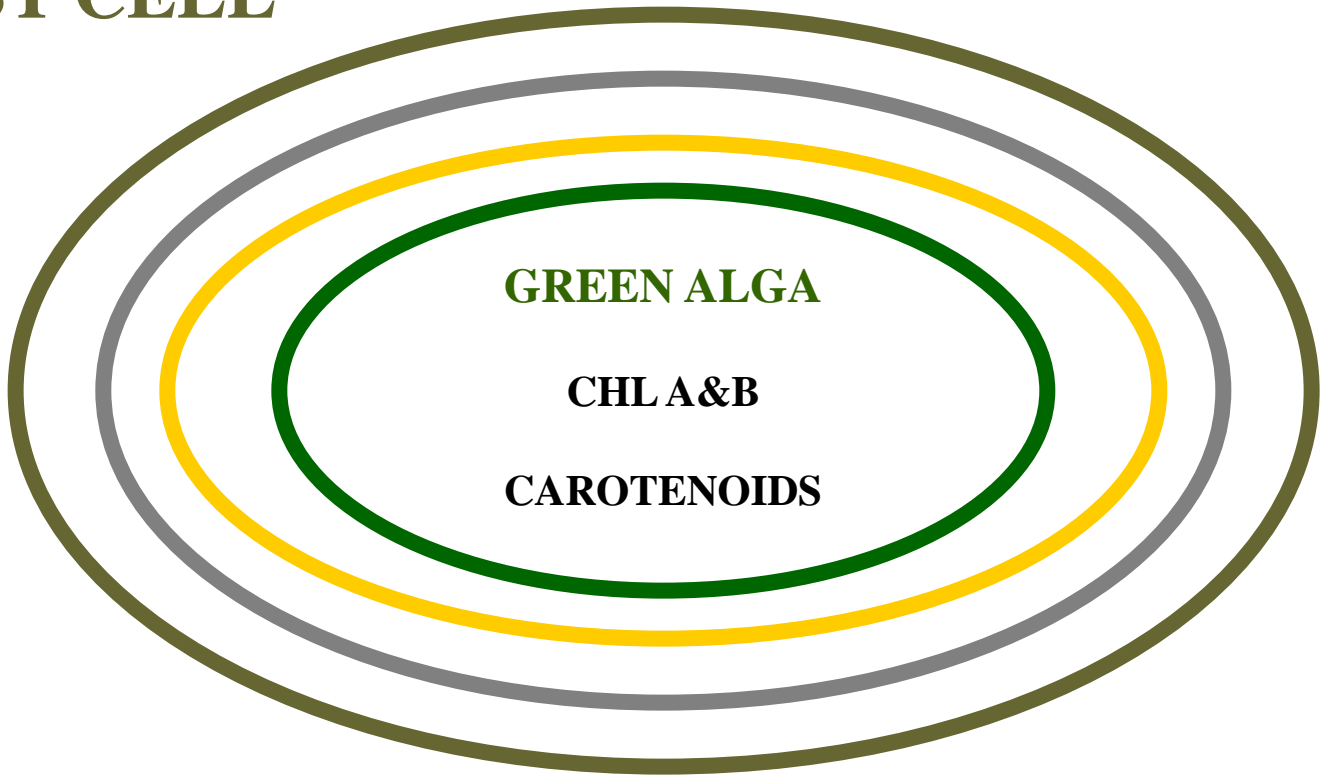
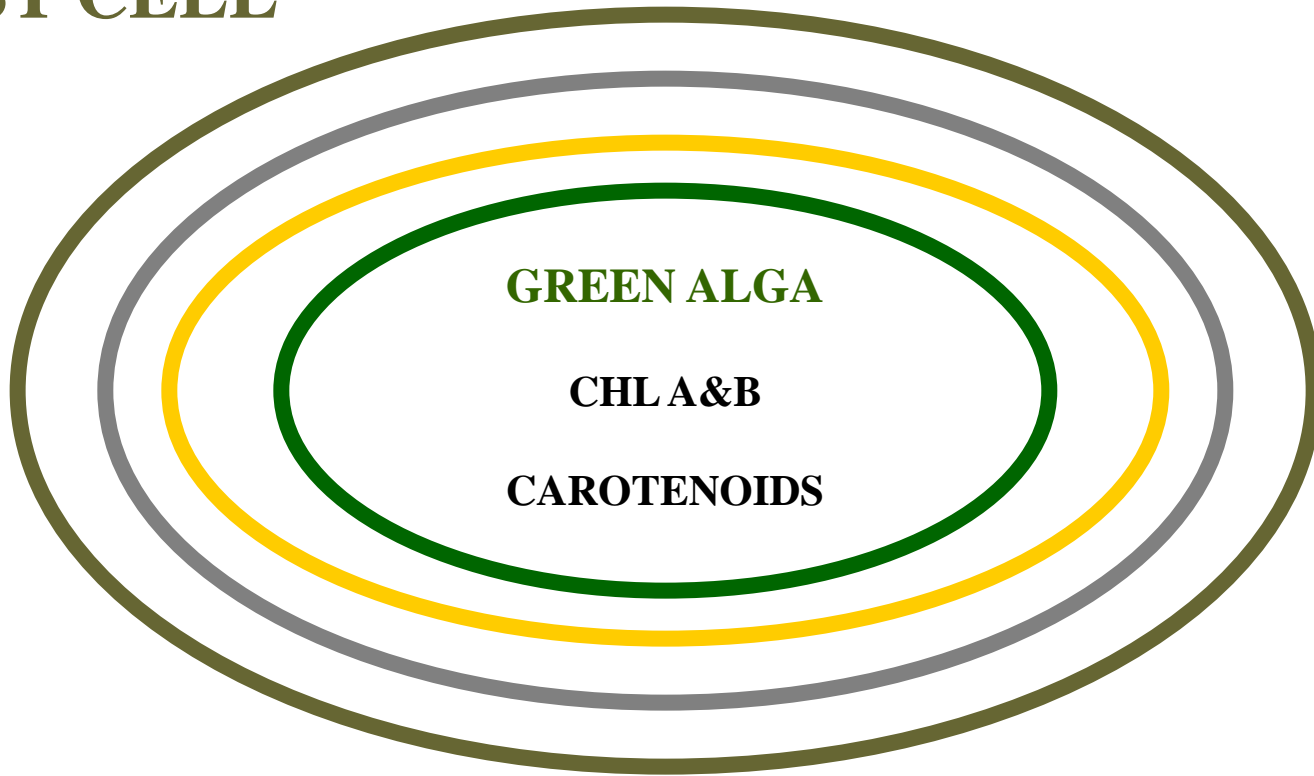


**EUGLENOID  
HOST CELL**



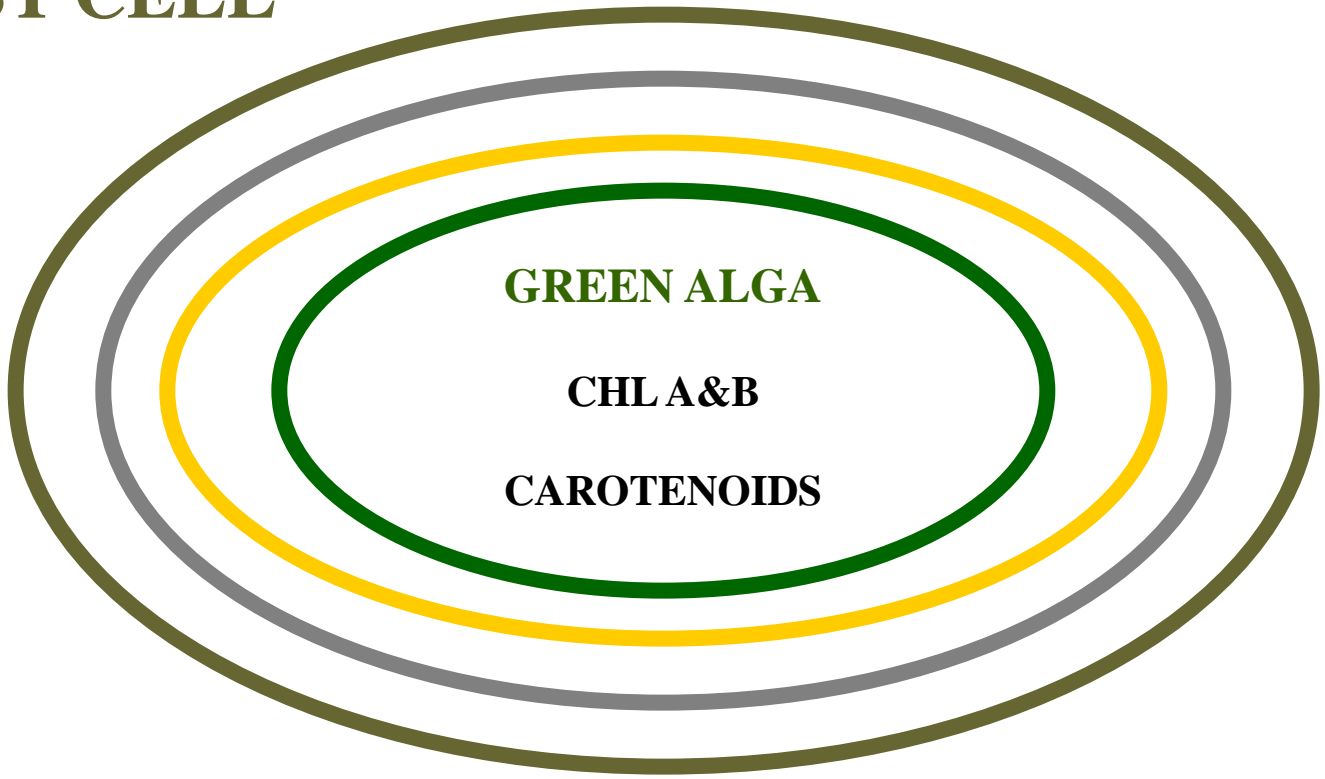
**GREEN ALGA LIVING W/IN EUGLENOID**

**EUGLENOID  
HOST CELL**



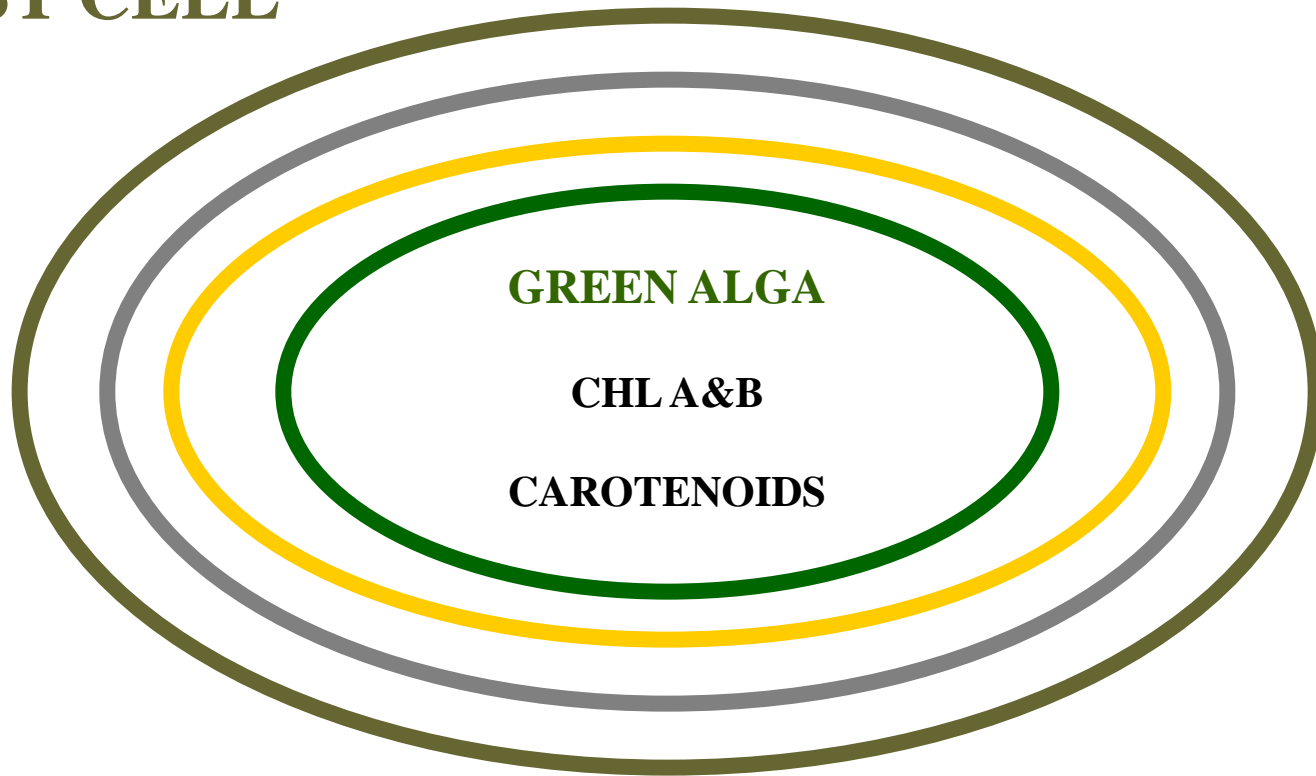
**SYMBIOSIS**

**EUGLENOID  
HOST CELL**



**ENDOSYMBIOSIS**

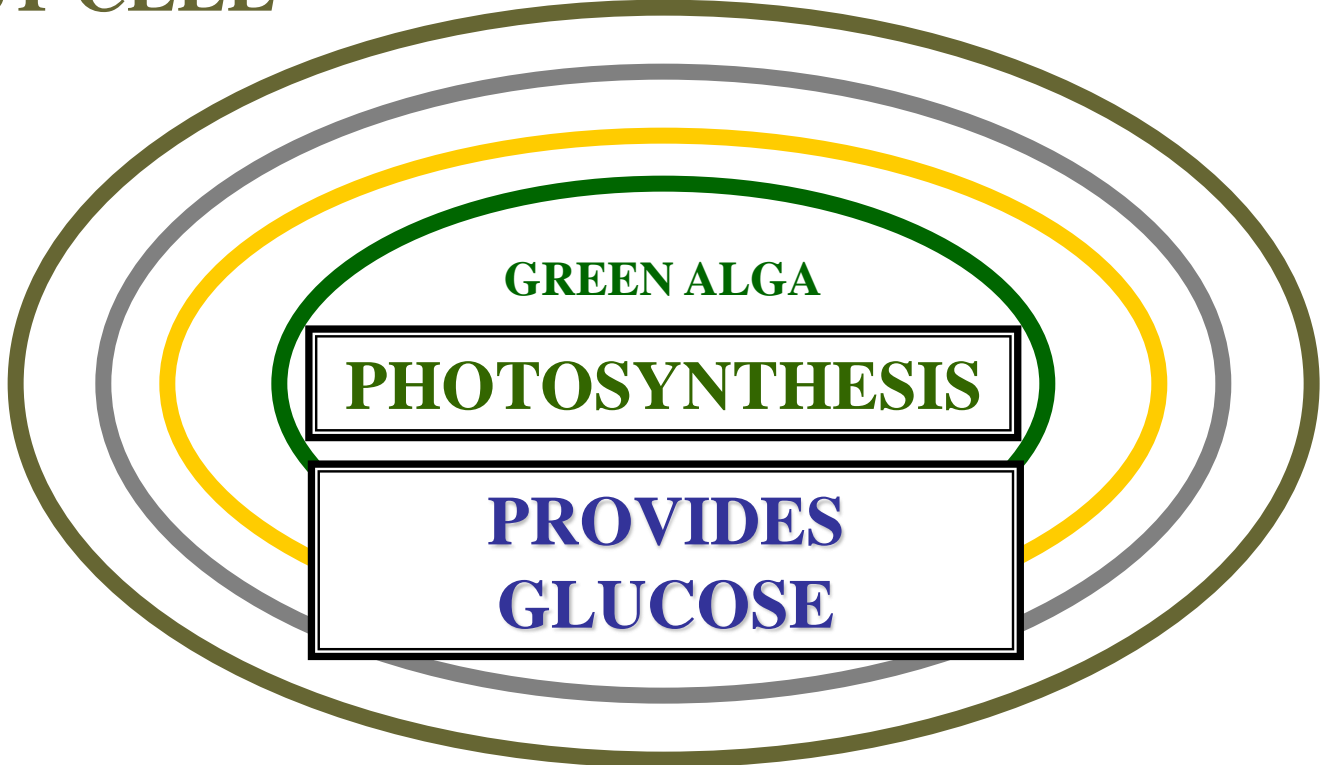
**EUGLENOID  
HOST CELL**



**GREEN ALGA PROVIDES EUGLENOID WITH?**

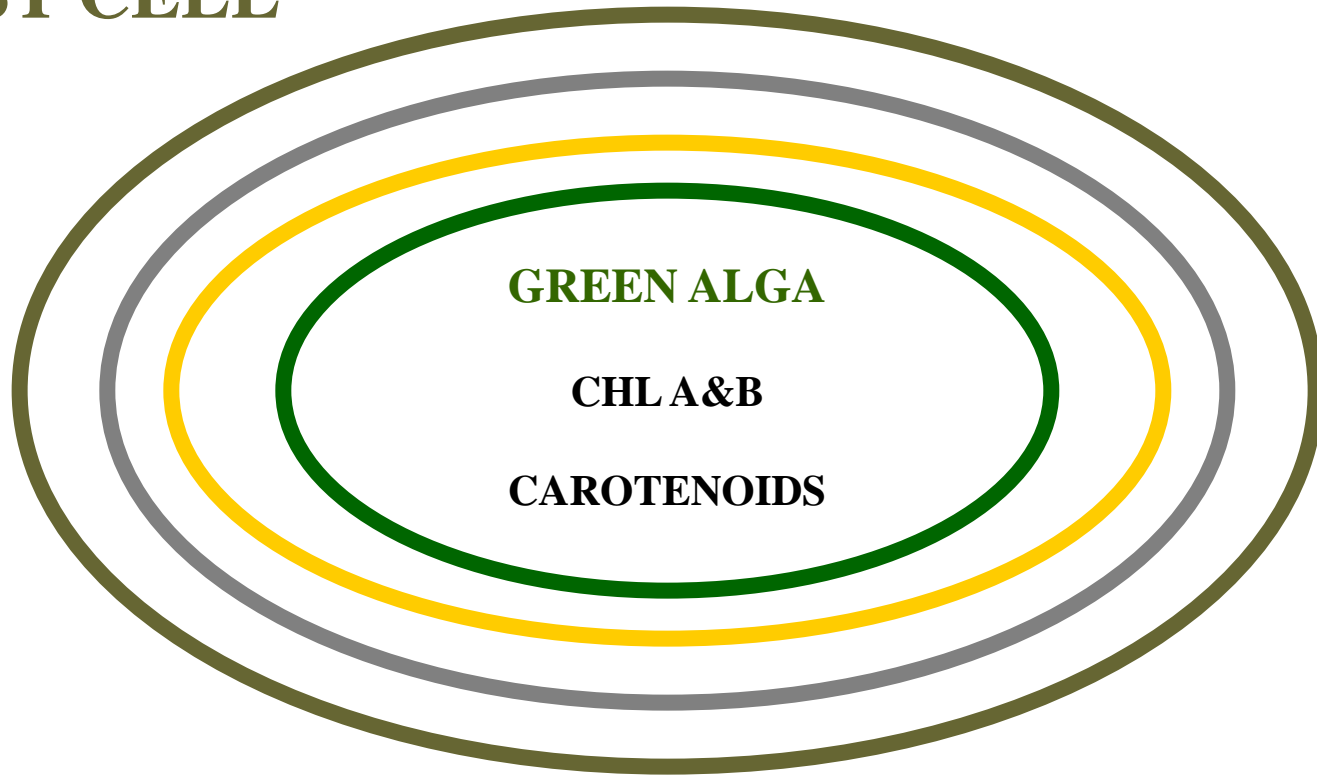
**EUGLENOID  
HOST CELL**

**GLUCOSE**



**GREEN ALGA PROVIDES EUGLENOID WITH?**

**EUGLENOID  
HOST CELL**



**EUGLENOID PROVIDES GREEN ALGA WITH?**

**EUGLENOID  
HOST CELL**

**PROVIDES  
SECURITY**



**GREEN ALGA**

**CHLA&B**

**SECURITY**

**EUGLENOID PROVIDES GREEN ALGA WITH?**

**EUGLENOID  
HOST CELL**

**PROVIDES  
GREEN ALGA  
SECURITY**

**GREEN ALGA**

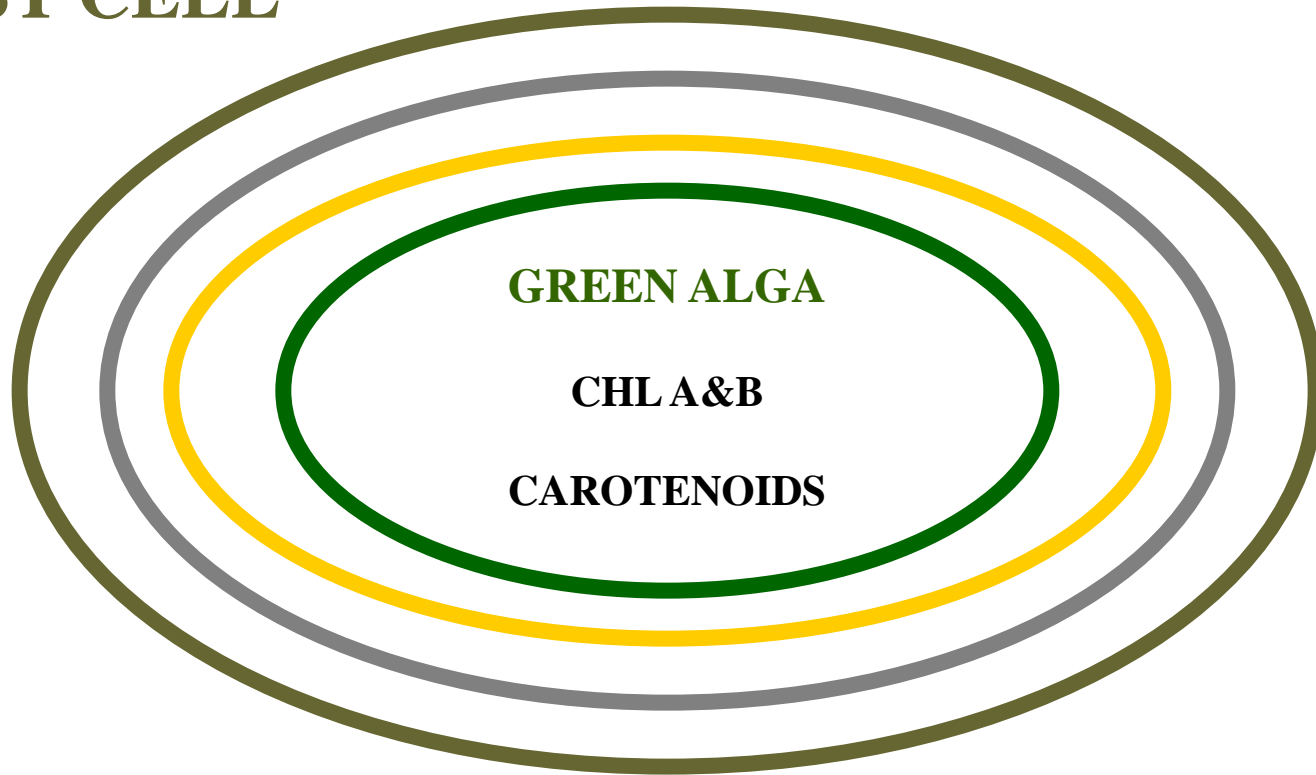
**CHL A&B**

**PROVIDES  
EUGLENOID  
GLUCOSE**

**BOTH SYMBIONTS BENEFIT**

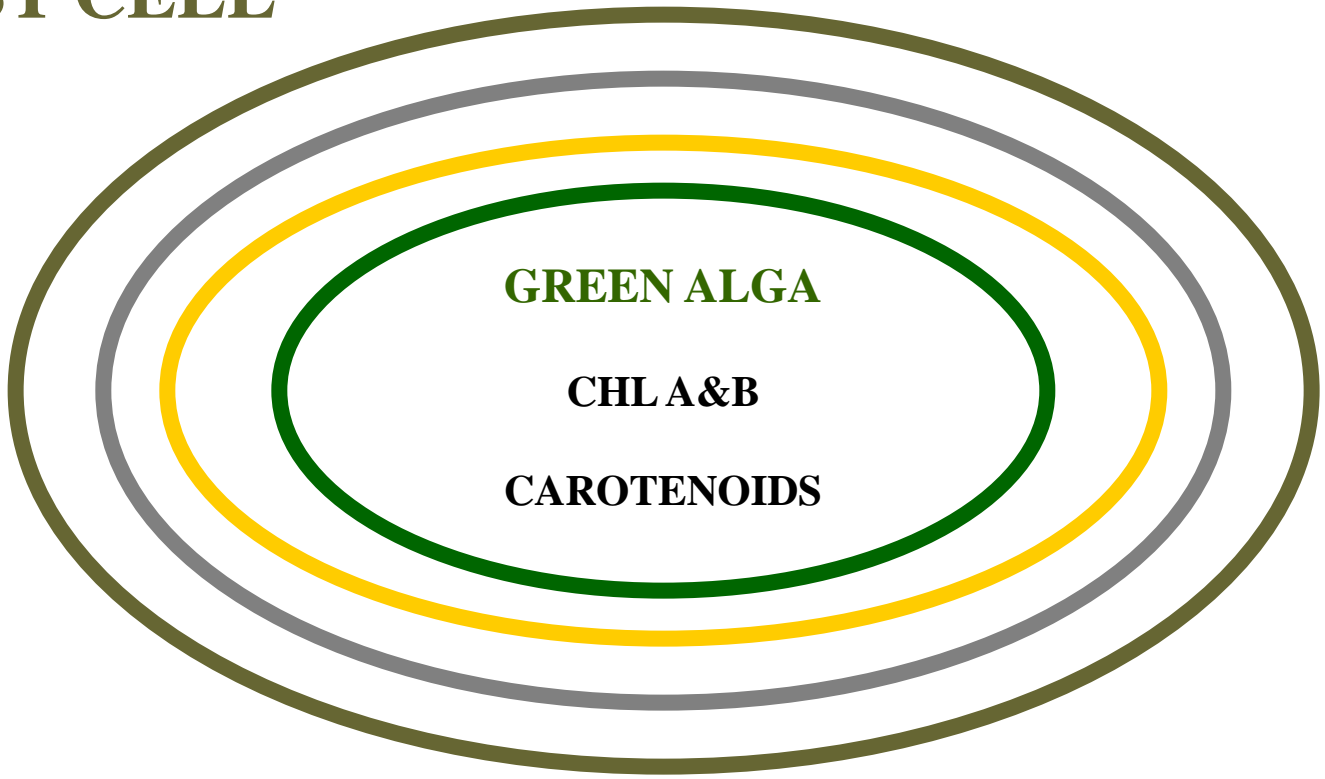


**EUGLENOID  
HOST CELL**



**MUTUALISTIC ENDSYMBIOSIS**

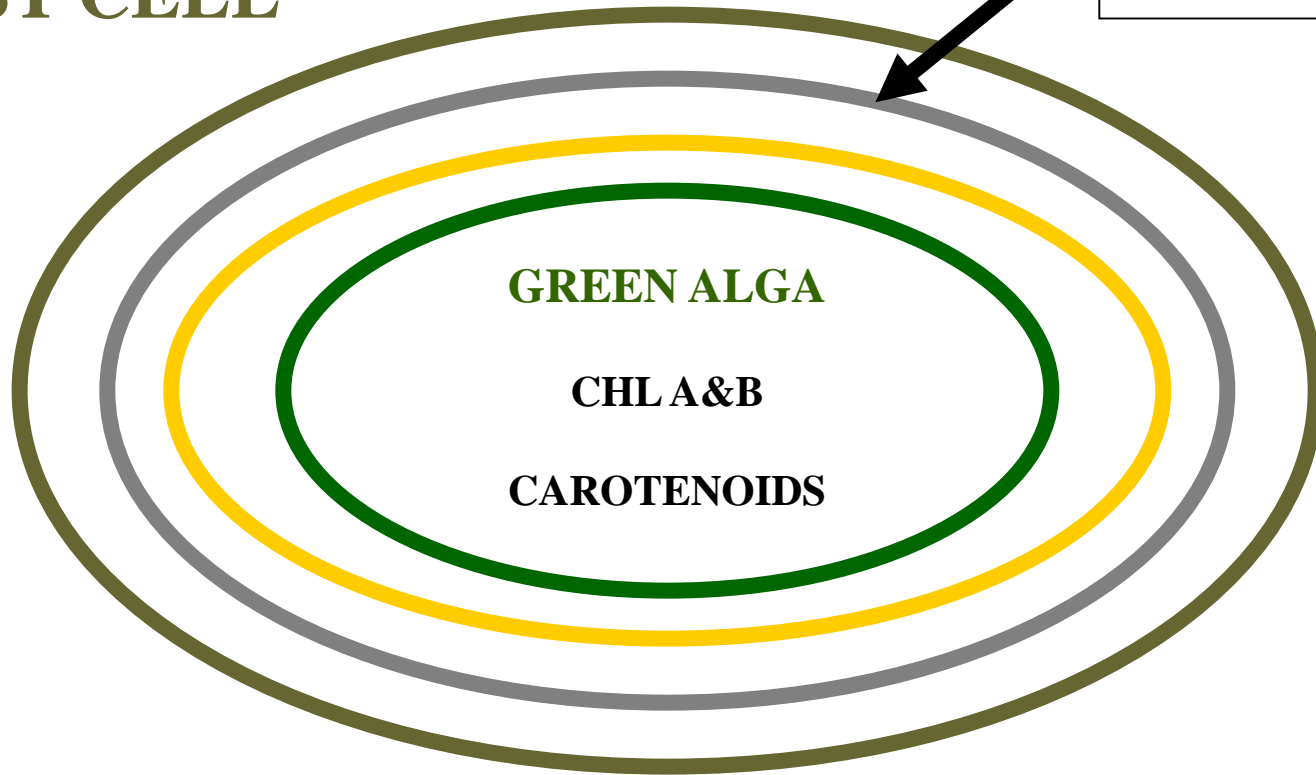
**EUGLENOID  
HOST CELL**



**GIVEN LONG TIME PERIOD**

**EUGLENOID  
HOST CELL**

**GREEN ALGA  
CELL  
MEMBRANE**



**GREEN ALGA**

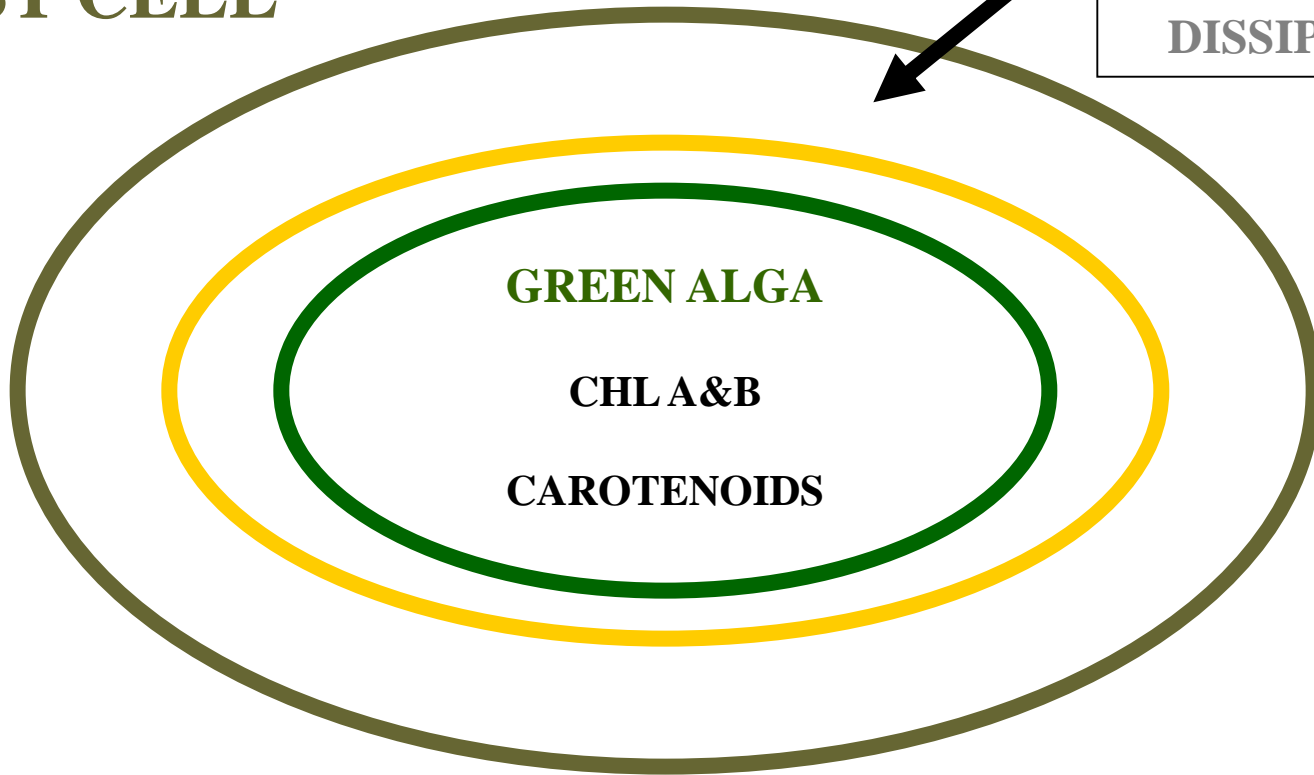
**CHL A&B**

**CAROTENOIDS**

**INTRICATE RELATIONSHIP**

**EUGLENOID  
HOST CELL**

**GREEN ALGA  
CELL  
MEMBRANE  
DISSIPATES**



**GREEN ALGA**

**CHL A&B**

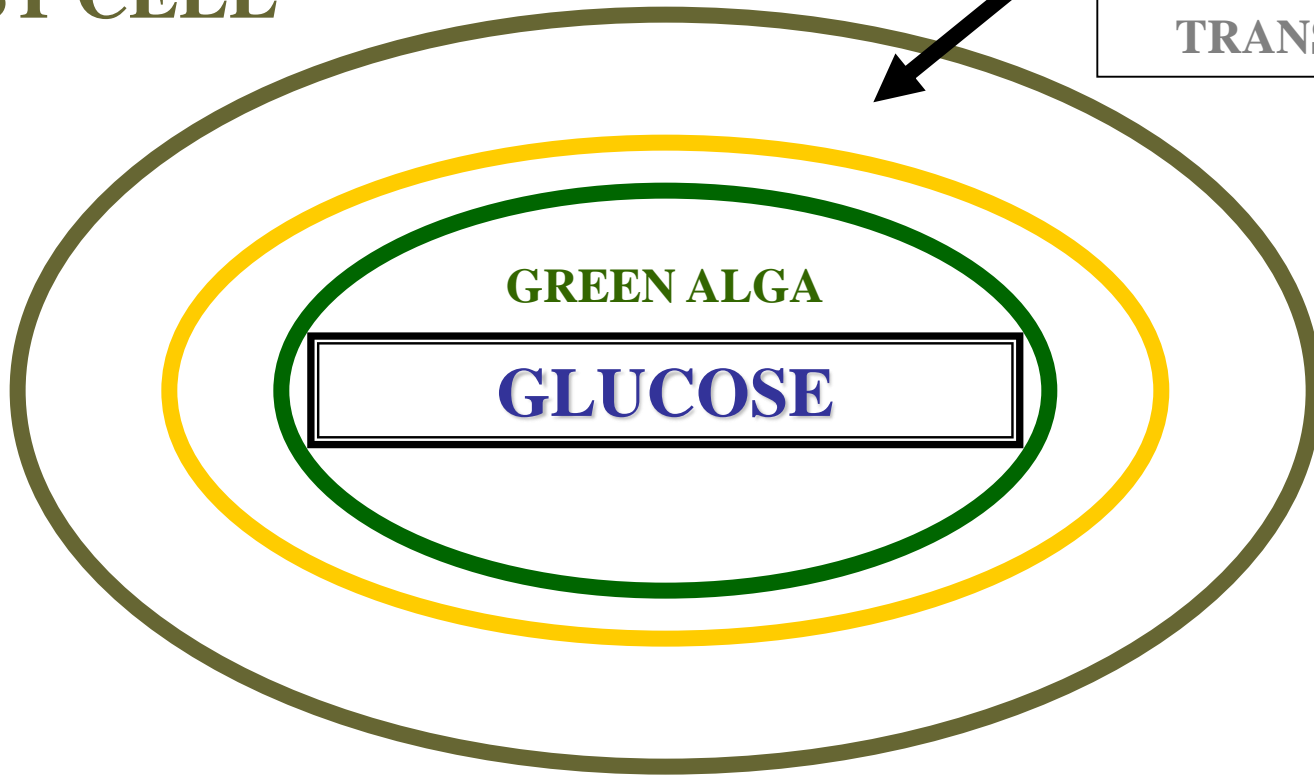
**CAROTENOIDS**

**INTRICATE RELATIONSHIP**

**EUGLENOID  
HOST CELL**

**GLUCOSE**

**MORE  
EFFICIENT  
GLUCOSE  
TRANSFER**

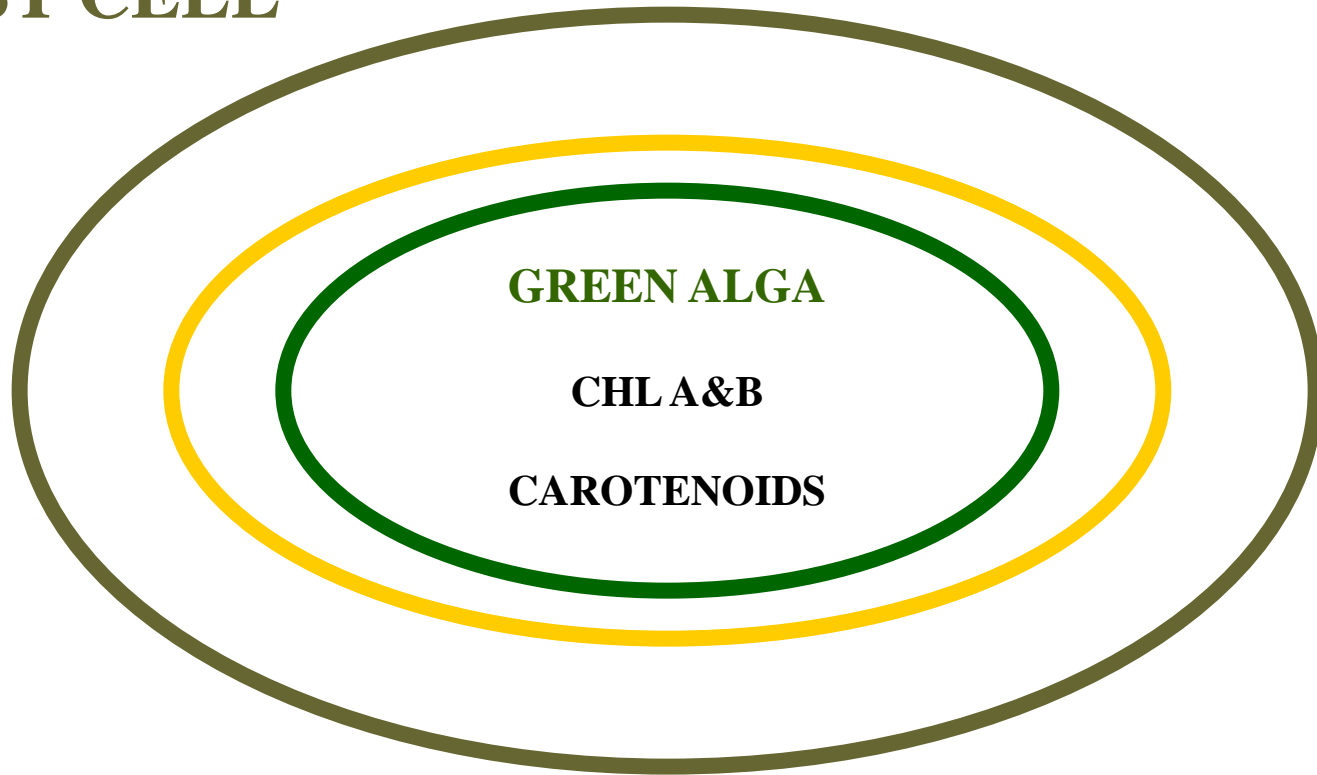


**GREEN ALGA**

**GLUCOSE**

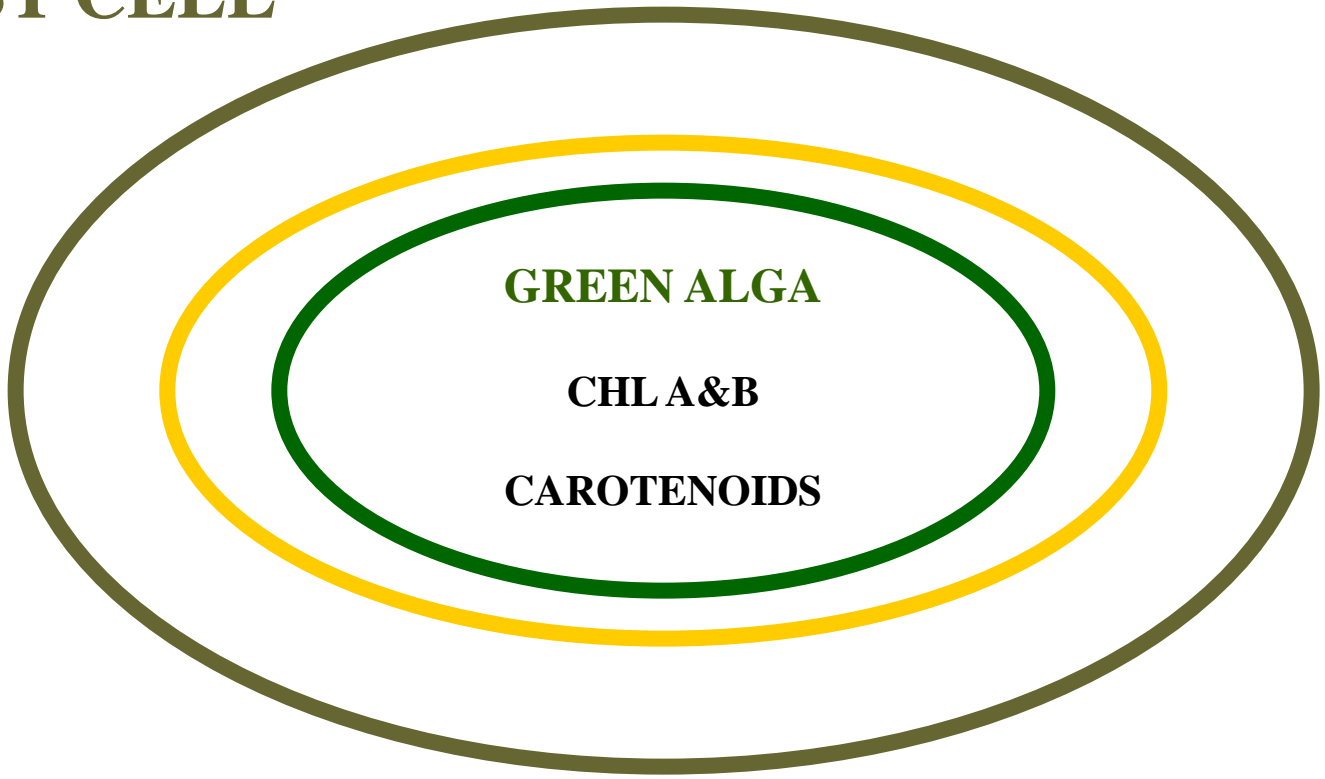
**INTRICATE RELATIONSHIP**

**EUGLENOID  
HOST CELL**



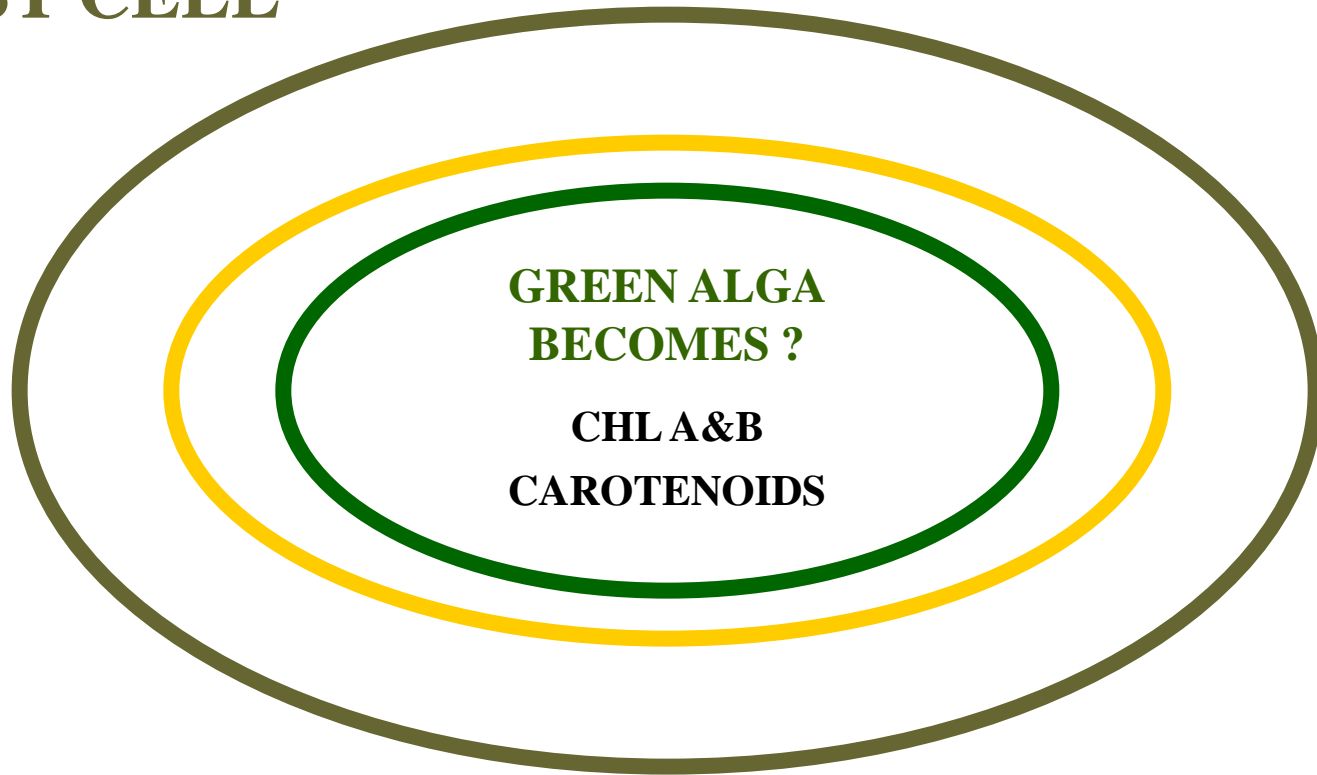
**GIVEN LONG TIME PERIOD**

**EUGLENOID  
HOST CELL**



**OBLIGATE RELATIONSHIP**

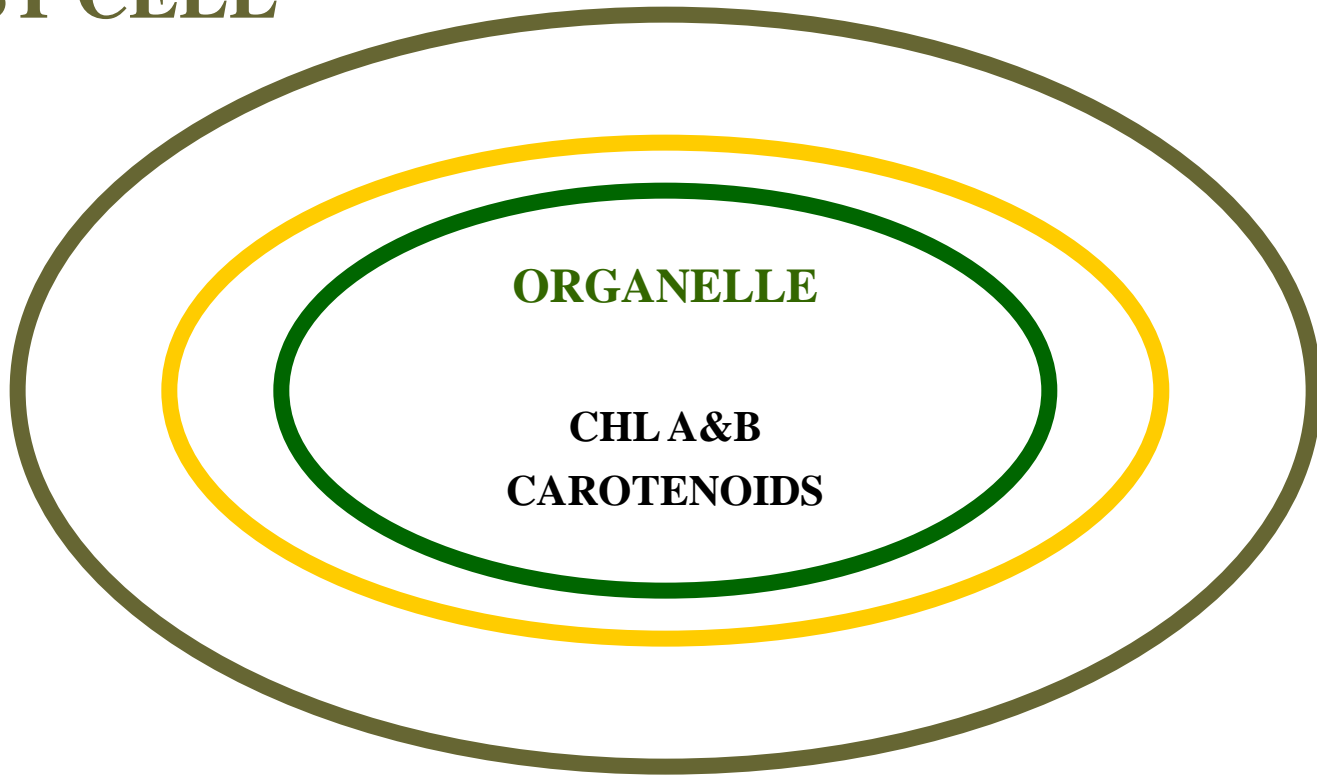
**EUGLENOID  
HOST CELL**



**OBLIGATE RELATIONSHIP**



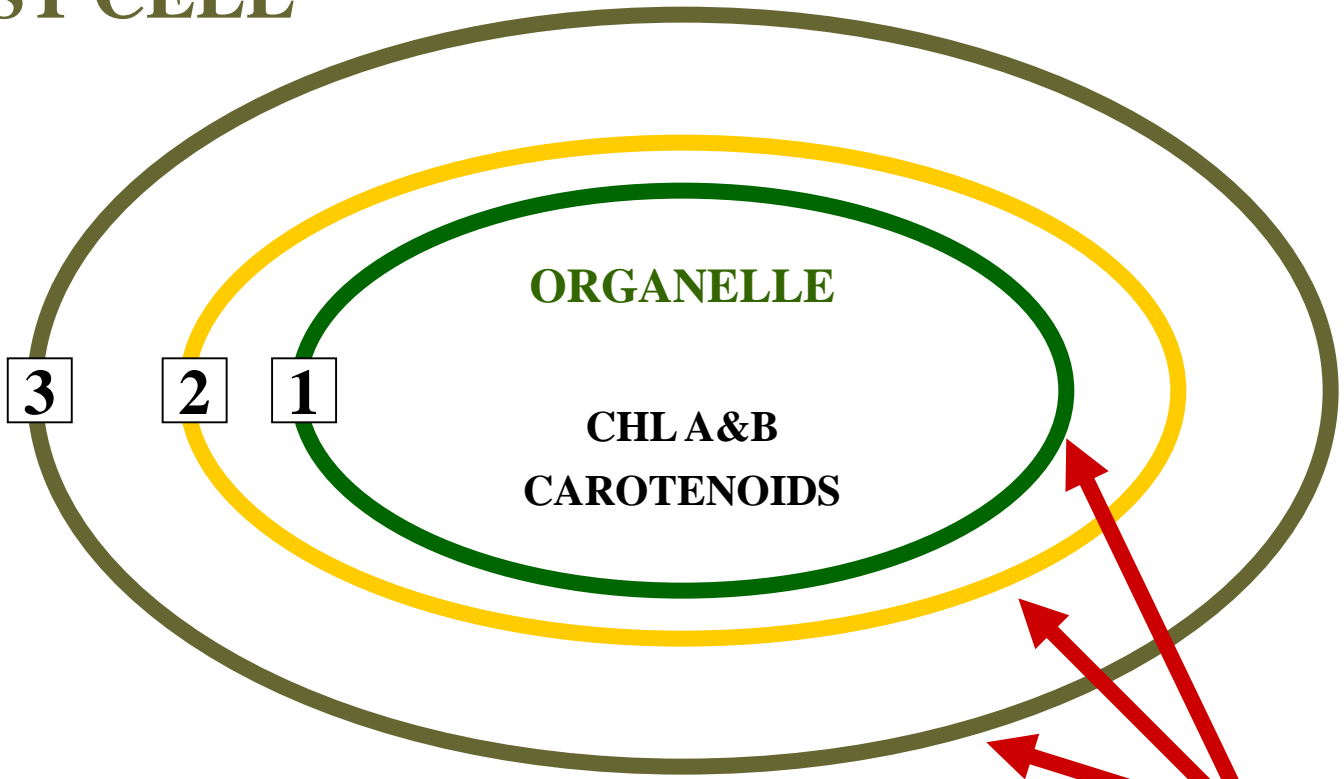
**EUGLENOID  
HOST CELL**



**ORGANELLE**

**CHL A&B  
CAROTENOIDS**

**EUGLENOID  
HOST CELL**



**ORGANELLE**

**CHL A&B  
CAROTENOIDS**

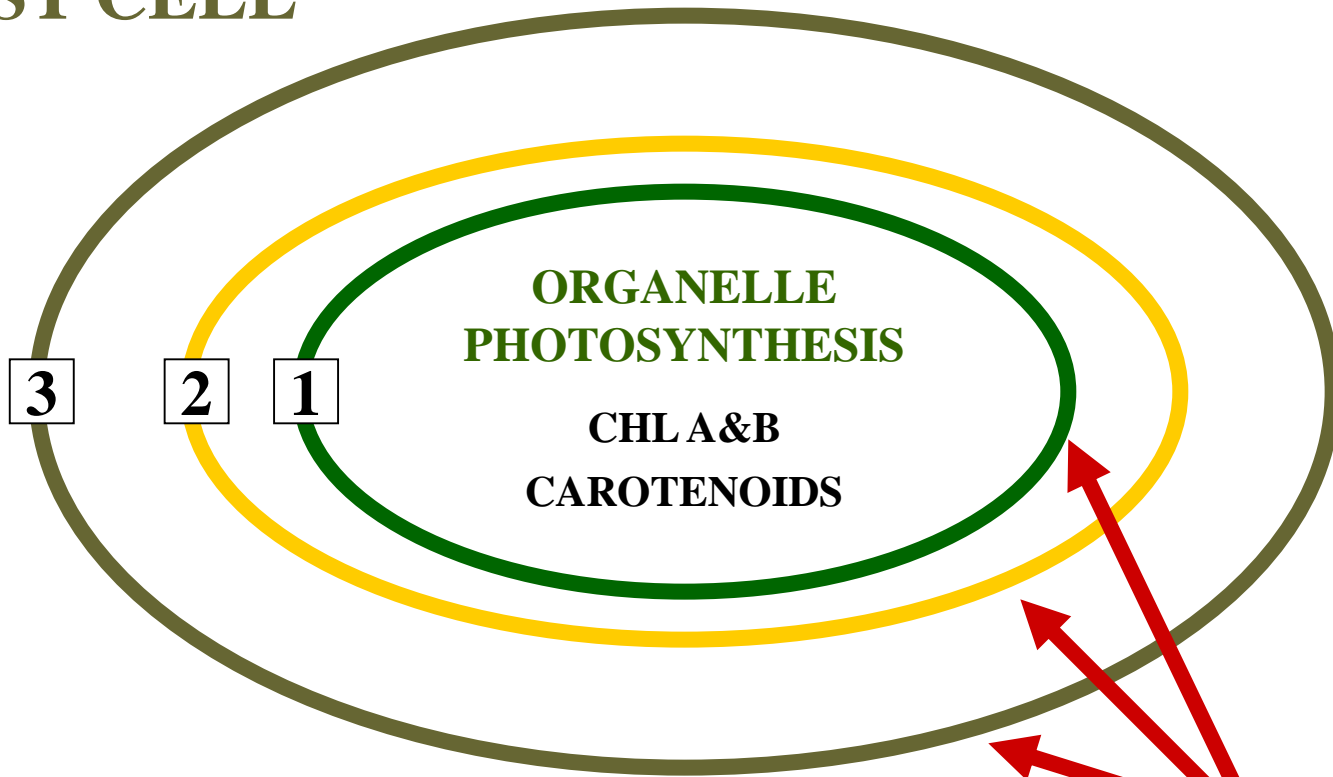
**3**

**2**

**1**

**TRIPLE MEMBRANE**

# EUGLENOID HOST CELL



**ORGANELLE  
PHOTOSYNTHESIS**

**CHL A&B  
CAROTENOIDS**

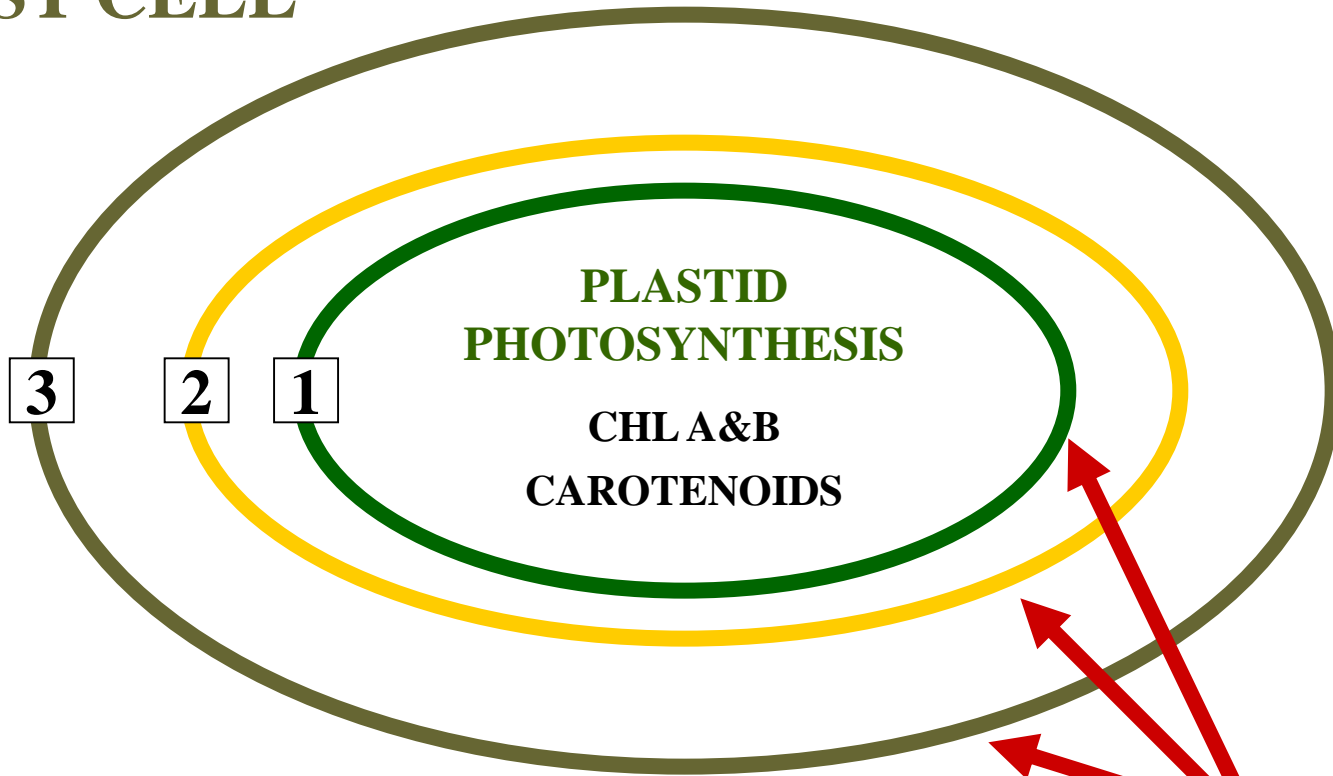
**3**

**2**

**1**

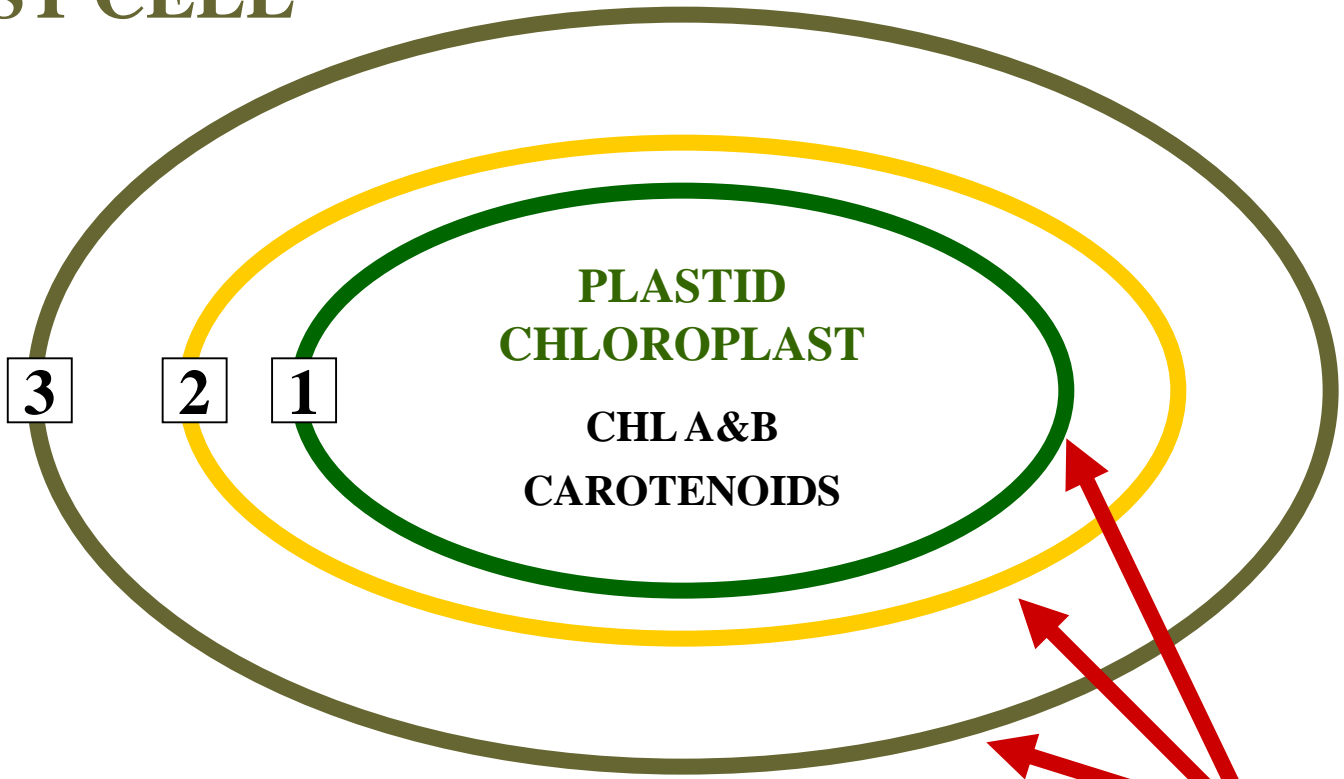
**TRIPLE MEMBRANE**

# EUGLENOID HOST CELL



**TRIPLE MEMBRANE**

# EUGLENOID HOST CELL

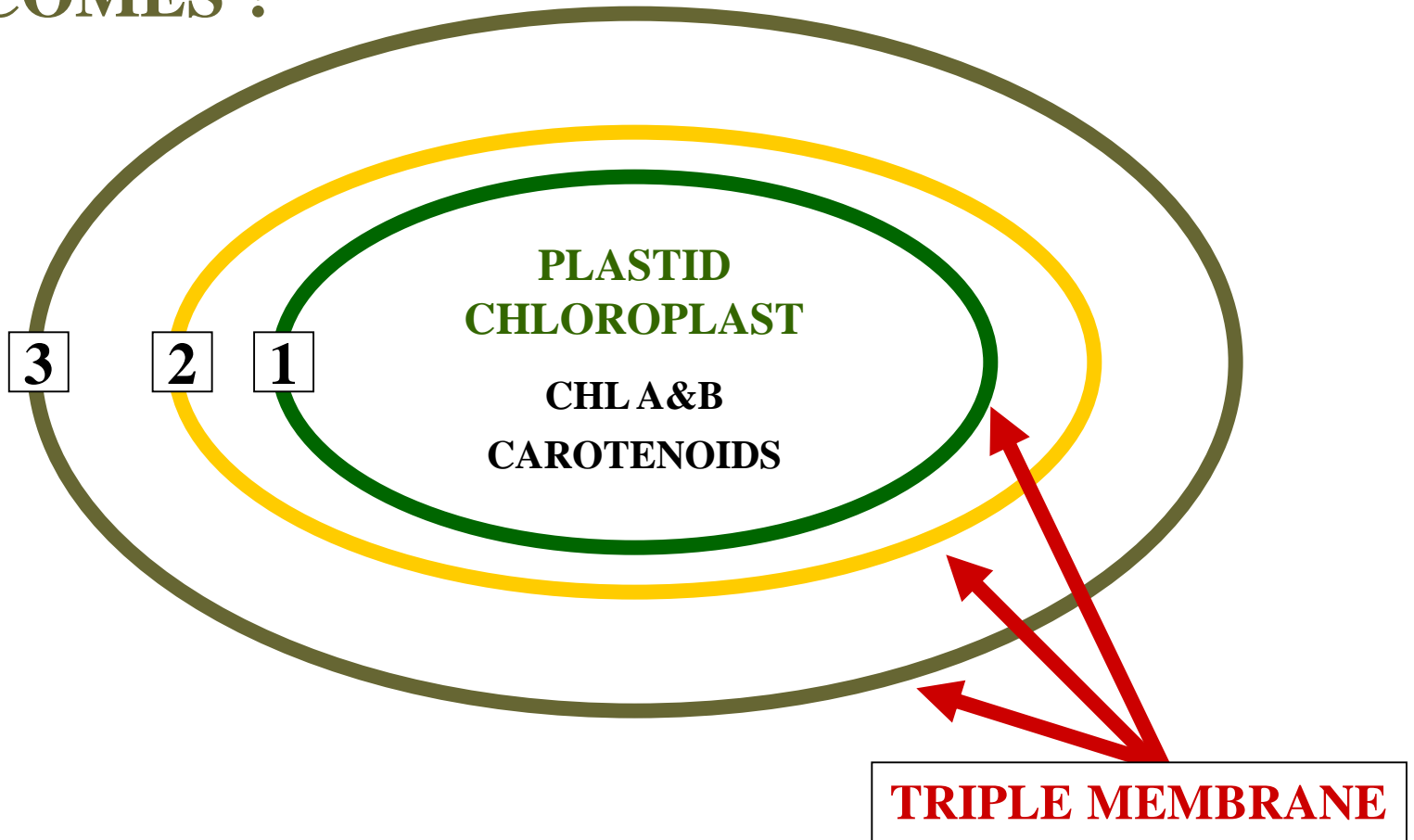


**PLASTID  
CHLOROPLAST**  
**CHL A&B**  
**CAROTENOIDS**

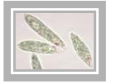
**3**   **2**   **1**

**TRIPLE MEMBRANE**

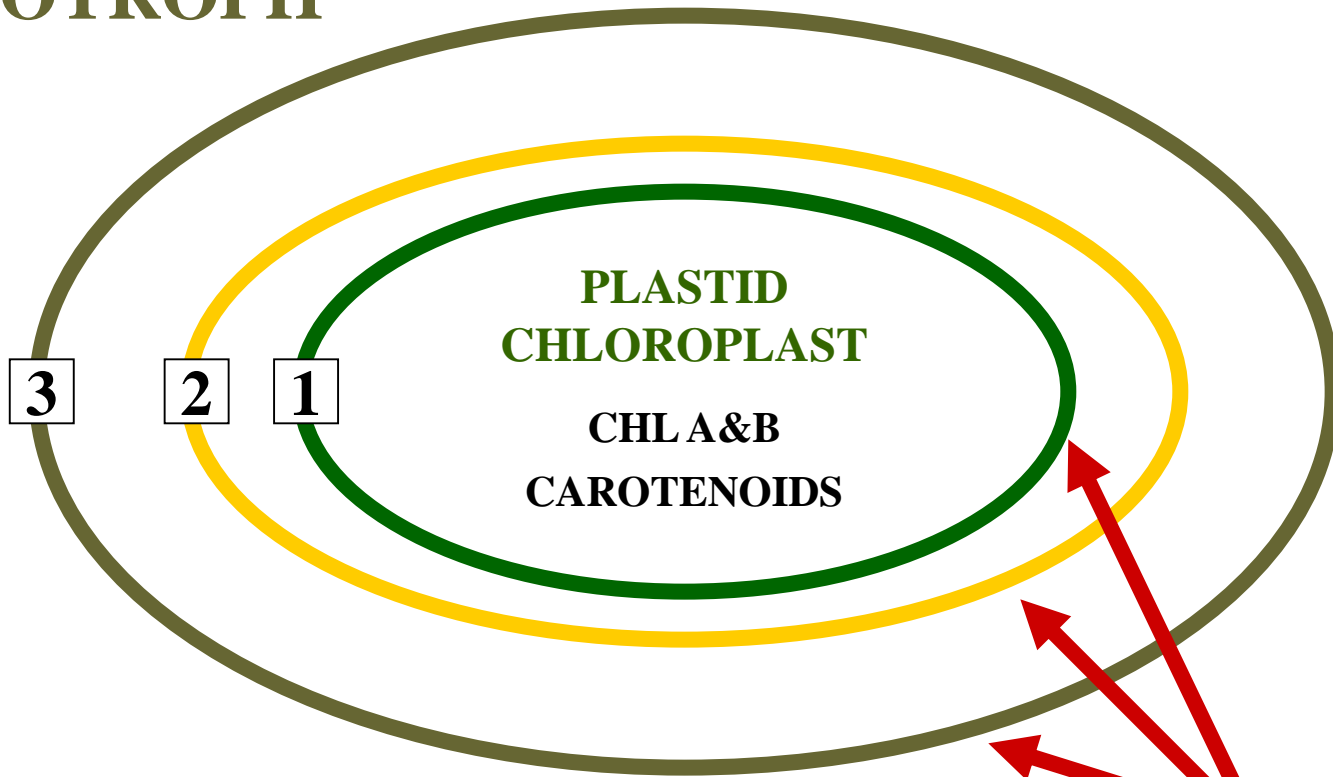
# EUGLENOID BECOMES ?



# EUGLENOID AUTOTROPH

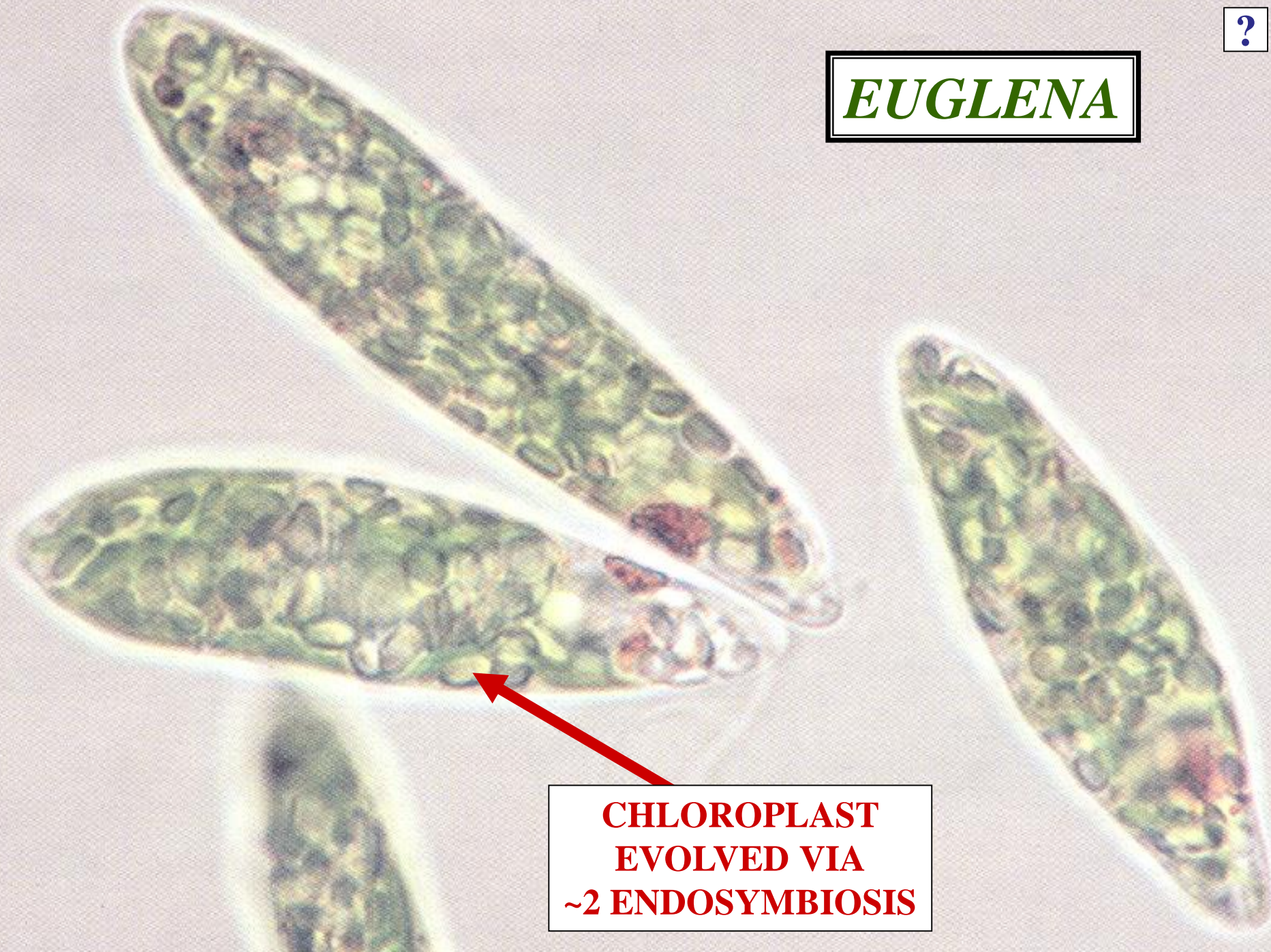


S



**TRIPLE MEMBRANE**

***EUGLENA***



**CHLOROPLAST  
EVOLVED VIA  
~2 ENDOSYMBIOSIS**



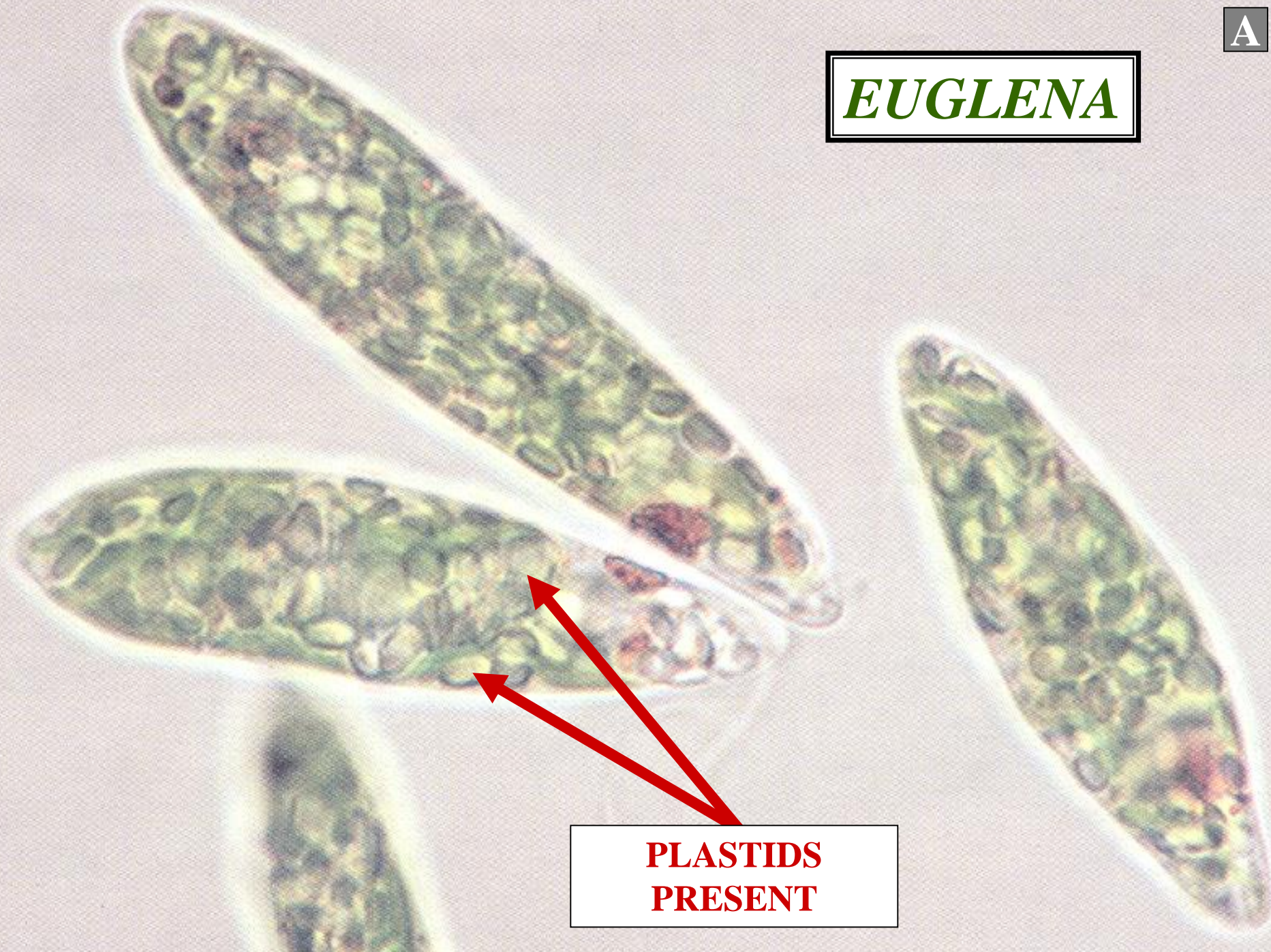
QUESTION



IS A *Euglena* A  
PLANT?

QUESTION

***EUGLENA***



**PLASTIDS  
PRESENT**



**ANSWER**

**YES**

**---**

**PLASTIDS**

**PRESENT**

**ANSWER**

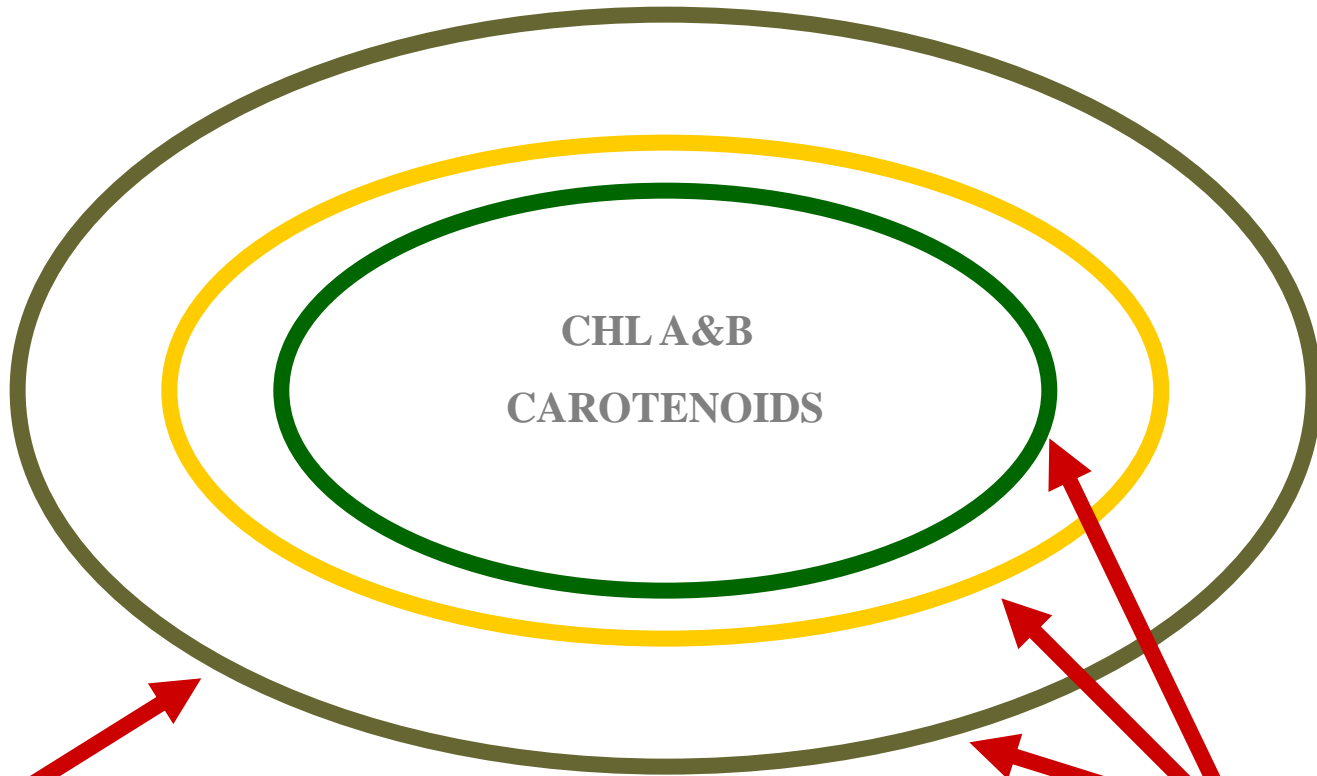
**QUESTION**



**IS A *Euglena* A  
TRUE PLANT?**

**QUESTION**

# *EUGLENA*



**PLASTID / CHLOROPLAST**

**TRIPLE MEMBRANE**

**ANSWER**



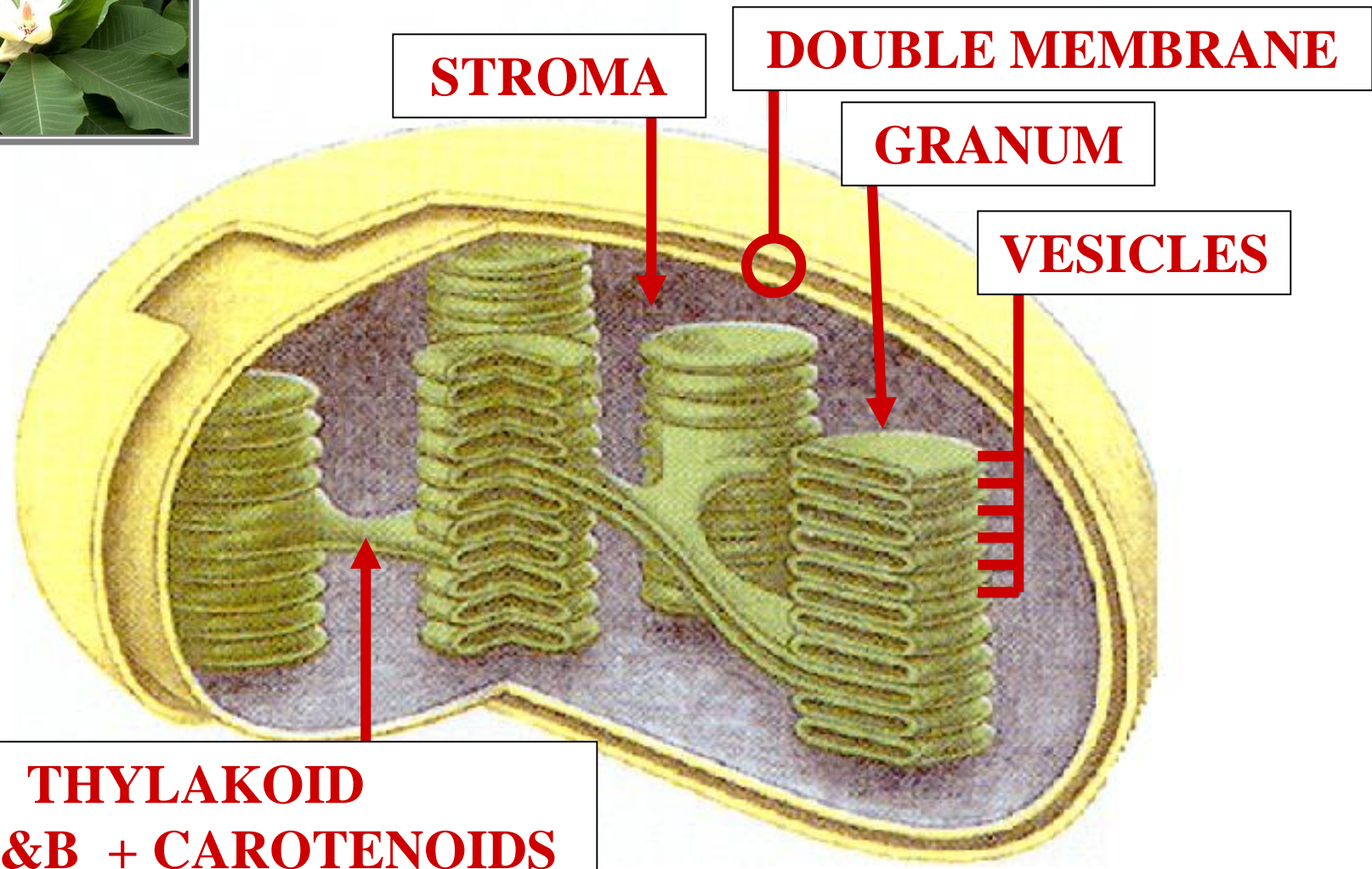
**NO**

**---**

**TRIPLE MEMBRANED  
PLASTIDS**

**ANSWER**

# TRUE PLANT CHLOROPLAST ULTRASTRUCTURE



**QUESTION**

IS A *Euglena*

**PHYLOGENETICALLY  
CLOSELY RELATED TO  
TRUE PLANTS?**

**QUESTION**



**ANSWER**

**NO**

**---**

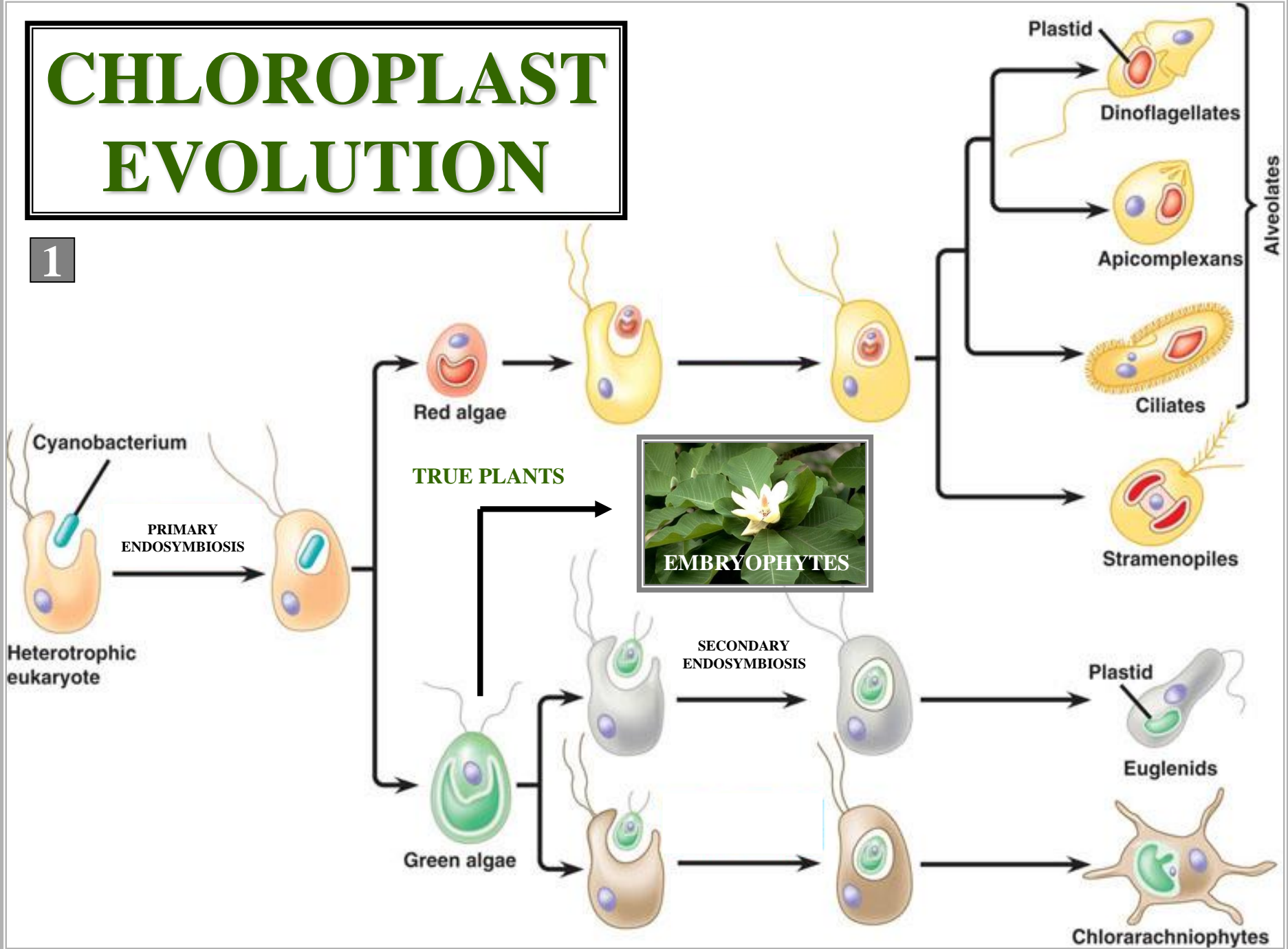
*Euglena* **UNDERWENT A  
SECONDARY  
ENDOSYMBIOSIS**

**ANSWER**



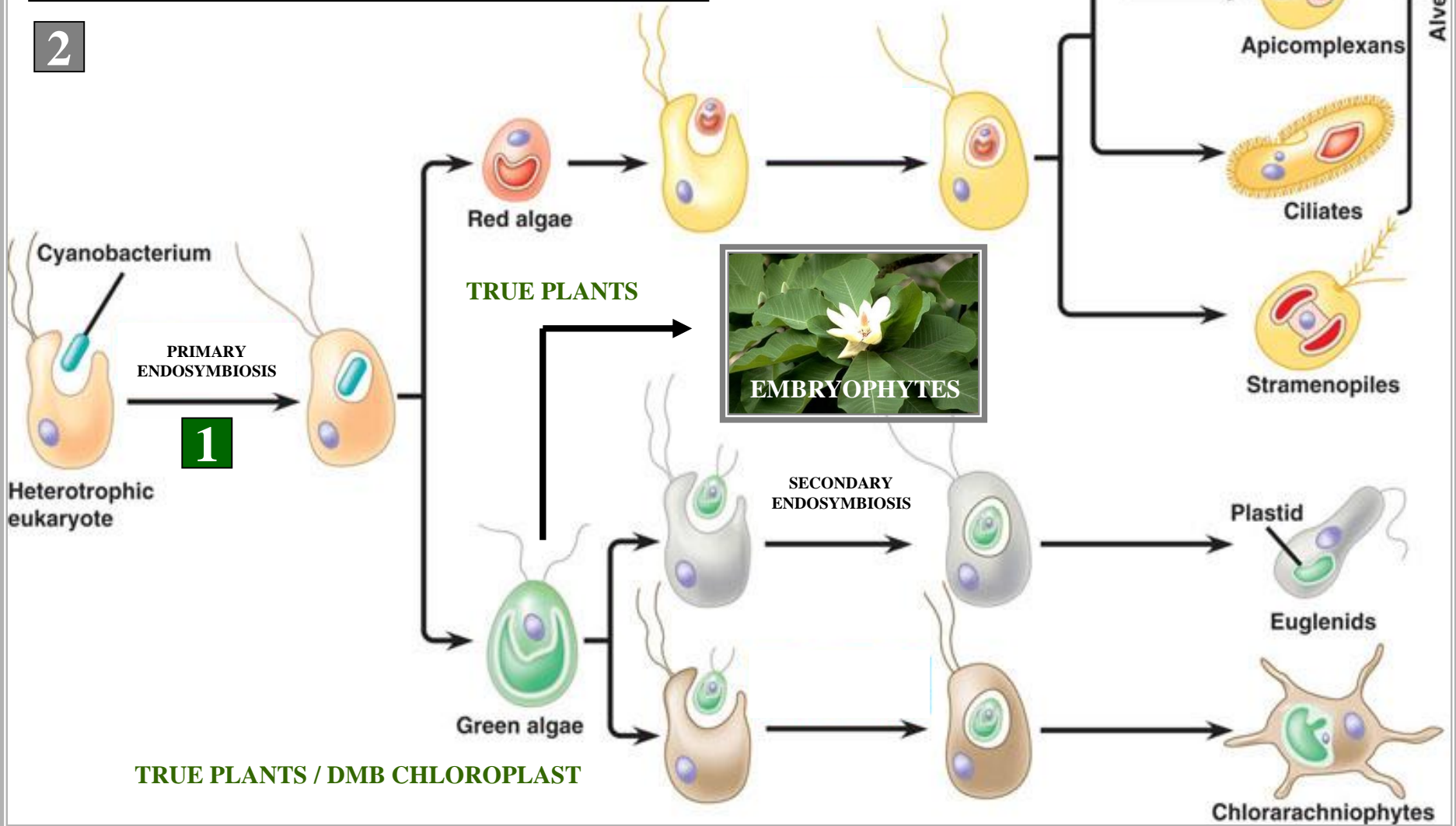
# CHLOROPLAST EVOLUTION

1

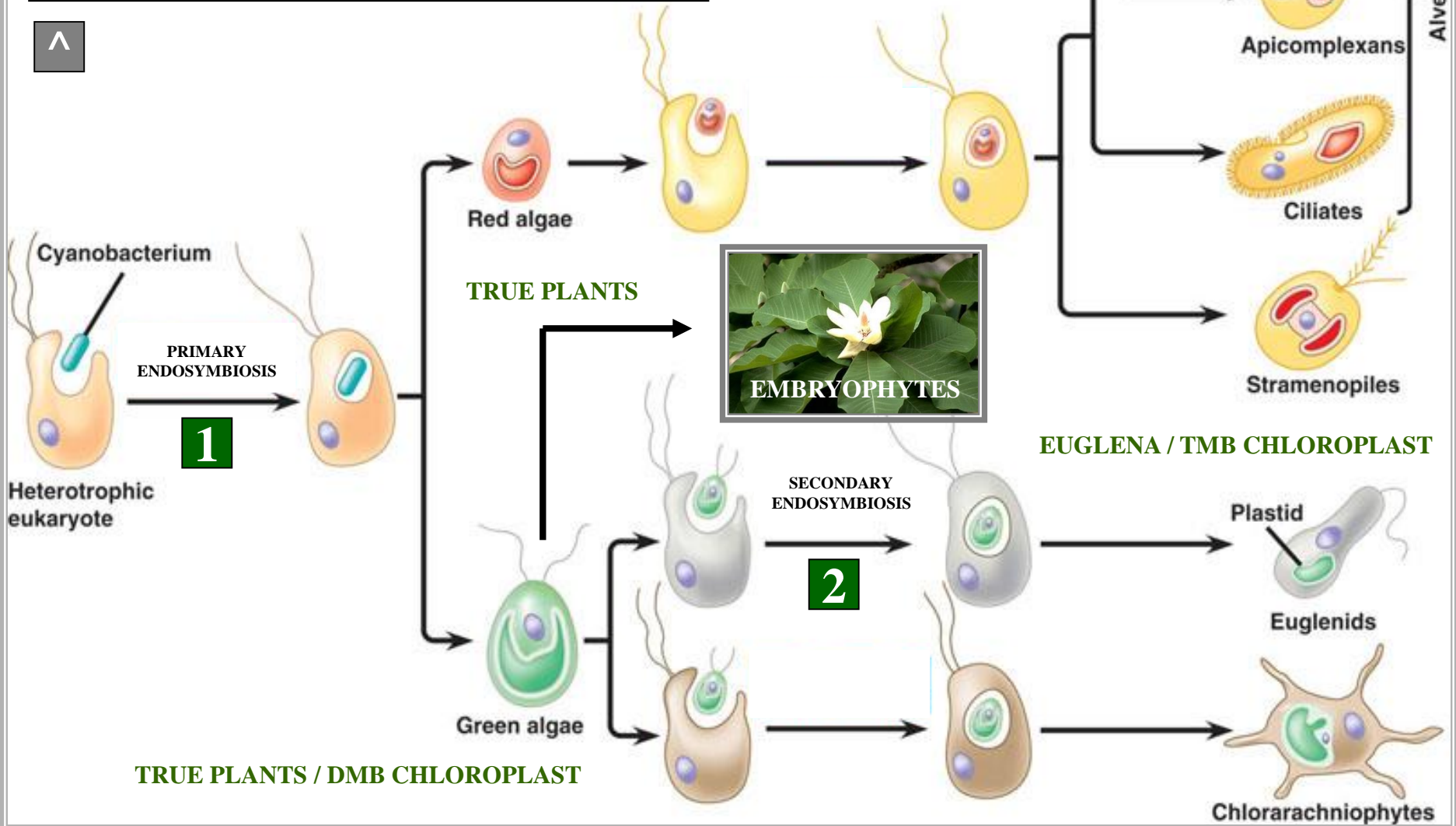


# CHLOROPLAST EVOLUTION

2



# CHLOROPLAST EVOLUTION





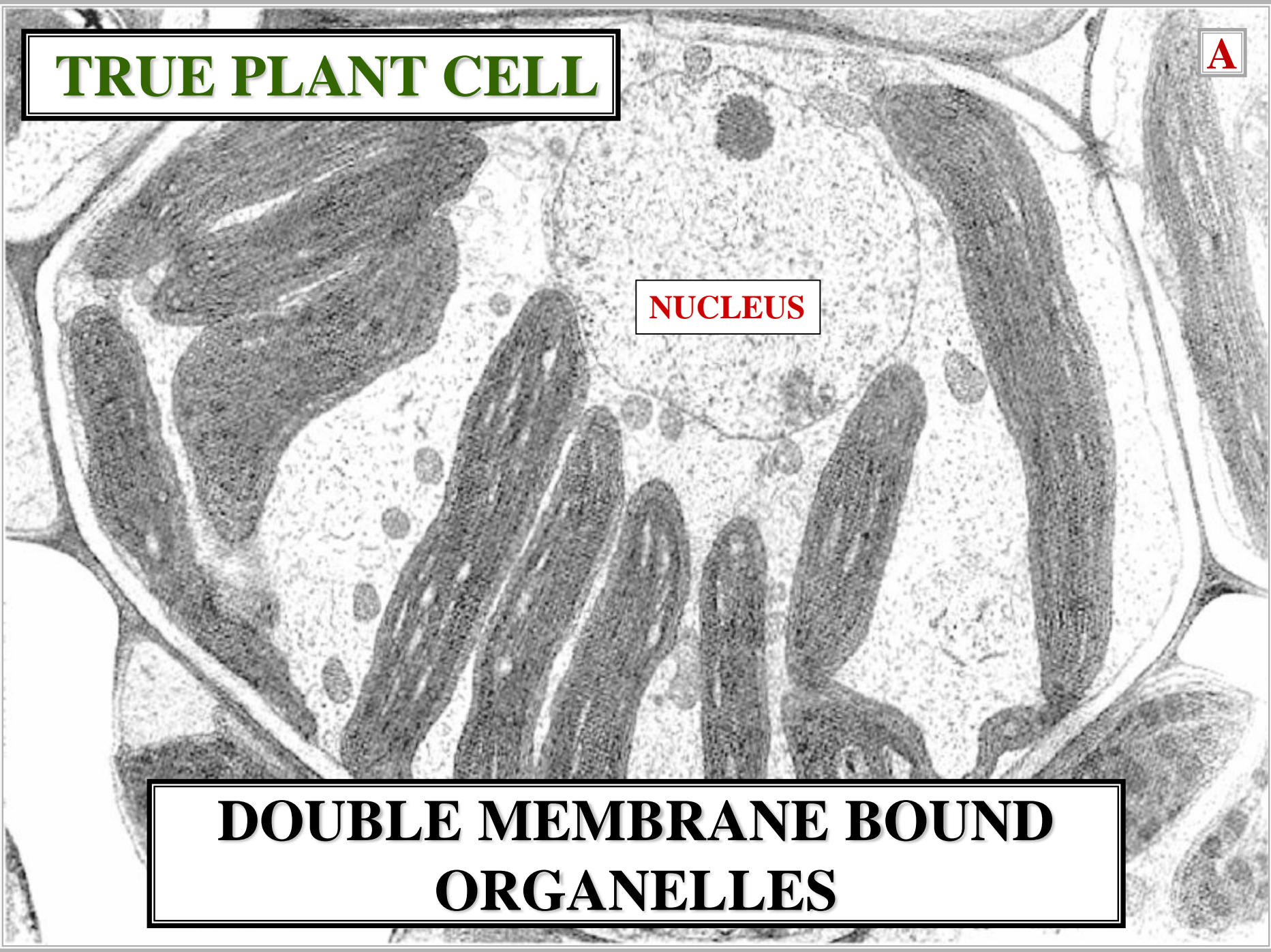
# DMBO EVOLUTION SUMMARY

# TRUE PLANT CELL

A

NUCLEUS

**DOUBLE MEMBRANE BOUND  
ORGANELLES**

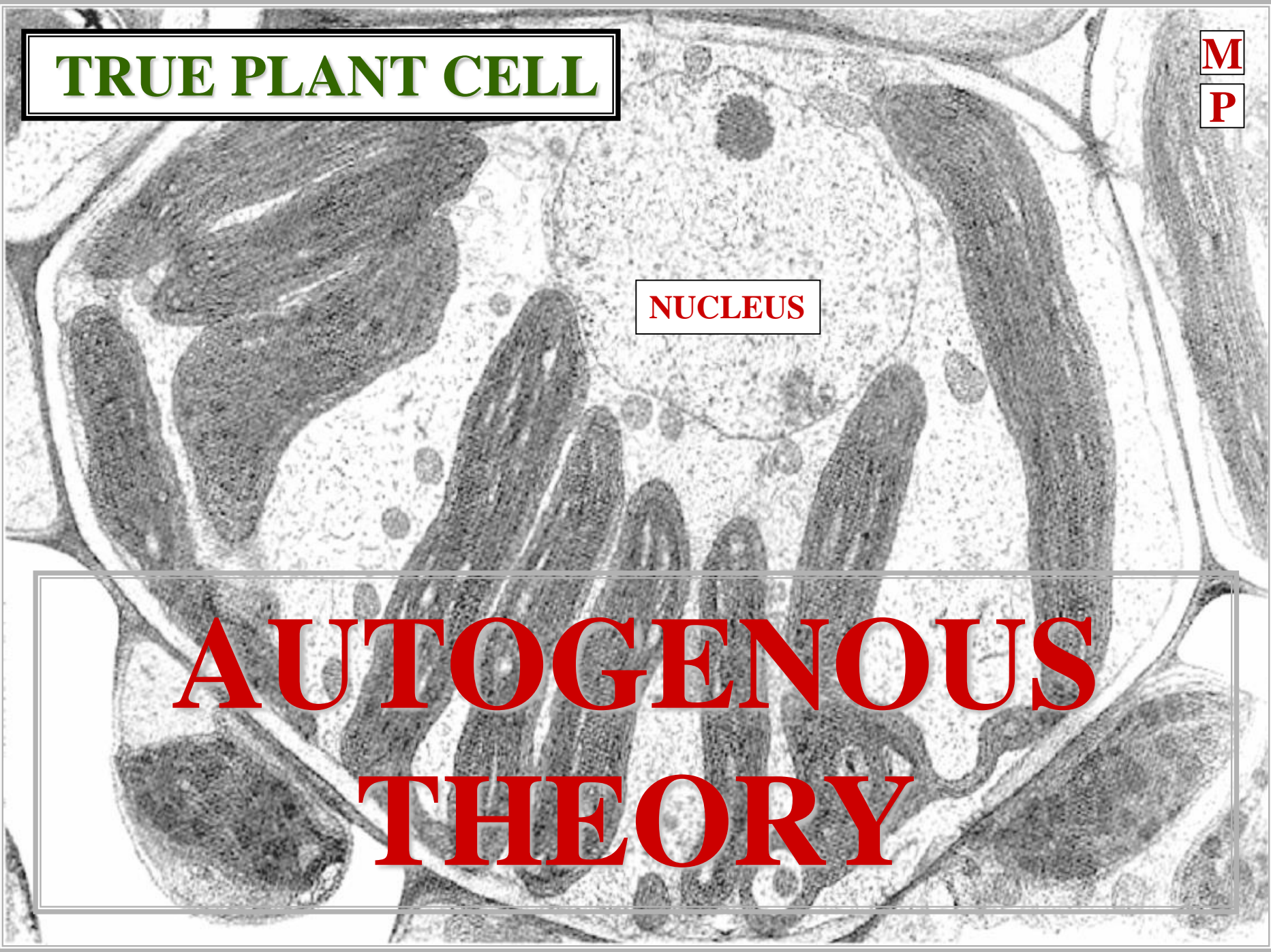


**TRUE PLANT CELL**

**M**  
**P**

**NUCLEUS**

**AUTOGENOUS  
THEORY**



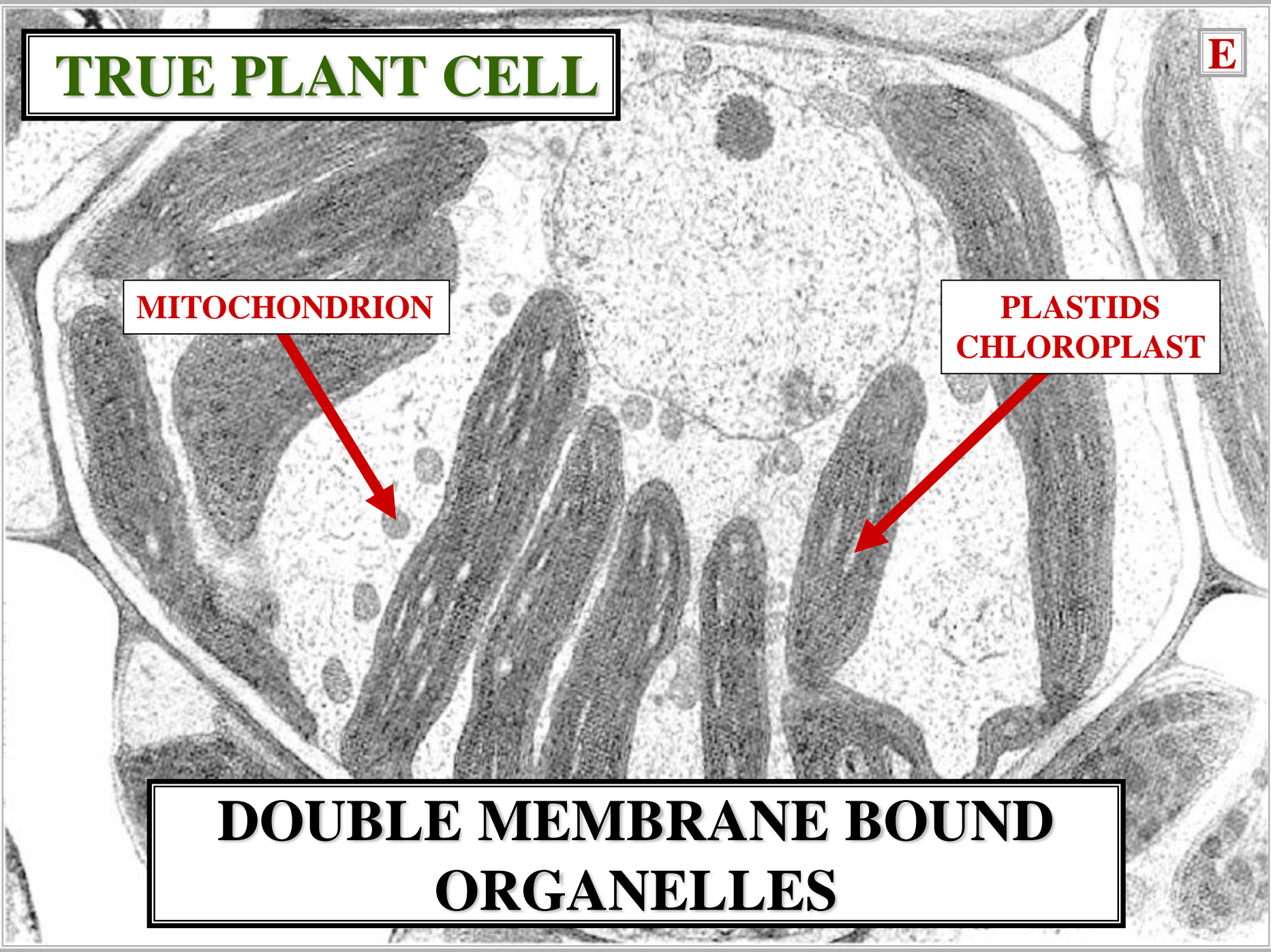
# TRUE PLANT CELL

E

MITOCHONDRION

PLASTIDS  
CHLOROPLAST

DOUBLE MEMBRANE BOUND  
ORGANELLES



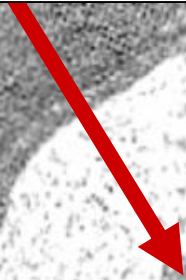


# TRUE PLANT CELL

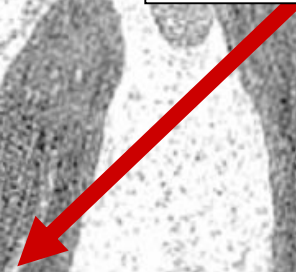


D

MITOCHONDRION



PLASTIDS  
CHLOROPLAST



# ENDOSYMBIOTIC THEORY



TP

2.1 – 1.8  
BILLION YEARS

**DIVERSE  
EUKARYOTE  
BIOTA**

**EARTH**



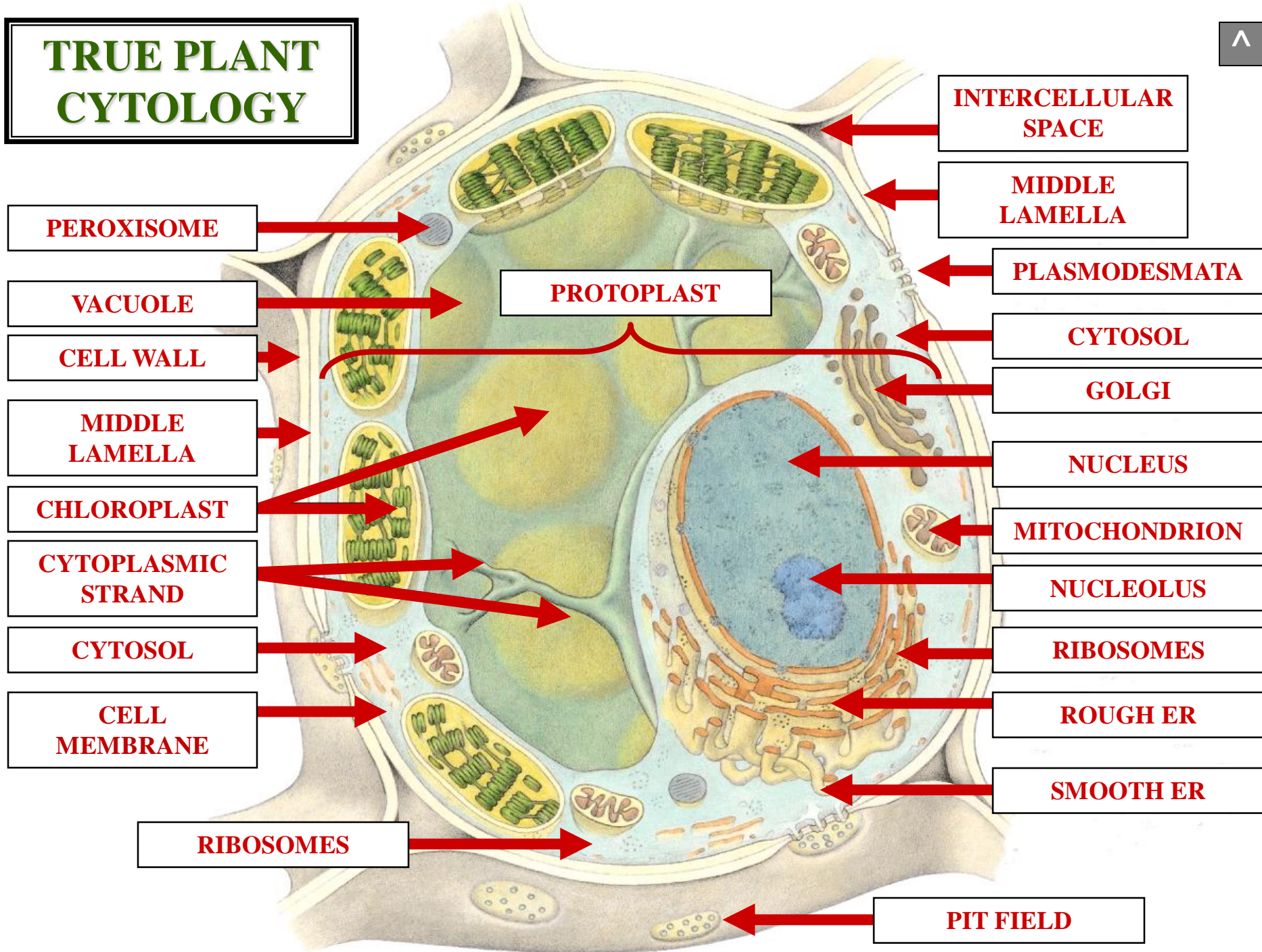
# TRUE PLANTS

EARTH



# TRUE PLANT CYTOLOGY

# TRUE PLANT CYTOLOGY



# MIDDLE LAMELLA

**MIDDLE LAMELLA**



# **MIDDLE LAMELLA**

**AREA BETWEEN ADJACENT  
PLANT CELLS**

**MIDDLE LAMELLA**





# **MIDDLE LAMELLA**

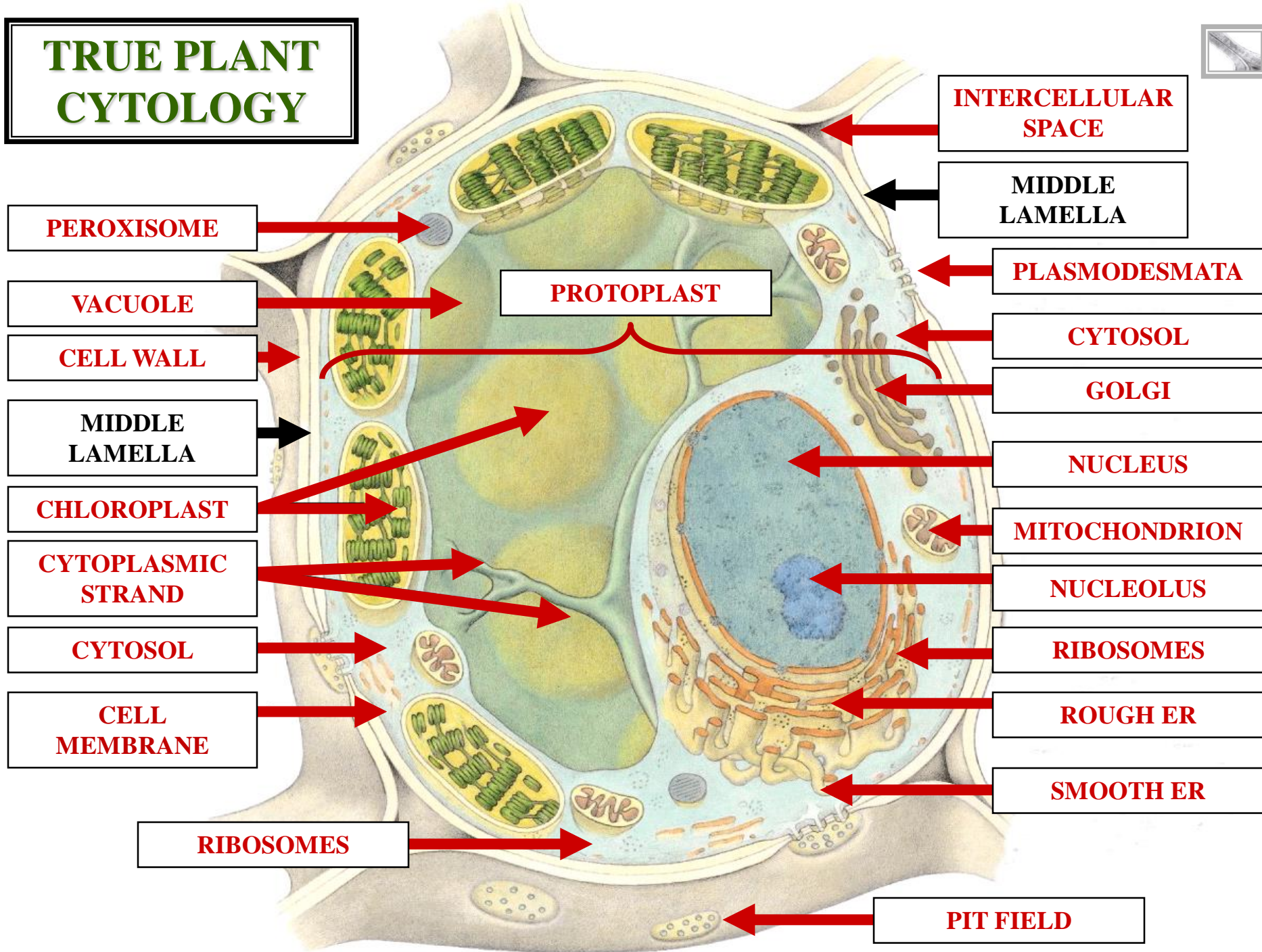
**AREA BETWEEN ADJACENT  
PLANT CELLS**

**---**

**BONDS ADJACENT CELLS**

**MIDDLE LAMELLA**

# TRUE PLANT CYTOLOGY





**CELL #2**

The image shows a grayscale micrograph of a biological specimen, likely a cross-section of a plant stem or a similar structure. The specimen is oriented diagonally from the top-left to the bottom-right. It consists of several distinct layers or cells. A prominent, thick, light-colored layer runs along the left side, labeled 'CELL #1'. To its right, there is a darker, more textured region labeled 'CELL #2'. At the very center, a thin, dark line is labeled 'C.S.'. The overall appearance is that of a layered, fibrous or cellular structure.

**C**

**CELL #1**

**C.S.**

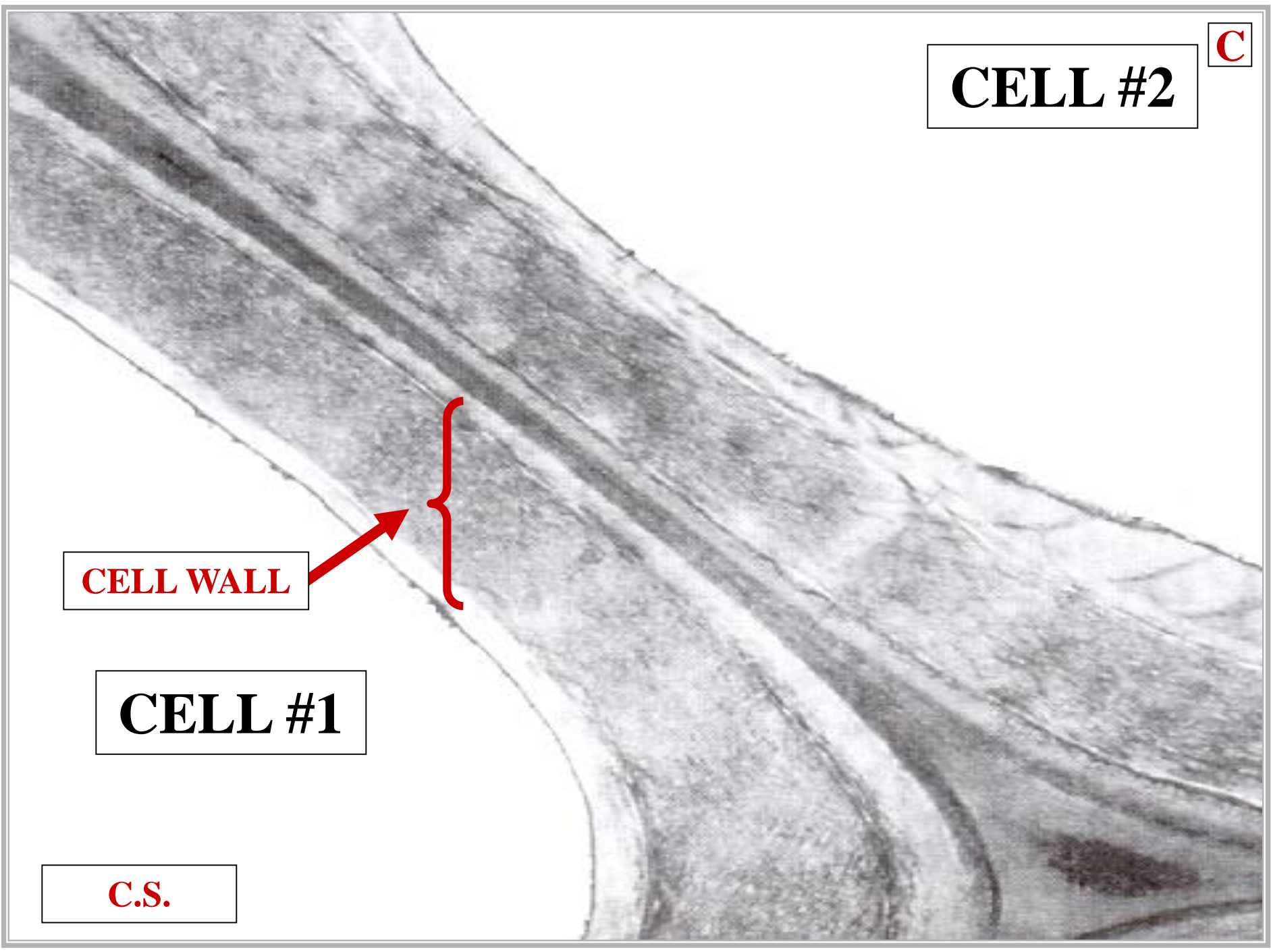
**CELL #2**

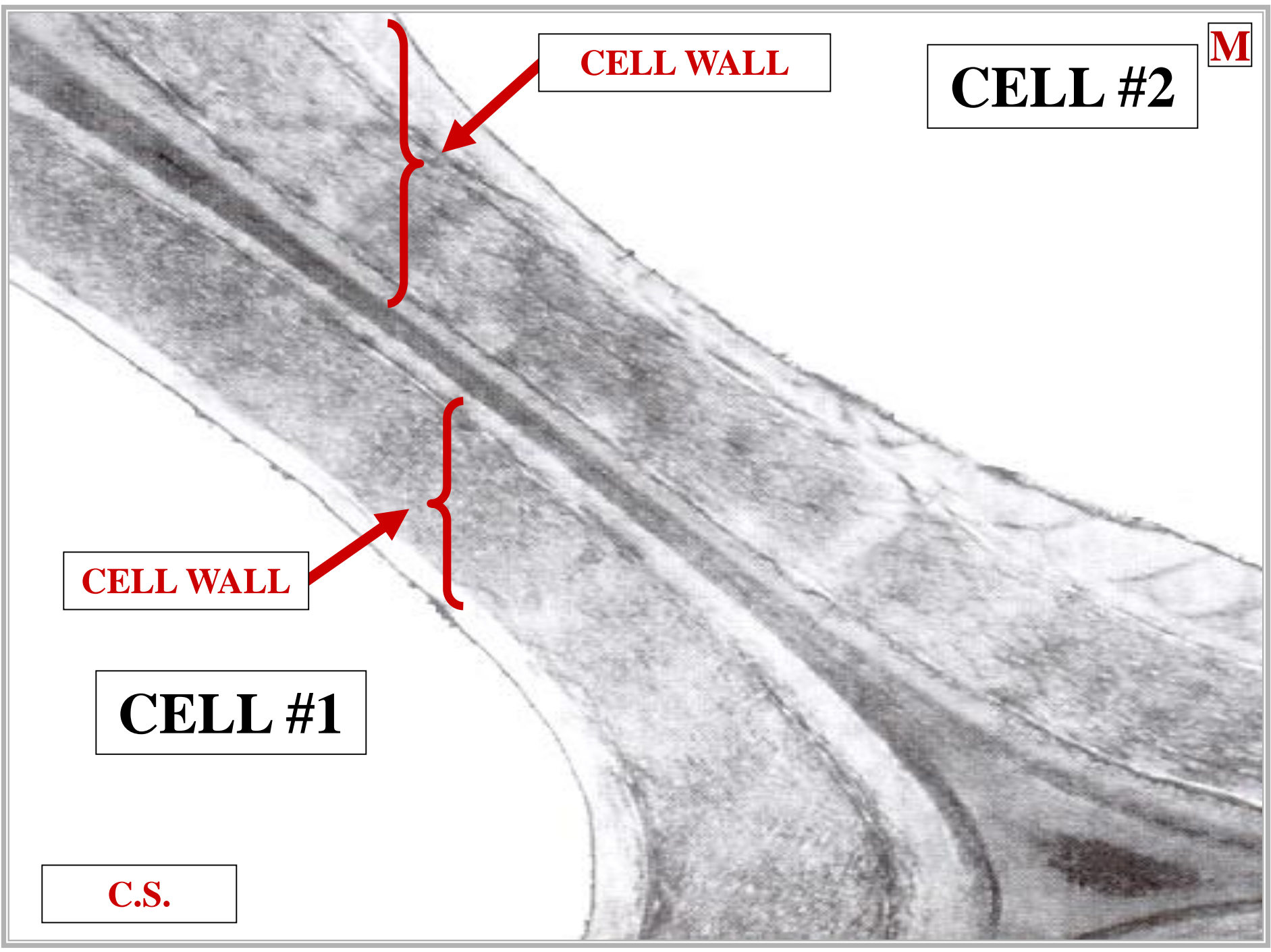
**C**

**CELL WALL**

**CELL #1**

**C.S.**





**CELL WALL**

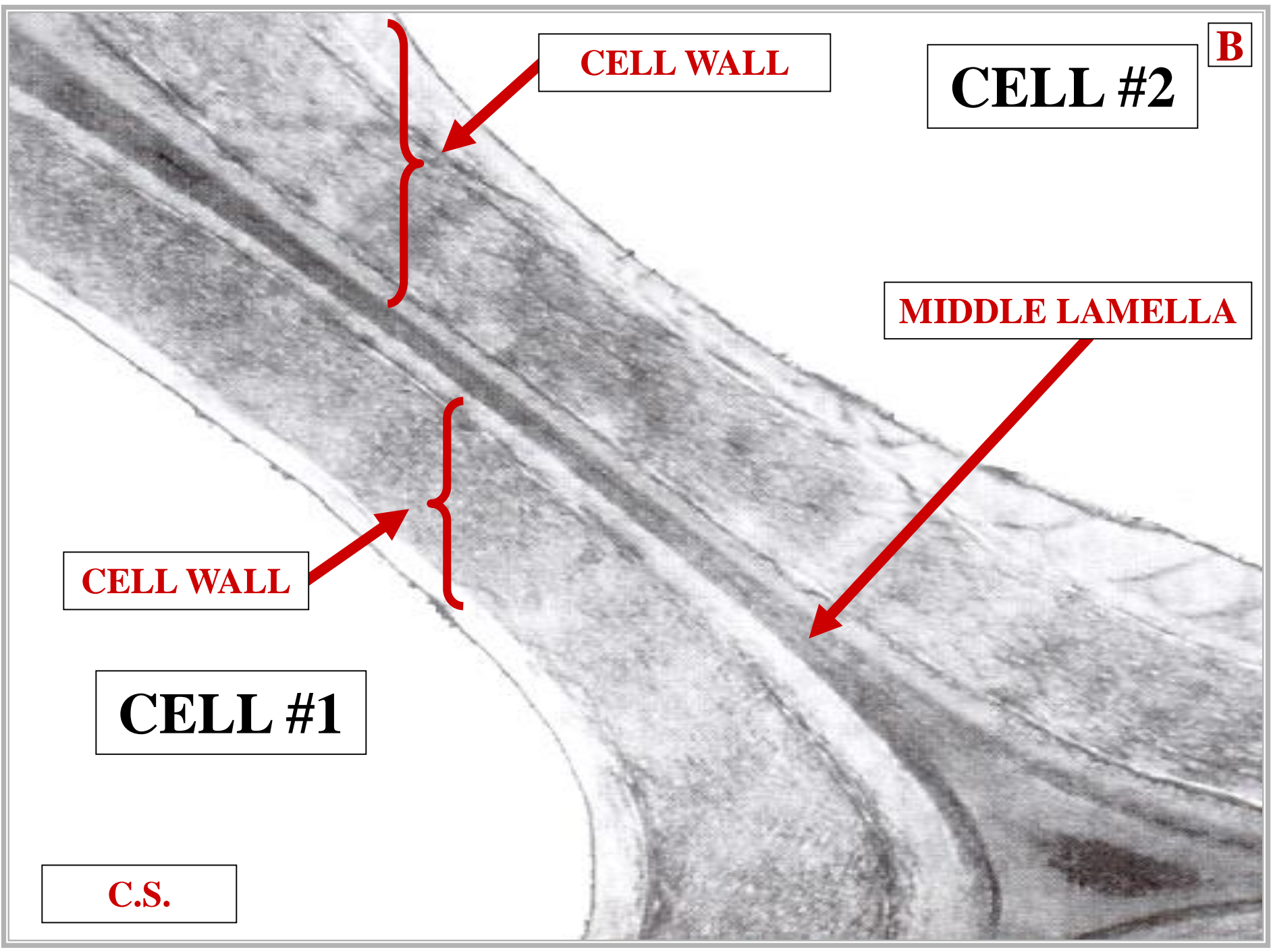
**CELL #2**

**M**

**CELL WALL**

**CELL #1**

**C.S.**



**CELL WALL**

**CELL #2**

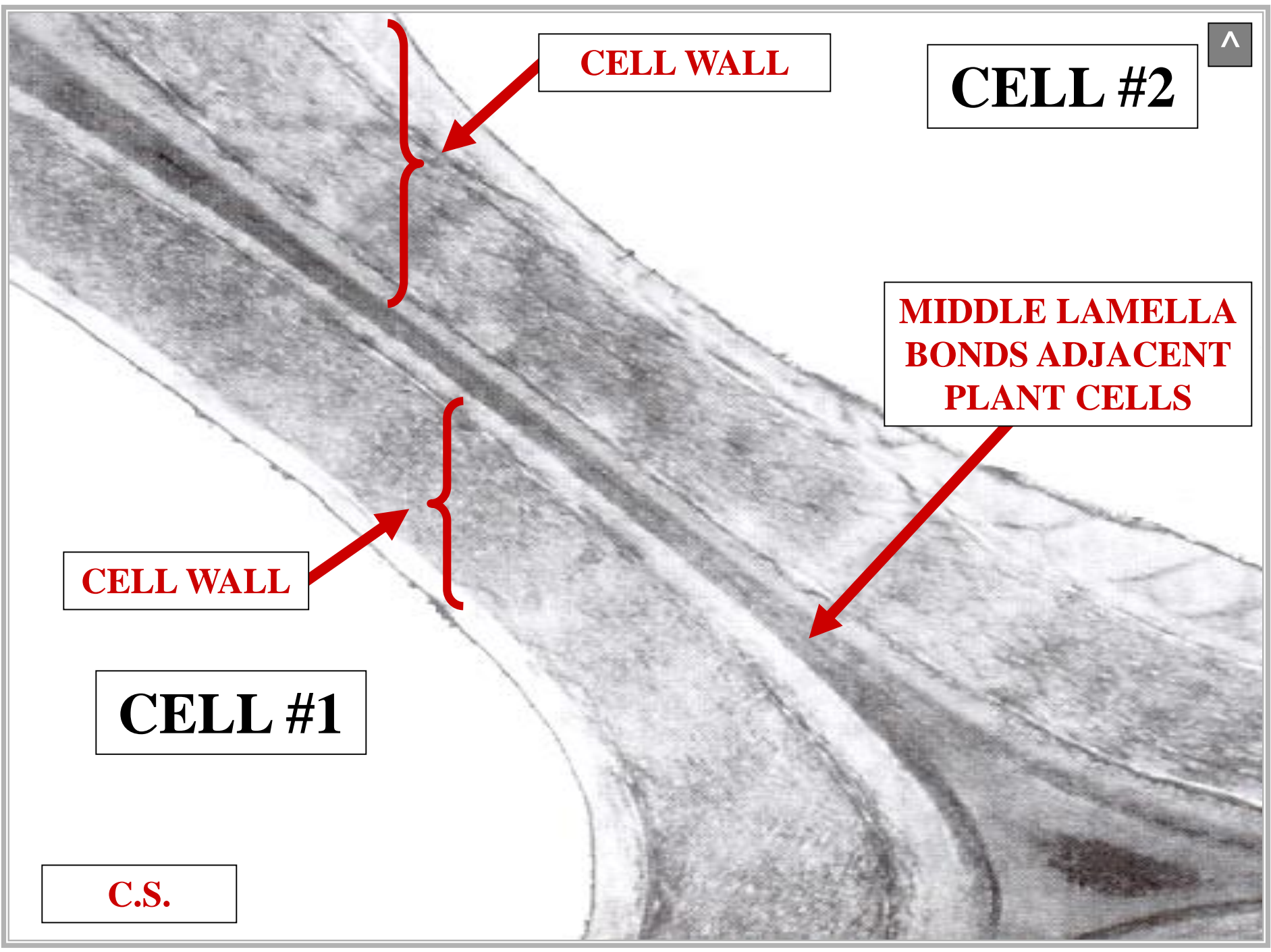
**B**

**MIDDLE LAMELLA**

**CELL WALL**

**CELL #1**

**C.S.**



**CELL WALL**

**CELL #2**



**MIDDLE LAMELLA  
BONDS ADJACENT  
PLANT CELLS**

**CELL WALL**

**CELL #1**

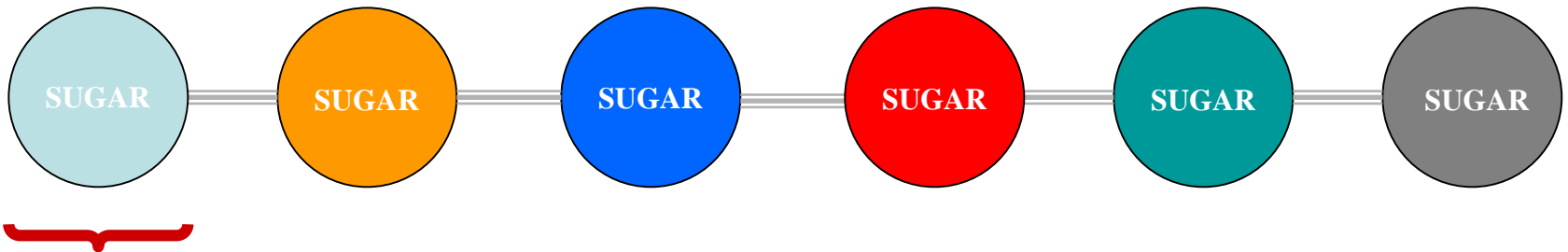
**C.S.**



# MIDDLE LAMELLA COMPOSITION

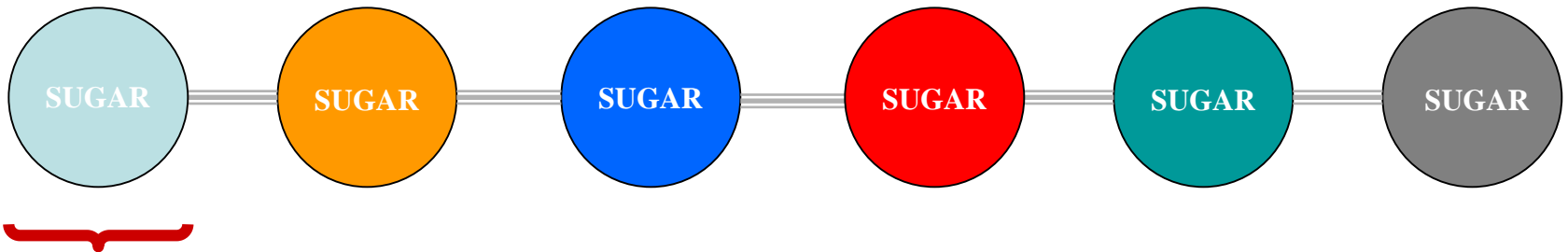


# MIDDLE LAMELLA COMPOSITION



**MONOSACCHARIDE** **== = BOND**

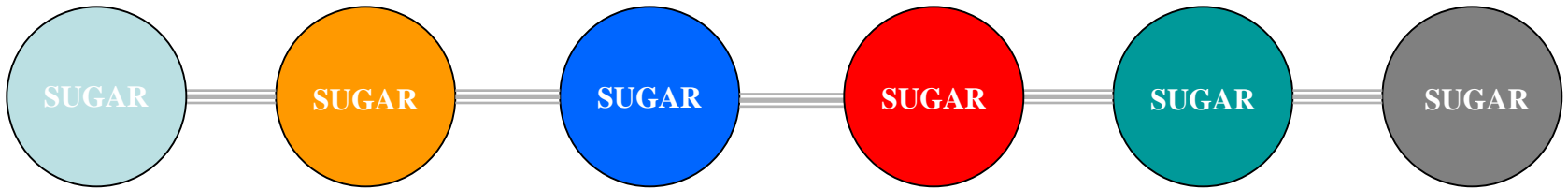
# MIDDLE LAMELLA COMPOSITION



**MONOSACCHARIDE**    **==** = **BOND**

?

# MIDDLE LAMELLA COMPOSITION



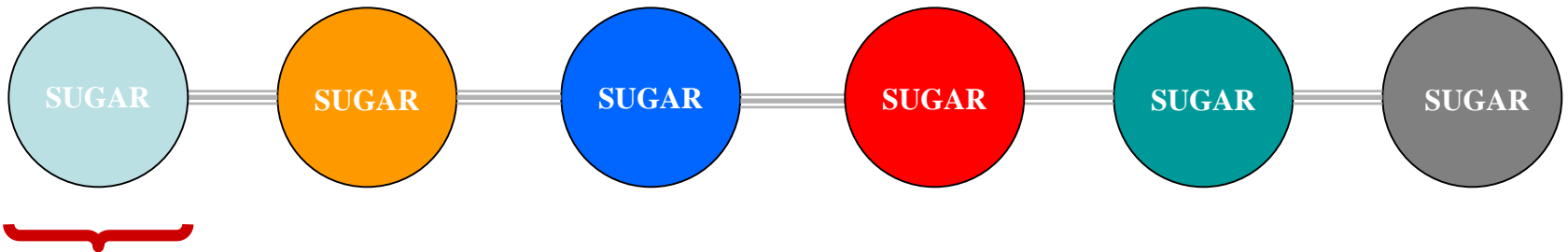
**MONOSACCHARIDE**    **==** = **BOND**



**POLYSACCHARIDE**

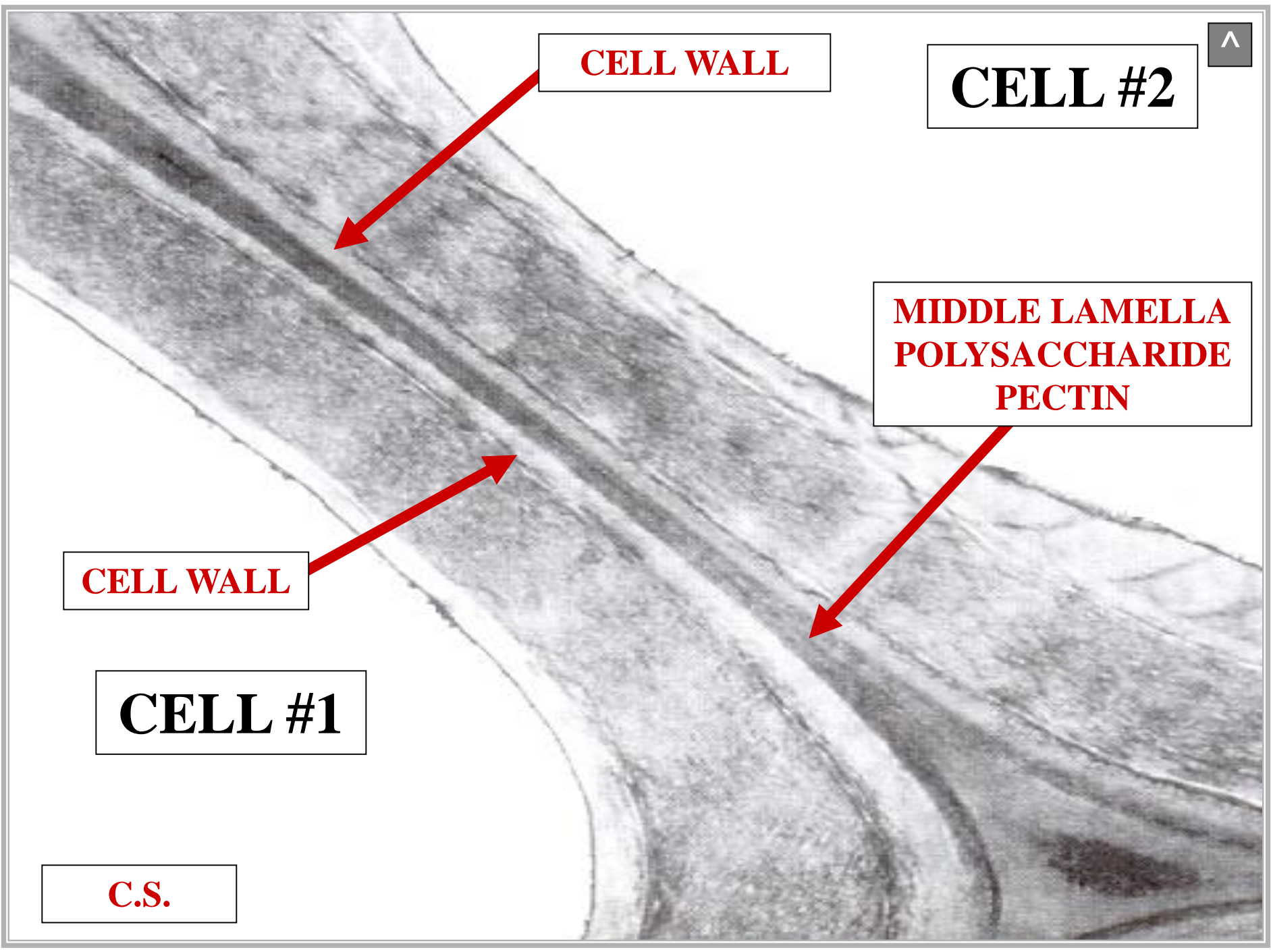


# MIDDLE LAMELLA COMPOSITION



**MONOSACCHARIDE** == = **BOND**

**POLYSACCHARIDE = PECTIN**



**CELL WALL**

**CELL #2**



**MIDDLE LAMELLA  
POLYSACCHARIDE  
PECTIN**

**CELL WALL**

**CELL #1**

**C.S.**

# CELL WALL

**CELL WALL**



**CELL WALL**

**NON-LIVING RIGID LAYER**

**CELL WALL**





# **CELL WALL**

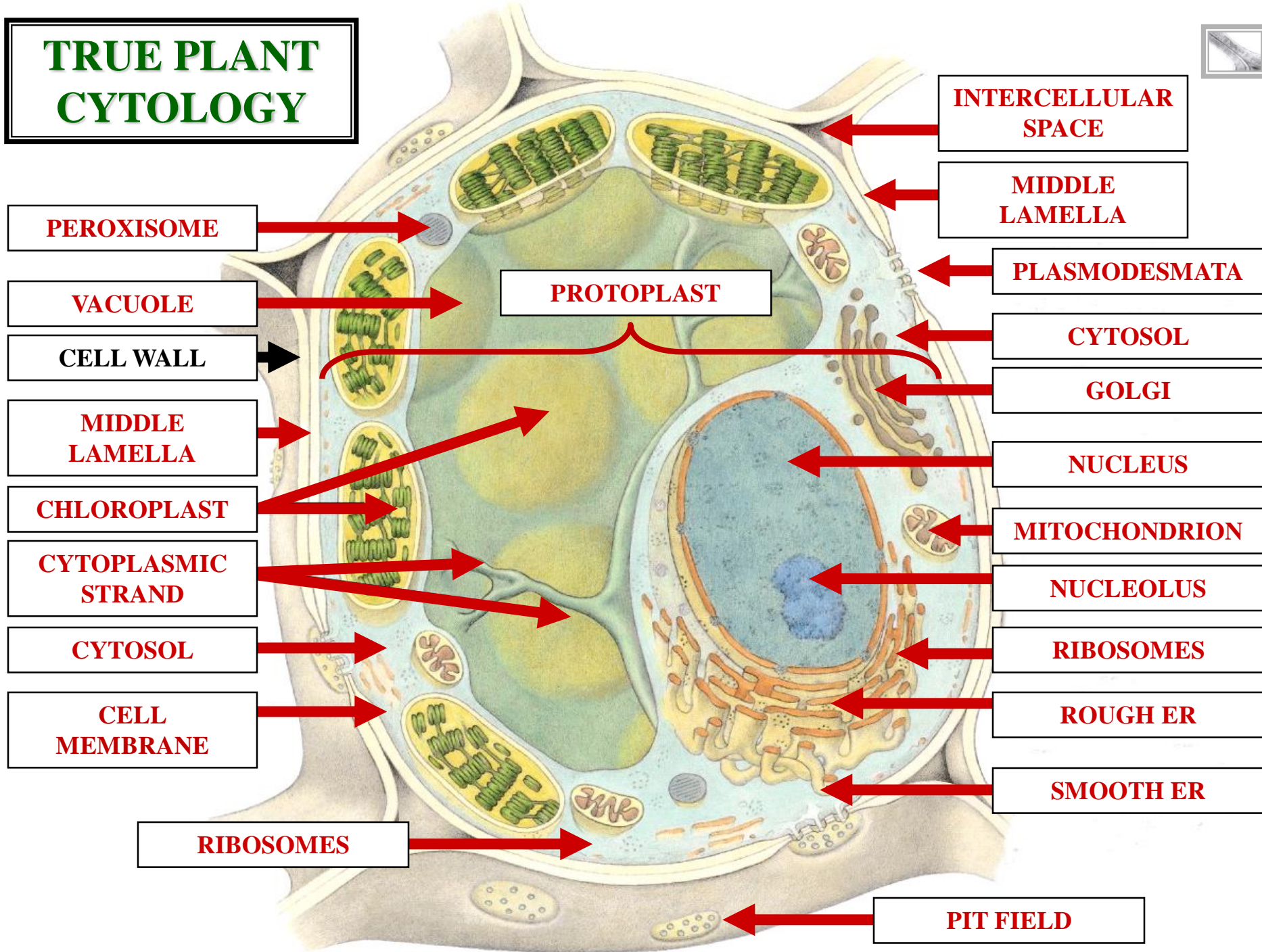
**NON-LIVING RIGID LAYER**

**---**

**SUPPORTS & PROTECTS  
CELL**

**CELL WALL**

# TRUE PLANT CYTOLOGY



A grayscale micrograph showing a biological specimen, likely a cross-section of a plant stem or a similar structure. The specimen is elongated and shows a central region with a distinct, lighter-colored, fibrous or layered structure. This central structure is flanked by two darker, more textured regions. The overall appearance is that of a longitudinal section of a plant stem, showing the vascular bundles and surrounding tissues. The image is framed by a thin black border.

**CELL #2**

**C**

**CELL #1**

**C.S.**

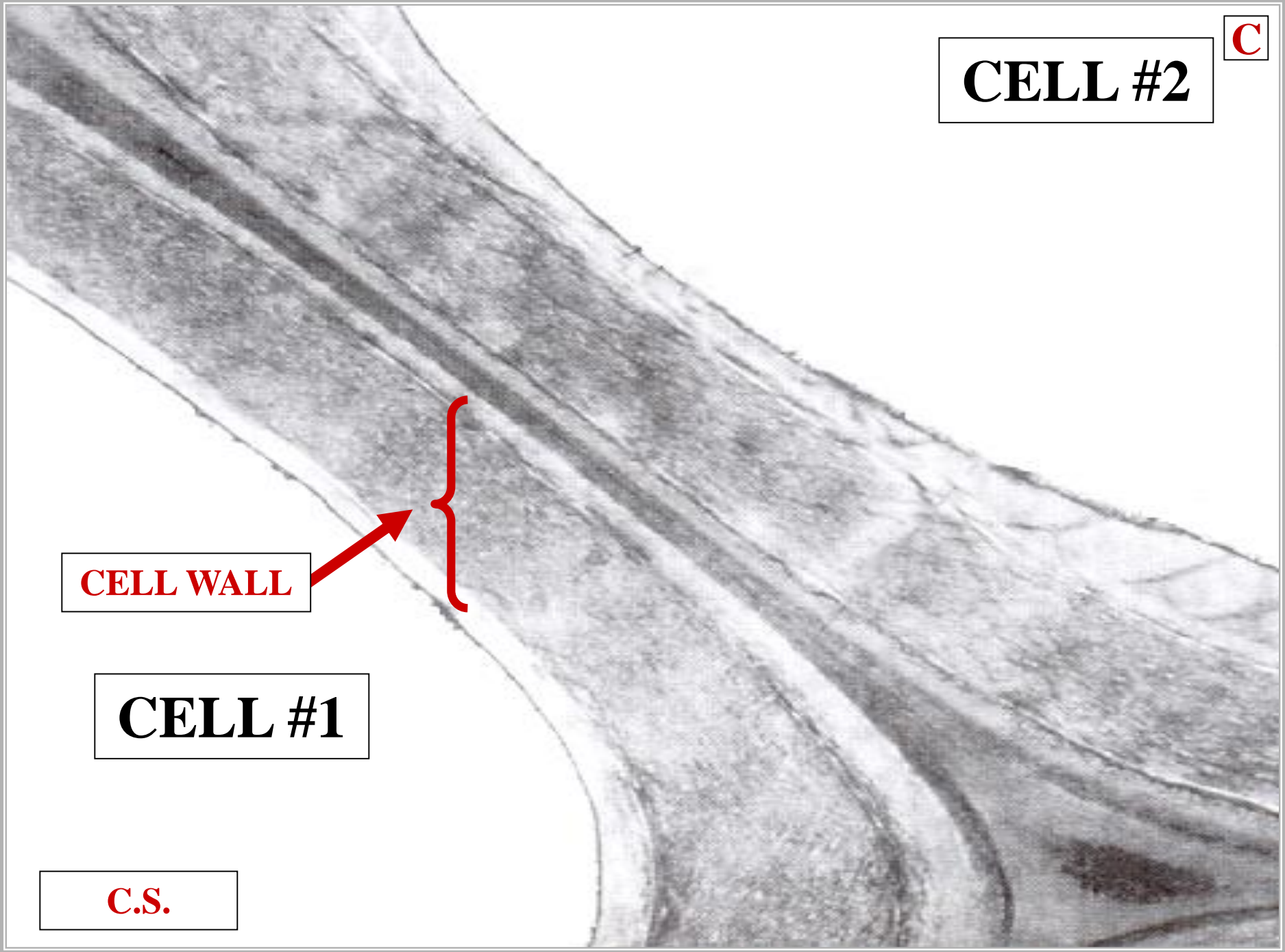
**CELL #2**

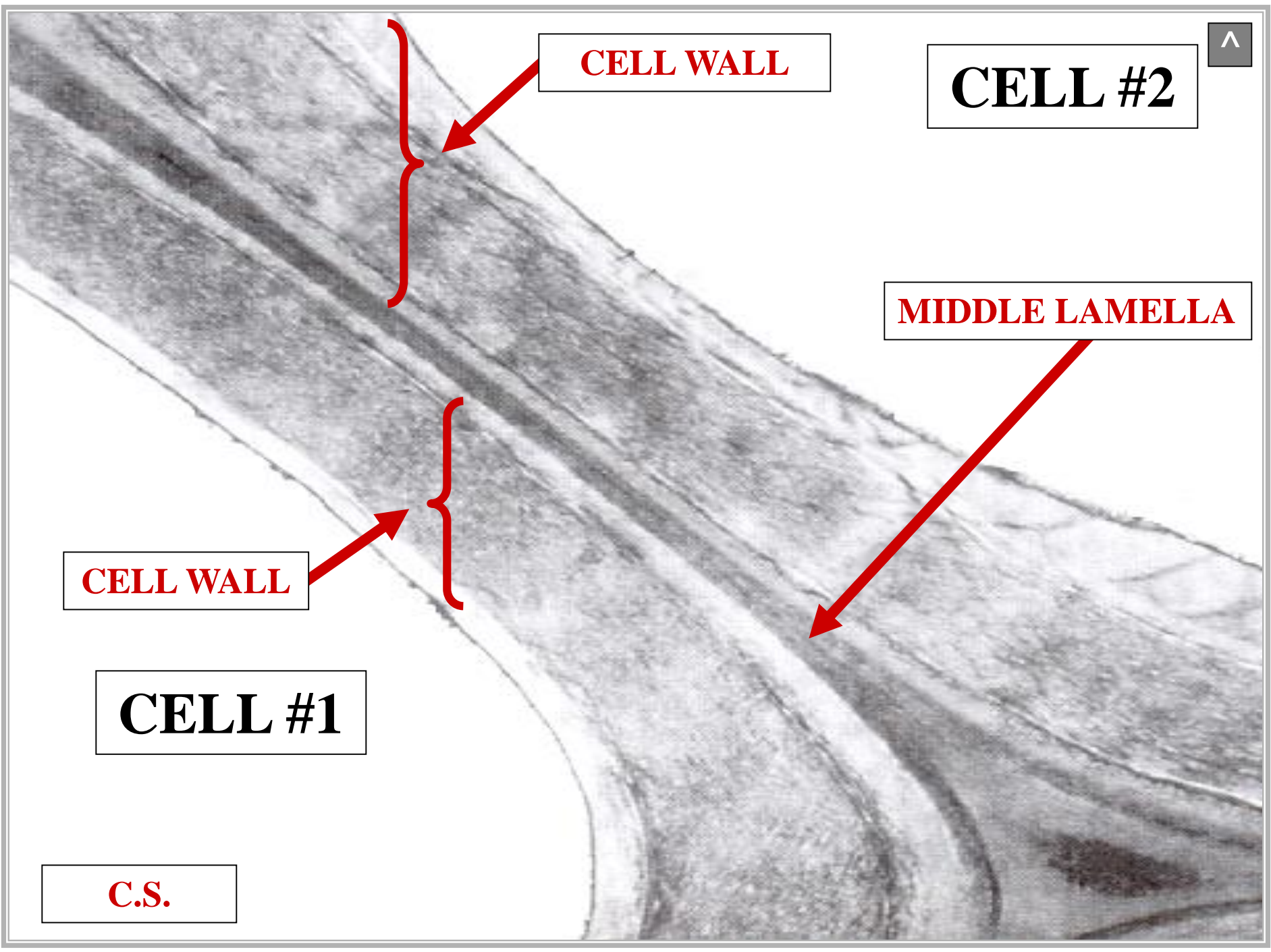
**C**

**CELL WALL**

**CELL #1**

**C.S.**





**CELL WALL**

**CELL #2**



**MIDDLE LAMELLA**

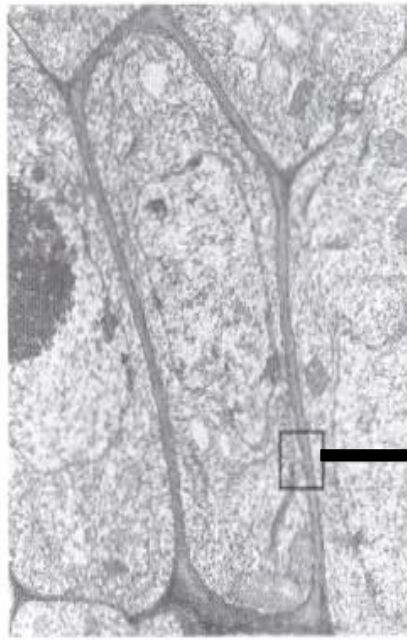
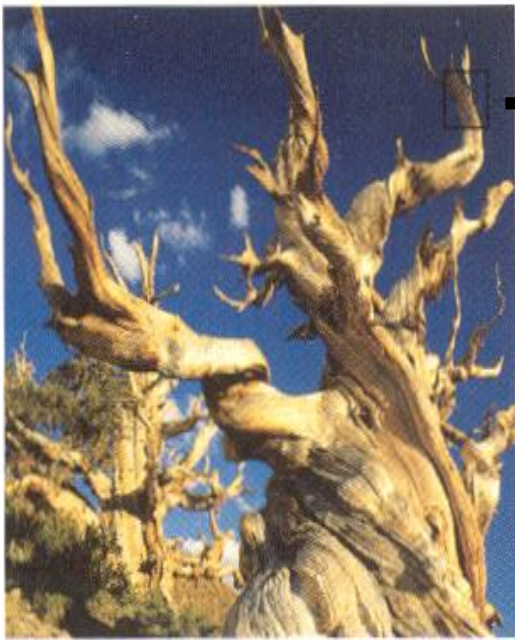
**CELL WALL**

**CELL #1**

**C.S.**



# CELL WALL COMPOSITION



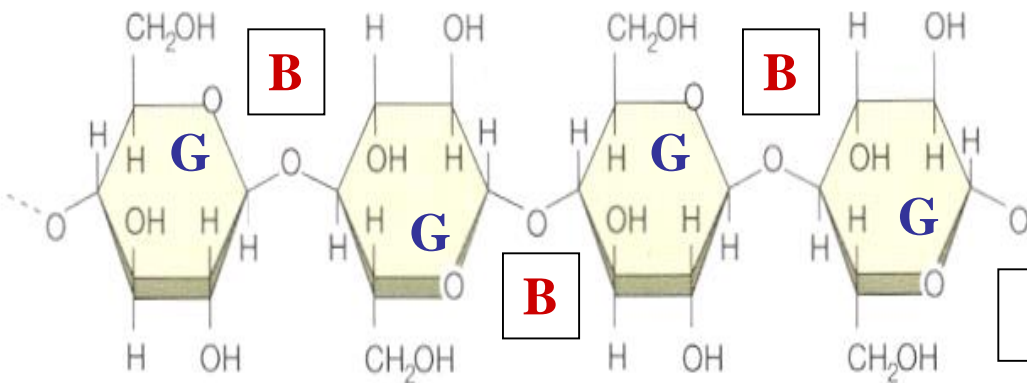
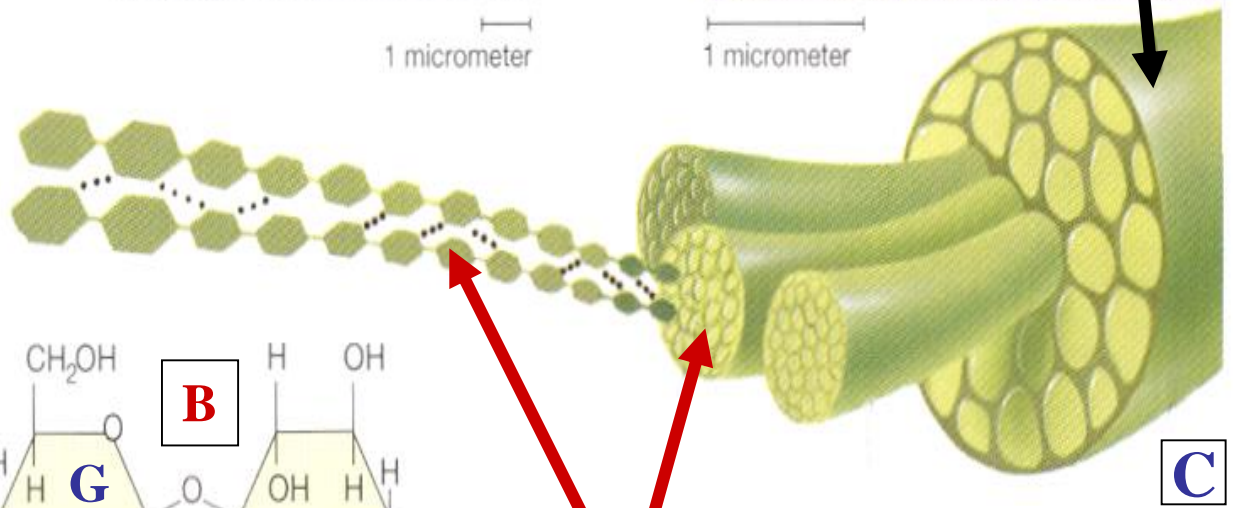
1 micrometer



1 micrometer

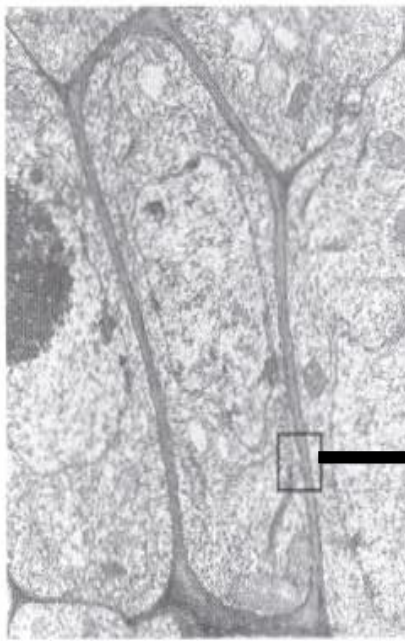
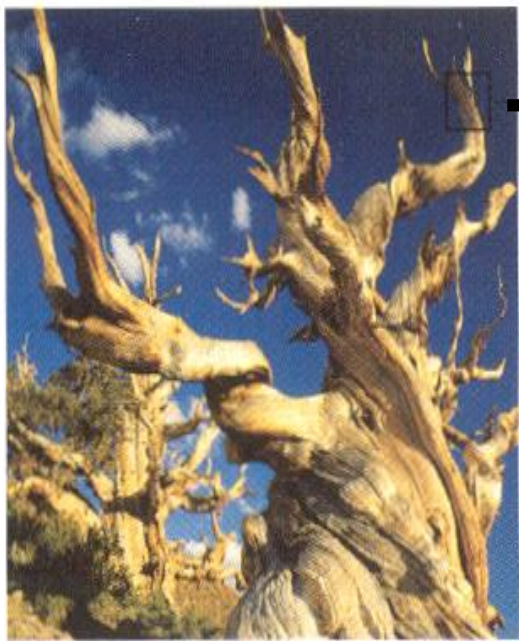
**C**

**TRUE PLANT CELL WALL**



**?**

**G = GLUCOSE**  
**B = BETA BOND**



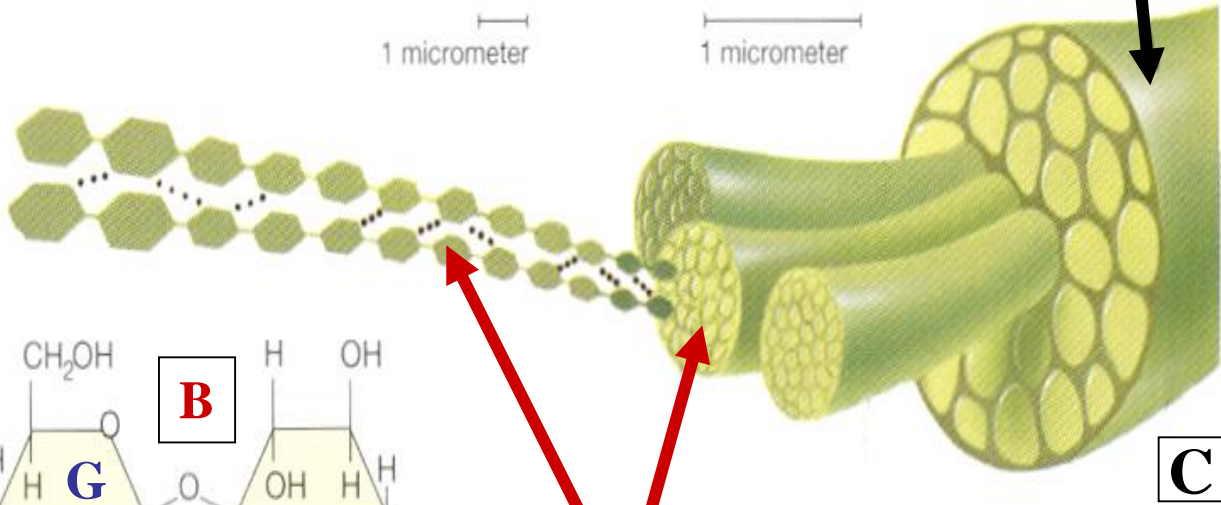
1 micrometer



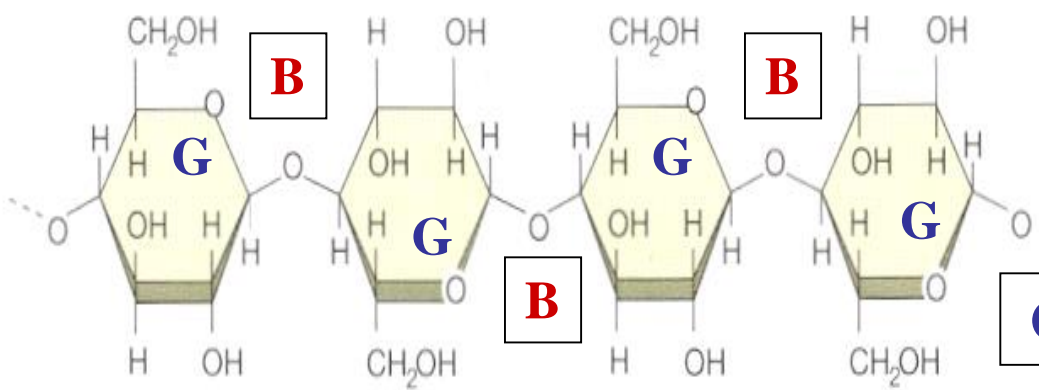
1 micrometer

**C**

# TRUE PLANT CELL WALL



**C**



**CELLULOSE**

**G = GLUCOSE**  
**B = BETA BOND**



**CELLULOSE**

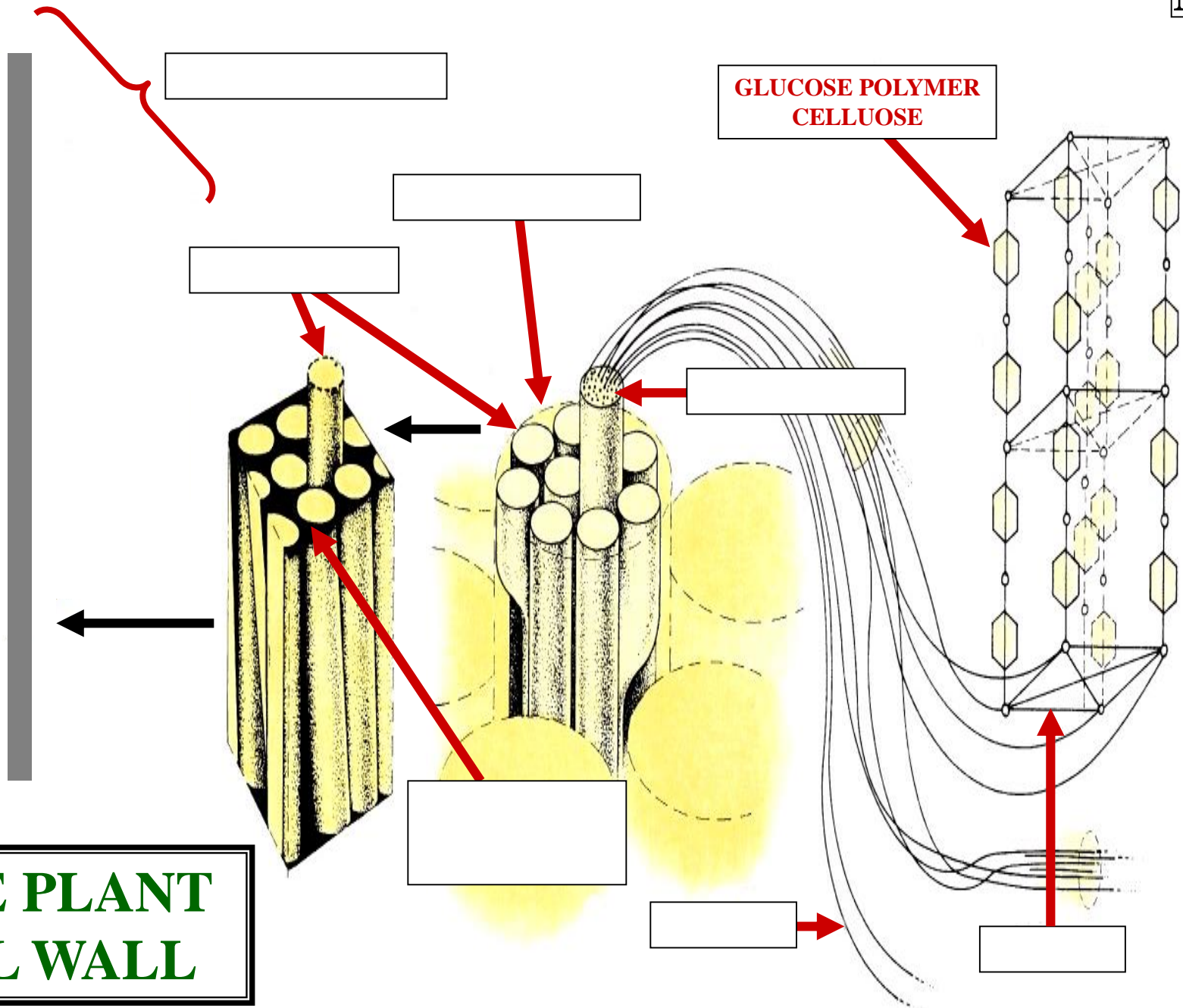
**CELL WALL  
CELLULOSE**



**C**

**GLUCOSE POLYMER**

**CELL WALL  
CELLULOSE**



**TRUE PLANT  
CELL WALL**

**GLUCOSE POLYMER  
CELLULOSE**

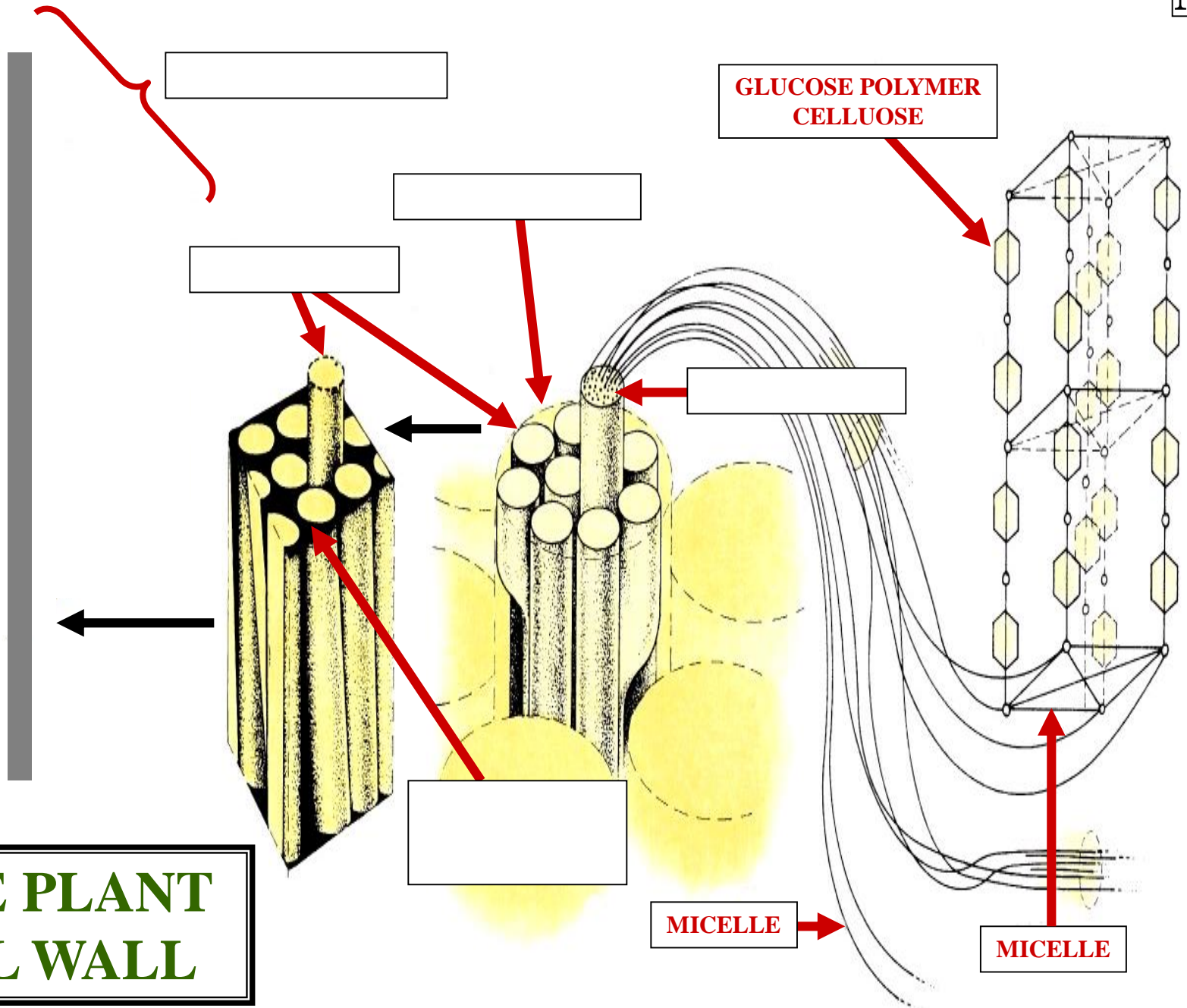
**MICELLE**



**CELL WALL  
MICELL**

**GLUCOSE  
CELLULOSE  
ASSEMBLAGE**

**CELL WALL  
MICELL**



[ ]

[ ]

[ ]

**GLUCOSE POLYMER  
CELLULOSE**

[ ]

[ ]

**MICELLE**

**MICELLE**

**TRUE PLANT  
CELL WALL**

**MICROFIBRIL**



**CELL WALL  
MICROFIBRIL**

**AGGREGATED  
MICELLES**

**CELL WALL  
MICROFIBRIL**





**HEMICELLULOSE**



**CELL WALL  
HEMICELLULOSE**

**FLEXIBLE-GLUE**

**CELL WALL  
HEMICELLULOSE**



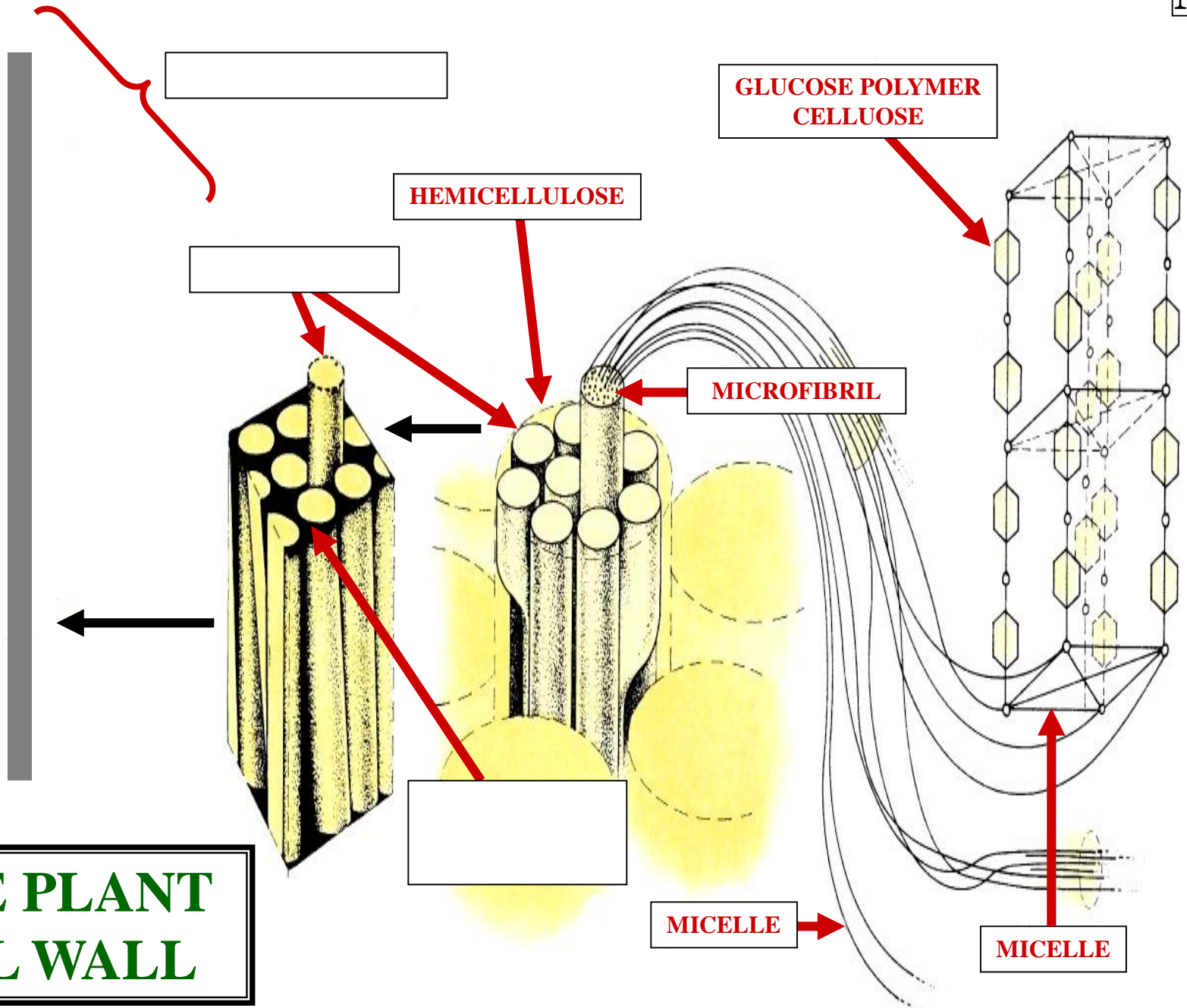
**CELL WALL  
HEMICELLULOSE**

**FLEXIBLE-GLUE**

**---**

**BONDS MICROFIBRILS**

**CELL WALL  
HEMICELLULOSE**



**TRUE PLANT  
CELL WALL**

[ ]

**HEMICELLULOSE**

**GLUCOSE POLYMER  
CELLULOSE**

**MICROFIBRIL**

[ ]

**MICELLE**

**MICELLE**

**MACROFIBRIL**



**CELL WALL  
MACROFIBRIL**

**AGGREGATED  
MICROFIBRILS**

**CELL WALL  
MACROFIBRIL**





**PECTIN**



**CELL WALL  
PECTIN**

**FLEXIBLE-GLUE**

**CELL WALL  
HEMICELLULOSE**

**CELL WALL**  
**PECTIN**

**FLEXIBLE-GLUE**

**---**

**BONDS MACROFIBRILS**

**CELL WALL**  
**HEMICELLULOSE**

**LIGNIN**



**CELL WALL  
LIGNIN**

**RIGID-GLUE**

**CELL WALL  
LIGNIN**

**CELL WALL  
LIGNIN**



**CW**



**RIGID-GLUE**

**---**

**BONDS MACROFIBRILS**

**CELL WALL  
LIGNIN**





# CELL WALL LAYERS



# PRIMARY CELL WALL

# **PRIMARY CELL WALL**



# **PRIMARY CELL WALL**

**DERIVED DURING CELL GROWTH**

# **PRIMARY CELL WALL**



# **PRIMARY CELL WALL**

**DERIVED DURING CELL GROWTH  
HIGH PECTIN CONTENT**

# **PRIMARY CELL WALL**