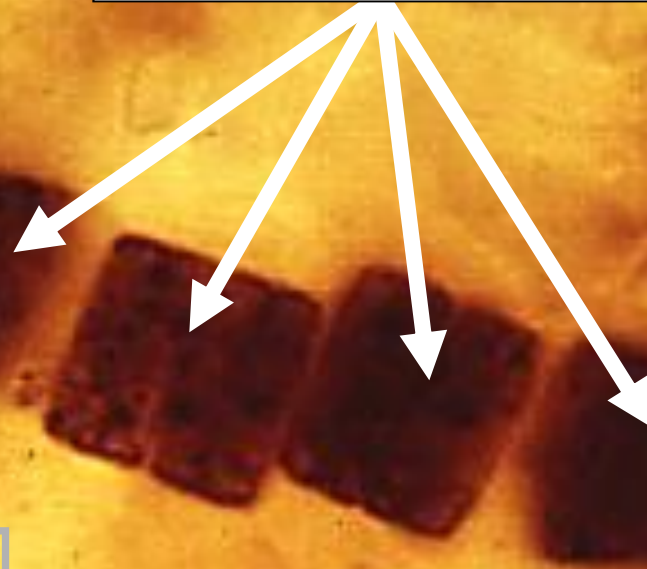
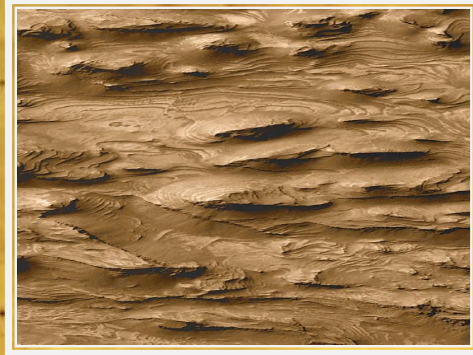


SEDIMENTARY ROCK ~3.5 BYA

**HIGH ORGANIC
CONTENT**



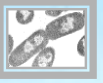
**FOSSIL
PROKARYOTES**



~3.4

BILLION YEARS

PRIMORDIAL EARTH OCEANS



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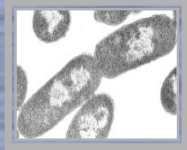
C-CMP

PRIMORDIAL EARTH OCEANS

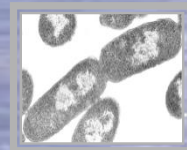
ORGANIC COMPOUNDS
BECOME SCARCE



C-CMP



C-CMP

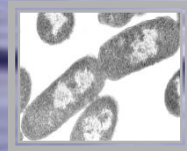


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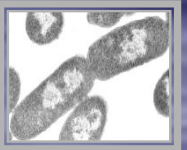


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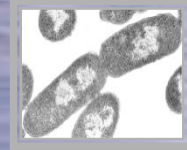


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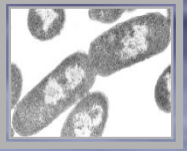


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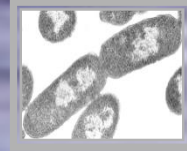


C-CMP

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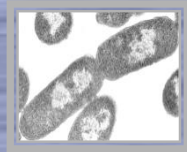
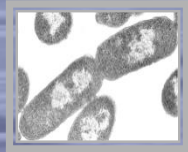
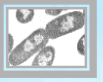
C-CMP



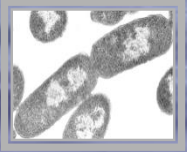
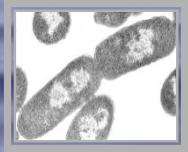
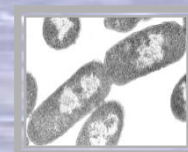
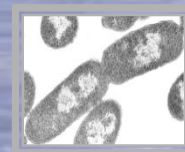
C-CMP

PRIMORDIAL EARTH OCEANS

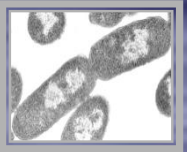
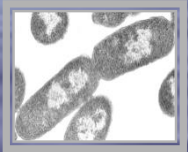
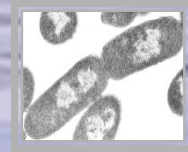
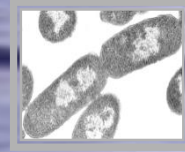
ORGANIC COMPOUNDS
BECOME SCARCE



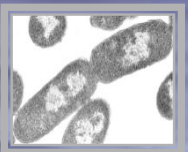
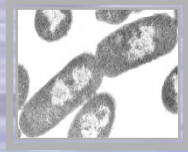
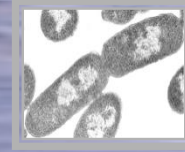
C-CMP



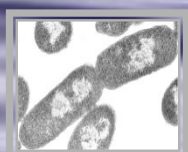
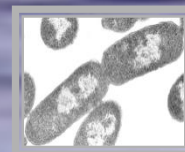
C-CMP



C-CMP



C-CMP



PROKARYOTES



ORGANIC COMPOUNDS
BECOME SCARCE
“FOOD SHORTAGE”

HETEROTROPHIC

HETEROTROPHIC

PROKARYOTES

ORGANIC COMPOUNDS
BECOME SCARCE
“FOOD SHORTAGE”



HETEROTROPHIC

A black and white micrograph showing several elongated, rod-shaped prokaryotic cells. The cells have a textured, granular appearance and are arranged in a somewhat parallel fashion.



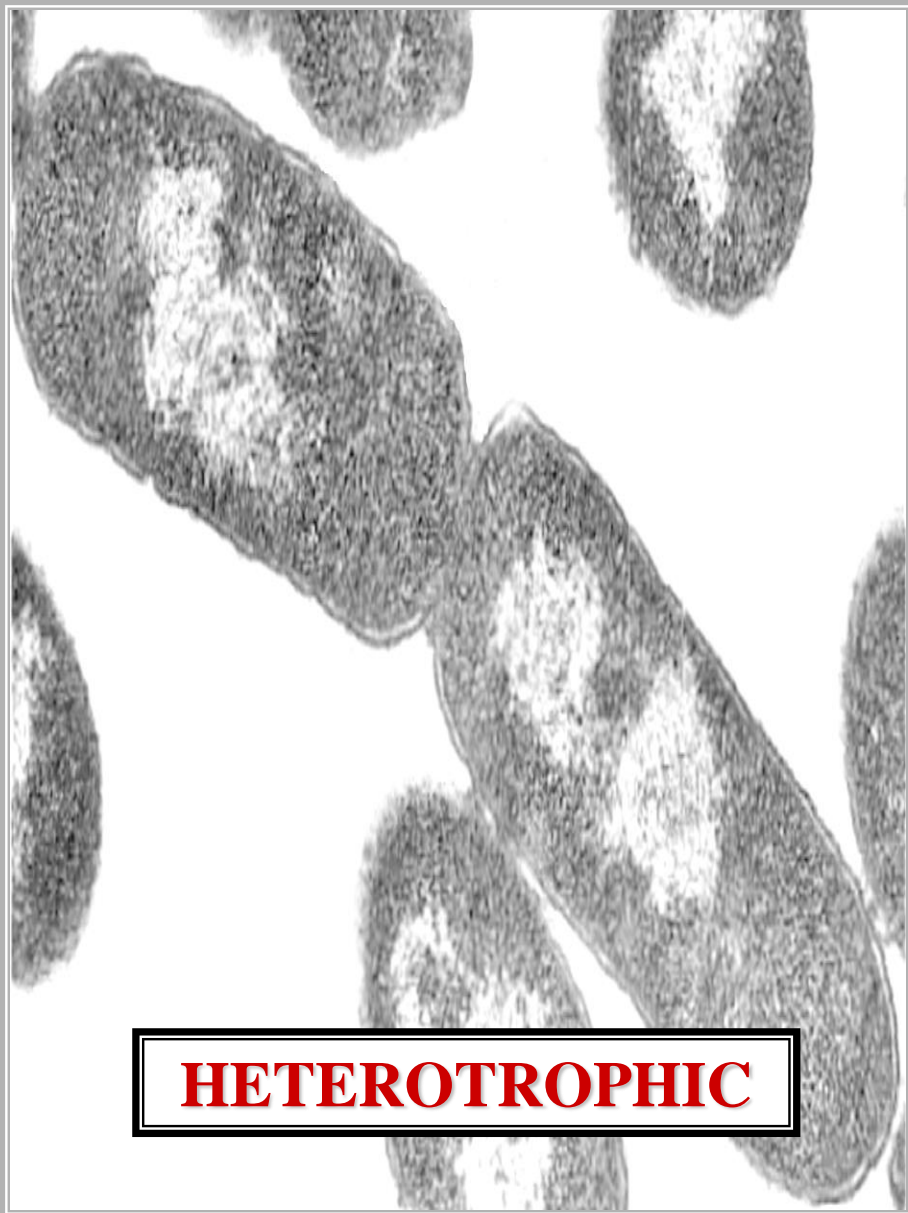
AUTOTROPHIC

A color micrograph showing numerous small, spherical prokaryotic cells. The cells are arranged in several distinct chains and appear to have a greenish-yellow color, characteristic of photosynthetic organisms like cyanobacteria.

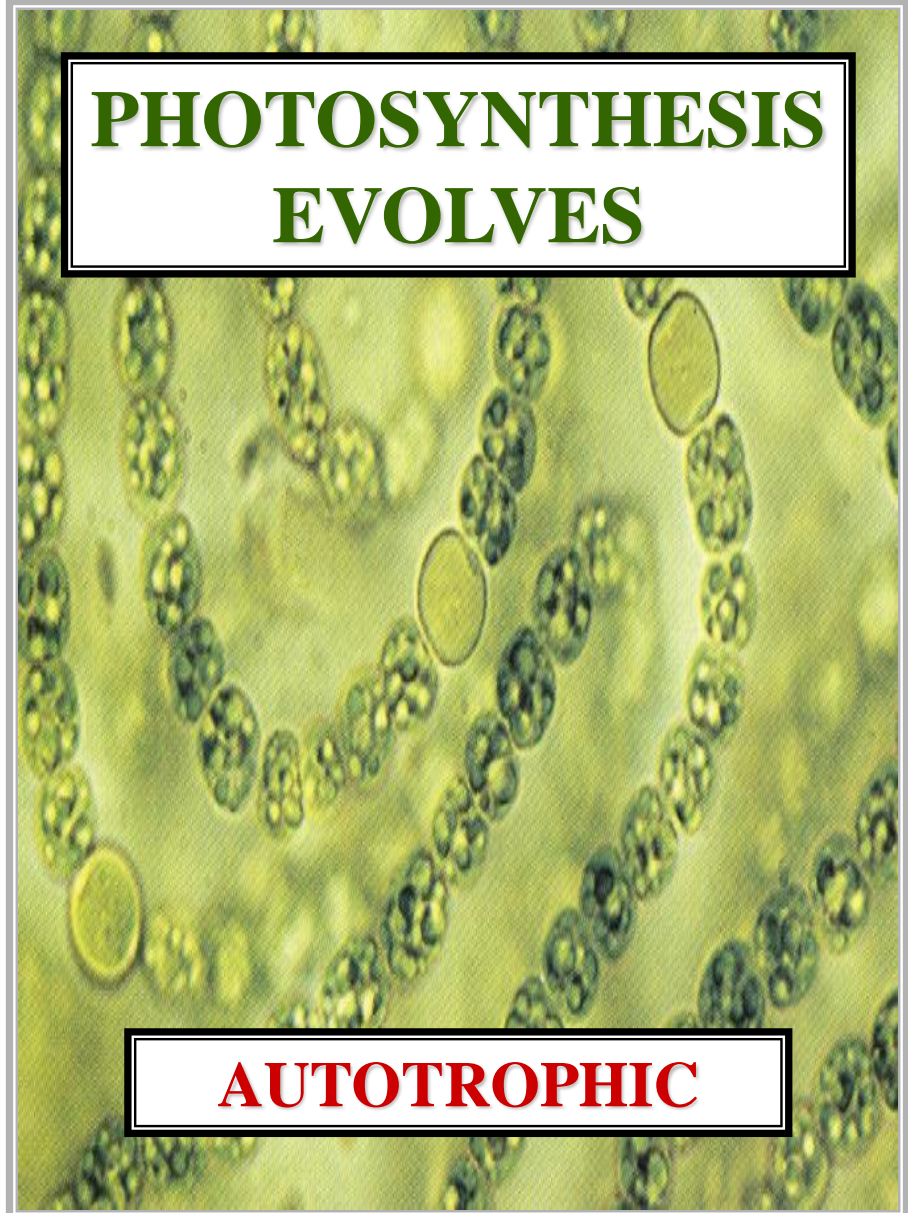
PROKARYOTES

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HETEROTROPHIC

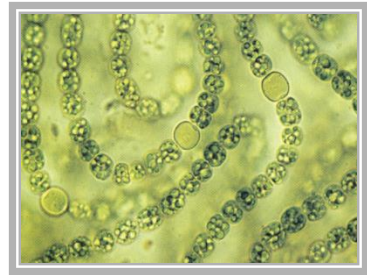


**PHOTOSYNTHESIS
EVOLVES**

AUTOTROPHIC

PHOTOSYNTHESIS

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WATER

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LIGHT ENERGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS

CHEMICAL ENERGY

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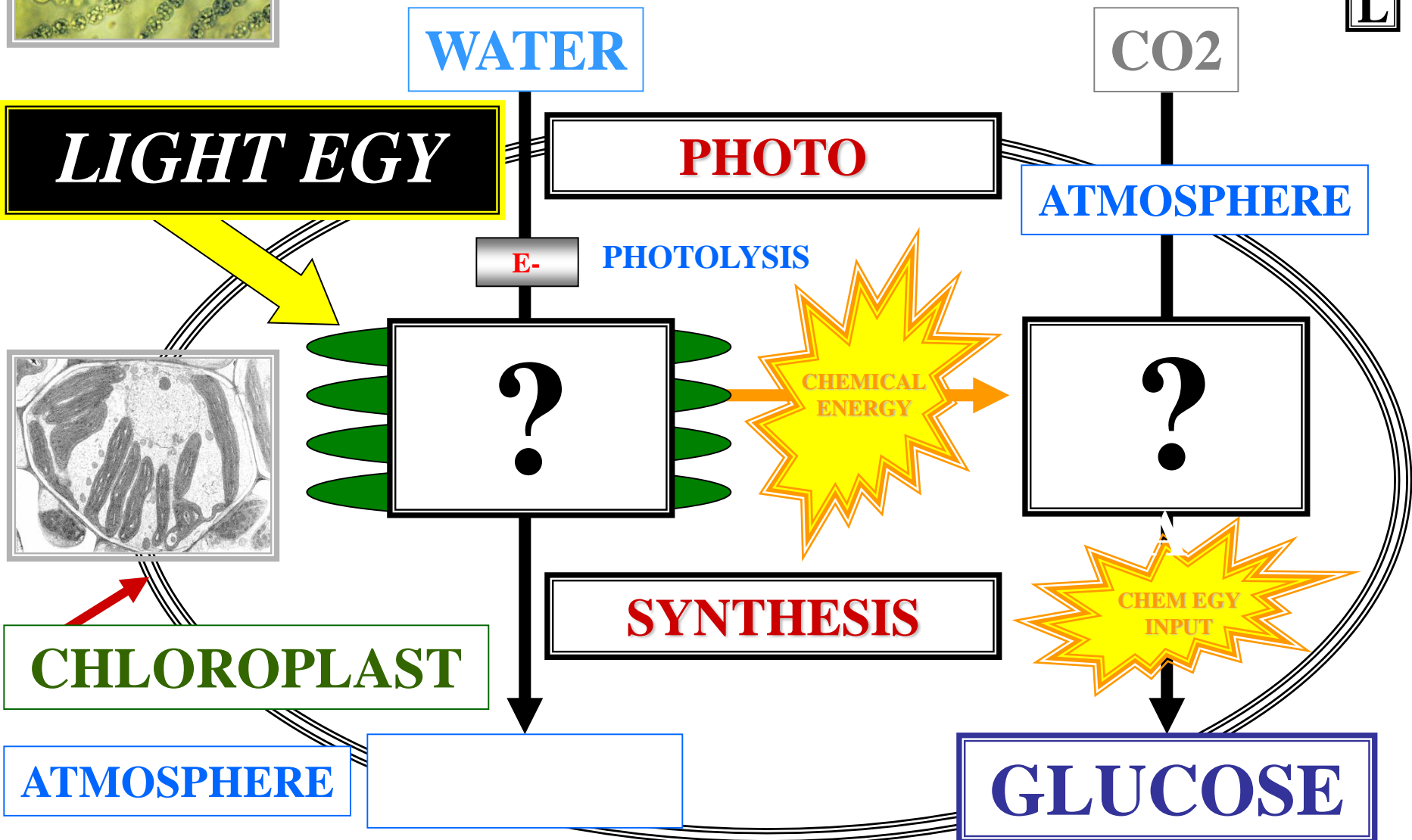
SYNTHESIS

CHEMICAL ENERGY INPUT

CHLOROPLAST

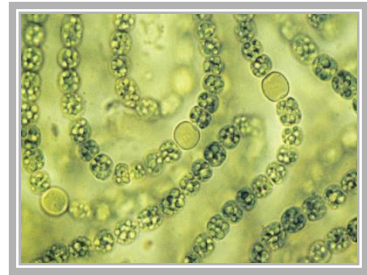
ATMOSPHERE

GLUCOSE



PHOTOSYNTHESIS

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LIGHT ENERGY

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ATMOSPHERE

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PHOTOLYSIS

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THYLAKOID

CHEMICAL ENERGY

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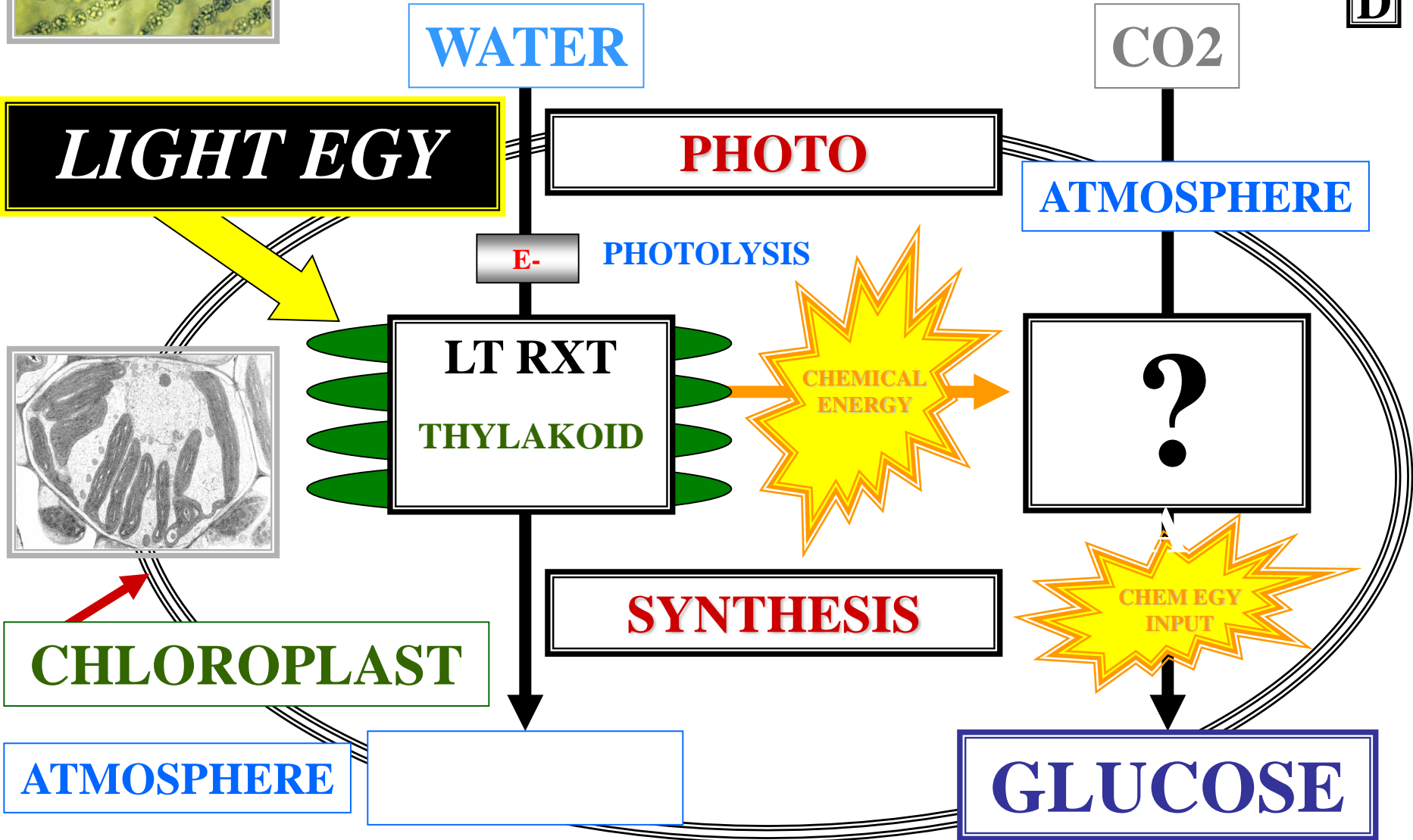
CHEMICAL ENERGY INPUT

CHLOROPLAST

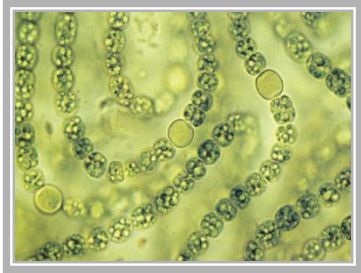
SYNTHESIS

ATMOSPHERE

GLUCOSE



PHOTOSYNTHESIS



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ATMOSPHERE

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STROMA

SYNTHESIS

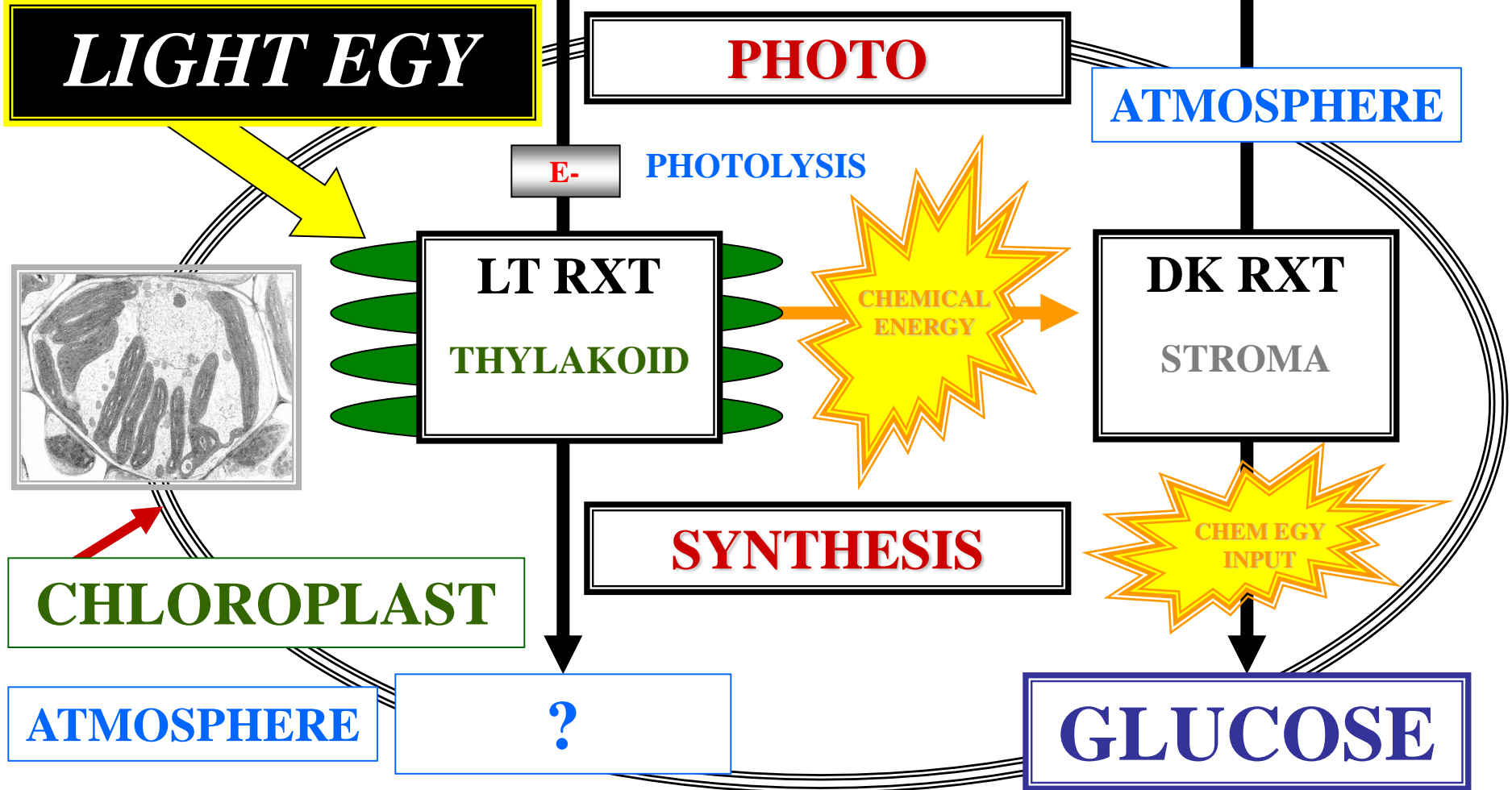
CHEMICAL ENERGY INPUT

CHLOROPLAST

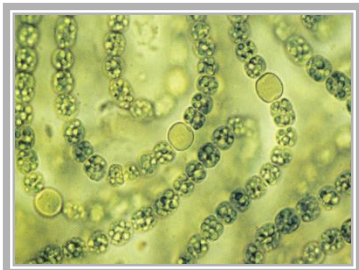
ATMOSPHERE

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GLUCOSE



PHOTOSYNTHESIS



WATER

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LIGHT ENERGY

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CHEMICAL ENERGY

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STROMA

SYNTHESIS

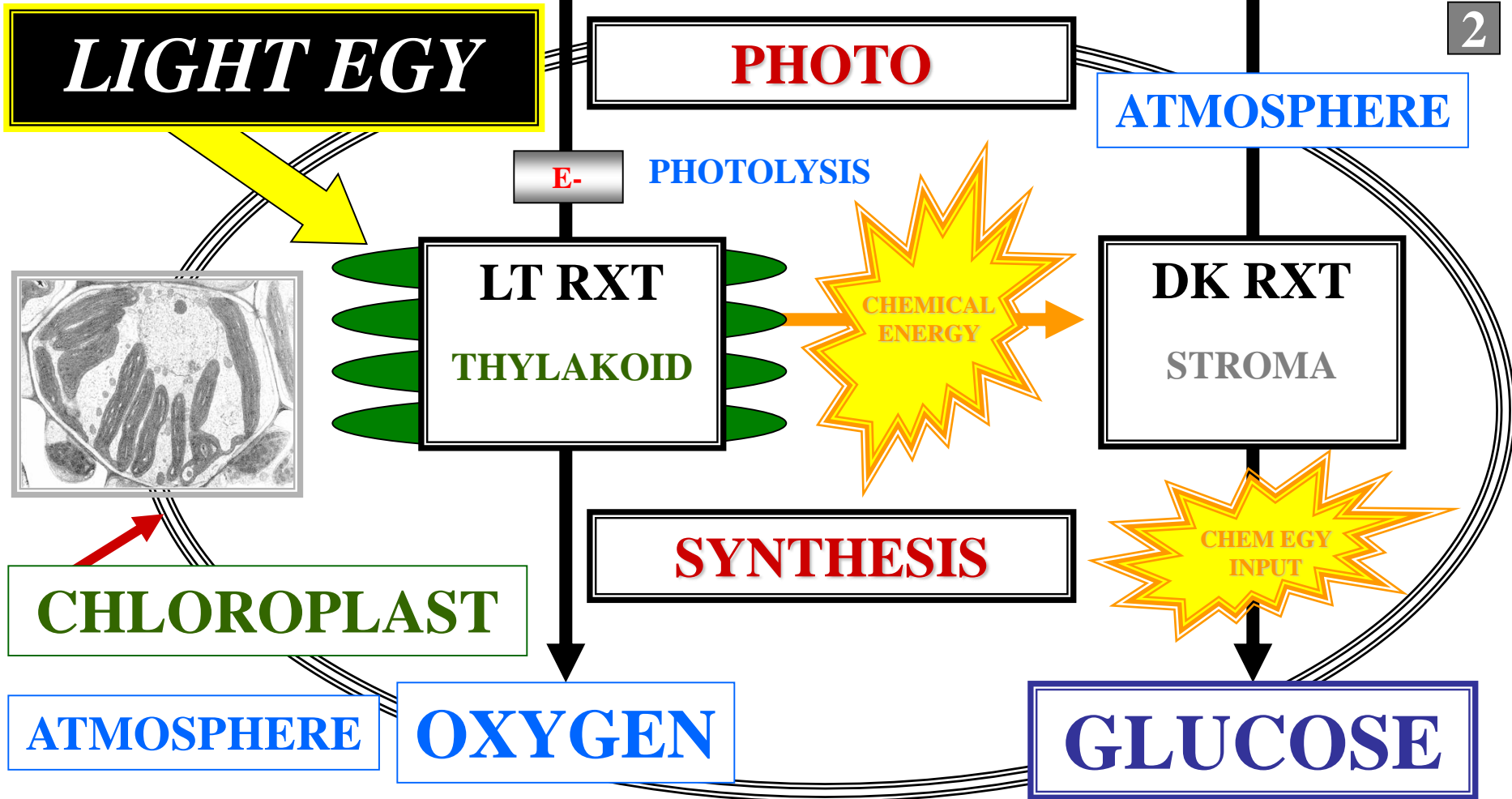
CHEMICAL ENERGY INPUT

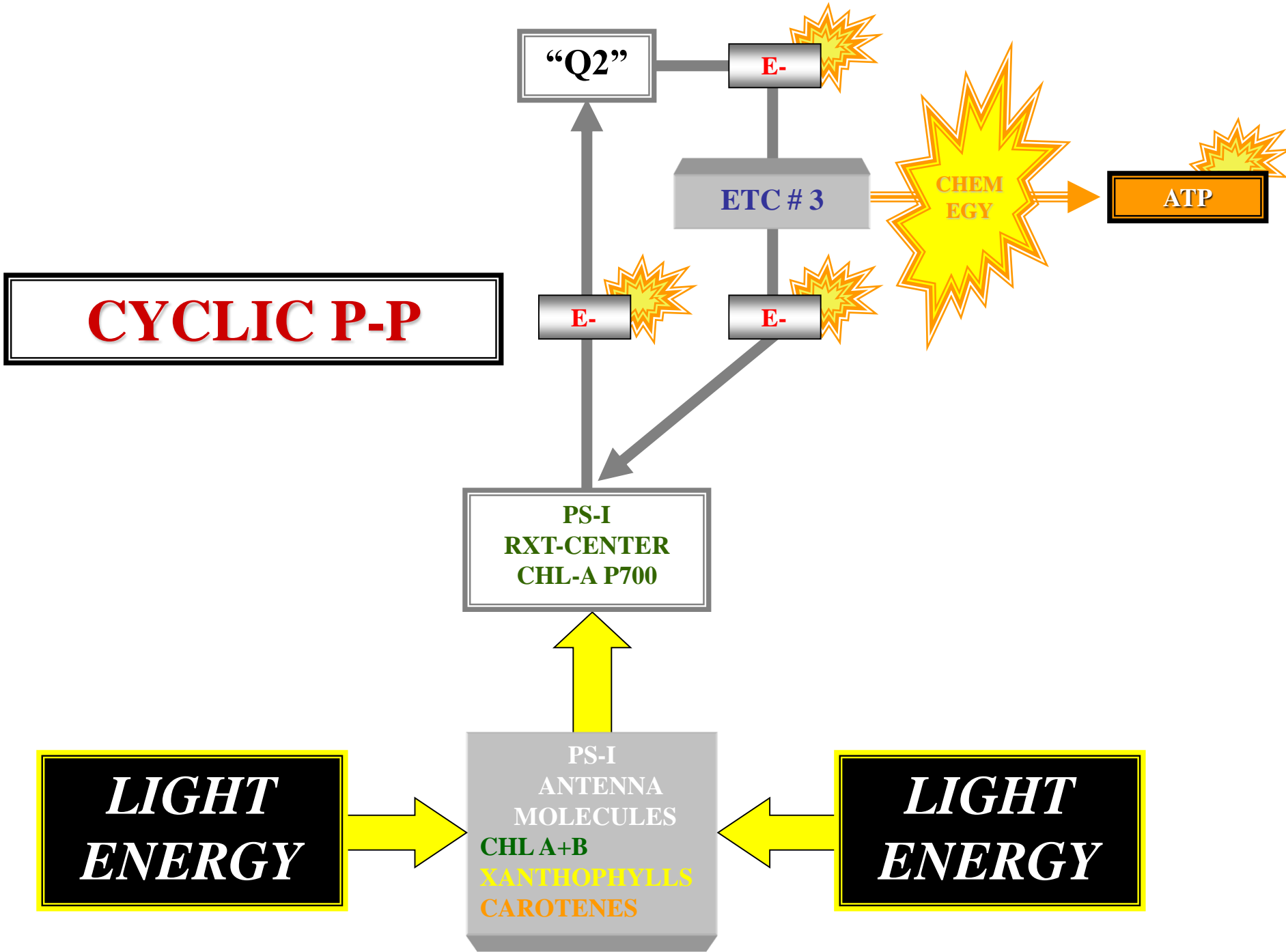
CHLOROPLAST

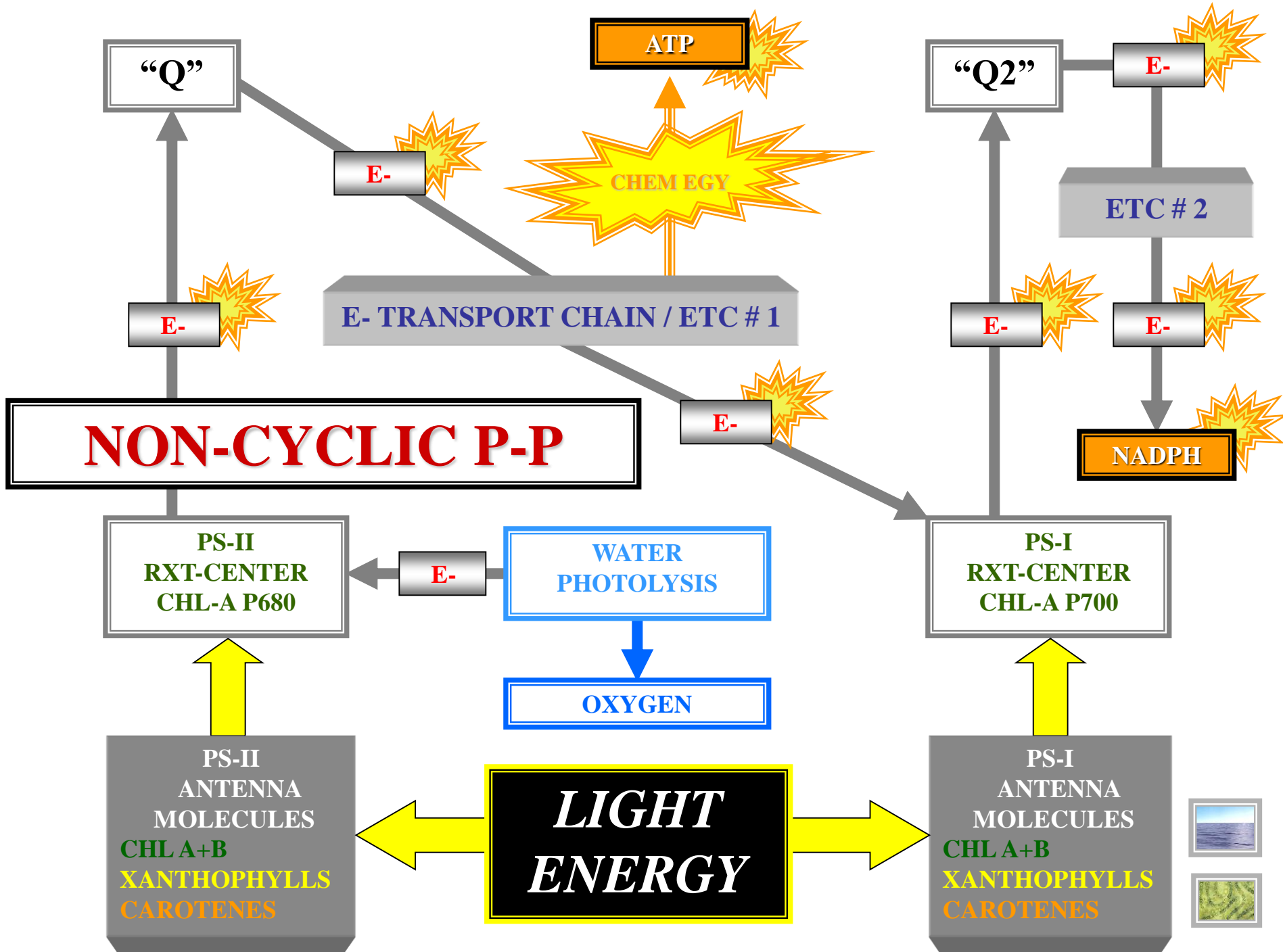
ATMOSPHERE

OXYGEN

GLUCOSE

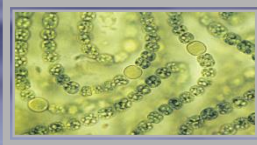
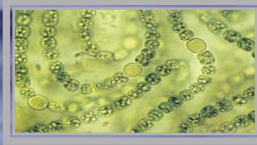
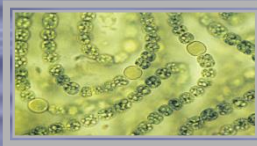
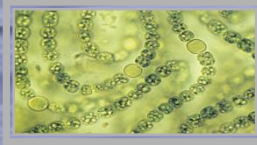






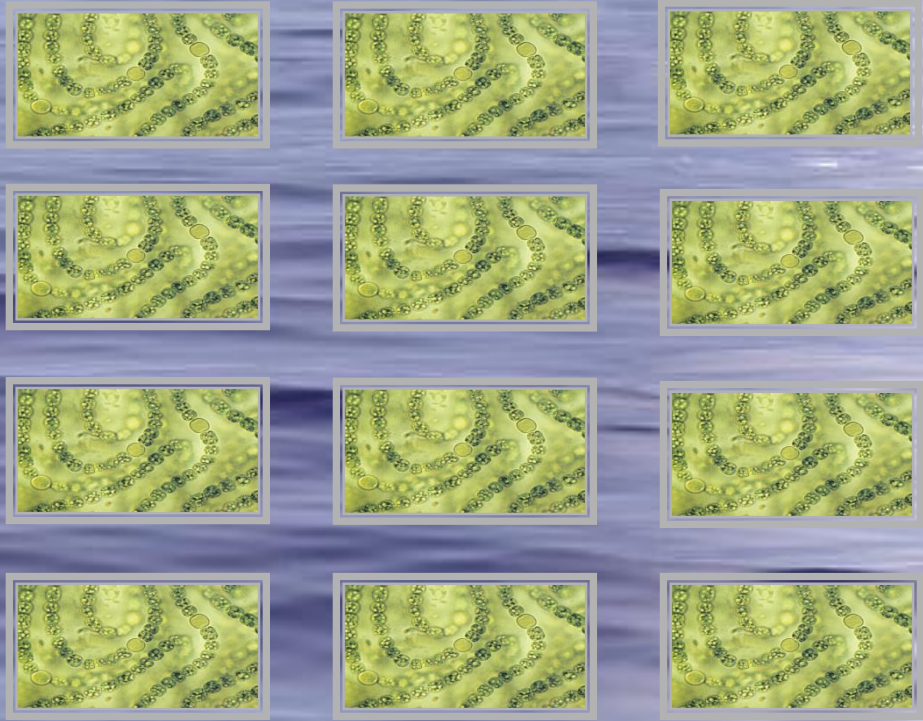
PRIMORDIAL EARTH OCEANS

PHOTOSYNTHESIS: PHOTOLYSIS



PRIMORDIAL EARTH OCEANS

PHOTOSYNTHESIS: PHOTOLYSIS



PRIMORDIAL EARTH OCEANS

PHOTOSYNTHESIS: PHOTOLYSIS



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PRIMORDIAL EARTH OCEANS



PHOTOSYNTHESIS: PHOTOLYSIS

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PRIMORDIAL EARTH OCEANS

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PHOTOSYNTHESIS: PHOTOLYSIS

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SUPPORTING EVIDENCE

PRIMORDIAL EARTH OCEANS



PHOTOSYNTHESIS: PHOTOLYSIS

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PRIMORDIAL EARTH OCEANS

PHOTOSYNTHESIS: PHOTOLYSIS

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PRIMORDIAL EARTH OCEANS



PHOTOSYNTHESIS: PHOTOLYSIS

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IRON-OXIDE

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IRON-OXIDE

PRIMORDIAL EARTH OCEANS



PHOTOSYNTHESIS: PHOTOLYSIS

IRON-OXIDE

IRON-OXIDE

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IRON-OXIDE FORMATION

~3.4 BYA

IRON-OXIDE





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BILLION YEARS

CYANOBACTERIA EVOLVE

S



CYANOBACTERIA EVOLVE



SUPPORTING EVIDENCE



STROMATOLITE FOSSILS

PRIMORDIAL EARTH OCEANS

S



STROMATOLITES

STROMATOLITE

STROMATOLITE

**CALCIUM CARBONATE
MOUND**

STROMATOLITE

STROMATOLITE

**CALCIUM CARBONATE
MOUND**

**CYANOBACTERIA
DEPOSITED**

STROMATOLITE



STROMATOLITE

STROMATOLITE

FOSSILS

CYANOBACTERIA

FOSSILS WITHIN

STROMATOLITE



CYANOBACTERIA

CYANOBACTERIA DEPOSITED

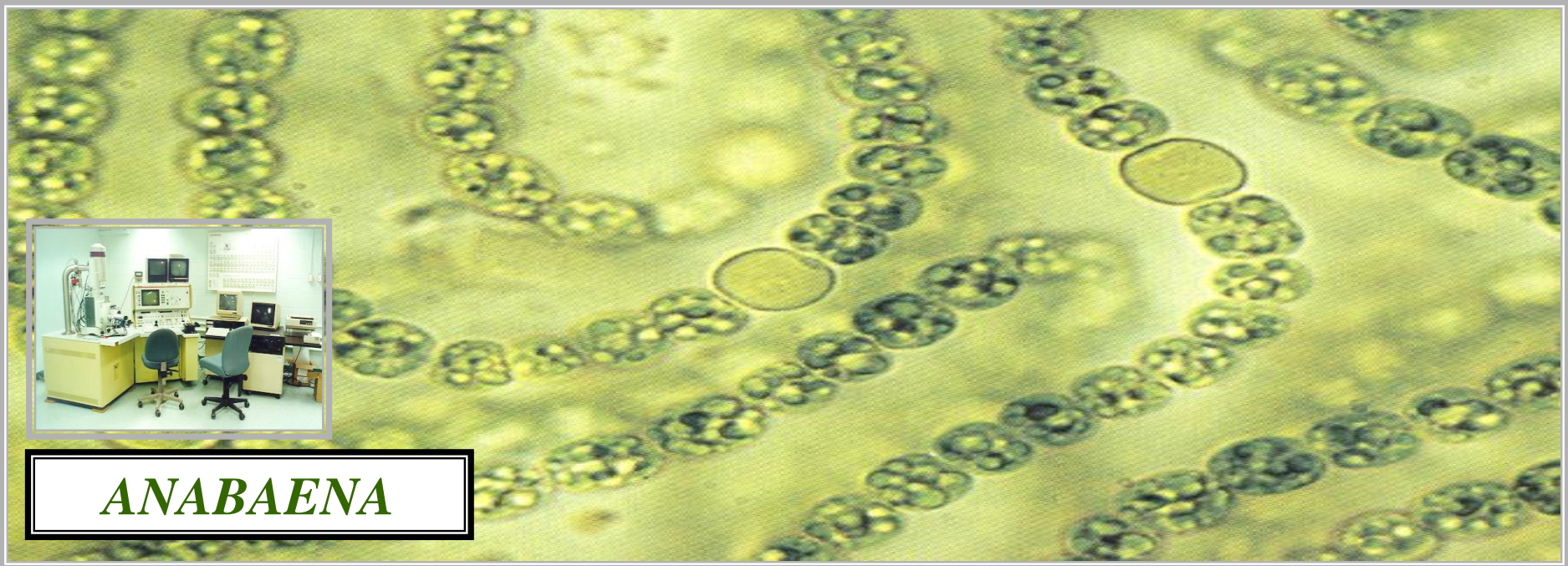
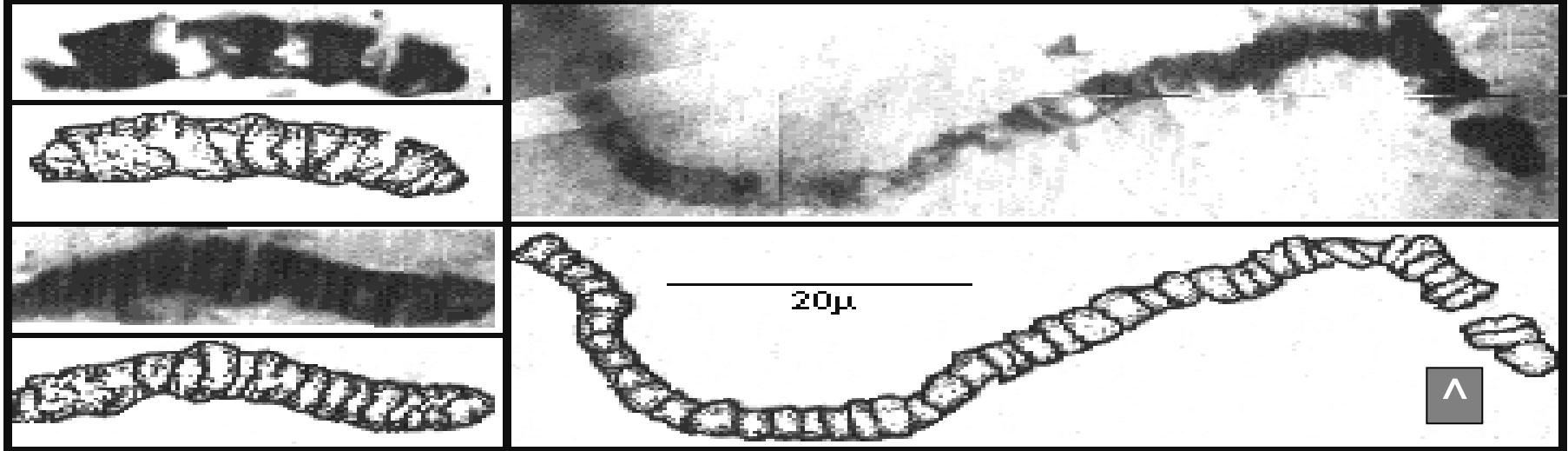
FOSSIL STROMATOLITE



SCANNING ELECTRON MICROSCOPE



STROMATOLITE CYANOBACTERIA FOSSILS



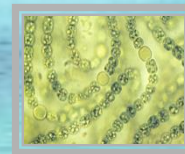
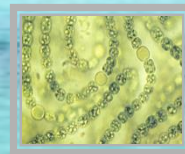
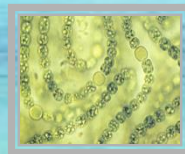
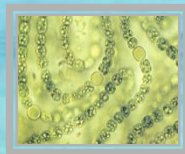
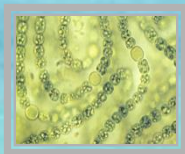
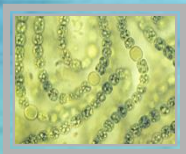


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BILLION YEARS

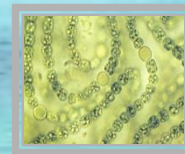
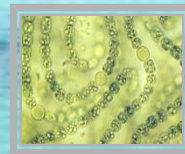
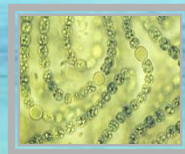
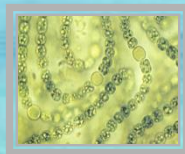
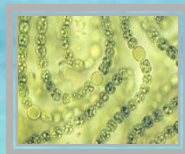
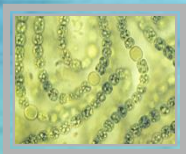
ANAEROBIC ATMOSPHERE

CYANOBACTERIA



ANAEROBIC ATMOSPHERE

PHOTOSYNTHESIS



ANAEROBIC ATMOSPHERE

OXYGEN SATURATED OCEANS

PHOTOLYSIS

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ANAEROBIC ATMOSPHERE

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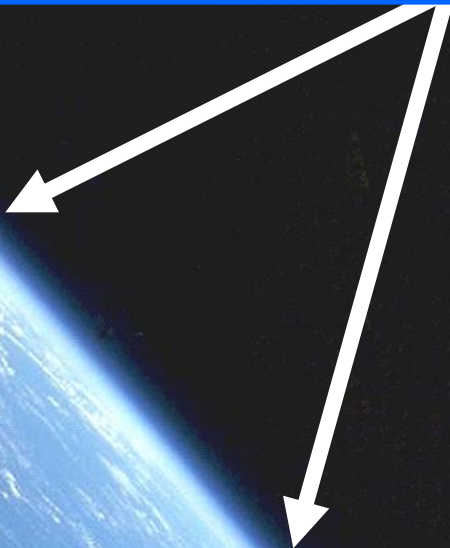
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**AEROBIC
ATMOSPHERE**

A satellite-style photograph of Earth from space, showing the curvature of the planet and the atmosphere. The atmosphere is depicted as a thin blue layer. A yellow arrow in the top right corner points left towards the atmosphere. A white box with a blue border at the top center contains the text 'OZONE LAYER'. Two white arrows originate from the bottom of this box and point to the blue atmospheric layer. A white box with a blue border at the bottom left contains the text 'AEROBIC ATMOSPHERE'.

OZONE LAYER

**AEROBIC
ATMOSPHERE**

A diagram of Earth from space, showing the blue atmosphere and white clouds. A box in the top right contains the text 'FILTERS HARMFUL RADIATION' in red. Yellow arrows point from this box towards the atmosphere. A box in the top left contains the text 'OZONE LAYER' in blue. A box in the bottom left contains the text 'AEROBIC ATMOSPHERE' in blue. A yellow arrow points right from the top right box.

OZONE LAYER

**FILTERS
HARMFUL
RADIATION**

**AEROBIC
ATMOSPHERE**



OZONE LAYER

**FILTERS
HARMFUL
RADIATION**

**AEROBIC
ATMOSPHERE**

A



**ADDITIONAL
HABITATS
OPEN**

EARTH



DIVERSE PROKARYOTE BIOTA

EARTH

AEROBIC ENVIRONMENT



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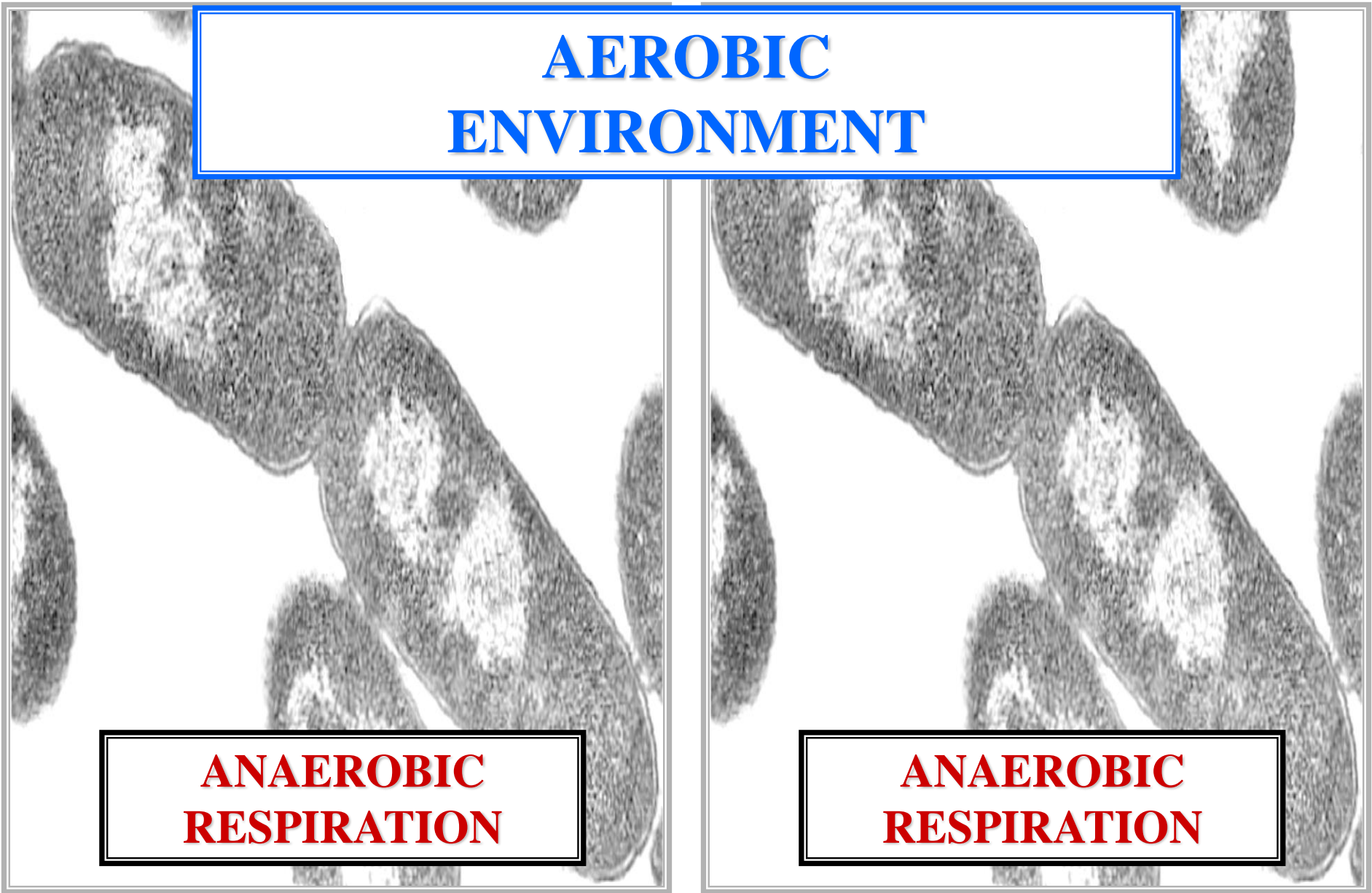
PROKARYOTES



**AEROBIC
ENVIRONMENT**

**ANAEROBIC
RESPIRATION**

**ANAEROBIC
RESPIRATION**



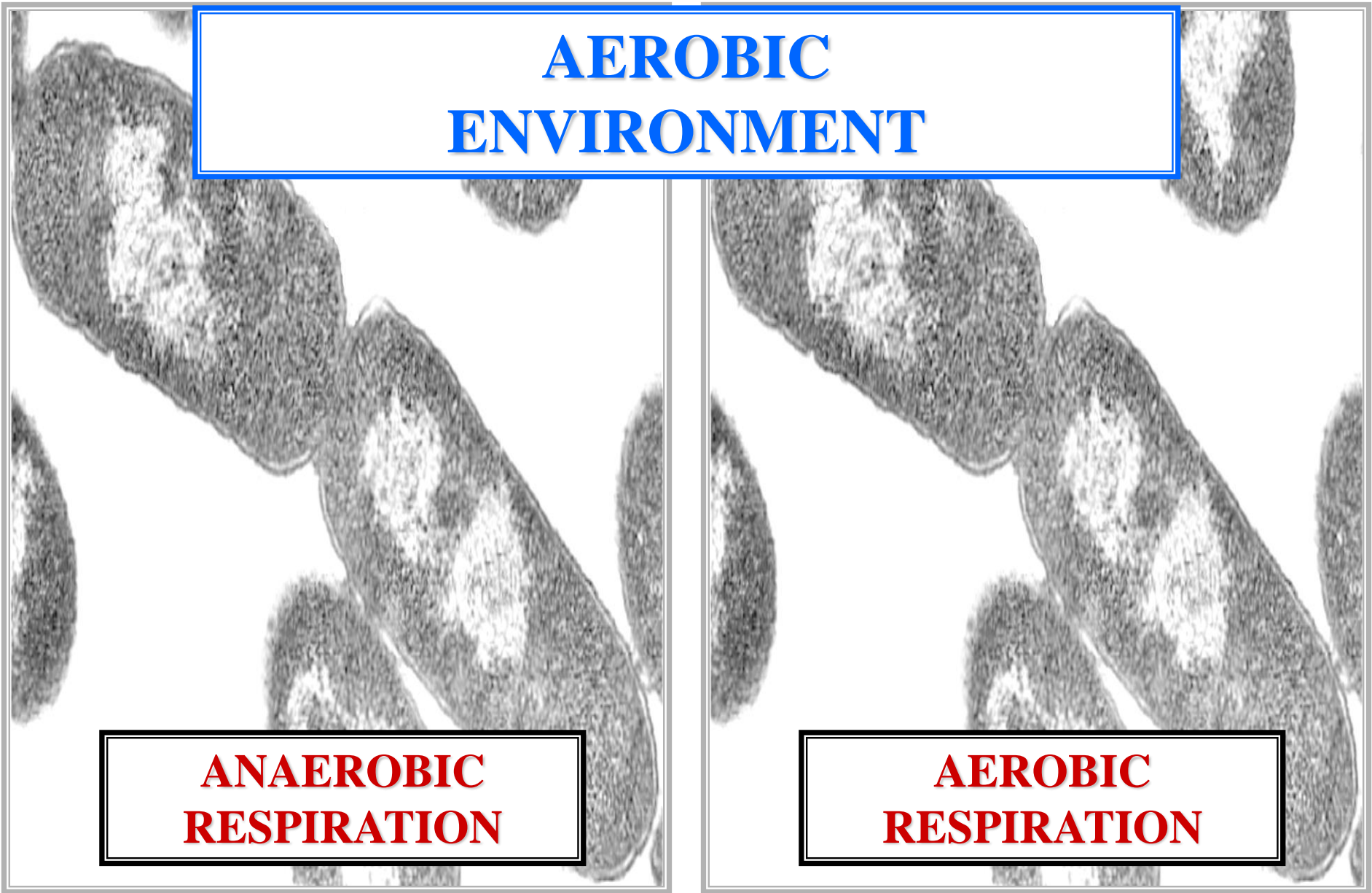
PROKARYOTES



**AEROBIC
ENVIRONMENT**

**ANAEROBIC
RESPIRATION**

**AEROBIC
RESPIRATION**

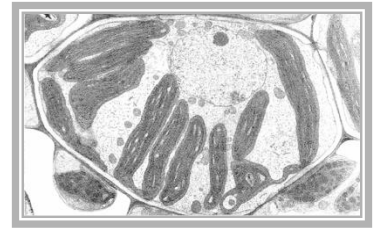




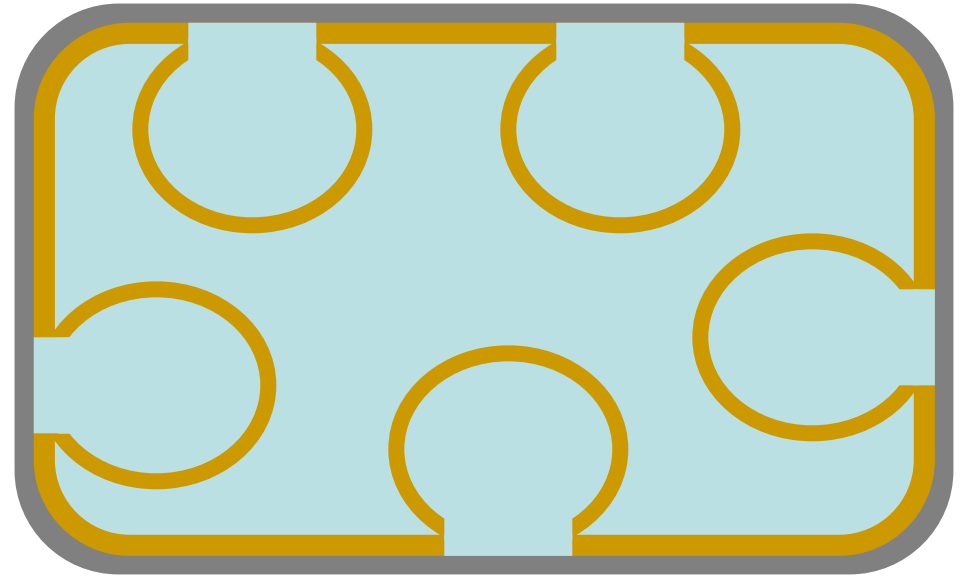
AEROBIC RESPIRATION REVIEW



AEROBIC RESPIRATION



G

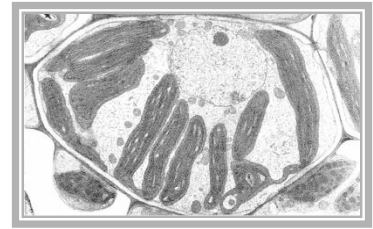


CELL

COMPONENT PATHWAYS



AEROBIC RESPIRATION



K

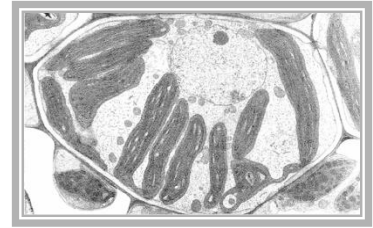
GLYCOLYSIS

CELL

COMPONENT PATHWAYS



AEROBIC RESPIRATION



E

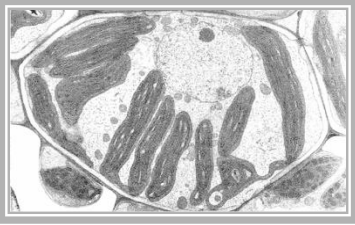
GLYCOLYSIS



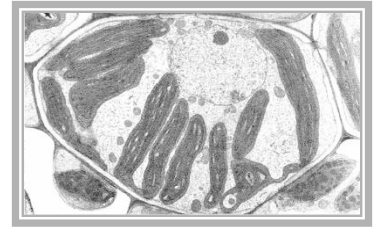
KREBS CYCLE

CELL

COMPONENT PATHWAYS



AEROBIC RESPIRATION



GLYCOLYSIS



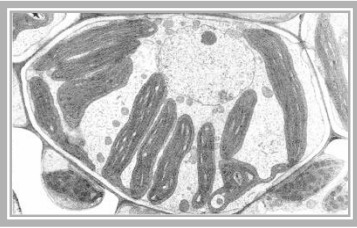
KREBS CYCLE



ETC

CELL

COMPONENT PATHWAYS

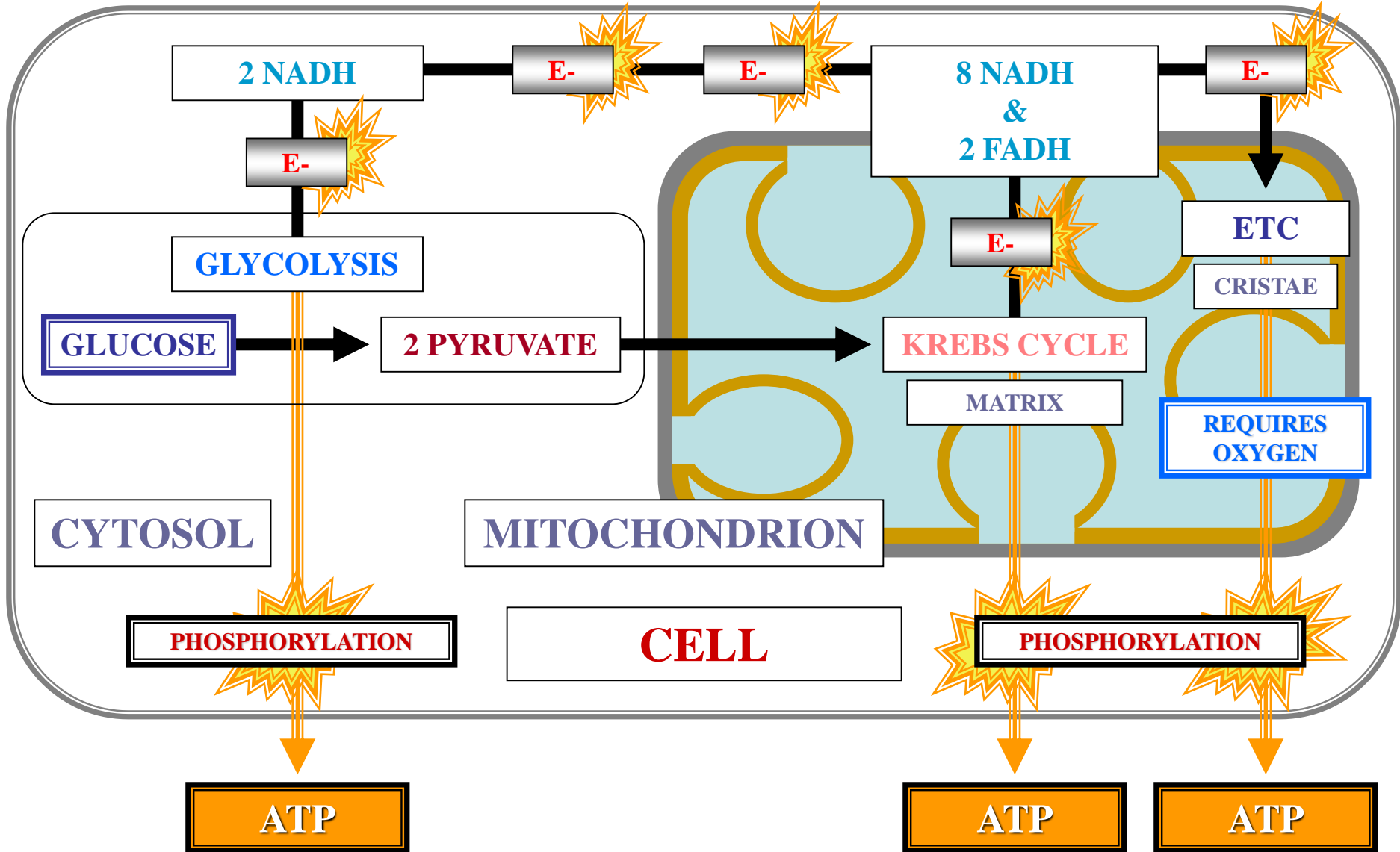


AEROBIC RESPIRATION



?

A



PROKARYOTES



AEROBIC RESPIRATION ATP NET

? ATP

**AEROBIC
RESPIRATION**

PROKARYOTES

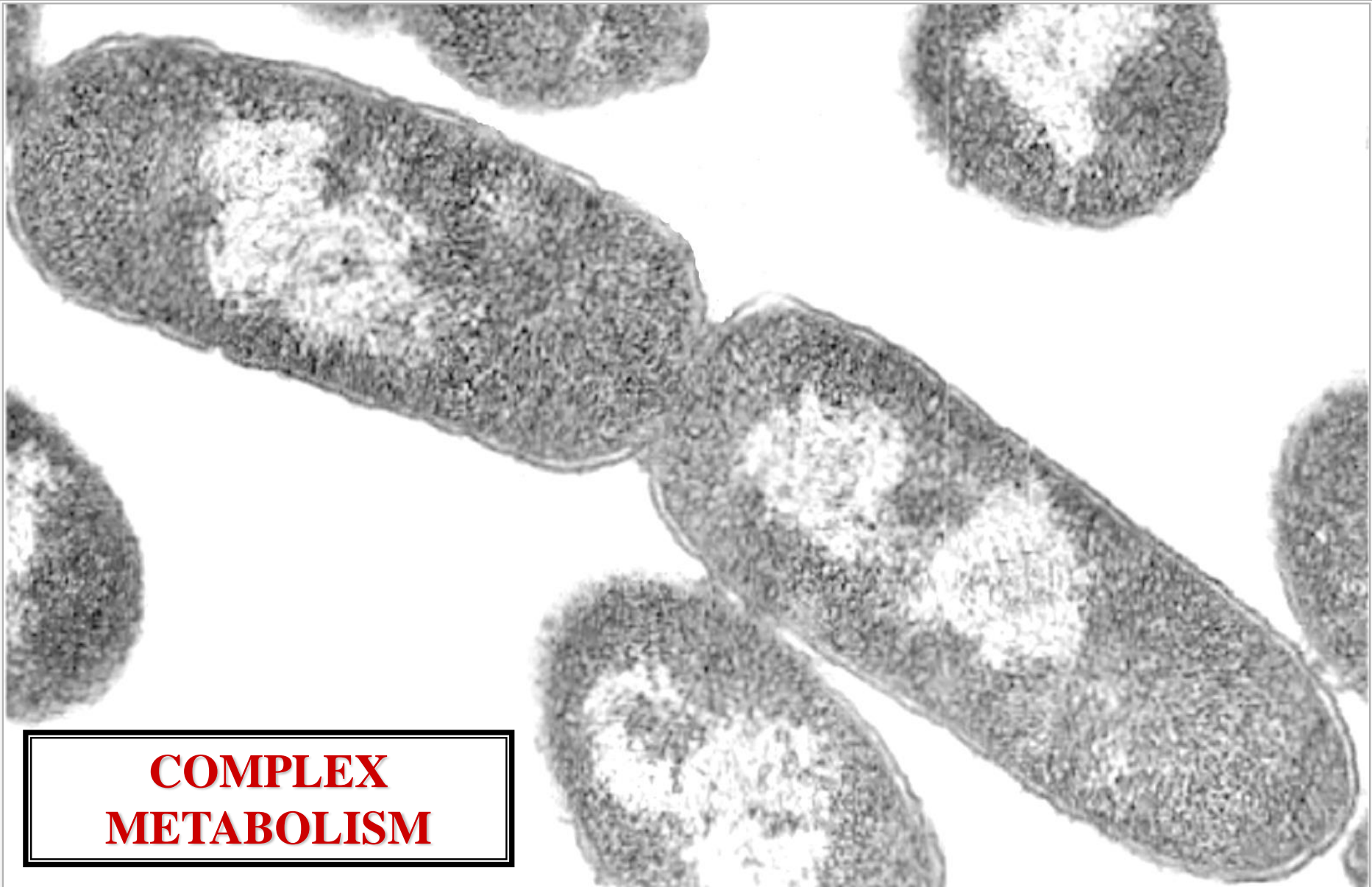


AEROBIC RESPIRATION ATP NET

36 ATP

**AEROBIC
RESPIRATION**


PROKARYOTES



**COMPLEX
METABOLISM**

ADDITIONAL HABITATS OPEN

EARTH

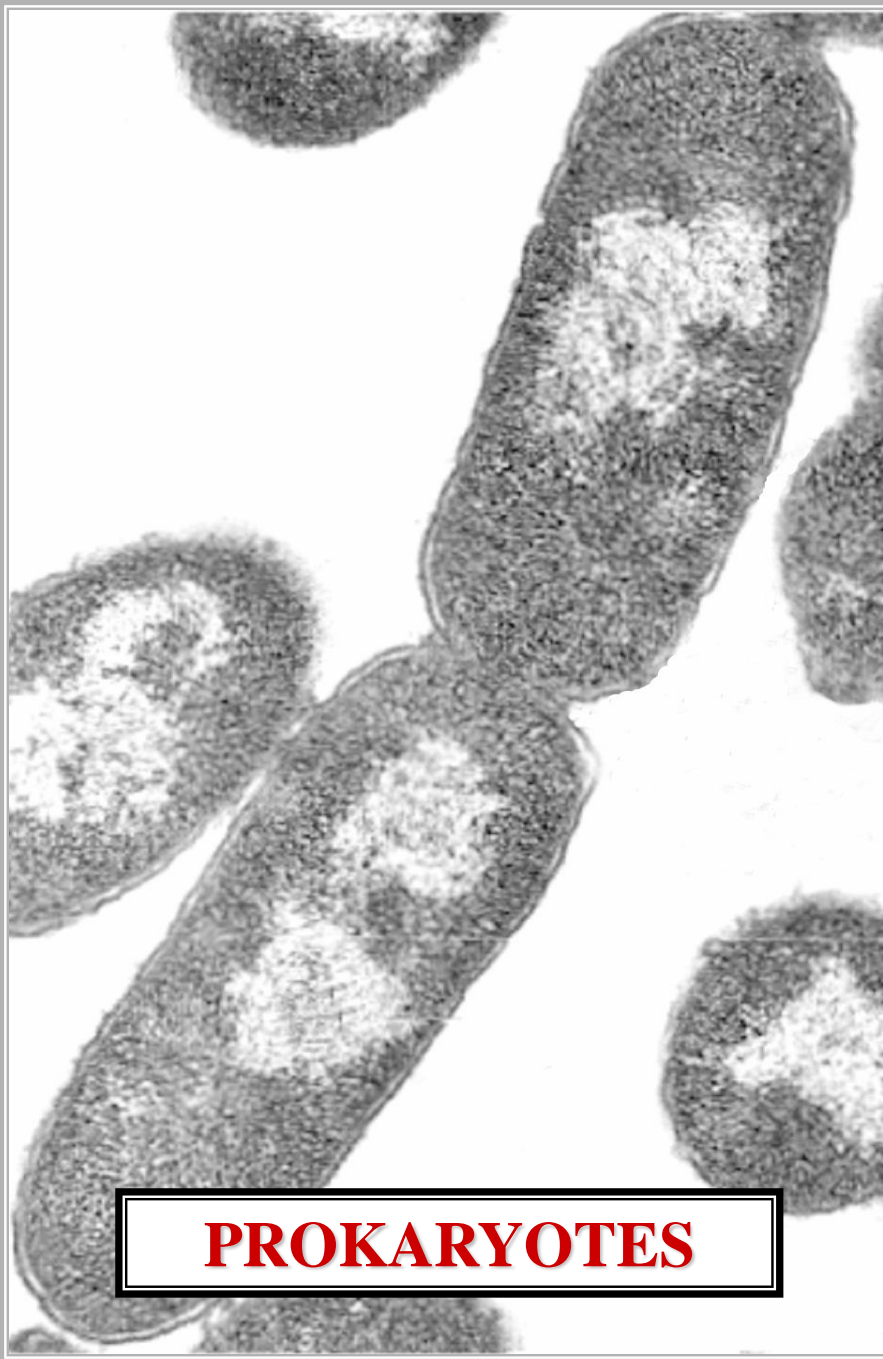


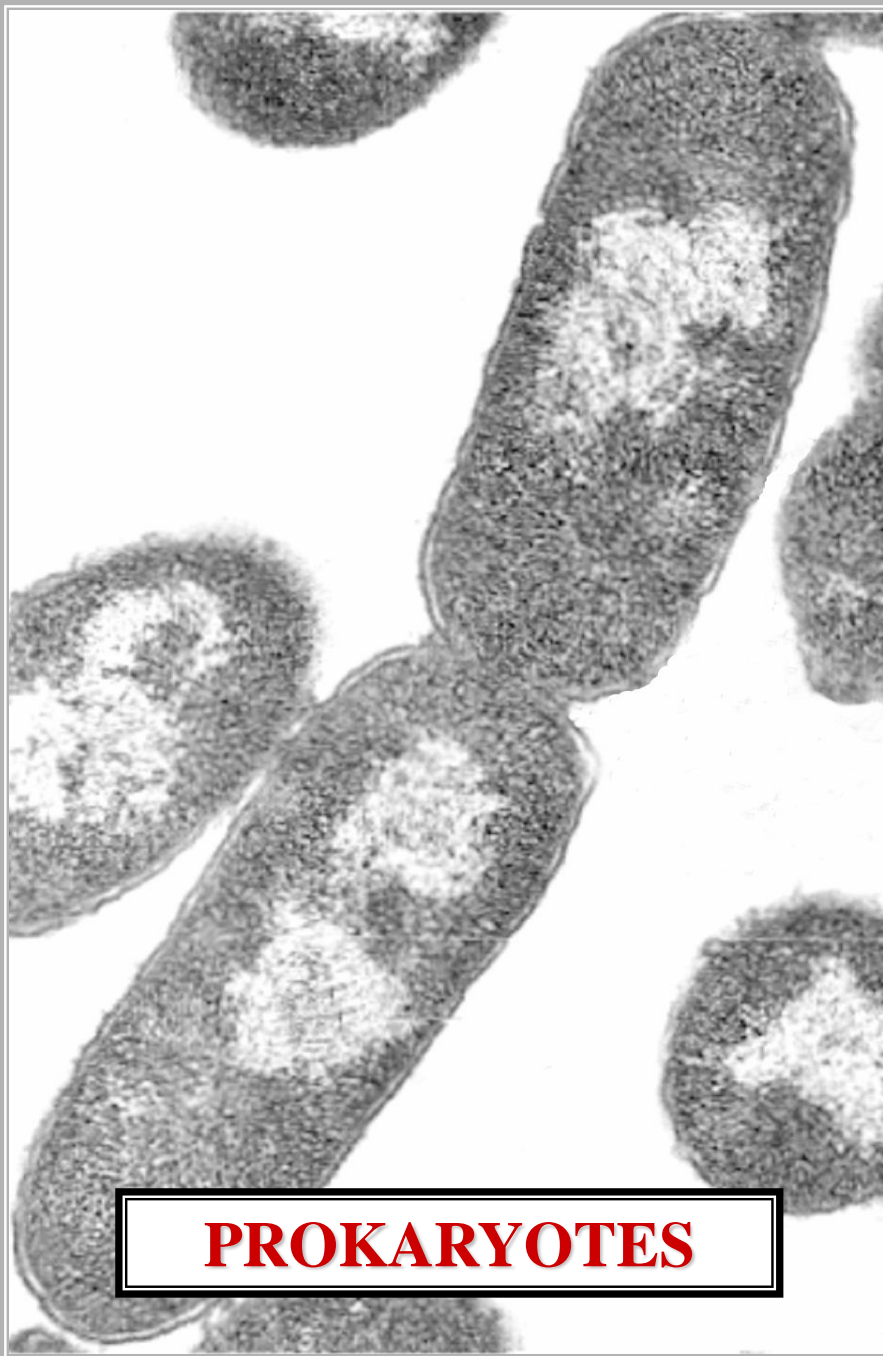
**DIVERSE
PROKARYOTE
BIOTA**

EARTH



~1.8
BILLION YEARS





PROKARYOTES



E

**MEMBRANE
BOUND
ORGANELLES**



EUKARYOTE EVOLUTION



**DOUBLE
MEMBRANE
BOUND
ORGANELLES
EVOLUTION**

EUKARYOTE CELL

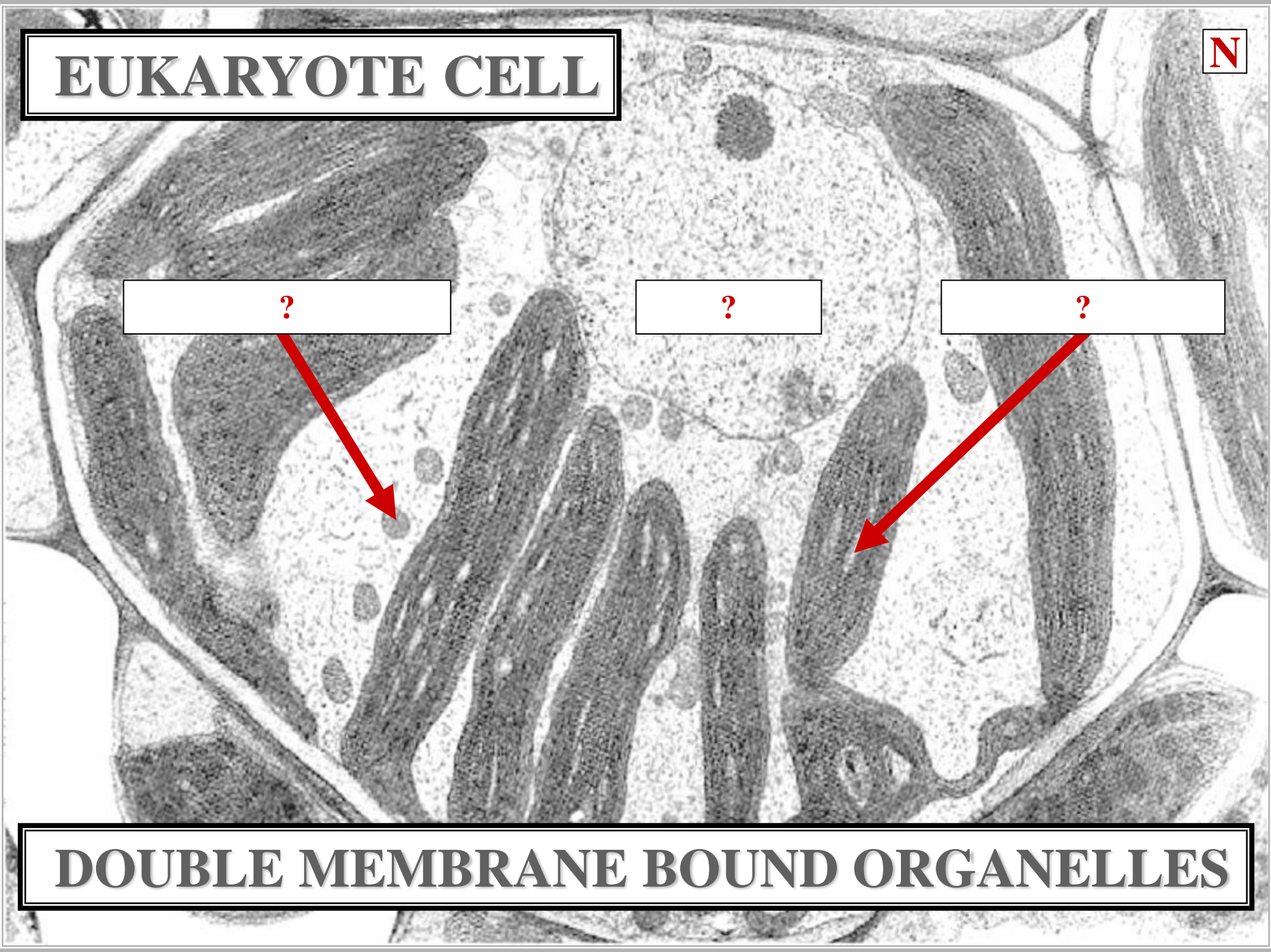
N

?

?

?

DOUBLE MEMBRANE BOUND ORGANELLES

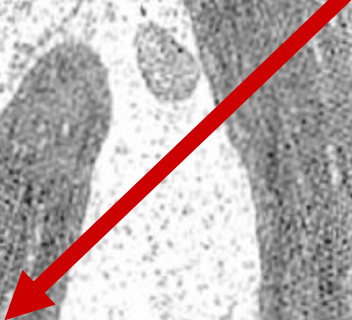


EUKARYOTE CELL

?

NUCLEUS

?



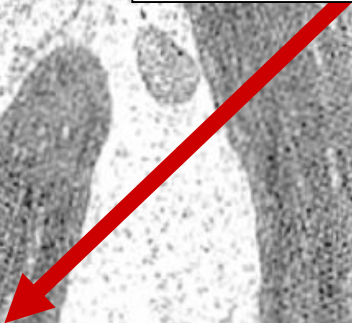
DOUBLE MEMBRANE BOUND ORGANELLES

EUKARYOTE CELL

MITOCHONDRION

NUCLEUS

?



DOUBLE MEMBRANE BOUND ORGANELLES

EUKARYOTE CELL

C

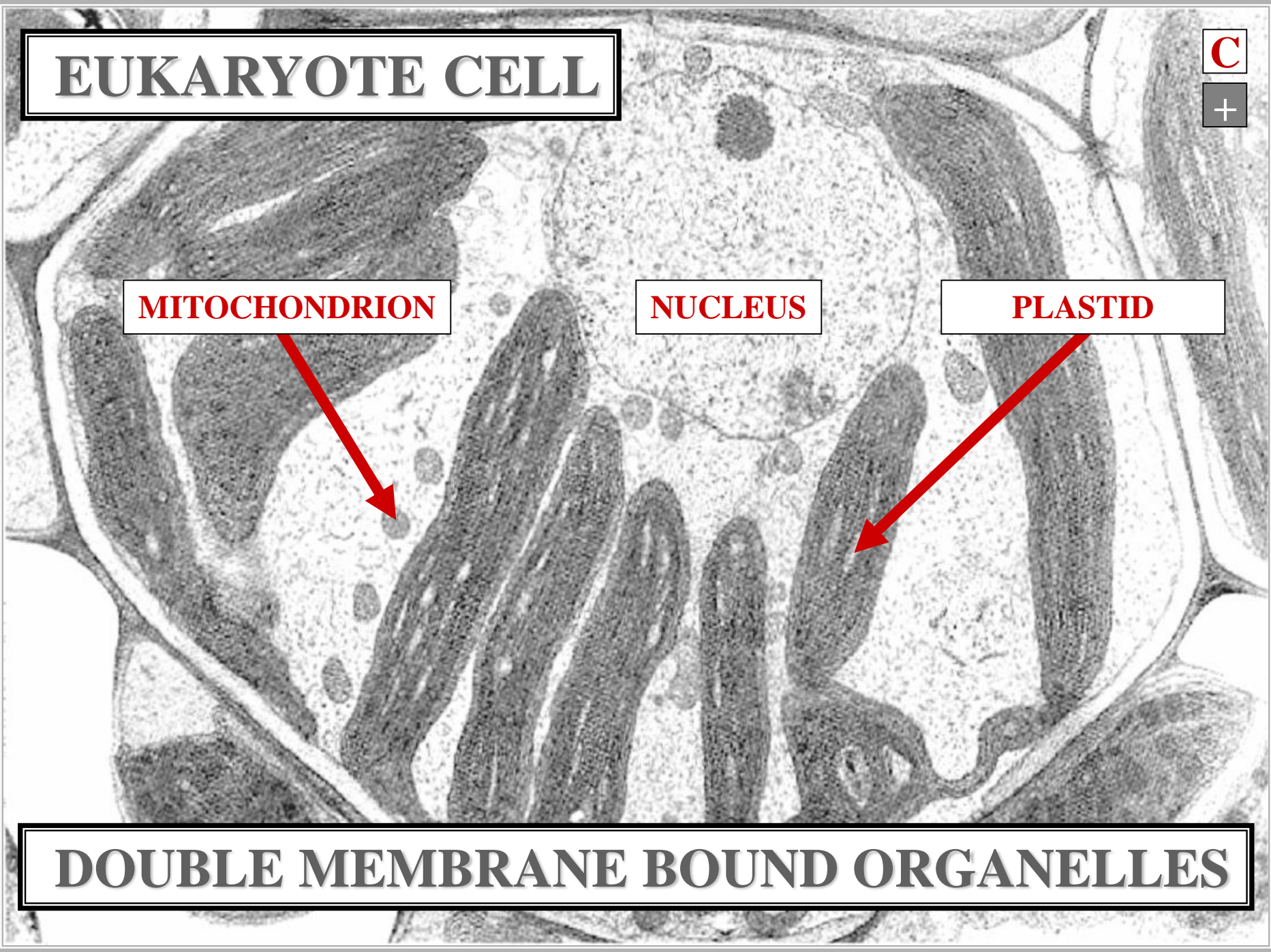
+

MITOCHONDRION

NUCLEUS

PLASTID

DOUBLE MEMBRANE BOUND ORGANELLES



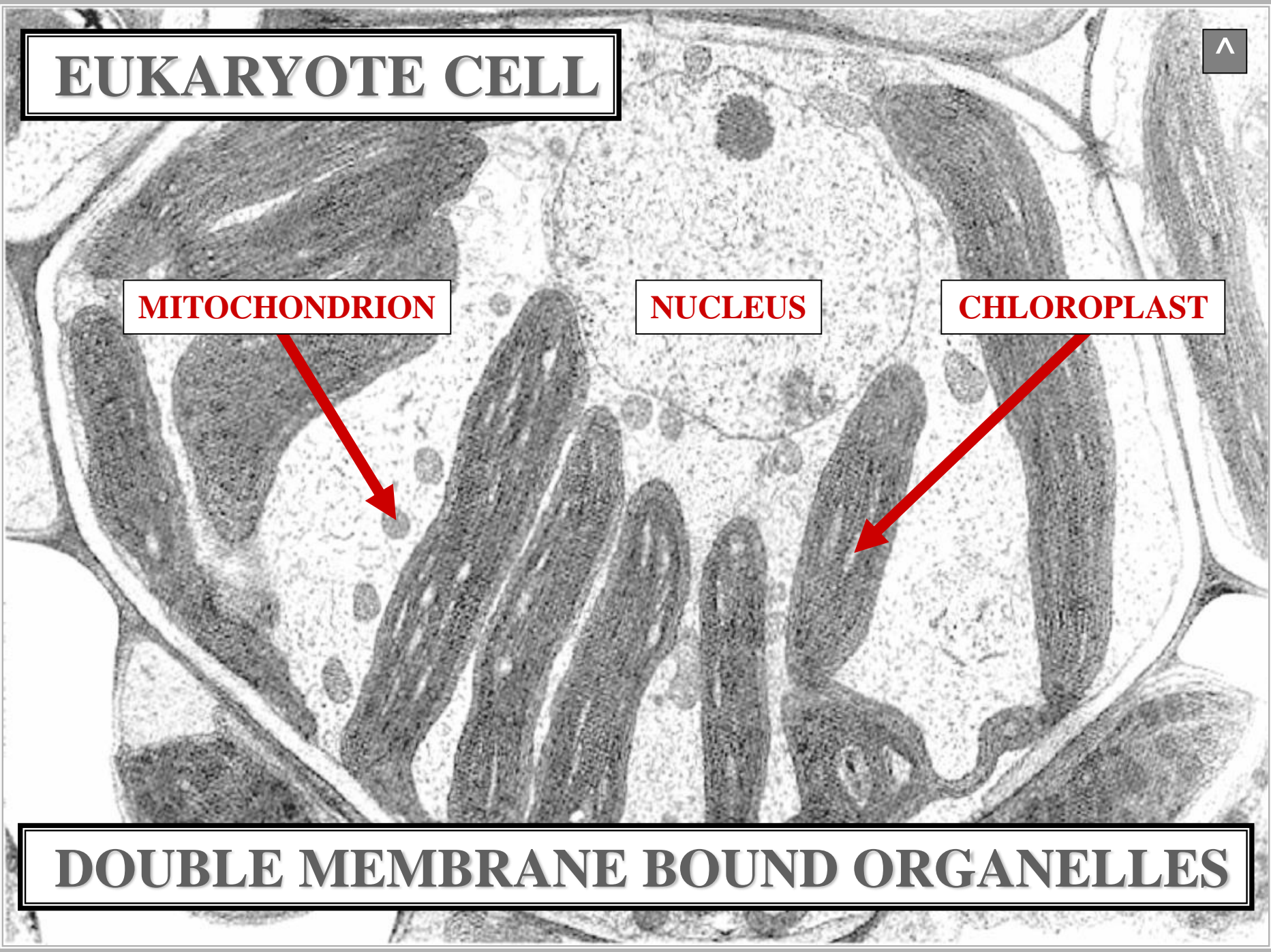
EUKARYOTE CELL

MITOCHONDRION

NUCLEUS

CHLOROPLAST

DOUBLE MEMBRANE BOUND ORGANELLES





**AUTOGENOUS
THEORY
&
ENDOSYMBIOTIC
THEORY**

AUTOGENOUS THEORY

AUTOGENOUS THEORY

AUTOGENOUS THEORY



NUCLEUS EVOLUTION

AUTOGENOUS THEORY

AUTOGENOUS THEORY



VIA PROKARYOTE MEMBRANE SPECALIZATION

AUTOGENOUS THEORY

EUKARYOTE CELL

A transmission electron micrograph (TEM) of a eukaryotic cell. The image shows a large, roughly spherical nucleus in the center, surrounded by a nuclear envelope. The cytoplasm is filled with various organelles, including several large, dark, elongated mitochondria with visible internal folds (cristae). There are also smaller, circular vesicles and other organelles scattered throughout the cell. The overall structure is complex and organized.

NUCLEUS

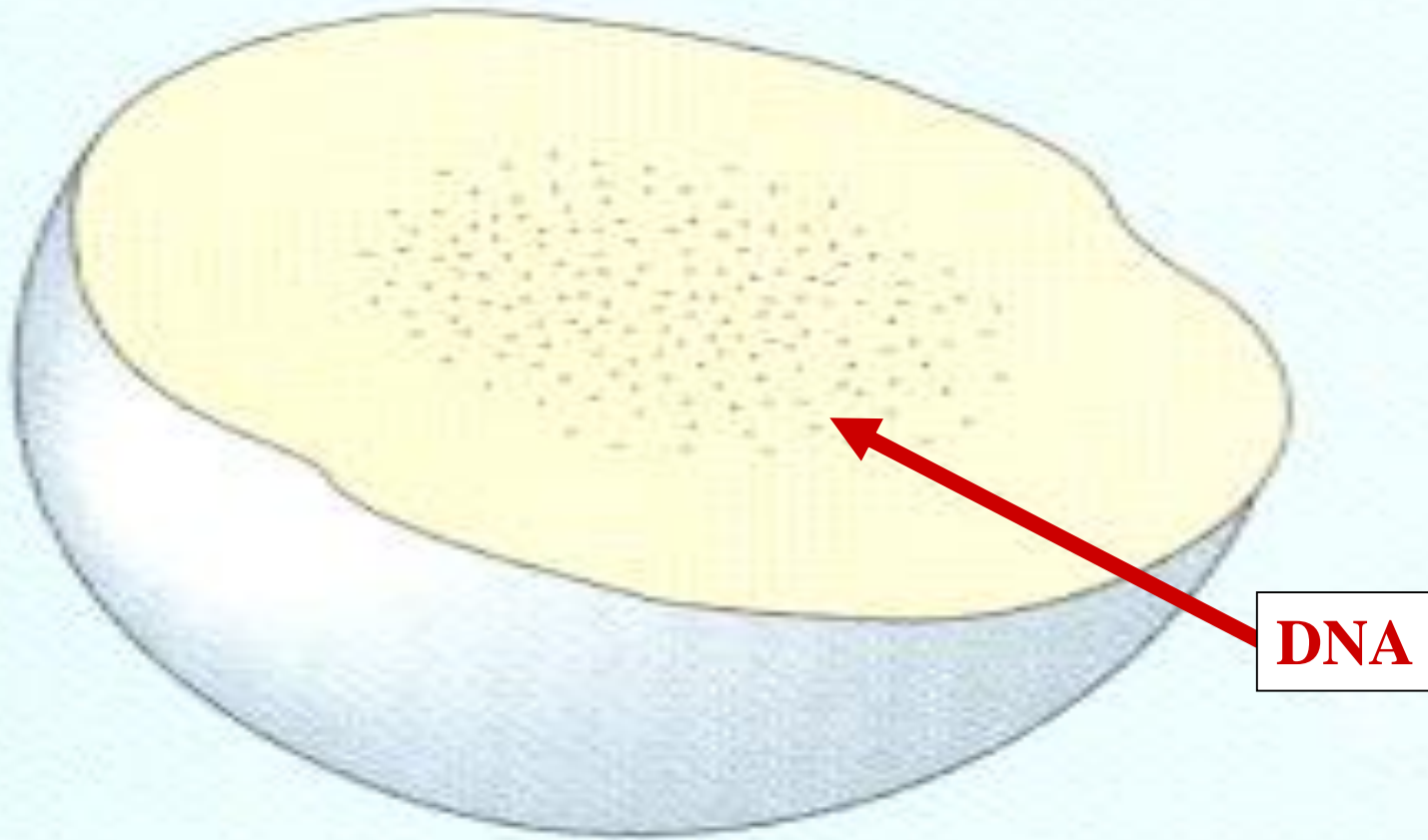
AUTOGENOUS THEORY



NUCLEUS EVOLUTION



NUCLEUS
EVOLUTION
HYPOTHETICAL
SCENARIO

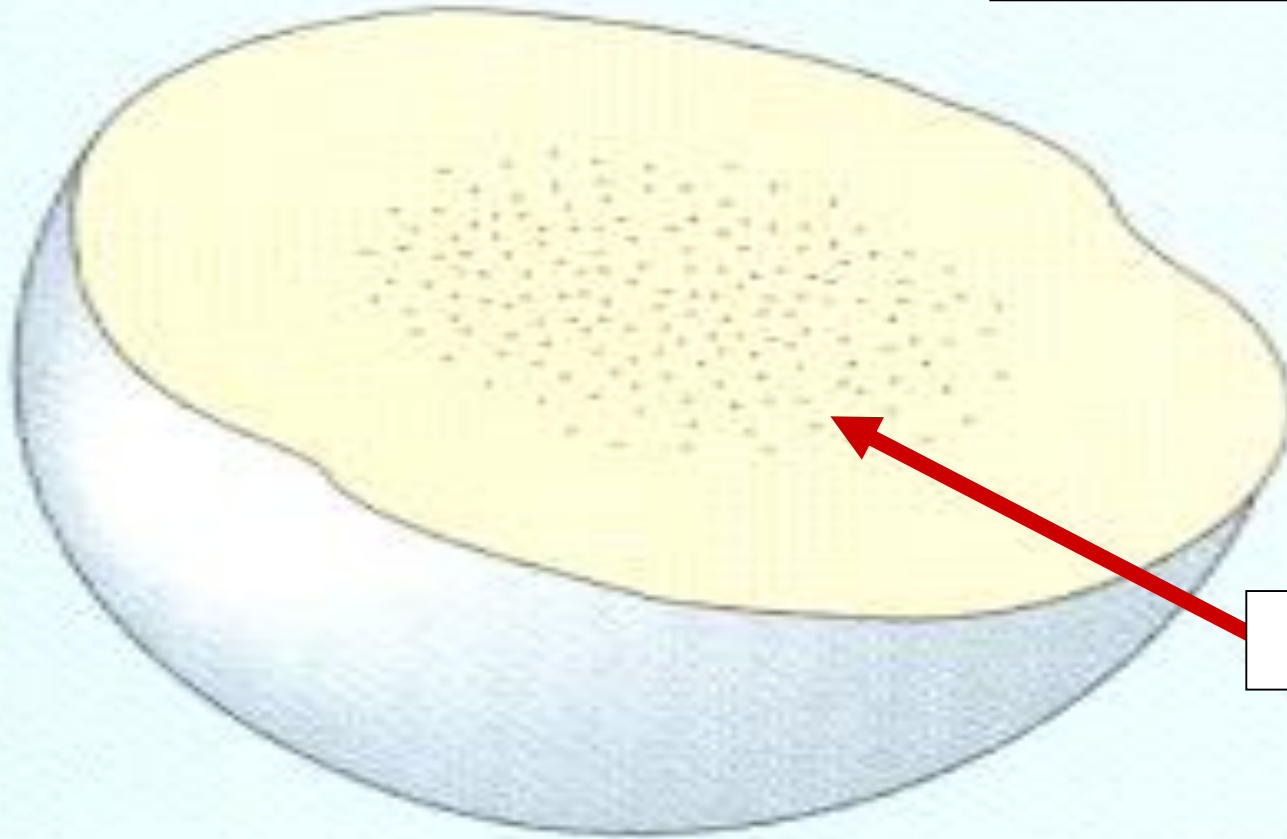


DNA

ANCESTRAL PROKARYOTE

N
AB

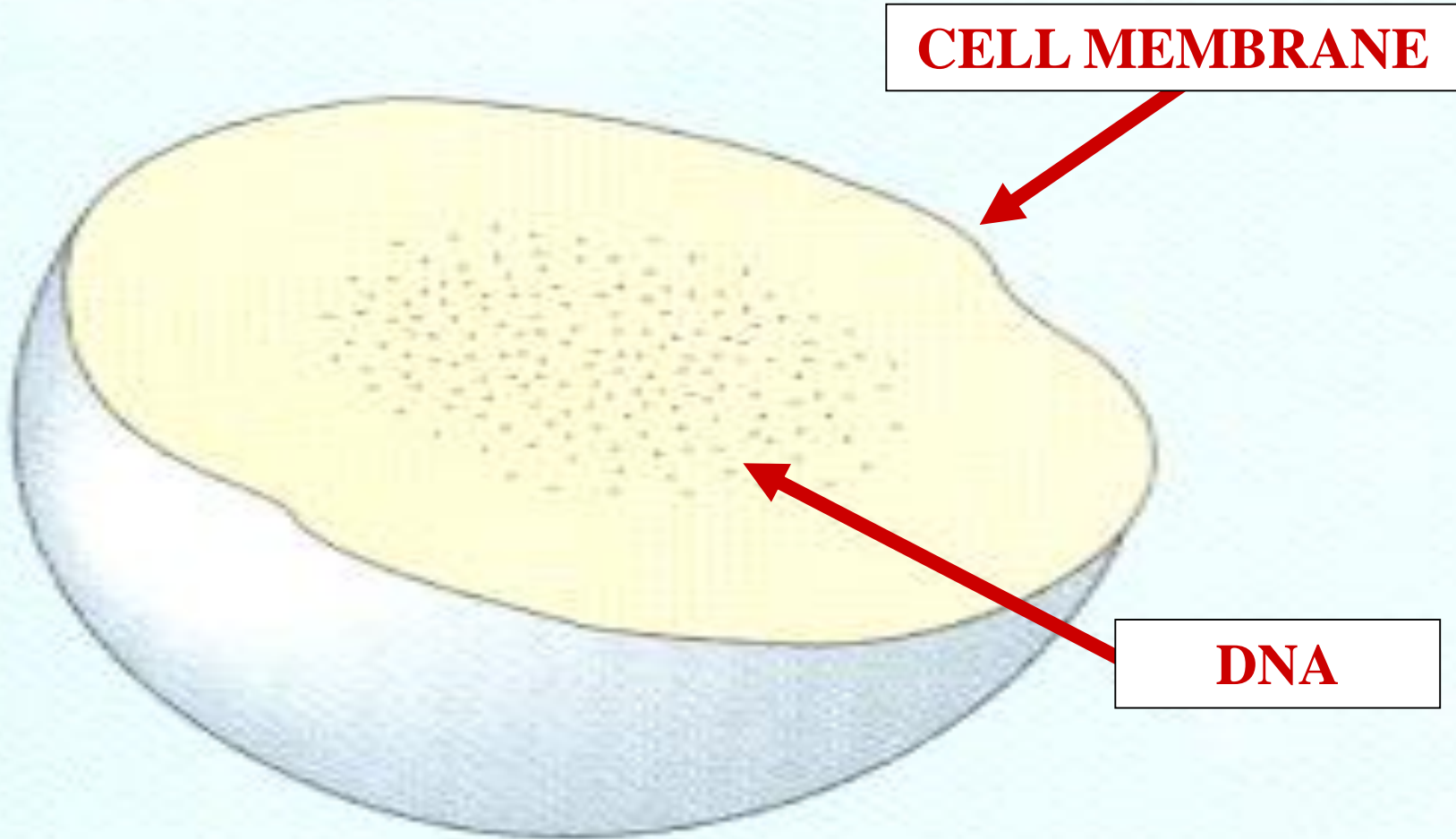
NUCLEUS: ABSENT



DNA

ANCESTRAL PROKARYOTE

CM



CELL MEMBRANE

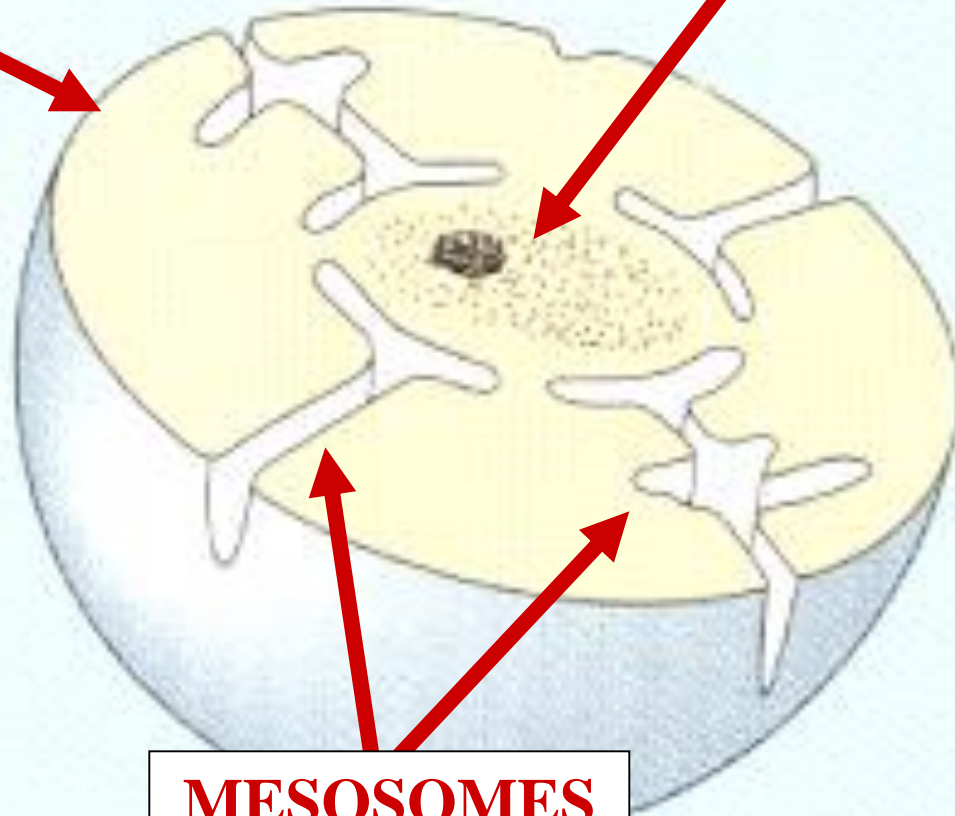
DNA

ANCESTRAL PROKARYOTE

M

CELL MEMBRANE

DNA



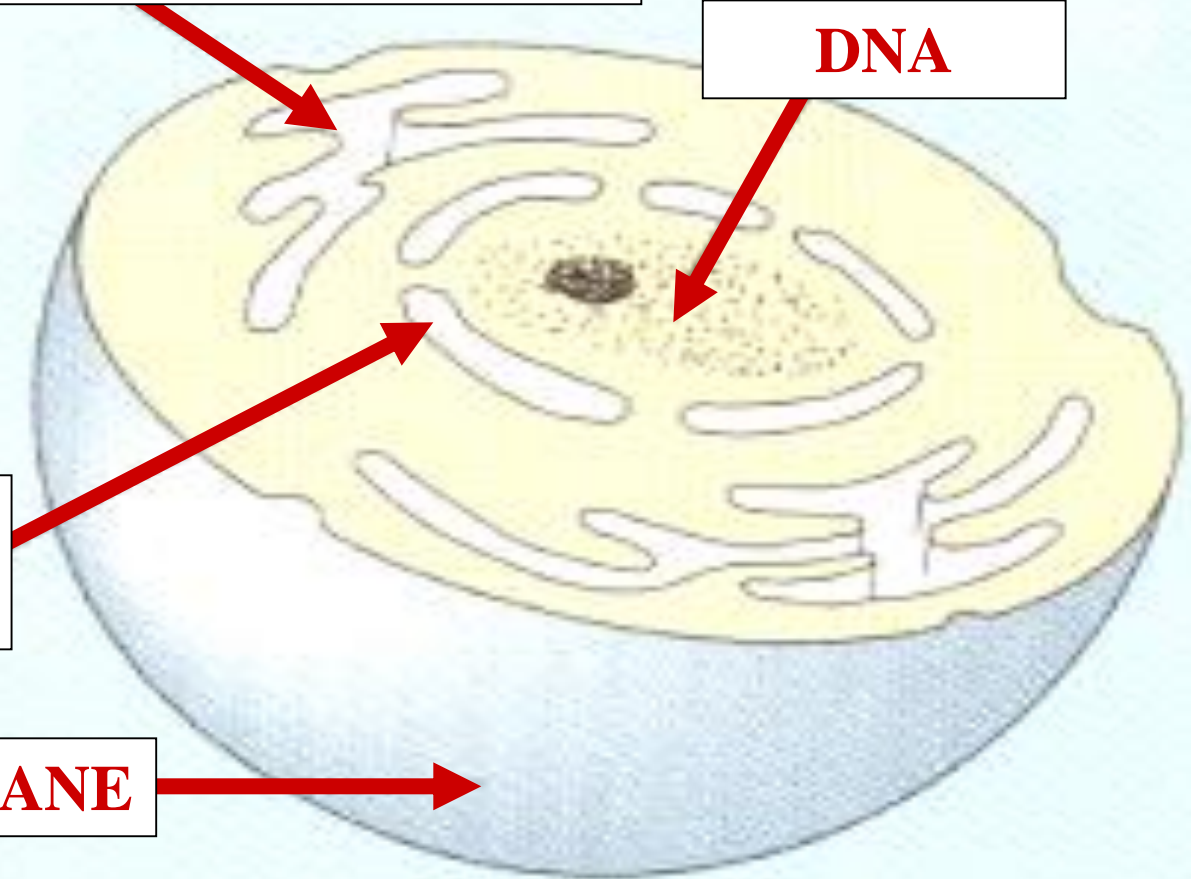
MESOSOMES

ANCESTRAL PROKARYOTE

IM

INTERNAL MEMBRANE

DNA



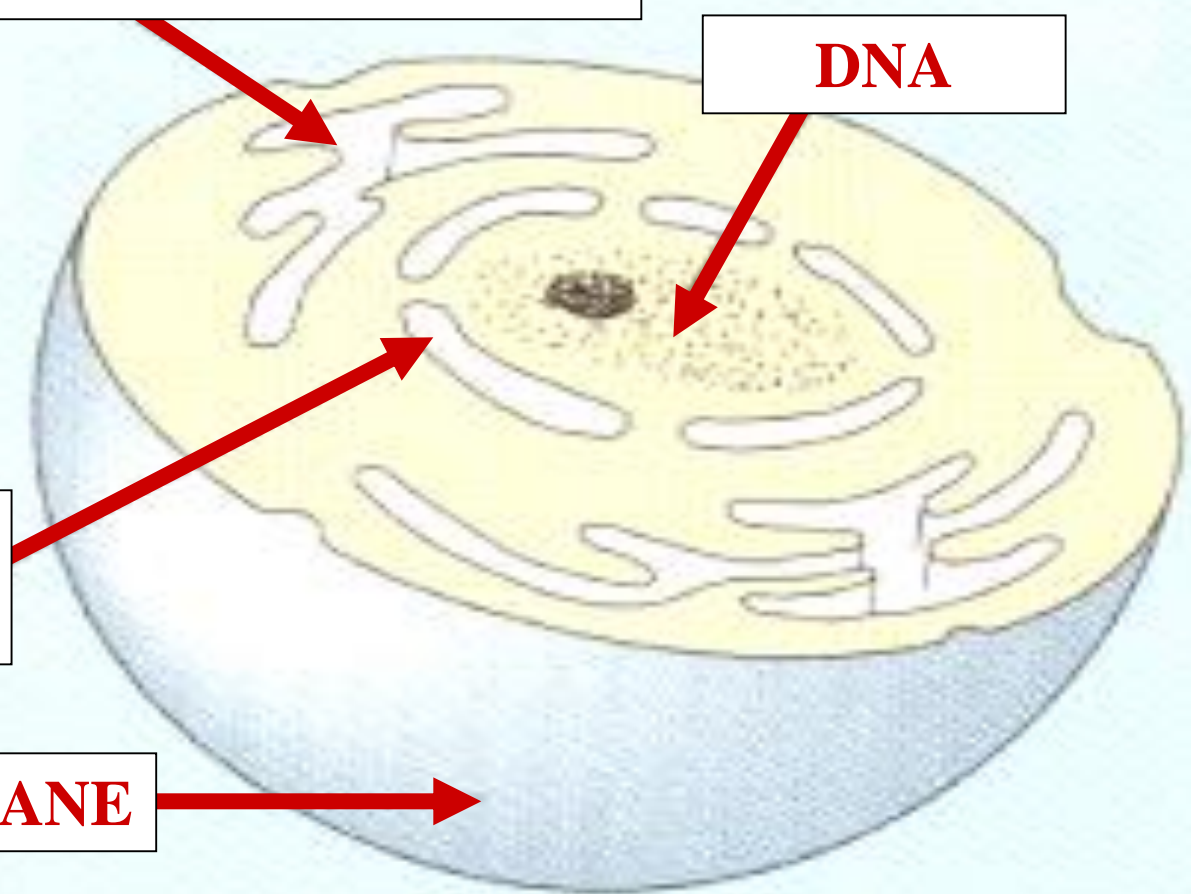
CELL MEMBRANE

ANCESTRAL PROKARYOTE

ER

ENDOPLASMIC RETICULUM

DNA



CELL MEMBRANE

ANCESTRAL PROKARYOTE

NM

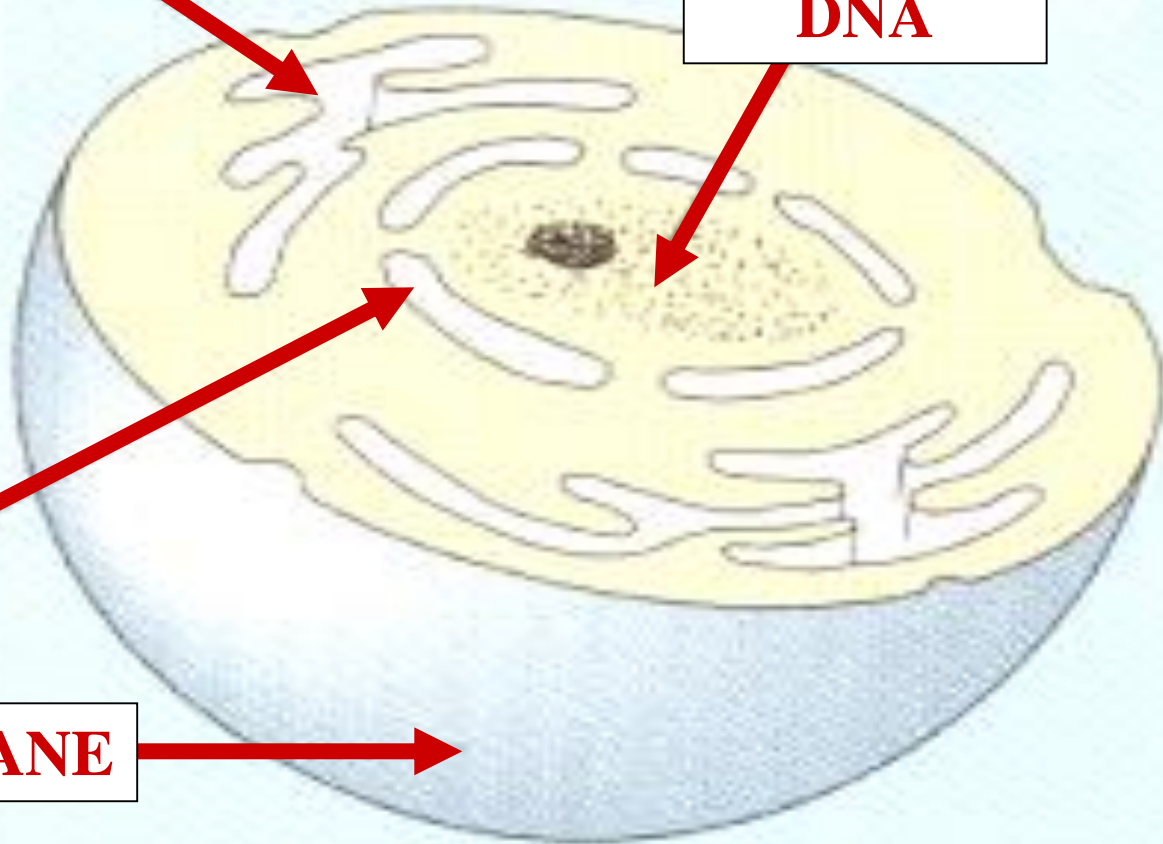


ENDOPLASMIC RETICULUM

DNA

NUCLEAR MEMBRANE

CELL MEMBRANE



ANCESTRAL PROKARYOTE



**AUTOGENOUS
THEORY
SUPPORTING
EVIDENCE**

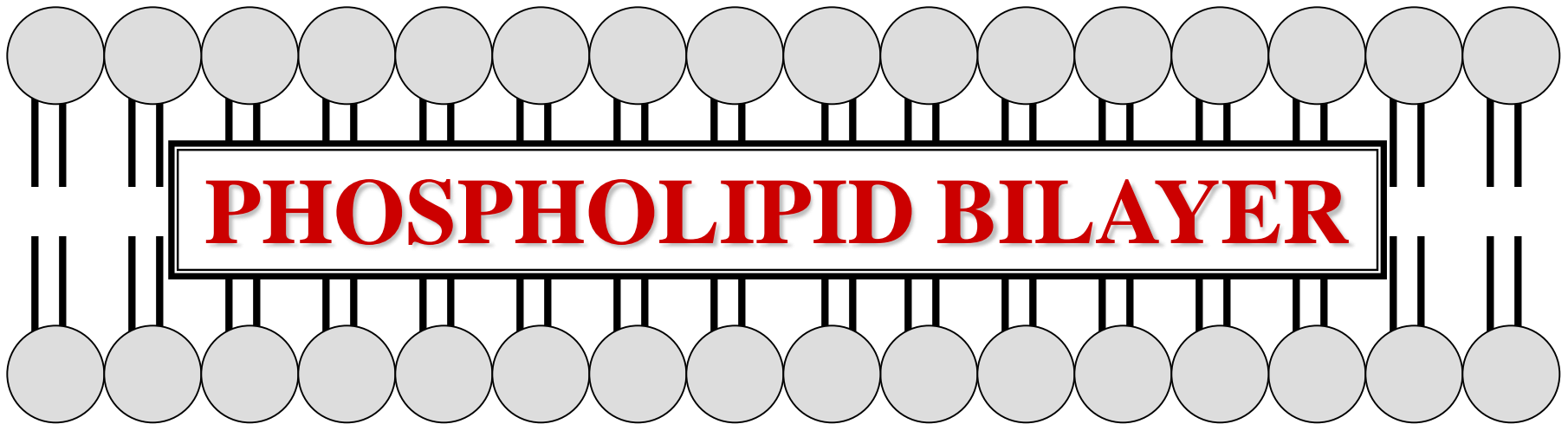


CELL MEMBRANE, ER & NUCLEAR MEMBRANE

WATER

WATER

WATER

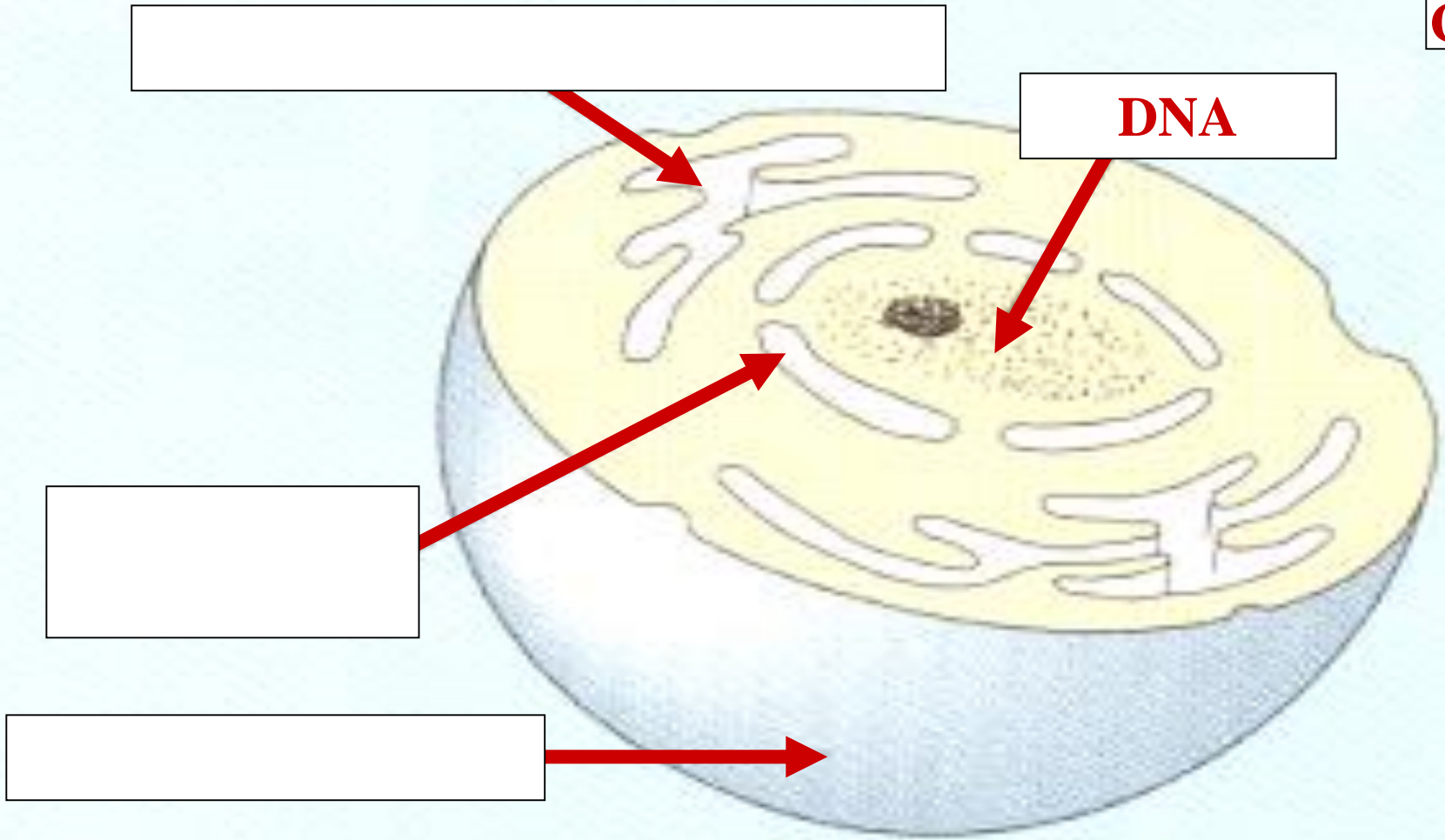


WATER

WATER

WATER

CELL MEMBRANE, ER & NUCLEAR MEMBRANE



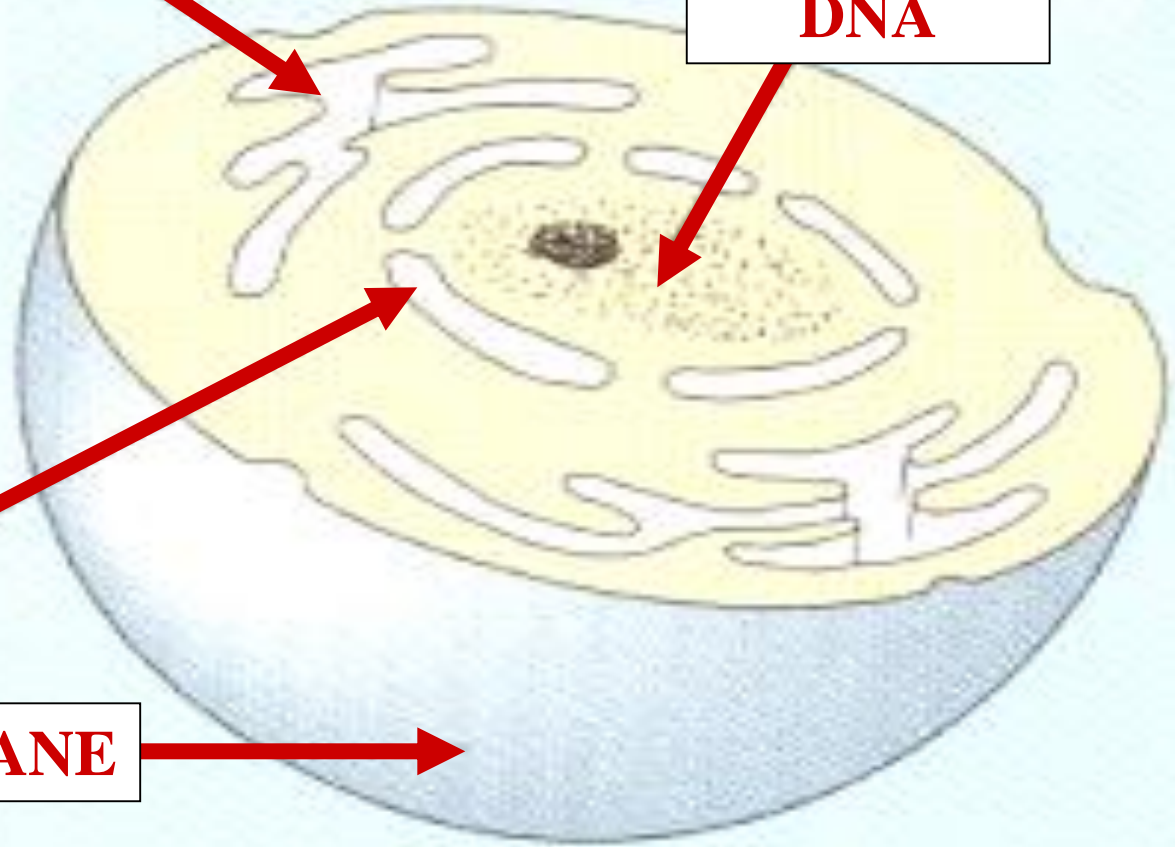
EUKARYOYTE CELL

ER

DNA

CELL MEMBRANE

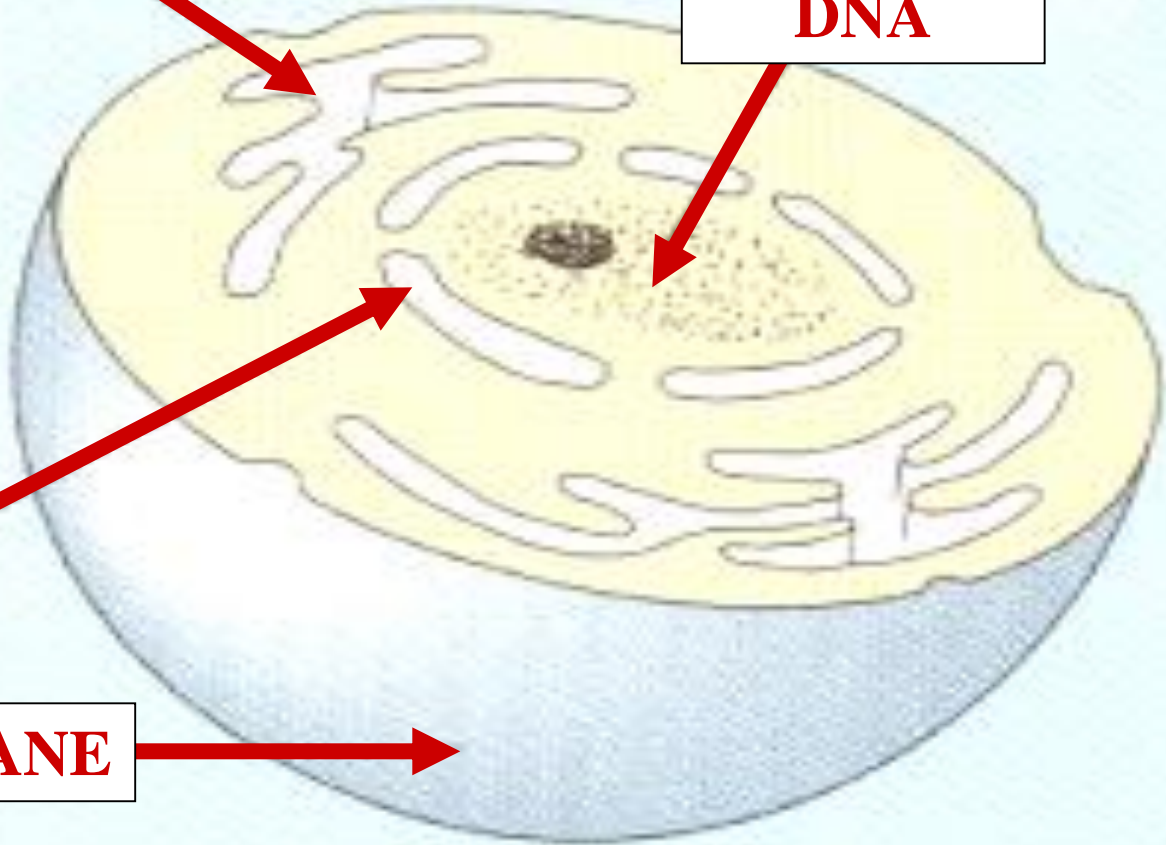
EUKARYOYTE CELL



ENDOPLASMIC RETICULUM

DNA

CELL MEMBRANE



EUKARYOYTE CELL

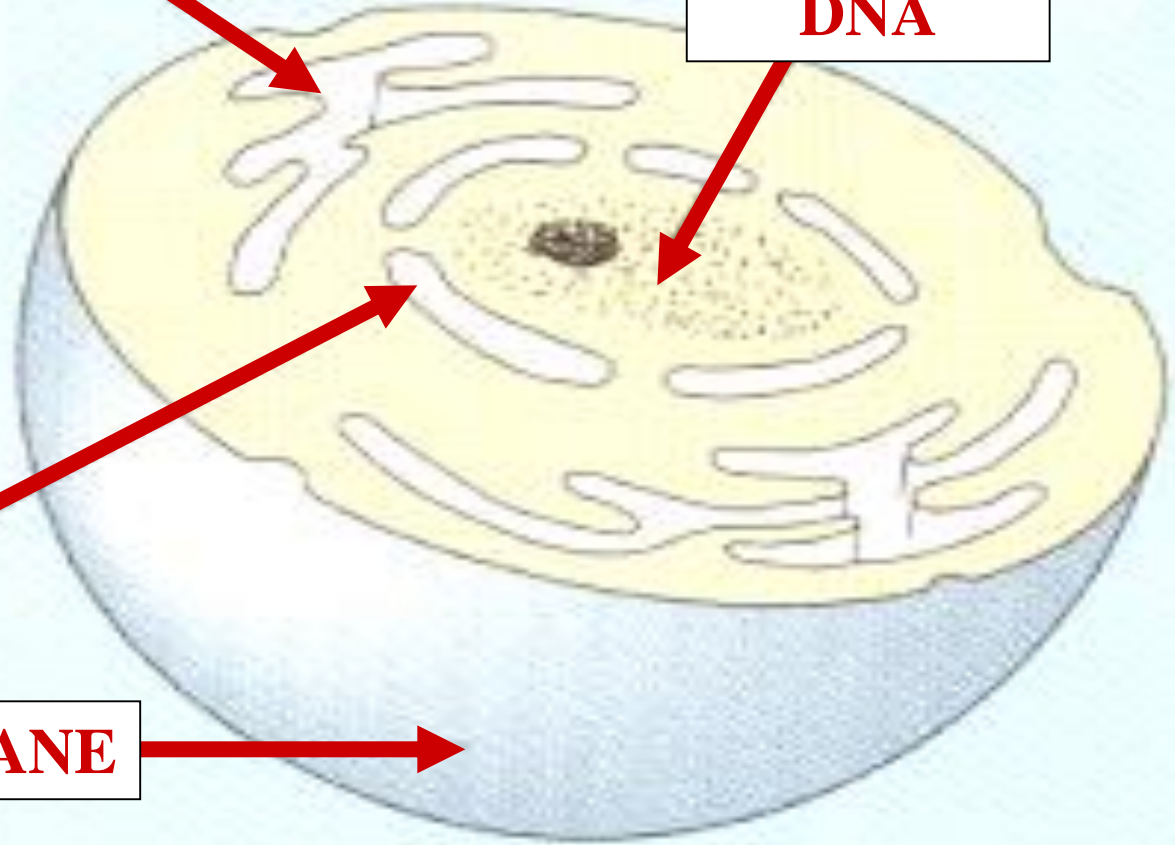
ENDOPLASMIC RETICULUM

DNA

**NUCLEAR
MEMBRANE**

CELL MEMBRANE

EUKARYOYTE CELL

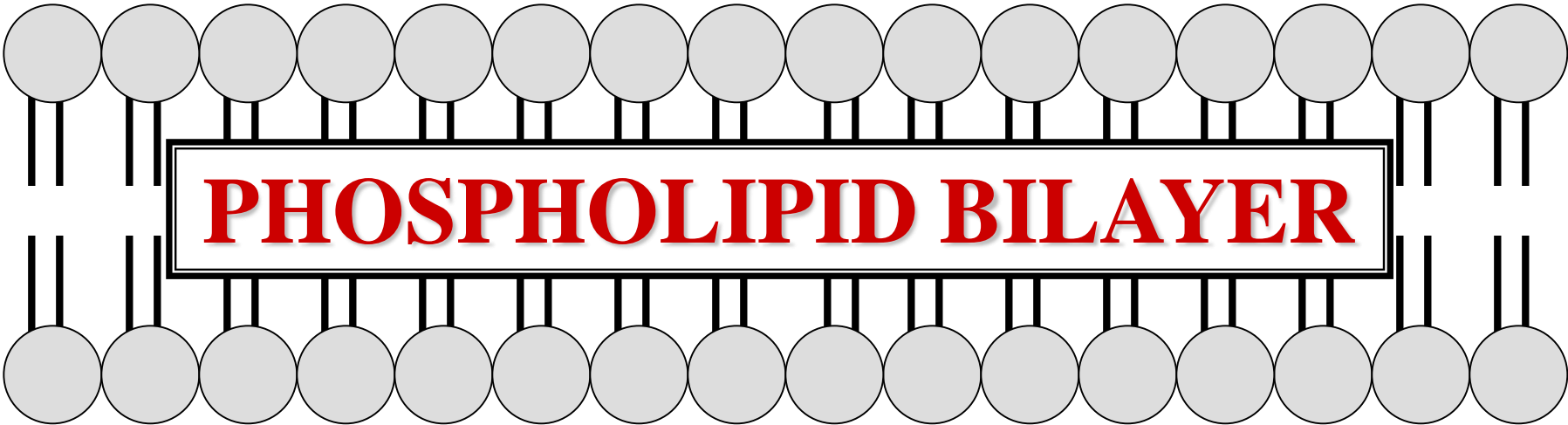


CELL MEMBRANE, ER & NUCLEAR MEMBRANE

WATER

WATER

WATER



WATER

WATER

WATER

CELL MEMBRANE, ER & NUCLEAR MEMBRANE

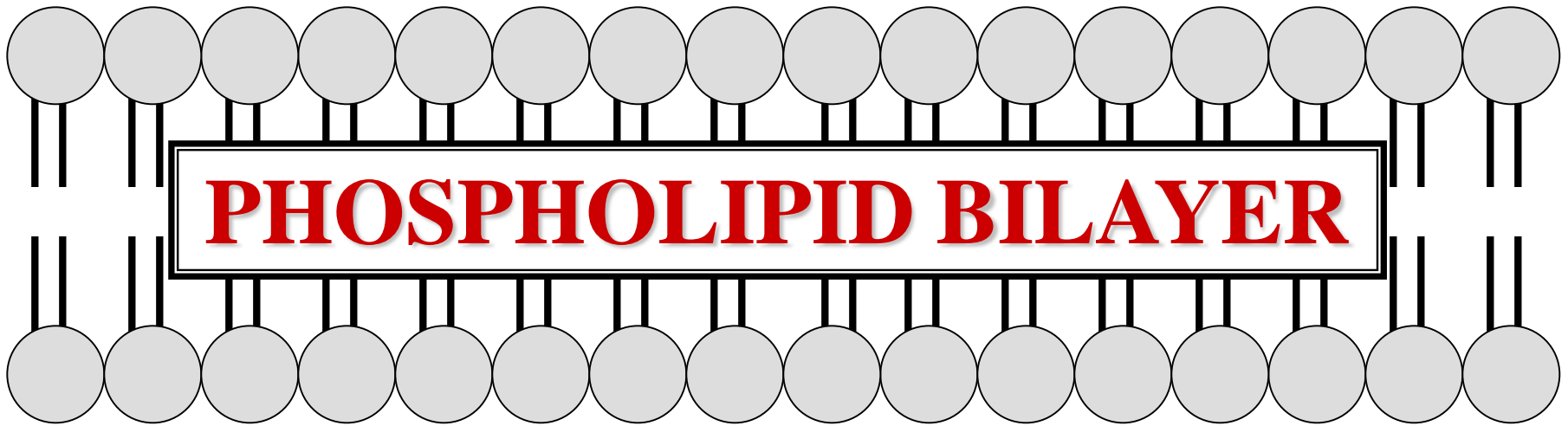


CELL MEMBRANE, ER & NUCLEAR MEMBRANE

WATER

WATER

WATER



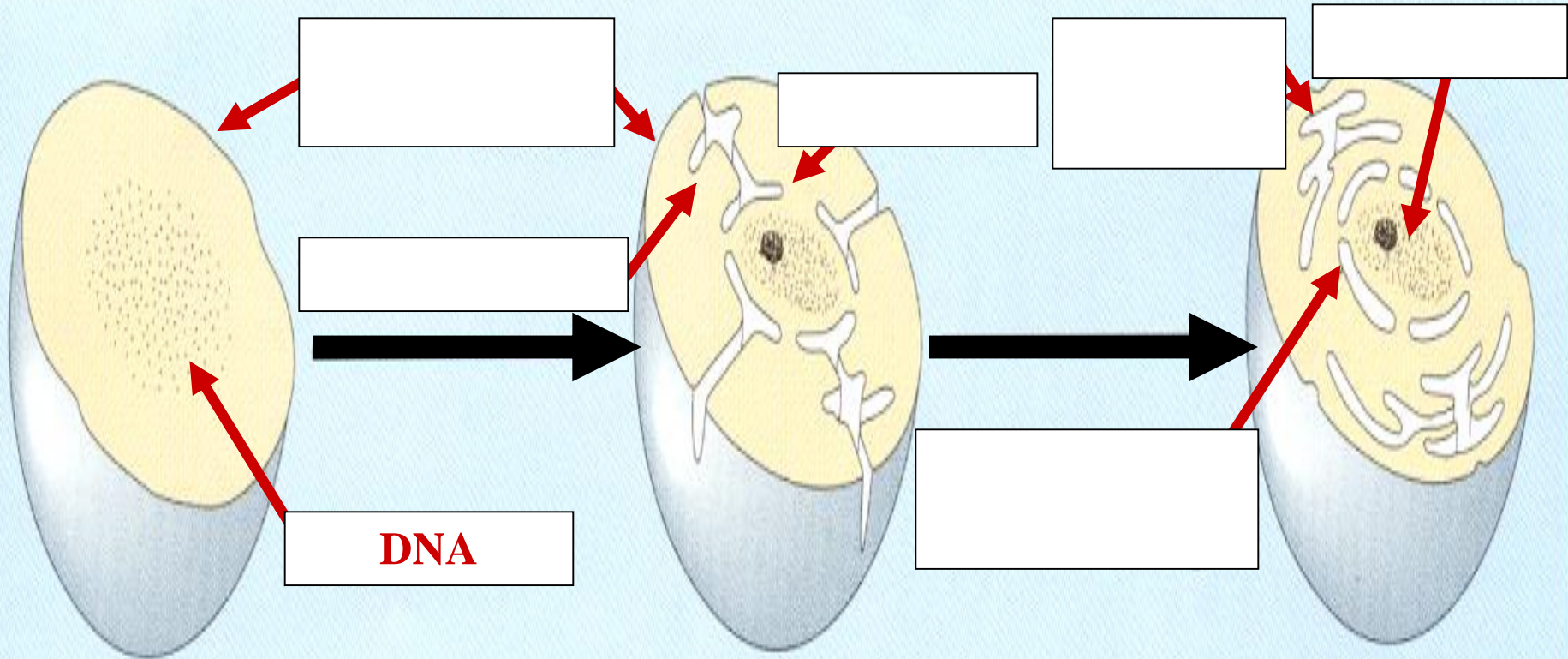
WATER

WATER

WATER

**PHOSPHOLIPIDS
IDENTICAL**

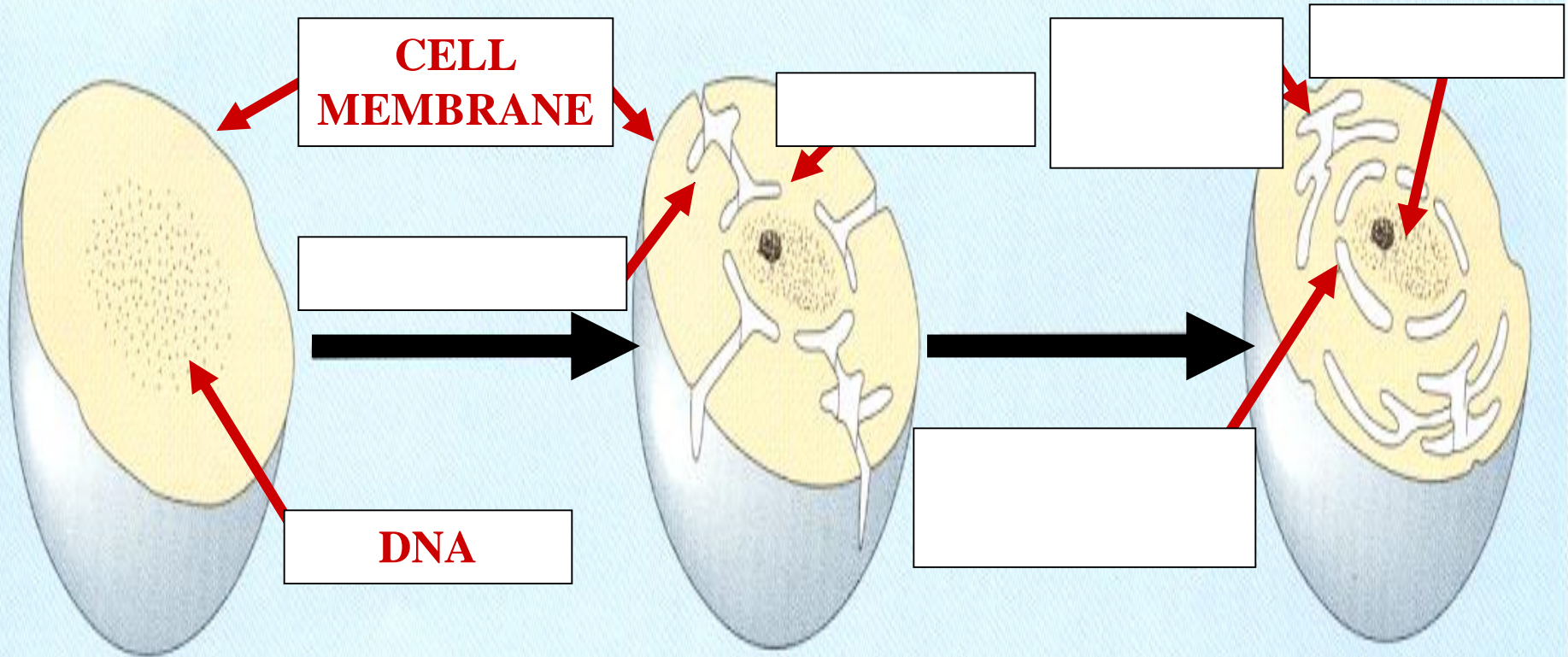
AUTOGENOUS THEORY



**ANCESTRAL
PROKARYOTE**

**NUCLEATED
EUKARYOTE**

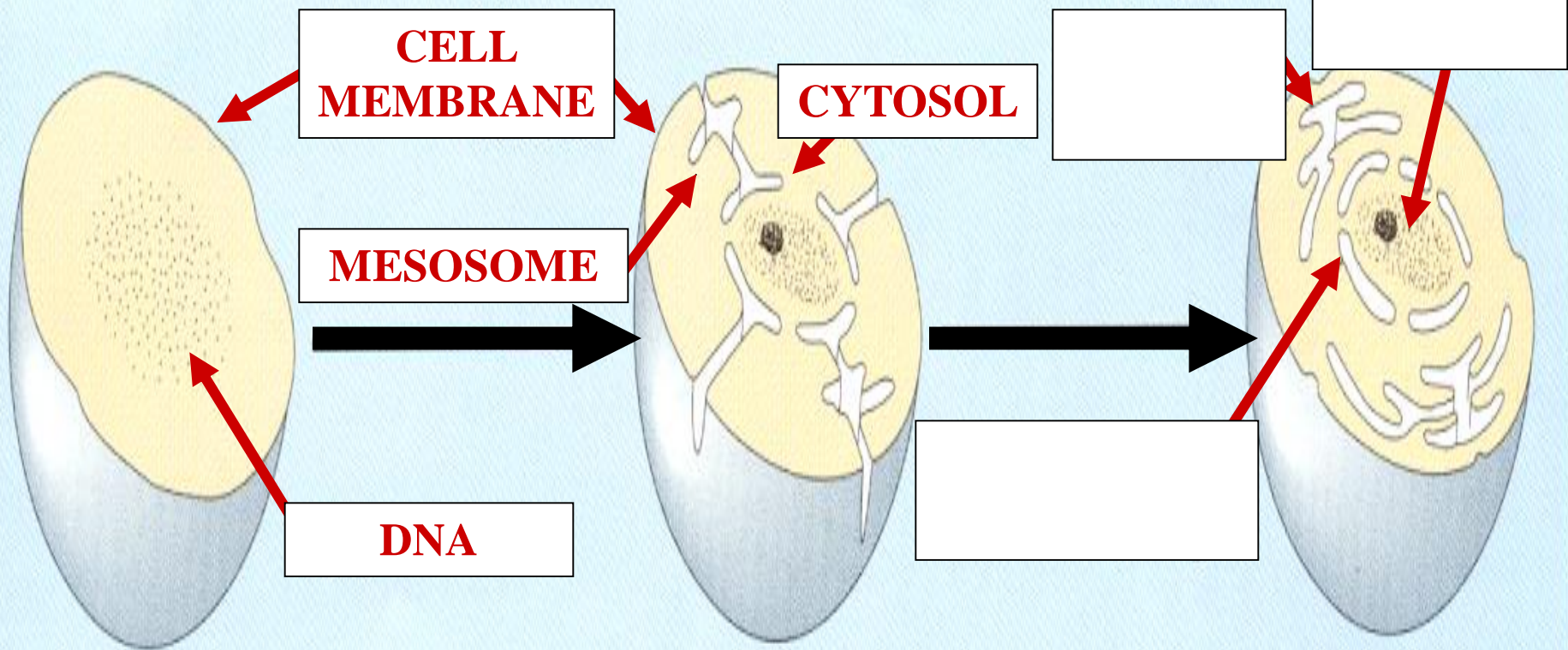
AUTOGENOUS THEORY



**ANCESTRAL
PROKARYOTE**

**NUCLEATED
EUKARYOTE**

AUTOGENOUS THEORY



**ANCESTRAL
PROKARYOTE**

**NUCLEATED
EUKARYOTE**