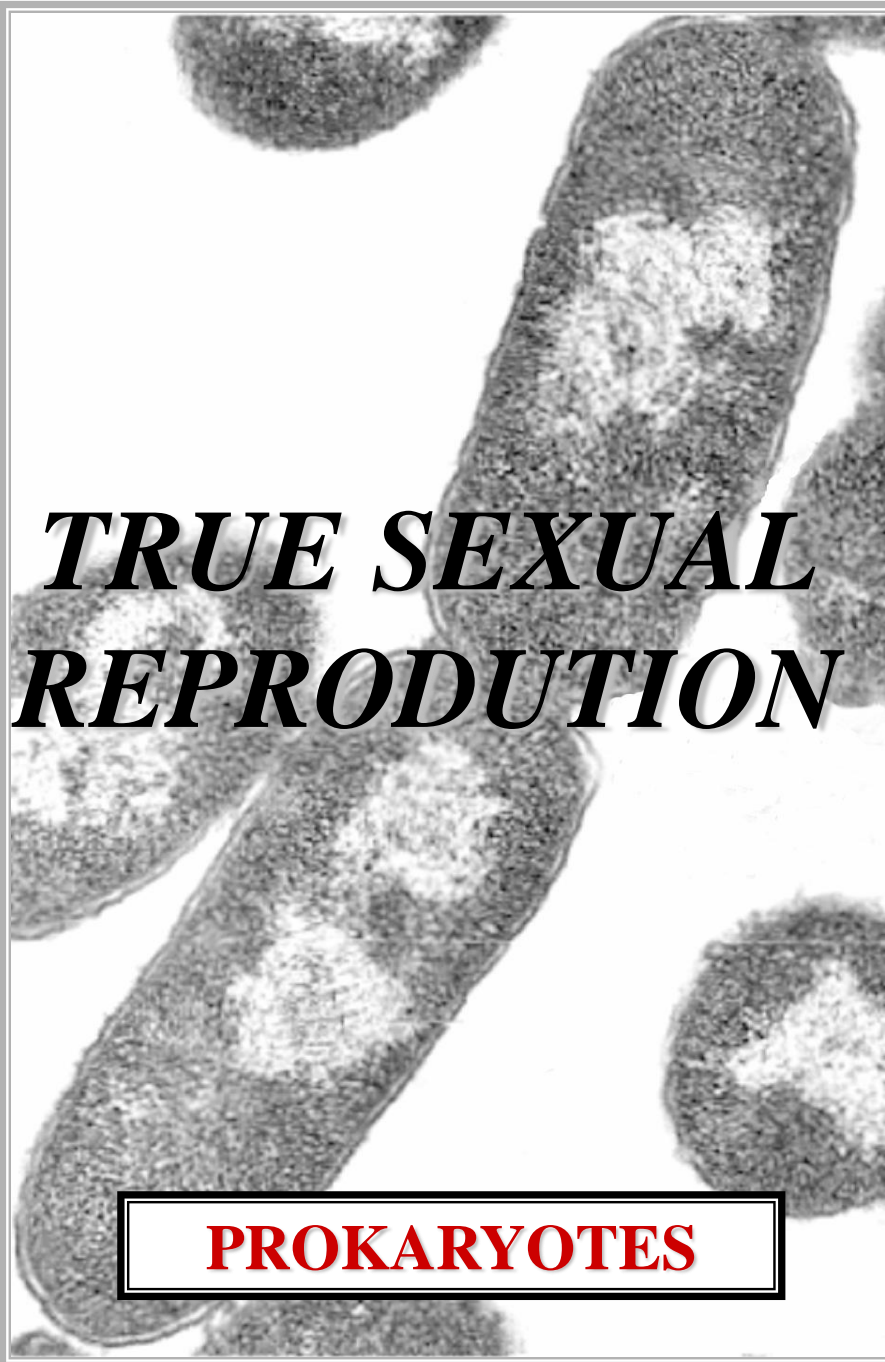
***CHROMOSOME***  
***HISTONE***  
***PROTEINS***  
***ABSENT***

**PROKARYOTES**



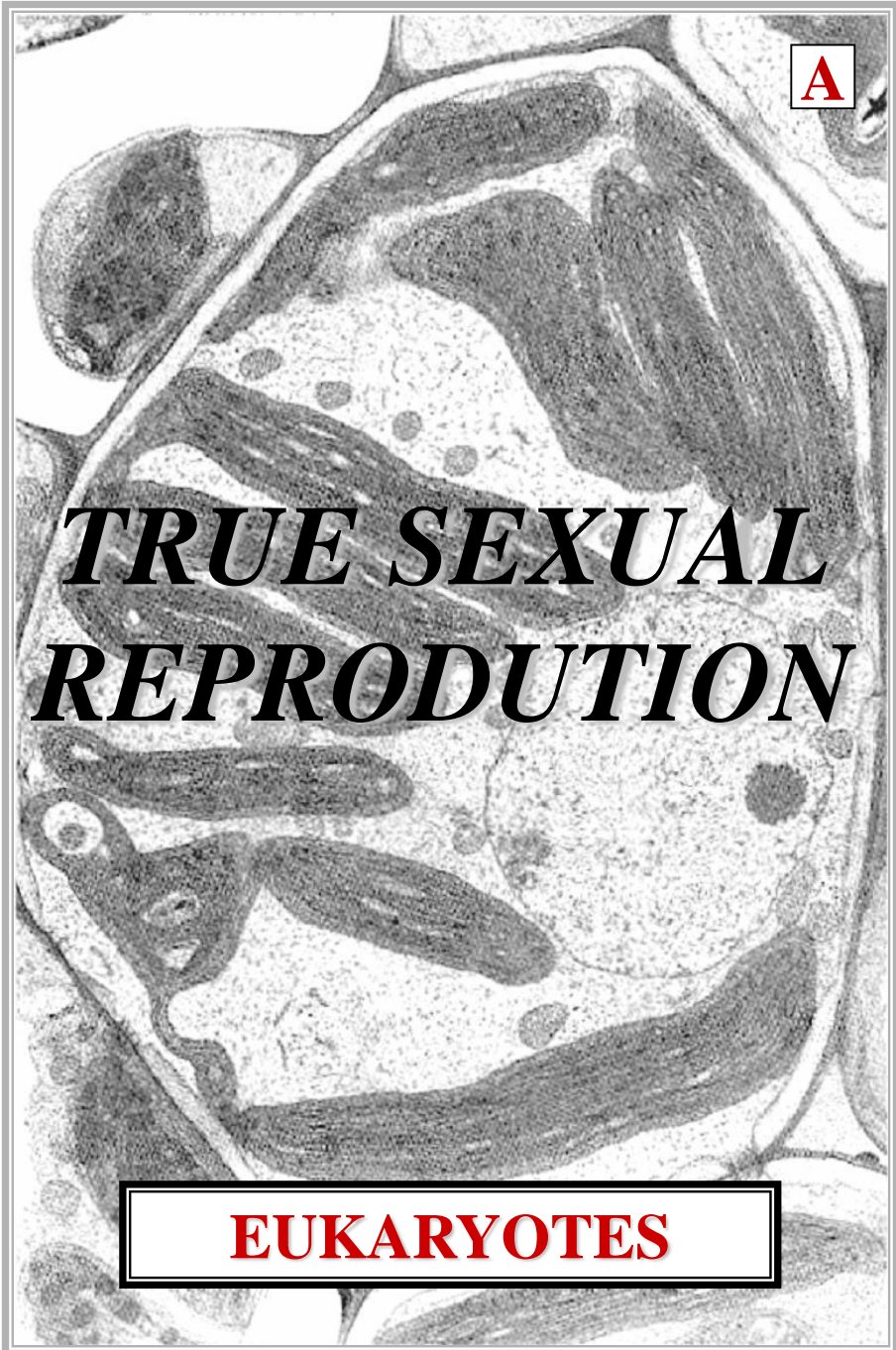
***CHROMOSOME***  
***HISTONE***  
***PROTEINS***  
***PRESENT***

**EUKARYOTES**



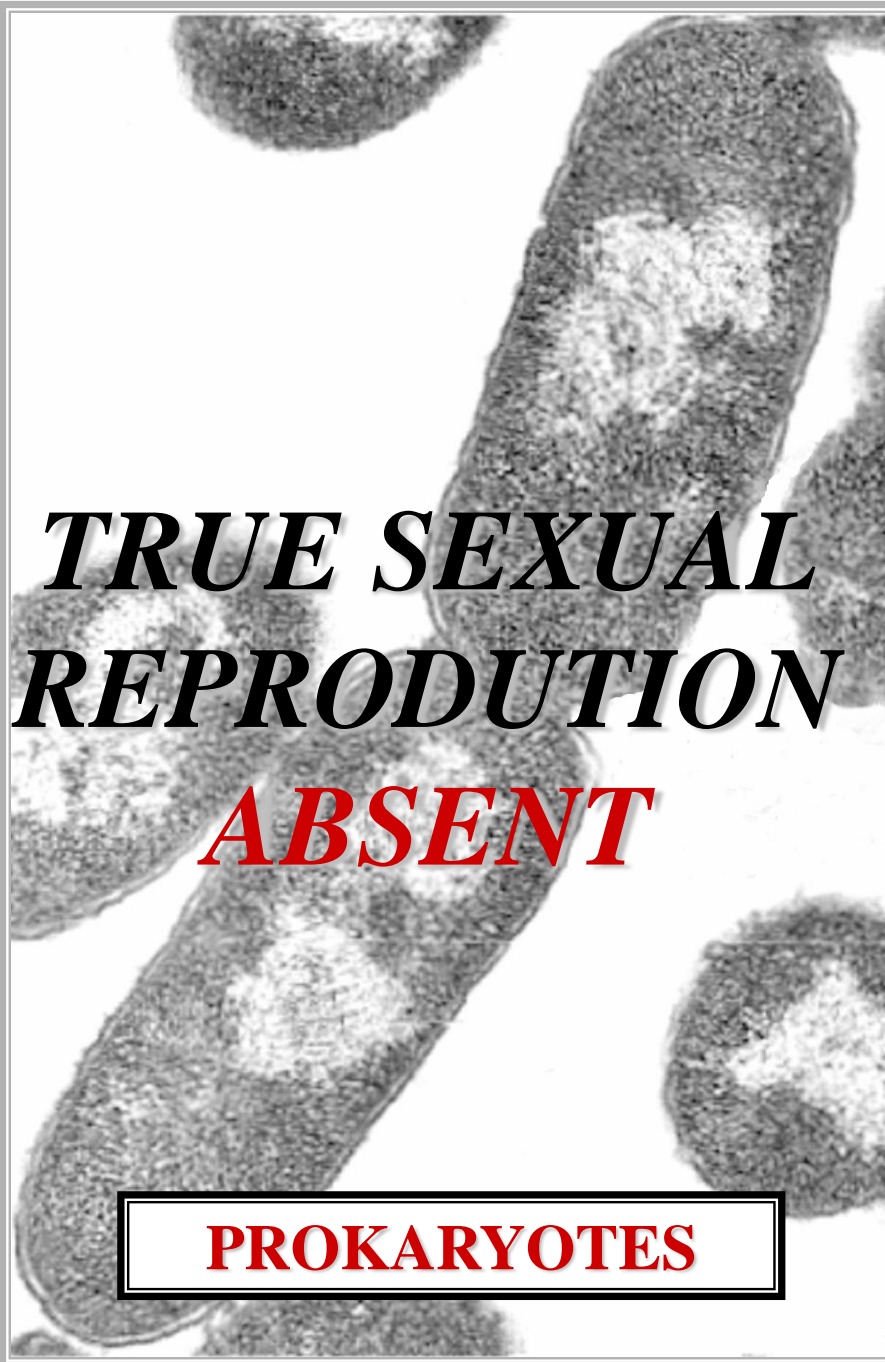
***TRUE SEXUAL  
REPRODUCTION***

**PROKARYOTES**



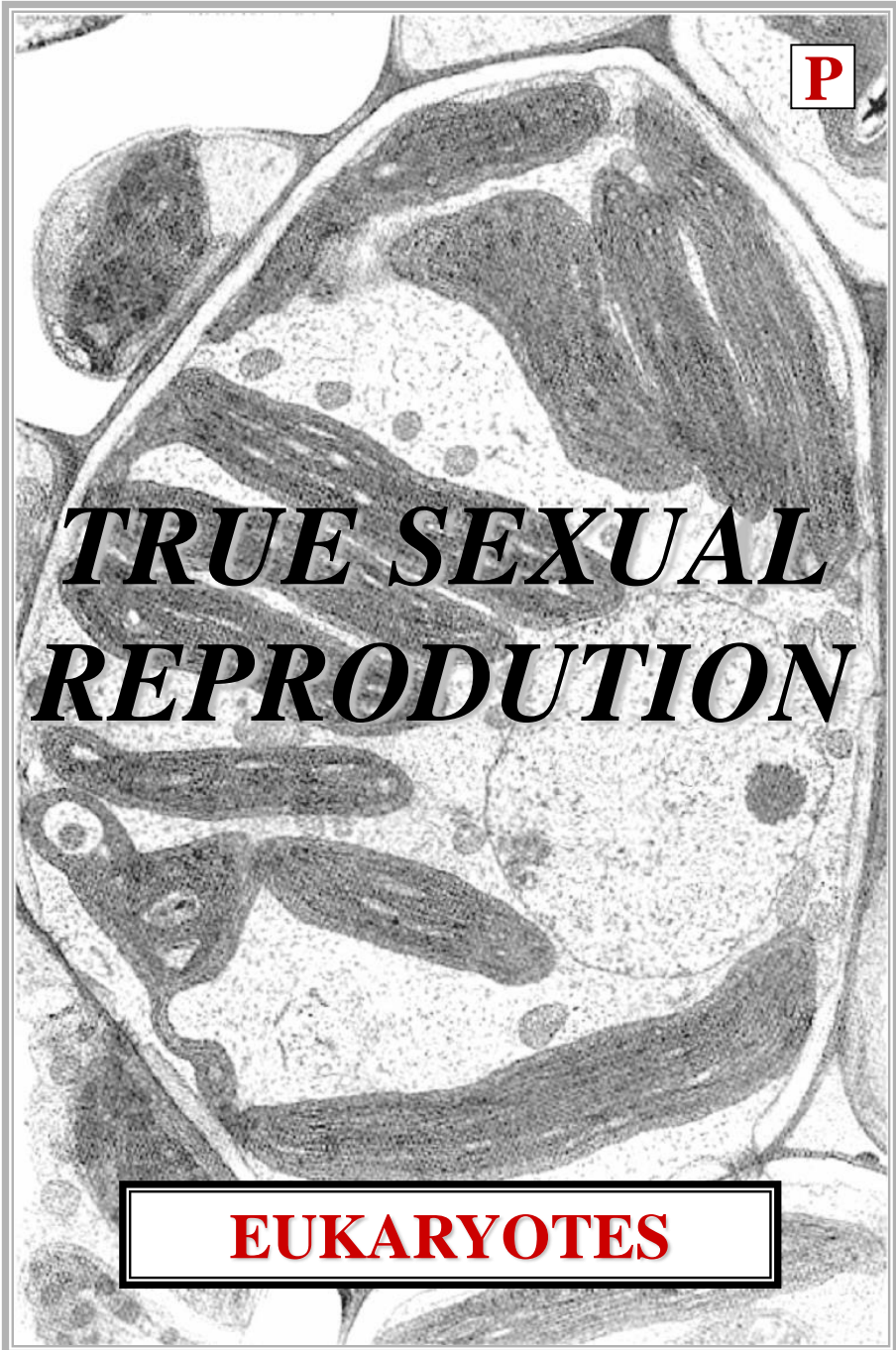
***TRUE SEXUAL  
REPRODUCTION***

**EUKARYOTES**



***TRUE SEXUAL  
REPRODUCTION  
ABSENT***

**PROKARYOTES**



***TRUE SEXUAL  
REPRODUCTION***

**EUKARYOTES**



An electron micrograph showing several rod-shaped prokaryotic cells. The cells have a thick, textured outer layer and a granular internal structure. The text is overlaid on the image.

***TRUE SEXUAL  
REPRODUCTION  
ABSENT***

**PROKARYOTES**

An electron micrograph showing a cross-section of a eukaryotic cell. The cell has a distinct nucleus with a nucleolus, surrounded by a nuclear envelope. The cytoplasm contains various organelles and a complex network of membranes. A small square with an upward-pointing arrow is in the top right corner. The text is overlaid on the image.

***TRUE SEXUAL  
REPRODUCTION  
PRESENT***

**EUKARYOTES**

This electron micrograph shows several rod-shaped prokaryotic cells. The cells have a thick, textured outer boundary and a granular internal structure. There are no distinct membrane-bound organelles visible.

***MEMBRANE  
BOUND  
ORGANELLES***

**PROKARYOTES**

This electron micrograph shows a cross-section of a eukaryotic cell. It features a large, centrally located nucleus with a prominent nucleolus and a network of endoplasmic reticulum. Other organelles like mitochondria and Golgi apparatus are also visible. A small red letter 'A' is in the top right corner.

***MEMBRANE  
BOUND  
ORGANELLES***

**EUKARYOTES**



***MEMBRANE  
BOUND  
ORGANELLES  
ABSENT***

**PROKARYOTES**



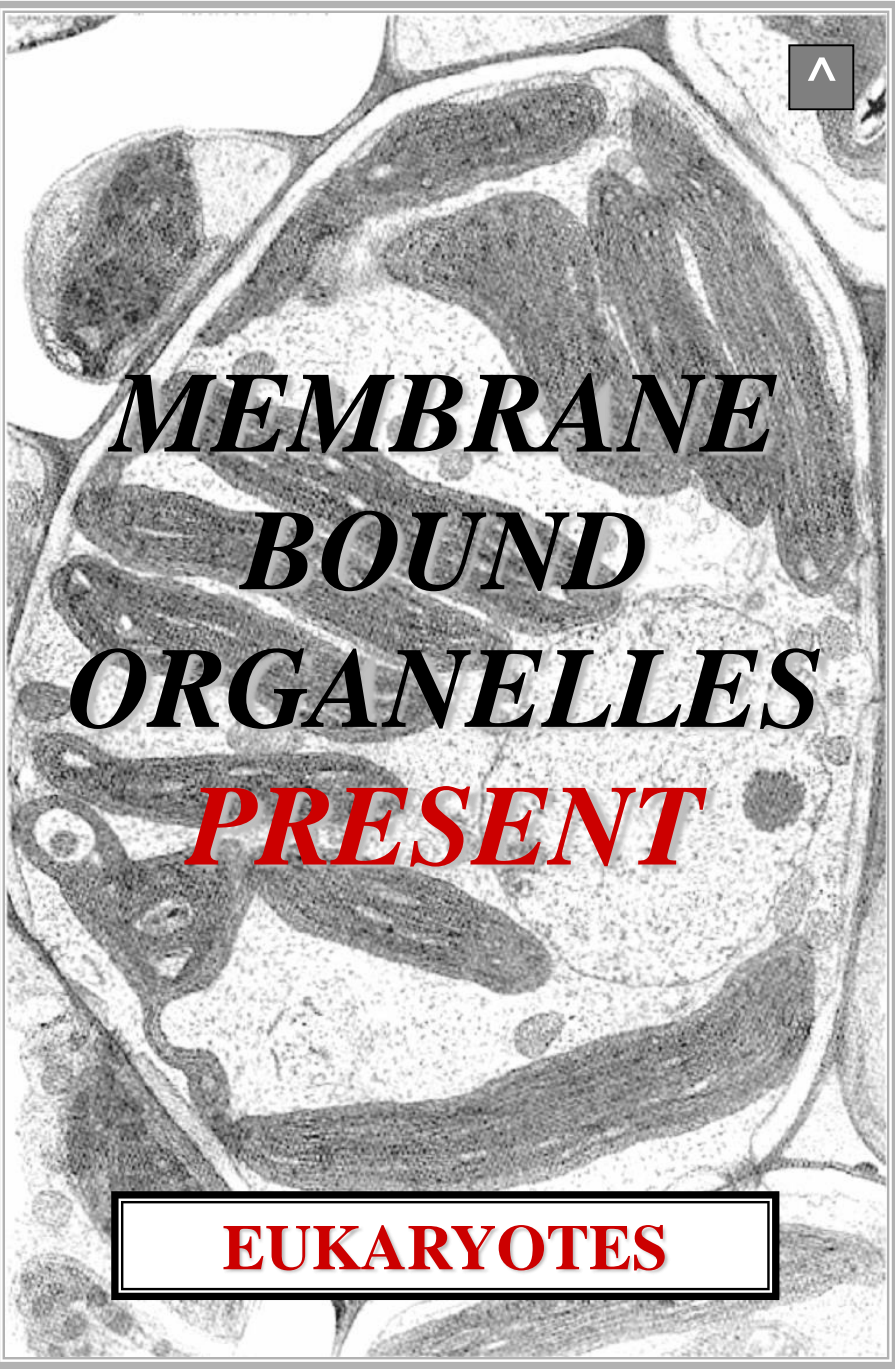
***MEMBRANE  
BOUND  
ORGANELLES***

**EUKARYOTES**



***MEMBRANE  
BOUND  
ORGANELLES  
ABSENT***

**PROKARYOTES**



***MEMBRANE  
BOUND  
ORGANELLES  
PRESENT***

**EUKARYOTES**

**DOUBLE  
MEMBRANE  
BOUND  
ORGANELLES**

**DOUBLE  
MEMBRANE  
BOUND  
ORGANELLES**

**DOUBLE MEMBRANE  
BOUND ORGANELLES**

**POSSESS**

**OUTER & INNER**

**PERIPHERAL**

**MEMBRANE**

**DOUBLE MEMBRANE  
BOUND ORGANELLES**

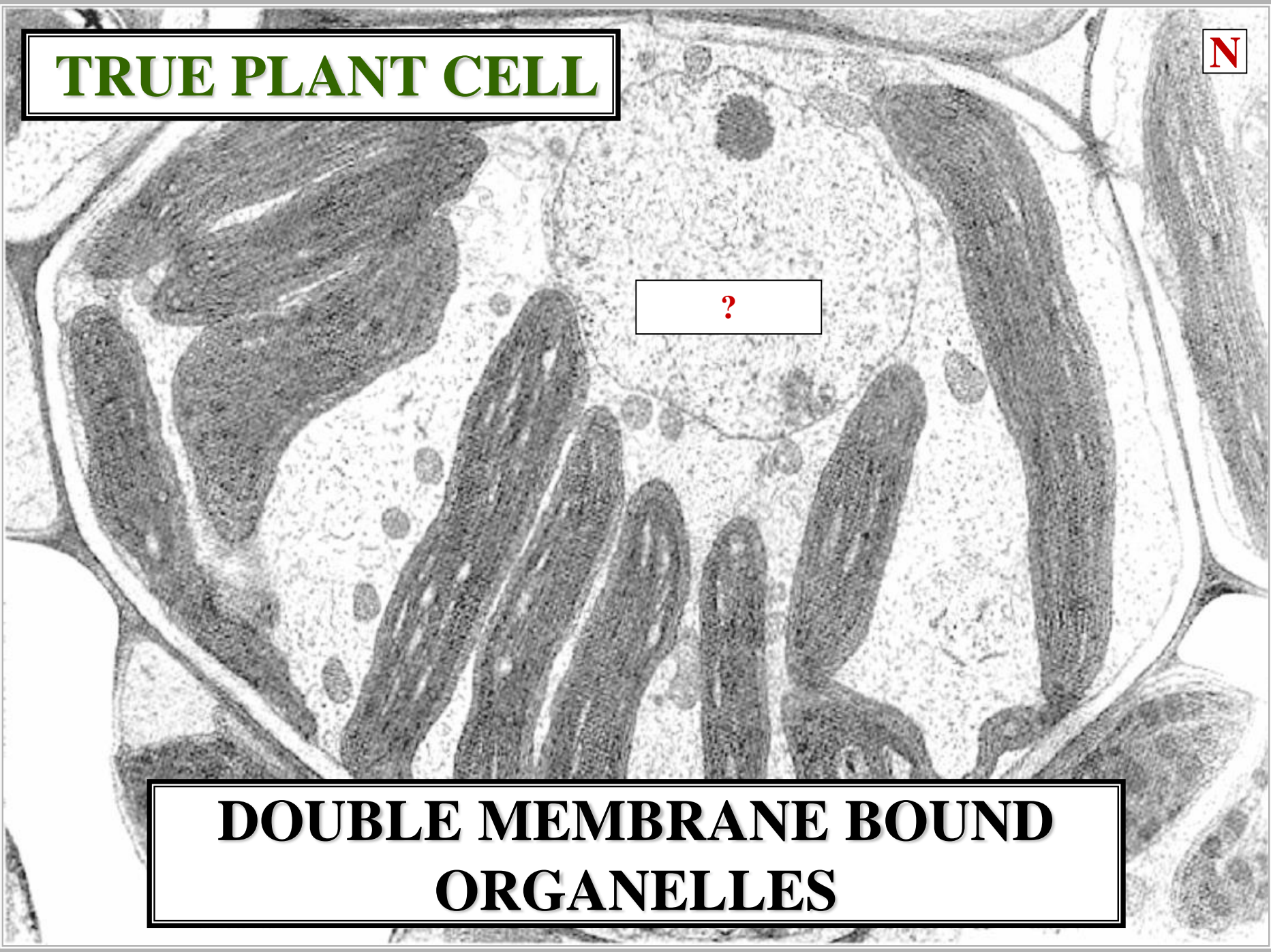


# TRUE PLANT CELL

N

?

**DOUBLE MEMBRANE BOUND  
ORGANELLES**





# TRUE PLANT CELL

An electron micrograph of a plant cell. The cell is roughly hexagonal in shape, bounded by a thick cell wall. In the center, there is a large, roughly circular nucleus with a dense, granular appearance. Surrounding the nucleus are several large, dark, elongated structures, which are chloroplasts, showing internal membrane structures (thylakoids). The cytoplasm is filled with various organelles and small vesicles. The overall structure is highly organized and characteristic of a plant cell.

?

NUCLEUS

**DOUBLE MEMBRANE BOUND  
ORGANELLES**

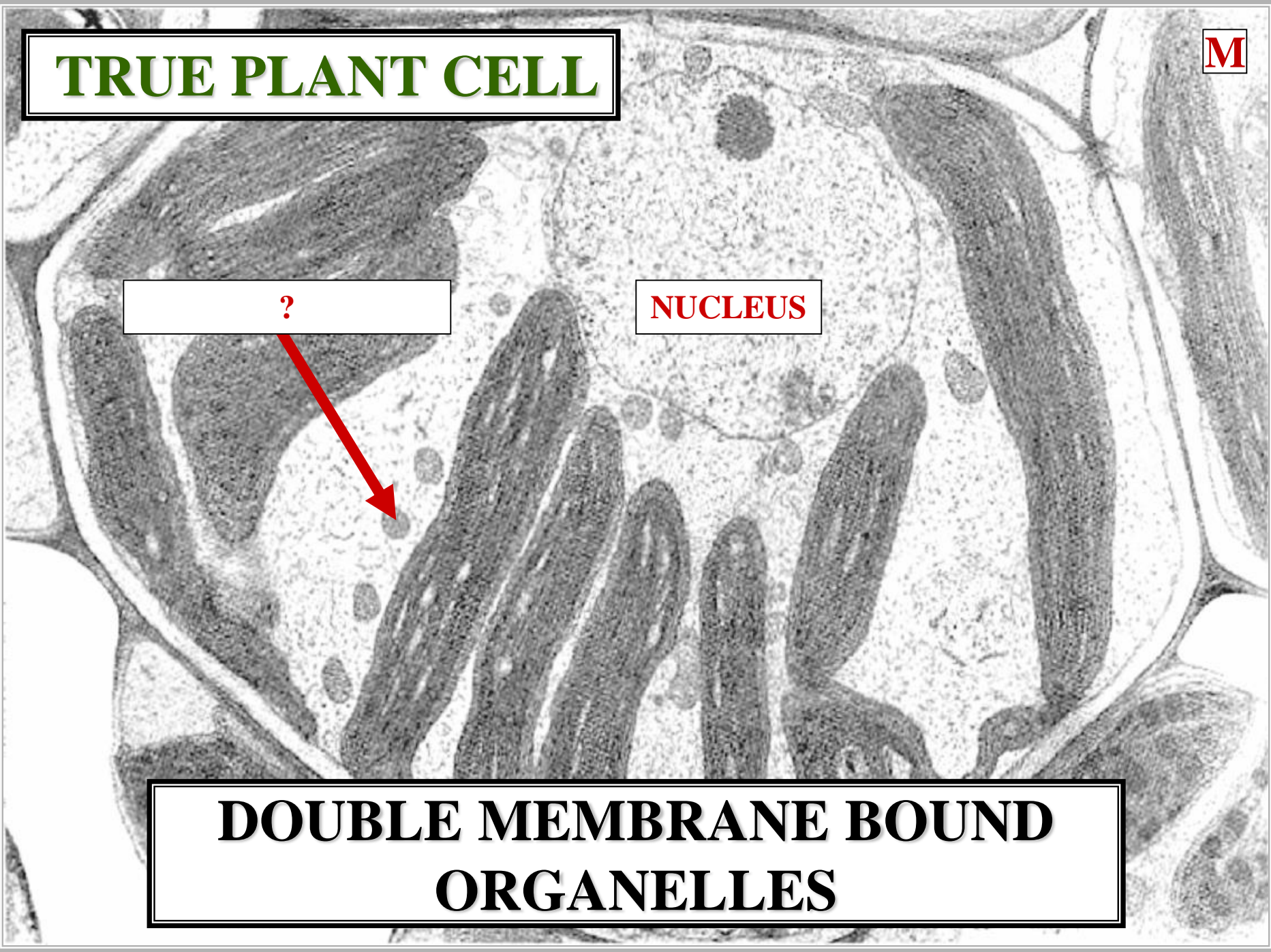
**TRUE PLANT CELL**

?



**NUCLEUS**

**DOUBLE MEMBRANE BOUND  
ORGANELLES**



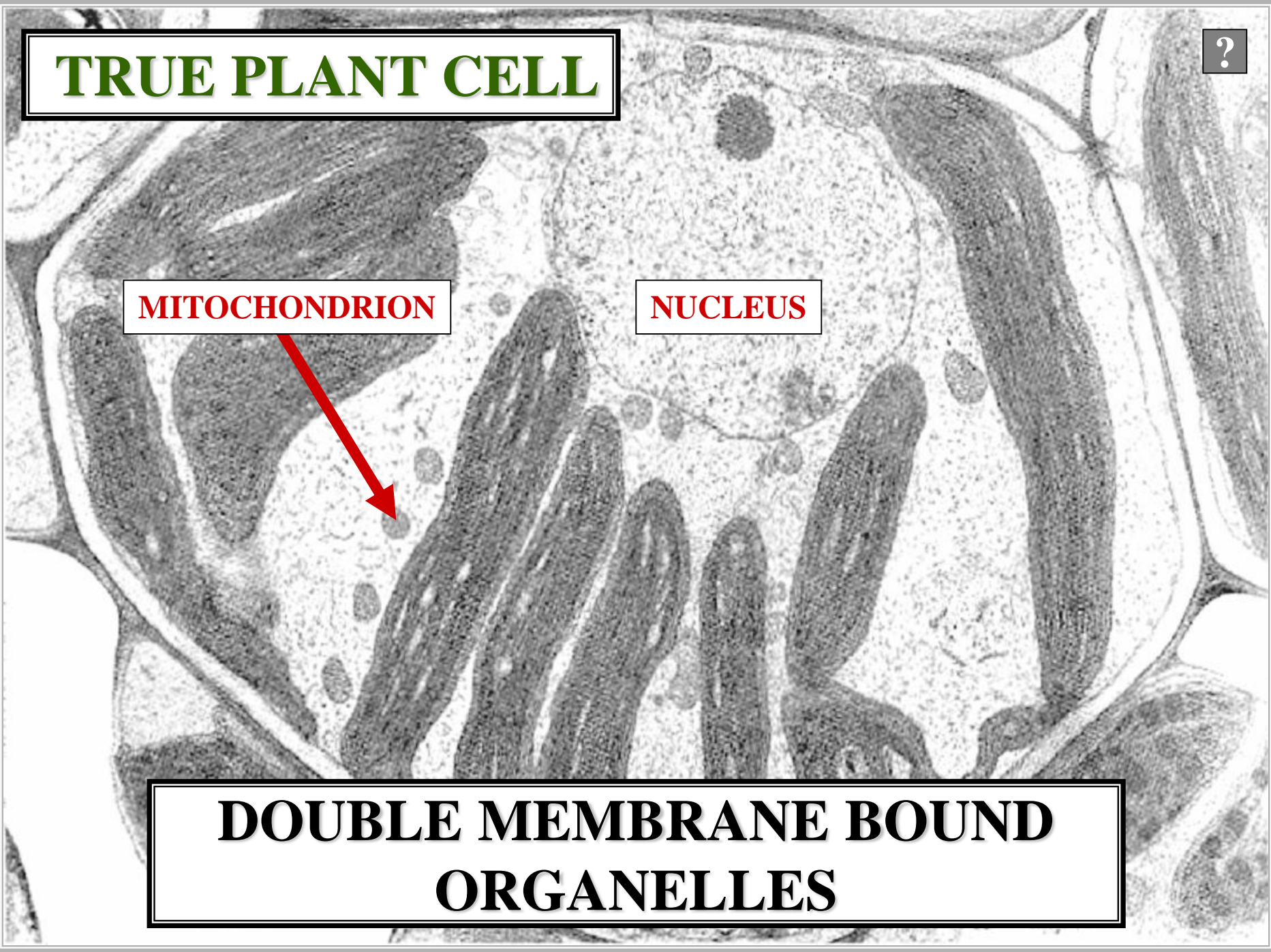
# TRUE PLANT CELL

?

MITOCHONDRION

NUCLEUS

DOUBLE MEMBRANE BOUND  
ORGANELLES



# TRUE PLANT CELL

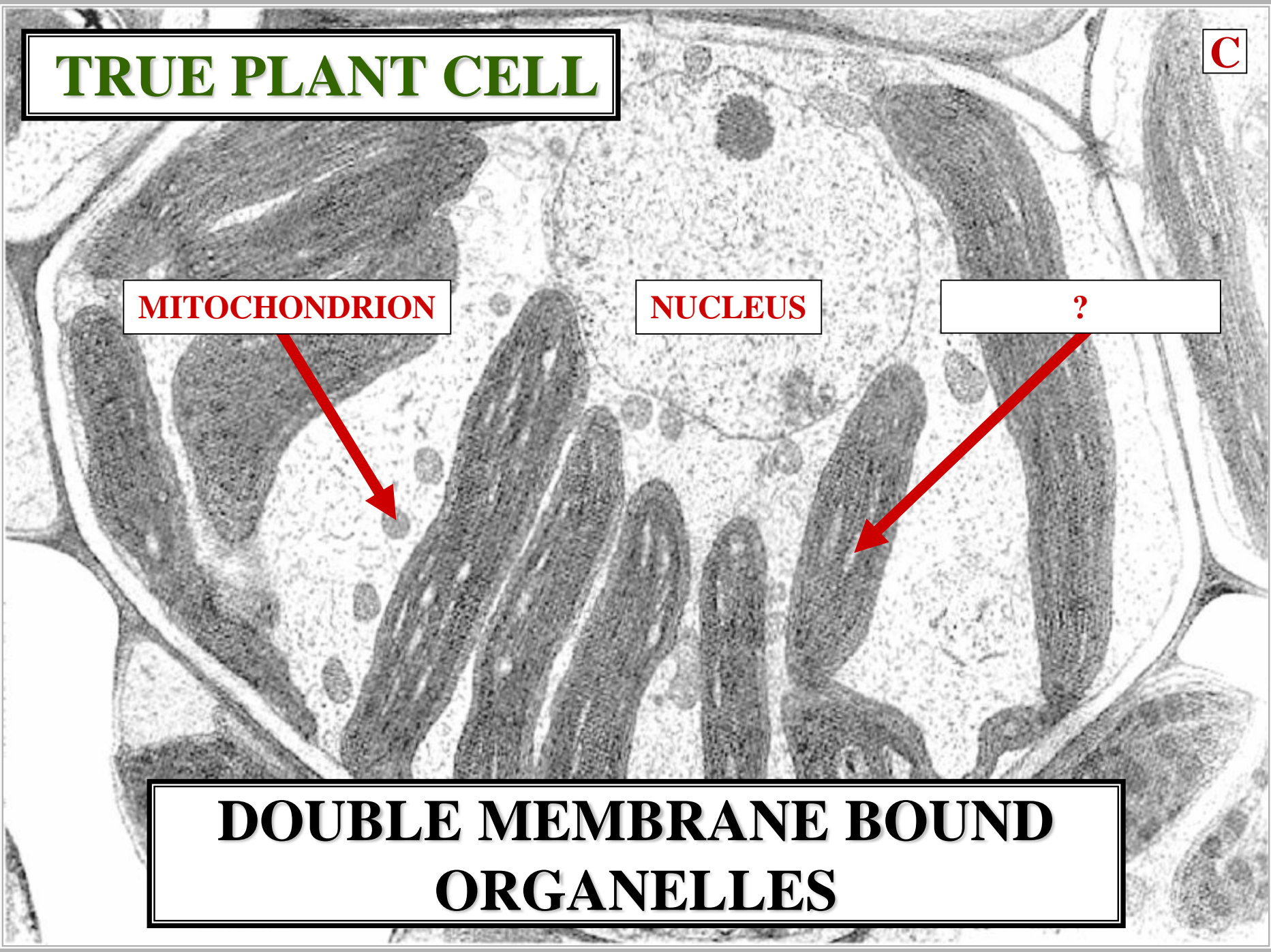
C

MITOCHONDRION

NUCLEUS

?

**DOUBLE MEMBRANE BOUND  
ORGANELLES**



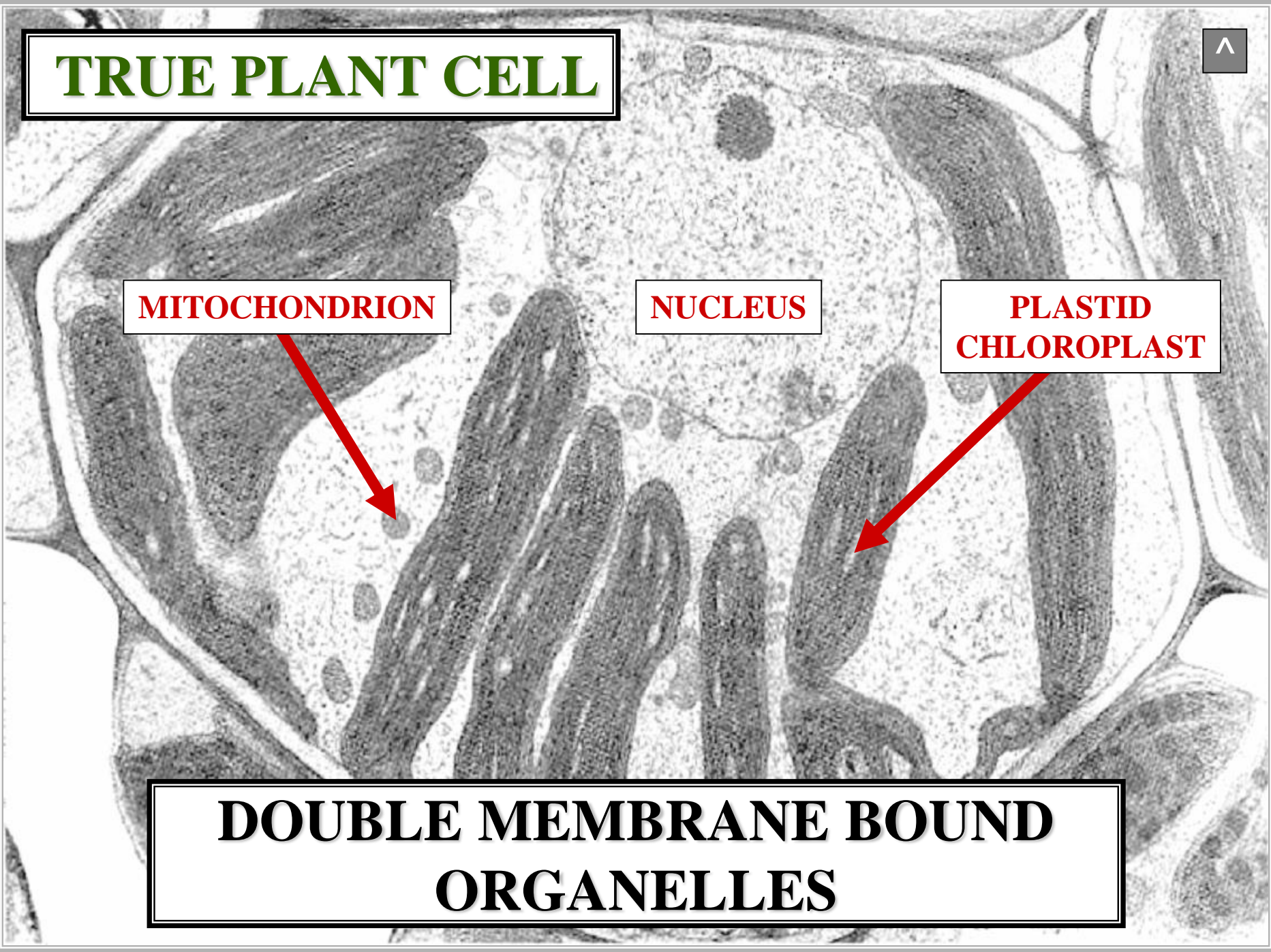
# TRUE PLANT CELL

MITOCHONDRION

NUCLEUS

PLASTID  
CHLOROPLAST

DOUBLE MEMBRANE BOUND  
ORGANELLES





**DOUBLE  
MEMBRANE  
BOUND  
ORGANELLE  
EVOLUTION**

# AUTOGENOUS THEORY

# **AUTOGENOUS THEORY**



# **AUTOGENOUS THEORY**



## **NUCLEUS EVOLUTION**

# **AUTOGENOUS THEORY**

# **AUTOGENOUS THEORY**



## **VIA PROKARYOTE MESOSOME SPECALIZATION**

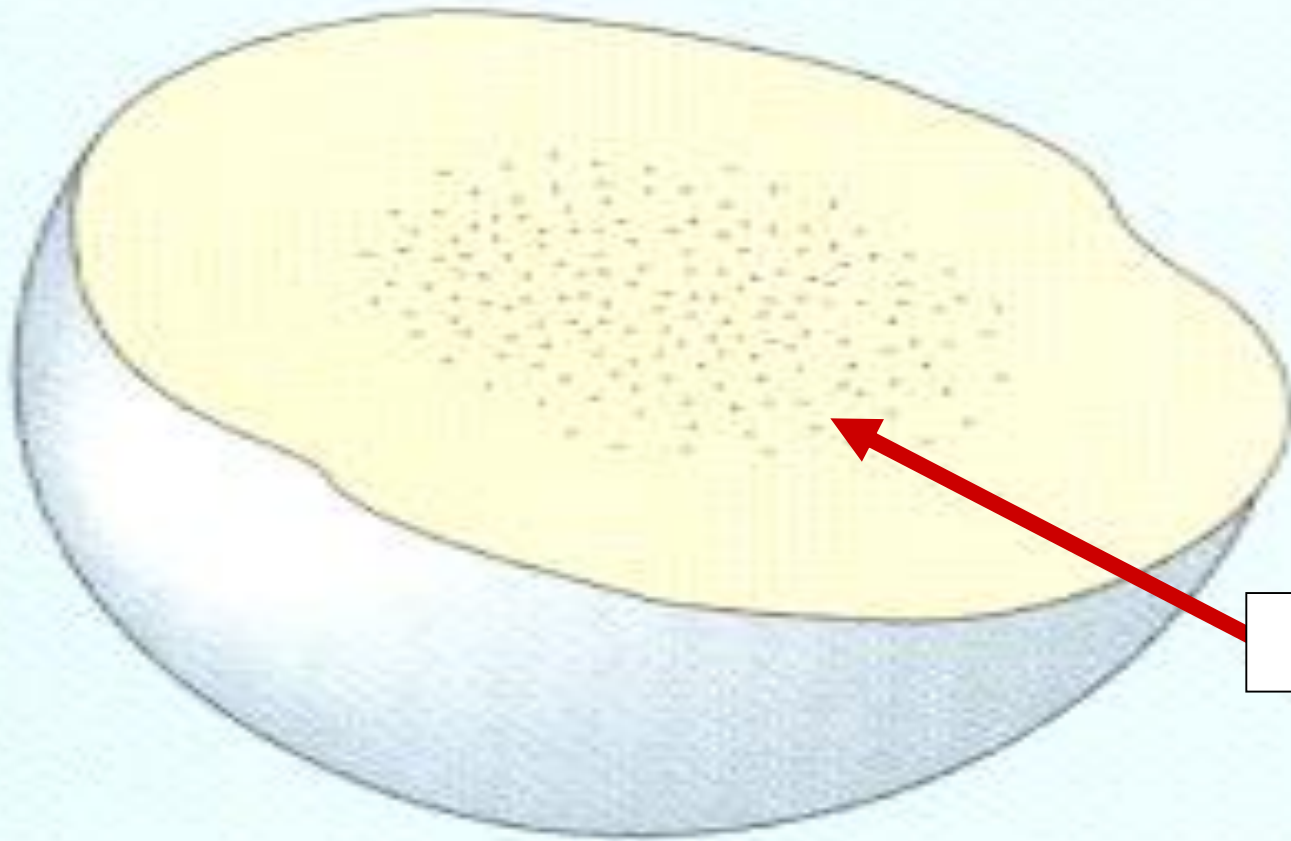
# **AUTOGENOUS THEORY**

# TRUE PLANT CELL

An electron micrograph of a plant cell. The cell is roughly rectangular with a thick cell wall. Inside, there are several large, dark, oval-shaped chloroplasts with visible internal membranes (grana). A large, light-colored nucleus is located in the upper right quadrant. The cytoplasm is filled with various organelles and granules. The overall structure is highly organized and typical of a plant cell.

NUCLEUS

# AUTOGENOUS THEORY



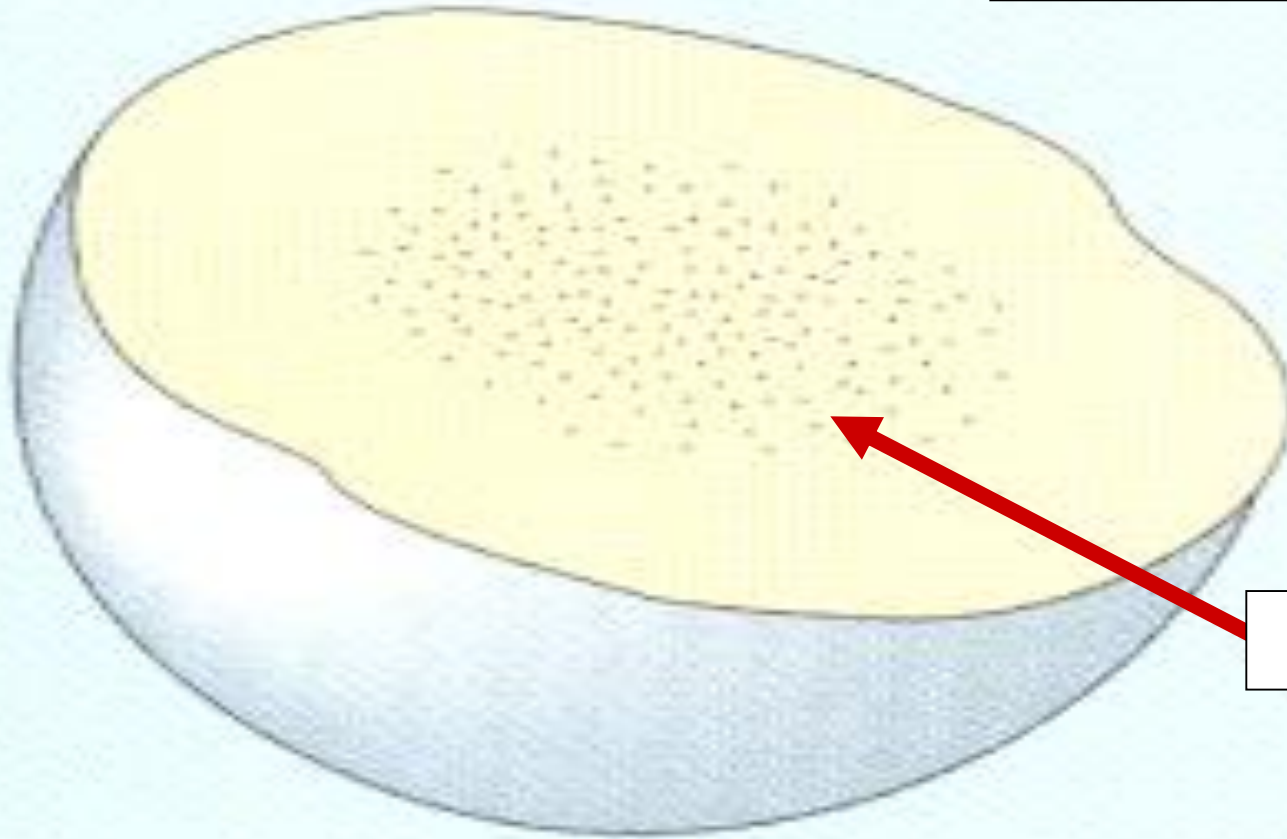
**DNA**

**ANCESTRAL PROKARYOTE**

**NU**

**AB**

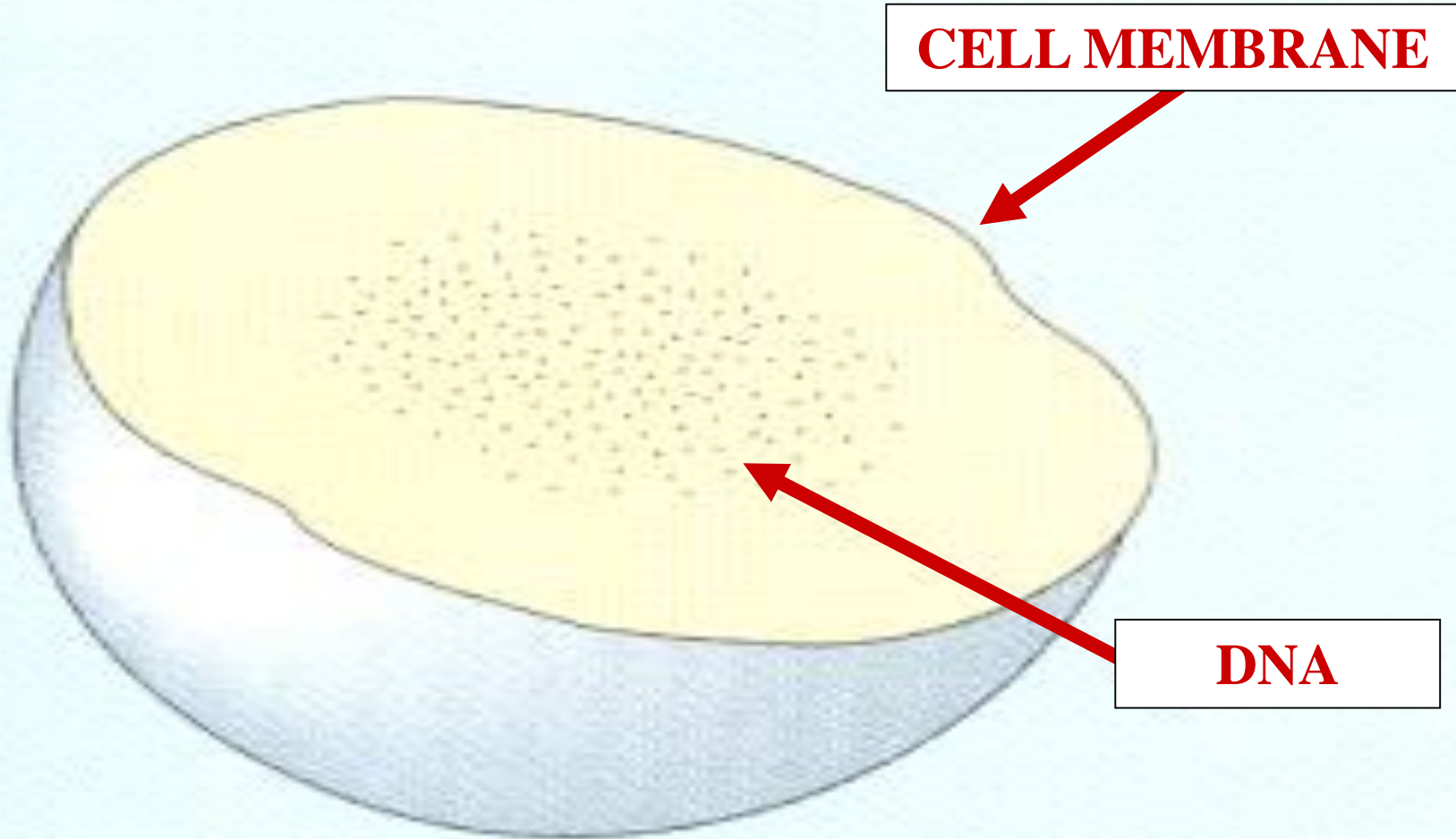
**NUCLEUS: ABSENT**



**DNA**

**ANCESTRAL PROKARYOTE**

**CM**



**CELL MEMBRANE**

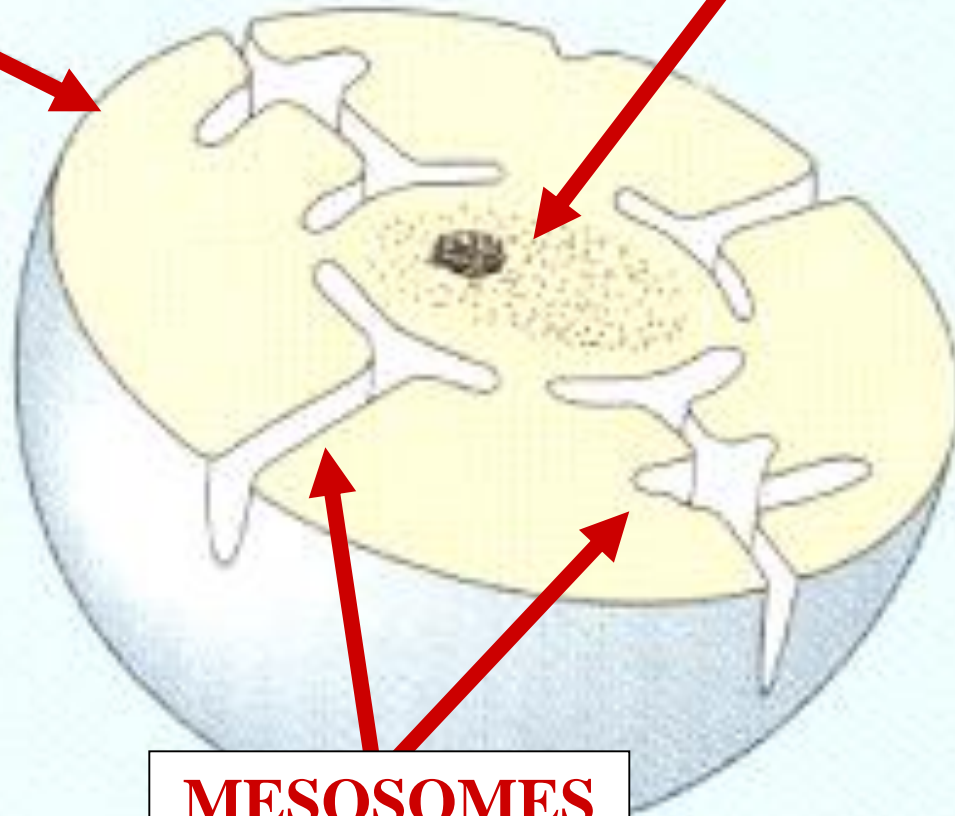
**DNA**

**ANCESTRAL PROKARYOTE**

**M**

**CELL MEMBRANE**

**DNA**



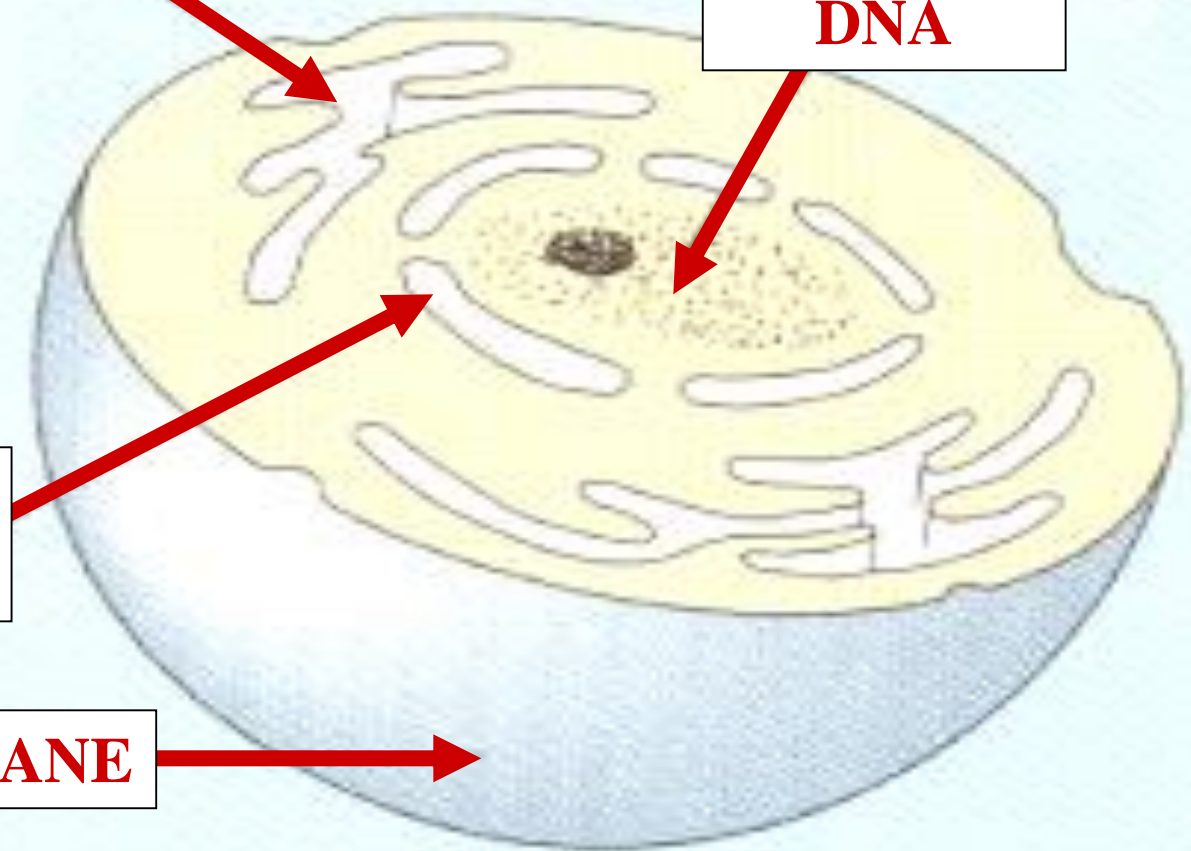
**MESOSOMES**

**ANCESTRAL PROKARYOTE**

**IM**

**INTERNAL MEMBRANE**

**DNA**



**CELL MEMBRANE**

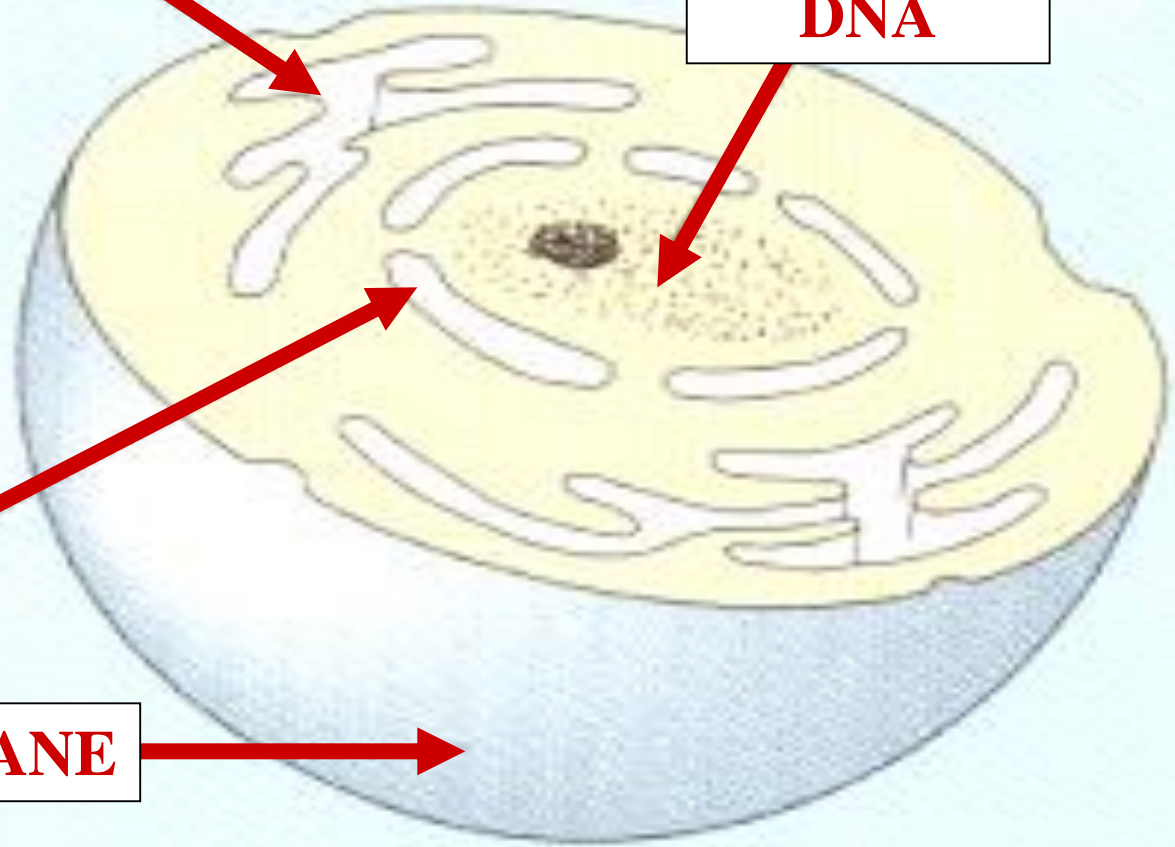
**ANCESTRAL PROKARYOTE**

**ER**



**ENDOPLASMIC RETICULUM**

**DNA**



**CELL MEMBRANE**

**ANCESTRAL PROKARYOTE**

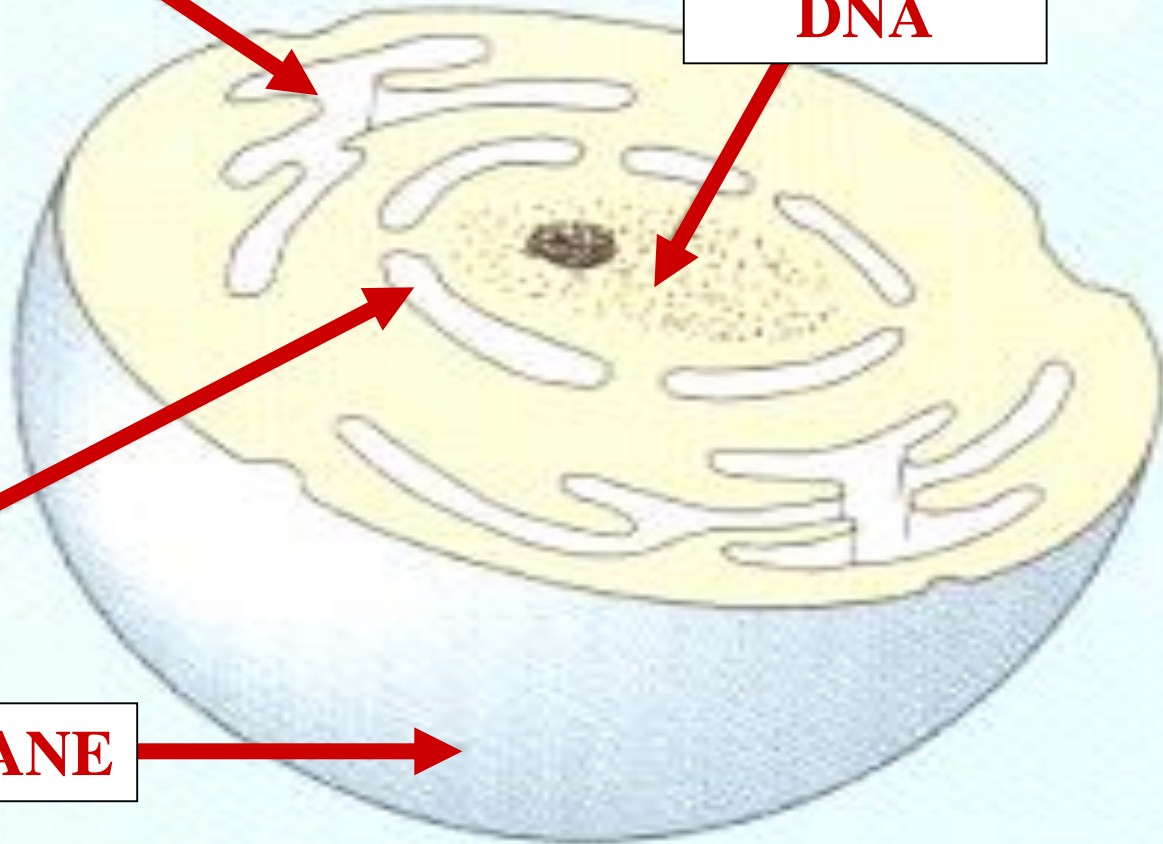
**NM**

**ENDOPLASMIC RETICULUM**

**DNA**

**NUCLEAR MEMBRANE**

**CELL MEMBRANE**



**ANCESTRAL PROKARYOTE**



# **AUTOGENOUS THEORY SUMMARY**

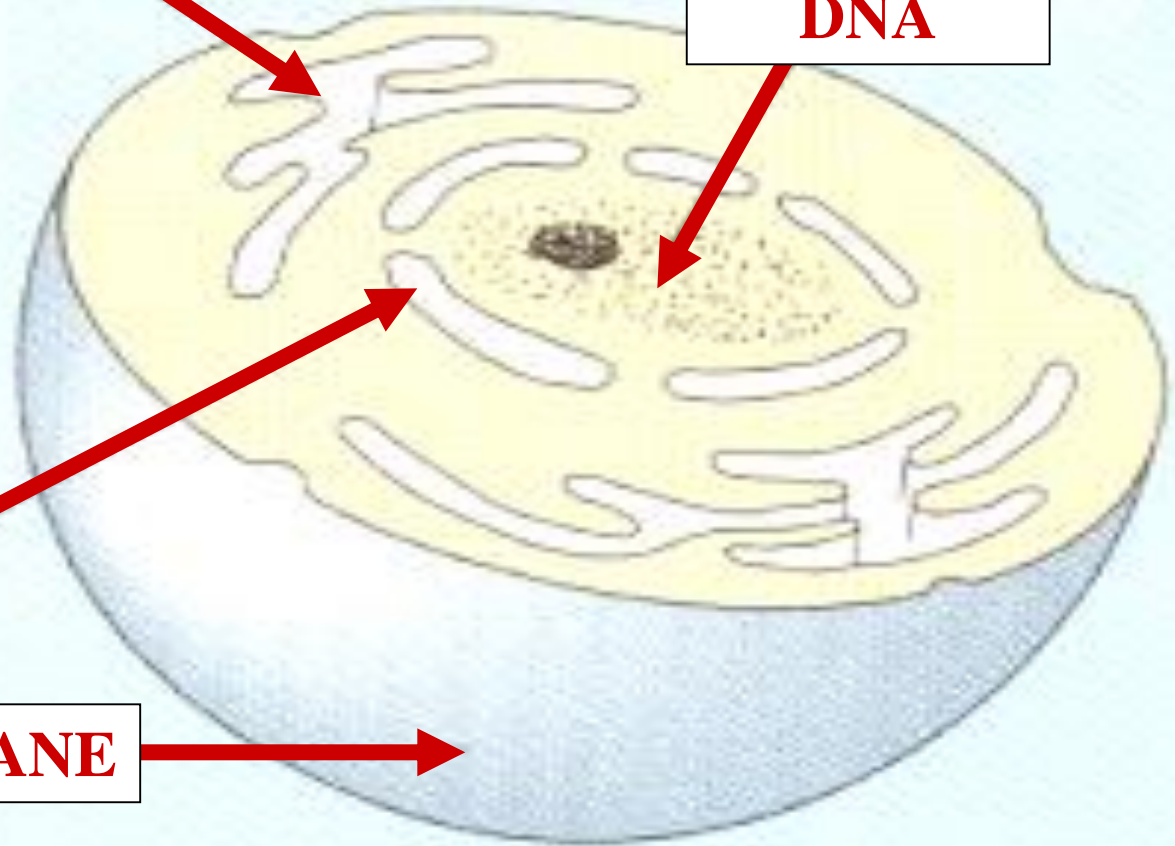
**ENDOPLASMIC RETICULUM**

**DNA**

**NUCLEAR  
MEMBRANE**

**CELL MEMBRANE**

**AUTOGENOUS THEORY**



**ENDOPLASMIC RETICULUM**

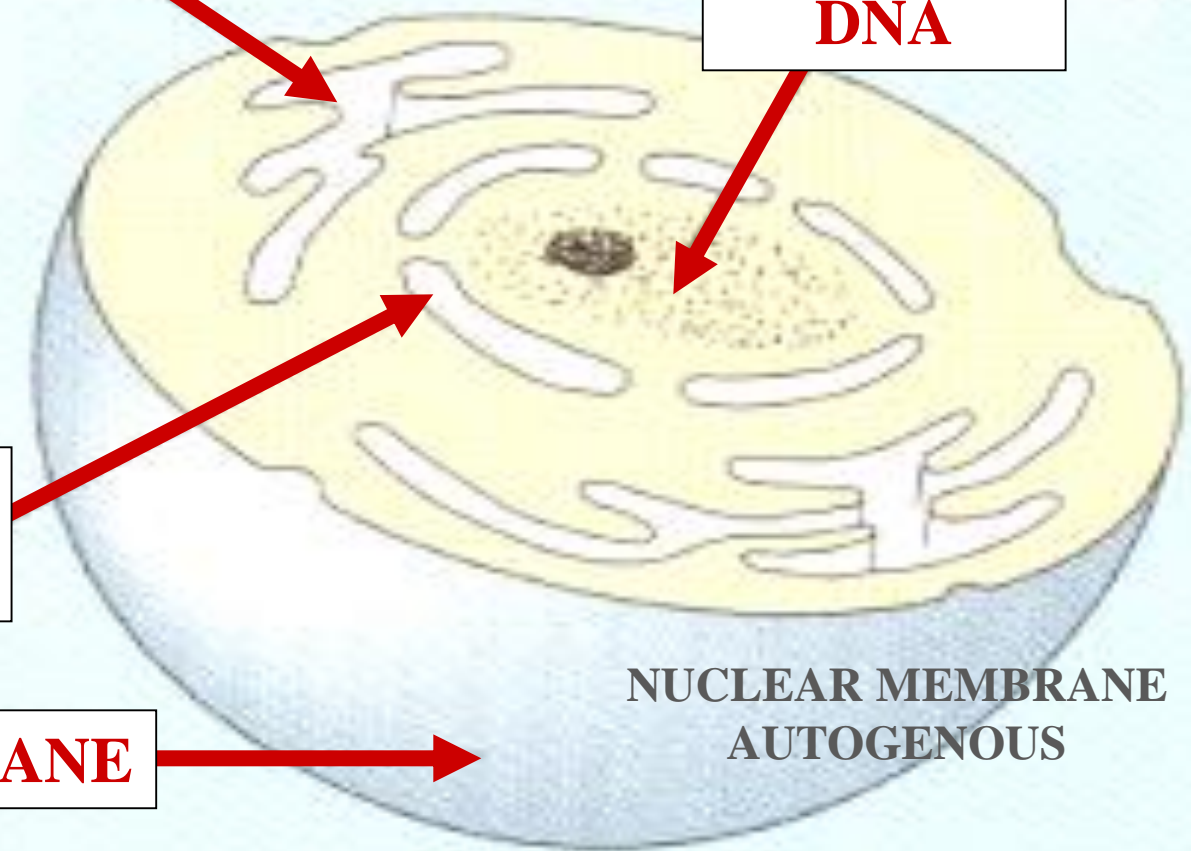
**DNA**

**NUCLEAR  
MEMBRANE**

**CELL MEMBRANE**

**NUCLEAR MEMBRANE  
AUTOGENOUS**

**AUTOGENOUS THEORY**



**ENDOPLASMIC RETICULUM**

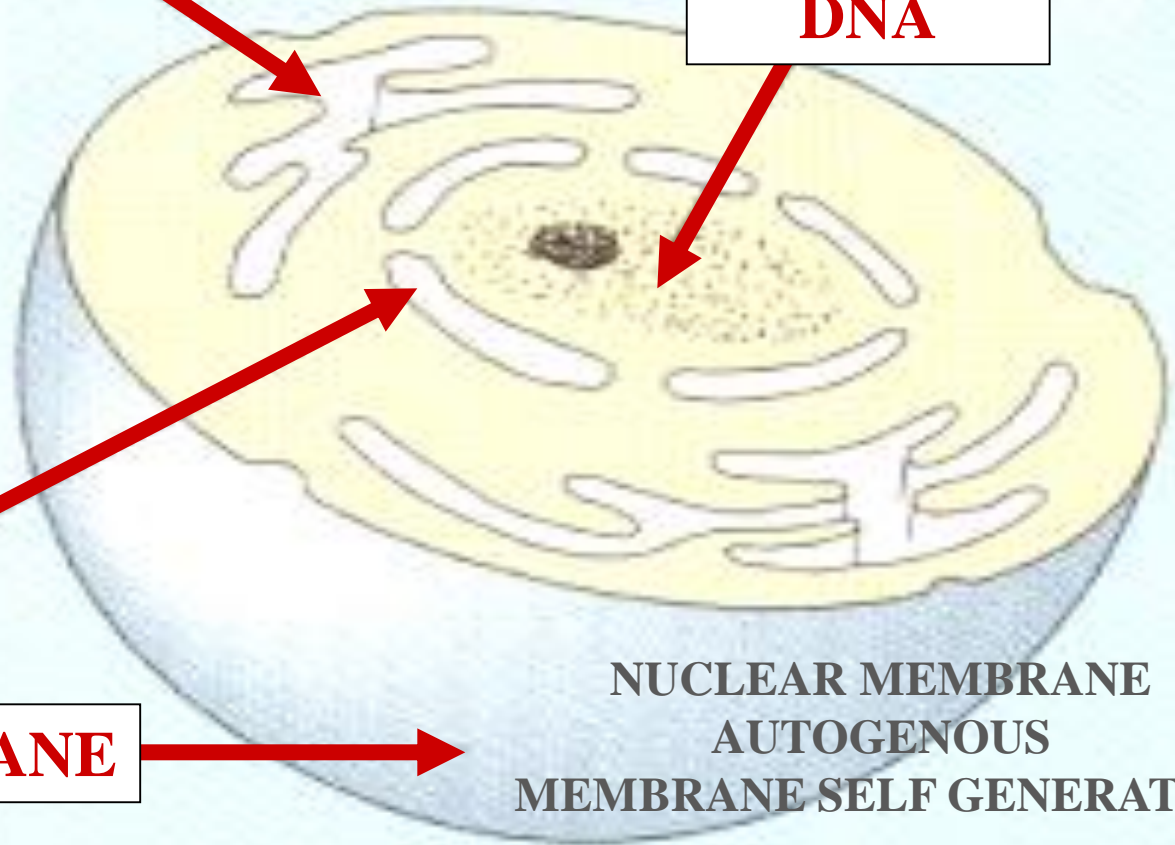
**DNA**

**NUCLEAR  
MEMBRANE**

**CELL MEMBRANE**

**NUCLEAR MEMBRANE  
AUTOGENOUS  
MEMBRANE SELF GENERATED**

**AUTOGENOUS THEORY**



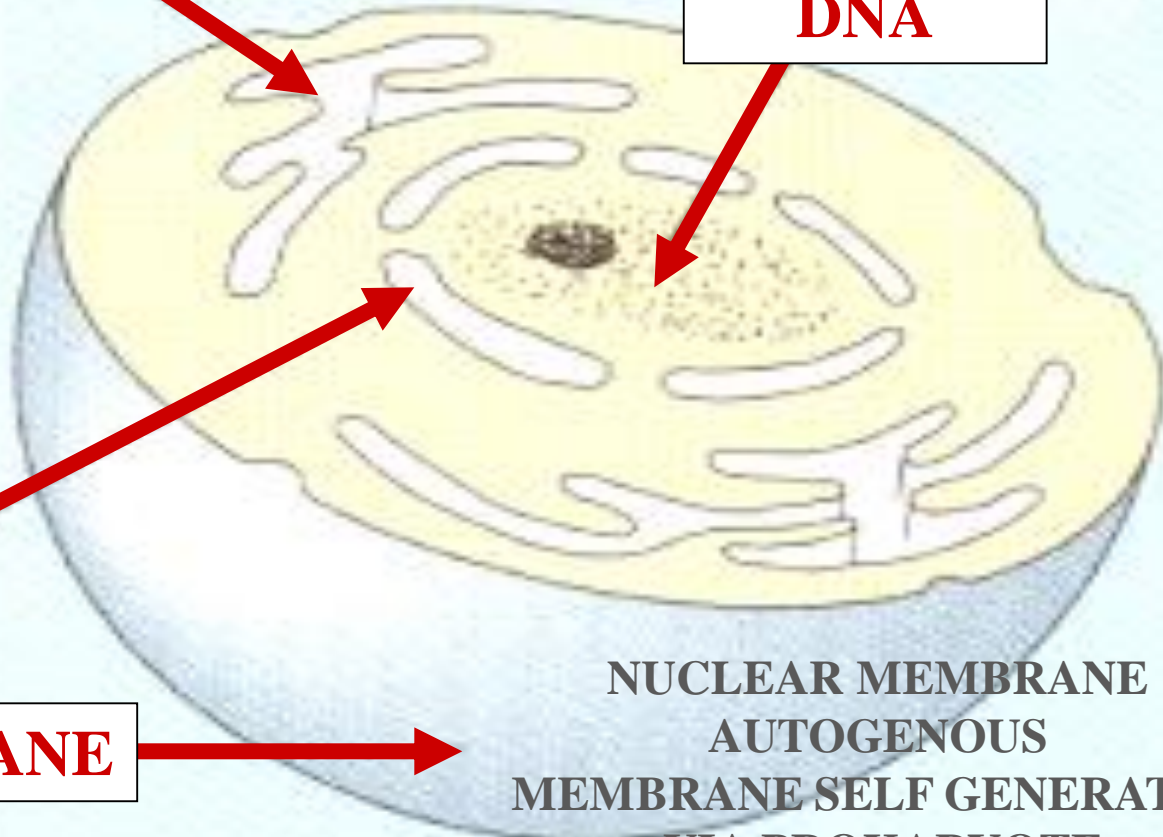


**ENDOPLASMIC RETICULUM**

**DNA**

**NUCLEAR MEMBRANE**

**CELL MEMBRANE**



**NUCLEAR MEMBRANE  
AUTOGENOUS  
MEMBRANE SELF GENERATED  
VIA PROKARYOTE  
MESOSOME SPECIALIZATION**

**AUTOGENOUS THEORY**



**AUTOGENOUS  
THEORY  
SUPPORTING  
EVIDENCE**



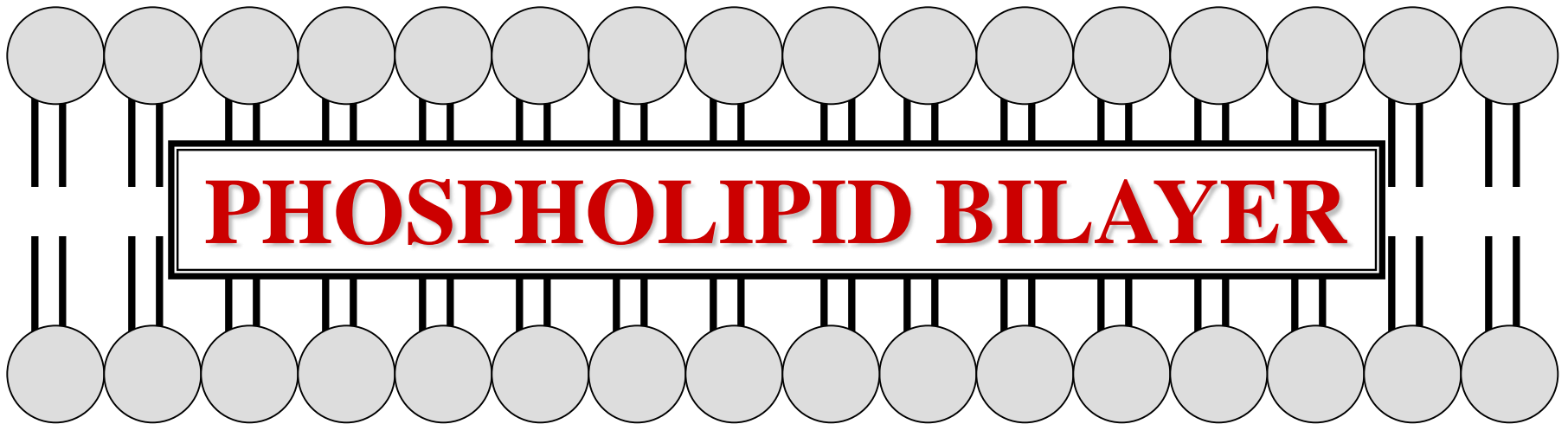


# CELL MEMBRANE, ER & NUCLEAR MEMBRANE

WATER

WATER

WATER



WATER

WATER

WATER

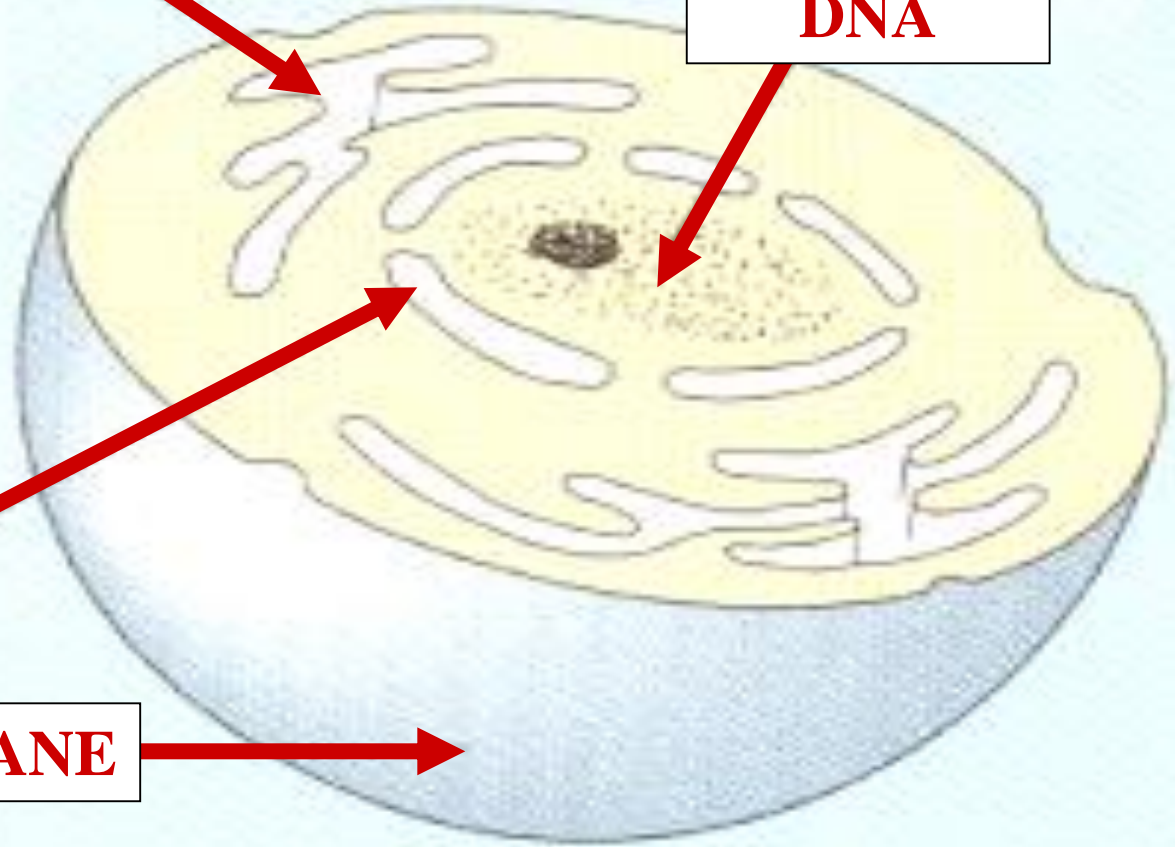
# CELL MEMBRANE, ER & NUCLEAR MEMBRANE

**ER**

**DNA**

**CELL MEMBRANE**

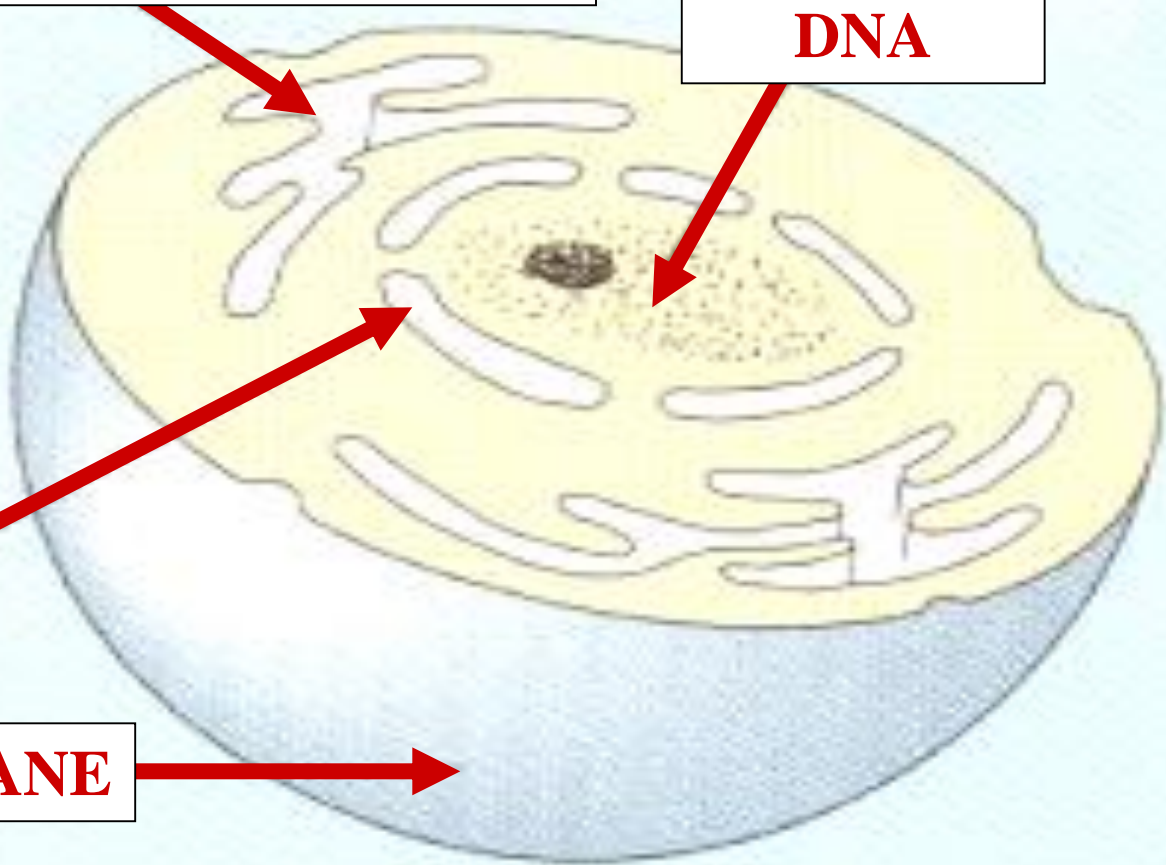
**EUKARYOYTE CELL**



**ENDOPLASMIC RETICULUM**

**DNA**

**CELL MEMBRANE**



**EUKARYOYTE CELL**

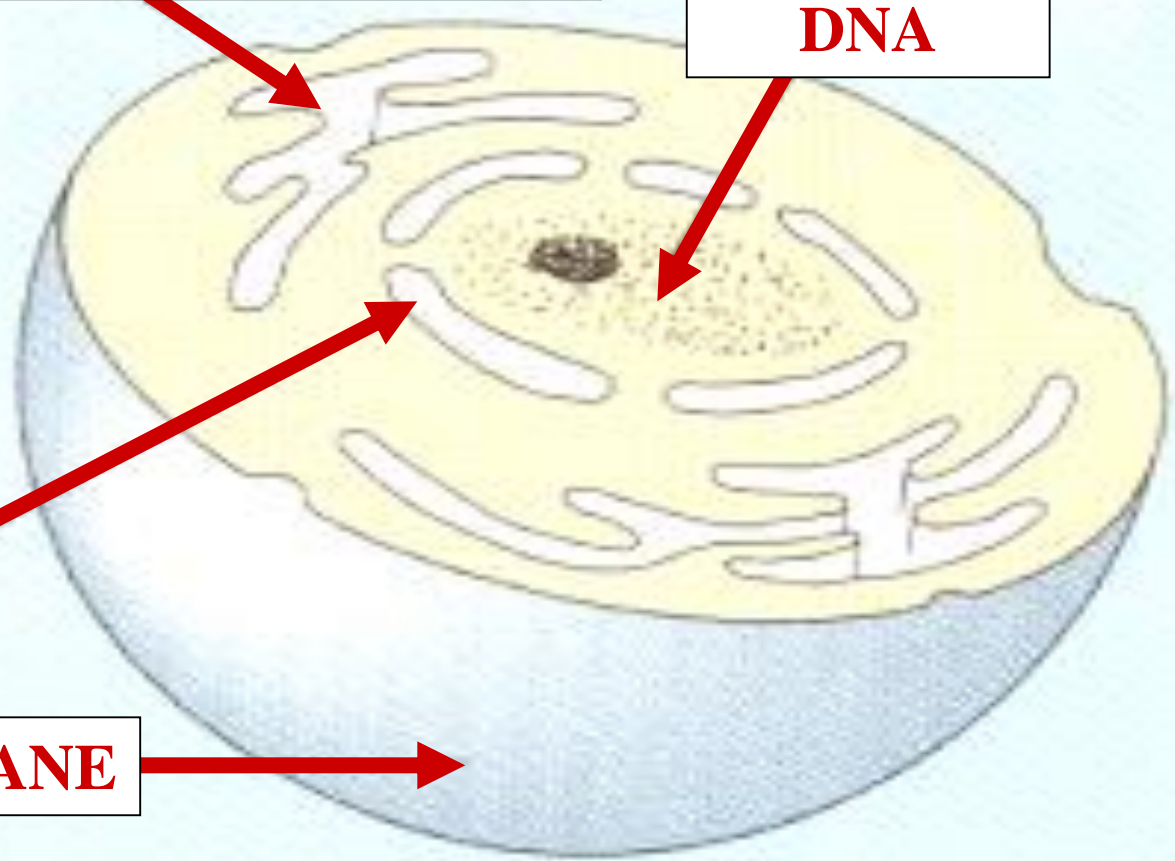


**ENDOPLASMIC RETICULUM**

**DNA**

**NUCLEAR  
MEMBRANE**

**CELL MEMBRANE**



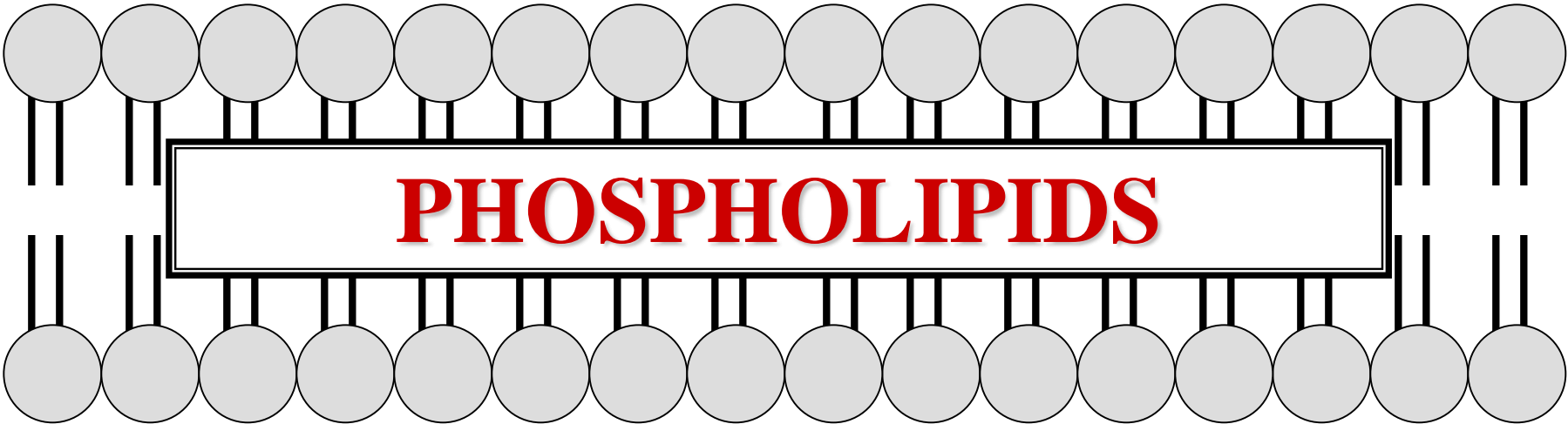
**EUKARYOYTE CELL**

# CELL MEMBRANE, ER & NUCLEAR MEMBRANE

WATER

WATER

WATER



WATER

WATER

WATER

PHOSPHOLIPIDS

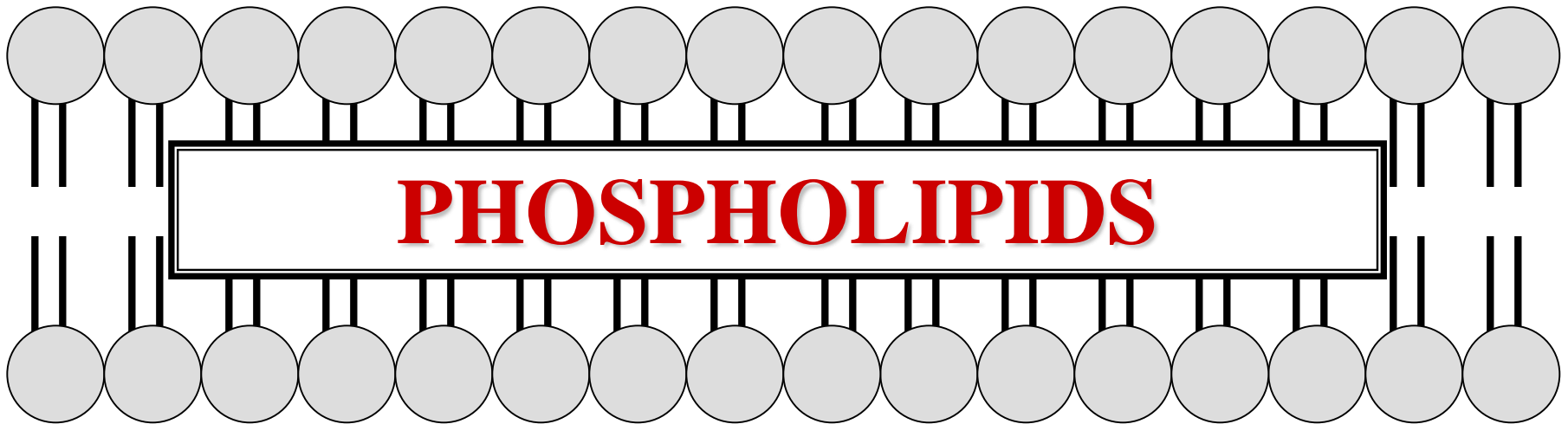
# CELL MEMBRANE, ER & NUCLEAR MEMBRANE



**WATER**

**WATER**

**WATER**



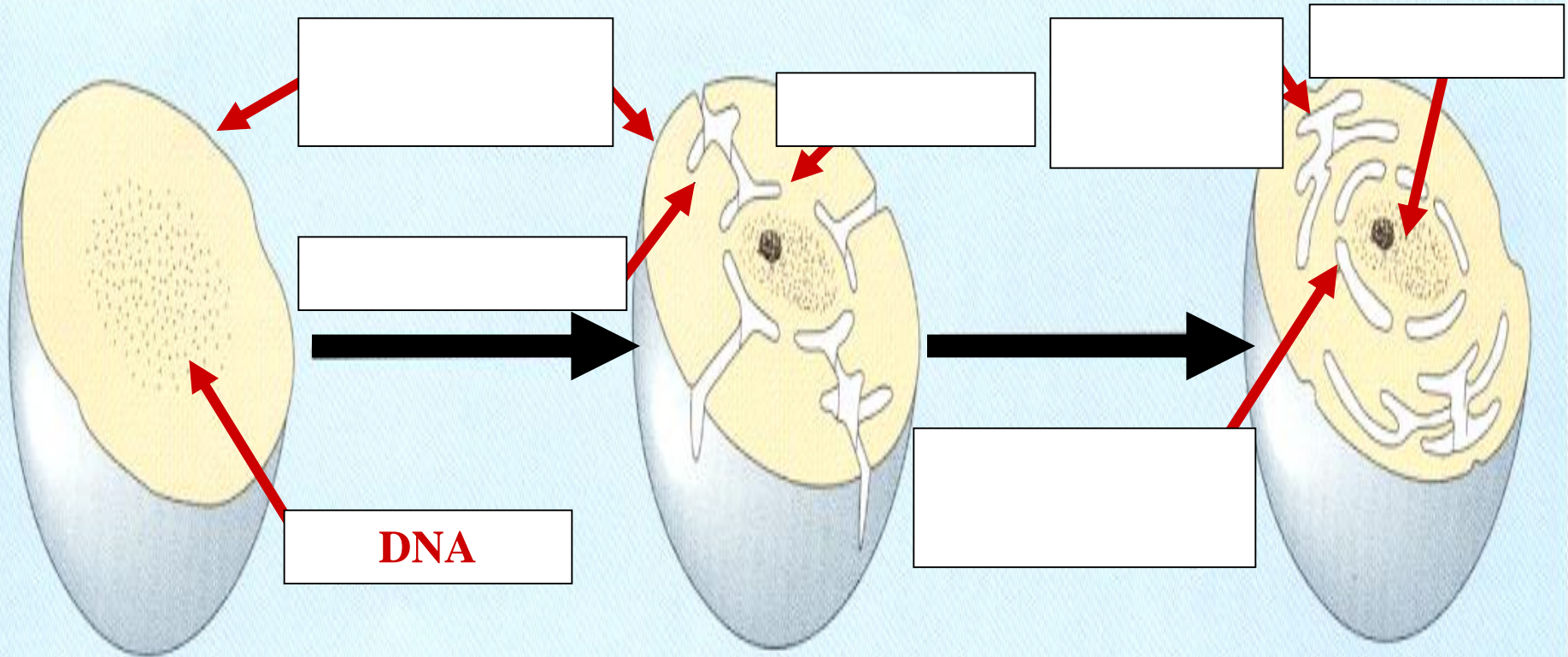
**WATER**

**WATER**

**WATER**

**PHOSPHOLIPIDS  
IDENTICAL**

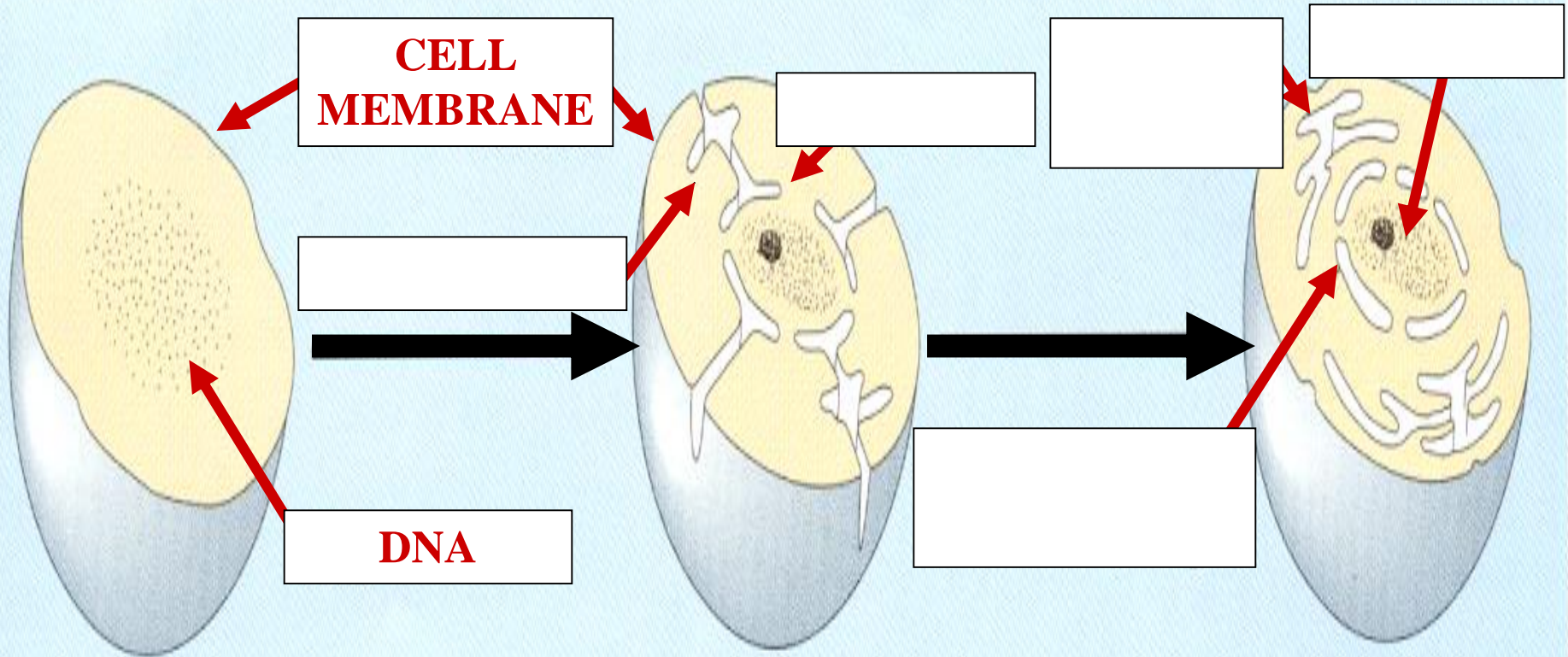
# AUTOGENOUS THEORY



**ANCESTRAL  
PROKARYOTE**

**NUCLEATED  
EUKARYOTE**

# AUTOGENOUS THEORY

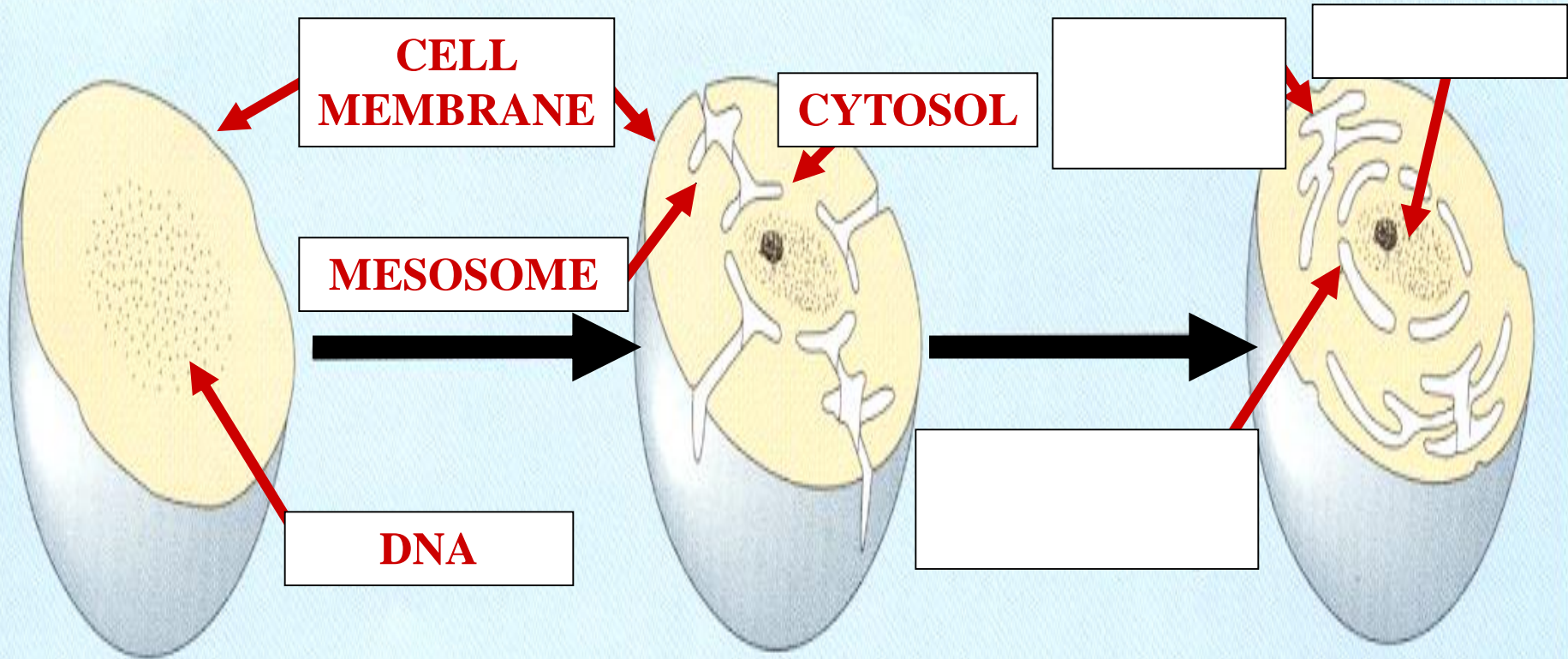


**ANCESTRAL  
PROKARYOTE**

**NUCLEATED  
EUKARYOTE**



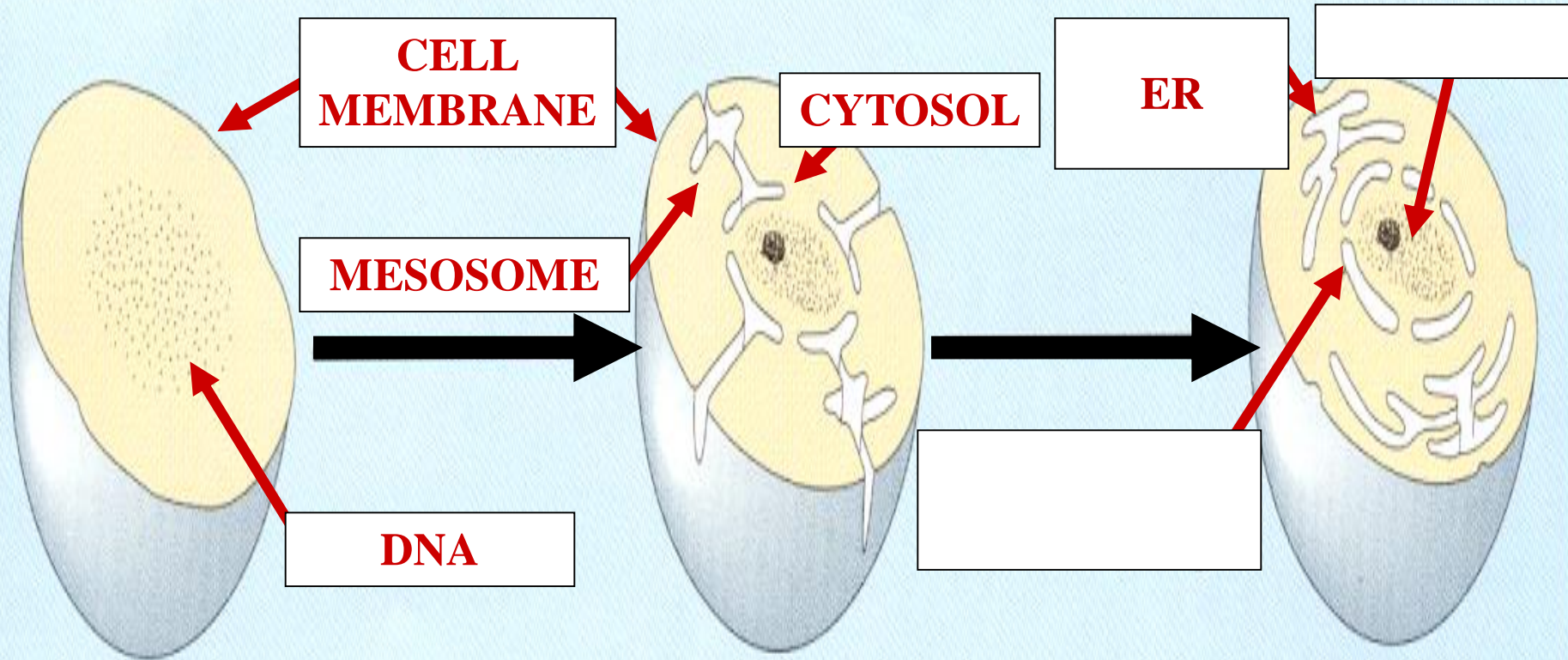
# AUTOGENOUS THEORY



**ANCESTRAL  
PROKARYOTE**

**NUCLEATED  
EUKARYOTE**

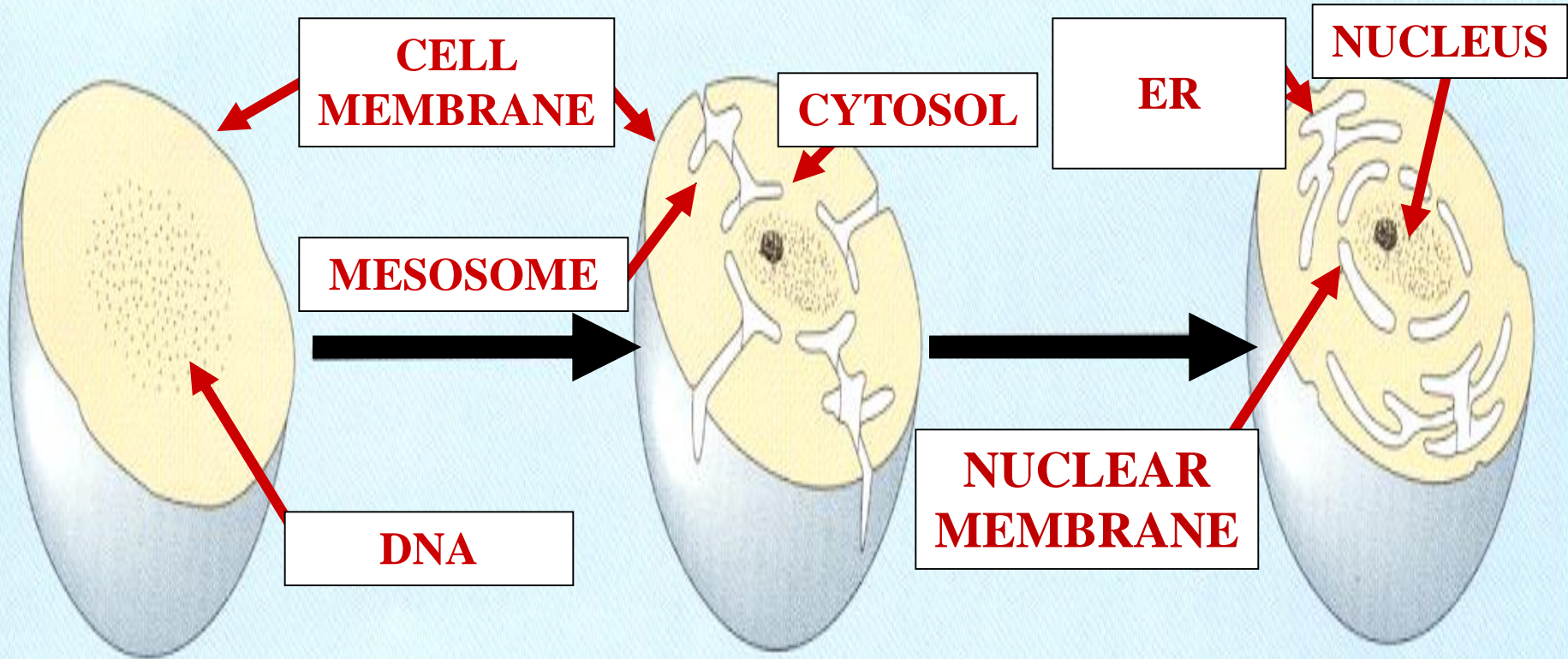
# AUTOGENOUS THEORY



**ANCESTRAL  
PROKARYOTE**

**NUCLEATED  
EUKARYOTE**

# AUTOGENOUS THEORY



**ANCESTRAL  
PROKARYOTE**

**NUCLEATED  
EUKARYOTE**

A detailed electron micrograph of a plant cell, showing various organelles such as the nucleus, chloroplasts, and cytoplasm. The cell is roughly rectangular with a thick cell wall. The nucleus is a large, dark, oval-shaped structure with a prominent nucleolus. Chloroplasts are visible as large, dark, oval-shaped structures with internal membranes. The cytoplasm is filled with various organelles and a network of membranes.

**TRUE PLANT CELL**

^

**NUCLEUS  
EVOLUTION  
EVIDENCE SUPPORTS**

**AUTOGENOUS  
THEORY**

# ENDOSYMBIOTIC THEORY

# **ENDOSYMBIOTIC THEORY**



**ENDOSYMBIOTIC  
THEORY**

**PLASTID**

**&**

**MITOCHONDRION**

**EVOLUTION**

**ENDOSYMBIOTIC  
THEORY**

# **ENDOSYMBIOTIC THEORY**



## **VIA PROKARYOTE ENDOSYMBIOSIS**

# **ENDOSYMBIOTIC THEORY**



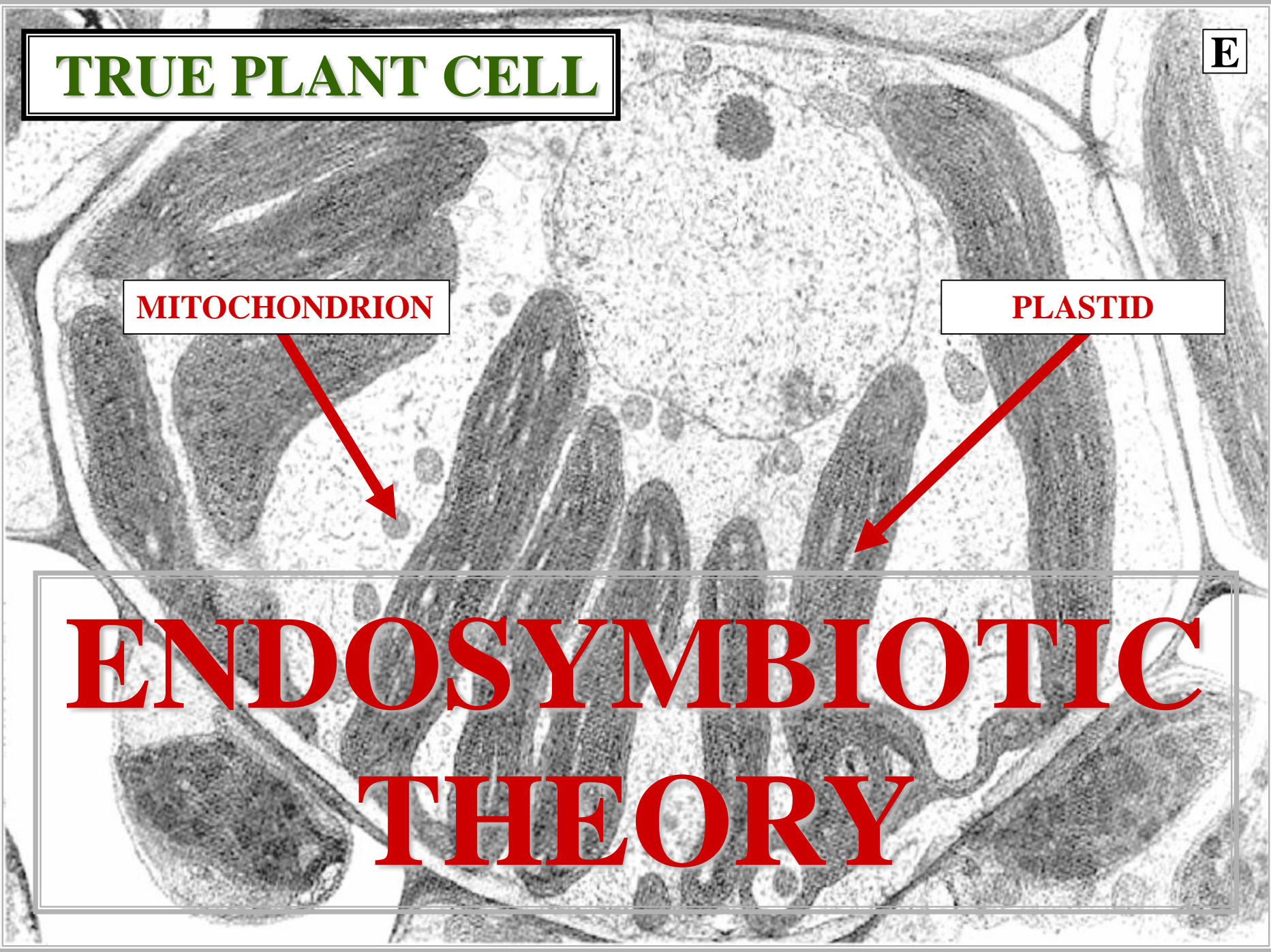
# TRUE PLANT CELL

E

MITOCHONDRION

PLASTID

# ENDOSYMBIOTIC THEORY



# ENDOSYMBIOSIS



# **ENDOSYMBIOSIS**

**ONE SPECIES  
LIVING WITHIN  
SECOND HOST SPECIES**

**ENDOSYMBIOSIS**

# PLANT CELL

P

CHLOROPLASTS

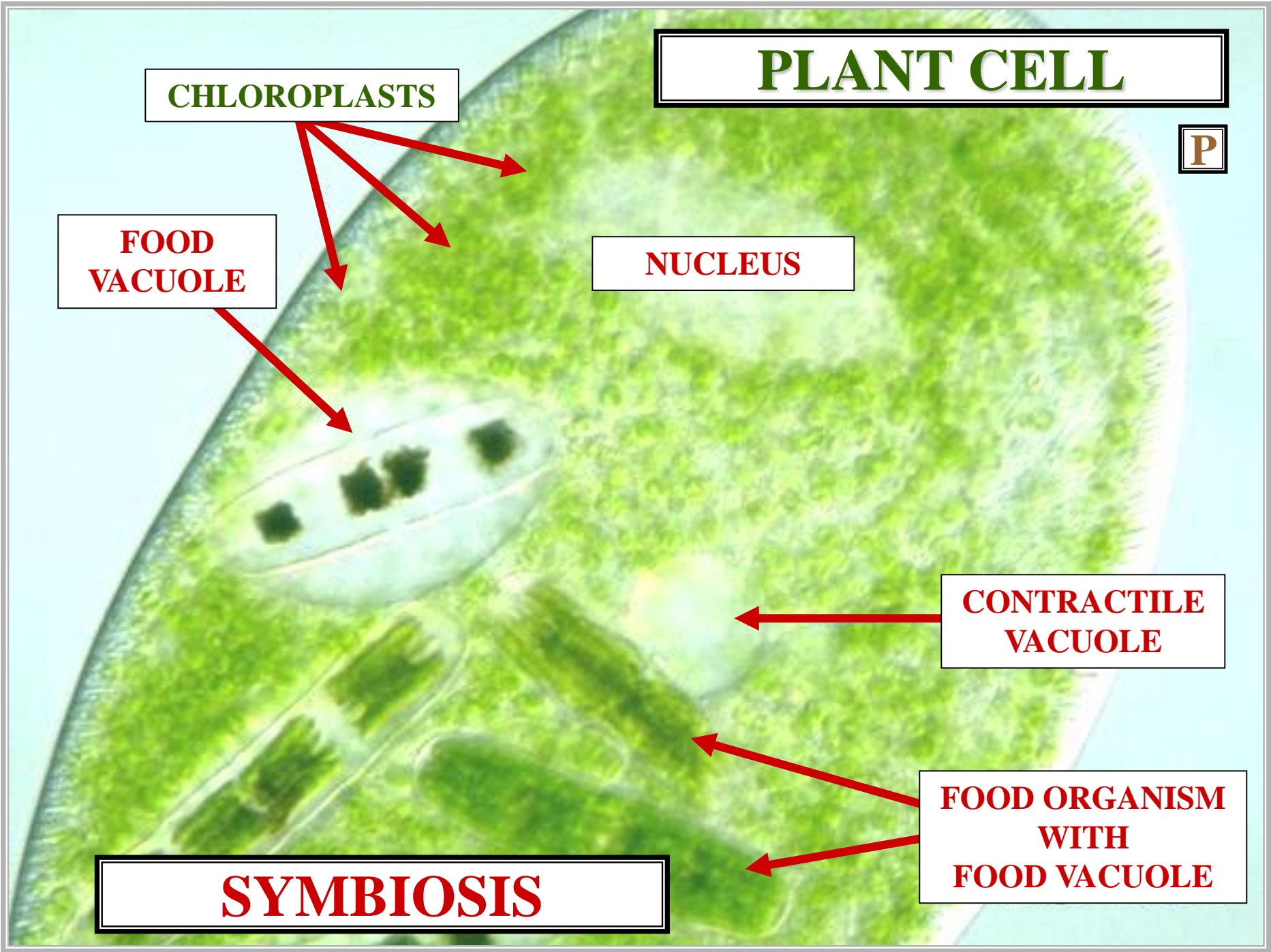
FOOD  
VACUOLE

NUCLEUS

CONTRACTILE  
VACUOLE

FOOD ORGANISM  
WITH  
FOOD VACUOLE

SYMBIOSIS



# PROTOZOAN

G

CHLOROPLASTS

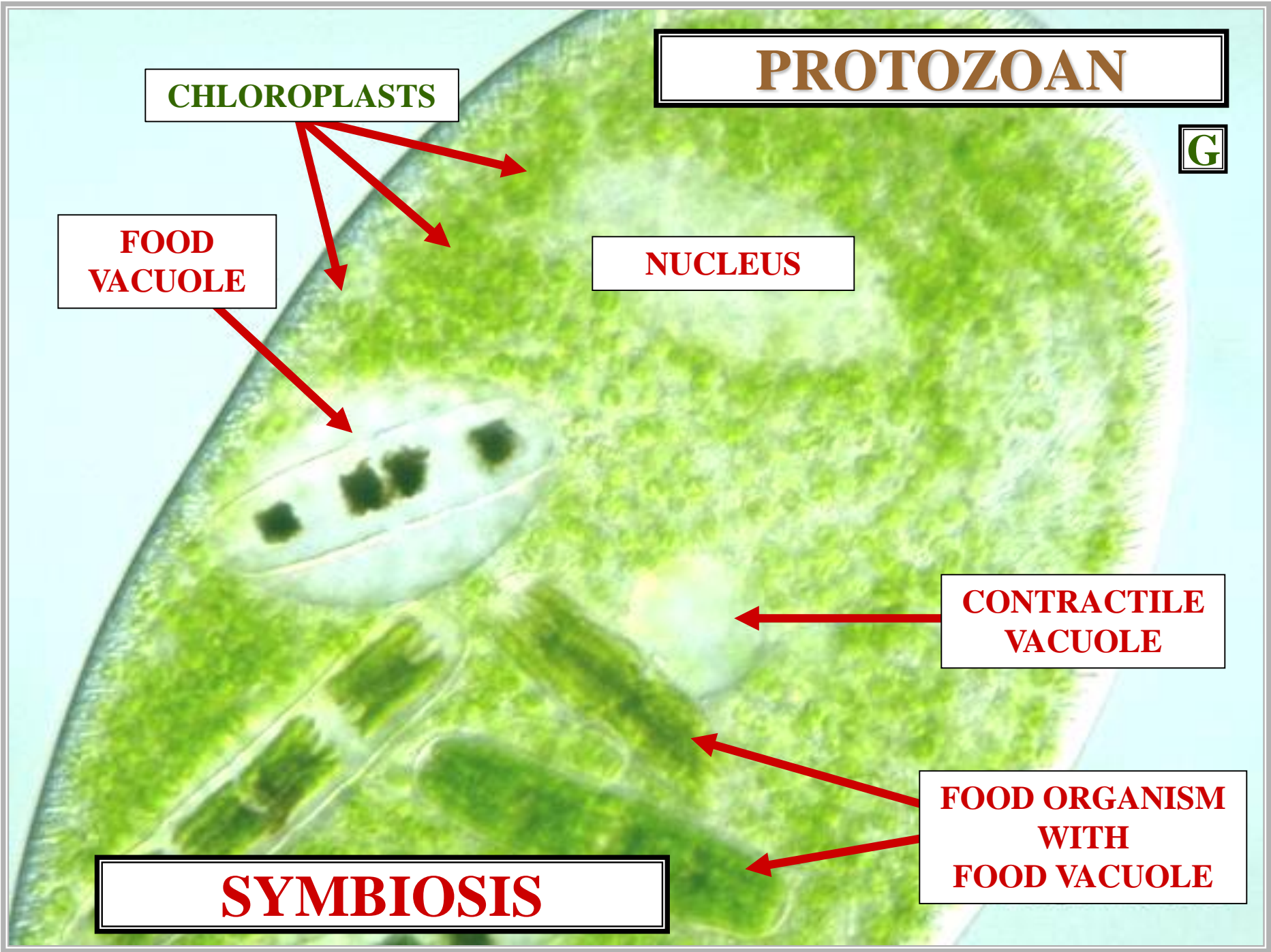
FOOD  
VACUOLE

NUCLEUS

CONTRACTILE  
VACUOLE

FOOD ORGANISM  
WITH  
FOOD VACUOLE

SYMBIOSIS



**SYMBIOTIC  
GREEN ALGAE**

**PROTOZOAN**

**EN**

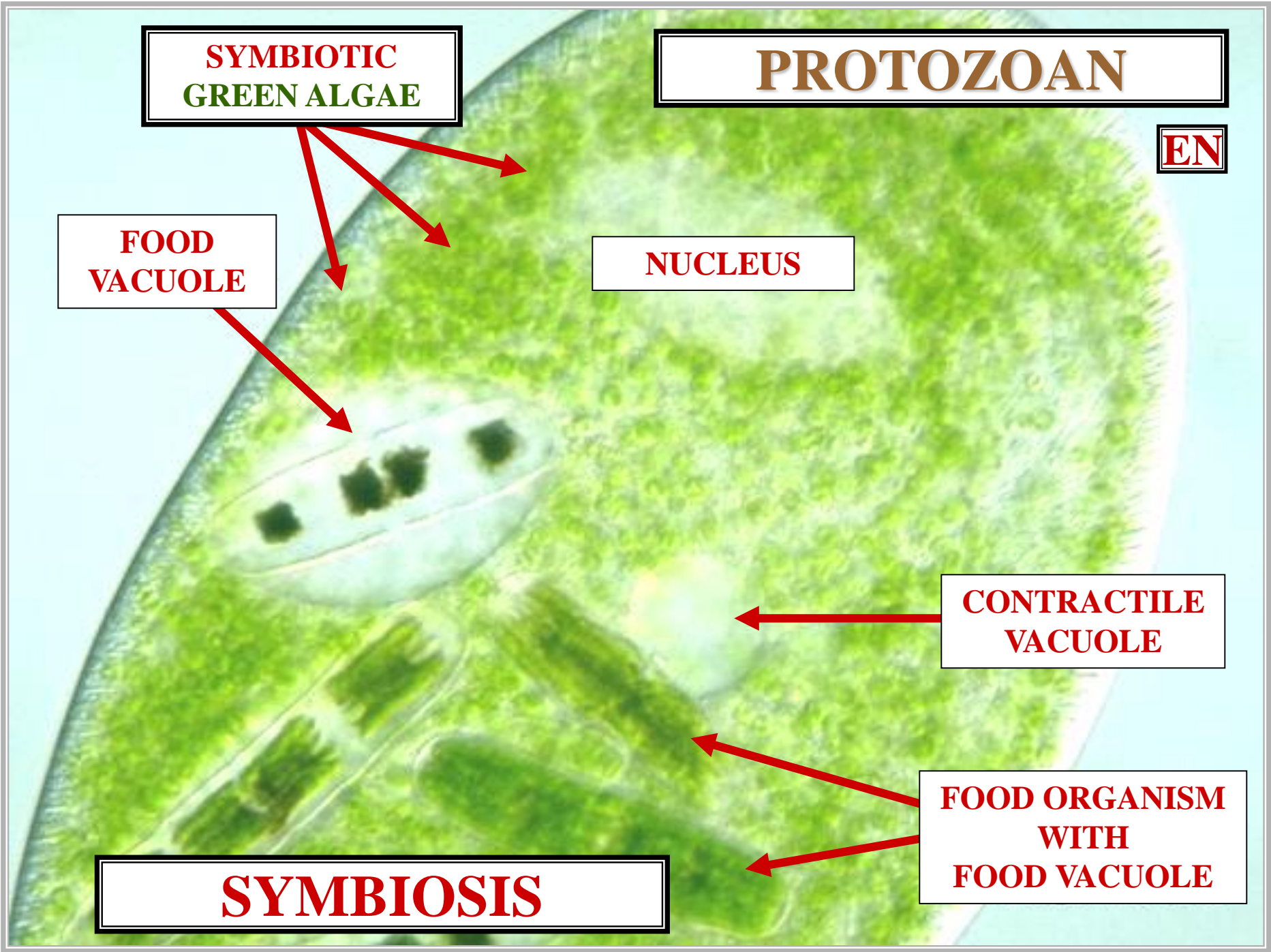
**FOOD  
VACUOLE**

**NUCLEUS**

**CONTRACTILE  
VACUOLE**

**FOOD ORGANISM  
WITH  
FOOD VACUOLE**

**SYMBIOSIS**



# PROTOZOAN

**ENDOSYMBIOTIC  
GREEN ALGAE**

**FOOD  
VACUOLE**

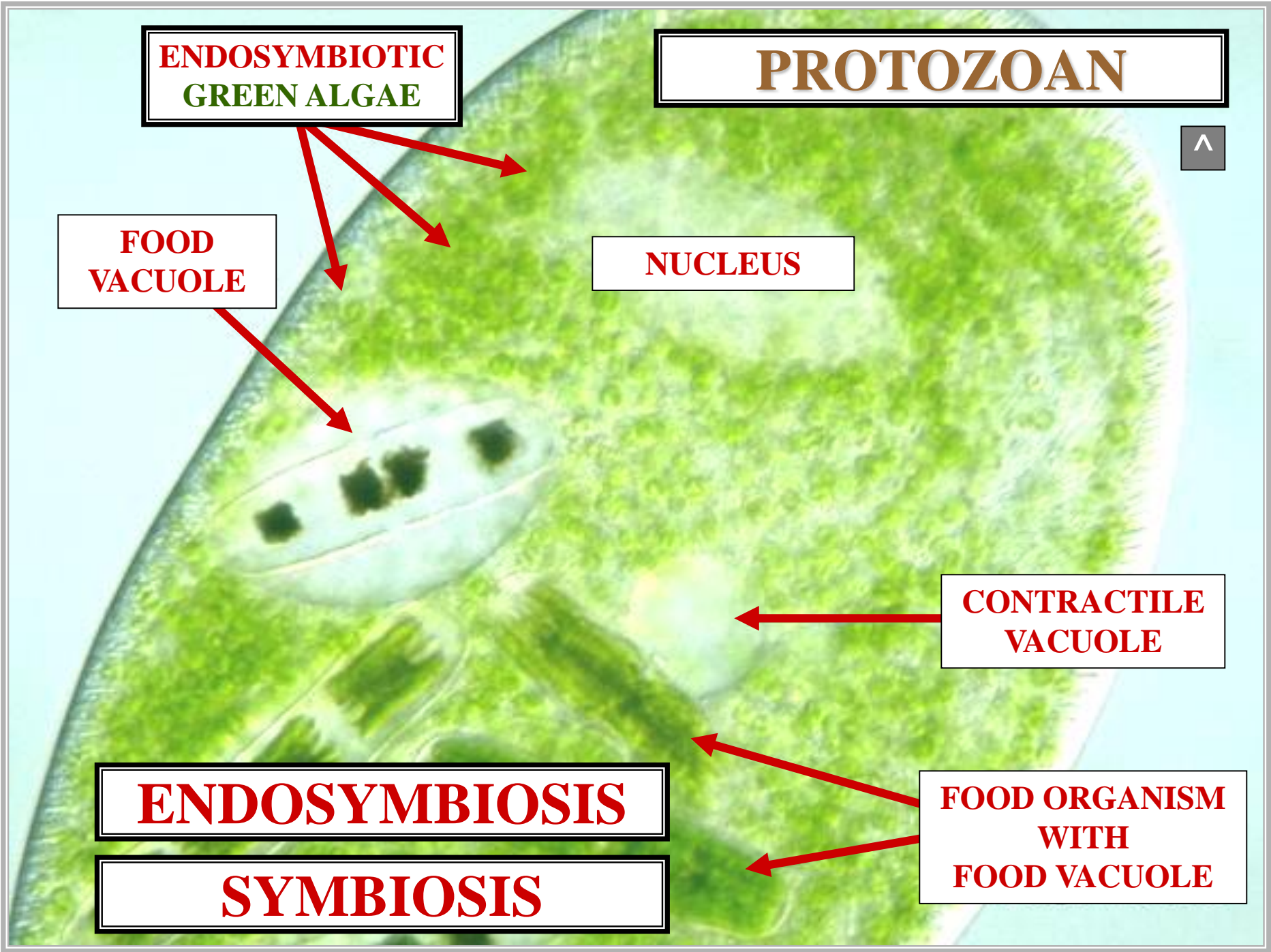
**NUCLEUS**

**CONTRACTILE  
VACUOLE**

**ENDOSYMBIOSIS**

**SYMBIOSIS**

**FOOD ORGANISM  
WITH  
FOOD VACUOLE**





# PLASTID EVOLUTION



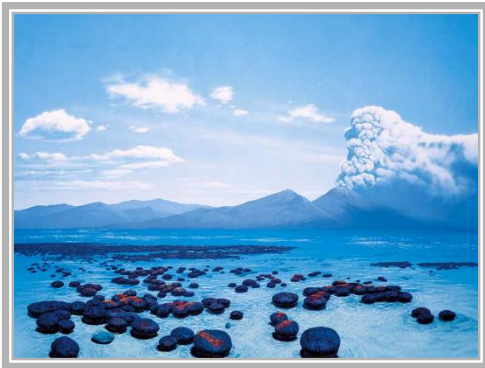


**PLASTID  
EVOLUTION  
HYPOTHETICAL  
SCENARIO**

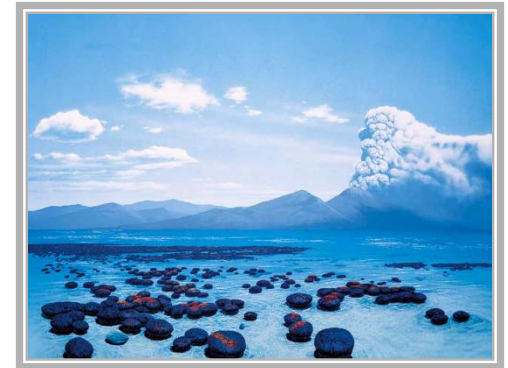
**HETEROTROPHIC  
HOST CELL**  
**DNA W\ HISTONE PROTEINS**  
**LARGE RIBOSOMES**

**AUTOTROPHIC  
PROKARYOTE**  
**DNA W\OUT HISTONE PROTEINS**  
**SMALL RIBOSOMES**

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



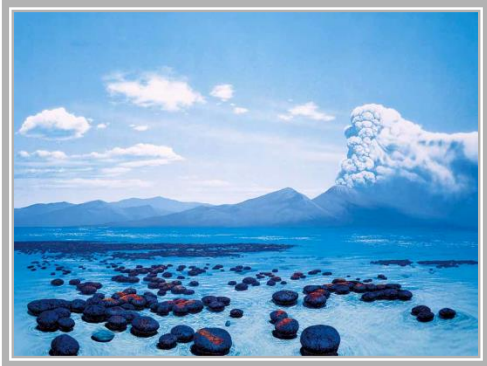
**AUTOTROPHIC  
PROKARYOTE  
DNA W\OUT HISTONE PROTEINS  
SMALL RIBOSOMES**



**HETEROTROPH & AUTOTROPH: SAME HABITAT**

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

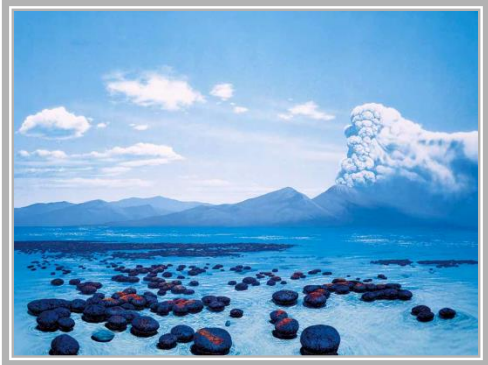
***CANNOT DERIVED* GLUCOSE**



**AUTOTROPHIC  
PROKARYOTE**

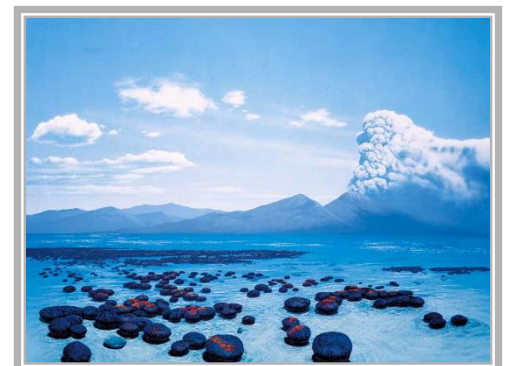
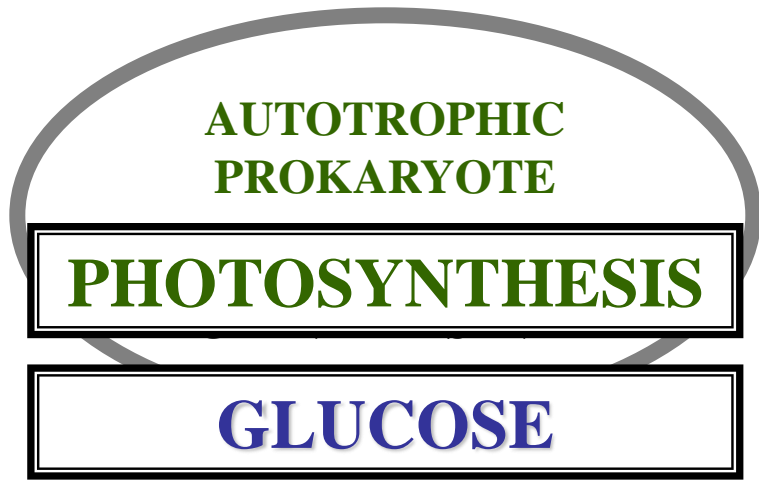
**PHOTOSYNTHESIS**

**GLUCOSE**



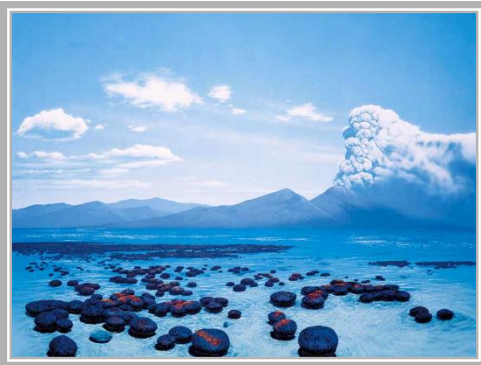
**HETEROTROPHIC  
HOST CELL**

**CONSUMES OTHER ORGANISMS  
CONSUMES AUTOTROPH**



**HETEROTROPHIC  
HOST CELL**

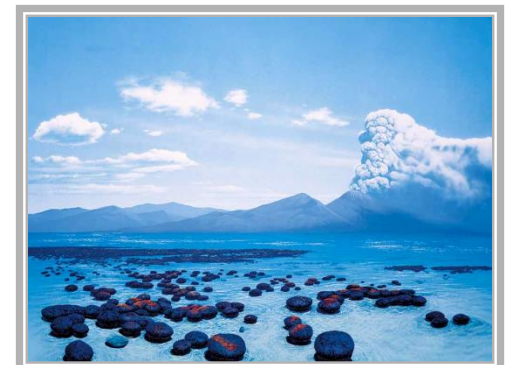
**CONSUMES OTHER ORGANISMS  
CONSUMES AUTOTROPH  
VIA ENDOCYTOSIS**



**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**

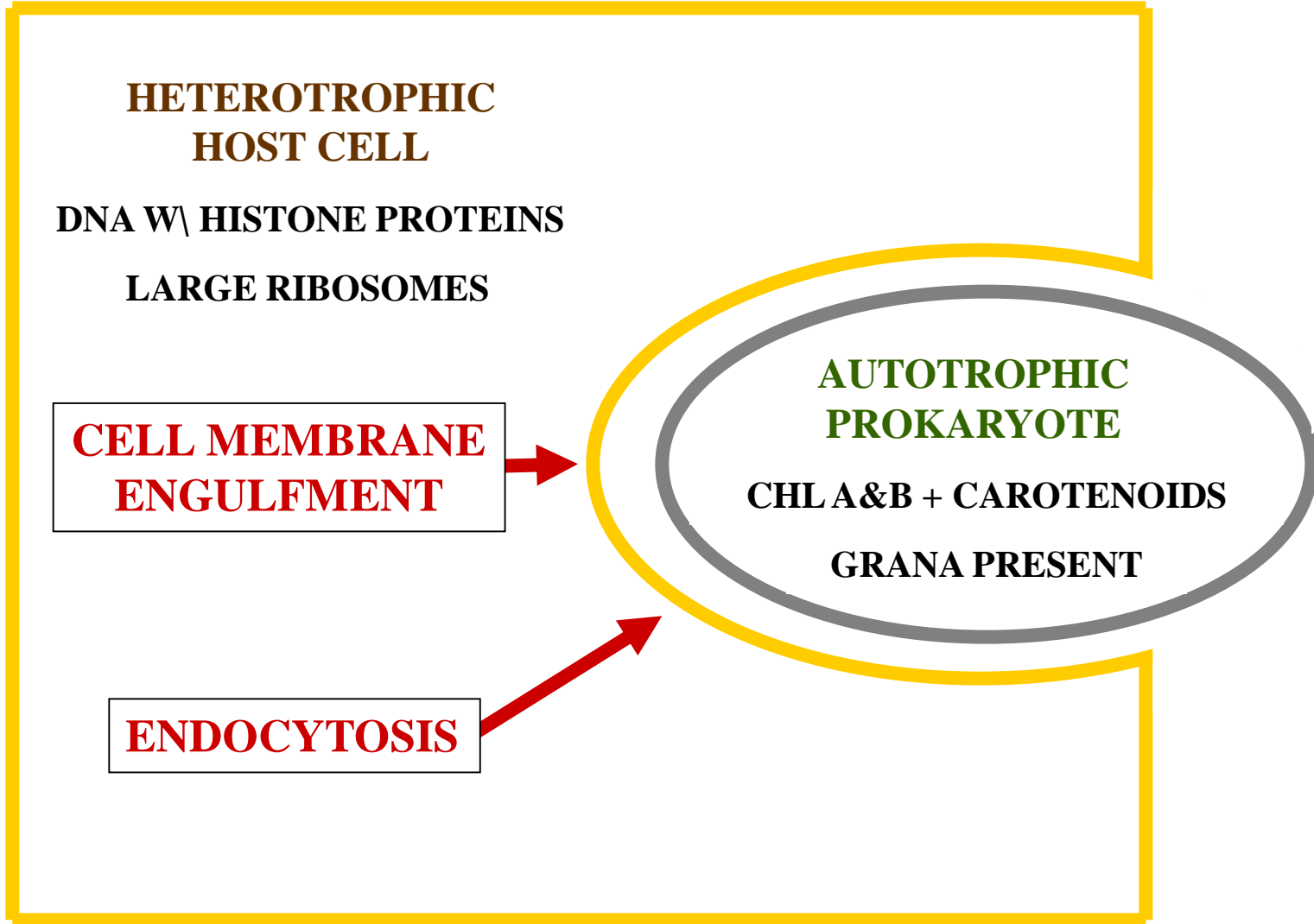
**CELL MEMBRANE  
ENGULFMENT**

**ENDOCYTOSIS**

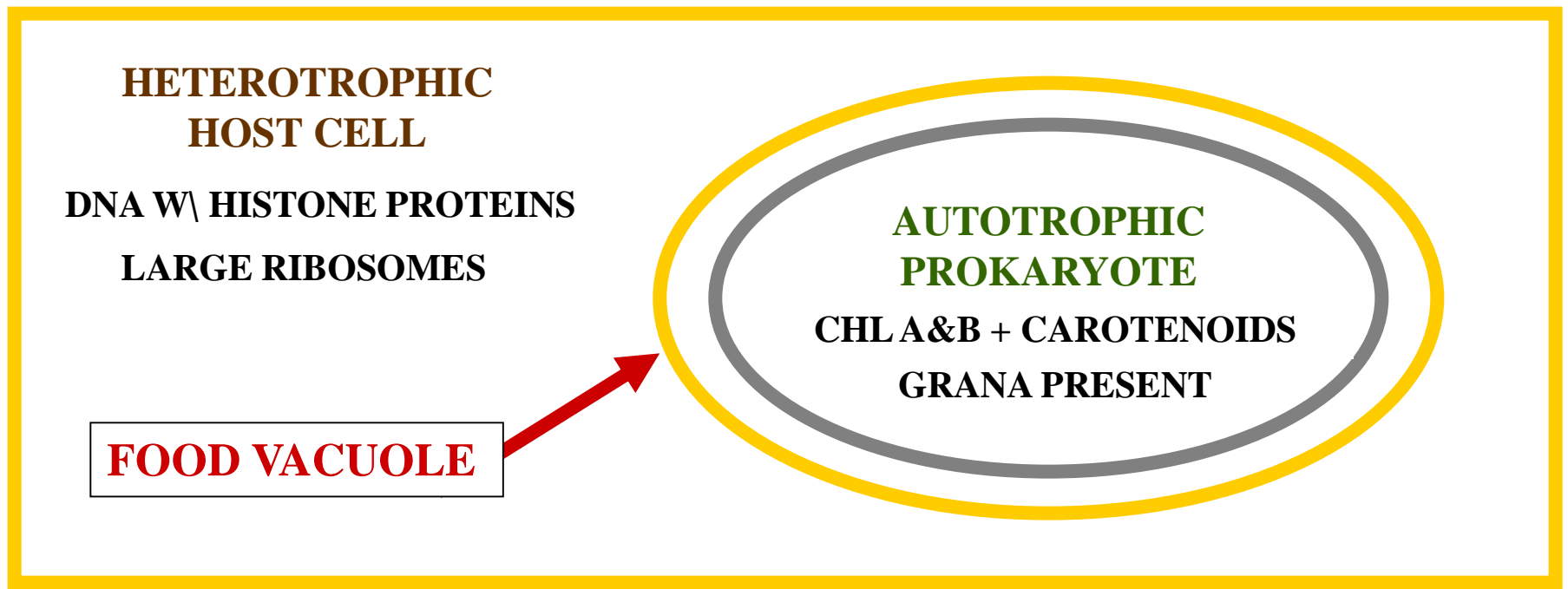
**AUTOTROPHIC  
PROKARYOTE**

**CHL A&B + CAROTENOIDS**

**GRANA PRESENT**

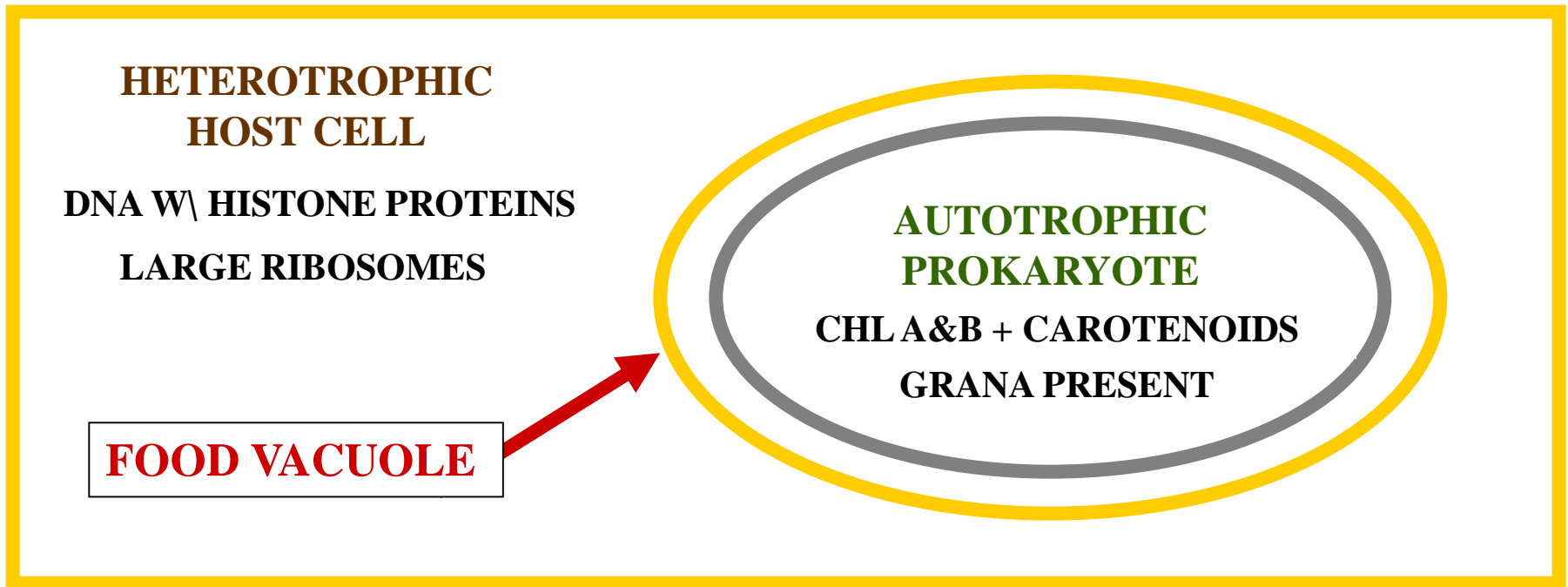


# AUTOTROPH WITHIN HETEROTROPH FOOD VACUOLE

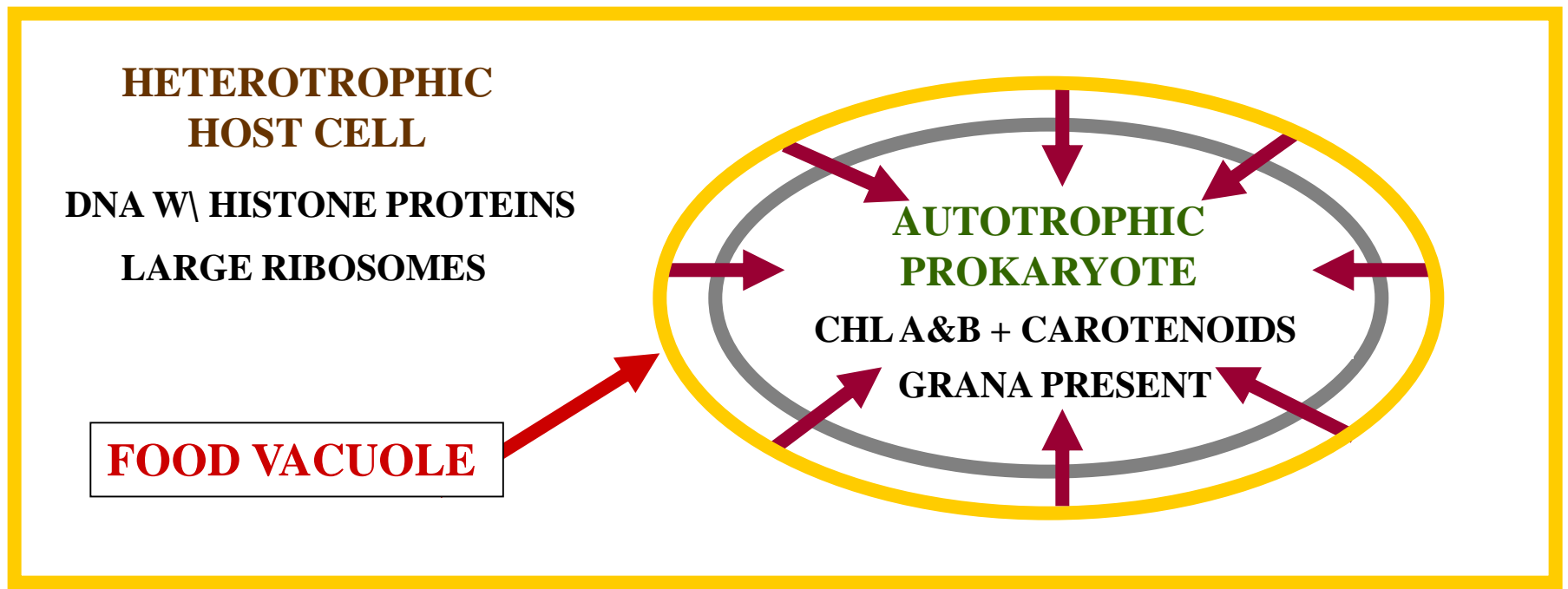




# INITIALLY HETEROTROPH DIGESTS AUTOTROPH

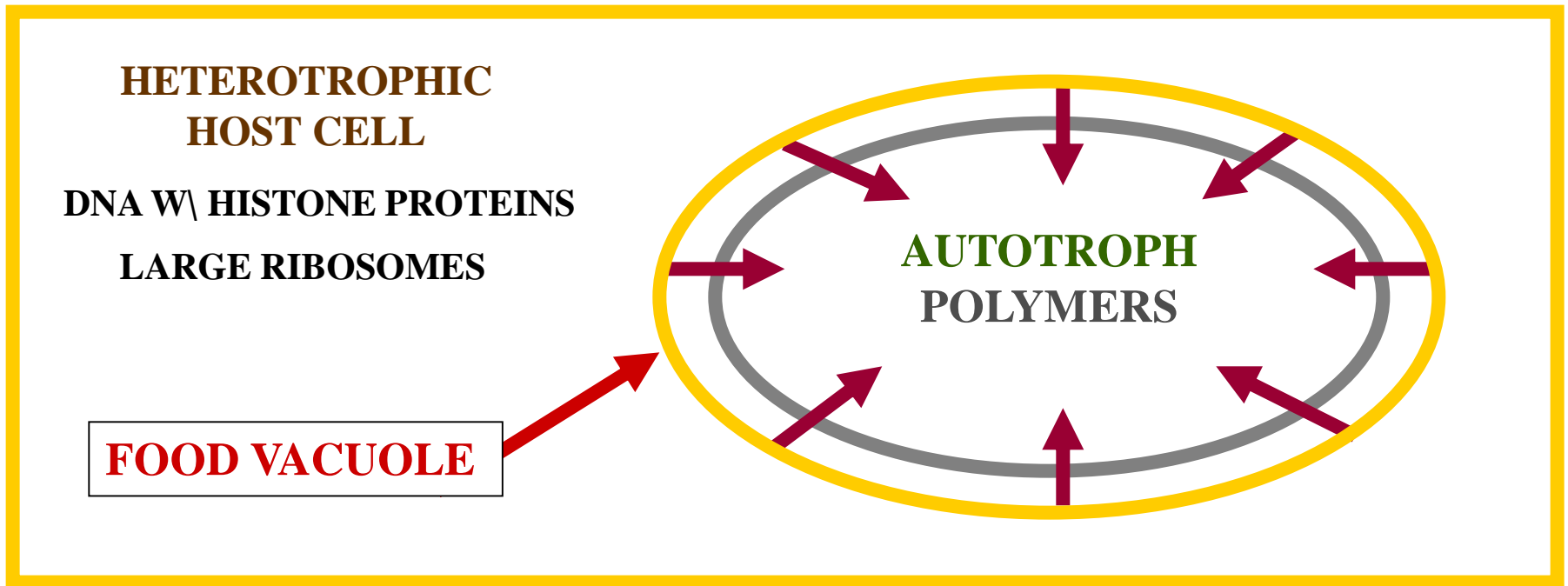


# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



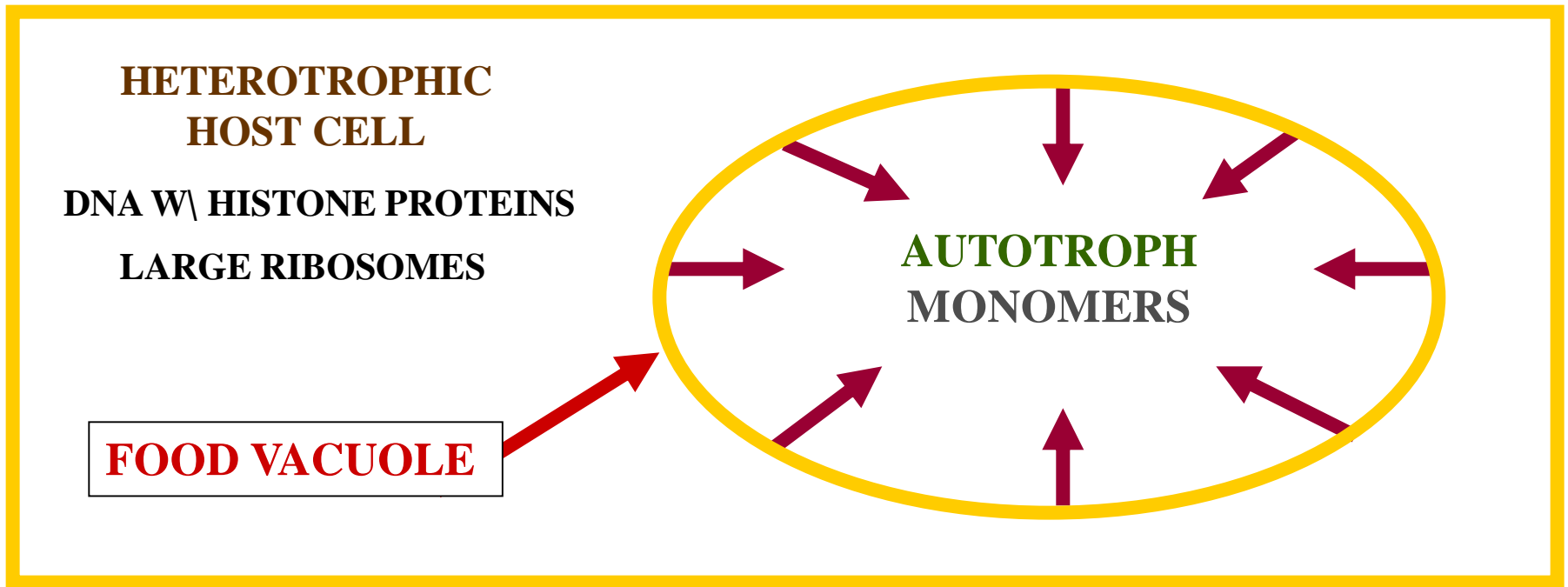
➔ = ENZYMES

# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



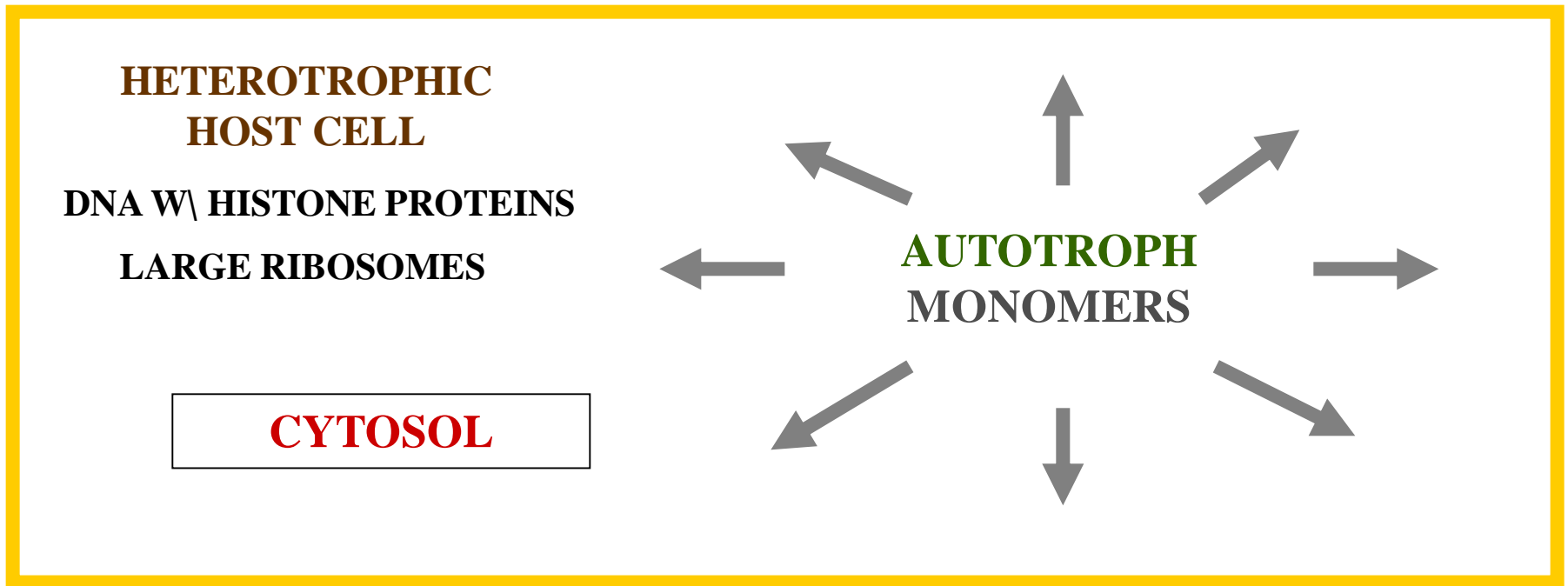
**→ = ENZYMES**

# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



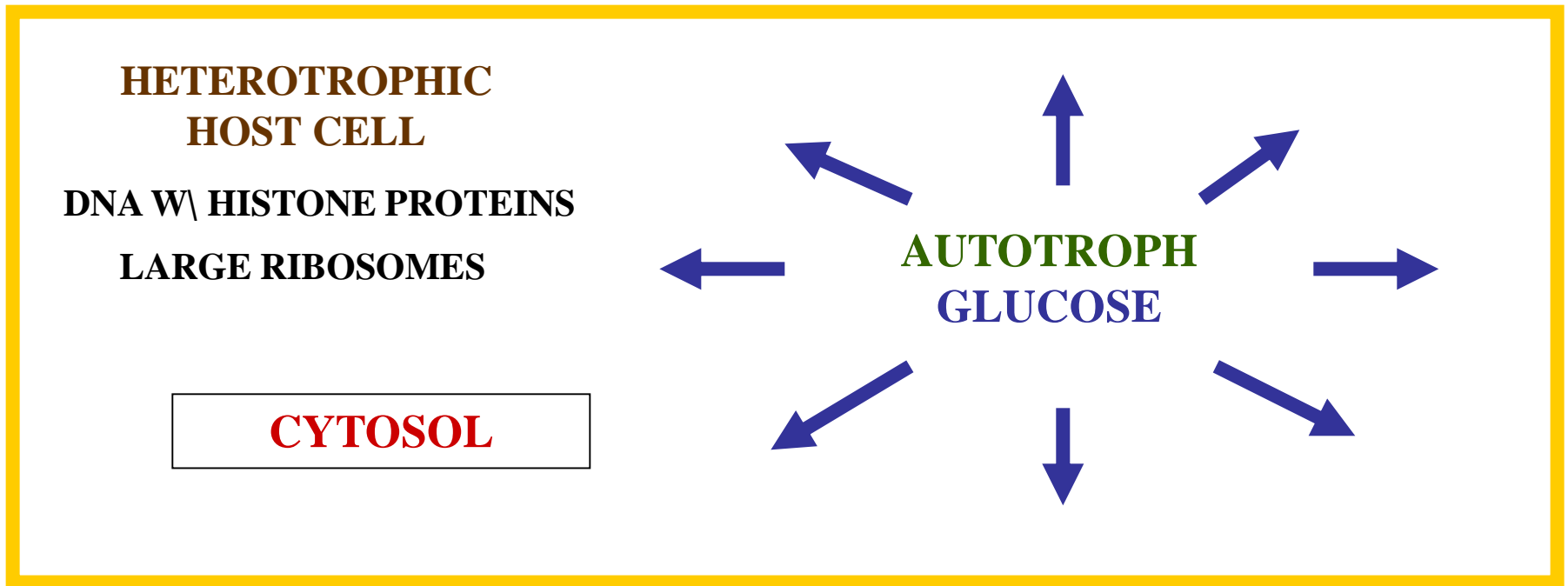
➡ = ENZYMES

# INITIALLY HETEROTROPH DIGESTS AUTOTROPH

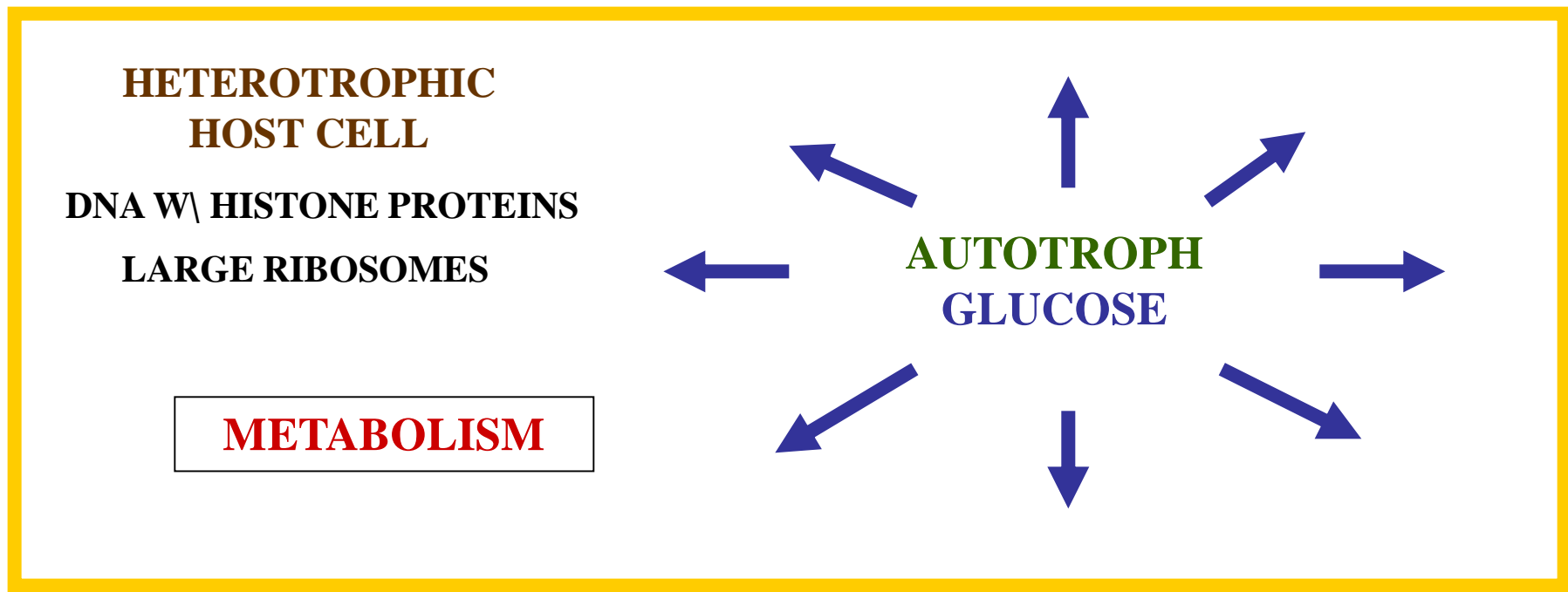




# INITIALLY HETEROTROPH DIGESTS AUTOTROPH



# 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**